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# Survey and management of rhizome rot complex disease in ginger

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**Abstract**
A survey was conducted in selected ginger growing areas of malnad districts of Karnataka to know the incidence of rhizome rot complex disease in ginger. Among the different places where survey was conducted, Banavasi in Uttar Kannada district recorded the highest incidence of disease 40-48 PDI and the least incidence(15-18 PDI) was recorded in Haveri district Among the different treatments, T9 (Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@ 5 kg/ton) + Neem cake (1.0 qt/ac.) + Pre-sowing rhizome treatment with 0.05% Streptocycline + 0.30% Copper oxy-chloride for 15 minutes followed by drenching with 0.30% Bleaching powder + 0.30% Copper oxy chloride + 0.15% Metalaxyl-MZ + 0.05% Streptocycline) recorded the least Per cent Disease Incidence (4.25) and the highest rhizome yield (370.83 Q/ha). The highest phenol content (3.622 and 4.117 mg/g leaf tissue), reducing sugars (4.976 and 2.954 mg/g of leaf tissue), non-reducing sugars (1.862 and 0.957 mg/g leaf tissue) at 60 and 90 Days after planting in inoculated plants recorded in CV. Himachal. Whereas, the highest chlorophyll content was recorded in Cv. Varada (39.46 and 31.94) at 60 and 90 days after planting.

**Keywords:** Survey, management, rhizome rot

## Introduction
Ginger (*Zingiber officinale* Rosc.) is one of the important commercial spice and medicinal crops grown extensively in malnad parts of Karnataka covering the districts of Uttar Kannada, Dakshina Kannada, Udupi, Shimoga, Coorg, Haveri and parts of Hassan to the tune of 50% area under ginger in Karnataka State. Uttar Kannada and neighbouring talukas of Shimoga district alone occupy more than 60 per cent of ginger grown in malnad region of Karnataka. The crop is suffering due to many diseases infected by bacteria, fungus, virus and nematodes. Among the diseases, the rhizome rot caused by *Pythium aphanidermatum* is an established fact (Shalini, 2006) [8]. In recent past, with the increased area, the diseased planting material is moving from one area to another which is acting as carrier of disease causing pathogen among farmers. An investigation was carried out during 2009 to know the association of bacteria (*Pseudomonas solanacearum* E.F. Smith) in causing the bacterial wilt earlier it was called as *Ralstonia solanacearum* in India (Dohroo, 1991) [3]. The area in Kerala state is drastically reduced due to Bacterial wilt. The loss is estimated to the tune of 90% in Kerala (Sharma *et al.*, 1978) [9]. As *Pythium aphanidermatum* and *Pseudomonas solanacearum* are rhizome and soil borne in nature an experiment was planned with integrated management modules to study their impact on disease management and yield of rhizome.

## Materials and Methods
A detailed survey was conducted during *Kharif* season of 2018-19 to assess the magnitude of rhizome rot disease in major ginger growing areas in Sirsi taluka of Uttar Kannada (comprising villages ie. Banavasi, Andagi, Kerekoppa, Unchalli, Kadagodu, Tigani, Gudnapur and Isalur), Soraba taluka in Shivamogga district (comprising villages like. Jade and Anavatti) and Byadagi, Hanagal and Hirekerur talukas in Haveri district. Two fields in each of the villages were selected and in each field a sampling was done in 450m$^2$ which included 3 sampling unit plots of 50 m x 3m dimensions. Rhizome rot complex disease intensity was recorded by the formula,

$$\text{Per cent Disease Incidence} = \frac{\text{Number of affected clumps}}{\text{Total number of clumps}} \text{ X } 100$$

Also, screening of five ginger genotypes against rhizome rot complex disease under pot culture for healthy and inoculated samples was carried out in University of Agricultural Sciences, Dharwad and subjected to chemical analysis (like.. Phenols, Reducing sugars, non-reducing sugars and Chlorophyll)

The investigation was carried out in ginger growing areas of Uttar Kannada, Shivamogga and Haveri districts of malnad region to assess the magnitude of wilt disease complex problem followed by management through integrated approach. The field experiment was laid out in Completely Randamized Block Design (RCBD) during 2018-19 in Masanakatte village of Hanagal taluka of Haveri district. There were ten treatments replicated thrice. The plot size was 10.0 m x 1.0 m. The cultivar used was Himachal. Three to four drenching of recommended chemical are to be taken up at 10 to 15 days interval depending upon rain fall/soil moisture status.

