

## RESEARCH ARTICLE

# The efficacy of bio consortium of against *S. rolfisii* under *in vitro* conditions disease of chickpea

■ Rakesh Gurjar, A.R. Wasnekar, Mahesh Kumar Mimrot and Yashowardhan Singh

### SUMMARY

A experiment was conducted in 2019-20 *Rabi* cropping season to obtain information on the incidence of chickpea diseases. The investigation was entitled the efficacy of bio consortium of against *S. rolfisii* under *in vitro* conditions disease of chickpea was conducted, Department of Plant pathology JNKVV. The experiment was laid out in Completely Randomized Design (CRD) concept comprising nine treatment combinations with three replications in vitro condition Dual culture technique was employed to test the efficacy of various bio consortiums. The maximum growth inhibition of *Sclerotium rolfisii* was recorded with *T. viride* + *T. harzianum* + *P. fluorescens* (65.74%). It is also found that treatment *T. viride* + *T. harzianum* + *P. fluorescens* are more efficient than other treatments according to the germination percentage, pre-emergence mortality, post-emergence mortality, phenotypic parameter and disease incidence.

Key Words : Bio consortium, *S. rolfisii* under *in vitro* conditions

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**C**hickpea (*Cicer arietinum* L.) is a major legumes crop grown worldwide and ranks second in the global farming. It belongs to the family *Fabaceae*,

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sub family *Papilionaceae*. Chickpea is a rich source of protein (20 to 25 %) and also enriches soil fertility by biological nitrogen fixation. In India, it is grown over an area 95.39 lac hectares, with an annual production of 90.75 lac tonnes and yield was 951kg/ha. However, the total area and production of chickpea in MP is 35.90 lac hectare and 45.95 lac tonnes respectively, having productivity of 1056kg/ha (Anonyms, 2017). Chickpea collar rot is most serious and challenging disease which cause severe yield losses (upto 60-70%) under favourable conditions (Nene, 1984). The disease causes damage on root and stem of plant. The pathogen produces sclerotia which overwinter in soil and on plant debris besides it can survive in a long period causing disease in the following season (Punja, 1985). Drying of plants with

foliage turned slightly yellow before death, scattered throughout the field is an indication of collar rot infection. The disease generally appears within two weeks of sowing and the younger plants collapse but older ones turn yellow and may dry without collapsing. The younger plants exhibit clear rotting at the collar region. The rotten portion is often covered with white mycelia strands of *S. rolfsii*. Thus, the control of the disease is very difficult. Various methods for controlling such disease have been investigated including the use of resistant varieties, chemical control, plant volatile compounds, plant extracts and biological control (Kumar and Tripathi, 1991; Dubey *et al.*, 2007 and El-Mougy *et al.*, 2007).

Management of plant disease through biological control has been considered as a viable alternative method as against the use of chemical pesticide and cultural practices. Different mode of action of bio control active micro-organism in controlling fungal plant disease include hyper-parasitism, predation, antibiosis, cross protection, competition for site and nutrient and induced resistance, the present investigation is mainly focussed to sort out the most effective organic amendments and antagonists for management of collar rot (*Sclerotium rolfsii*) disease of chickpea.

## MATERIAL AND METHODS

The present investigation was conducted to check the efficacy of bio consortium and oil cake against *S. rolfsii* under *in vitro* conditions. The pathogen was isolated from infected gram seedlings by hyphal tip method of fungal isolation. Identification of *Sclerotium rolfsii* were done by morphological characters formed white mat of hyaline mycelium with formation of initially white sclerotia which later turned into brown hard structure. Sclerotia were black, varied from spherical to irregular in shape and measured 80 to 85 µm in diameter. Pycnidial production was not observed in culture plates. Required bio-inoculants and oil cake *Trichoderma viride*, *Trichoderma harzianum*, *Trichoderma aureoviride* and *Pseudomonas fluorescens*, respectively were obtained from Microbes Research and Production Canter, JNKVV Jabalpur (M.P.).

### Dual culture technique :

To test the efficacy of antagonistic fungus, twenty ml of sterilized melted PDA was plated in Petri plates and allowed to solidify. Mycelial discs measuring 5 mm diameter from three-day old cultures of both fungal

antagonist and the test pathogen were pieced at equidistant on sterile petri plate containing PDA medium.

To test efficacy of antagonistic bacterium 4cm line was streaked at one side of the plate. On the opposite side to the antagonist, mycelia disc measuring 5 mm diameter from four-day old culture of test pathogen was placed on sterile petri plate containing PDA medium.

