Studies on *Rhizoctonia solani* (Kuhn) causing web blight of urd bean and its management

THESIS

Submitted to

Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur

In partial fulfilment of the requirements for the Degree of

MASTER OF SCIENCE

In

AGRICULTURE
(Plant Pathology)

By

Babli Verma
(170118001)

Department of Plant Pathology
College of Agriculture, Jabalpur
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur - 482004 (M.P.)

2019

CERTIFICATE – I

This is to certify that the thesis entitled **"Studies on *Rhizoctonia solani* (Kuhn) causing web blight of urd bean and its management"** submitted in partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE (Ag.)** in **Plant Pathology** of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by **Ms. Babli Verma**, **ID No. 170118001**, under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instruction.

All the assistance and help received during the course of the investigation has been acknowledged by her.

Place: Jabalpur **(Dr. Ashish Kumar)**

Date: **Chairman of the Advisory Committee**

THESIS APPROVED BY THE STUDENT'S ADVISORY

Committee	Name	Signature
Chairman	**Dr. Ashish Kumar**	…………………………
Member	**Dr. S. N. singh**	…………………………
Member	**Dr. Manoj Srivastava**	....……………………..
Member	**Dr. H. L. Sharma**	…………………………

CERTIFICATE – II

This is to certify that the thesis entitled **"Studies on *Rhizoctonia solani* (Kuhn) causing web blight of urd bean and its management"** submitted by **Babli Verma** to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in partial fulfilment of the requirements for the degree of **Master of Science** in **Agriculture** in the Department of **Plant Pathology** has been, after evaluation, approved by the External Examiner and by Student's Advisory Committee after an oral examination on the same.

Place: Jabalpur **(Dr. Ashish Kumar)**

Date: **Chairman of the Advisory Committee**

MEMBER OF THE ADVISORY COMMITTEE

Committee	Name	Signature
Chairman	**Dr. Ashish Kumar**	..………………………
Member	**Dr. S. N. Singh**	… ………………………
Member	**Dr. Manoj Srivastava**	. ...…….…
Member	**Dr. H. L. Sharma**	…………………...……
Head of the Department	**Dr. S. N. Singh**	....
Director of Instruction	**Dr. S. D. Upadhyaya**	....

Declaration and Undertaking by the Candidate

I, **Babli Verma** D/o Mr. Sooraj Singh Certify that the work embodied in the thesis entitled **"Studies on *Rhizoctonia solani* (Kuhn) causing web blight of urd bean and its management"** is my own first hand bonafide work carried out by me under the guidance of **Dr. Ashish Kumar**, Assistant Professor in Plant Pathology, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur during 2018-2019**.**

The matter embodied in the thesis has not been submitted for the award of any other degree/diploma. Due credit has been made to all the assistance and help.

I, undertake the complete responsibility that any act of misinterpretation, mistakes and errors of fact are entirely of my own.

I, also abide myself with the decision taken by my advisor for the publication of material extracted from the thesis work and subsequent improvement, on mutually beneficial basis, provided the due credit is given thereof and will not include any unauthorized name in research publications.

Place: Jabalpur **(Babli Verma)**

Date:

Copyright © and IPR Rights
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur, Madhya Pradesh – 2019

Copyright and IPR Right Transfer Certificate:

Title of the Thesis	:	**"Studies on *Rhizoctonia solani* (Kuhn)causing web blight of urd bean and its management"**
Name of the candidate	:	Babli Verma
Subject	:	Plant Pathology
Department	:	Plant Pathology
College	:	College of Agriculture, Jabalpur Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur, Madhya Pradesh
Year of thesis submission	:	2019

Copyright and IPR Rights Transfer:

The undersigned **Babli Verma** assigns to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, all rights under Copyright and IPR Right Act, that may exists in and for the thesis entitled **"Studies on *Rhizoctonia solani* (Kuhn) causing web blight of urd bean and its management"** submitted for the award of M. Sc. (Ag.) degree.

Date:

Place: Jabalpur

Dr. Ashish Kumar — **Babli Verma**

(Major advisor) — **(Student)**

ACKNOWLEDGEMENT

Thanks to god and his blessings by which I was able to complete my thesis and gave me an opportunity to express my heartful gratitude to all those who have given me helping hands to make this study a success.

It is pleasure for me to express my indebtness to Dr. Ashish Kumar Chairperson of my advisory committee and Scientist plant pathology, in college of Agriculture, JNKVV, Jabalpur, Madhya Pradesh India for initiating flora of research in me, continuing encouragement, insightful, guidance, untiring help, keen attention, constant stimulation and constructive criticism extended all along during the investigation and for its proper presentation in form of thesis.

I wish to remembrance of my venerable Advisory committee. I am grateful to Dr. S.N. Singh, Department of Plant Pathology and Dr. Manoj srivastava, Senior Scientist plant pathology, and Dr. H. L. Sharma, Professor Department of Agriculture statistics for their valuable suggestions , and illuminating guidance, and generous help throughout the course of the investigations. I sincerely express my heartiest thanks to our Honorable Vice Chancellor Dr. P.K. Bisen, Dean Faculty of Agriculture, Dr. D. Khare, Director Research Services, Dr. P.K. Mishra, Director Instruction, Dr. S.D. Upadhyay, Director Extension Services, Dr.(Mrs) Om Gupta, Director Farms, Dr. Sharad Tiwari, Dean College of Agriculture, Dr. R.M. Sahu, Professor and Head, Department of Plant Pathology, Dr. S.N. Singh, JNKVV, Jabalpur for providing necessary facilities during the course of investigation.

I sincerely express my appreciation and gratitude to respected teachers of plant Pathology Dr. U. K. Khare, Dr. M. S. Bhale, Dr. Sanjeev Kumar, Dr. (Mrs.) Usha Bhale, Shri A. R. Wasnikar, Dr. Mrs, Vibha Pandey, for their time to time suggestions, encouragement and help in various ways.

I am thankful to the office staff and workers of department of Plant Pathology for needful co-operation. I also wish to express my feelings towards my Seniors Jainpal Sir Praveen Sir and batchmates, Megha , Yeshwardhan, Neelam, Sonali, Diksha, Sanjay, Pushpendra, Mahesh, Rahul, Rahul, Abhisekh, Subham and my juniors

Place: Jabalpur (**Babli Verma)**

Date:

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATION

Abbreviation		Stand for
%	:	Per cent
@	:	At the rate of
ºC	:	Degree Celsius
CD	:	Critical difference
Sem	:	Standard error of mean
DAI	:	Days after inoculation
et al.	:	And other
Fig.	:	Figure
i.e.	:	That is
gm	:	Gram
Cm	:	Centi meter
No.	:	Number
Wt	:	Weight
viz.	:	Namely
T	:	Treatment
ppm	:	Parts per million
BOD	:	Biological Oxygen Demand
PDA	:	Potato Dextrose Agar

INTRODUCTION

The urd bean (*Vigna mungo* (L.) Hepper) is an important pulse crop of India. This crop is a major source of dietary proteins, minerals and vitamins for vegetarian population of India. It is also rich in phosphoric acid. Urd bean fixes 38 kg/ ha nitrogen in soil. The rapid increase in population has led to lowering per capita availability of pulses from 69g/day in 1960-61 to 35.5 gm/day in 1999-2000 but WHO have recommended 80 g/captia/day (Lal, 1984). Urd bean is also cultivated as mixed crop with finger millet or barnyard millet in the hills of Uttaranchal during the kharif season. In North India, it is grown in kharif and summer season. In India, urd bean is cultivated in 2.89 million ha area with production of 1.28 million tones and productivity of 440 kg/ha (Anonymous, 2003). it is cultivated in kharif, spring and summer seasons in India and covering 3.77 million hectares area and production 1.52 million tonnes. (Purushottam and Singh, 2015).

