"EFFICACY OF CERTAIN BOTANNGICALS AND BIOAGENTS AGAINST *RHIZOCTONIA SOLANI* (KUHN) CAUSING WEB BLIGHT OF MUNGBEAN [*VIGNA RADIATA* (L.) WILCZEK]"

THESIS

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BY

ABHISHEK SINGH

I.d. No. A- 10507/18

DEPARTMENT OF PLANT PATHOLOGY

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U.P. INDIA
उत्तर प्रदेश भारत
अन्नं हि जीवानां ज्येष्ठम्

DEDICATED

TO MY

BELOVED PARENTS

Abhishek Singh.....

Dr. V.P. Chaudhary
Assistant Professor

Department of plant Pathology
College of Agriculture
A.N.D.University Agri. & Tech.
Narendra Nagar, (Kumarganj),
Ayodhya - 224229 (U.P.) India

CERTIFICATE - 1

This is to certify that the thesis entitled **"Efficacy of certain Botanicals and Bio-agents against *Rhizoctonia solani* (Kuhn) Causing Web Blight of Mungbean "[*Vigna radiata* (L.) wilczek]"** Submitted for the degree of **Master of Science (Agriculture)** in the subject of **Plant Pathology** of the Narendra Deva University of Agriculture & Technology , Narendra Nagar (Kumarganj), Ayodhya is a bonafide research work carried out by Mr. **Abhishek Singh , I.D. NO. A-10507/18** under my supervision and that no part of this thesis has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

Place : **Kumarganj, Ayodhya**

(*V.P. Chaudhary*)
Major Advisor & Chairman

Dated:

CERTIFICATE - II

This is to certify that the thesis entitled **"Efficacy of certain Botanicals and Bio-agents against *Rhizoctonia solani* (Kuhn) Causing Web Blight of Mungbean "[*Vigna radiata* (L.) wilczek]"** Submitted by **Mr. Abhishek Singh , I.D. NO. A-10507/18** to the Narendra Deva University of Agriculture & Technology , Narendra Nagar (Kumarganj), Ayodhya (u.p.) in partial fulfillment of the requirements for the degree of **Master of Science (Agriculture)** in the subject of **Plant Pathology** has been approved by the Advisory Committee after an oral examination of the student in collaboration with an External Examiner.

(External Examiner)

Major Advisor& Chairman : **Dr. V.P. Chaudhary**
Assistant Professor
Department of Plant Pathology

Member from Major : **Dr. Subhash Chandra**
Assistant Professor
Department of Plant Pathology

Member from Minor : **Dr. Pankaj Kumar**
Assistant Professor
Department of Entomology

Member from Related field : **Dr. Vinod Singh**
Associate Professor
Department of Genetics Plant Breeding

Dean's nominee : **Dr. Shiva Nath**
Associate Professor
Department of Genetics Plant Breeding

Dean College Of Agriculture **Head of Department**

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(Abhishek Singh)

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INTRODUCTION

Chapter I

INTRODUCTION

Pulses constitute an important ingredient of the predominantly vegetarian diet in Indian. Besides being rich in protein, they also play an important role in sustainable agriculture by enriching the soil through biological nitrogen fixation. These crops lit in various cropping system without disturbing the main crops. Pulses are the main source of protein particularly for vegetarians and contribute about 14 percent of the total protein of an Indian average diet. Production of pulses in the country is far below the requirement to meet even the minimum level of per capita consumption. According to Indian Council of Medical Research (ICMR) optimum requirement of the pulse for a person to maintain his normal health is 104 g per day. However, not even half of this quality is available to people, which is causing malnutrition among the growing people. Therefore, it is necessary that agricultural scientists should evolve the strategy of increasing the production of pulses to meet the protein requirement of increasing population of the country.

Mungbean [*Vigna radiata* (L.) Wilczek] is primarily a rainy season crop but with the development of early maturing varieties, it has also proved to be an ideal crop for spring and summer season. Mungbean is an excellent source of protein (24.5%) with high quality of lysine (460 mg/g N) and tryptophan (60 mg/g N). It has also remarkable quantity of ascorbic acid when sprouted and also contains riboflavin (0.21 mg/ 100 gm) and minerals (3.84 g/100g) (Gopalan *et. al.*, 1995). Mungbean, being a short duration crop, it is suitable in various multiple and inter-cropping systems. After picking of pods, mungbean plants may be used as green fodder or green manure. Beside these, the crop also enriches soil by fixing atmospheric nitrogen. Among the pulses , mungbean [*Vigna radiate*: (L) Wilczek]

also known as green gram or golden gram is one of the most important short duration pulse crops of India and grown in kharif, spring and summer seasons. Mungbean plant posses deep root system which binds soil particles and thus prevent soil erosion. Mungbean is mainly used as dehulled grain, hulled (dal), husked and dehusked dal. Soaked and sprouted grains are used as salad. It is also used for various culinary purposes.

In India, mungbean, urdbean, pigeonpea, lentil, rajmash, fieldpea and chickpea are the commonly cultivated pulses. Among them, Mungbean or Green gram botanically known as *Vigna radiata* (L.) Wilczek belonging to the family leguminosae, is one of the most important pulse crops of the country. It is grown in Kharif, spring and summer seasons. Mungbean is native to Asia particularly North Eastern Indo Burma region. The progenitor of mungbean is *Vigna radiata* var. *sublobata* (Roxb.) which can be seen growing wild in wasteland of Central India. Mungbean is annual herbaceous self pollinated plant, erect or semi erect, 45-120 cm tall sometimes with a little tendency of twining usually in the upper branches. The central stem is more or less erect while the sides branches are semi erect depending upon the plant type being grown. Plants have trifoliate leaves with long petioles. The leaves and stem are covered with short hairy structures generally shorter than those of present in urdbean. Yellow coloured flowers are produced in aggregation of 10 to 20 in axillaries racemes. Pods are straight 6 to 10 cm long without a beak having 7-10 green or golden yellow seeds within them. Seeds germinate in epigeal manner and cotyledons are yellow in colour with flat white hilum.

Mungbean is cultivated on 3.07 m ha produced 1.52 m tones of grains. it is mainly grown in Rajasthan, Maharashtra, Karnataka, Andhra Pradesh, Orissa, Bihar, Tamilnadu, Madhya Pradesh and Uttar Pradesh (Anonymous, 2019).

In Uttar Pradesh it is cultivated on 93000 ha with production of 94800 tones. Average productivity of mungbean in India and U.P. are 567 kg/ha and 536 kg/ha, respectively which is very low as compare to genetic potential of 1500-2000 kg/ha (Anonymous, 2019). The major limiting factors for its poor yield are due to attack of various biotic and abiotic stresses. Among them diseases caused by fungi, bacteria and viruses are major potential threats which adversely affect the productivity of mungbean.

From different parts of the world, several fungal, bacterial and viral ailments so far have been reported on mungbean leading to heavy yield losses. Among these diseases, web blight (*Rhizoctonia solani* Kühn), *cercospora* leaf spot (*Cercospora cruenta*), anthracnose (*Colletotrichum capsici*), powdery mildew (*Erysiphe polygoni*) macrophomina blight (*Macrophomina phaseolina*), bacterial lea f blight (Xanthomonas phaseoli Dc.), leaf crinkle (*Urdbean leaf crinkle virus*) and yellow mosaic (*Mungbean Yellow mosaic virus*) are the important ones. In warm and humid tropic zones of the world, web blight of mungbean is one of the major serious constraints in its production. Also, it is said to be one of the most devastating fungal diseases of mungbean leading to heavy yield losses particularly in Uttar Pradesh and Tarai region of Uttarakhand (Saksena and Dwivedi, 1973).

In 1924, web blight was reported for the first time on mungbean from Philippines (Nacien, 1924).While in India, Dwivedi and Saksena (1974) first reported it on mungbean from Kanpur, Uttar Pradesh. Further, it has also been reported from Assam (Saikia, 1976), Punjab (Bainset al., 1988), Madhya Pradesh (Tiwari and Khare, 1998), Bihar, Rajasthan, Haryana, Himachal Pradesh and Jammu & Kashmir (Anonymous,2004).The pathogen causes huge losses in yield of mungbean and urdbean in India (Dubey2003).

Web blight caused by *Rhizoctonia solani* (Kuhn) is one o f the most important fungal diseases which appear every year in varying intensity and causes

heavy reduction in yield. The losses in grain yield is more when the plants get infected earlier i.e. after 25 days after sowing (DAS) than 35 and 40 DAS (Gupta el al., 2003). Gupta et al. (2010) reported losses in yield and lost weight were 33.40 to 37.80 per cent and 23.12 to 28.60 per cent. respectively in different varieties of mungbean i.e. K 851, T44 and Pusa Baisakhi.

Though the web blight could be managed by the use of fungicide but due to the emergence of several problems like environmental pollution. residual effect in grains , killing non targeted organisms its use should be discouraged. Hence, for minimizing the losses caused by web blight need in-expensive and environmentally safe management practices. Several botanicals and Bio-agents have been found effective for management of different crops including web blight of mungbean caused by *Rhizoctonia solani* , therefore keeping in view the importance of the crop and seriousness of diseases present research work will be undertaken with following objectives:

1. Isolation, purification and identification of *Rhizoctonia solani* causing web blight from infected Mungbean .
2. Varietal Screening of mungbean germplasm against web blight .
3. Efficacy of botanicals, bio-agents against *Rhizoctonia solani In vitro* .
4. Efficacy of botanicals, bio-agents against *Rhizoctonia solani In vivo*.

REVIEW OF LITERATURE

Chapter - II

REVIEW OF LITERATURE

Rhizoctonia blight of mungbean (*Vigna radiata* L. Wilczek.) is an important discase caused by *Rhizoctonia solani* Kuhn. The disease is widely distributed throughout the country and causes heavy losses in grain yield, the chapter deals with geographical distribution, symptomatology, pathogen disease cycle and disease management with botanicals and bio-agents.

2.1 Geographical distribution.

Web blight is a common and wide spread disease in India causing heavy losses in quality and quantity of mungbean produce. Dwivedi and Saksena (1974) made the first report of its occurrence in India on mungbean.

In India the disease is known to occur in Uttar Pradesh, Bihar, Rajasthan, Punjab, Haryana, Himanchal Pradesh, Jammu and Kashmir (Anonymous, 1999) and Uttaranchal (Anonymous, 2004). The disease is also found on the other leguminous crop like black gram (Saksena and Dwivedi, 1973; Sharma and Tripathi, 2001), cowpea (Dwivedi, 1977), soybean (Verma and Thapliyal, 1976). However, the fungus appears to be less specified for their habitat. Reports on infection of several host plants by *R. solani* are summarized and given in Table 1. In Uttar Pradesh. This disease emerged as a main threat to mungbean cultivation and causes heavy losses wherever mungbean is grown.

Table 1. List of other host plant exhibiting aerial infection of *R. solani.*

Crop	Country	References

Arhar	India	Dwivedi and Saksena, 1975
Bajra	India	Singh and Saksena, 1980
Bean	North Argentina	Westem Ploper, 1981
Beans and Lima bean	Florida	Webber, 1939
Blackgram	India	Saksena and Dwivedi,1973
Kusum	Lousioma	Holcomb and Carling, 2002
Cetery	California	Houston and Kendrick, 1949
Coffee	El Salvador	Webber and Abrego,1958
Cotton	Lousioma	Neal, 1944; Kotile, 1945
Ginger	India	Sundram, 1953
Larch	Japan	Ito *et al.*, 1955
Lespendeza	Lousioma and North Carolina	Allisons, 1951 and Stroube, 1954
Maize	India	Ahuza, 1976
Mungbean	India	Dwivedi and Saksena, 1974
Mungbean	Pakistan	Alam et al., 1985
Paddy	North India	Saksena and Choubey, 1973
Pakchoi	Trinidad	Rajnauth,1987
Soybean	Puerto Rico	Heperly *et al*.,1982
Soybean	Lousioma	Atkins and Lewis, 1954
Sugarbeet	Virginia and North Central States	Kotile, 1947

Sugarbeet	Philippincs	Lee,1922
Vigna angularis	India	Singh *et al*, 1979
Yellow Saga	Europe	Garibaldi *et al*, 2003

2.2 Economic importance.

Limited information is available on yield losses of *R. solani* in mungbean. Status of web blight of mungbean in eastern Uttar Pradesh was 1.0 to 69.0 per cent with an average of 12.7 per cent (Singh *et al*, 2003). The losses in grain yield and 1000 seed weight in susceptible variety (K 851) were 37.4 per cent and 28.6 per cent, respectively in mungbean due to infection of *R solani* (Gupta and Singh,2002).The losses in grain yield is more when the plants get infected earlier i.e. after 25 days after sowing (DAS) than 35 and 40 DAS (Gupta *et al*, 2003). Gupta *et al*. (2010) reported losses in yield and test weight were 33.40 to 37.80 per cent and 23.12 to 28.60 per cent, respectively in different varieties of mungbean i.e. K 851, T 44 and Pusa Baisakhi. The losses in grain yield was due to reduction in number of pods (plant,number seed/pod, seed size and 1000 seed weight (Gupta ,2000).

Environmental factors play vital role in the appearance and further disease development. Web blight was favored by high relative humidity and rainfall (82.6% and 105 mm) with temperature of 28.5"C and sunshine of 5.85 hr/day. The disease intensity was higher in kharif than spring and summer season (Gupta *et al*., 2002).

2.3 The symptoms.

The fungus infects all above ground parts of the plant i.e. leave, petioles, stem and pods but most destructive is on foliage. Symptoms on leaves appear as initial small circular brown spots. These spots enlarge and are surrounded by water

soaked areas. The lesion expands and collapses and white fungal growth may be seen on the lower surface of leaves and young branches. The mycelium on infected leaves appears as spider web, thus, called as Web blight'.

Lesion on stem and petioles generally appears when infected plants have lost many of their infected leaves or after they have been completely defoliated. Lesions on stem and petiole are linear to oval and reddish brown in appearance. White brown sclerotia are produced abundantly on infected stem and petioles. The affected parts shriveled, dry and finally premature defoliation of affected plant parts may be observed. The leaf canopy is completely destroyed and in severe cases, affected plants die prematurely before flowering and pod formation. Spots on young pods are light tan and irregular in shape but on mature pods they are dark brown and sunken.

The pathogen may cause seedling mortality and collar rot when infection occurs on collar region as reddish brown lesions which soon girdles the basal portion of stem. At this point seedling wilts and collapses and called as collar rot (Dwivedi and Saksena, 1974).

2.4 The pathogen.

The hyphae of *R.* solani are initially hyaline but later brown and are characteristically branched. The branches arise at right angles (90%) from below the septa and show distinct constriction of the point of origin under microscope. Light to dark brown sclcrotia are abundantly forms on infected surface at the periphery (Alexopolas , 1996 and Dubey , 2005). The perfect stage of *R. solani* has been reported by Dwivedi and Saksena (1974).

2.5 Disease cycle.

The primary infection of disease comes through seed, soil and naturally infected collateral hosts. Secondary spread of the disease is due to basidiospores and contact between diseased and healthy plants (Ratan and Dwivedi, 1998).

2.6 Disease management.

Management of disease is very difficult, as the pathogen has wide host range and soil borne in nature. Attempts have been made to control this disease through use of fungicide, bio-agents and different plant extracts. Among the various control measures synthetic fungicides has led to the emergence of several problems like environment pollution, residual effect in grain, killing of non target organism(s). Management of plant disease through bio-agents and use of plant extracts is a cheap, safe and eco-friendly. Bio-agents (*Trichoderma* spp.) and plant extracts from different species have been found effective against *R. solani* causing different disease in different crops.

2.6.1 Evolution of mungbean genotypes .

Chandra *et al*., (2016) Rice is one of the most important cereal crops of the world. In India it occupies an area of 42.86 million hectares with production of 95.97 million tones, and productivity of 2.239 tones/ha. It contributes 20.25 per cent to agricultural G.D.P. This crop is attack by many diseases caused by fungi, bacteria, viruses, nematodes and several physiological disorders which caused annual loss of 12 to 25 per cent of the total production, while fungal diseases alone caused annual damage of 12 to 20 per cent of its production. Among these diseases, the sheath blight caused by *Rhizoctonia solani* Kuhn, earlier considered as minor disease is now regarded as an internationally important. The pathogen mainly infect leaf sheath but symptoms may be produced on any aerial part of the

rice plant, Thus , sheath blight caused by *Rhizoctonia solani* Kuhn. is most economically important disease and have possessed challenge to the farmers for successful cultivation of rice and ultimately to the plant pathologists. Keeping this fact in view, to find out resistant / tolerant germplasm against the causal pathogen, screening was under taken in field as well as laboratory conditions. Out of 108 germplasm , screened under natural as well as under artificial inoculated condition, none of the entities were found immune or resistant. However, forty Jive entries viz., Ramkajra, Baigani black, Beni, Prasada, Narendra-118, Narendra-97, Aswani. madhuri, Sawani, IET-14807, Pant Dhan-11, Gaigour, IET-16711, Karahnl, Daikachari , Bagri, Rambli-AS, Motiforam, Ram bhog , Kaland, Aktahwa -R, Lelkawa, Tulsi, IR-36,Suggapankhi , IET-16706, basti cul-9, Aktahwa- FIO, CR 1446, Sonachoor, Alktahwa, Bansfool, Saket-4, IR-24, NDR-359, NDR-637 Pant Dhan-4, NDR-330, Gajgour, T-162, IET.16705, Pusa-33, Akasi, IR-8, Saryukushmaha were found moderately resistant, 37 moderately susceptible and fourteen were observed susceptible. Rest of the entries showed highly susceptible reaction, Under artificial 'inoculated condition, out of 82 entries, none of the entry was found resistant, Only two entries viz., Baigani black and Prasada showed moderately resistant reaction, seventeen moderately susceptible and twenty seven entries susceptible. Rest of the entries was found highly susceptible.