The petri plates with pathogen inoculated at one end alone, served as control. The petri plates were then incubated at 28±2°C. Four replications were maintained in each treatment. Growth of antagonists, pathogen and zone of inhibition of the pathogen in control plate. Per cent inhibition of mycelia growth over control was calculated by using the formula given by Vincent (1947):

$$I = \frac{C - T}{C} \times 100$$

where,

I = Per cent inhibition in growth of test pathogen

C = Radial growth (mm) in control

T = Radial growth (mm) in treatment.

## RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

### Evaluation of bio consortium against radial growth of *Sclerotium rolfsii* :

To compare the growth rate different consortium on radial growth of *Sclerotium rolfsii* was studied and observation have been presented in Table 1 and Plate 2. In dual culture test, each of all tested consortium differentially limited the growth of the test pathogen and overgrew the pathogen colony when compared to control. Minimum radial growth (30.83 mm) of pathogen with maximum per cent inhibition of radial growth (65.74 %) was recorded in *T. viride* + *T. harzianum* + *P. fluorescens* followed by *Trichoderma viride* + *Trichoderma harzianum* which recorded radial growth of 32.37 mm with radial growth inhibition of 64.04 per cent which were statistically at par with each other. Consortium *T. viride* + *Pseudomonas fluorescens*, *T. viride* + *T. harzianum* + *T. aureoviride*, *T. harzianum* + *Pseudomonas fluorescens*, *T. viride* + *T. aureoviride* and *T. harzianum* + *T. aureoviride* inhibited radial growth of target pathogen by 61.30, 60.92, 59.07, 55.41 and 51.81 per cent, respectively. Maximum radial growth 47.43 mm and minimum inhibition 47.30 per cent was recorded in *T. viride* + *T. harzianum* + *T.*





Collar rot infected plants



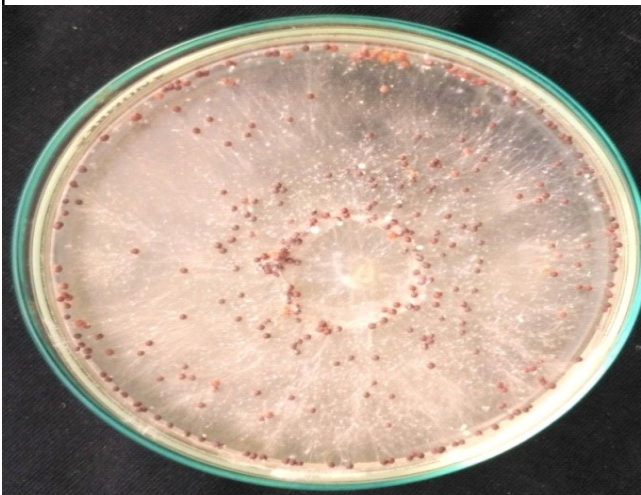
Infected root



Linear colony growth



Whitish colony



Sclerotia formation



Mass multiplication

Palate 1: Collection isolation and identification of *Sclerotium rolfsii*

**Table 1: Evaluation of bio consortium against on radial growth of *S. rolfsii***

Sr. No.	Name of treatment	Radial growth of pathogen (mm)	Per cent growth inhibition
T <sub>1</sub>	<i>Trichoderma viride</i> + <i>Trichoderma harzianum</i>	32.37	64.04
T <sub>2</sub>	<i>T. viride</i> + <i>T. aureoviride</i>	40.13	55.41
T <sub>3</sub>	<i>T. viride</i> + <i>Pseudomonas fluorescens</i>	34.83	61.30
T <sub>4</sub>	<i>T. harzianum</i> + <i>T. aureoviride</i>	43.37	51.81
T <sub>5</sub>	<i>T. harzianum</i> + <i>Pseudomonas fluorescens</i>	36.83	59.07
T <sub>6</sub>	<i>T. viride</i> + <i>T. harzianum</i> + <i>P. fluorescens</i>	30.83	65.74
T <sub>7</sub>	<i>T. viride</i> + <i>T. harzianum</i> + <i>T. aureoviride</i>	35.17	60.92
T <sub>8</sub>	<i>T. viride</i> + <i>T. harzianum</i> + <i>T. aureoviride</i> + <i>Pseudomonas fluorescens</i>	47.43	47.30
T <sub>9</sub>	Control	90.00	-
	S.E. ±	0.33	-
	C.D. (P=0.05)	0.98	-

*aureoviride* + *P. fluorescens*. The test pathogen showed 90.00 mm growth after 120 hours of incubation

In dual culture test, each of all tested fungal and bacterial consortium limited the growth of the pathogen and overgrew the pathogen colony when compared to the control. In consortium treatment, maximum per cent inhibition of *Sclerotium rolfsii* was observed in *T. viride* + *T. harzianum* + *P. fluorescens* (65.74) similarly result reported by Singh *et al.* (2013) in which combination of *Trichoderma* spp. and *Pseudomonas* spp. to assess the synergistic effect of compatible isolates for plant growth promotion and management of *S. rolfsii*. In dual culture, in consortium treatment, maximum inhibition of *Sclerotium rolfsii* was observed in *T. viride* + *T. harzianum* + *P. fluorescens* (65.74%).