Despite being an important pulse crop its productivity has been quite low probably due to various biotic and abiotic constraints. Urdbean is vulnerable to a variety of diseases *viz.*, anthracnose (*Glomerella lindemuthianum*), dry root rot (*Macrophomina phaseolina*), leaf spot (*Cercospora canescens*), powdery mildew (*Erysiphe polygoni),* rust (*Uromyces phaseoli*), web blight (*Rhizoctonia solani*), Mosaic and leaf crinkle (Bara, 2007). Among the biotic constraints, Web blight disease of urdbean caused by *Rhizoctonia solani* Kuhn [Teleomorph: *Thanatephorous cucumeris* (Frank) Donk] is considered as an important constraint accountable for losses in production as well as productivity in India up to 20-30% (Kumar *et al.* 2018). The disease had been reported in other countries; like Pakistan, Sri Lanka, West Indies, Japan, Philippines, Myanmar, North America, South America, Argentina, Brazil, and Mexico too beside India. The disease has been reported from various urdbean growing areas of India including; Punjab, Haryana, Bihar, Rajasthan, Uttarakhand, Madhya Pradesh, Uttar Pradesh, West Bengal, Himachal Pradesh and Jammu and Kashmir (Shailbala and Tripathi, 2007). The disease appears about 21-25 days after sowing depending on cultivars, environmental conditions, crop stages and cultivation practices (Dubey and Patel, 2001; Shailbala and Tripathi, 2007). Seed quality and grain yield are heavily affected in this disease.

Web blight of urd bean is a seed and soil borne disease (Saksena and Dwivedi, 1973; Dwivedi and Saksena, 1974) and managed by chemical seed treatment (Dubey and Dwivedi, 1988). The chemicals not only disturb the ecology of soil but also develop hazardous impact on surroundings including *Rhizobium* sp. Biological seed treatment with fungal antagonist has significant promise against such devastating pathogens (Mukhopadhyay, 1994) but suitable methods of seed treatment and optimum doses are ingredients for successful management.

The first report of occurrence of web blight on urdbean caused by *Rhizoctonia solani* Kuhn [Teleomorph: *Thanatephorous cucumeris* (Frank) Donk] in India was reported by Saksena and Dwivedi in 1973. This disease is known to occur in other leguminous crops like mungbean (Dwivedi and Saksena, 1975), pigeonpea (Dwivedi and Saksena, 1975), cowpea (Lakshman *et al.* 1979), soybean (Verma and Thapliyal, 1976), groundnut (Dwivedi and Dubey, 1986) and ricebean (Jalali, 1989).

The *Rhizoctonia solani* Kuhn is a soil-borne fungal pathogen, polyphagous, necrotrophic and adaptability to diversified ecosystems, have made the management of the disease caused by this pathogen a challenging job. Even no single method is available currently for effective and economic management of web blight disease. However, there are few important control measures which are applicable either as single or integration.

Progress in breeding for Web blight resistance in urdbean is limited due to considerable variability in varietal reaction and less understanding of the pathogen variation and disease resistance mechanisms. Sufficient augmentation in agriculture produce can also be brought through biological control instead of using pesticides.

Seed treatment with *Trichoderma viride*, carboxin and *Rhizobium* sp. provides additive effect for better management of disease due to variation in the mode of action of the fungicide and bioagent. *Rhizobium* is not inhibited by *Trichoderma* but contributes greater root nodulation during seed treatment. Many workers have reported successful use of different species of *Trichoderma* like *T. virens*, *T. harzianum*, *T. viride* for management of R. *solani* causing web blight of urdbean (Dubey and Patel, 2001; Shailbala and Tripathi, 2010; Kumar and Tripathi, 2011, Ray *et al.* 2007, Sharma and Tripathi, 2001).

The presence of antifungal compounds in higher plants has long been recognized as an important factor to control disease (Mahadevan, 1982). Ansari (1995) reported fungistatic activity of extracts of *Ocimum sanctum*, *Mentha arvensis* and *Eucalyptus* sp. against *R. solani*. Foliar spray of *Pongamia glabra* leaf extract successfully reduced web blight of urd and mungbean and can be further exploited in organic farming (Dubey, 2002). Similarly many workers have reported use of botanicals/phytoextracts for the management of *R. solani*. However, there is need to explore more phytoextracts against *R. solani*.

Keeping this in view, the present study entitled "Studies on *Rhizoctonia solani* (kuhn) causing web blight of urd bean and its management" is therefore proposed to be undertaken with the following objectives:

- Collection, isolation and purification of *R. solani* from diseased samples.
- Cultural characterization of *R. solani* isolates.
- *In vitro* evaluation of chemicals and botanicals against *R. solani.*

REVIEW OF LITERATURE

2.1 *Rhizoctonia sp*: An introduction

Shailbala and Tripathi (2007) reported that urd bean (*Vigna mungo* (L.)Hepper) is an important pulse crop of India. It is rich in phosphoric acid. The genus *Rhizoctonia* was described to accommodate the non sporulating root pathogen *R. erocorum*. Genus *Rhizoctonia* has gained the reputation of being a wide spread, destructive and versatile plant pathogen. It was reported that 26 - 28^{0}C temperatures and 90 - 100 per cent relative humidity (RH) favored for maximum disease development. *R. solani* Kuhn is a common soil borne pathogen that has many hosts, forms sclerotia in/on soil and survives for a long period in the absence of a host either as sclerotia or thick walled brown hyphae in plants debris. The web blight disease severity is recorded by using 1 - 9) rating scale. Cultural practices, chemical control and biological control are effective methods for management web blight of urd bean.

Anderson (1982) reported that *Rhizoctonia solani* is a soil and seed borne pathogen which has wide host range and it causes various diseases on important agricultural and horticultural crops. Carling (1996) reported that the anastomosis group does not always correspond to morphology, pathogenecity or other physiological features.

The genus *Rhizoctonia* was described by De Candole (1815) to accommodate the non sprouting root pathogen *R. crocorum* D.C. ex Fr. Kuhn (1858) observed the pathogen on diseased potato tubers and named it as *Rhizoctonia solani* Kuhn.

Boosalis and Scnaren (1959) reported that *R. solani* Kuhn is a common soil-borne pathogen that has many hosts, forms sclerotia in/on soil and survives for a long period in the absence of a host either as sclerotia or thick walled brown hyphae in plant debris.

Parmeter *et al*. (1967) reported that *Rhizoctonia solani* has gained the reputation of being a widespread, destructive and versatile plant pathogen capable of attacking a very wide range of host plants causing seed decay, damping-off, stem canker, root rots and foliage diseases.

Saksena and Dwivedi (1973) reported Web blight of black gram caused by *Rhizoctonia solani* Kuhn which is prevalent in Punjab, Haryana, Bihar, Rajasthan, Uttaranchal, Uttar Pradesh, West Bengal, Himachal Pradesh and Jammu and Kashmir states.

Elad *et al*. (1980) also reported that *Rhizoctonia solani* is capable of attacking a tremendous range of host plants causing seed decay, damping-off, stem cankers, root rot, fruit decay and foliage disease. The *Rhizoctonia solani* fungus survives as hyphae (fine fungal threads) or sclerotia (thick walled hyphae) in organic matter between crops and grows on young seedlings following germination. The fungus spreads via crop residue, seed, machinery, animals and wind-borne material. It is most active between10 to 15^{0}C in the top 10-15 cm of the soil.

Wiese (1987) reported that *Rhizoctonia solani* does not produce spores and hence, identified only from mycelial characteristics or DNA analysis. Its hyphal cells are multinucleate. It produces white to deep brown mycelium when grown on artificial medium. The hyphae are 4–15 μm wide and tend to branch at right angles.

Singh and Malhotra (1994) carried out their work on the host range of the fungus *R. solani* causing web blight of winged bean and observed that urd bean, lobia, soybean, groundnut, arhar, french bean, mung bean, paddy, castor, bottle gourd, bitter gourd, tomato, brinjal, chillies and okra were also infected by the fungus.

Ogoshi (1996) studied the host range of *R. solani* and reported that the fungus causes various diseases on important crop plants of the world including species in the *Solanaceae, Fabaceae, Asteraceae, Poaceae, and Braccicaceae* as well as ornamental plants and forest trees.

Sharma and Tripathi (2001) worked on the host range of mungbean isolates of *R. solani* and found the wide host range belongs to family *Leguminoceae, Solanaceae, Brassicaceae, Malvaceae, Cucurbitaceae etc.*

Mubarak (2003) reported that *Rhizoctonia solani* Kuhn has heterogeneous strains and diversity in host range. It occurs throughout the world and can damage any part or all the parts of a plant. It is known to cause seed decay, damping-off, seedling blight, root rot and crown rot, as well as soreshim and wire stem, hypocotyls cankers, bud rot, foliage blight and storage rots.