Chandra *et al*., (2016) Out of 108 germplasm, screened under natural as well as under artificial inoculated condition, none of the entries were found immune or resistant. However, forty five entries *viz.*, Ramkajra,Baigani black, Beni, Prasada, Narendre-118, Narendra-97, Aswani,madhuri,Sawani,TET-I4807, Pant Dhan-11. Gajgour, JET-16711, Karahni, Dalkachari, Bagri, Rambli-AS, Motiforam, Ram bhog , Kaland, Aktahwa -R, Lalkswa, Tuisi, IR~36, Suggapankhi, TET-16706, basti cul-9, Atahwa· FIO, CR-1446, Sanachoor, Aktahwa, Bansfool, Saket-4, 1R-24, NDR-359, NDR-637, Pant Dhan-4, NDR-359 , NDR-637, Pant Dhan-4, Gajgour, T-182, IET-16705, Pusa-33, Akasi, IR-8, Saryukushmaha were found

moderately resistant, 37 moderately susceptible and fourteen were observed susceptible. Rest of the entries showed highly susceptible reaction. Under artificial inoculated condition, out of 82 entries, name of the entry was found resistant. Only two entries viz. Baigani black and Prasada showed moderately resistant reaction, seventeen moderately susceptible and twenty seven entries susceptible. Rest of the entries was found highly susceptible.

Chandra *et al*., (2019) Web blight (*Rhizoctonia solani*) of mungbean is a very destructive disease caused by fungus *Rhizoctonia solani*. In India, mungbean crop suffers a great loss due to this disease. Use of resistant genotypes is the best method of avoiding the occurrence of the disease. Keeping this point in view, fifty two genotypes of mungbean were tested for the resistance against web blight in field condition. Out of fifty two genotypes of mungbean were carried out under field condition of natural infection, where twenty nine genotypes *viz*.; BM 2012-09, Palampur 93/kulu-4, LGC 574, NUL 516, T-44, SGC 20, SML 1082 (SC), IPM 312-19, IGKM 06-42, VG 10-008, MH 921, ML 2412, PUSA 571, RMG 1082, PUSA 1472, ML 2410, ML 2333, COGG-912, KM 2348, AKM 12-17, IPM 312-20, GM 11-02, KM 2241, ML 818, HUM-1, CO6, LGG 460, IPM 02-3 and GM 04-02 were found resistant, five genotypes were recorded moderately resistant, thirteen genotypes were noticed moderately susceptible, four genotypes *viz*.; NVL 825, DUG 5, VBN 4, RMG 1028 were recorded susceptible. Only one genotype K-851was found highly susceptible.

2.6.2 Botanical and Bio-agents management.

Meena *et al.* (2002) evaluated 9 plant extracts in which bulb extract of Garlic at 5 per cent concentration (w/v) completely inhibited the mycelial growth of *R. solani* causing sheath blight of rice.

Shinde and Patel (2004) observed bulb extract of Garlic gave hundred per cent inhibition of mycelial growth and sclerotial production of *R. solani* causing black scurf of potato followed by Ginger, Tulsi, Eucalyptus and Neem.

The bulb extract of Garlic completely inhibited growth and sclerotia formation of *R. solani* causing black scurf of potato followed by leaf extract of Eucalyptus, Tulsi, bulb extract of Onion, rhizome extract of Ginger *in vitro* (Mittal and Goswami, 2004).

Upmanyu and Gupta (2005) evaluated 16 plant species against *R. solani* and found that extracts of *Ocimum sanctun*, *Alliun cepa* and *Phyllanthus emblica* completely inhibited the growth of *R. solani* on 25, 50 and 75 per cent concentration at 24, 48 and 72 hours of incubation.

Inhibition of *Rhizoctonia solani* with extracts of various plant species have been reported *in vitro*. The extracts of garlic (*Allium sativum*), Sadabahar (*Vinca rosea*), Ashoka (*Polyanthia longifolia*), Eucalyptus (*Eucalyptus globules*), Onion (*Allium cepa*), Tulsi (*Ocimum sanctun*), Neem (*Azadirachta indica*), Madar (*Calotropis giganiea*), Karanj (*Pongamia pinnata*), Parthenium (*Parthenium hysterophores*), Ginger (*Zingiber officinale*), Lantana *(Lantana camara*) were found effective against *R. solani* causing different disease in different crops. Mishra et al. (2005) evaluated 9 aqueous plant extracts (*Calotropis gigantea, Vinca rosea, Ocimum sanctum, Azadirachata indica, Pongamia globosa, Lamtana camara, Eucalyptus citriodora, Allium cepa and Zingiber officinale*) against R. *solani* in green gram in vitro and found that highest inhibitory action (86.11%) was recorded in Ginger (Rhizome).

Yadav (2007) evaluated 8 plant extracts against R. solani causing web blight of French bean where Garlic extracts gave maximum inhibition in mycclium growth and sclerotial formation followed by Ginger, Neem, Onion, Datura, Tulsi, Eucalyptus and Congress grass *in vitro.*

Kansal *et al.* (2008) reported Neem extract (*Azadirachta indica*) was effective against R. *solani* causing web blight of French bean. Neem extracts was found effective against R *solani* causing sheath blight of rice. It reduces the disease severity and increased grain yield in field (Muralidharan *et al.* 2003).

In field, neem formulation (Achook, Neem Azal, Neem Gold, Spictop, Tricure and Wallis) have also been reported in reducing the disease severity and increasing the yield against sheath blight of rice caused by R. *solani* (Raji and Nair, 2004 and Karthikeyan *et al*, 2007).

Mall and Asif (2008) reported extract of *Vinca rosea* was effective against R. *solani* causing different disease in different crops, banded and sheath blight of maize, sheath blight of rice, damping off and color rot of coffee, wilt of Pyrethrum and root rot of cotton *in vitro.*

Somani (2009) evaluated fresh leaf extract of 20 botanicals against *R. solani* causing black scurf of potato and found Tulsi was effective and Neem and Onion gave good control, when used as seed dip treatment of potato.

Kumar and Tripathi (2012) evaluated six plant extracts viz., onion (*Allium cepa*), neem (*Azadirachta indica*), garlic (*Allium sativum*), bhang (*Canabis sativa*). datura (*Datura stramonium*) and ginger (*Zingiber officinale*) belonging to different family were evaluated *in vitro* and in for their fungitoxicity against *Rhizoctonia solani* Kuhn, causing web blight disease of urdbean. Extract of Canabis was found inhibitory to radial growth of *Rhizoctonia solani*. *In vivo* studies revealed that seed treatment followed by three foliar sprays of *Canabis* extract showed lowest disease severity, highest grain yield as well as maximum 1000-grain weight over control.

Sonakar *et al*. (2014) conducted an experiment to determine the efficacy of botanicals *in vitro* against *Rhizoctonia solani* Kuhn causing aerial blight of soybean. The efficacy of seven botanical extracts @ 5 per cent *viz*.,Garlic,

Calotropis, Ginger, Aloevera, Neem, Makoy, Datura were tested. Among them, Garlic was found highly effective under in vitro conditions as it showed 88.47 per cent inhibition in radial growth of the fungus at 5 per cent concentration followed by calotropis @5 per cent. On the other hand, Datura was found least effective as compared to the rest of the plant extracts.

Chandra, Kumar and Gupta (2016) evaluated six botanicals *in vitro* against *R. solani*. It was observed that Neem gold @ 0.3 per cent and Wanis @ 0.80 per cent were found best in inhibiting radial growth of R. *solani*. Singh *et al*. 2017) conducted an experiment in vivo to check the disease intensity of web blight in mungbean using three botanicals viz. Garlic (*Allium sativum*), Onion (*Allium cepa*) and Neem (*Azadirachta indica*) @10 per cent. The maximum disease control was recorded in case of garlic followed by neem and onion. Yield and 100 seed weight were also found maximum in garlic followed by neem and onion.

The use of antagonistic micro-organism against *Rhizoctonia solani* has been explored as an alternative tool for disease management. Several species of *Trichoderma* has been successfully used against several soil borne pathogens under green house and field study (Melo 1991; Nelson,1991; Papavizas, 1992).

Dubey and Patel (2001) used bio-agents (*Trichoderma harzianum, T. viride* and *Gliocladium virens*) against R. *solani* causing web blight of mungbean and found that *T. viride* and *G. virens* were better than *T. harziamumn* in suppressing mycelial growth and sclerotial formation *in vitro*.

Dubey (2002) used bio-agents (*G, virens* and *T. viridae*) against web blight of mungbean as foliar spray and found that *G. virens* and *T. viride* reduced the disease intensity and increased grain yield.

Dubey and Patel (2002) standardized the inoculation of *T. viride* and *G. virens* and found 6g/kg soil dose as appropriate for increasing growth of plants as

well as disease management of urdbean and mungbean against *R. solani* causing web blight.

Trichoderma harzianum, *T. viride* and *G, virens* have been used by Singh *et al.* (2008) against root rot of mungbean caused by *R. solani* and found that *T. harzianum* was better in reducing mycelia growth *in vitro* and glass house.

Dubey (2003) reported that seed trecatment with slurry or water mixed spore of *T. viride* and *G. virens* gave the best protection to germinating seeds of urd/mungbean against *Rhizoctonia* blight when used at the rate of 106 spores/ml/10g seed.

Mathew and Gupta (1998) found that *T. harzianum* (*in vitro*) and *G. virens, T. harziamum* (under glass house condition) were most effective against *R. solani* causing root rot of French bean.

Trichoderma harzianum was found inhibitory to *R. solani* causing sheath blight of rice when applied as spray in the field (Tewari and Singh. 2005).

Khan and Sinha (2007) studied the effect of *T. harzianum* and *T. viride* and their volatile compounds against *R. solani* causing sheath blight of rice and reported that inhibition in mycelial growth was maximum in *T. harzianum* and its volatile compounds in dual culture technique.

Ray *et al.*(2007) reported the efficacy of *Trichoderma viride,Trichoderma harzianum* and *Pseudomonas fluorescens* under in vitro conditions against *R. solani.* It was found that *Trichoderma harzianum* (82.43 mm) effectively inhibited the mycelium growth of *R. solani* after 96 hr of incubation followed by *T. viride* (80.36 mm) and *P. fluorescence.* However, after 120 hr of incubation *T. harzianum* and *T. viride* completely covered the inoculation plates and *P. fluorescens* overlapped the test pathogen.

Sharma *et al.* (2009) concluded that *Trichoderma* sp, isolates were effective in suppressing the growth of *R. solani* and all the treatments were significantly different from control. Growth of an isolate of *Trichoderma* was directly associated with its ability to inhibit the pathogen. Initially. pathogen grew very fast as compared to the antagonist and covered almost the entire plate within 48 hr but after 48 hr, the isolate of *Trichoderma* sp.started covering the pathogen and checked its further growth.

Meena *et al*. (2002) observed *T. harzianum* suppressed mycelia growth by 65.2 per cent and sclerotial formation by 35.9 per cent of R. *solani* followed by *T. viride* through volatile and non-volatile activity, causing banded leaf and sheath blight of maize.

Sonakar *et al.,* (2014). A pot experiment was conducted at the College of Agriculture in C.S.A.U.A & T, Kanpur (U.P.), India; during the *Kharif* season of 2012 and 2013 to study the Aerial blight of soybean caused by *Rhizoctonia solani* Kuhn. The efficacy of seven botanical extract *viz.*, Garlic, Madar, Ginger, Aloevera, Neem, Makoy, Datura *i.e.* application @ 5 per centand six bio-agents *viz., Trichoderma viride, T. atroviride, T. harzianum, T. longibrachiatum, T. koningii & Aspergillus niger* were tested *in vitro* and *in vivo* conditions were against *Rhizoctonia solani*, the causal organism of aerial blight of soybean. Results revealed that the under *in vitro* conditions, botanical extracts of Garlic was found highly effective showed 88.47 per cent inhibition in radial growth of the fungus at 5 per cent concentration followed by Madar at 5 per cent concentration. Dhatura was found least effective than rest of the plant extract. The use of bio-agents is risk free and the best alternative to sustain plant protection. *Trichoderma viride* was the most significantly effective 70.42 per cent as it inhibited the mycelial growth of *Rhizoctonia solani* after 7 days of incubation followed by *T. atroviride* and *T. harzianum* where 62.47 per cent and 47.68 per cent growth of fungus was

observed, respectively. However, minimum effect on growth 8.62 per cent was observed in *Aspergillus niger.*

Vikas Kumar Singh *et al .,* (2017). Three botanicals viz. Neem (*Azadirachta indica*), Garlic (*Allium sativum*), Onion (*Allium cepa*) and a chemicals carbendazim (treated) were used *in vivo* (in field) at 10 per cent and 0.1% concentration. To check the disease intensity of web blight in mungbean. The minimum disease intensity and maximum disease control were recorded in garlic (value) followed by neem, onion, *Trichoderma viride, T. harzianum* as compared to treated and untreated check. The yield (value) and 100-seed weight were also recorded maximum in garlic (value) followed by neem, onion, *Trichoderma viride, T. harzianum* as compared to treated and untreated check. The avoidable loss in yield was recorded maximum in garlic followed by neem, onion, *Trichoderma viride, T. harzianum* as compared to treated and untreated check. The bio-agents *Trichoderma harzianum* and *Trichoderma viride* have been evaluated in field (0.5 % concentration spray) also.

Chandra *et al*., (2016) Out of eight fungicides and six neem based products, evaluated in field conditions, propiconazole25 EC@0.1 per cent appeared to be most effective which reduced the disease Severity by 86.0 per cent and 86.11 per cent and increased yield by 136.06 per cent and 137.20 per cent in Kharif 2001 and 2002, respectively. Among the six botanicals evaluated as field spray, Neem azal @0.3 per cent was found to be most effective and it reduced 79.07 and 80.0 per cent severity of disease and increased 102.07 per cent and 100.94 per cent crop yield in Kharif 2001 and 2002, respectively.

Vipin Kumar *et al*., (2017). Among the fungal diseases, sheath blight, caused by multinucleate *Rhizoctonia solani* Kuhn (teleomorph: *Thanatephorus cucumeris* Donk), a ubiquitous pathogen, is an important fungal disease of rice ranking only after blast and often rivaling it. The potential losses due to sheath

blight alone in India has been up to 51.3%. In this study an attempt was made to investigate the antifungal efficacy of botanicals viz., neem (*Azadirachtaindica*), tulsi (*Ocimum sanctum*), garlic (*Allium sativum*), onion (*Allium cepa*), ginger (*Zingiberofficinale*) and various fungicides namely mancozeb, propiconazole, hexaconazole, carbendazim, and copper oxychloride against *Rhizoctonia solani in vitro* by poison food technique. *R. solani* was allowed to grow at 5%, 10% concentrations of botanicals and at 200, 500, 1000ppm of fungicides amended potato dextrose agar (PDA) medium. The effect of botanicals and fungicides on mycelial growth inhibition was recorded after 36, 48 and 72 post hrs inoculation (phi). It was observed that bulb extract of *Allium sativum* and rhizome extract of *Zingiber officinale* suppressed the mycelial growth (80.19 and 76.32, respectively) @ 10% followed by leaf extract of *Azadirachtaindica* (72.78 %) after 72 phi. Among the fungicides, the complete fungal growth inhibition was observed in propiconazole and carbendazim fungicides amended medium.

MATERIALS AND METHODS

Chapter-III

MATERIALS AND METHODS

The present studies were carried out in the laboratory and glass housc of the Department of Plant Pathology, Aacharya Narendra Dev University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.). The details of materials used, experimental procedures followed and techniques adopted are given as under.

3.1 Collection of web blight infected mungbean plants

Mungbean leaves and pods showing characteristic web blight symptoms, were collected from Student's Instructional Farm of Aacharya Narcndra Dev University of Agriculture & Technology, Kumarganj, Ayodhya , U.P. and farmer's field. The infected mungbean leaves and pods were kept in rough dry envelops and marked clearly mentioning location, variety, date of collection etc and brought to the laboratory for isolation of the pathogen. The samples were dried for 24 hours in shade in order to remove excess of surface moisture. After the drying, the sample were kept in B.O.D. incubator in paper envelops and maintained at 10 ℃ for isolation and further studies.

3.2 Sterilization of metal and glasswares

Metallic objects like blade, scissor, forceps, inoculation, needle, cork borer etc were sterilized by dipping in the spirit and heating on flame to red hot before

inoculation. Laminar flow was sterilized with formalin and ultra violet lamp before use. Sprit was used as general disinfectant of hand.

Glassware, such as, Petri dishes culture tubes, funnel, glass rods, beakers and flasks etc were cleaned in chromic acid (potassium di- chromate 60g.concentrated sulphuric acid 60 ml and water 100 ml) followed by washing in running water. Dry glasswares were sterilized at 180 °C for 2 hours in an electric hot air oven.

3.3 Preparation of culture media

Potato-Dextrose-Agar medium (PDA medium)

PDA medium having following composition was prepared by following method described by Johnston and Booth (1983) was used for present study.

Peeled Potato - 200.00g

Dextrose - 20.00g

Agar- 20.00g

Distilled water- 1000.00 ml

The peeled potatoes were cut in 12 mm cubes; Two hundred grams of potato cubes were rinsed in water and boiled for 20 minutes in 500 ml water. Potato broth was filtered through cheese cloth and kept in measuring cylinder. Agar was melted in 500 ml of water by heating and added to potato broth. Dextrose was added in it. The final volume was made up to 1000 ml by adding distilled water. The pH was adjusted to 7.0.The PDA was poured in test tube for preparation of PDA slant and also in flask. Then these were sterilized at 15 *p.s.i.* for 20 minutes in an autoclave.

3.4 Method of isolation

Leaf sample showing distinct symptoms, were subjected to usual isolation procedures after washing in fresh sterilized water. Smaller pieces having healthy portion also were cut down. Thus, obtained pieces were surface sterilized with 0.1 per cent mercuric chloride solution followed by washing thrice with sterilized water thoroughly. Excess water were removed by placing on the folds of sterilized blotting paper. These pieces were subsequently transferred to Petri dishes and PDA slants under aseptic conditions. Petri dishes were properly marked with glass marker and incubated at 26 ± 2 "C in BOD incubator.

3.5 Pure culture of pathogen

The pure culture of pathogen (*Rhizoctonia solani*) was made by using hyphal tip method.

Water suspension of hyphal tip (1.0 ml) was poured aseptically over a molten but still warm plain agar (2%) Petri dishes to form a very thin layer. The growth of fungus was allowed on plain agar for 24-48 hours and critically observed under microscope. The areas having hyphal tip arc marked with a glass pencil on the back of Petri dishes. The hyphal tips along with medium is scooped out and transferred to slants to obtain a single hyphal tip culture. After proper growth of fungus obtained by hyphal tip, regular sub-culturing was done to check contamination at 15 days interval. These PDA slants having R. *solani* were kept in refrigerator at 6 to 8 "C temperature for further studies.