In dule culture test, each of all tested consortium differentially limited the growth of the test pathogen and overgrew the pathogen colony when compared to control. Minimum radial growth (30.83 mm) of pathogen with maximum per cent inhibition of radial growth (65.74%) was recorded in *T. viride* + *T. harzianum* + *P. fluorescens* followed by *Trichoderma viride* + *Trichoderma harzianum* which recorded radial growth of 32.37 mm with radial growth inhibition of 64.04 per cent which were statistically at par with each other. Consortium *T. viride* + *Pseudomonas fluorescens*, *T. viride* + *T. harzianum* + *T. aureoviride*, *T. harzianum* + *Pseudomonas fluorescens*, *T. viride* + *T. aureoviride* and *T. harzianum* + *T. aureoviride* inhibited radial growth of target pathogen by 61.30, 60.92, 59.07, 55.41 and 51.81 per cent, respectively. Maximum radial growth 47.43 mm and minimum inhabitation 47.30 per cent was recorded in *T. viride* + *T. harzianum* + *T.*

*aureoviride* + *P. fluorescens*. The test pathogen showed 90.00 mm growth after 120 hours of incubation.

### Effect of bio consortium against collar rot (*Sclerotium rolfsii*) disease incidence on variety JG-12 :

#### Germination percentage :

Among the treatments minimum germination per cent 76.67 per cent was observed in T<sub>8</sub> (*T. viride* + *T. harzianum* + *T. aureoviride* + *Pseudomonas fluorescens*) followed by 77.78 per cent in T<sub>4</sub> (*T. harzianum* + *T. aureoviride*), 80.00 per cent in T<sub>2</sub> (*T. viride* + *T. aureoviride*), 81.11 per cent T<sub>5</sub> (*T. harzianum* + *Pseudomonas fluorescens*), 84.44 per cent in T<sub>7</sub> (*T. viride* + *T. harzianum* + *T. aureoviride*), 86.67 per cent in T<sub>3</sub> (*T. viride* + *Pseudomonas fluorescens*), 87.78 per cent in T<sub>1</sub> (*Trichoderma viride* + *Trichoderma harzianum*) and highest germination 91.11 per cent was recorded in T<sub>6</sub> (*T. viride* + *T. harzianum* + *P. fluorescens*) as compare to control.

#### Pre-emergence mortality :

Maximum pre-emergence mortality 23.33 per cent was recorded in T<sub>8</sub> (*T. viride* + *T. harzianum* + *T. aureoviride* + *Pseudomonas fluorescens*) followed by 22.22 per cent in T<sub>4</sub> (*T. harzianum* + *T. aureoviride*), 20.00 per cent in T<sub>2</sub> (*T. viride* + *T. aureoviride*), 18.89 per cent in T<sub>5</sub> (*T. harzianum* + *Pseudomonas fluorescens*), 15.56 per cent in T<sub>7</sub> (*T. viride* + *T. harzianum* + *T. aureoviride*), 13.33 per cent in T<sub>3</sub> (*T. viride* + *Pseudomonas fluorescens*), 12.22 per cent in T<sub>1</sub> (*Trichoderma viride* + *Trichoderma harzianum*). Minimum pre-emergence mortality 8.89 per cent was



