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# *IN VITRO* AND *IN VIVO* EFFICACY OF DIFFERENT BOTANICALS AGAINST *RHIZOCTONIA* SPP. INCITING ROOT ROT DISEASE IN COTTON (*GOSSYPIUM* SPP.)

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**ABSTRACT**

The root rot of cotton caused by *Rhizoctonia bataticola* (Taub) Butler and *Rhizoctonia solani* (Kuhn) is one of the most serious disease of cotton particularly in the northern region of India. The repeated use of chemicals and fungicides results in developing resistance against the pathogen followed by residue hazards. This leads to an urgent need to develop alternate eco-friendly methods to manage the disease and incidence of pathogen. The performance of different botanicals against cotton root rot was evaluated under both *in vitro* and *in vivo* conditions in Department of Plant Pathology, CCSHAU, Hisar and at Regional Research Station, Bawal during *Kharif*, 2021 and 2022. Seven different botanicals namely Neem (*Azadirachta indica*), Garlic (*Allium sativum*), Ginger (*Zingiber officinale*), *Parthenium* (*Parthenium hysterophorus*), Datura (*Datura stramonium*), Turmeric (*Curcuma longa*), *Lantana* (*Lantana camara*) were used at four different concentrations as 5, 10, 15, 20 per cent. Among the botanicals evaluated under *in vitro* conditions against RB5 and RS2, *Lantana camara* showed maximum inhibition of the mycelial growth (77.14% and 75.67%) of RB5 and RS2 respectively, at 20 per cent concentration and least was showed by ginger (*Zingiber officinale*). Among the fungicides evaluated under *in vivo* conditions against root rot, both in American and *Desi* cotton, *Lantana camara* showed maximum disease control and minimum disease incidence at 20 per cent concentration and least was showed by ginger (*Zingiber officinale*).

***Keywords*** : Cotton, efficacy, root rot, *Rhizoctonia,* botanical, incidence

## Introduction

Cotton is one of the most important fiber and cash crop of India and plays a dominant role in the industrial and agricultural economy of the country. It provides the basic raw material (cotton fibre) to cotton textile industry. Cotton in India provides direct livelihood to 6 million farmers and about 40-50 million people are employed in cotton trade and its processing (Anonymous 2022). In India, there are ten major cotton growing states which are divided into three zones, viz. north zone, central zone and south zone. North zone consists of Punjab, Haryana, and Rajasthan. Central zone includes Madhya Pradesh, Maharashtra and Gujarat. South zone comprises Andhra Pradesh, Telangana, Karnataka and Tamil Nadu. Besides these ten States, cotton cultivation has gained momentum in the Eastern State of Orissa. Cotton is also cultivated in small areas of non-traditional States such as Uttar Pradesh, West Bengal & Tripura.The cotton crop is grown extensively with a limiting factor, that is infected by many fungal, bacterial and viral diseases. Out of all the diseases, root rot of cotton is the most devastating disease and now a days this disease has become a major limiting factor in cotton cultivation.

Nearly 65 percent cotton area is rainfed, mainly in the Central and Southern States.

The root rot caused by *Rhizoctonia bataticola* (Taub) Butler and *Rhizoctonia solani* (Kuhn) is one of the most serious diseases of cotton particularly in the northern region of India. The disease affects both, the *hirsutum* and *arboreum* cotton species being more serious on later grown in the region. The disease first appears in month of June and becomes vigorous during July. First and the most prominent symptoms are bronzing or yellowing of the leaves and shredding of bark. In the field, affected plants can be easily pulled out except the tap root. The most common symptom of root rot is the sudden wilting of plants from top to downwards.

Diseases are controlled through different strategies such as use of resistant cultivars, cultural practices, use of chemicals and by bio-control agents. Although each of these methods of disease management practices has their own importance, yet none is completely successful when applied alone for disease control (Chandel and Deepika, 2010). The chemical control based on the use of fungicides is most effective and reliable method but the repeated use of chemicals and fungicides results in developing resistance against the pathogen followed by residue hazards. This leads to an urgent need to develop alternate eco-friendly methods to manage the disease and incidence of pathogen. Their application in the farmers fields can only be recommended against the causal pathogens after a successful laboratory evaluation. The present study was carried out to evaluate different botanicals against cotton root rot, both under *in vitro* and *in vivo* conditions.