3.6 Identification of the fungus

The pathogen was identified on the basis of their cultural and morphological characters as given below:

3.6.1 Colony and growth characters

The cultural and morphological characters of the fungus were recorded on PDA medium after 5-6 days of incubation. Colour and type of mycelium were observed with the help of microscope.

3.6.2 Mycelial characters

The colour, septation and branching pattern of mycelium were microscopically recorded.

3.6.3 Sclerotial characters

The colour shape and size of sclerotia were recorded at 5-6 days of incubation.

3.7 Pathogenicity test of R. *solani*

Pathogenicity of R. *solani* was done in pots by sowing 15 seeds of susceptible mungbean variety (K 851). Four pots were filled with sterilized soil, (Autoclaved of 1.10 kg/cm ‘pressure for 2 hours) which was previously washed with 5.0 per cent formalin solution. Ten plants were finally maintained in each pot. The inoculation of plants with pure culture of R. *solani* was done by using mycelial suspension having 15-20 bits per microscopic field (100 x).The prepared suspension of inoculums was sprayed with the help of sterilized automizer on the third/fourth leaf and stem from the ground level. The plants without inoculation in three pots were kept as check and sprayed with distilled water alone. The inoculated and non-inoculated pots were kept in glass house and observed critically for appearance of disease symptoms daily. The pathogen was re-isolated from the infected plants on PDA to prove Koch´s postulate.

3.8 Preparation of inoculum

Potato-dextrose broth medium was used for preparation of inoculum in large quantity. The 200 g peeled potatoes were cut in 12 mm cubes. Two hundred gram

of potatoes cubes were rinsed in water and boiled for 20 minutes in 500 ml water. Potato broth was filtered through cheese cloth and filled it in measuring cylinder. Twenty gram dextrose was added in it. The final volume was made upto 1000 ml adding distilled water. The pH was adjusted to 7.0.

Potato-Dextrose broth medium was collected in conical flasks and sterilized at 15 *p.s.i*. for 20 minutes in an autoclave. Three discs of pure culture of R. *solani* grown in Petri dishes were cut by 5 mm cork borer and then transferred to each flasks containing potato dextrose broth after cooling. These flasks were incubated at 26 ± 1 ℃ for three days and were shaken daily by hand to achieve high growth of R. *solani*. For artificial inoculation contents of each flasks were grinded by Pestle and Mortar after five days of incubation and filtered through cheese cloth. Mycelial suspension having 15-20 bits per microscopic field (100 x) were used for artificial inoculation of the plants.

3.10 Management

3.10.1 Varietal Screening

Seeds of mungbean genotypes were obtained from Indian Institute of Pulses Research, Kanpur and Pulse Section department of Genetics and Plant Breeding, Aacharya Narender Dev University of Agriculture and Technology. Kumarganj, Ayodhya. Total one hundred thirteen genotypes (Table-3.1) were evaluated in R.B.D. with three replications during *Kharif* - 2019. Two rows of 4m length spaced 45 cm apart with plant to plant distance of 15 cm. , After every genotypes, one row of K-851 (Highly susceptible variety of mungbean) was planted and the experimental plot was also surrounded by two rows of K-851 to ensure uniform spread of the disease. Observations on disease severity were recorded at 15 days interval, starting with first appearance of symptoms till the maturity of crop using 1-9 rating scale of Mayee and Datar (1986) (Table-1).

Table-2. Varietal screening of mungbean genotypes against *Rhizoctonia solani*

Name of germplasm
AKM 12-24, AKM 104, AKM 8802, BM 4, COGG 912, DGGV 59, IGKM 0-18-3, IGKM 5-6-27, IPM 02-14, IPM 02-3, IPM 410-9, IPM 512-1, IPM 604-1, JAUM 936, JLM 707-5, K 851, KM 2241, KM 2355, LGG-450, LGG 460, LGG 630, MGG 399, MH 1142, MH 1323, MH 1344, MH 2-15, ML 2479, ML 2483, ML 818, NDMK 16-324, NVL 855, OBGG 101, OBGG 102, OBGG 56, OBGG58, Pant M-4, Pant M-6, PKV AKM 4, PM 1511, PM 1522, Pusa 0672, Pusa M 1871, Pusa M 1872, RMB 12-07, RMG 1087, SKAU M-365, SKNM 1504, SKNM 1514, SKNM 1516, SML 1808, SML 1901, SVM 6262, T 44, TMB 126, TRCM 171-B-B-12-6, VGG 16-055, VGG 17-002, VGG 17-009, Pusa 1771, BM 4, NVL 855, AKM 8802, AKM 12-28, AKM 12-24, ML 2479, ML 818, SML 1808, SKNM 1504, SKNM 1502, VGG 16-055, VGG 16-036, LGG 607, LGG 460, LBG 450, Pant M 4, Pant M 6, PM 14-3, PM 14-11, COGG 13-39, COGG 13-19, COGG 912, KM 2355, KM 2241, Type 44, Pusa 1772, Pusa 1771, Pusa 0672, RMG 1087, RMG 1092, RMG 1097, NDMK 16-324, SVM 6133, NMK 15-08, MDGGV 18, JLM 302-46, JAUM 0936, MH 2-15, MH 1142 MH 1323, K-851 and Kopergoan.

After germination, observations were recorded regularly up to 30 days for the first appearances of the disease *i.e* web blight of mungbean . The disease was recorded by using 1-9 scale as described in table 2.

Table-3: Disease rating scale for CLS (Mayee and Datar, 1986)

Sl. No.	Grade	% Foliage affected	Reaction
1.	1	No infection	Free
2.	2	0.1-5	Highly Resistant
3.	3	5-10	Resistant
4.	4	11-15	Moderately Resistant
5.	5	15-20	Moderately Susceptible
6.	6	21-30	Susceptible
7.	7	31-50	Susceptible
8.	8	51-75	Highly Susceptible
9.	9	Above 75	Highly Susceptible

3.10.2 ***In vitro***

3.10.2.1 Efficacy of plant extracts against *R. solani*

In order of find out the efficacy of various plant extracts against R. *solani*, sixteen plants extract viz., leaves of Neem, Garlic, Tulsi, onion, Ginger, Sadabahar, and Clerodendron were used

Table 4. List of plants with Common name, English name, Botanical name, family and their part used.

S.NO.	Common Name	English Name	Botanical Name	Family	Part used
1.	Neem	Neem	*Azadirachta indica*	Meliaceae	Leaves
2.	Lahsun	Garlic	*Allium sativum*	Liliaceae	Bulb
3.	Tulsi	Ocimum	*Ocimum cepa*	Lobiotae	Leaves
4.	Pyaj	Onion	*Allium cepa*	Liliaceae	Bulb
5.	Adarakh	Ginger	*Zingiber officinale*	Zingiberaceae	Rhizome
6.	Sadabahar	Sadabahar	*Vinca rosea*	Apocynaceae	Leaves
7.	Clerodendron	Clerodendron	*Clerodendron increme*	Verbenaceae	Leaves

Fresh leaves, bulb and rhizome were collected and washed thoroughly in clean water. Hundred gram of each washed plant material was grinded in Pestle and Mortar by adding equal amounts (100 ml) of sterilized water (1:I w/v) and boiled at 80 °C for 10 minute in hot water bath. The material was filtered through double layered muslin cloth followed by filtering through sterilized Whatman No.1

filter paper and treated as standard plant extract (100 per cent). The 5.0, 7.5 and 10.0 per cent concentration were made by adding in requisite amount of sterilized PDA medium.

All the plant extracts were tested at 5.0,7.5 and 10.00 per cent concentration under in vitro condition by using poison food technique to study the inhibitory effect of these botanical on mycelial growth of *R. solani*.Five.7.5 and 10.0 ml plant extract of each stock solution were added to the 95.0.92.5 and 90.0 ml of sterilized cooled PDA medium. The flasks were thoroughly shaken to get uniform mix of the extract under aseptic condition before pouring it into the Petri dishes. Twenty ml medium was poured into each Petri dishes. Sixteen treatments having four replication were maintained. Control treatment was maintained by pouring PDA medium without plant extracts. Five mm discs of 3 days old culture of R. *solani* were cut with sterilized cork borer and placed in the centre of plant extracts amended Petri dishes. The Petri dishes having PDA alone were inoculated in the same manner. These Petri dishes were incubated at 26±1°CC.The observation were recorded on radial growth at 24, 36 and 48 hours of incubation in plant extracts amended Petri dishes as well as in control.

Per cent growth inhibition was calculated by using formula (Vincent, 1947).

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

Where,

I = Per cent inhibition of fungal growth

C = Radial growth of control

T = Radial growth in treated Petri dish

3.10.2.2 Efficacy of bio-agents against *R. solani* in vitro.

The efficacy of *Trichoderma viride* and *Trichoderma harziamm* against *Rhizoctonia solani* were assessed by using dual culture technique by measuring the radial growth of *R . solani* as well as that of *Trichoderma* spp.

Twenty ml of sterilized melted PDA was ascpectically poured in sterilized Petri dishes (90 mm diameter) and allowed to solidify. Five mm disc of each antagonist and *R. solani* cut with the help of sterilized cork borer from the age of three days old culture and were placed in Petri dishes having solidified PDA in such a manner that they lie opposite to each other 60 mm apart in four replications. In check Petri dishes were inoculated only with *R .solani* bits. These Petri dishes were kept in BOD incubator at 26±1 °CC.

Observations were recorded on colony growth of bio-agents and *R. solani* at 24, 36 an d 48 hours in dual culture as well as control.

The per cent growth inhibition of *R. solani* was calculated as follows:

$$\text{Percent growth inhibition} = \frac{\text{A1} - \text{A2}}{\text{A1}} \text{ X } 100$$

Whereas,

A_1= Area covered by the *R solani* in control.

A_2 = Area covered by the *R. solani* in dual culture.

3.10.3 Efficacy of plant extracts against *R. solani in vivo*

The concentration of plant extracts found effective *in vitro* studies, were further tested in vivo. Sixty eight pots were filled with sterilized soil @ 4 kg per pots. Fifteen seeds of susceptible mungbean variety (K 851) was sown in each pots and 10 plants were maintained finally. Inoculation of plants with pure culture of *R. solani* was done uniformly by using mycelial suspension having 15-20 bits per microscopic field (100 x) after 25 days of sowing on the third/fourth leaf and stem

from the ground level. After eight hours of inoculation the effective concentration of plant extracts were sprayed to protect the plants. A total of five sprays of plant extracts were done at weekly interval. Check plants were sprayed only with distilled sterilized water alone.

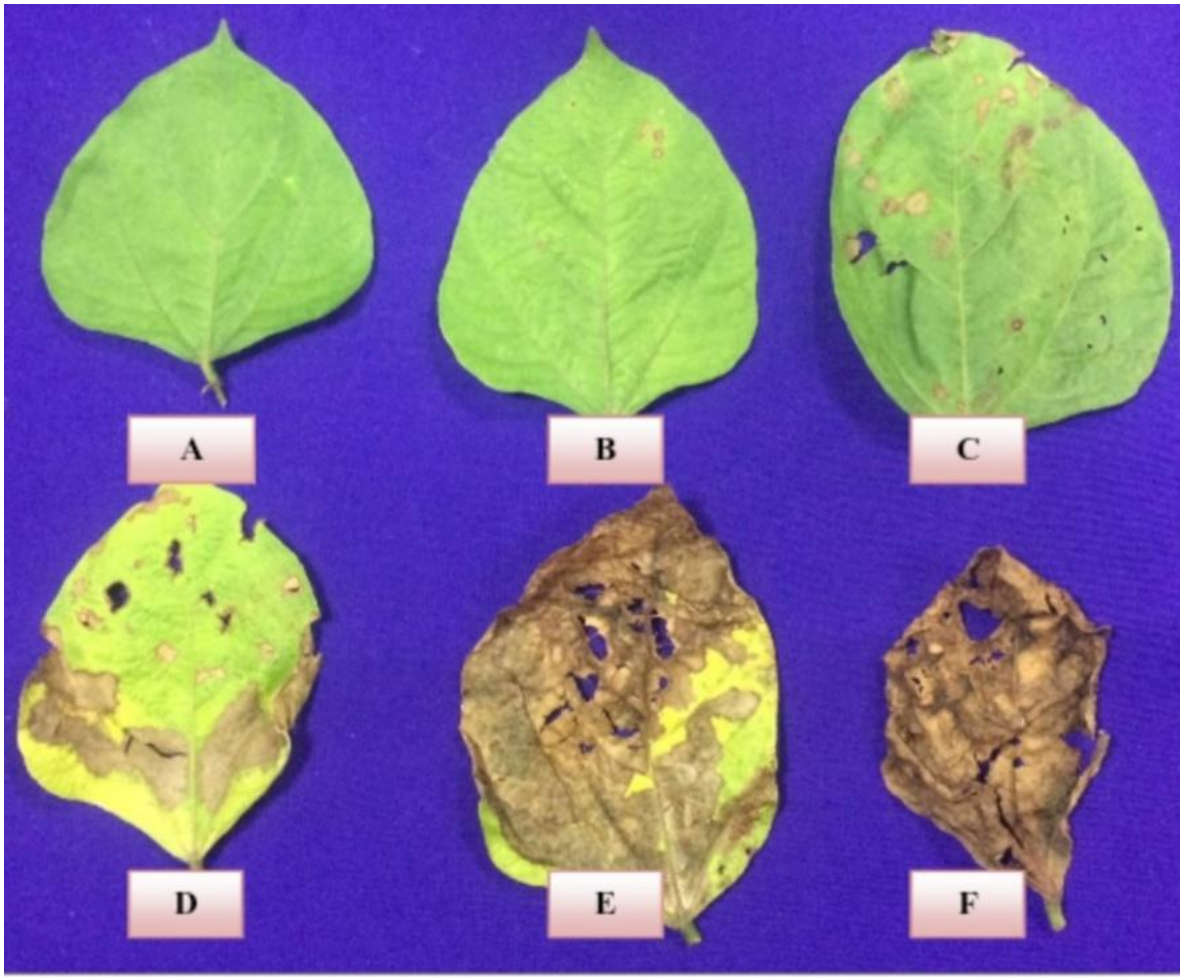
The experiment was conducted in CRD (Completely Randomized Design) with seventeen treatments (plant extracts) including check and four replications kept in glass house.

First appearance of disease was observed. Disease severity was taken in 1- 9 scale given by Stone house, 1994

Disease rating scale for *Rhizoctonia* blight (Stone house, 1994)

Scale	**Description**	**Reaction**
1-2	No lesion on leaves	Highly resistant
3-4	1-25% area covered by lesions	Moderately resistant
5-6	25.1-50% area covered by lesions	Moderately resistant
7-8	50.1-75% area covered by lesions , pods also affected.	Susceptible
9	75.1-100% area covered by lesions, pods and stem also highly affected.	Highly Susceptible

PLATE I : Disease Rating Scale (1-9)



A : 1 (Highly resistant)

B&C : 3 (Moderately resistant)

D : 5 (Moderately susceptible)

E : 7 (Susceptible)

F : 9 (Highly susceptible)

The Per cent Disease Intensity (PDI) was calculated as described below:

Per cent Disease Intensity (PDI)

$$\text{PDI} = \frac{\text{Sum of all numerical rating}}{\text{Total number of leaves examined x Maximum grade}} \text{ X } 100$$

The per cent disease control (PDC) was calculated by using following formula:

$$\text{Percent growth inhibition} = \frac{\text{A1} - \text{A2}}{\text{A1}} \text{ X } 100$$

Where as

C= PDI in control

T= PDI in individual treatment.

3.10.4 Efficacy of bio-agents against *R. solani in vivo.*

Trichoderma viride and *T. harzianum* were also used to see their effect by spraying on web blight of mungbean caused by *R. solani in vivo*.

Fifteen seed of susceptible variety (K 851) were sown in each pot and finally 10 plants were maintained. The experiment was conducted in CRD with 3 treatments (bio-agents including control) in 4 replication. Pots were kept in glass house. Inoculation of plants by R. *solani* was done to ensure the disease appearance.

Bio-agents were sprayed @10' cfu (in 10 ml of water) after 8 hours by sterilized atomizer on the plants except check. Five sprays of bio-agents were done at weekly interval.

First appearance of disease was recorded. Per cent Disease Intensity and PDC were calculated as described earlier.

3.11 Statistical analysis.

The data were statistically analyzed to draw the conclusion. Statistical analysis of laboratory and pot experiments were done by the method of Completely Randomized Design (CRD) prescribed by Goon et al.(1931).The significance of treatments differences was tested by variance ratio test of 5 per cent level of probability.

The observation of per cent inhibition of mycelial growth, disease incidence and disease control were transformed in to "Arc sin Transformation" = $Sin^{-1}\sqrt{\frac{P}{100}}$ used for statistical analysis.

EXPERIMENTAL FINDINGS

Chapter-IV

EXPERIMENTAL FINDINGS

The salient findings of the present investigation are described under the following heads.

4.1 Isolation, identification of pathogens and its pathogenecity

4.2 Evaluation of mungbean genotype against web blight .

4.3 Disease management through use of plant extracts

4.4 Disease management through use of bio-agents

4.1.1 Isolation and identification of the pathogen

lsolation were made from diseased materials collected from infected plants parts. The pathogen was readily isolated on PDA medium by transferring surface sterilized portion of the diseased materials. Subsequently, it was sub cultured on PDA plants. The culture was maintained on PDA slants for further studies.

The pathogen under study was identified as *Rhizoctonia solani* Kuhn on the basis of cultural and morphological characters as described by Parameter and Whitney (1970) on PDA medium (PLATE II)

Colony

Colonies grew fast, usually white to brown grown after 5 days of incubation.

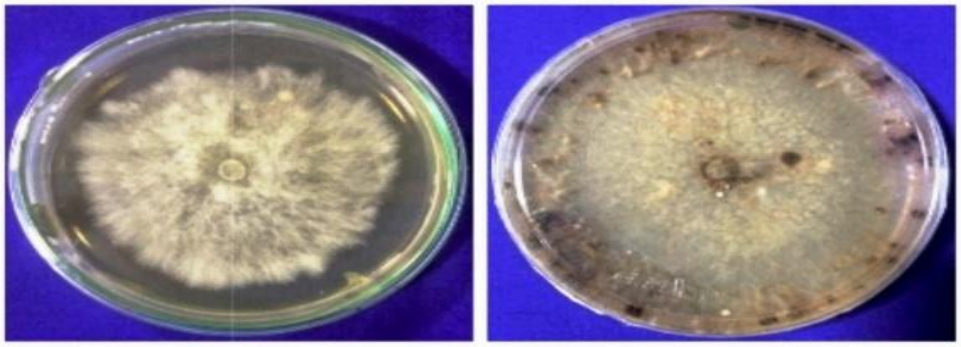
Mycelium

The colour of the mycelium was white, the beginning which later turn tan brown with age and branched near the distal septum of mother hyphal cell or right angles. The branches were constricted at or near the point of septum (PLATE I).