Tripathi (2001) reported that environmental factors play a vital role in the development of web blight disease of urdbean *vigna mungo* (L.) Hepper caused by *Rhizoctonia solani* Kuhn. Higher aerial temperature (28-30 C), relative humidity (80%) and soil temperature (30-33 C) favoured development of high disease severity. Rainfall (91-97 mm) had a significant role in severe development of web blight during early stage of the crop. Significant and positive correlation was observed between web blight severity and relative humidity, aerial temperature, rainfall and soil temperature.

R. solani has been reported to infect a wide host range of plants comprising 188 species in 32 families (Kozaka, 1965). Tsai (1970) studied the host range of *R. solani* on 20 species of weeds belonging to 11 families,of which most weeds belonged to *Gramineae* and *Cyperaceae*. Saikia and Roy (1975) reported that *R. solani* was pathogenic to 60 different plant species from 19 families. Haque (1975) found that *Abelmoschus esculentus, Arachis hypogea*, *Celosiaargentina, Cyperus difformis, Echinochloa crusgalli, E. colona, Monochoria vaginalis, Phaseolus aureus, Sorghum vulgare* and *Zea mays* were susceptible to sheath blight fungus. Nayak *et al.* (1979) and Mew (1980) have reported weed hosts *viz, Choris sp. Cyperus iria, C. radiates, C rotundus, Cynodon doctylon, Digitarea spp, Echinochloa repens, Leptochloa chinensis, Papspalum distinctum, P. flavidum, P. sorobieatum* and *setaria glauca* as hosts of *R. solani*.

2.2 **Symptomatology**,

The first symptom appears as small circular brown spot on the leaves. These spot enlarge often show concentric banding and surrounded by irregular shaped water soaked areas (Singh,2006). The lesions expend and coalease and white fungal growth is observed on lower surface of the infected including petioles and young branches of infected plants. The spots become greenish to reddish brown and later turn brown to black. The coloured, spider web like mycelial growth and white microsclerotia develop in abundance on the affected plant parts. The mycelium on infected leaves appears as a spider web thus suggested the name web blight disease.

Shailbala and Tripathi (2007) described the symptoms of web blight on urd bean and reported that symptoms of web blight occur on roots, stems, petioles and pods but the disease is the most destructive on foliage. The pathogen is soil borne, seed borne and airborne in nature. During second to third week of plants growth, it causes seedling mortality. Seed decay, pre and post emergence mortality. The first symptoms appear as small circular brown spots on the primary leaves. These spots enlarge, often show concentric banding and surrounded by irregular water soaked areas. The lesion expands and coalesces and white mycelial fungal growth can be seen under surface of infected leaves and young branches.

Godoy-Lutz *et al*. (2008) observed at least six different subgroups of *Rhizoctonia solani* causing web blight symptoms in common bean.

Kumar *et al*. (2018) reported that production and productivity of urdbean ranks lower in India as compared to that of world average due to the biotic and abiotic constraints. Web blight of Urdbean is caused by *Rhizoctonia solani* Kuhn and is a soil borne pathogen and initial inoculum come mainly from soil splashes which fall on leaves during heavy rains. Respective optimum temperature and relative humidity i.e. 26–28^{o}C and 90–100% favors disease development chronically. The pathogen can survive very longer in the absence of a host either as sclerotia or thick walled brown hyphae in plants debris. Currently the disease is prevalent in many countries across the globe. The pathogen is highly variable in terms of its pathogenecity, culture, morphology, biochemical and molecular characteristics. The severity of this disease is directly linked with the population of viable sclerotia in the soil. Yield losses due to this disease vary in between 20-30% depending upon prevailing conditions.

2.3 Cultural characteristics

2.3.1 Cultural characteristics of *Rhizoctonia solani*

Thakur *et al.* (1992) studied the colony characteristics of 19 isolates of *Rhizoctonia solani* and characterized them into 3 distinct morphological groups*i.e.* microsclerotial, macrosclerotial and non-sclerotial.

Singleton *et al*. (1992) reported that *R. solani* morphology was characterised by brown septate hyphae with right-angle branching and a slight constriction in the hyphae prior to branching. The fungus does not produce clamp connections, rhizomorphs or conidia (asexual spores) and if sclerotia are produced they are not differentiated into rind and medulla.

Lakpale *et al.* (1997) studied the mycelial growth and sclerotial formation of rice isolates of *Rhizoctonia solani* and reported that 30^0C temperature is best for growth. Desiccation of sclerotia and compactness of basal medium did not influence mycelia growth and sclerotial formation.

Meena *et al.* (2001) reported that Potato dextrose agar medium supported the maximum mycelial growth and sclerotial production, while the minimum mycelia growth and sclerotial production were observed in Czapek's Dox medium.

Tiwari and Khare (2002) reported that Czapek's Dox Agar was best for sclerotial production. Isolates were grouped based on sclerotia colour and forming pattern. It was observed that isolates produced two groups forming dark brown and light brown sclerotia. However, based on sclerotia forming pattern, they were grouped into 3 groups of excellent, good and fair.

Zhou *et al.* (2002) studied the effect of 12 media on the mycelia growth, sclerotial number and mass of *Rhizoctonia solani* AG-1IA. Cooked rice straw extract agar, water agar, PDA and maltose agar were found better media for *Rhizoctonia solani*, while beef extract peptone agar was the worst medium. Richards's agar was recorded best for sclerotial formation and maximum sclerotial numbers and mass was obtained in this medium.

Grosch and Kofoet (2003) reported that hyphal growth of *R. solani* isolates was existing in a temperature range of 20°C - 30°C with an optimum at 25°C depicting maximum mycelium growth.

Singh and Singh (2007) observed maximum fungal colony diameter (89.7 mm) of *Rhizoctonia solani* on potato dextrose agar (PDA), which was at par with PDA + rice leaf extract agar. Maximum sclerotial production was recorded on PDA followed by Richard's agar, soybean decoction sucrose agar and B-R agar.

Ray and Kumar (2009) reported that Czapek's dox agar maximum supported the mycelial growth and sclerotial production of *Rhizoctonia solani* followed by Potato dextrose agar, Richard's medium and Corn meal agar media. Maximum colony diameter and sclerotial production were recorded at 30^0C and maximum mycelial dry weight was recorded at pH 7.0, while minimum at pH 3.0.

Prasad and Kumar (2013) observed the cultural and morphological characteristics of *Rhizoctonia solani* on different solid media viz., Potato Dextrose Agar (PDA) medium, Czapek's Dox Agar (CDA) medium and Rose Bengal Agar (RBA) medium. On PDA, mycelial growth was abundant, but sclerotia production was delayed. On CDA, though the mycelial growth was moderate and slower than on PDA, sclerotia production was early.

Goswami *et al*. (2010) reported that *Rhizoctonia solani*collected from the soil samples of different agro-ecological zones of Bangladesh were classified into five different clusters on basis of morphological and cultural characters.

Sharma *et al*. (2013) isolated six isolates of *R. solani* from soybean which were further characterized on the basis of cultural and physiological nature and colony diameter, growth, coloured and sclerotia formation were recorded. Potato Dextrose Agar (PDA) was found best for growth and development. The isolates were grown on varied range of temperatures *i.e.* 10, 15, 25, 30, 35 and 40^0C and growth of different isolates of *R. solani* was recorded at 10 - 40^0C. It was observed that isolates showed maximum growth at 30^0C. Isolates were grown on five broth media (Asthana & Hawkers, Potato Dextrose broth, Czapek's Dox broth, Corn Meal broth and Richards's broth) for fresh and dry weight. It was recorded that corn meal agar medium produced maximum fresh and dry mycelium mass.

Upmanyu and Paul (2013) isolated forty isolates of *Rhizoctonia solani* from different hosts and they recorded that isolates exhibited variation in respect of cultural, morphological, physiological characteristics and anastomosis behavior.

Parmeter and Whitney (1970) and Ogoshi (1985) conducted their studies on cultural characterization and pathogenecity. It was observed that fungus which cause aerial foliar blight and dieback of durian is *R. solani* Kuhn (*teleomorph- Thanatephorus cucumeris* (Frank Donk), and the isolates studied, exhibited indistinguishable characteristics.