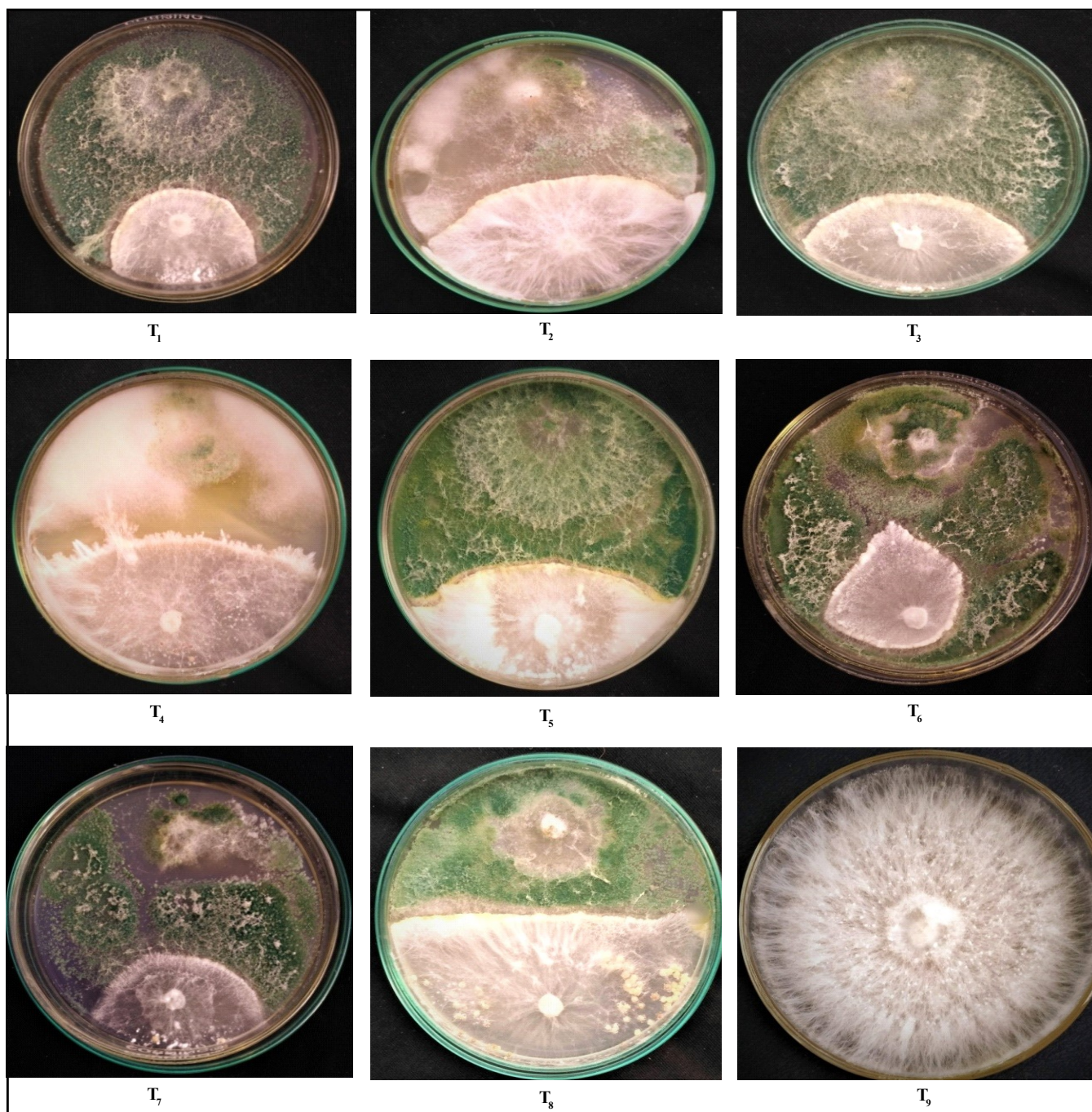


Plate 2: *In-vitro* efficacy of Bio-consortium against *Sclerotium rolfsii* after 120 hours

recorded in T<sub>6</sub> (*T. viride* + *T. harzianum* + *P. fluorescens*), ) as compare to control.

*Post-emergence mortality:*

Maximum disease incidence of 24.48 and 22.77 percent was observed in T<sub>8</sub> (*T. viride* + *T. harzianum* + *T. aureoviride* + *Pseudomonas fluorescens*) and T<sub>4</sub> (*T. harzianum* + *T. aureoviride*), respectively.

Minimum disease incidence recorded in control.

*Total mortality (%):*

Maximum mortality of 90.17 per cent was recorded in control (T<sub>9</sub>) followed by 47.81 per cent was observed in T<sub>8</sub> (*T. viride* + *T. harzianum* + *T. aureoviride* + *Pseudomonas fluorescens*) and minimum mortality 17.37% was recorded in T<sub>6</sub> (*T. viride* + *T. harzianum*

+ *P. fluorescens*).

**Effect of bio consortium on collar rot (*Sclerotium rolfsii*) disease and phenotypic parameters on variety JG-12 :**

**Germination percentage :**

All the treatment had higher germination percentage as compare to control. Among the treatments minimum germination per cent 78.60 per cent was observed in T<sub>8</sub> (*T. viride* + *T. harzianum* + *T. aureoviride* + *Pseudomonas fluorescens*) followed by 79.77 per cent in T<sub>4</sub> (*T. harzianum* + *T. aureoviride*), 80.00 per cent in T<sub>2</sub> (*T. viride* + *T. aureoviride*), 83.50 per cent T<sub>5</sub> (*T. harzianum* + *Pseudomonas fluorescens*), 85.54 per cent in T<sub>7</sub> (*T. viride* + *T. harzianum* + *T. aureoviride*), 88.67 per cent in T<sub>3</sub> (*T. viride* + *Pseudomonas fluorescens*), 89.85 per cent in T<sub>1</sub> (*Trichoderma viride* + *Trichoderma harzianum*) and highest germination

94.40 per cent was recorded in T<sub>6</sub> (*T. viride* + *T. harzianum* + *P. fluorescens*).