Sclerotia

Sclerotia were dark brown, round to irregular and consisted of brown and barrel shaped monition cells (PLATE II).

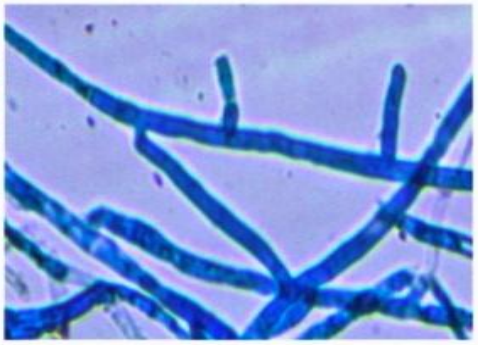
PLATE II : Culture and morphological features of *R . solani*



A

B

C



D

E

Fig. A & B Culture of *R. solani* on PDA (Fresh mycelium and sclerotial stage)
Fig. C & D Mycelium of *R. solani* showing branching pattern
Fig. E Maintenance of culture of *R. solani* on PDA

4.1.2 Symptoms

After inoculation with the fungus (*R. solani*) the sequential development of disease symptoms were observed in pot sown mungbean plants grown in glass house.

The disease symptoms were observed on all above ground parts of the plants i.e. leaves, petioles, stems and pods most destructive on foliage (PLATE III & PLATE IV).

4.1.3 Pathogenicity test

The pathogenicity test revealed that the pathogen produced the similar symptoms of the disease after 3-4 days of inoculation. The plant sprayed with sterilized water, served as check and could not produce any symptoms. The growth of *R. solani* was observed from artificially inoculated disease plant during re-isolation of the pathogen. The cultural and morphological behavior of the pathogen from naturally infected and artificially inoculated mungbean plants were similar. Thus, Koch's postulate was proved (PLATE V).

PLATE III : Symptoms of web blight on mungbean leaves , pods and seeds.

A B C

D E F

G

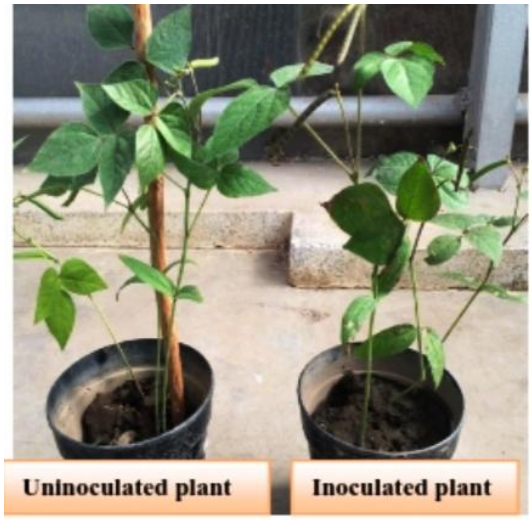
Fig. A Initial symptoms on leaves
Fig. B & C Mycelium appears as web on infected leaves
Fig. D Sclerotia formed on diseased leaves
Fig. E Healthy and infected leaves
Fig. F Healthy and infected pods
Fig. G Healthy and infected seeds

PLATE IV : Field view of mungbean web blight

A. Severely infected plot

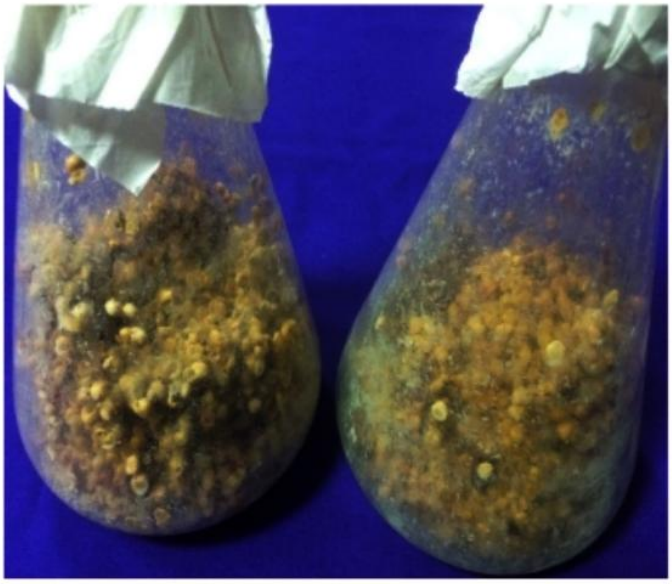
B. Field view of Web blight severity

PLATE V : Pathogenicity and mass mulitiplication of *R . solani* .



A

B



C

Fig. A: Pathogenicity test **Fig. B: Lesions on inoculated plant**

Fig. C: Mass multiplication of *R. solani* on sorghum grains

4.2 Evaluation of mungbean genotype against web blight.

One hundred genotypes were screened for their reaction to web blight **(***Rhizoctonia solani*) in the field it is clear from table (5): that out of total test entries screened. One genotype *viz.*, Pusa 1771 was found resistant, while three genotypes *viz*., Pant M-6, VGG16-055, KMP17-19, were found moderately resistant. While twenty three genotypes *viz*., IGKM 5-6-27, IPM 02-14, LGG 460, LGG 630, OBGG58, PKV AKM4, PM 1522, Pusa M 1872, SML1808, SML1901, TMB 126, TRCM-171-BB-12-6, VGG 17-009, SKNM 1507, LGG 607, COGG 13-19, RMG 1097, SVM 6133, NMK15-08, JLM 312-19, IPM 312-20, MGG 387, Barabanki Local, were found moderately susceptible. While twenty two genotypes *viz*., NVL 825, DUG 5, VBN 4, RMG 1028 AKM 12-24, COGG 912, Kopergaon, MH 2-15, NDMK 16-324, PM 1511, RMB 12-07, SKNM 1504, VGG 16-036, LBG 450, COGG 13-39, Type 44, Pusa 1772, MDGGV 18, JAUM 0936, IPM 14-7 , IPM 312-19, IGKM 2016-1, were found susceptible. While twenty one genotypes *viz*., AKM 8802, BM 4, IGKM 06-18-3, IPM 512-1, IPM 604-1, JAUM 936, KM 2241, KM 2355, LGG 450, ML 2479, ML 2483, ML 818 , OBGG 102 , OBGG 56, Pant M-4, Pusa 0672, RMG 1087, SKNM 1504, SKNM 1514, SVM 6262, PM 14-3, were found susceptible. While twelve genotypes *viz*., KMP 18-2, DGGV 59, IPM 02-3, IPM 410-9, JLM 707-5, MH 1142, MH1323, MH 1344, NVL1142, OBGG 101, Pusa M 1871, SKAV M-365, were found highly susceptible. While two genotypes *viz*., K 851, AKM 12 – 28 were found highly susceptible.

Table 5: Reaction of mungbean genotypes against *Rhizoctonia solani* .

Rating scale	Reaction	No. of germplasm	Name of germplasms
1.	Free from infection	0	Nil
2.	Highly resistant	0	Nil
3.	Resistant	1	Pusa 1771
4.	Moderately resistant	3	Pant M-6, VGG16-055, KMP17-19
5.	Moderately susceptible	23	IGKM 5-6-27, IPM 02-14, LGG 460, LGG 630, OBGG58, PKV AKM4, PM 1522, Pusa M 1872, SML1808, SML1901, TMB 126, TRCM-171-BB-12-6, VGG 17-009, SKNM 1507, LGG 607, COGG 13-19, RMG 1097, SVM 6133, NMK15-08, JLM 312-19, IPM 312-20, MGG 387, Barabanki Local
6.	Susceptible	22	NVL 825, DUG 5, VBN 4, RMG 1028 AKM 12-24, COGG 912, Kopergaon, MH 2-15, NDMK 16-324, PM 1511, RMB 12-07, SKNM 1504, VGG 16-036, LBG 450, COGG 13-39, Type 44, Pusa 1772, MDGGV 18, JAUM 0936, IPM 14-7 , IPM 312-19, IGKM 2016-1
7.	Susceptible	21	AKM 8802 BM 4, IGKM 06-18-3, IPM 512-1, IPM 604-1, JAUM 936, KM 2241, KM 2355, LGG 450, ML 2479, ML 2483, ML 818 , OBGG 102 , OBGG 56, Pant M-4, Pusa 0672, RMG 1087, SKNM 1504, SKNM

			1514, SVM 6262, PM 14-3
8.	Highly susceptible	12	KMP 18-2, DGGV 59, IPM 02-3, IPM 410-9, JLM 707-5, MH 1142, MH1323, MH 1344, NVL1142, OBGG 101, Pusa M 1871, SKAV M-365 .
9.	Highly susceptible	2	K 851, AKM 12 – 28

4.3 Disease management

4.3.1 *In vitro*

Seven plant extracts used in present studies were evaluated *in vitro* against *R. solani* by poison food technique at 5.0, 7.5 and 10.0 per cent concentration after 24, 36 and 48 hours of incubation.

(i) At 24 hours of incubation.

In 5.0 per cent concentration minimum radial growth was obtained in Garlic (18.5 mm) followed by Ginger (19.75 mm), Neem (22.51 mm). Onion (23.25 mm), Tulsi (24.01 mm), Clerodendron (29.51mm) and Sadabahar (32.51mm) as compared to control (46.50 mm) each treatment was superior to control. Garlic and Ginger, Neem, Onion and Tulsi were at par to each other and Sadabahar, clerodendron were significantly different from each other (Table 6).

The radial growth ranged from 16.25 mm to 46.50 mm in 7.5 per cent concentration. Similar pattern were found as 5.0 per cent concentration and treatments Sadabahar, Clerodendron and Tulsi were statistically differed to each other while Neem and Onion, Garlic and Ginger were at par to each other (Table 6).

In 10.0 per cent concentration minimum radial growth was obtained in Garlic (9.26mm) followed by Ginger (11.00 mm), Neem (13.51 mm), Onion (15.00 mm), Tulsi (17.01 mm), Clerodendron (23.01mm), Sadabahar (28.25 mm)

as compared to control (45.26 mm). Neem and Onion were at par to each other while Garlic, Tulsi, Ginger, Sadabahar and Clerodendron were significantly different from each other at 10.0 per cent (Table 6 , Fig 1).

Table 6: Effect of different Concentration of plant extracts against *R. solani* on mycelia growth *in vitro* at 24 hrs.

Plant extract	Mycelia growth (mm)		
	Concentration (%)		
	5.00	**7.50**	**10.00**
Neem	22.51	18.51	13.51
Garlic	18.50	15.51	9.26
Tulsi	24.01	22.01	17.01
Onion	23.25	20.01	15.01
Ginger	19.75	16.34	11.00
Sadabahar	32.51	29.01	27.01
Clerodendron	29.51	25.51	23.01
Control	45.26	45.26	45.26
CD at 5%	1.83	1.783	1.728

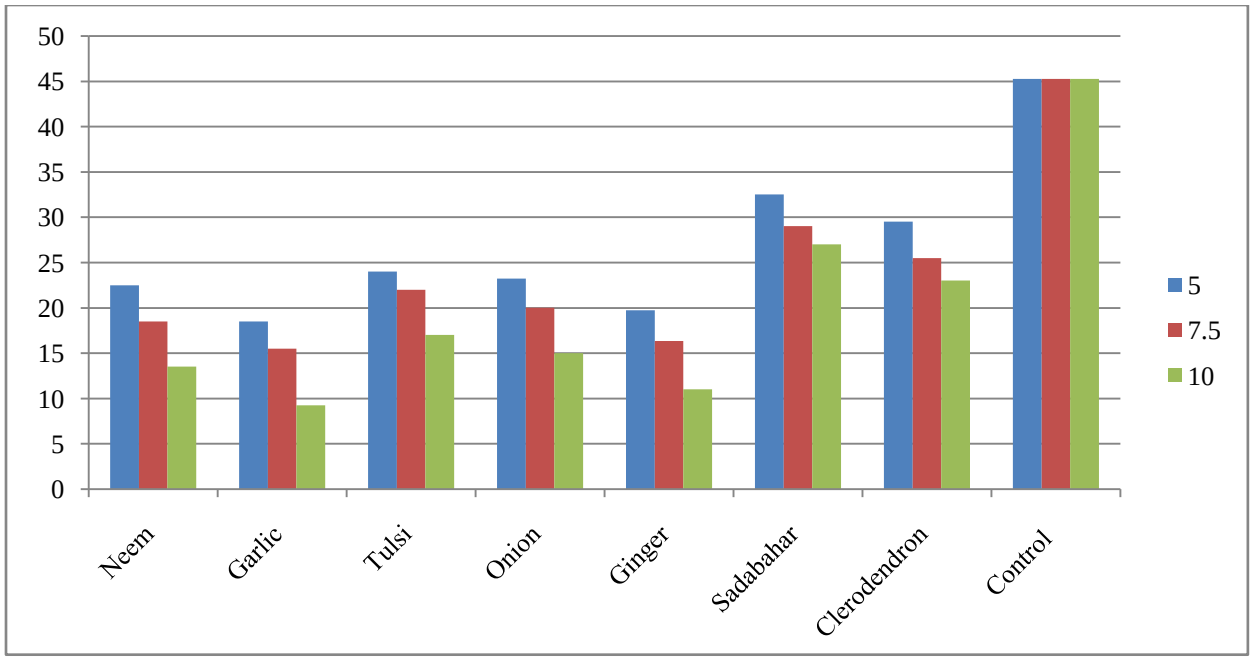


Fig 1 : Effect of different Concentration of plant extracts against *R. solani* on mycelia growth *in vitro* at 24 hrs.

The minimum radial growth was obtained in 5.0, 7.5 and 10.0 per cent concentration in Garlic followed by Ginger, Neem, Onion, Tulsi, Clerodendron and Sadabahar at 24 hours of incubation.

(ii) At 36 hours of incubation.

In 5.0 per cent concentration minimum radial growth was obtained in Garlic (26.51 mm) followed by Ginger (28.00 mm), Neem (29.51 mm). Onion (31.01 mm), Tulsi (33.05 mm), Clerodendron (37.00 mm), Sadabhar (41.01mm), as compared to control (45.26 mm), however Garlic and Ginger , Ginger and Neem, Neem and onion were at to each other while Tulsi, Clerodendron and Sadabahar were significantly different to each other (Table 7).

The similar results were obtained in 7.5 per cent concentration as 5.0 per cent concentration and radial growth ranged from 20.50 mm to 72.00 mm. However Garlic, Ginger, Neem, Clerodendron and Sadabahar were statistically differed to each other, while Tulsi and Onion were at par to each other (Table 7).

Among 10.0 per cent concentration lowest radial growth was obtained in Garlic (14.01 mm) followed by Ginger (16.00 mm), Neem (18.51 mm), Onion (20.00 mm), Tulsi (23.25 mm), Clerodendron (28.25 mm) and Sadabahar (33.25 mm), as

compared to control (71.26mm) However Garlic, Ginger, Tulsi, Clerodendron and Sadabahar were significantly different to each other , while Neem and Onion were at par to each other (Table 7 , Fig 2).

Table 7: Effect of different Concentration of plant extracts against *R. solani* on mycelia growth *in vitro* at 36 hrs.

Plant extract	Mycelia growth (mm)		
	Concentration (%)		
	5.00	**7.50**	**10.00**
Neem	29.51	25.02	18.51
Garlic	26.51	20.58	14.01
Tulsi	33.05	29.88	22.00
Onion	31.01	28.13	20.00
Ginger	28.00	22.88	16.00
Sadabahar	41.01	39.63	32.00
Clerodendron	37.00	34.88	27.0
Control	45.26	71.76	71.26
CD at 5%	1.723	1.752	1.732

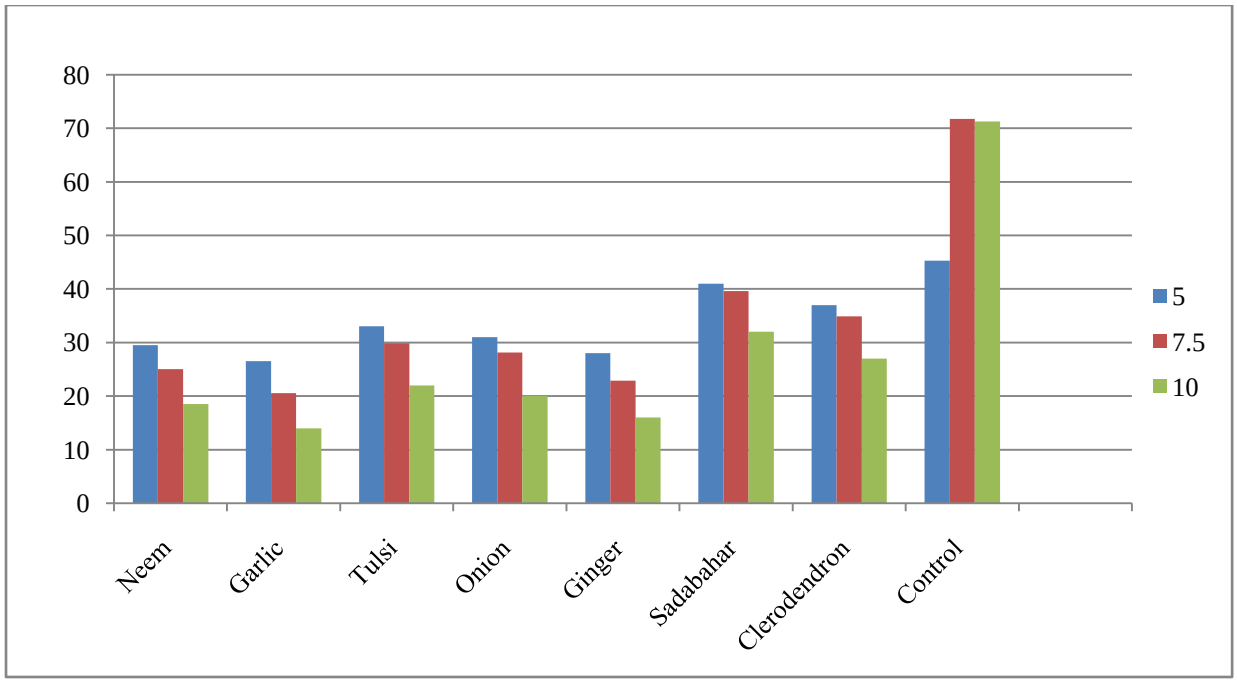


Fig 2: Effect of different Concentration of plant extracts against *R. solani* on mycelia growth *in vitro* at 36 hrs.