2.4 **Management**:

2.4.1 Phytoextracts:

Yoon *et al.* (2013) reported that plants are attacked by various phyto-pathogenic fungi. For many years, synthetic fungicides have been used to control plant diseases. Although synthetic fungicides are highly effective and their repeated use has led to problems such as environmental pollution, development of resistance with residual toxicity. This has prompted intensive research on the development of bio pesticides, including botanical fungicides. To date, relatively few botanical fungicides have been registered and commercialized. However, many scientists have reported isolation and characterization of a variety of antifungal plant derivatives.

Some plants are known to possess certain antifungal compounds and plant pathologists are endeavoring to exploit their use in disease management. Tewari (1984) reported that leaf extract of Henna or tree mignonette (*Lawsonia innermis*), Betel leaf (*Piper betle*) and Bale tree (*Aegle marmelos*) are toxic to the mycelia and sclerotia of *R. solani* from rice and less toxic to rice plant. *Piper betle* and *Ocimum sanctum* were very effective in reducing the fungal growth in *vitro* and check the spread of sheath blight disease in vivo (Tewari and Mandakini 1991). Some essential oils of *Citrus sinensis*, *Eucalypus globulues, Ocimum canum* and *Pinus roxburghii* were also toxic to the fungus indicating the presence of antifungal compounds in them (Shukla *et al*. 1990). reported that *Cymbopogon citrate* oil and extracts of *Cymbopogon maxima* and *Annona squamosa* completely inhibited in – *vitro* growth of *R. solani*. The *R. solani* growth was also completely inhibited by crystalline mimosine and crude extract of mimosine from seeds of Leucaena leucocephala at 1:10 dilution (Radha, 1991).

Fifty per cent aqueous extracts of Bracken fern (*Diplazim esculentum*), Goat weed (*Ageratum houstonianum*) and Polygonum (*Polygonum plebeleium*) were found to exhibit more than 90 per cent in *vitro* inhibition of *R. solani* while in *vivo* results also confirmed that Bracken fern extract followed by Goat weed and Sickle pod senna (*Cassia tora*) extract resulted in significant reduction in lesion length (Sharma *et al.*1999) in rice.

Kumar *et al.* (2017) reported in their study about the antifungal efficacy of botanicals against sheath blight of rice and the botanicals viz., neem (*Azadirachtaindica)*, tulsi (*Ocimum sanctum*), garlic (*Allium sativum*), onion (*Allium cepa*), ginger (*Zingiber officinale*) and various fungicides namely mancozeb, propiconazole, hexaconazole, carbendazim, and copper oxychloride against *Rhizoctonia solani* in vitro by poisoned 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 *Azadirachta indica* (72.78 %) after 72 phi. Among the fungicides, the complete fungal growth inhibition was observed in propiconazole and carbendazim fungicides amended medium.

Patole *et al.* (2016) reported the effects of botanical extract on root rot of soybean under glass house condition from pot culture experiment in glass house and it was found that minimum PDI was observed in seed treatment with botanical extracts viz., *Zingiber officinale* L. (31.48) followed by *Allium sativum* L. (35.18) and *Azardirachta indica* (40.18).

Seema *et al.* (2011) studied the antifungal effect of 10 plant extracts viz., *Thevetia peruviana, Ocimum basilicum,* Piper betel, *Murraya koenigii, Chrysanthemum coronarium, Polyalthia longifolia, Catharanthus roseus, Pelargoniumgraveolens, Moringa officinalis* and *Lawsonia inermi*s by poisoned food technique against *Rhizoctonia solani* Kuhn, the causal organism of sore shin disease of tobacco. Among all the plants screened only four plants namely, *Lawsonia inermis*, Piper betel, *Polyalthia longifolia* and *Pelargonium graveolens* have recorded significant antifungal activity against *Rhizoctonia solani*. The effective concentration inhibiting the growth of mycelium and sclerotia formation of the pathogen by the plant extract of *Piper betel* was at 50% concentration. However, *Lawsonia inermis* inhibited the growth at 75%, and *Polyalthia longifolia* and *Pelargonium graveolens* suppressed the growth at 100% concentration. Organic solvents viz., n-hexane, ethyl acetate and methanolic extracts of four plants viz., *Lawsonia inermis*, Piper betel, *Polyalthia longifolia* and *Pelargonium graveolens* were investigated for their antifungal activity against this phyto pathogenic fungus. Ethyl acetate extracts showed 100% inhibition of mycelial growth and sclerotia formation of *Rhizoctonia solani* at 1000 ppm. Methanol extracts moderately inhibited the growth at 1000 ppm and n-hexane extracts were not effective against the test organism. Aqueous extract of *Piper betel* can be recommended to the farmers for the control of *Rhizoctonia solani.*

Castillo *et al.* (2013) revealed that there is a lack of knowledge about the antimicrobial activity of plant extracts obtained with organic solvents different to ethanol, methanol or acetone. They reported that plant extracts from *Larrea tridentata*, *Flourensia cernua*, *Agave lechuguilla*, *Opuntia* sp. and *Yucca* sp., obtained with alternative organic solvents (lanolin and cocoa butter) and water were tested against the fungus *Rhizoctonia solani*. In addition, the IC_{50} concentration of each plant extract was determined. Extractions using the alternative organic solvents permitted the extraction of tannins in higher amount than those obtained using water as solvent. Tannin extraction was strongly dependent on plant species as well as on the solvent used. Results showed that extracts from *L. tridentata* and *F. cernua* using lanolin and cocoa butter to dozes 2000 and 1000 ppm of total tannins inhibited 100% the *R. solani* growth. The IC_{50} for each extract was highly variable; the lowest IC_{50} value was obtained with *L. tridentata* extract using lanolin to 1.85×10^2 ppm. The lanolin and cocoa butter solvents allowed high recovery of polyphenolic molecules with strong antifungal activity against *R. solani*, and offer an alternative in production of antimicrobial agents for organic agriculture.

Abdulaziz *et al.* (2010) reported that antifungal activity of ethanol-water extracts of four medicinal plants, cinnamon (*Cinnamomum verum Presl*.), anise (*Pimpinella anisum* L.), black seed (*Nigella sativa* L.) and clove (*Syzygium aromaticum* L. Merr. & Perry.) against pea (*Pisum sativum* L.) root-rot fungus *Rhizoctonia solani*. *In vitro* antifungal activity test showed a high growth inhibition at concentration (4%) of each plant extract. The highest antifungal activity was recorded for clove extract which caused complete growth inhibition at concentration of 1%. Efficacy of clove extract on disease incidence of *Rhizoctonia* root-rot of pea was investigated in the greenhouse pot experiment. Clove extract at concentration 4% as well as the chemical fungicide recorded highly significant increase in the percentage of survived plants (40 and 48%, respectively) and highly significant decrease in disease incidence.

2.4.2 Fungicides:

Akhtar (2014) conducted his study for the management of different diseases of green and black gram through chemicals and reported that two foliar sprays of propiconazole @ 0.1% at an interval of 8-10 days was most effective as it reduced severity of Cercospora leaf spot (85.77 and 80.10 %), web blight (77.87 and 85.29 %) and powdery mildew (100.00 % each) with average yield of 9.08 and 8.83q/ha of green gram and black gram, respectively.

Basandrai (2016) reported that web blight caused by *Rhizoctonia solani* causes huge yield loses in urdbean (*Vigna mungo*). All the commercially grown varieties are susceptible. Hence, more than ten fungicides were evaluated as foliar sprays during kharif season 2005, 2007-2010 using susceptible variety UL 338. Two foliar sprays of fungicides, namely; hexaconazole 5EC (Contaf 5EC)@ 0.1%, difenconazole 25EC (Score 25EC) @ 0.05%, carbendazim 50WP (Bavistin 50WP) @ 0.1% and propiconazole 25EC (Tilt 25EC) @ 0.1% significantly reduced the disease severity resulting in 81.1, 80.6, 65.9 and 76.2% control over unsprayed check with corresponding mean yield of 872, 821, 791 and 754 kg/ha compared with the mean yield of 584 kg /ha in unsprayed control .