## Material and Methods

### Experimental site and sample collection

The study was carried out during *kharif*, 2021 and 2022 in Department of plant Pathology, CCSHAU, Hisar and at Regional Research Station, Bawal.

### Survey of Cotton Growing areas

Survey of root rot of cotton was conducted to assess the prevalence and incidence in the cotton growing areas of Haryana. Different cotton growing districts *viz.,*Hisar, Sirsa, Fatehabad, Bhiwani, Charki Dadri, Mahendergarh, Rewari, Gurugram, Nuh, Palwal were selected for survey. The survey was conducted in the month of June and July in both the years of study. In each district, minimum four locations/villages were selected and the per cent disease incidence was calculated by the given formula

$$\text{Disease incidence} = \frac{\text{Number of infected plants}}{\text{Total number of plants observed}} \times 100$$

### Collection of samples

The root rot infected samples appeared as yellowing and bronzing of leaves, wilting of lower leaves of plant with easily uprooted root system were collected from locations of

major cotton growing districts of Haryana during *Kharif,* 2021 and 2022. Total twenty-one samples were collected from naturally occurring inoculum in the field. The samples were separately bagged, labeled, air dried and stored in a refrigerator at 4°C for further studies in the future.

### Isolation, Purification and multiplication of culture of different isolates

The isolation of fungus was done by following the standard isolation technique. The parts of root which were showing the symptoms were washed in running tap water and cut into small bits. The surface sterilization of bits was done with the help of 0.1 per cent mercuric chloride solution for 30 seconds and were washed thoroughly in sterilized distilled water for three times to remove traces of mercuric chloride and then aseptically transferred to sterilized potato dextrose agar (PDA) plates and were incubated at 27°C for three days for fungal growth. Later, the bit of mycelium was transferred on PDA slants. The pure culture of fungus was also obtained by following the hyphal tip method (Rangaswami, 1972). After 7 days, pure culture was obtained and it was maintained at 4°C for further studies. A 5 mm mycelial disc from actively growing culture of each isolate was placed in 90 mm PDA plates with three replicates and incubated at 28±1°C. The growth of each isolate was recorded at 24 hours, 48 hours, 72 hours interval by taking average of cross section diameter until the mycelium reached the periphery of the plate. The mycelial growth per hour *i.e.* growth rate was calculated. On the basis of the mycelial growth after 72 hours of each isolate, two isolates (RB5 and RS2) were selected for further studies.

As in the present study efficacy of different botanicals was tested against both the isolates under *in vitro* conditions and against root rot both in *Desi* and and American cotton under *in vivo* conditions during *Kharif* year 2021 and 2022.

**Evaluation of different botanicals against *Rhizoctonia* spp. under *in vitro* and *in vivo* conditions**

**Preparation of Botanicals**

Seven botanicals viz., Neem (*Azadirachta indica*), Garlic (*Allium sativum*), Ginger (*Zingiber officinale*), *Parthenium* (*Parthenium hysterophorus*), Datura (*Datura stramonium*), Turmeric (*Curcuma longa*), *Lantana(Lantana camara*) at different concentrations i.e., 5, 10, 15 and 20 per cent were evaluated for their efficacy against two different *Rhizoctonia bataticola* and *Rhizoctonia solani* isolates (RB5 and RS2) under *in vitro* conditions using poison food technique (Grover and Moore, 1962). To obtain the desired concentration in per cent (%), the required volumes of each test botanical was combined in a conical flask containing 100 ml molten PDA medium. The flask containing the poisoned medium was vigorously shaken to ensure an even distribution of botanicals and 20 ml was poured into each sterilized Petri plate. After the solidification of media in the Petri plates, the plates were inoculated with fungal mycelial disc of 5 mm diameter of actively growing pure culture of each tested isolates in the center. The inoculated Petri plates were incubated in BOD incubator at 25±2°C temperature. The radial growth of mycelium was recorded when there is 90 mm growth in check plates at 25±2°C and per cent growth inhibition was estimated by using the formula given by Vincent (1927).