**Integrated treatment details**

| Treatment | Treatment details |
|---|---|
| T1 | Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@5 kg/ton) + Neem cake (1qt/ac.) + Pre-sowing rhizome treatment with 0.05% Streptocycline + 0.3% Copper oxy-chloride for 15 minutes followed by drenching with 0.30% Bleaching powder + 0.15% Metalaxyl- MZ |
| T2 | Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@5 kg/ton) + Neem cake (1qt/ac.) + Pre-sowing rhizome treatment with 0.05% Streptocycline + 0.10% Metalaxyl- MZ for 15 minutes followed by drenching with 0.3% Bleaching powder + 0.15% Metalaxyl MZ + 0.30% Copper oxy chloride |
| T3 | Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@5 kg/ton) + Neem cake (1qt/ac.)+ Pre-sowing rhizome treatment with 0.6% Metalaxyl- MZ for 15 minutes + followed by soil drenching with 0.20% Metalaxyl -MZ at disease inception. |
| T4 | Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@5 kg/ton) + Neem cake (1qt/ac.) + Pre-sowing rhizome treatment with 0.05% Streptocycline + 0.30% Copper Oxy-chloride for 15 minutes followed by drenching with 0.30% Bleaching powder + 0.3% Copper oxy chloride + 0.15% Metalaxyl -MZ |
| T5 | Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@ 5 kg/ton) + Neem cake (1qt/ac.) + Pre-sowing rhizome treatment with 0.05% Streptocycline + 0.30% Copper Oxy-chloride for 15 minutes followed by drenching with 0.20% Bleaching powder + 0.20% Copper oxy chloride +0.10% Metalaxyl -MZ |
| T6 | Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@ 5 kg/ton) + Neem cake (1qt/ac.) followed by soil application with 2.00% *Trichoderma harzianum* and *20% Pseudomonas fluorescens* at disease inception. |
| T7 | Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@ 5 kg/ton) + Neem cake (1qt/ac.) followed by drenching with 0.30% copper oxychloride. |
| T8 | Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@ 5 kg/ton) + Neem cake (1qt/ac.) + Pre-sowing rhizome treatment with 0.05% Streptocycline + 0.30% Copper oxy chloride for 15 minutes + followed by drenching with 0.20% Bleaching powder and 0.10% Metalaxyl MZ |
| T9 | Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@ 5 kg/ton) + Neem cake (1qt/ac.) + Pre-sowing rhizome treatment with 0.05% Streptocycline + 0.30% Copper oxy-chloride for 15 minutes followed by drenching with 0.30% Bleaching powder + 0.30% Copper oxy chloride + 0.15% Metalaxyl MZ + 0.05% Streptocycline |
| T10 | Control |

**Results and Discussion**

**The results were discussed under different sub headings**

**a) Survey on incidence of wilt complex disease under field conditions**

Across different places, Byadagi in Haveri taluka recorded the least incidence of disease (15 to 18% PDI). Whereas, the highest incidence of disease (40 48% PDI) was recorded in Banavasi village of Uttar Kannada district. In general, the disease incidence was highest in Sirsi Taluka of Uttar Kannada district followed by Sorab in Shivamogga district, Byadagi, Hirekerur and Hanagal taluks of Haveri Distict.

Among different cultivars, across locations, the highest disease incidence (40-48% PDI) was recorded in Sirsi local followed by Rio-De-Janeiro (35-38% PDI) and the least (15-18% PDI) was recorded in cultivar Himachal in Byadagi taluka of Haveri district. Whereas, the Cv. Rio-de-Janeiro and Sirsi local were highly susceptible to rhizome rot complex disease (Table-1).