**Plants height (Shoot and Root) :**

Maximum shoot height 24.33, 22.07, 20.07, 19.27, 16.37, 15.67, 14.23 and 13.30 cm were recorded in T<sub>6</sub> (*T. viride* + *T. harzianum* + *P. fluorescens*), T<sub>1</sub> (*Trichoderma viride* + *Trichoderma harzianum*), T<sub>3</sub> (*T. viride* + *Pseudomonas fluorescens*), T<sub>7</sub> (*T. viride* + *T. harzianum* + *T. aureoviride*), T<sub>5</sub> (*T. harzianum* + *Pseudomonas fluorescens*), T<sub>2</sub> (*T. viride* + *T. aureoviride*), T<sub>4</sub> (*T. harzianum* + *T. aureoviride*), T<sub>8</sub> (*T. viride* + *T. harzianum* + *T. aureoviride* + *Pseudomonas fluorescens*), respectively. As compare to control T<sub>9</sub> (control) which was 10.67 cm, respectively.

Maximum root height 10.37, 10.27, 10.00, 9.60, 9.40, 9.10, 8.36 and 8.03 cm were recorded in T<sub>6</sub> (*T. viride* + *T. harzianum* + *P. fluorescens*), T<sub>1</sub> (*Trichoderma*

**Table 2 : Evaluation of bio consortium against on radial growth of *S. rolfsii***

T.N.	Name of treatment	Radial growth of pathogen(mm)	Per cent growth inhibition
T <sub>1</sub>	<i>Trichoderma viride</i> + <i>Trichoderma harzianum</i>	32.37	64.04
T <sub>2</sub>	<i>T. viride</i> + <i>T. aureoviride</i>	40.13	55.41
T <sub>3</sub>	<i>T. viride</i> + <i>Pseudomonas fluorescens</i>	34.83	61.30
T <sub>4</sub>	<i>T. harzianum</i> + <i>T. aureoviride</i>	43.37	51.81
T <sub>5</sub>	<i>T. harzianum</i> + <i>Pseudomonas fluorescens</i>	36.83	59.07
T <sub>6</sub>	<i>T. viride</i> + <i>T. harzianum</i> + <i>P. fluorescens</i>	30.83	65.74
T <sub>7</sub>	<i>T. viride</i> + <i>T. harzianum</i> + <i>T. aureoviride</i>	35.17	60.92
T <sub>8</sub>	<i>T. viride</i> + <i>T. harzianum</i> + <i>T. aureoviride</i> + <i>Pseudomonas fluorescens</i>	47.43	47.30
T <sub>9</sub>	Control	90.00	-
	S.E.±	0.33	-
	C.D. (P=0.05)	0.98	-

**Table 3 : Effect of bio consortium against collar rot (*Sclerotium rolfsii*) disease incidence on variety JG-12**

T.N.	Combination	Germination	Pre emergence mortality	Post emergence mortality	Total mortality
T <sub>1</sub>	<i>Trichoderma viride</i> + <i>Trichoderma harzianum</i>	87.78	12.22	13.96	26.18
T <sub>2</sub>	<i>T. viride</i> + <i>T. aureoviride</i>	80.00	20.00	20.74	40.74
T <sub>3</sub>	<i>T. viride</i> + <i>Pseudomonas fluorescens</i>	86.67	13.33	15.50	28.83
T <sub>4</sub>	<i>T. harzianum</i> + <i>T. aureoviride</i>	77.78	22.22	22.77	44.99
T <sub>5</sub>	<i>T. harzianum</i> + <i>Pseudomonas fluorescens</i>	81.11	18.89	20.50	39.39
T <sub>6</sub>	<i>T. viride</i> + <i>T. harzianum</i> + <i>P. fluorescens</i>	91.11	8.89	8.48	17.37
T <sub>7</sub>	<i>T. viride</i> + <i>T. harzianum</i> + <i>T. aureoviride</i>	84.44	15.56	20.92	36.48
T <sub>8</sub>	<i>T. viride</i> + <i>T. harzianum</i> + <i>T. aureoviride</i> + <i>Pseudomonas fluorescens</i>	76.67	23.33	24.48	47.81
T <sub>9</sub>	Control	62.22	36.67	53.51	90.17
	S.E. ±	1.92	1.99	2.83	2.93
	C.D. (P=0.05)	5.76	5.97	8.48	8.77