Shailbala (2010) reported that eight fungicides and one bio-control agent were screened in vitro against *Rhizoctonia solani* causal agent of web blight of urdbean. Propiconazole, hexaconazole, carbendazim, tebuconazole and epoxiconazole were tested at 1.25, 2.5, 5.0 and 10 µg/ml concentration where as mancozeb, probineb and thiophanate methyl at 25, 50, 100 & 200 µg/val concentration respectively. Epoxiconazole inhibited the growth at 2.5, 5.0, and 10 µg/ml concentration while propiconazole at 5.0 and 10.0 µg/ml. Carbendazim was effective at 10.0 µg/ml and mancozeb at 200 µg/ml where as thiophanate methyl was effective at 100 µg/ml and 200 µg/ml. However, tebuconazole and probineb showed non-significant effects. Based on effectiveness of fungicides *in vitro*, they further evaluated them under field conditions. Propiconazole @ 0.1% applied thrice as prophylactic spray showed lower disease severity, higher grain yield as well as maximum 1000 grain weight followed by carbendazim @ 0.1%, mancozeb @ 0.25% respectively.

Kumar *et al.* (2017) reported that six fungicides were tested at different concentration *in vitro* and *in vivo* for the management of web blight of urd bean. Tilt, contaf, and bavistin were screened against *R. solani* at 1.0, 5.0, 10.0, 15.0 and 20.0 ppm concentrations for their antifungal activity where as captaf, sulphur, and mancozeb at 1.0, 25.0, 50.0,100.0 and 400.0 ppm concentrations, respectively. They observed that at 15ppm concentration bavistin (0.1%), tilt (0.1%) completely checked the growth of the fungus. Based on effectiveness of fungicides under *in vitro* conditions, field evaluation of selected fungicides was conducted for the management of *R. solani*. It was observed that Bavistin @ 0.1% applied as seed treatment followed by foliar spray showed lowest disease severity, highest grain yield as well as maximum 1000grain weight followed by tilt @ .1 per cent.

Basandrai *et al.* (1999) reported that one hundred diverse stocks of blackgram were evaluated during 1995-97 against 5 diseases widely prevalent in Himachal Pradesh. The different genotypes of blackgram showed varying levels of resistance to anthracnose, *Colletotrichum lindemuthianum* (Sacc. and Magnus) Brioso and Cavara, *Cercospora* leaf spot, *Cercospora canescens* (Ell, and Martin, Mulder and Holliday) and *C. cruenta* (Sacc.), powdery mildew, *Sphaerotheca fuliginea* (Schlecht ex Fr Poll), web blight, *Rhizoctonia solani* Kuhn and mung yellow mosaic virus and mung yellow mosaic gemini virus respectively.

Two genotypes 'HPBU 51' and 'P 38' were found resistant to Cercospora leaf spot, powdery mildew, web blight and mung yellow mosaic virus. Nine genotypes were resistant to two diseases ie 'HPBU 38', 'HPBU 153', 'LBG 626' and 'UG 367' (mung yellow mosaic virus and web blight) 'HPBU 78' (mung yellow mosaic virus and powdery mildew), 'HPBU 98'(Cercospora leaf spot and powdery mildew), 'P 44' (anthracnose and web blight), 'WBG 57' (*Cercospora* leaf spot and web blight), 'WVG 108' (*Cercospora* leaf spot and mung yellow mosaic virus), whereas 5 genotypes were resistant to 3 diseases, viz 'KU 305' and 'WVG 110' (anthracnose, *Cercospora* leaf spot and mung yellow mosaic virus), 'Pusa 3' and 'UPU 91-

7' (anthracnose, mung yellow mosaic virus and web blight) and 'UG 407' (*Cercospora* leaf spot, mung yellow mosaic virus and powdery mildew).

Akhtar (2014) reported that field screening conducted during Kharif, 2008 and 2009 revealed that out of 31 genotypes of green gram, only one genotype ML 1299 and out of 14 genotypes of black gram, only 3 genotypes viz, BS 2-3, IPU 02-43 and B 3-8-8 showed resistant or highly resistant response against multiple diseases including *Cercospora* leaf spot, web blight and powdery mildew.

MATERIAL AND METHODS

The present study entitled "**Studies on *Rhizoctonia solani* (Kuhn) causing web blight of urd bean and its management**" was carried out at Department of Plant Pathology, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur (MP). The details of materials used and procedures adopted in experimentation are described under the following headings.

3.1 Glasswares and chemicals

Whenever required, the glassware of Borosil, blotter paper of standard grade and chemicals of standard grade (Qualigens fine chemicals etc.) were used during the course of investigation. All the glasswares, polythene bags etc. were procured from the Department of Plant Pathology, College of Agriculture, Jabalpur (MP). All the chemicals were procured from Department of Plant Pathology, College of Agriculture, Jabalpur (MP).

3.2 Equipments used

The equipments and/or materials used in present investigation were as following -

1. Autoclave for media sterilization
2. BOD incubator for incubation
3. Hot air oven for glassware sterilization
5. Forceps, needles, blades, inoculation needle
6. Laminar air flow for isolation and purification
7. Sprit lamp
8. Electronic weighing balance
9. Refrigerator
10. Thermometer

3.3 Cleaning and sterilization of materials

Before use, glasswares were cleaned with detergent powder and washed with tap or distilled water as per requirement of the experiment. The dried glasswares were sterilized in hot air oven at 160˚C for 2 hours. The forceps, inoculation needle and other metallic instruments were sterilized by dipping them in alcohol and heating over the flame of sprit lamp before using. The medium and distilled water employed were sterilized in autoclave at 15lbs p.s.i at 121.6°C for 15 minutes.

3.4 Experimental site:

The present investigations were carried out at the Department of Plant Pathology, JNKVV Jabalpur. All *in vitro* studies on *Rhizoctonia solani* were conducted in the laboratory of Department of Plant Pathology, JNKKV, Jabalpur.

3.5 Culture Media

Following media were used during laboratory studies. For each set of treatment different replications were used in all the *in vitro* studies. In general, in each petriplate about 15-20 ml of the medium was poured. Composition of different media are as following:

(I) Potato Dextrose agar medium

Pealed potato	-	200 g
Dextrose	-	20 g
Agar- Agar	-	20 g
Distilled Water	-	1000 ml

(II) Corn meal agar

Corn meal power	-	20.0 g
Glucose	-	20.0 g
Agar- agar	-	20.0 g

Distilled water	-	1000 ml

(III) Richards agar

Potassium nitrate	-	10 g
Monopotassium		
Dihydrogen phosphate	-	5 g
Magnesium sulphate	-	2.5 g
Ferric chloride	-	0.02 g
Sucrose	-	50 g
Agar- Agar	-	20 g
Distilled water	-	1000 ml

(IV) Czapek's Dox Agar medium

Potassium chloride	-	0.5 g
Di potassium hydrogen phosphate	-	1 g
Magnesium sulphate	-	0.5 g
Ferrous sulphate	-	0.01 g
Sodium nitrate	-	2 g
Sucrose	-	30 g
Agar-agar	-	20 g
Distilled water	-	1000 ml

3.5.1 Potato Dextrose Agar

Required amount of peeled potato was cut into fine pieces. It was boiled in 500 ml of distilled water for 30 minutes and filtered through muslin cloth. Thereafter, 20 g of dextrose and 20 g of Agar-agar were dissolved in 500 ml boiling water. Potato extract was added in boiling mixture and mixed thoroughly by stirring with glass rod. After few minutes of boiling it was transferred to, about 200 ml in each, 500 ml capacity flasks and plugged with non- absorbent cotton. The pH of the medium was adjusted to 7.0 ± 0.2 and autoclaved at 15 lbs p.s.i. at 121.6°C for 15 minute.

3.5.2 Czapek's Dox Agar (C_ZDA)

A quantity of 35 grams of the medium was suspended in one litre of distilled water. It was mixed well and dissolved by heating with frequent agitation. Boiled until complete dissolution. Dispensed about 200 ml in each, 500 ml capacity flasks and plugged with non- absorbent cotton and sterilized in autoclave at 15 lbs pressure (121°C) for 15 minutes. The pH of the medium was adjusted to 7.0 ± 0.2. The prepared medium was stored at 4°C. The color was colorless and showed a slight precipitate. The dehydrated medium was homogeneous, free-flowing and clear beige in color. If there was any physical change, the medium was discarded.