**Observations Recorded**

$$\text{Growth Inhibition}\,(\%) = \frac{\text{Growth in control}}{\text{growth in treatment}} \times 100$$

$$\text{Growth Inhibition}\,(\%) = \frac{\text{Growth in control}}{\text{Growth in control}} \times 100$$

$$\text{Growth Inhibition}\,(\%) = \frac{(C - T)}{C} \times 100$$

Where;

I = Per cent inhibition of mycelial growth

C = Radial mycelium growth of *Rhizoctonia* spp. in control

T = Radial mycelium growth of *Rhizoctonia* spp. in treatment

The effect of different botanicals was also tested on both *Desi* and American cotton at all four different concentrations to test the efficacy of botanicals against root rot disease *in vivo* conditions. Different botanicals were evaluated to formulate the suitable management strategy to control root rot disease *in vivo* under screen house conditions. Earthen pots were filled with sterilized sandy loam soils @ of 3kg soil/ pot. Upper one cm layer of soil in pot was inoculated with 30ml of mycelial suspension (15 mg/L water). Seeds of both (*Desi* and American cotton) were soaked in 5, 10, 15 and 20 per cent concentrations of each botanical for 24 hours and after drying in shade, sowing of seeds was done. Five plants per pot were grown in artificially inoculated soil. Four replications of the below mentioned treatments were maintained as CRD and un-inoculated pots were also maintained as control. Then per cent disease incidence was recorded after 60 days of interval.

$$\text{Per cent Disease Incidence}\,(\%) = \frac{\text{Number of Diseased Plants}}{\text{Total Number of Plants}} \times 100$$

## Results and Discussion

Different botanicals were evaluated against RB5 and RS2 isolates to test their efficacy under *in vitro* conditions at four different concentrations. The data of per cent growth inhibition of RB5 isolate of *Rhizoctonia bataticola* indicated that *Lantana camara* was found best to inhibit the growth of pathogen *i.e.,* RB5 isolate of *Rhizoctonia bataticola.* Among the tested botanicals, *Lantana camara* was found the best as it showed 77.14 per cent mycelial growth inhibition at 20 per cent concentration and least mycelial growth inhibition was showed by Ginger (*Zingiber officinale*) as 24.61%. The effect of different botanicals was also evaluated on mycelial growth of RB5 isolates of *Rhizoctonia bataticola* and maximum mycelial growth was shown by Ginger (*Zingiber officinale*) as 75.74 mm and least was shown by *Lantana camara* as 30.05 mm at 5 per cent. (Table 1) (Plate 1)

The data of per cent growth inhibition of RS2 isolate of *Rhizoctonia solani* indicated that *Lantana camara* was found best to inhibit the growth of pathogen *i.e.* RS2 isolate of *Rhizoctonia solani.* Among the tested botanicals, *Lantana camara* was found the best as it showed 75.67 % mycelial growth inhibition at 20 per cent concentration and least mycelial growth inhibition was showed by Ginger (*Zingiber officinale*) as 22.75%. (Table 2) (Plate 1)

The effect of different botanicals was also evaluated on mycelial growth of RS2 isolates of *Rhizoctonia solani*. Maximum mycelial growth was shown by $T_3$ (Ginger (*Zingiber officinale*)) as 77.89 mm and least was shown by $T_7$ (*Lantana camara*) as 31.23 mm at 5 per cent concentration. Least growth was observed at 20 per cent concentration in all the treatments and significantly differs with other concentration *i.e.,* 15, 10 and 5 per cent.