*viride* + *Trichoderma harzianum*), T<sub>3</sub> (*T. viride* + *Pseudomonas fluorescens*), T<sub>7</sub> (*T. viride* + *T. harzianum* + *T. aureoviride*), T<sub>5</sub> (*T. harzianum* + *Pseudomonas fluorescens*), T<sub>2</sub> (*T. viride* + *T. aureoviride*), T<sub>4</sub> (*T. harzianum* + *T. aureoviride*) and T<sub>8</sub> (*T. viride* + *T. harzianum* + *T. aureoviride* + *Pseudomonas fluorescens*), respectively. As compare to control T<sub>9</sub> (control) which was 6.43 cm, respectively.

**Vigour index :**

Maximum vigour index per cent of 3,274.21 and 2,906.31 was recorded in T<sub>6</sub> (*T. viride* + *T. harzianum* + *P. fluorescens*) and T<sub>1</sub> (*Trichoderma viride* + *Trichoderma harzianum*), as compare to control. Minimum vigour index per cent of 1,676.34 and 1,794.34

were observed in T<sub>8</sub> (*T. viride* + *T. harzianum* + *T. aureoviride* + *Pseudomonas fluorescens*) and T<sub>4</sub> (*T. harzianum* + *T. aureoviride*), respectively.

**Effect of bio consortium on collar rot (*Sclerotium rolfsii*) disease incidence on variety JG-14 :**

**Germination percentage :**

Data presented in Table 5 indicated that germination percentage among treatment range from 77.78 to 92.22 per cent. All the treatment had higher germination percentage as compare to control. Among the treatments minimum germination per cent 77.78 per cent was observed in T<sub>8</sub> (*T. viride* + *T. harzianum* + *T. aureoviride* + *Pseudomonas fluorescens*) followed by 78.89 per cent in T<sub>4</sub> (*T. harzianum* + *T. aureoviride*),

**Table 4 : Effect of bio consortium on collar rot (*Sclerotium rolfsii*) disease and phenotypic parameters on variety JG-12**

T.N.	Combination	Germination	Shoot length	Root length	Vigour index
T <sub>1</sub>	<i>Trichoderma viride</i> + <i>Trichoderma harzianum</i>	89.85	22.07	10.27	2,906.31
T <sub>2</sub>	<i>T. viride</i> + <i>T. aureoviride</i>	80.00	15.17	9.10	1,941.33
T <sub>3</sub>	<i>T. viride</i> + <i>Pseudomonas fluorescens</i>	88.67	20.07	10.00	2,666.47
T <sub>4</sub>	<i>T. harzianum</i> + <i>T. aureoviride</i>	79.77	14.23	8.27	1,794.34
T <sub>5</sub>	<i>T. harzianum</i> + <i>Pseudomonas fluorescens</i>	83.50	16.37	9.40	2,151.22
T <sub>6</sub>	<i>T. viride</i> + <i>T. harzianum</i> + <i>P. fluorescens</i>	94.40	24.33	10.37	3,274.21
T <sub>7</sub>	<i>T. viride</i> + <i>T. harzianum</i> + <i>T. aureoviride</i>	85.54	19.27	9.60	2,469.57
T <sub>8</sub>	<i>T. viride</i> + <i>T. harzianum</i> + <i>T. aureoviride</i> + <i>Pseudomonas fluorescens</i>	78.60	13.30	8.03	1,676.34
T <sub>9</sub>	Control	70.32	10.67	6.43	1,202.93
	S.E. ±	1.02	0.45	0.16	45.07
	C.D. (P=0.05)	3.05	1.33	0.48	134.96

**Table 5 : Effect of bio consortium on collar rot (*Sclerotium rolfsii*) disease incidence on variety JG-14**

T.N.	Combination	Germination	Pre emergence mortality	Post emergence mortality	Total mortality
T <sub>1</sub>	<i>Trichoderma viride</i> + <i>Trichoderma harzianum</i>	88.89	11.11	12.49	23.60
T <sub>2</sub>	<i>T. viride</i> + <i>T. aureoviride</i>	81.11	18.89	19.17	38.06
T <sub>3</sub>	<i>T. viride</i> + <i>Pseudomonas fluorescens</i>	87.78	12.22	15.19	27.42
T <sub>4</sub>	<i>T. harzianum</i> + <i>T. aureoviride</i>	78.89	21.11	22.49	43.60
T <sub>5</sub>	<i>T. harzianum</i> + <i>Pseudomonas fluorescens</i>	83.33	16.67	18.69	35.35
T <sub>6</sub>	<i>T. viride</i> + <i>T. harzianum</i> + <i>P. fluorescens</i>	92.22	7.78	8.47	16.24
T <sub>7</sub>	<i>T. viride</i> + <i>T. harzianum</i> + <i>T. aureoviride</i>	85.56	14.44	15.54	29.99
T <sub>8</sub>	<i>T. viride</i> + <i>T. harzianum</i> + <i>T. aureoviride</i> + <i>Pseudomonas fluorescens</i>	77.78	22.22	24.27	46.49
T <sub>9</sub>	Control	65.56	34.44	50.79	85.24
	S.E.±	1.77	2.32	2.60	2.36
	C.D. (P=0.05)	5.32	6.12	5.50	7.06