3.5.3 Richard's medium

A quantity of 82.52 grams of the medium has suspended in one litre of distilled water. It was mixed and dissolved by heating with frequent agitation. Boiled until complete dissolution. Dispensed about 200 ml in each, 500 ml capacity flasks and plugged with non- absorbent cotton and sterilized in autoclave at 15 lbs pressure (121°C) for 15 minutes. Cooled to 50ºC, mixed well and dispensed into Petri dishes. The prepared medium was stored at 2-8°C.

3.5.4 Corn Meal Agar (CMA)

A quantity of 17 grams of the medium has suspended in one litre of distilled water. Mixed well and dissolved by heating with frequent agitation. Boiled until complete dissolution. Dispensed about 200 ml in each, 500 ml capacity flasks and plugged with non- absorbent cotton and sterilized in autoclave at 15 lbs pressure (121°C) for 15 minutes. Cooled to 50ºC, mixed well and dispensed into Petri dishes. The prepared medium was stored at 8-15°C. The color was opaque and white. The dehydrated medium was homogeneous, free-flowing and beige in color. In case of any physical changes, the medium was discarded.

3.5.5 Potato Dextrose broth

Required amount of peeled potato was cut into fine pieces. It was boiled in 500 ml of distilled water for 30 minutes and filtered through muslin cloth. Thereafter, 20 g of dextrose was dissolved in 500 ml boiling water. Potato extract was added in boiling mixture and mixed thoroughly by stirring with glass rod. After few minutes of boiling it was transferred about 200 ml in each, 500 ml capacity flasks and plugged with non- absorbent cotton. The pH of the medium was adjusted to 7.0 ± 0.2 and autoclaved at 15 lbs p.s.i. at 121.6°C for 15 minute.

3.6 Slant preparation and PDA plating

The melted potato dextrose agar (PDA) medium was transferred @ 5 ml per culture tube. While transferring care was taken that medium should not touch the inner wall of culture tubes. The culture tubes were sterilized at 15 lbs p.s.i. at 121.6°C for 15 minutes. After sterilization, it was allowed to solidify in slanting position and then stored in refrigerator for further use. Similarly, the sterilized and melted medium was poured aseptically in sterilized petri plates @ 20 ml per petri plate.

3.7 Isolation and purification procedure for *R. solani*

The entire work of isolation was done in a laminar air flow which was sterilized by UV light, alcohol or formaldehyde prior to use.

The diseased samples showing typical symptoms of web blight of urd bean were thoroughly washed repeatedly in tap water. Thereafter, small pieces measuring about 5 mm were cut using sterilized blade, for isolation. Care was taken to ensure that each cut piece had healthy parts as well. The pieces were then surface sterilized in mercuric chloride ($HgCl_2$) solution (1:1000) for 20-30 sec. followed by three thorough rinsing in sterilized distilled water. The surface sterilized pieces were then aseptically transferred separately to the slants/plates containing Potato dextrose agar medium and then incubated at 24 ± 2°C. After 48-72 h of incubation, the growing mycelium from the margin of apparently distinct colonies was sub cultured and purified on fresh PDA slants. In this way, the culture of different isolates of *R. solani* was maintained. Culture of *R. Solani* was identified on the basis of characters illustrated by Ceresini (1999).

3.8 *In vitro* evaluation of cultural and morphological characters of *Rhizoctonia solani* causing web blight of urd bean.

Cultural characters of *R. solani* were studied on 20 ml sterilized Potato Dextrose Agar medium. Five mm mycelium disc of *R. solani* isolates were transferred aseptically at the center of each Petri plate in three replications and incubated at 24±2ºC for 15 days. Colony characters were recorded as follows: a) growth of the fungus, b) ability to produce sclerotia, c) appearance:- submerged/cottony/fluffy d) formation of sclerotia:- scattered/smooth/clumped; shape of sclerotia.

3.9 Cultural characteristics and Radial growth

Cultural characteristics of *Rhizoconia solani* was studied on four culture media namely Potato Dextrose Agar (PDA), Czapek's Dox Agar (C_ZDA), Richard's medium and Corn Meal Agar (CMA).

3.9.1 Effect of temperature on growth of *R. solani* isolates

Effect of four different temperatures viz*.* 15°C, 20°C, 25°C and 30°C, was studied on growth of *Rhizoctonia solani* on potato dextrose agar. Mycelial discs of 5mm diameter were cut from the edge of 3 days old culture of five isolates grown at 25ºC and were transferred to the center of 90mm Petri dish and incubated at different temperatures. Each treatment was replicated three times in a completely randomized design. The average diameter of the fungal colony was recorded at 24 hrs, 48 hrs, 72 hrs, 96 hrs and 120 hrs after incubation.

3.9.2 Effect of pH on growth of *R. solani* isolates

Effect of six different pH viz*.* 4, 5,6,7,8 and 9 was studied on growth of *Rhizoctonia solani* on potato dextrose agar. The pH of the medium was adjusted to desired level by using N/10HCl or N/10NaOH.Mycelial discs of 5mm diameter were cut from the edge of 3 days old culture of five isolates grown at 25ºC and were transferred to the center of 90mm Petri dish and incubated at different temperatures. Each treatment was replicated three times in a completely randomized design. The average diameter of the fungal colony was recorded at 24 hrs, 48 hrs, 72 hrs, 96 hrs and 120 hrs after incubation.

3.9.3 *In-vitro* evaluation of phyto-extracts against *Rhizoctonia solani*

Plant based pesticides i.e., botanicals which are relatively economical, safe and non-hazardous have been used against the multiphagous pathogenic fungus *R. solani*. A total of eight plant extracts/ botanicals (Table 1) were selected to know their efficacy against mycelial growth of *R. solani*. These extracts/botanicals were tested by using poisoned food technique (Nene and Thapliyal, 1973) at two different concentrations of 10 and 20 per cent.

3.10.1 Preparation of phyto-extracts:

Fresh plant materials were collected and washed first in tap water and then in distilled water. Hundred grams of fresh sample was chopped and then crushed in a surface sterilized mixer & grinder by adding 100 ml sterile water (1:1 w/v). The extract was filtered through Whatman filter paper No.1, thereafter centrifuged at 8000- 10000 rpm and filtered through bacteria-proof MF-Millipore membrane filters (thickness, 0.22 µm) under aseptic conditions. The filtrate was used as stock solution. Ten and twenty ml of stock solution was mixed with 90 and 80 ml of sterilized molten PDA medium respectively, so as to get 10 and 20 per cent concentrations. The medium was thoroughly shaken for uniform mixing of the extracts. Twenty ml of the medium was poured into sterile Petri plates (90mm). The mycelial discs of five mm size from actively growing (4 days old) culture of the *R. solani* were cut by using sterile cork-borer and one such disc was placed in inverted position at the centre of each PDA plate and incubated at 27±1°C for seven days in BOD incubator. The per cent inhibition of the radial growth of the pathogen over control was calculated by using the formula given by Vincent (1947), as depicted below.

$$\text{Per cent growth inhibition} = (C-T) \times 100/C$$

Where,

C = Radial growth of test pathogen in check plate

T = Radial growth of test pathogen in the treatment plate

Table 1 : Name of antifungal plant, formulation and their doses

Treatment	Name of plant	Local name	Formulation	Concentration (%)
T_1	*Allium cepa*	Onion	Bulb powder	10, 20
T_2	*Azadirachta indica*	Neem	Leaf powder	10, 20
T_3	*Ocimum santum*	Tulsi	Leaf powder	10, 20
T_4	*Allium sativum*	Garlic	Bulb powder	10, 20
T_5	*Pongamia glabra*	Karan	Leaf powder	10, 20
T_6	*Datura stramonium*	Dhatura	Leaf powder	10, 20
T_7	*Jetropha curcas*	Jatropha	Leaf powder	10, 20
T_8	*Curcuma longa*	Turmeric	Leaf powder	10, 20
T_9	PDA as control	-	-	-

3.11 Effect of fungicides on radial mycelium growth of *Rhizoctonia solani*

In order to find out suitable fungicides for management of *Rhizoctonia solani* of black gram six fungicides namely Azoxystrobin, propconazole, tebuconazole, Carbendazim and copper oxychloride along with control was evaluated against *Rhizoctonia solani* by following the poisoned food technique under *in vitro* condition. PDA poisoned with each fungicide quantity was poured into three sterilized petriplates @ 20 ml/plate and allowed to solidify. Plates containing PDA without fungicide served as check. After solidification each petriplate was inoculated with 5 mm mycelial disc aseptically. Plates were incubated at 28 $\pm$ 1^0C and observation on radial mycelium growth of test fungus. Growth was measured at 48, 72 and 96 hours the colony in the control plate was covered with the growth of mycelium of pathogen. The details about fungicides have been give in table

2 and 3. The per cent inhibition of the radial growth of the pathogen over control was calculated by using the formula given by Vincent (1947), as depicted below.