The minimum radial growth was obtained in 5.0, 7.5, 10.0 per cent concentration in garlic followed by Ginger, Neem, Onion, Tulsi, Clerodendron and Sadabahar, at 36 hours of incubation.

(iii) At 48 hours of incubation.

In 5.0 per cent concentration the minimum radial growth was obtained in Garlic (29.50 mm) followed by Ginger (32.0 mm), Neem (34.00 mm), Onion (36.10 mm), Tulsi (38.00 mm), Clerodendron (42.50mm) and Sadabahar (50.25 mm). which were significantly different from each other (Table 8).

The similar pattern was obtained in 7.5 per cent concentration and radial growth ranged from 25.00 mm to 89.00 mm. Every treatment statistically differed to each other (Table 8).

Among 10.0 per cent concentration minimum radial growth was observed in Garlic (15.5 mm), followed by Ginger (17.8 mm), Neem (20.1 mm), Onion (22.2 mm), Tulsi (24.6 mm), Clerodendron (29.3 mm) and Sadabahar (33.6 mm), as compared to control (90.00 mm) which were significantly superior to each other (Table 8, Fig 3).

Table 8: Effect of different Concentration of plant extracts against *R. solani* on mycelia growth *in vitro* at 48 hrs.

Plant extract	Mycelia growth (mm)		
	Concentration (%)		
	5.00	**7.50**	**10.00**
Neem	34.0	31.5	20.1
Garlic	29.5	25.13	15.5
Tulsi	38.00	36.3	24.6
Onion	36.1	34.1	22.2
Ginger	32.0	27.6	17.8
Sadabahar	49.0	47.1	33.6
Clerodendron	42.5	40.8	29.3
Control	88.76	88.76	88.76
CD at 5%	1.730	1.731	1.735

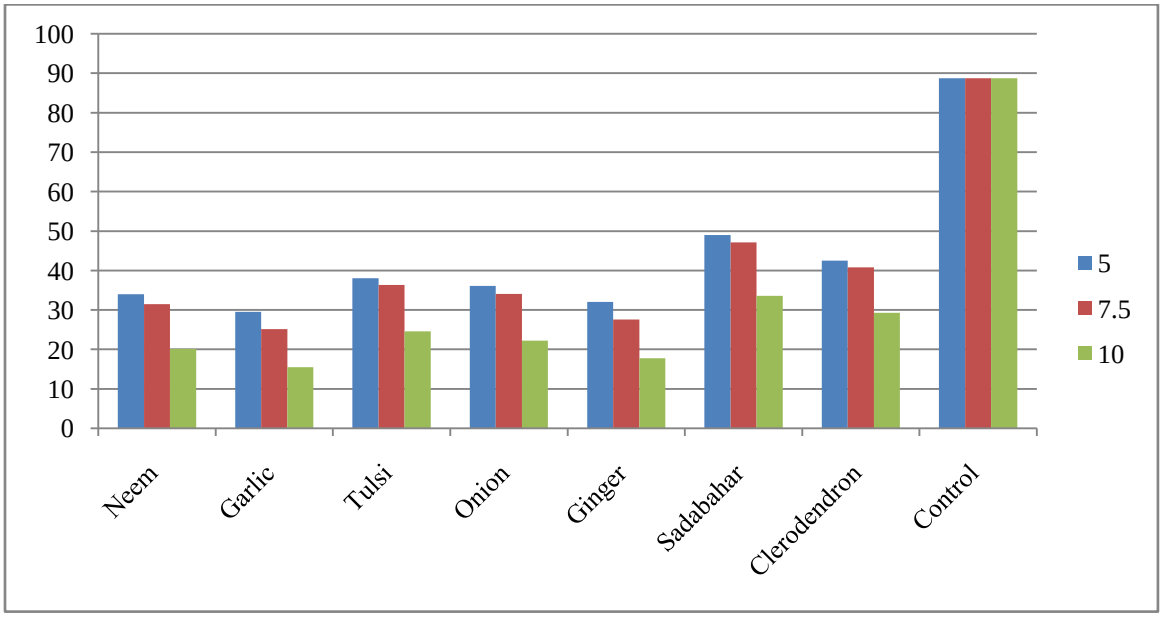


Fig 3: Effect of different Concentration of plant extracts against *R. solani* on mycelia growth *in vitro* at 48 hrs.

Minimum radial growth was obtained in 5.0, 7.5 and 10.0 per cent concentration in Garlic followed by Ginger, Neem, Onion, Tulsi, Clerodendron and Sadabahar at 48 hours of incubation.

The results clearly indicated that plants extracts reduced the radial growth of *R. solani* at 5.0, 7.5 and 10.0 per cent concentration after 24, 36 and 48 hours of incubation and effectiveness of extracts increased with the increase of their concentration.

4.3.1.2 Efficacy of plant extract against *R. solani* on per cent inhibition

(i) At 24 hours of incubation.

In 5.0 per cent concentration the maximum per cent inhibition was recorded in Garlic (59.08%) followed by Ginger (56.92%) , Neem (50.27%), Onion (48.66%), Tulsi(46.91%), Clerodendron (34.00%), Sadabahar (28.12%). The per cent inhibition in Garlic and Ginger, Tulsi and Onion Neem, were at par to each other , while Clerodendron, Sadabahar differed significantly to each other (Table 9).

The similar pattern were obtained in 7.5 per cent concentration and per cent inhibition ranged from 66.0% to 36.00% Garlic and Ginger, Onion and Neem, were at par to each other , while Tulsi , Clerodendron, Sadabahar differed significantly to each other (Table 9, Fig 4).

Among 10.0 per cent concentration the maximum per cent inhibition was recorded in Garlic (79.52%) followed by Ginger (75.66%), Neem (70.18%), Onion (66.84%), Tulsi (62.42%),Clerodendron (49.16%), Sadabahar (40.30%), however Onion and Neem were at par to each other while Per cent inhibition in all the other treatments differed significantly to each other (Table 9, Fig 4).

The maximum per cent inhibition was obtained in 5.0, 7.5 and 10.0 per cent concentration in Garlic followed by Ginger, Neem, Onion, Tulsi, Clerodendron, Sadabahar, after 24 hours in incubation.

Table 9: Effect of different Concentration of plant extracts against *R. solani* on per cent inhibition in *vitro* at 24 hrs.

Plant extract	Percent inhibition		
	Concentration (%)		
	5.00	**7.50**	**10.00**
Neem	50.27 (45.153)	59.11 (50.250)	70.18 (56.904)
Garlic	59.08 (50.233)	65.71 (54.164)	79.52 (63.116)
Tulsi	46.91 (43.226)	51.27 (45.727)	62.42 (52.197)
Onion	48.66 (44.232)	55.75 (48.307)	66.84 (54.851)
Ginger	56.92 (48.983)	63.86 (53.058)	75.66 (60.458)
Sadabahar	28.18 (32.060)	35.91 (36.813)	40.30 (39.404)
Clerodendron	34.80 (36.152)	43.59 (41.315)	49.16 (44.512)
Control	0.00 (1.281)	0.00 (1.281)	0.00 (1.281)
CD at 5%	1.996	2.452	2.627

Figure given in parenthesis are transformed value.

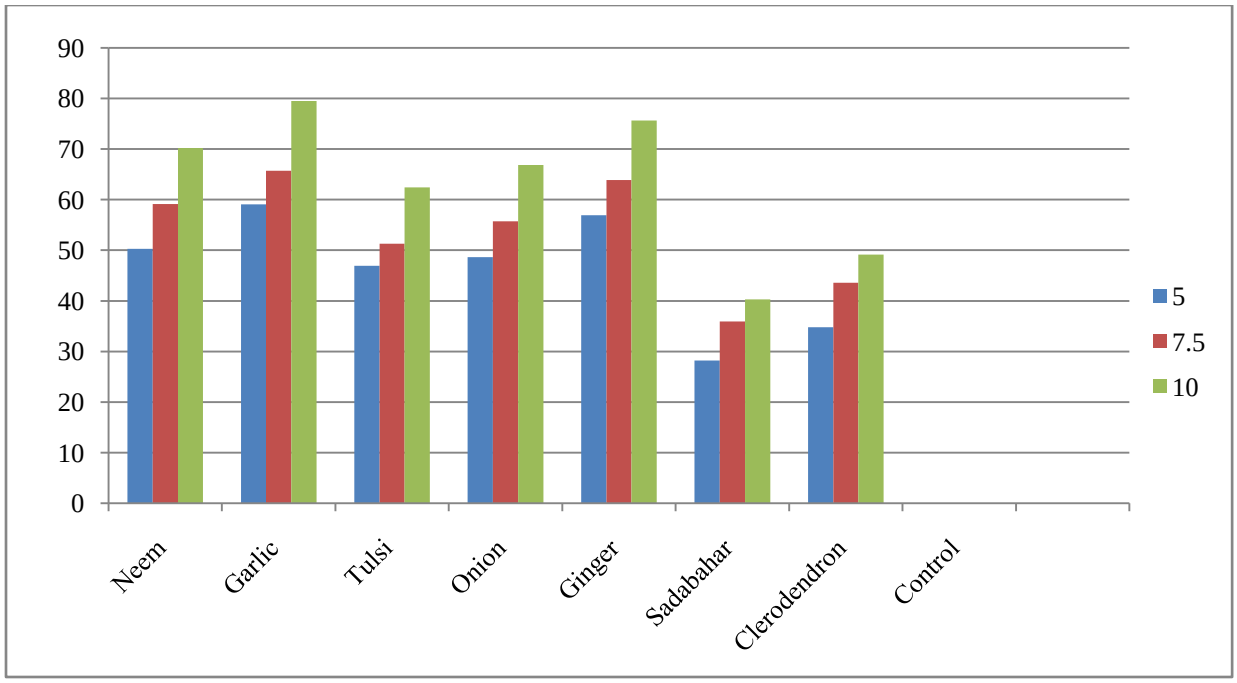


Fig 4: Effect of different Concentration of plant extracts against *R. solani* on per cent inhibition in *vitro* at 24 hrs.

(i) At 36 hours of incubation.

In 5.0 per cent concentration the maximum per cent inhibition in mycelium growth of R. solani was recorded in Garlic (41.44%), followed by Ginger (38.11%), Neem (34.81%), Onion (31.44%), Tulsi (27.00%), Clerodendron (18.23%) and Sadabahar (11.60)% The per cent inhibition in all the treatments differed significantly to cach other (Table 10, Fig 5).

Similar pattern were obtained in 7.5 per cent concentration and per cent inhibition ranged from 72.00% to 44.00 %. Hoewever Tulsi and Onion were at par to each other, all other treatments significantly differed to each other (Table 10).

Among 10.0 per cent concentration maximum per cent inhibition was recorded in Garlic (80.32%) and followed by Ginger (77.53%), Neem (74.03%), Onion (71.92%), Tulsi (69.12%), Clerodendron (62.09%) and Sadabahar (55.08%). However Per cent Inhibition in Onion and Neem were at par to each other , while rest of the treatments differed significantly to each other (Table 10).

The maximum per cent inhibition was obtained in 5.0, 7.5 and 10.0 per cent concentration in Garlic followed by Ginger, Neem, Onion, Tulsi, Clerodendron and Sadabahar after 36 hours of incubation.

Table 10: Effect of different Concentration of plant extracts against *R. solani* on per cent inhibition *in vitro* at 36 hrs.

Plant extract	Percent inhibition		
	Concentration (%)		
	5.00	**7.50**	**10.00**
Neem	34.81 (36.156)	65.14 (53.814)	74.03 (59.364)
Garlic	41.44 (40.073)	71.35 (57.645)	80.32 (63.683)
Tulsi	27.00 (31.310)	58.38 (49.827)	69.12 (56.24)
Onion	31.44 (34.088)	56.79 (48.907)	71.92 (58.009)
Ginger	38.11 (38.120)	68.11 (55.618)	77.53 (61.716)
Sadabahar	11.60 (19.909)	44.75 (41.986)	55.08 (47.919)
Clerodendron	18.23 (25.251)	51.41 (45.808)	62.09 (52.000)
Control	0.00 (1.281)	0.00 (1.281)	0.00 (1.281)
CD at 5%	1.746	1.498	1.724

Figure given in parenthesis are transformed value.

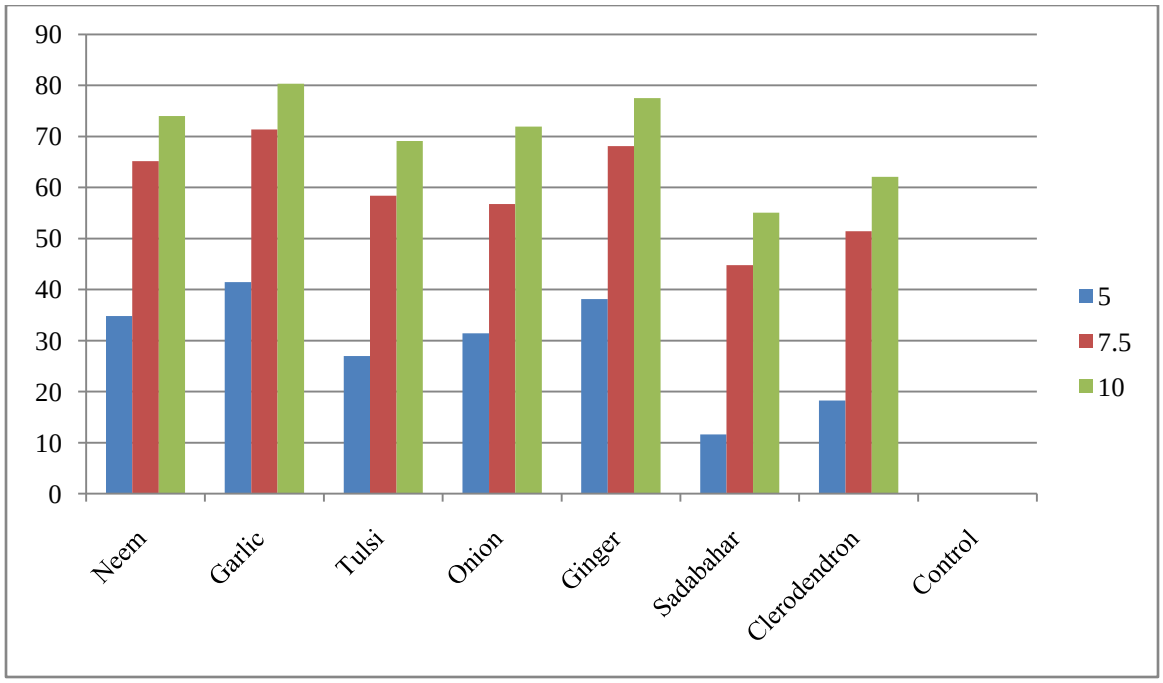


Fig 5: Effect of different Concentration of plant extracts against *R. solani* on per cent inhibition *in vitro* at 36 hrs.

(ii) At 48 hours of incubation.

In 5.0 per cent concentration the maximum per cent inhibition in mycelium growth of *R. solani* was recorded in Garlic (66.77%), followed by Ginger (63.94%), Neem (61.69%), Onion (59.10%), Tulsi (57.19%), Clerodendron (52.11%) and Sadabahar (44.79%) The per cent inhibition in all the treatments differed significantly to each other (Table 11 , Fig 6).

Similar pattern were obtained in 7.5 per cent concentration and per cent inhibition ranged from 72.00% to 47.00 %. However all treatments significantly differed to each other (Table 11).

Among 10.0 per cent concentration maximum per cent inhibition was recorded in Garlic (82.53%) and followed by Ginger (79.94%), Neem (77.36%), Onion (74.98%), Tulsi (72.26%), Clerodendron (67.01%) and Sadabahar (62.15%). However Per cent Inhibition in all treatments differed significantly to each other (Table 11).

The maximum per cent inhibition was obtained in 5.0, 7.5 and 10.0 per cent concentration in Garlic followed by Ginger, Neem, Onion, Tulsi, Clerodendron and Sadabahar after 48 hours of incubation.

Table 11: Effect of different Concentration of plant extracts against *R. solani* on per cent inhibition *in vitro* at 48 hrs.

Plant extract	Percent inhibition		
	Concentration (%)		
	5.00	**7.50**	**10.00**
Neem	61.69 (51.726)	64.50 (53.433)	77.36 (53.433)
Garlic	66.77 (54.799)	71.72 (57.433)	82.53 (57.878)
Tulsi	57.19 (49.132)	59.10 (50.246)	72.26 (50.246)
Onion	59.33 (50.376)	61.57 (51.694)	74.98 (51.694)
Ginger	63.94 (53.095)	68.90 (56.106)	79.94 (56.106)
Sadabahar	44.79 (42.007)	46.94 (43.246)	62.15 (43.246)
Clerodendron	52.11 (46.208)	54.03 (47.314)	67.01 (47.314)
Control	0.00 (1.281)	0.00 (1.281)	0.00 (1.281)
CD at 5%	1.174	1.093	1.093

Figure given in parenthesis are transformed value.