The different botanicals were tested for their efficacy against root rot of A. cotton at different concentrations i.e., 5, 10, 15 and 20 % *in vivo* condition during the *Kharif,* 2021 & 2022. The data revealed that *Lantana camara* was found the best at all concentrations and statistically significant over other botanicals in both the years of experiment i.e., 2021 and 2022. The data also revealed that at higher concentration *i.e.,* 200 ppm, per cent disease incidence was minimum while per cent disease control was maximum and significantly differ with other concentration *i.e.,* 15,10 and 5 per cent in all the treatments in both the years of experiment i.e., 2021 and 2022. Maximum disease control (64.87 and 65.51%) during the year 2021 and 2022 respectively at 200 ppm was recorded in *Lantana camara* which was statistically significant over other treatments.

The different botanicals were tested for their efficacy against root rot of *Desi* Cotton at different concentrations i.e., 5, 10, 15 and 20% *in vivo* condition during the *Kharif,* 2021 & 2022. It is evident that *Lantana camara* was found the best at all concentrations and statistically significant over other botanicals in both the years of experiment *i.e.,* 2021 and 2022. The data also revealed that at higher concentration i.e., 20 per cent, per cent disease incidence was minimum while per cent disease control was maximum and significantly differ with other concentration *i.e.,* 15,10 and 5 per cent in all the treatments in both the years of experiment *i.e.,* 2021 and 2022. Maximum disease control (59.88 and 61.66%) during the year 2021 and 2022 respectively at 20 per cent was recorded in *Lantana camara* which was statistical significant over other treatments, whereas, minimum diseases control was recorded ginger (*Zingiber officinale*) in both the years.

The pooled data of American and *Desi* cotton for evaluation of botanicals against root rot of cotton. It was calculated that *Lantana camara* was the best in both American and *Desi* cotton at all concentration and statistically significant over other treatments in both the years of experiment *i.e.,* 2021 and 2022. It is evident from the data that at higher concentration *i.e.,* 20 %, per cent disease incidence was minimum and disease control was maximum and significantly differs with other concentration *i.e.,* 15,10 and 5 per cent in both the years of experiment *i.e.,* 2021 and 2022. Maximum disease control (65.18%) and Minimum disease incidence (14.09%) was recorded in $T_7$ at 20 % Concentration, whereas, Minimum disease control (26.64%) and maximum disease incidence (29.69%) was observed in $T_1$ at 5 per cent during *Kharif,* 2021 while Maximum disease control (60.06%) and Minimum disease incidence (16.66%) was recorded in $T_7$ at 200 ppm, whereas, Minimum disease control (23.00%) and maximum disease incidence (32.61%) was observed in $T_1$ at 5 per cent during *Kharif*, 2022.

The results found similarities up to a level recorded by Dhingani *et al.* (2013) who tested the bio-efficacy of phytoextracts of thirteen plant species against *Macrophomina phaseolina* and Khamari *et al.* (2017) who tried phytoextracts of thirty plant species against the pathogen causing root rot of sesame. The results were supported by Kumar *et al*. (2019) who observed the effect of botanicals on *Rhizoctonia* and revealed that phytoextracts reduced the disease spread by 36.62 and 35.38 per cent. Matloob *et al.* (2021) also supported the results who tested the efficacy of phytoextracts against *Rhizoctonia solani* causing root rot of cotton and observed that 10% concentration of common bugloss (*Anchusa officinalis*) and black cumin (*Nigella sativa*) showed maximum fungal growth with inhibition percentage of 37.0 and 25.9 respectively. Savaliya *et al.* (2015) evaluated the efficacy of phytoextracts of nine plant species under *in vitro* conditions using poison food technique against *M. phaseolina* and revealed that maximum growth of mycelium was inhibited by *Allium sativum.*

## Conclusion

The present study gave a relative efficiency analysis of some of the plant extracts for the management of root rot and suggests the possibility of using them in the integrated management of *Rhizoctonia* spp. in cotton, however, more work need to be done to optimise the correct dose of treatment and application methods.