In Karnataka, mostly Pythiaceous soft rots have been reported by several workers (Mathew *et al*., 1979; Dohroo, 1991) [4, 3] and in some areas *Fusarium* and *Sclerotium* have also been recorded (Dake and Edison, 1989) [2]. Till today, the observation of high intensity of *Ralstonia* wilt has been recorded in ginger growing areas by very few workers in India (Kumar, 2005) [5]. In Kerala, rampant nature of bacterial wilt was attributed for making extensive sick areas and resulting unfit for ginger cultivation (Sharma *et al*. 1978) [9].

**b) Effect of rhizome rot disease on Phenol content in different ginger genotypes**

The leaf tissues were analyzed for the phenol content of healthy and inoculated samples at 60 and 90 days after planting.

At 60 days after planting, the cv. Himachal recorded the highest phenol content (3.122 and 3.622 mg/g of leaf tissue) in healthy and inoculated plants respectively followed by Cv. Varada (2.511 and 2.950 mg/g of leaf tissue). In cv. Rio-de-Janeiro the least phenol content (1.481 and 1.685 mg/g of leaf tissue) was recorded (Table-2)

At 90 days after planting, the cv. Himachal recorded the highest phenol content (3.294 and 4.117 mg/g of leaf tissue) in healthy and inoculated plants respectively followed by Cv. Varada (2.986 and 3.944 mg/g of leaf tissue). In cv. Rio-de-Janeiro the least phenol content (0.995 and 1.992 mg/g of leaf tissue) was recorded (Table-2)

**c) Effect of rhizome rot disease on Reducing sugars in different ginger genotypes**

The leaf tissues were analyzed for the reducing sugars in healthy and inoculated samples at 60 and 90 days after

planting.
At 60 days after planting, the cv. Himachal recorded the highest reducing sugars content (5.959 and 4.976 mg/g of leaf tissue) in healthy and inoculated plants respectively followed by Cv. Varada (4.974 and 3.987 mg/g of leaf tissue). In cv. Rio-de- Janeiro the least reducing sugars content (3.767 and 1.843 mg/g of leaf tissue) was recorded (Table-3)
At 90 days after planting, the cv. Himachal recorded the highest reducing sugars content (3.719 and 2.954 mg/g of leaf tissue) in healthy and inoculated plants respectively followed by Cv. Varada (2.777 and 2.762 mg/g of leaf tissue). In cv. Rio-de- Janeiro the least reducing sugars content (1.338 and 1.224 mg/g of leaf tissue) was recorded (Table-3)

**d) Effect of rhizome rot disease on non-reducing sugars in different ginger genotypes**

The leaf tissues were analyzed for the non-reducing sugars in healthy and inoculated samples at 60 and 90 days after planting.
At 60 days after planting, the cv. Himachal recorded the highest non-reducing sugars content (2.041 and 1.862 mg/g of leaf tissue) in healthy and inoculated plants respectively followed by Cv. Varada (1.973 and 1.766 mg/g of leaf tissue). In cv. Rio-de- Janeiro the least reducing sugars content (1.153 and 0.952 mg/g of leaf tissue) was recorded (Table-4)
At 90 days after planting, the cv. Himachal recorded the highest non-reducing sugars content (1.836 and 0.957 mg/g of leaf tissue) in healthy and inoculated plants respectively followed by Cv. Varada (1.630 and 0.836 mg/g of leaf tissue). In cv. Sirsi local the least reducing sugars content (0.460 and 0.354 mg/g of leaf tissue) was recorded (Table-4).

**e) Effect of rhizome rot disease on chlorophyll in different ginger genotypes**

The leaf tissues were also analyzed for the chlorophyll content both in healthy and inoculated samples at 60 and 90 days after planting.
At 60 days after planting, the cv. Varada recorded the highest leaf chlorophyll content (43.84 and 39.46) in healthy and inoculated plants respectively followed by Cv. Himachal (43.51 and 38.53). In cv. Rio-de- Janeiro the least leaf chlorophyll content (34.21 and 29.67) was recorded (Table-5)
At 90 days after planting, the cv. Varada recorded the highest non-leaf chlorophyll content (42.26 and 31.94) in healthy and inoculated plants respectively followed by Cv. Himachal (41.52 and 31.30). In cv. Sirsi local the least leaf chlorophyll content (28.58 and 24.19) was recorded (Table-5)