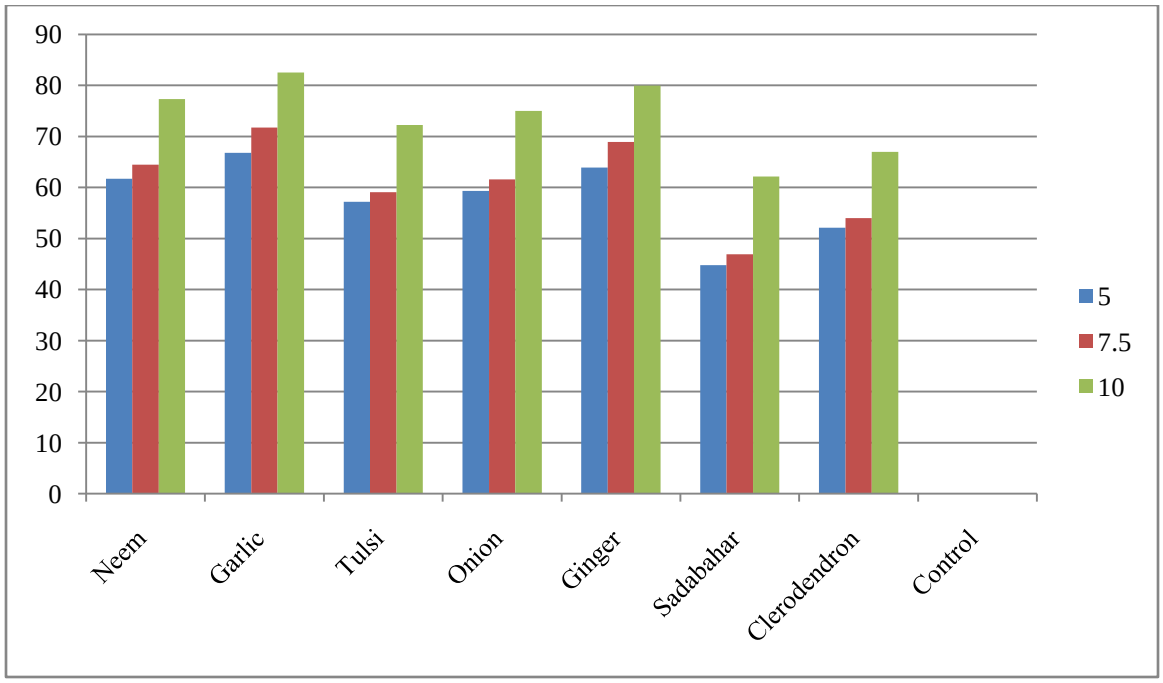


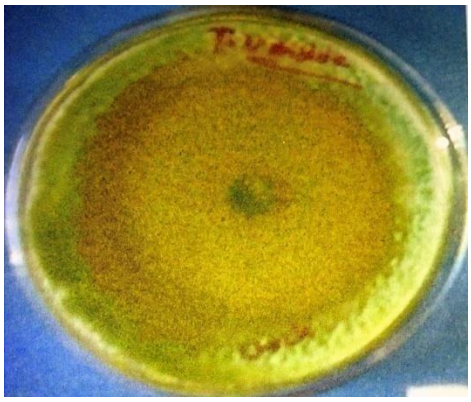
Fig 6: Effect of different Concentration of plant extracts against *R. solani* on per cent inhibition *in vitro* at 48 hrs.

4.3.1.3 Efficacy of bio-agents against *R. solani on* radial growth

The efficacy of bio-agents *Trichoderma harzianum* and *T. viride* are tested for mycelial growth and per cent inhibition of *R. solani* by using dual culture technique. (PLATE VI).

Results clearly indicated that radial growth was minimum in *T. viride* (18.8 mm) followed by *T. harzianum* (23.3 mm) as compared to control (46.00 mm).The radial growth significantly differed with each other in all the treatments at 24 hours of incubation (Table 12, Fig 7)

PLATE VI : Efficacy of bio-agents against *R. solani on* radial growth.



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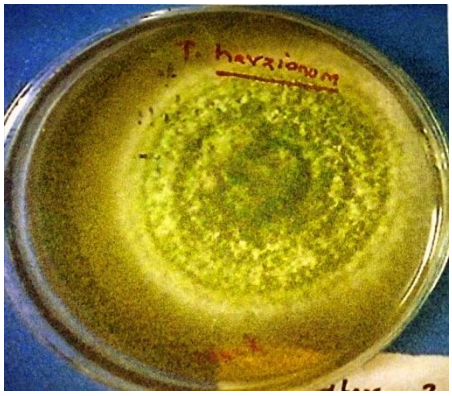

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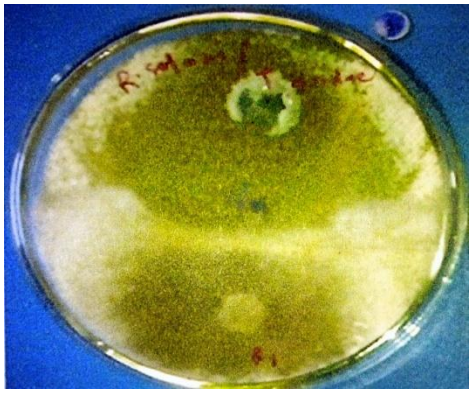

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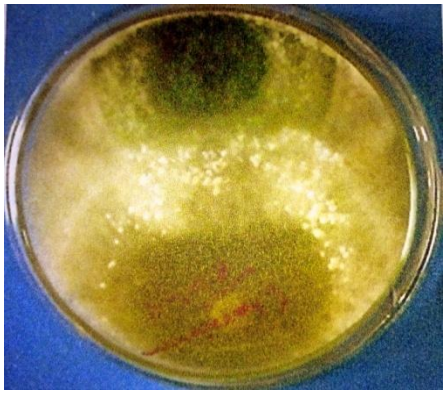

D.

Fig A. Pure culture of *T. viride.*

Fig B. Pure culture of *T. harzianum.*

Fig C. Dual culture of *T. viride* and *R.solani*

Fig C. Dual culture of *T. harzianum* and *R.solani*

Table 12: Effect of bio-agents against *R. solani* on mycelia growth *in vitro* using dual culture technique.

Fungal antagonist	Mycelial growth (mm)		
	24 hours	36 hours	48 hours
T. viride	18.80	23.30	25.40
T. harzianum	23.30	31.60	39.60
Control	46.00	73.90	90.00
CD at 5%	3.72	5.95	6.90

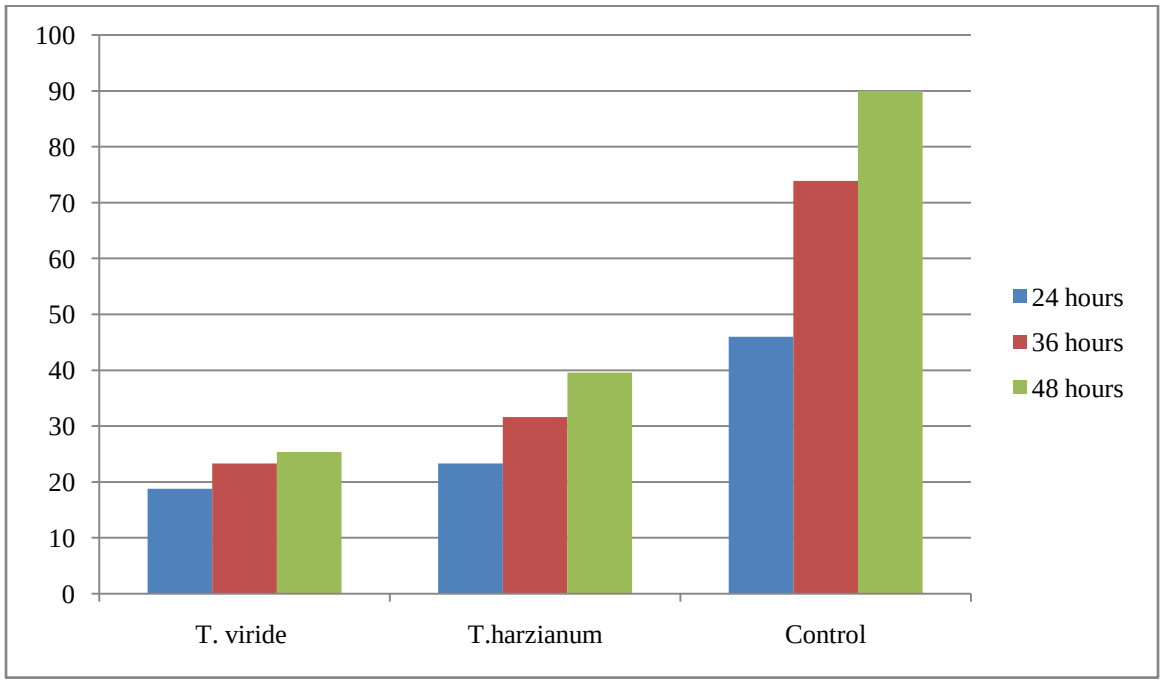

Fig 7: Effect of bio-agents against *R. solani* on mycelia growth *in vitro* using dual culture technique

The similar results were also obtained at 36 hours of incubation, however, the radial growth were 23.30 mm, 31.60 mm and 73.90 mm in *T. viride*, *T. harzianum* and control, respectively (Table 12, Fig 7).

At 48 hours of incubation the radial growth ere 25.40 mm, 39.60 mm and 90.00 mm in *T viride*, *T. harziamum* and control, respectively (Table 12, Fig 7).

Minimum radial growth was obtained in *T. viride* than *T. harziamum* after 24, 36 and 48 hours of incubation and all treatments are statistically differed to each other.

4.3.1.4 Effect of bio-agents against *R. solani* on per cent inhibition.

T. viride and *T. harzianum* significantly inhibition the growth of *R.solani* as compared to control at 24, 36 and 48 hours of incubation. *T. viride* showed higher per cent inhibition (59.13, 68.47 and 71.78 per cent) in mycelial growth as compared to *T. harziamam* (49.35, 57.75 and 56.66 per cent) at 24, 36 and 48 hours of incubation, respectively which significantly differed with each other (Table 13 and Fig 8)

Table 13 : Effect of bio-agents against *R. solani* on percent inhibition *in vitro* using dual culture technique.

Fungal antagonist	**Percent inhibition**		
	24 hours	**36 hours**	**48 hours**
T. viride	59.13 (50.26)	68.47 (55.85)	71.78 (57.93)
T.harzianum	49.35 (44.63)	57.24 (49.16)	56.00 (48.45)
Control	0.00	0.00	0.00
CD at 5%	2.04	2.47	2.63

Figure given in parenthesis are transformed value

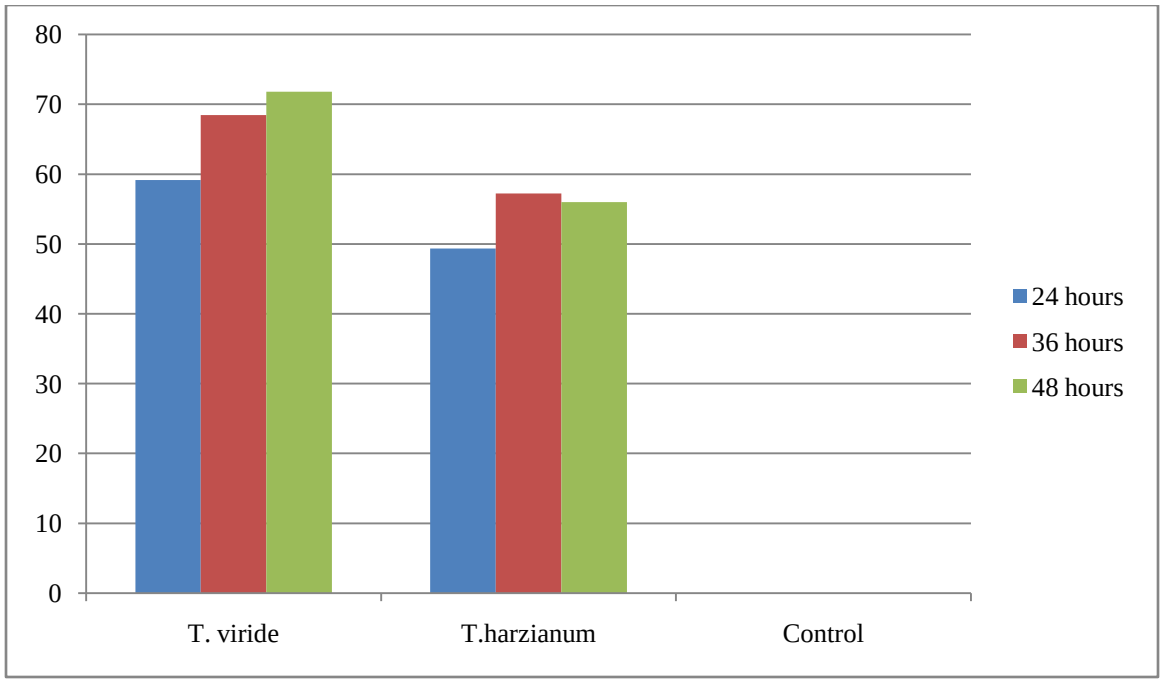

Fig 8 : Effect of bio-agents against *R. solani* on percent inhibition *in vitro* using dual culture technique.

Thus it is very clear that *T. viride* was better in inhibiting radial growth of *R. solani* as compared to *T. harzianum in vitro.*

4.3.2 *In vivo*

4.3,2.1 Efficacy of plant extract against *R. solani* on disease incidence

Ten per cent concentration of plant extracts was found most effective *in vitro* and was further tested *in vivo* to find out the effectiveness of the seven plant extracts at pre-maturity stages of crops *i.e.* 50 days after sowing.

Table 14: Effect of plant extract on disease incidence against web blight *in vivo* at 50 days.

Plant extract	Concentration (%)	Disease incidence
Neem	10	25.40
Garlic	10	20.27
Tulsi	10	31.30
Onion	10	28.20
Ginger	10	22.70
Sadabhar	10	42.60
Clerodendron	10	37.10
Control	10	82.60
CD at 5%		4.34

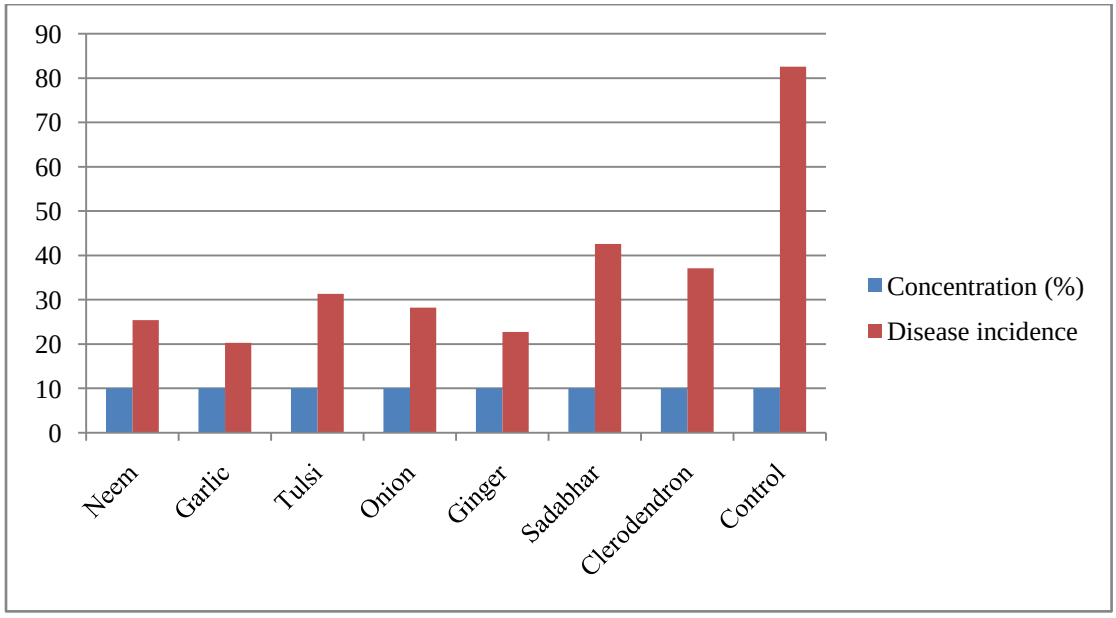

Fig 9: Effect of plant extract on disease incidence against web blight *in vivo* at 50 days.

The results clearly indicated that the minimum disease incidence was found Garlic (20.27%) followed by Ginger (22.27%), Neem (25.4%), Onion (28.20%),

Tulsi(31.3%), Clerodendron (37.10%) and Sadabahar (42.60%), as compared to control (82.6%). Each treatment significantly superior to control where Garlic and Ginger , Ginger and Neem , Neem and Onion, Onion and Tulsi were at par to each other . Tulsi, Clerodendron and Sadabhar were statiscally differed to each other (Table 14 & Fig 9)

4.3.2.2 Efficacy of plant extracts against *R. solani* on per cent disease control.

The maximum disease control was found in Garlic(75.34%) followed by Ginger (72.52%), Neem (69.25%), Onion (65.86%), Tulsi (62.11%), Clerodendron (55.05%) and Sadabahar (48.43%). Each treatment were significantly superior to control, Sadabhar and Clerodendron were statistically differed to each other. Tulsi and Onion , Onion and Neem , Neem and Ginger , Ginger and Garlic were at par to each other (Table 15, Fig 10) .

Table 15: Effect of plant extract on per cent disease control against web blight in vivo at 50 days

Plant extract	Concentration (%)	Percent disease control
Neem	10	69.25
Garlic	10	75.34
Tulsi	10	62.11
Onion	10	65.86
Ginger	10	72.52
Sadabhar	10	48.43
Clerodendron	10	55.08
Control	10	0.00
CD at 5%		3.87

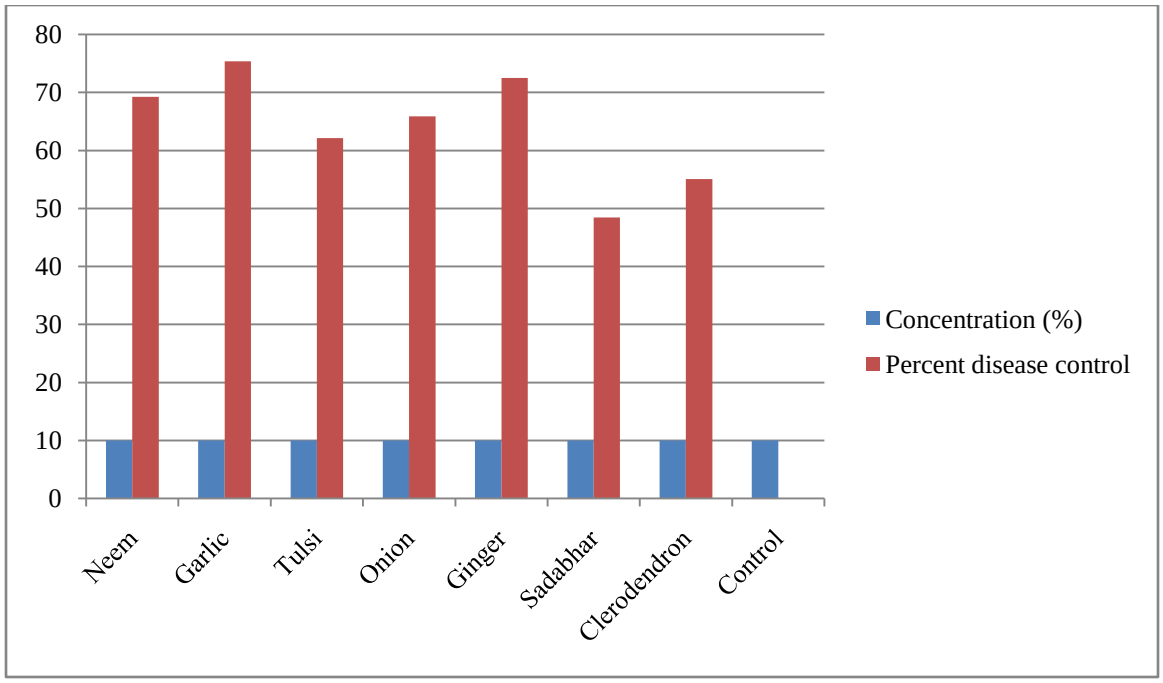

Fig 10 : Effect of plant extract on per cent disease control against web blight in vivo at 50 days.