**Table 1 :** *In vitro* evaluation of botanicals on RB5 isolate of *Rhizoctonia bataticola*

| Sr. No. | Treatments | Per cent growth inhibition Concentrations | | | | | Mycelial Growth Concentrations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5% | 10% | 15% | 20% | Mean | 5% | 10% | 15% | 20% | Mean |
| $T_1$ | Neem (*Azadirachta indica*) | 28.33* (32.13)** | 30.63 (33.58) | 33.94 (35.61) | 38.71 (38.45) | 32.90 | 64.51* (53.41)** | 62.44 (52.18) | 59.45 (50.42) | 55.17 (47.94) | 60.39 |
| $T_2$ | Garlic (*Allium sativum*) | 46.01 (42.69) | 48.34 (44.03) | 51.82 (46.02) | 55.83 (48.32) | 50.50 | 48.60 (44.17) | 46.49 (42.97) | 43.36 (41.16) | 39.76 (39.07) | 44.55 |
| $T_3$ | Ginger (*Zingiber officinale*) | 15.84 (23.38) | 16.45 (23.89) | 21.71 (27.73) | 24.61 (29.71) | 19.65 | 75.74 (60.49) | 75.19 (60.11) | 70.46 (57.06) | 67.85 (55.44) | 72.31 |
| $T_4$ | *Parthenium (Parthenium hysterophorus)* | 64.24 (53.25) | 67.91 (55.47) | 69.36 (56.37) | 72.11 (58.10) | 68.40 | 32.19 (34.54) | 28.88 (32.49) | 27.57 (31.65) | 25.11 (30.05) | 28.44 |
| $T_5$ | Datura (*Datura stramonium*) | 39.48 (38.90) | 49.86 (44.89) | 51.69 (45.95) | 54.88 (47.79) | 48.97 | 54.47 (47.54) | 45.13 (42.18) | 43.48 (41.23) | 40.61 (39.55) | 45.92 |
| $T_6$ | Turmeric (*Curcuma longa*) | 40.23 (39.34) | 48.13 (43.91) | 51.46 (45.81) | 54.60 (47.62) | 48.60 | 53.80 (47.16) | 46.68 (43.07) | 43.69 (41.35) | 40.86 (39.70) | 46.26 |
| $T_7$ | *Lantana(Lantana camara)* | 66.62 (54.68) | 70.56 (57.17) | 73.10 (58.75) | 77.14 (61.43) | 71.85 | 30.05 (33.22) | 26.50 (30.91) | 24.21 (29.44) | 20.58 (26.94) | 25.33 |
| $T_8$ | Control | – | – | – | – | - | 90.00 (71.54) | 90.00 (71.54) | 90.00 (71.54) | 90.00 (71.54) | - |
| | | CD (p=0.05) | | SE (m) ± (m) | | | CD (p=0.05) | | SE (m) ± (m) | | |
| | Treatment | 1.66 | | 0.58 | | | 1.49 | | 0.53 | | |
| | Concentration | 1.25 | | 0.44 | | | 1.13 | | 0.40 | | |
| | T×C | 3.32 | | 1.17 | | | 2.98 | | 1.06 | | |