Per cent growth inhibition= (C-T) X 100/C

Where,

C = Radial growth of test pathogen in check plate

T = Radial growth of test pathogen in the treatment plate

Table 2: List of fungicides with their trade name and chemical name

Common Name	Trade Name	Chemical Name	Manufacturer
Azoxystrobin	Amistar	Methyl (2E)-2-(2-{[6-(2-cyanophenoxy)pyrimidin-4-yl]oxy}phenyl)-3-methoxyacrylate	Syngenta India Ltd.
Propiconazole	Tilt	1-[[2-(2,4-dichlorophenyl)-4-propyl-1,3-dioxolan-2-yl]methyl]-1,2,4-triazole	Syngenta India Ltd.
Difenocnazole	Score	1-((2-(2-Chloro-4-(4-chlorophenoxy)phenyl)-4-methyl-1,3-dioxolan-yl)methyl)-1H-1,2,4-triazole	Syngenta India Ltd.
Tebuconazole	Folicur	1-(4-Chlorophenyl)- 4,4-dimethyl-3-(1H, 1,2,4-triazol-1-ylmethyl) pentan- 3-ol	Bayer Crop Science
Carbendazim	Quintal	Methyl 1H-benzimidazol-2-ylcarbamate	Bayer Crop Science
Copperoxychloride	blitox	Copper oxychloride	Rallis India Ltd.

Table 3 : Name of fungicides, formulation and their doses

Treatment	**Name of fungicides**	**Formulation**	**Doses (ppm)**
T_1	Azoxystrobin	Liquid	250,500,1000,1500,2000 ppm
T_2	Propiconazole	Liquid	250,500,1000,1500,2000 ppm
T_3	Difenocnazole	Liquid	250,500,1000,1500,2000 ppm
T_4	Tebuconazole	Liquid	250,500,1000,1500,2000 ppm
T_5	Carbendazim	Powder	250,500,1000,1500,2000 ppm
T_6	Copperoxychloride	Powder	250,500,1000,1500,2000 ppm
T_7	Control	-	-

3.18 Statistical Analysis

The data were analyzed statistically using Complete Randomized Design (CRD). Treatments were compared by mean of critical differences at 5% level of significance.

Skeleton of analysis of variance:

Source of variation	DF	SS	MSS	T.CAL	F.TAB (5%)
Treatments					
Error					
Total					

Test of significance:

To test the significance difference among the treatment means following formula were used for calculating the critical differences.

$$S.Em\pm = \sqrt{\frac{MSE}{r}}$$

C.D. = S.Em × √2 × ‘t’ at error d.f.

Where :

D.F. = Degree of Freedom

S.S. = Sum of square

M.S.S. = Mean sum of square

The significant difference between mean was determined by using critical difference.

$$S.Em \pm = \sqrt{EMss/replication}$$

$$C.D. = S.Ed. \times t\ 5\% \text{ at error d.f.}$$

RESULTS

The results of experiment entitled "**Studies on *Rhizoctonia solani* (kuhn) causing web blight of urd bean and its management**" are presented in this chapter. The experiment was carried out at Department of Plant Pathology, College of Agriculture, Jabalpur (MP). The experimental data have been summarized and the results are presented with statistical analysis and supported with relevant diagrams where ever necessary.

4.1 Collection of diseased samples and Symptomatology

Diseased samples showing typical symptoms of web blight of urd bean were collected from experimental field of Department of Plant Pathology, JNKVV, Jabalpur. Symptoms of web blight disease were carefully observed in urd bean. It was observed that symptoms were present on leaves, stem, pods and petiole. First symptom of web blight appeared as small circular brown spot on the primary young leaves after two months of sowing. Leaf lesions were light to dark brown with distinct zonate patterns. Dark brown lesions were also seen on petioles and branches of the plants. Lesions gradually increased, expanded and coalesced. After appearance of symptoms, whole plant was blighted within a week. Further, it was observed that dead leaves covered with fungal mycelium and were seen hanging around the base of the stem. White mycelial fungal growth was seen under surface of infected leaves and young branches. Sclerotia were observed on severely blighted leaves.

4.1.1 Isolation of *Rhizoctonia solani*

Web blight infected leaf samples were processed for isolation of *R. solani* from infected portion of urd bean leaf. The isolated pathogen was purified and fresh culture was used for further investigation. Web blight infected leaf sample and isolated *R. solani* has been depicted in Plate 1.

4.2 Cultural Characterization

Isolated pathogen *R. solani* causing web blight of urd bean was subjected to cultural characterization based on colony morphology, type, radial growth on different media, pH and temperature.

4.2.1 Colony morphology and radial growth

Five days old culture of *R. solani* on potato dextrose agar medium produced light brown coloured hyphal growth. Microscopic study clearly indicated constriction at the point of branching and right angle branching in matured hyphae. The isolate shared typical characteristics of *R. solani* like a) branching at right angle near the distal septum of the cell in young vegetative hyphae, b) formation of a septum in the branch near the point of origin, c) constriction of the branch at origin d) undifferentiated sclerotia and g) absence of rhizomorphs. Sclerotia were produced after 10 days of growth of culture. The sclerotia were irregular in shape and brown to black in colour. Ten days old culture of *R. solani* showing sclerotia production has been shown in Plate 1.

Colony radial growth was recorded at regular interval on PDA medium and it was observed that after 48 hours of incubation period 23.50 mm radial growth was attained by the culture. However, complete petriplate growth was recorded after 7 days of incubation period. Production of sclerotia started after prolonged incubation of the culture and it started after 10 days of incubation. Thereafter, massive irregular shaped, brown to black coloured sclerotia were produced. Colony radial growth of *R. solani* after different incubation period has been shown in table 4.

Table 4: Colony radial growth of *Rhizoctonia solani* on potato dextrose agar medium after different incubation period

Incubation period (hrs)	Radial Growth (mm)
48 hrs	23.50
72 hrs	34.16
96 hrs	49.50
120 hrs	70.16
144 hrs	89.00

4.2.2 Cultural characteristics of *Rhizoctonia solani* on different media

To identify the suitable medium for colony growth of *R. solani* from urd bean, a set of four different media were used viz. Potato Dextrose Agar (PDA) medium, Czapek's Dox, Richard's Agar and Corn meal Agar medium. Radial growth was recorded on all these four media after different incubation period. In all these media *R. solani* was able to cover the full petriplate growth on 6th day after incubation, but the rate of growth varied determining the preference for a substrate for growth. It was observed that after 48 hrs of incubation period maximum radial growth of 26.16 mm was recorded on Richard's Agar medium followed by 23.50 mm on PDA medium. However, minimum radial growth of 17.6 mm was recorded on Czapek's Dox agar medium. The colony radial growth kept on increasing with increased incubation period until full petriplate growth. After prolonged incubation period of 72 hrs, 96 hrs, 120 hrs and 144 hrs, similar fashion of colony radial growth was recorded and Richard's Agar medium maximum supported the growth of *R. solani* from urd bean. After 144 hrs of incubation period maximum radial growth of 90.00 mm was recorded on Richard's Agar medium. However, Czapek's Dox Agar medium least supported the growth of *R. solani* from urd bean and minimum radial growth of 71.83 mm was recorded. The detailed data for colony radial growth of *R. solani* from urd bean after different incubation period on different media is given in table 5. The colony morphology of *R. solani* on different media did not show any significant variation and light brown-submeged mycelial growth was recorded on all the four media. The graphical representation of colony radial growth of *R. solani* from urd bean after different incubation period on different media is given in fig.1. Pictorial representation of different isolates of *R. solani* from urd bean on different media is given in Plate 2.