**f) Effect of Integrated treatment modules on Rhizome rot disease incidence and yield**

Among the different treatments T9 (Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@ 5 kg/ton) + Neem cake (1qt/ac.) + Pre-sowing rhizome treatment with 0.05% Streptocycline + 0.3% Copper oxy-chloride for 15 minutes followed by drenching with 0.30% Bleaching powder + 0.30% Copper oxy chloride + 0.15% Metalaxyl - MZ + 0.05% Streptocycline) recorded the highest rhizome yield (370.83 Q/ha) which is significantly superior over rest of the treatments. Treatment T9 was followed by treatment T4 (351.25 q/ha) (Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@5 kg/ton) + Neem cake (1qt/ac.) + Pre-sowing rhizome treatment with 0.05% Streptocycline + 0.3% Copper oxy-chloride for 15 minutes followed by drenching with 0.3% Bleaching powder + 0.3% Copper oxy chloride + 0.15% Metalaxyl –MZ). Whereas, the untreated control (T10) recorded the least yield (135.00 q/ha.)
The treatment T9 **(**Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@ 5 kg/ton FYM) + Neem cake (1qt/ac.) + Pre-sowing rhizome treatment with 0.05% Streptocycline + 0.3% Copper oxy-chloride for 15 minutes followed by drenching with 0.30% Bleaching powder + 0.30% Copper oxy chloride + 0.15% Metalaxyl-MZ + 0.05% Streptocycline) recorded the least Per cent Disease Incidence (4.25) followed by T4 (8.25 PDI) (Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@5 kg/ton) + Neem cake (1qt/ac.) + Pre-sowing rhizome treatment with 0.05% Streptocycline + 0.3% Copper oxy-chloride for 15 minutes followed by drenching with 0.3% Bleaching powder + 0.3% Copper oxy chloride + 0.15% Metalaxyl –MZ) Whereas, the untreated control recorded the highest Per cent Disease Incidence (58.40) (Table-6).
Ram *et. al*. (1999) [7] proved that the effective management of rhizome rot of ginger by combination of biological control agents (BCA's) with 0.1 per cent metalaxyl -MZ. Shanmugam *et al.* (1999) [10] also opined that, the combination of BCA's and fungicide in effective suppression of ginger soft rot disease by showing the best efficacy of rhizome treatment with *Trichoderma harzianum* followed by soil drenching with 0.3 per cent copper oxychloride. Similarly, the best performance of metalaxyl over copper fungicides in the management of rhizome rot of ginger has been proved by many workers (Bhagawath, 1961; Thakur, 1988) [1, 11].
Rajan and Agnihotri (1989) [6] could estimate a yield loss up to 100 per cent in ginger by *Pythium* rot alone. Likewise cent per cent yield loss in ginger by bacterial wilt has been reported in Kerala state (Sharma *et al*., 1978) [9]. However, use of bleaching powder in very low concentrations was inevitable to combat wilt problem and help farmers to arrest the pathogenic development in the subsequent crop and in boosting yields.

**Table 1:** Intensity of wilt complex disease in different ginger genotypes across locations

| Taluk | Village | Variety* | Per cent Disease Incidence (PDI) |
|---|---|---|---|
| SIRSI | Banvasi | Himachal | 24.0-26.0 |
| | | Sirsi local | 30.0-48.0 |
| | Andagi | Rio-de-Janeiro | 35.0-38.0 |
| | | Himachal | 25.0-28.0 |
| | Kerekoppa | Himachal | 24.0-26.0 |
| | Unchalli | Himachal | 22.0-29.0 |
| | | Sirsi local | 38.0-45.0 |
| | Kadagodu | Sirsi local | 26.0-37.0 |

| | | | |
|---|---|---|---|
| | | Himachal | 24.0-27.0 |
| | Tigani | Himachal | 24.0-26.0 |
| | | Sirsi local | 40.0-45.0 |
| | Gudnapur | Himachal | 24.0-27.0 |
| | Isalur | Himachal | 34.0-36.0 |
| Soraba | Jade | Himachal | 25.0-26.0 |
| | | Rio-de-Janeiro | 35.0-38.0 |
| | Anavatti | Himachal | 21.0-24.0 |
| | | Sirsi local | 23.0-35.0 |
| Haveri | Byadagi | Himachal | 15.0-18.0 |
| | Hangal | Himachal | 18.0-22.0 |
| | Hirekerur | Himachal | 16.0-25.0 |