Thus, Garlic was most effective and Sadabhar was least effective reducing disease incidence.

4.3.2.3 Efficacy of bio-agents against R. *solani* on disease incidence

Disease incidence were found 62.90 per cent and 63.18 per cent in *T. viride* and *T. harzianum* , respectively as compared to control 82.56 per cent. The disease incidence in *T. viride and T. harziamumn* were at par but differed with control (Table 16, Fig 11).

Table 16: Effect of bio-agents on disease incidence against web blight *in vivo* at 50 days.

Treatment	Disease incidence %
T. viride	62.90
T. harzianum	63.18
Control	82.50
CD at 5%	15.29

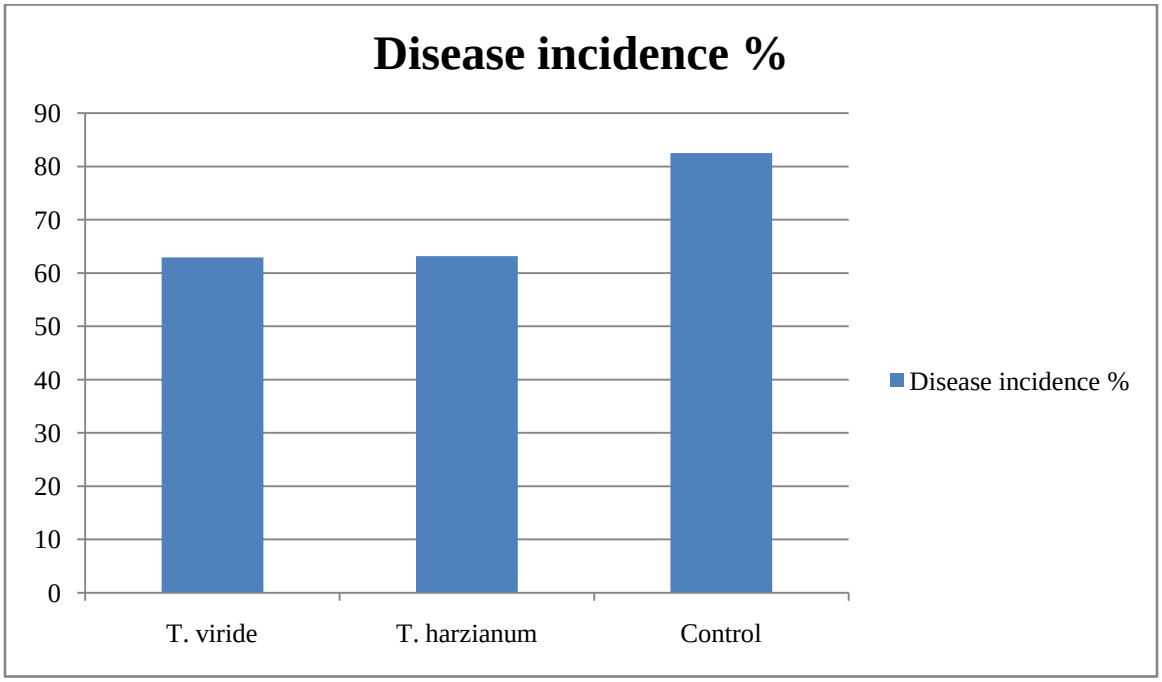

Fig 11: Effect of bio-agents on disease incidence against web blight *in vivo* at 50 days.

4.3.2.4 Efficacy of bio-agents against *R. solani* on per cent disease control.

Per cent disease control were found 24.40 per cent and 23.56 per cent in *T. viride* and *T. harzianum*, respectively. *Trichoderma viride* and *T. harzianum* were at par with each other (Table 17, Fig 12).

Thus, results clearly indicated that *T. viride* and *T. harzianum* suppressed the growth of *R. solani in vitro* but did not show any effect *in vivo.*

Table 17: Effect of bio-agents on percent disease control against web blight *in vivo* at 50 days.

Treatment	Percent disease control
T . viride	24.40 (29.03)
T. harzianum	23.56 (29.03)
Control	0.00 (0.00)
CD at 5%	3.67

Figure given in parenthesis are transformed value.

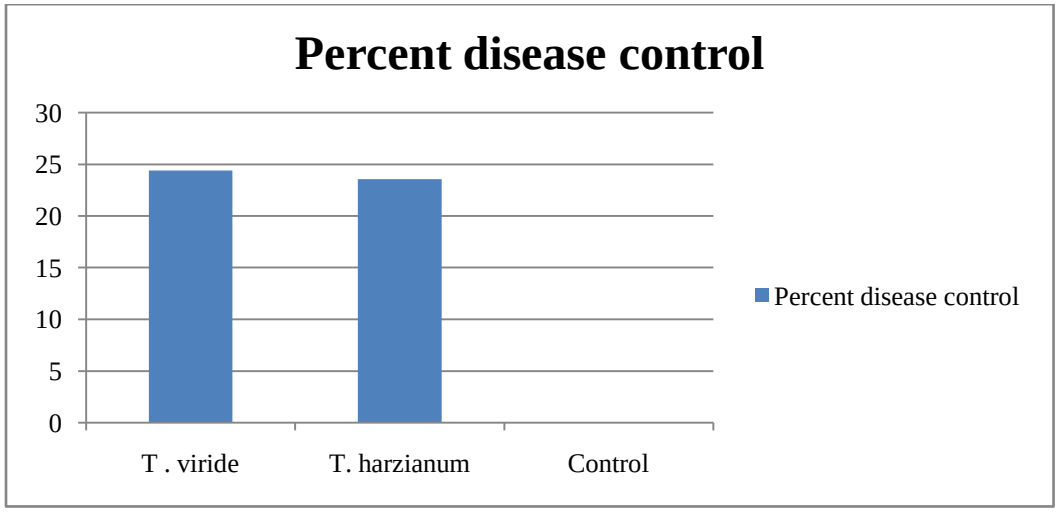

Fig 12: Effect of bio-agents on percent disease control against web blight *in vivo* at 50 days.

DISCUSSION

Chapter-V

DISCUSSION

Mungbean [*Vigna radiata* (L.) Wilczek] also known as green gram is an important pulse crop of India and grown in *kharif*, spring and summer season. The major limiting factors of its poor yield are due to attack of several diseases. Among them web blight caused by *Rhizoctonia solani* (Kuhn) is one of the most important fungal diseases which appear every year in varying intensity and causes heavy reduction in yield. It causes yield losses and 1000 seed weight in susceptible variety (K 851) 37-40 and 28.60 per cent, respectively (Gupta and Singh. 2002). The losses in grain yield is more when the plants get infected earlier i.e. after 25 days after sowing (DAS) than 35 and 40 DAS (Gupta *et al.*, 2003). Recently Gupta et al. (2010) reported losses in yield and test weight were. 33.40 to 37.80 per cent 23.12 to 28.60 per cent, respectively in different varieties of mungbean i.e. K 851, T44 and Pusa Baisakhi. Though, the web blight can be managed by the use of fungicide but due to the emergence of several problems like environmental pollution, residual effect in grains, killing of non-targent organism(s) its use should be discouraged. Hence, for minimizing the losses caused by web blight need inexpensive and environmentally safe management practices. Several botanicals and bio-agents have been found effective for management of web blight of mungbean caused *R. solani*. Therefore, keeping in view the importance of crop and seriousness of the diseases, it was thought worthwhile to investigate the disease with objectives as outlined in the introductory chapter and the results obtained are discussed in the light of available literature as follows:

5.1 Isolation and identification of the pathogen.

Pathogen was isolated on PDA medium and identified on the basis of their cultural and morphological character of *R. solani* (Kuhn). The colony of the fungus grew fast, usually white to brown, measuring 90 mm growth in petridishes after 2 days of incubation. The color of mycelium was white in beginning which later turned tan brown with age and branched near the distal septum of mother hyphal cell at acute angles. Sclerotia were dark, round to irregular and consisted of brown and barrel shaped moniliod cells. The similar cultural and morphological characters of the test fungus has also been described by Alexopoulas (1996) and Dubey (2005).

5.2 Pathogenecity test.

The pathogenecity test revealed that different plants parts namely, leaves, stems, petioles and pods were readily infected by the pathogen and showed disease symptoms after 5-6 days after inoculation. The pathogen was reisolated from the affected portion and found similar morphological characters of the pathogen and thus confirmed its pathogenecity.

5.3 Host resistance

Use of resistant genotypes is the best method of avoiding the occurrence of the disease. Keeping this point in view, out of One hundred genotypes were screened for their reaction to web blight **(***Rhizoctonia solani*) in the field (photo) in field condition. It is clear from table (5) that out of total test entries screened. One genotype *viz.*, Pusa 1771 was found resistant, while three genotypes *viz*., Pant M-6, VGG16-055, KMP17-19, were recorded moderately resistant. While twenty three genotypes were noticed moderately susceptible. twenty two genotypes were found susceptible and twenty one genotypes were documented susceptible. As well as

twelve were found highly susceptible. While two genotypes *viz*., K 851, AKM 12 – 28 were notced highly susceptible.

However different reports are available in literature in supports to almost same findings as mine , such as Chandra *et al*., (2019) Web blight (*Rhizoctonia solani*) of mungbean, fifty two genotypes of mungbean were tested for the resistance against web blight in field condition. Out of fifty two genotypes and found 29 genotypes were resistant, 5 genotypes were recorded moderately resistant, 3 genotypes were noticed moderately susceptible, four genotypes were recorded susceptible. Only one genotype K-851was found highly susceptible.

5.4 Disease management:

5.4.1 Efficacy of botanicals *in vitro* and *in vivo*

In vitro: During present investigation extracts of seven plants species *viz.* Neem, Garlic, Onion, Tulsi, Sadabahar, Ginger, Clerodendron were evaluated for fungi toxicity against *R. solani* by using poison food technique.

Effect of different Concentration of plant extracts against *R. solani* on mycelia growth *in vitro* .

At 24 hours of incubation.

In 5.0 per cent concentration the maximum per cent inhibition was recorded in Garlic (59.08%) followed by Ginger (56.92%), Neem (50.27%), Onion (48.66%), Tulsi(46.91%), Clerodendron (34.00%), Sadabahar (28.12%). The per cent inhibition in Garlic and Ginger, Tulsi and Onion Neem, were at par to each other, while Clerodendron, Sadabahar differed significantly to each other (Table 9). The similar pattern were obtained in 7.5 per cent concentration and per cent inhibition ranged from 66.0% to 36.00% Garlic and Ginger, Onion and Neem, were at par to each other , while Tulsi , Clerodendron, Sadabahar differed significantly to each other (Table 9). Among 10.0 per cent concentration the

maximum per cent inhibition was recorded in Garlic (79.52%) followed by Ginger, Neem, Onion, Tulsi, Clerodendron, Sadabahar, however Onion and Neem were at par to each other while Per cent inhibition in all the treatments differed significantly to each other (Table 9). Thus, it is very clear that Garlic was most effective in suppressing the growth of *Rhizoctonia solani in vitro* at different concentration.

At 36 hours of incubation.

In 5.0 per cent concentration minimum radial growth was obtained in Garlic (26.51 mm) followed by Ginger (28.00 mm), Neem (29.51 mm). Onion (31.01 mm), Tulsi (33.05 mm), Clerodendron (37.00 mm), Sadabhar (41.01mm), as compared to control (45.26 mm), however Garlic and Ginger , Ginger and Neem, Neem and onion were at par to each other while Tulsi, Clerodendron and Sadabahar were significantly different to each other (Table 7). The similar results were obtained in 7.5 per cent concentration as 5.0 per cent concentration and the radial growth ranged from 20.50 mm to 72.00 mm. However Garlic, Ginger, Neem, Clerodendron and Sadabahar were statistically differed to each other, while Tulsi and Onion were at par to each other (Table 7). Among 10.0 per cent concentration lowest radial growth was obtained in Garlic (14.01 mm) followed by Ginger, Neem, Onion, Tulsi, Clerodendron and Sadabahar. However Garlic, Ginger, Tulsi, Clerodendron and Sadabahar were significantly different to each other, while Neem and Onion were at par to each other (Table7).

At 48 hours of incubation.

In 5.0 per cent concentration the minimum radial growth was obtained in Garlic (29.50 mm) followed by Ginger (32.0 mm), Neem (34.00 mm), Onion (36.10 mm), Tulsi (38.00 mm), Clerodendron (42.50mm) and Sadabahar (50.25 mm). which were significantly different from each other (Table 8). The similar pattern was obtained in 7.5 per cent concentration and radial growth ranged from

25.00 mm to 89.00 mm. Every treatment statistically differed to each other (Table 8). Among 10.0 per cent concentration minimum radial growth was observed in Garlic (15.5 mm), followed by Ginger, Neem, Onion, Tulsi, Clerodendron and Sadabahar which were significantly superior to each other (Table 8). Minimum radial growth was obtained in 5.0, 7.5 and 10.0 per cent concentration in Garlic. The results clearly indicated that plants extracts reduced the radial growth of *R. solani* at 5.0, 7.5 and 10.0 per cent concentration after 24, 36 and 48 hours of incubation and effectiveness of extracts increased with the increase of their concentration.

Efficacy of plant extract against *R. solani* on per cent inhibition .

At 24 hours of incubation.

In 5.0 per cent concentration the maximum per cent inhibition was recorded in Garlic (59.08%) followed by Ginger (56.92%) , Neem (50.27%) , Onion (48.66%), Tulsi(46.91%), Clerodendron (34.00%), Sadabahar (28.12%). The per cent inhibition in Garlic and Ginger, Tulsi and Onion Neem, were at par to each other (Table 9). The similar pattern were obtained in 7.5 per cent concentration and per cent inhibition ranged from 66.0% to 36.00% Garlic and Ginger, Onion and Neem, were at par to each other (Table 9). Among 10.0 per cent concentration the maximum per cent inhibition was recorded in Garlic (79.52%) followed by Ginger (75.66%), Neem (70.18%), Onion (66.84%), Tulsi (62.42%),Clerodendron (49.16%), Sadabahar (40.30%), however Onion and Neem were at par to each other while Per cent inhibition in all the other treatments differed significantly to each other (Table 9). The maximum per cent inhibition was obtained in 5.0, 7.5 and 10.0 per cent concentration in Garlic after 24 hours in incubation.

At 36 hours of incubation.

In 5.0 per cent concentration the maximum per cent inhibition in mycelium growth of R. solani was recorded in Garlic (41.44%), followed by Ginger (38.11%), Neem (34.81%), Onion (31.44%), Tulsi (27.00%), Clerodendron (18.23%) and Sadabahar (11.60%). The per cent inhibition in all the treatments differed significantly to each other (Table 10). Similar pattern were obtained in 7.5 per cent concentration and per cent inhibition ranged from 72.00% to 44.00 %. Hoewever Tulsi and Onion were at par to each other; all other treatments significantly differed to each other (Table 10). Among 10.0 per cent concentration maximum per cent inhibition was recorded in Garlic (80.32%) and followed by Ginger, Neem, Onion, Tulsi, Clerodendron and Sadabahar. However Per cent Inhibition in Onion and Neem were at par to each other (Table 10). The maximum per cent inhibition was obtained in 5.0, 7.5 and 10.0 per cent concentration in Garlic followed by Ginger, Neem, Onion, Tulsi, Clerodendron and Sadabahar after 36 hours of incubation.

At 48 hours of incubation.

In 5.0 per cent concentration the maximum per cent inhibition in mycelium growth of *R. solani* was recorded in Garlic (66.77%), followed by Ginger (63.94%), Neem (61.69%), Onion (59.10%), Tulsi (57.19%), Clerodendron (52.11%) and Sadabahar (44.79%) The per cent inhibition in all the treatments differed significantly to each other (Table 11). Similar pattern were obtained in 7.5 per cent concentration and per cent inhibition ranged from 72.00% to 47.00 %. However all treatments significantly differed to each other (Table 11). Among 10.0 per cent concentration maximum per cent inhibition was recorded in Garlic (82.53%) and followed by Ginger, Neem, Onion, Tulsi, Clerodendron and Sadabahar. However Per cent Inhibition in all treatments differed significantly to each other (Table 11). The maximum per cent inhibition was obtained in 5.0, 7.5

and 10.0 per cent concentration in Garlic followed by Ginger after 48 hours of incubation. It was very clear from the studies that effectively of extracts increased with the increase in concentration and time of incubation.

Though, the effect of different plant extracts are lacking specifically in mungbean caused by *R. solani*. However, different reports are available in literature against *R. solani* causing different diseases in different crops.

Meena *et al*. (2002) were also found that extract of Garlic at 5.0 per cent concentration (w/v) completely inhibited the mycelial growth of *R .solani* causing sheath blight of rice and similarly Shinde and Patel (2004) found that bulb extract of Garlic gave hundred per cent inhibition of myeclial growth of R solani causing black scurf of potato followed by Ginger, Tulsi, Eucalyptus and Neem. Mittal and Goswami (2004) also found that in lab condition, Garlic extract completely inhibited the myeelial growh of *R. solani* causing black scurf of potato, followed by Eucalyptus, Tulsi, bulb extract of onion, rhizome extract. Yadav (2007) also found extract of Garlic gave maximum per cent inhibition in mycelial growth of *R. solani* causing web blight of French bean, followed by Ginger, Neem. Onion, Datura, Tulsi, Eucalyptus and Congress grass. This is in agreement with present findings. In contrary to present findings Mishra *et al.* (2005) found Ginger was most effective in inhibiting radial growth of *R. solani* as compared to *Calotropis gigantia, Vinca rosea, Ocimum sanctum, Azadirachta indica, Pongamia pinnata, Lantana camara, Eucalyptus citriodora, Allitun cepa in vitro.*

In vivo.