81.11 per cent in T<sub>2</sub> (*T. viride* + *T. aureoviride*), 83.33 per cent T<sub>5</sub> (*T. harzianum* + *Pseudomonas fluorescens*), 85.56 per cent in T<sub>7</sub> (*T. viride* + *T. harzianum* + *T. aureoviride*), 86.67 per cent in T<sub>3</sub> (*T. viride* + *Pseudomonas fluorescens*), 88.89 per cent in T<sub>1</sub> (*Trichoderma viride* + *Trichoderma harzianum*) and highest germination 92.22 per cent was recorded in T<sub>6</sub> (*T. viride* + *T. harzianum* + *P. fluorescens*).

#### Pre-emergence mortality

All the treatment has significantly reduced the pre-emergence mortality as compared to control. Maximum pre-emergence mortality 22.22 per cent was recorded in T<sub>8</sub> (*T. viride* + *T. harzianum* + *T. aureoviride* + *Pseudomonas fluorescens*) followed by 21.11 in T<sub>4</sub> (*T. harzianum* + *T. aureoviride*), 18.89 in T<sub>2</sub> (*T. viride* + *T. aureoviride*), 16.67 in T<sub>5</sub> (*T. harzianum* + *Pseudomonas fluorescens*), 14.44 in T<sub>7</sub> (*T. viride* + *T. harzianum* + *T. aureoviride*), 12.22 in T<sub>3</sub> (*T. viride* + *Pseudomonas fluorescens*), 11.11 in T<sub>1</sub> (*Trichoderma viride* + *Trichoderma harzianum*). Minimum pre-emergence mortality 7.78 per cent was recorded in T<sub>6</sub> (*T. viride* + *T. harzianum* + *P. fluorescens*).

#### Post-emergence mortality:

Disease intensity, at flowering stage, among treatment varied from 8.47 to 24.27 as compared to control post-emergence mortality was 50.79 per cent. Maximum disease incidence of 24.27 and 22.49 per cent was observed in T<sub>8</sub> (*T. viride* + *T. harzianum* + *T. aureoviride* + *Pseudomonas fluorescens*) and T<sub>4</sub> (*T. harzianum* + *T. aureoviride*), respectively. Minimum

disease incidence of 8.47 was recorded in T<sub>6</sub> (*T. viride* + *T. harzianum* + *P. fluorescens*).

#### Total mortality (%) :

Total mortality per cent among treatment ranges from 16.24 to 46.49 per cent as compared to control 85.24 per cent. Maximum mortality of 46.49 per cent was observed in T<sub>8</sub> (*T. viride* + *T. harzianum* + *T. aureoviride* + *Pseudomonas fluorescens*) and minimum mortality 16.24 per cent was recorded in T<sub>6</sub> (*T. viride* + *T. harzianum* + *P. fluorescens*).

#### Effect of bio consortium on collar rot (*Sclerotium rolfsii*) disease and phenotypic parameters on variety JG-14:

##### Germination percentage :

Data presented in Table 6 indicated that germination percentage among treatment range from 80.68 to 96.52 per cent. All the treatment had higher germination percentage as compare to control. Among the treatments minimum germination percent 80.68 per cent was observed in T<sub>8</sub> (*T. viride* + *T. harzianum* + *T. aureoviride* + *Pseudomonas fluorescens*) followed by 82.55 per cent in T<sub>4</sub> (*T. harzianum* + *T. aureoviride*), 84.45 per cent in T<sub>2</sub> (*T. viride* + *T. aureoviride*), 87.76 per cent T<sub>5</sub> (*T. harzianum* + *Pseudomonas fluorescens*), 89.35 per cent in T<sub>7</sub> (*T. viride* + *T. harzianum* + *T. aureoviride*), 90.70 per cent in T<sub>3</sub> (*T. viride* + *Pseudomonas fluorescens*), 91.85 per cent in T<sub>1</sub> (*Trichoderma viride* + *Trichoderma harzianum*) and highest germination 96.52 per cent was recorded in T<sub>6</sub> (*T. viride* + *T. harzianum* + *P. fluorescens*).