*Mean of four replications

** Values in parenthesis are angularly transformed

**Table 2 :** *In vitro* evaluation of different fungicides on RS2 isolate of *Rhizoctonia solani*

| Sr. No. | Treatments | Per cent growth inhibition Concentrations | | | | | Per cent growth inhibition Concentrations | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5% | 10% | 15% | 20% | Mean | 5% | 10% | 15% | 20% | Mean |
| $T_1$ | Neem (*Azadirachta indica*) | 26.71* (31.08)** | 28.01 (31.93) | 31.64 (34.19) | 37.68 (37.84) | 31.01 | 65.97* (54.29)** | 64.79 (53.58) | 61.53 (51.64) | 56.09 (48.47) | 62.09 |
| $T_2$ | Garlic (*Allium sativum*) | 44.62 (41.89) | 47.36 (43.47) | 49.64 (44.77) | 53.85 (47.19) | 48.86 | 49.85 (44.89) | 47.38 (43.47) | 45.32 (42.29) | 41.54 (40.10) | 46.01 |
| $T_3$ | Ginger (*Zingiber officinale*) | 13.46 (21.40) | 14.22 (22.11) | 21.90 (27.85) | 22.75 (28.46) | 18.08 | 77.89 (61.96) | 77.20 (61.46) | 70.29 (56.96) | 69.52 (56.47) | 73.72 |
| $T_4$ | *Parthenium (Parthenium hysterophorus)* | 62.53 (52.24) | 65.06 (53.75) | 67.16 (55.01) | 71.55 (57.77) | 66.57 | 33.72 (35.47) | 31.45 (34.08) | 29.56 (32.91) | 25.61 (30.35) | 30.08 |
| $T_5$ | Datura (*Datura stramonium*) | 38.08 (38.08) | 47.67 (43.64) | 49.74 (44.83) | 52.93 (46.66) | 47.10 | 55.73 (48.27) | 47.10 (43.31) | 45.23 (42.24) | 42.36 (40.58) | 47.60 |
| $T_6$ | Turmeric (*Curcuma longa*) | 39.31 (38.81) | 46.66 (43.06) | 49.83 (44.88) | 52.56 (46.45) | 47.09 | 54.62 (47.63) | 48.01 (43.84) | 45.16 (42.20) | 42.70 (40.77) | 47.62 |
| $T_7$ | *Lantana(Lantana camara)* | 65.30 (53.89) | 68.55 (55.88) | 71.38 (57.65) | 75.67 (60.43) | 70.22 | 31.23 (33.95) | 28.30 (32.11) | 25.76 (30.46) | 21.90 (27.87) | 26.79 |
| | Control | – | – | – | – | - | 90.00 (71.54) | 90.00 (71.54) | 90.00 (71.54) | 90.00 (71.54) | |
| | | CD (p=0.05) | | SE (m) ± | | | CD (p=0.05) | | SE (m) ± | | |
| | Treatment | 1.72 | | 0.61 | | | 1.55 | | 0.55 | | |
| | Concentration | 1.30 | | 0.46 | | | 1.17 | | 0.41 | | |
| | T×C | 3.45 | | 1.22 | | | 3.10 | | 1.10 | | |

*Mean of four replications ** Values in parenthesis are angularly transformed

**Table 3 :** *In vivo* evaluation of different botanicals against root rot of American cotton during *Kharif,* 2021 and 2022