**Table 2:** Effect of rhizome rot disease on phenol content in different ginger genotypes

| Genotypes | Total phenol content (mg/g of leaf tissues) | | | | Reaction |
|---|---|---|---|---|---|
| | 60 DAP | | 90 DAP | | |
| | Healthy | Inoculated | Healthy | Inoculated | |
| Himachal | 3.122 | 3.622 | 3.294 | 4.117 | MR |
| Varada | 2.511 | 2.950 | 2.986 | 3.944 | MR |
| Humanabad local | 1.844 | 1.908 | 1.635 | 2.230 | S |
| Sirsi Local | 1.622 | 1.845 | 1.433 | 1.967 | S |
| Rio-de-Janeiro | 1.481 | 1.685 | 0.995 | 1.992 | S |

MR: Moderately resistant S: Susceptible

**Table 3:** Effect of rhizome rot disease on reducing sugars content in different ginger genotypes

| Genotypes | Total reducing sugars content (mg/g of leaf tissues) | | | | Reaction |
|---|---|---|---|---|---|
| | 60 DAP | | 90 DAP | | |
| | Healthy | Inoculated | Healthy | Inoculated | |
| Himachal | 5.959 | 4.976 | 3.719 | 2.954 | MR |
| Varada | 4.974 | 3.987 | 2.777 | 2.762 | MR |
| Humanabad local | 4.556 | 3.861 | 2.579 | 2.464 | S |
| Sirsi Local | 3.828 | 1.659 | 1.534 | 1.276 | S |
| Rio-de-Janeiro | 3.767 | 1.843 | 1.338 | 1.224 | S |

MR: Moderately resistant S: Susceptible

**Table 4:** Effect of rhizome rot disease on non-reducing sugars content in different ginger genotypes

| Genotypes | Total non-reducing sugars content (mg/g of leaf tissues) | | | | Reaction |
|---|---|---|---|---|---|
| | 60 DAP | | 90 DAP | | |
| | Healthy | Inoculated | Healthy | Inoculated | |
| Himachal | 2.041 | 1.862 | 1.836 | 0.957 | MR |
| Varada | 1.973 | 1.766 | 1.630 | 0.836 | MR |
| Humanabad local | 1.448 | 1.249 | 0.882 | 0.652 | S |
| Sirsi Local | 1.357 | 1.241 | 0.460 | 0.354 | S |
| Rio-de-Janeiro | 1.153 | 0.952 | 0.528 | 0.424 | S |

MR: Moderately resistant S: Susceptible

**Table 5:** Estimation of chlorophyll content in different ginger genotypes by SPAD method

| Genotypes | SPAD | | | | Reaction |
|---|---|---|---|---|---|
| | 60 DAP | | 90 DAP | | |
| | Healthy | Inoculated | Healthy | Inoculated | |
| Himachal | 43.51 | 38.53 | 41.52 | 31.30 | MR |
| Varada | 43.84 | 39.46 | 42.26 | 31.94 | MR |
| Humanabad local | 41.57 | 37.55 | 44.34 | 32.30 | S |
| Sirsi Local | 36.83 | 32.50 | 28.58 | 24.19 | S |
| Rio-de-Janeiro | 34.21 | 29.67 | 32.41 | 24.37 | S |