**Table 6 : Effect of bio consortium on collar rot (*Sclerotium rolfsii*) disease and phenotypic parameters on variety JG-14**

T. N.	Combination	Germination	Shoot length	Root length	Vigour index
T <sub>1</sub>	<i>Trichoderma viride</i> + <i>Trichoderma harzianum</i>	92.85	24.90	10.73	3,309.11
T <sub>2</sub>	<i>T. viride</i> + <i>T. aureoviride</i>	84.45	16.37	9.20	2,159.88
T <sub>3</sub>	<i>T. viride</i> + <i>Pseudomonas fluorescens</i>	90.70	22.77	10.23	2,993.02
T <sub>4</sub>	<i>T. harzianum</i> + <i>T. aureoviride</i>	82.55	15.17	8.63	2419.17
T <sub>5</sub>	<i>T. harzianum</i> + <i>Pseudomonas fluorescens</i>	87.76	18.10	9.47	2,463.27
T <sub>6</sub>	<i>T. viride</i> + <i>T. harzianum</i> + <i>P. fluorescens</i>	96.52	26.37	11.53	3,658.07
T <sub>7</sub>	<i>T. viride</i> + <i>T. harzianum</i> + <i>T. aureoviride</i>	89.35	21.10	9.67	2749.31
T <sub>8</sub>	<i>T. viride</i> + <i>T. harzianum</i> + <i>T. aureoviride</i> + <i>Pseudomonas fluorescens</i>	80.68	15.20	8.27	1,893.21
T <sub>9</sub>	Control	77.60	12.57	6.77	1,500.40
	S.E. ±	0.67	0.41	0.35	57.44
	C.D. (P=0.05)	2.02	1.24	1.04	171.98



### Plants Height (Shoot and Root):

Data represented in Table 6 at the time of maturity so that shoot height and root length was significantly increased in all the treatment except T<sub>9</sub> (control) which was 12.57 cm and 6.77 cm, respectively.

Maximum shoot height 26.37, 24.90, 22.77, 21.10, 18.10, 14.37, 16.17 and 15.20 cm were recorded in T<sub>6</sub> (*T. viride* + *T. harzianum* + *P. fluorescens*), T<sub>1</sub> (*Trichoderma viride* + *Trichoderma harzianum*), T<sub>3</sub> (*T. viride* + *Pseudomonas fluorescens*), T<sub>7</sub> (*T. viride* + *T. harzianum* + *T. aureoviride*), T<sub>5</sub> (*T. harzianum* + *Pseudomonas fluorescens*), T<sub>2</sub> (*T. viride* + *T. aureoviride*), T<sub>4</sub> (*T. harzianum* + *T. aureoviride*) and T<sub>8</sub> (*T. viride* + *T. harzianum* + *T. aureoviride* + *Pseudomonas fluorescens*), respectively.

Maximum root length 11.53, 10.73, 10.23, 9.67, 9.47, 9.20, 8.63 and 8.27 cm were recorded in T<sub>6</sub> (*T. viride* + *T. harzianum* + *P. fluorescens*), T<sub>1</sub> (*Trichoderma viride* + *Trichoderma harzianum*), T<sub>3</sub> (*T. viride* + *Pseudomonas fluorescens*), T<sub>7</sub> (*T. viride* + *T. harzianum* + *T. aureoviride*), T<sub>5</sub> (*T. harzianum* + *Pseudomonas fluorescens*), T<sub>2</sub> (*T. viride* + *T. aureoviride*), T<sub>4</sub> (*T. harzianum* + *T. aureoviride*) and T<sub>8</sub> (*T. viride* + *T. harzianum* + *T. aureoviride* + *Pseudomonas fluorescens*), respectively.

### Vigour index

Data presented in Table 6 indicated that vigour index (%) recorded at the time of maturity sowing that indicated that all the treatment has higher vigour index per cent as compared to T<sub>9</sub> (control). At the time of maturity, it varied from 1,893.21 to 3,658.07 as compare to 1,500.40 in T<sub>9</sub> (control). Maximum vigour index per cent of 3,658.07 and 3,309.11 was recorded in T<sub>6</sub> (*T. viride* + *T. harzianum* + *P. fluorescens*) and T<sub>1</sub> (*Trichoderma*

*viride* + *Trichoderma harzianum*). Minimum vigour index per cent of 1,893.21 and 2419.17 were observed in T<sub>8</sub> (*T. viride* + *T. harzianum* + *T. aureoviride* + *Pseudomonas fluorescens*) and T<sub>4</sub> (*T. harzianum* + *T. aureoviride*), respectively.

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19<sup>th</sup>  
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