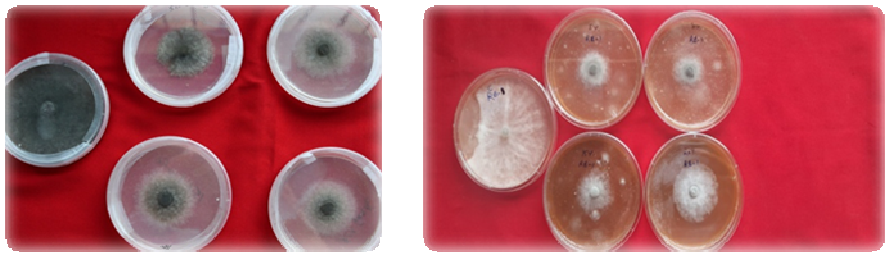
| Sr. No. | Treatments | DI | DC(%) | DI | DC(%) | DI | DC(%) | DI | DC(%) | DI | DC(%) | DI | DC(%) | DI | DC(%) | DI | DC(%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2021 | | | | | | | | 2022 | | | | | | | |
| | | Concentrations (ppm) | | | | | | | | Concentrations (ppm) | | | | | | | |
| | | 5% | | 10% | | 15% | | 20% | | 5% | | 10% | | 15% | | 20% | |
| $T_1$ | Neem | 33.33* (35.23)** | 23.35 | 30.00 (33.19) | 31.00 | 28.34 (32.14) | 34.83 | 27.33 (31.49) | 37.14 | 31.89 (34.35) | 22.62 | 29.31 (32.75) | 28.90 | 27.62 (31.68) | 32.99 | 26.30 (30.83) | 36.19 |
| $T_2$ | Garlic | 30.16 (33.28) | 30.65 | 27.64 (31.68) | 36.44 | 25.16 (30.08) | 42.13 | 22.40 (28.22) | 48.48 | 28.38 (32.16) | 31.15 | 26.98 (31.27) | 34.55 | 24.22 (29.44) | 41.25 | 21.51 (27.59) | 47.82 |
| $T_3$ | Ginger | 36.22 (36.97) | 16.70 | 33.47 (35.32) | 23.03 | 30.25 (33.34) | 30.43 | 28.67 (32.35) | 34.06 | 34.03 (35.66) | 17.44 | 32.85 (34.95) | 20.29 | 29.57 (32.92) | 28.25 | 27.89 (31.85) | 32.34 |
| $T_4$ | *Parthenium* | 25.11 (30.05) | 42.26 | 22.52 (28.31) | 48.20 | 19.53 (26.19) | 55.09 | 17.52 (24.71) | 59.70 | 23.94 (29.26) | 41.91 | 21.74 (27.75) | 47.26 | 18.98 (25.80) | 53.96 | 16.72 (24.08) | 59.44 |
| $T_5$ | Datura | 27.64 (31.68) | 36.44 | 25.24 (30.14) | 41.95 | 22.37 (28.20) | 48.55 | 20.47 (26.86) | 52.92 | 26.63 (31.05) | 35.39 | 24.73 (29.80) | 40.00 | 21.72 (27.73) | 47.31 | 19.84 (26.41) | 51.87 |
| $T_6$ | Turmeric | 32.33 (34.63) | 25.65 | 30.13 (33.27) | 30.72 | 27.53 (31.61) | 36.69 | 25.14 (30.07) | 42.19 | 30.62 (33.57) | 25.71 | 29.43 (32.83) | 28.59 | 26.72 (31.10) | 35.18 | 24.19 (29.42) | 41.32 |
| $T_7$ | *Lantana* | 24.33 (29.54) | 44.05 | 21.37 (27.50) | 50.84 | 18.65 (25.54) | 57.11 | 17.45 (24.65) | 59.88 | 22.97 (28.61) | 44.27 | 20.35 (26.78) | 50.63 | 17.80 (24.90) | 56.81 | 15.80 (23.39) | 61.66 |
| $T_8$ | Control | 43.48 (41.23) | | 43.48 (41.23) | | 43.48 (41.23) | | 43.48 (41.23) | | 41.22 (39.92) | | 41.22 (39.92) | | 41.22 (39.92) | | 41.22 (39.92) | |
| CD (p=0.05) | | 2.85 | | 2.80 | | 2.74 | | 2.66 | | | | **2.72** | | 2.77 | | 2.86 | |
| SE (m) ± | | 0.97 | | 0.95 | | 0.93 | | 0.90 | | 0.93 | | 0.92 | | 0.94 | | 0.97 | |

*Mean of four replications
** Values in parenthesis are angularly transformed
(DI- Disease Incidence DC%- Disease Control in per cent)

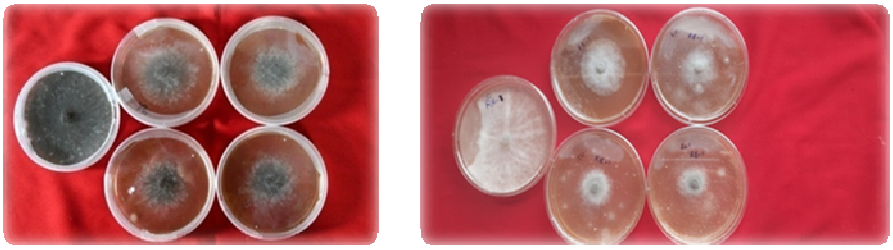
**Table 4 :** *In vivo* evaluation of different botanicals against root rot of *Desi* cotton during *Kharif,* 2021 and 2022