MR: Moderately resistant S: Susceptible

**Table 6:** Effect of integrated management practices on per cent disease incidence (PDI) and yield of ginger

| Treatment | Treatment details | Pooled mean | |
|---|---|---|---|
| | | PDI* (%) | Yield (Q/ha.) |
| T1 | Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* FYM enriched (@5 kg/ton FYM) + Neem cake (1qt/ac.) + Pre-sowing rhizome treatment with 0.05% Streptocycline + 0.3% Copper oxy-chloride for 15 minutes followed by drenching with 0.3% Bleaching powder + 0.15% Metalaxyl MZ | 14.25 | 288.75 |

| | | | |
|---|---|---|---|
| T2 | Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* FYM enriched (@5 kg/ton FYM) + Neem cake (1qt/ac.) + Pre-sowing rhizome treatment with 0.05% Streptocycline + 0.10% Metalaxyl MZ for 15 minutes followed by drenching with 0.3% Bleaching powder + 0.15% Metalaxyl MZ + 0.3% Copper oxy chloride | 12.33 | 301.65 |
| T3 | Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* FYM enriched (@5 kg/ton FYM) + Neem cake (1qt/ac.)+ Pre-sowing rhizome treatment with 0.6% Metalaxyl MZ for 15 minutes + followed by soil drenching with 0.2% Metalaxyl MZ at disease inception. | 25.66 | 238.75 |
| T4 | Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* FYM enriched (@5 kg/ton FYM) + Neem cake (1qt/ac.) + Pre-sowing rhizome treatment with 0.05% Streptocycline + 0.3% Copper Oxy-chloride for 15 minutes followed by drenching with 0.3% Bleaching powder + 0.3% Copper oxy chloride + 0.15% Metalaxyl -MZ | 8.25 | 351.25 |
| T5 | Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@ 5 kg/ton FYM) + Neem cake (1qt/ac.) + Pre-sowing rhizome treatment with 0.05% Streptocycline + 0.3% Copper Oxy-chloride for 15 minutes followed by drenching with 0.2% Bleaching powder + 0.2% Copper oxy chloride +0.1% Metalaxyl -MZ | 16.33 | 277.00 |
| T6 | Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@ 5 kg/ton FYM) + Neem cake (1qt/ac.) followed by soil application with 2% *Trichoderma harzianum* and *2% Pseudomonas fluorescens* at disease inception. | 27.40 | 241.50 |
| T7 | Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@ 5 kg/ton FYM) + Neem cake (1qt/ac.) followed by drenching with 0.3% copper oxychloride. | 28.50 | 233.33 |
| T8 | Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@ 5 kg/ton FYM) + Neem cake (1qt/ac.) + Pre-sowing rhizome treatment with 0.05% Streptocycline + 0.3% Copper oxy chloride for 15 minutes + followed by drenching with 0.2% Bleaching powder and 0.1% Metalaxyl MZ | 18.50 | 266.25 |
| T9 | Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@ 5 kg/ton FYM) + Neem cake (1qt/ac.) + Pre-sowing rhizome treatment with 0.05% Streptocycline + 0.3% Copper oxy-chloride for 15 minutes followed by drenching with 0.30% Bleaching powder + 0.30% Copper oxy chloride + 0.15% Metalaxyl MZ + 0.05% Streptocycline | 4.25 | 370.83 |
| T10 | Control | 58.40 | 135.00 |
| SEM + | | 0.27 | 1.225 |
| CD (5%) | | 0.81 | 3.65 |

*PDI- Per cent Disease Incidence

## Conclusion

Among the different treatments, Pre-sowing soil application with *Trichoderma harzianum* enriched FYM (@ 2 kg/ton) + *Pseudomonas fluorescens* enriched FYM (@ 5 kg/ton) + Neem cake (1.0 qt/ac.) + Pre-sowing rhizome treatment with 0.05% Streptocycline + 0.30% Copper oxy-chloride for 15 minutes followed by drenching with 0.30% Bleaching powder + 0.30% Copper oxy chloride + 0.15% Metalaxyl-MZ + 0.05% Streptocycline recorded the least Per cent Disease Incidence (4.25) and the highest rhizome yield (370.83 Q/ha). The Highest phenol content (3.622 and 4.117 mg/g leaf tissue), reducing sugars (4.976 and 2.954 mg/g of leaf tissue), non-reducing sugars (1.862 and 0.957 mg/g leaf tissue) was recorded CV. Himachal. Whereas, the highest chlorophyll content was recorded in Cv. Varada (39.46 and 31.94).

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