Ten per cent concentration of plant extract was found most effective in reducing radial growth *in vitro* which was further tested *in vivo* to find out the effectiveness of the seven plant extracts at 50 days after sowing for Fusarium wilt management.

Ten per cent concentration the minimum disease incidence was recorded in Garlic (20.27%) followed by Ginger (22.27%), Neem (25.4%), Onion (28.20%), Tulsi(31.3%), Clerodendron (37.10%) and Sadabahar (42.60%), as compared to control (82.6%). Each treatment significantly superior to control where Garlic and Ginger , Ginger and Neem , Neem and Onion, Onion and Tulsi were at par to each other (Table 14).

Similarly, the maximum disease control was observed in Garlic(75.34%) followed by Ginger (72.52%), Neem (69.25%), Onion (65.86%), Tulsi (62.11%), Clerodendron (55.05%) and Sadabahar (48.43%), while Sadabhar and Clerodendron, Tulsi and Onion, Onion and Neem, Neem and Ginger, Ginger and Garlic were at par to each other (Table 15) . Thus, Garlic was most effective and Sadabhar was least effective reducing disease incidence.

It is very clear from the present studies that the plant extracts which were better in inhibiting the radial growth *in vitro* also and showed reduction in disease incidence and per cent disease control was higher accordingly.

Muralidharan *et al*. (2003) ; Raji and Nair (2004) and Karthikeyan *et al*. (2007) studied the effectivity of Neem extract under field condition and reproted against *R. solani* causing sheath blight of rice and found that disease severity was reduced and grain yield were increased. Similarly Kansal *et al*. (2008) reported that Neem extract was effective against *R. solani* causing web blight of French bean. These reports supported the present findings where Neem extract was found effective in reducing radial growth and disease incidence.

5.4.2 Efficacy of bio-agents *in vitro* and *in vivo*.

In vitro : The efficacy of bio-agents *Trichoderma harzianum* and *T. viride* are tested for mycelial growth and per cent inhibition of *R. solani* by using dual culture technique. Results clearly indicated that radial growth was minimum in *T. viride*

(18.8 mm) followed by *T. harzianum* (23.3 mm) as compared to control (46.00 mm).The radial growth significantly differed with each other at 24 hours of incubation (Table 12) The similar results were also obtained at 36 hours of incubation, however, the radial growth were 23.30 mm, 31.60 mm and 73.90 mm in *T. viride, T. harzianum* and control, respectively (Table 12). At 48 hours of incubation the radial growth are 25.40 mm, 39.60 mm and 90.00 mm in *T viride, T. harziamum* and control, respectively (Table 12).

Minimum radial growth was obtained in *T. viride* than *T. harziamum* after 24, 36 and 48 hours of incubation and both treatments are statistically differed to each other.

The per cent inhibition was also higher in *T. viride* and *T. harzianum* significantly inhibition the growth of *R.solani* as compared to control at 24, 36 and 48 hours of incubation. *T. viride* showed higher per cent inhibition (59.13, 68.47 and 71.78 per cent) in mycelial growth as compared to *T. harziamam* (49.35, 57.75 and 56.66 per cent) at 24, 36 and 48 hours of incubation, respectively which significantly differed with each other (Table 13)

Thus it is very clear that *T. viride* was better in inhibiting radial growth of *R. solani* as compared to *T. harzianum in vitro.* It seems that *T. viride* was better in inhibiting the radial growth as compered to *T. harzianum.*

Dubey and Patel (2001) and Dubey (2002) also reported that *T viride* was better in inhibiting radial growth of *R. solani* as compared to *T. harzianum in vitro* which support the present findings. However, Meena *et al*. (2002) and Khan & Sinha (2007) found T. harziamum was better in inhibiting the mycelial growth of *R. solani* as compared to *T. viride*.

In vivo: The effect of bio-agents (*T. viride and T. harziamum*) were also studied to find out their role in suppressing the web blight of mungbean in pot sown crop as foliar application.

The disease control was 24.40 and 23.56 per cent in *T. viride* and *T.* harziamum , respectively (Table-17) which were at par to each other. Thus, the effect of bio-agents were very less when applied as foliar spray. This might be due to that the conditions were not favorable for increasing the population of bio-agents on the plants. As the bio-agents is mostly soil inhabitant and grow saprophytically in presence of high organic matter in soil and increase their population very fast.

In most of the cases bio-agents have been used either as seed treatments or in soil for suppressing the soil borne pathogen and reducing the disease incidence, through hyper parasitism, antibiosis and competition (Wells, 1988; Desai and Schlosser, 1999; Yadav *et al*, 2005; Mukhopadhyay, 1988 and Pandey & Upadhyay, 2000).

In present findings the bio-agents were not much effective against web blight of mungbean when applied as foliar application.

SUMMARY AND CONCLUSION

Chapter - VI

SUMMARY AND CONCLUSION

Mungbean [*Vigna radiata* (L.) Wilezek] is an important pulse crop and play very important role in the supply of protein to under nourished vegetarian population of the country. It suffers from a number of diseases.web blight of mungbean caused by *Rhizactonia solani* (Kuhn) is one of the most important fungal diseases which appear every year in varying intensity and causes heavy reduction in yield.

Use of synthetic fungicides has led to the emergence of several problems like environmental pollution, residual effect in grains and killing of non-target organism(s). Hence, for minimizing the losses caused by web blight disease needs in expensive and environmentally safe blight, this management practices. Many plant extracts and bio-agents are known for their antifungal activity.

Different aspects of disease as well as pathogen were studied with symptomatology and disease management through plant extracts and bio- agents against *R. solani* causing web blight of mungbean.

The salient findings of studies are summarized below:

1. *Rhizoctonia solani* was isolated from leaves of mungbean showing typical symptoms of web blight on PDA. The cultural and morphological characters of the fungus were studied after isolation of the fungus. The colony of the fungus grew very fast, measuring 90.00 mm growth in Petri dishes aftter 2 days of incubation. The color of mycelium was whitish in beginning which later turns tan brown with age. Sclerotia were dark brown, round to irregular and consisted of brown and barrel shaped moniliod cell.
2. The pathogenicity of *R. solani* was proved following the Koch's postulates.

3. The first appearance of web blight was noticed after 5 days of inoculation (30 DAS) on pot sown crop. The fungus infects all above ground parts of the plant *i.e.* leave, petioles, stem and pods but most destructive is on foliage. Symptoms on the leaves appear as initial small circular brown spots. These spots enlarge and are surrounded by water soaked areas. The lesion expands and collapses and white fungal growth may be seen on lower surface of leaves and young branches. The mycelium on infected leaves appeared as spider web.

4. One hundred genotypes were screened for their reaction to web blight **(***Rhizoctonia solani*) in the field it is clear from table (5): that out of hundred genotypes, one genotype Pusa 1771 was found resistant, while 3 genotypes *viz*., Pant M-6, VGG16-055, KMP17-19, were found moderately resistant. 23 genotypes were recorded moderately susceptible, 22 genotypes were noticed susceptible, 21 were found susceptible, 12 genotypes were recorded highly susceptible, 2 genotypes *viz*., K 851, AKM 12 – 28 were found highly susceptible.
5. Effect of different concentration of plant extracts against *R. solani* on mycelia growth *in vitro* at 24 hours of incubation: In 5.0 per cent concentration minimum radial growth was obtained in Garlic (18.5 mm) followed by Ginger (19.75 mm), Neem (22.51 mm). Onion (23.25 mm), Tulsi (24.01 mm), Clerodendron (29.51mm) and Sadabahar (32.51mm) as compared to control (46.50 mm). Garlic and Ginger, Neem, Onion and Tulsi were at par to each other (Table 6). The radial growth ranged from 16.25 mm to 46.50 mm in 7.5 per cent concentration. Similar pattern were found as 5.0 per cent concentration (Table 6). In 10.0 per cent concentration minimum radial growth was obtained in Garlic (9.26mm) followed by Ginger (11.00 mm), Neem (13.51 mm), Onion (15.00 mm), Tulsi (17.01 mm), Clerodendron (23.01mm), Sadabahar (28.25 mm) as compared to control (45.26 mm). Neem and Onion were at par to each other at 10.0 per cent (Table 6).

The minimum radial growth was obtained in 5.0, 7.5 and 10.0 per cent concentration in Garlic followed by Ginger, Neem, Onion, Tulsi, Clerodendron and Sadabahar at 24 hours of incubation.

6. Effect of different Concentration of plant extracts against *R. solani* on mycelia growth *in vitro* at 36 hours of incubation: In 5.0 per cent concentration minimum radial growth was obtained in Garlic (26.51 mm) followed by Ginger (28.00 mm), Neem (29.51 mm). Onion (31.01 mm), Tulsi (33.05 mm), Clerodendron (37.00 mm), Sadabhar (41.01mm), as compared to control (45.26 mm), however Garlic and Ginger , Ginger and Neem, Neem and onion were at to each other (Table7). The similar results were obtained in 7.5 per cent concentration as 5.0 per cent concentration and radial growth ranged from 20.50 mm to 72.00 mm (Table 7).

   Among 10.0 per cent concentration lowest radial growth was obtained in Garlic (14.01 mm) followed by Ginger (16.00 mm), Neem (18.51 mm), Onion (20.00 mm), Tulsi (23.25 mm), Clerodendron (28.25 mm) and Sadabahar (33.25 mm), as compared to control (71.26mm) while Neem and Onion were at par to each other (Table 7).

   The minimum radial growth was obtained in 5.0, 7.5, 10.0 per cent concentration in garlic followed by Ginger, Neem, Onion, Tulsi, Clerodendron and Sadabahar, at 36 hours of incubation. Effect of different Concentration of plant extracts against *R. solani* on mycelia growth *in vitro*.

7. Effect of different Concentration of plant extracts against *R. solani* on mycelia growth *in vitro* At 48 hours of incubation : In 5.0 per cent concentration the minimum radial growth was obtained in Garlic (29.50 mm) followed by Ginger (32.0 mm), Neem (34.00 mm), Onion (36.10 mm), Tulsi (38.00 mm), Clerodendron (42.50mm) and Sadabahar (50.25 mm). Which were significantly different from each other (Table 8). The similar pattern was obtained in 7.5 per cent concentration and radial growth ranged from 25.00

mm to 89.00 mm. Every treatment statistically differed to each other (Table 8). Among 10.0 per cent concentration minimum radial growth was observed in Garlic (15.5 mm), followed by Ginger (17.8 mm), Neem (20.1 mm), Onion (22.2 mm), Tulsi (24.6 mm), Clerodendron (29.3 mm) and Sadabahar (33.6 mm), as compared to control (90.00 mm) which were significantly superior to each other (Table 8).

Minimum radial growth was obtained in 5.0, 7.5 and 10.0 per cent concentration in Garlic followed by Ginger, Neem, Onion, Tulsi, Clerodendron and Sadabahar at 48 hours of incubation.

The results clearly indicated that plants extracts reduced the radial growth of *R. solani* at 5.0, 7.5 and 10.0 per cent concentration after 24, 36 and 48 hours of incubation and effectiveness of extracts increased with the increase of their concentration.

8. Efficacy of plant extract against *R. solani* on per cent inhibition At 24 hours of incubation : In 5.0 per cent concentration the maximum per cent inhibition was recorded in Garlic (59.08%) followed by Ginger (56.92%) , Neem (50.27%), Onion (48.66%), Tulsi(46.91%), Clerodendron (34.00%), Sadabahar (28.12%). The per cent inhibition in Garlic and Ginger, Tulsi and Onion Neem, were at par to each other, (Table 9).

   The similar pattern were obtained in 7.5 per cent concentration and per cent inhibition ranged from 66.0% to 36.00% Garlic and Ginger, Onion and Neem, were at par to each other (Table 9).

   Among 10.0 per cent concentration the maximum per cent inhibition was recorded in Garlic (79.52%) followed by Ginger (75.66%), Neem (70.18%), Onion (66.84%), Tulsi (62.42%),Clerodendron (49.16%), Sadabahar (40.30%), however Onion and Neem were at par to each other (Table 9).

The maximum per cent inhibition was obtained in 5.0, 7.5 and 10.0 per cent concentration in Garlic followed by Ginger, Neem, Onion, Tulsi, Clerodendron, Sadabahar, after 24 hours in incubation.

9. Efficacy of plant extract against *R. solani* on per cent inhibition At 36 hours of incubation : In 5.0 per cent concentration the maximum per cent inhibition in mycelium growth of *R. solani* was recorded in Garlic (41.44%), followed by Ginger (38.11%), Neem (34.81%), Onion (31.44%), Tulsi (27.00%), Clerodendron (18.23%) and Sadabahar (11.60)% The per cent inhibition in all the treatments differed significantly to cach other (Table 10). Similar pattern were obtained in 7.5 per cent concentration and per cent inhibition ranged from 72.00% to 44.00 %. Hoewever Tulsi and Onion were at par to each other (Table 10).

   Among 10.0 per cent concentration maximum per cent inhibition was recorded in Garlic (80.32%) and followed by Ginger (77.53%), Neem (74.03%), Onion (71.92%), Tulsi (69.12%), Clerodendron (62.09%) and Sadabahar (55.08%). However Per cent Inhibition in Onion and Neem were at par to each other (Table 10).

   The maximum per cent inhibition was obtained in 5.0, 7.5 and 10.0 per cent concentration in Garlic followed by Ginger, Neem, Onion, Tulsi, Clerodendron and Sadabahar after 36 hours of incubation.

10. Efficacy of plant extract against *R. solani* on per cent inhibition At 48 hours of incubation : In 5.0 per cent concentration the maximum per cent inhibition in mycelium growth of *R. solani* was recorded in Garlic (66.77%), followed by Ginger (63.94%), Neem (61.69%), Onion (59.10%), Tulsi (57.19%), Clerodendron (52.11%) and Sadabahar (44.79%) The per cent inhibition in all the treatments differed significantly to each other (Table 11).

Similar pattern were obtained in 7.5 per cent concentration and per cent inhibition ranged from 72.00% to 47.00 %. (Table 11).

Among 10.0 per cent concentration maximum per cent inhibition was recorded in Garlic (82.53%) and followed by Ginger (79.94%), Neem (77.36%), Onion (74.98%), Tulsi (72.26%), Clerodendron (67.01%) and Sadabahar (62.15%) (Table 11).

The maximum per cent inhibition was obtained in 5.0, 7.5 and 10.0 per cent concentration in Garlic followed by Ginger, Neem, Onion, Tulsi, Clerodendron and Sadabahar after 48 hours of incubation.

Thus, Garlic was most effective and Sadabahar was least effective in reducing disease incidence.

11. Efficacy of bio-agents against *R. solani on* radial growth. The efficacy of bio-agents *Trichoderma harzianum* and *T. viride* are tested for mycelial growth and per cent inhibition of *R. solani* by using dual culture technique. Results clearly indicated that radial growth was minimum in *T. viride* (18.8 mm) followed by *T. harzianum* (23.3 mm) as compared to control (46.00 mm).The radial growth significantly differed with each other at 24 hours of incubation (Table 12)

    The similar results were also obtained at 36 hours of incubation, however, the radial growth were 23.30 mm, 31.60 mm and 73.90 mm in *T. viride*, *T. harzianum* and control, respectively (Table 12).

    At 48 hours of incubation the radial growth are 25.40 mm, 39.60 mm and 90.00 mm in *T. viride, T. harzianum* and control, respectively (Table 9). Minimum radial growth was obtained in *T. viride* than *T. harziamum* after 24, 36 and 48 hours of incubation and both treatments are statistically differed to each other.

12. Effect of bio-agents against *R. solani* on per cent inhibition, *T. viride* and *T. harzianum* significantly inhibition the growth of *R. solani* as compared to

control at 24, 36 and 48 hours of incubation. *T. viride* showed higher per cent inhibition (59.13, 68.47 and 71.78 per cent) in mycelial growth as compared to *T. harziamam* (49.35, 57.75 and 56.66 per cent) at 24, 36 and 48 hours of incubation, respectively which significantly differed with each other (Table 13)

Thus it is very clear that *T. viride* was better in inhibiting radial growth of *R. solani* as compared to *T. harzianum in vitro.*

13. Effect of plant extract on disease incidence against web blight *in vivo* at 50 days: The results clearly indicated that the minimum disease incidence was found Garlic (20.27%) followed by Ginger (22.27%), Neem (25.4%), Onion (28.20%), Tulsi(31.3%), Clerodendron (37.10%) and Sadabahar (42.60%), as compared to control (82.6%) where Garlic and Ginger , Ginger and Neem , Neem and Onion, Onion and Tulsi were at par to each other . Table (14).
14. Efficacy of plant extracts against *R. solani* on per cent disease control. The maximum disease control was found in Garlic (75.34%) followed by Ginger (72.52%), Neem (69.25%), Onion (65.86%), Tulsi (62.11%), Clerodendron (55.05%) and Sadabahar (48.43%). Each treatment were significantly superior to control, Sadabhar and Clerodendron were statistically differed to each other. Tulsi and Onion , Onion and Neem , Neem and Ginger , Ginger and Garlic were at par to each other (Table 15) .

    Thus, Garlic was most effective and Sadabhar was least effective reducing disease incidence.
15. Efficacy of bio-agents against R. *solani* on disease incidence. Disease incidence were found 62.90 per cent and 63.18 per cent in *T. viride* and *T. harzianum* , respectively as compared to control 82.56 per cent. The disease

incidence in *T. viride and T. harziamumn* were at par to each other (Table 16).

16. Efficacy of bio-agents against *R. solani* on per cent disease control. Per cent disease control were found 24.40 per cent and 23.56 per cent in *T. viride* and *T. harzianum*, respectively. *Trichoderma viride* and *T. harzianum* were at par with each other (Table 17).

Thus, results clearly indicated that *T. viride* and *T. harzianum* suppressed the growth of *R. solani in vitro* but did not show any effect *in vivo.*

The effect of *T. viride* and *T. harzianum* were very less in disease management when applied as foliar spray.

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