| Sr. No. | Treatments | DI | DC(%) | DI | DC(%) | DI | DC(%) | DI | DC(%) | DI | DC(%) | DI | DC(%) | DI | DC(%) | DI | DC(%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2021 | | | | | | | | 2022 | | | | | | | |
| | | Concentrations (ppm) | | | | | | | | Concentrations (ppm) | | | | | | | |
| | | 5% | | 10% | | 15% | | 20% | | 5% | | 10% | | 15% | | 20% | |
| $T_1$ | Neem | 33.33* (35.23)** | 23.35 | 30.00 (33.19) | 31.00 | 28.34 (32.14) | 34.83 | 27.33 (31.49) | 37.14 | 31.89 (34.35) | 22.62 | 29.31 (32.75) | 28.90 | 27.62 (31.68) | 32.99 | 26.30 (30.83) | 36.19 |
| $T_2$ | Garlic | 30.16 (33.28) | 30.65 | 27.64 (31.68) | 36.44 | 25.16 (30.08) | 42.13 | 22.40 (28.22) | 48.48 | 28.38 (32.16) | 31.15 | 26.98 (31.27) | 34.55 | 24.22 (29.44) | 41.25 | 21.51 (27.59) | 47.82 |
| $T_3$ | Ginger | 36.22 (36.97) | 16.70 | 33.47 (35.32) | 23.03 | 30.25 (33.34) | 30.43 | 28.67 (32.35) | 34.06 | 34.03 (35.66) | 17.44 | 32.85 (34.95) | 20.29 | 29.57 (32.92) | 28.25 | 27.89 (31.85) | 32.34 |
| $T_4$ | *Parthenium* | 25.11 (30.05) | 42.26 | 22.52 (28.31) | 48.20 | 19.53 (26.19) | 55.09 | 17.52 (24.71) | 59.70 | 23.94 (29.26) | 41.91 | 21.74 (27.75) | 47.26 | 18.98 (25.80) | 53.96 | 16.72 (24.08) | 59.44 |
| $T_5$ | Datura | 27.64 (31.68) | 36.44 | 25.24 (30.14) | 41.95 | 22.37 (28.20) | 48.55 | 20.47 (26.86) | 52.92 | 26.63 (31.05) | 35.39 | 24.73 (29.80) | 40.00 | 21.72 (27.73) | 47.31 | 19.84 (26.41) | 51.87 |
| $T_6$ | Turmeric | 32.33 (34.63) | 25.65 | 30.13 (33.27) | 30.72 | 27.53 (31.61) | 36.69 | 25.14 (30.07) | 42.19 | 30.62 (33.57) | 25.71 | 29.43 (32.83) | 28.59 | 26.72 (31.10) | 35.18 | 24.19 (29.42) | 41.32 |
| $T_7$ | *Lantana* | 24.33 (29.54) | 44.05 | 21.37 (27.50) | 50.84 | 18.65 (25.54) | 57.11 | 17.45 (24.65) | 59.88 | 22.97 (28.61) | 44.27 | 20.35 (26.78) | 50.63 | 17.80 (24.90) | 56.81 | 15.80 (23.39) | 61.66 |
| $T_8$ | Control | 43.48 (41.23) | | 43.48 (41.23) | | 43.48 (41.23) | | 43.48 (41.23) | | 41.22 (39.92) | | 41.22 (39.92) | | 41.22 (39.92) | | 41.22 (39.92) | |
| CD (p=0.05) | | 2.85 | | 2.80 | | 2.74 | | 2.66 | | | | **2.72** | | 2.77 | | 2.86 | |
| SE (m) ± | | 0.97 | | 0.95 | | 0.93 | | 0.90 | | 0.93 | | 0.92 | | 0.94 | | 0.97 | |

*Mean of four replications
** Values in parenthesis are angularly transformed
(DI- Disease Incidence DC%- Disease Control in per cent)



(a) ***Lantana camara***



(b) ***Parthenium hysterophorus***

**(c) *Zingiber officinale***

**Plate 1 :** Efficacy of different botanicals against RB5 and RS2 under *in vitro* Conditions

## Conflict of Interest

No conflict of interest.

## Authors'Contribution

PV, NKY designed the study and prepared the manuscript. PV, P and LY analyzed the data. All authors interpreted the data, critically revised the manuscript for important intellectual contents and approved the final version.

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