Table 5: Effect of different media on mycelial growth of *Rhizoctonia solani* after different incubation period

Treatment	Medium	Colony Radial growth (mm) after*				
		48(Hrs.)	**72(Hrs.)**	**96(Hrs)**	**120(Hrs.)**	**144(Hrs.)**
T_1	PDA	23.50	34.16	49.50	70.16	89.00
T_2	Czapek's Dox Agar	17.16	28.50	38.50	59.50	71.83
T_3	Richard's Agar	26.16	37.83	54.50	75.83	90.00
T_4	Corn meal Agar	19.50	31.50	43.33	66.50	87.58
	S.Em±	A= 0.241,	B= 0.269,		A x B= 0.539	
	CD (5%)	A= 0.691,	B= 0.773,		A x B= 1.546	

*Each value is a mean of three replications.

A = Treatment
B = Replication
C = Interaction (Treatment x Replication)

4.2.3 Effect of temperature on growth of *R. solani*

The *R. solani* was grown on four different temperatures (15°C, 20°C, 25^{0}C and 30°C) and colony radial growth was recorded. It was observed that *R. solani* showed differential behavior at different temperatures. However, at 25^{0}C maximum radial growth of *R. solani* was recorded after different incubation period. Further, it was observed that *R. solani* was not able to grow well at low temperature (15^{0}C and 20^{0}C). However, at 30^{0}C colony radial growth was better than at 15^{0}C and 20^{0}C. At 15^{0}C and 20^{0}C average colony radial growth of *R. solani was* 7.16 mm and 9.5 mm after 48 hrs of incubation period. However, at 30^{0}C 22.5 mm colony radial growth was recorded after 48 hrs of incubation period. The maximum colony radial growth of 24.50 mm was recorded at 25^{0}C after 48 hrs of incubation period. Similar pattern of radial growth was observed after prolonged incubation period of 72 hrs, 96 hrs, 120 hrs and 144 hrs. Maximum radial growth of 90.00 mm was recorded at 25 after 144 hrs of incubation period. However, minimum radial growth of 54.33 mm was recorded at 15^{0}C after 144 hrs of incubation period. In this way 25^{0}C temperature found most suitable for growth of *R. solani*. Detailed data for *R. solani* after different incubation period at four different temperature is presented in table.6. Pictorial representation of effect of temperature on radial growth of *R. solani* has been given in plate.3. The graphical representation of colony radial growth of *R. solani* from urd bean after different incubation periods at different temperature has been presented in figure 3.

Table 6: Effect of different temperatures on mycelial growth of *Rhizoctonia solani* after different incubation periods

Treatment	Temperature	Colony Radial growth (mm) after*				
		48(Hrs.)	72(Hrs.)	96(Hrs)	120(Hrs.)	144(Hrs.)
T_1	15^0C	7.16	16.66	27.50	35.00	54.33
T_2	20^0C	9.50	22.16	33.50	46.33	71.50
T_3	25^0C	24.50	41.16	61.00	79.16	90.00
T_4	30^0C	22.50	35.33	57.50	76.50	88.16
	S.Em±	A= 0.263,	B= 0.294,		A x B= 0.588	
	CD (5%)	A= 0.754,	B= 0.844,		A x B= 1.687	

*Each value is a mean of three replications.

A = Treatment
B = Replication
C = Interaction (Treatment x Replication)

4.2.4 Effect of pH on growth of *R. solani*

The pH of the medium always plays a crucial role in growth and sporulation of the fungus. To identify the suitable pH for maximum growth of *R. solani*, it was grown on six different pH (4, 5, 6, 7, 8 and 9) under laboratory conditions on potato dextrose agar medium and colony radial growth was recorded. It was observed that *R. solani* showed differential behaviour at different pH. However, maximum radial growth of *R. solani* was recorded a pH 7.0 after different incubation periods. Further, it was observed that neutral pH 7.0 and slightly alkaline pH favours the colony growth of *R.solani* in comparision to acidic pH. Maximum colony radial growth of 25.33 mm was recorded at 7.0 pH after 48 hrs of incubation period. However, colony radial growth kept on reducing on increasing or decreasing the pH of the medium. Slightly alkaline conditions of the medium favoured better for colony radial growth of *R. solani* in comparision to acidic conditions and it was observed that colony radial growth of 22.00 mm was recorded at pH 8.0 after 48 hrs of incubation period. However, at pH 6.0

15.83 mm colony radial growth was recorded after 48 hrs of incubation period. Minimum colony radial growth of 6.66 mm was recorded at pH 4.0 after 48 hrs of incubation period. Similar pattern of radial growth was observed after prolonged incubation period of 72 hrs, 96 hrs, 120 hrs and 144 hrs on different pH of the medium. Maximum radial growth of 89.83 mm was recorded at pH 7.0 after 144 hrs of incubation period. However, minimum radial growth of 55.50 mm was recorded at pH 4.0 after 144 hrs of incubation period. In this way neutral pH 7.0 found most suitable for growth of *R. solani*. Detailed data for *R. solani* after different incubation period at six different pH are presented in table 7. Pictorial representation of effect of pH on radial growth of *R. solani* is given in plate 4. The graphical representation of colony radial growth of *R. solani* from urd bean after different incubation periods at different pH is presented in figure 3.

Table 7: Effect of different pH on mycelial growth of *Rhizoctonia solani* after different incubation periods

Treatment	**pH**	**Colony Radial growth (mm) after***				
		48(Hrs.)	**72(Hrs.)**	**96(Hrs)**	**120(Hrs.)**	**144(Hrs.)**
T_1	4.0	6.66	17.16	25.50	37.53	55.50
T_2	5.0	11.00	23.16	41.83	54.66	75.50
T_3	6.0	15.83	31.50	52.33	65.83	80.50
T_4	7.0	25.33	39.50	67.50	82.83	89.83
T_5	8.0	22.00	43.66	56.50	70.50	88.50
T_6	9.0	17.50	37.83	37.83	57.33	85.33
	S.Em±	A= 0.240,	B= 0.219,		A x B= 0.536	
	CD (5%)	A= 0.680,	B= 0.621,		A x B= 1.521	

*Each value is a mean of three replications.

A = Treatment
B = Replication
C = Interaction (Treatment x Replication)

4.2 Effect of phyto-extracts on mycelial growth of *Rhizoctonia solani*

A set of eight phytoextracts including Onion, Neem, Tulsi, Garlic, Karanj, Dhatura, Jatropha and Turmeric were used to evaluate their efficacy in inhibiting *R. solani* at 10 % and 20 per cent concentrations under in-vitro conditions using poisoned food technique. Colony radial growth was measured after 120 hrs and 144 hrs of incubation and per cent inhibition in growth of *R. solani* was calculated in comparision to control.

All the eight tested phytoextracts significantly inhibited the growth of *R. solani* under *in vitro* conditions. However, inhibition in growth of *R. solani* varied from treatment to treatment. The data presented in the table 8 revealed that after 120 hrs of incubation maximum radial growth of 39.33 mm and 34.33 mm was recorded in 10 and 20% Jatropha leaf extract. However, minimum radial growth of 8.00 mm and 5.25 mm was recorded in 10 and 20% garlic bulb extract. The per cent inhibition in growth of *R. solani* was calculated and it was observed that per cent inhibition in growth of *R. solani* ranged from 51.64 % to 90.16 %. The maximum per cent inhibition (90.16 %) in growth of *R. solani* was shown by garlic bulb extract followed by Onion bulb extract where as 72.14 % inhibition was recorded after 120 hrs of incubation period at 10 per cent concentration. On increasing the concentration of phytoextracts from 10 to 20 %, the per cent inhibition in growth of *R. solani* also increased. After 120 hrs of incubation, maximum inhibition of 96.93 % in growth of *R. solani* was recorded by 20 % garlic bulb extract. However, minimum inhibition of 57.79 % was recorded in 20 % Jatropha leaf extract. The detailed data for mean radial growth of different treatments at 10 and 20 % concentration after 120 hrs of incubation has been presented in (table 8). The graphical representation of mean radial growth of different treatments at 10 and 20 % concentration after 120 hrs of incubation has been presented in fig.4.

The efficacy of phytoextracts was also recorded after prolonged incubation of 144 hrs where growth of control plate was full and it was observed that after 144 hrs of incubation maximum radial growth of 67.33

mm and 63.83 mm was recorded in 10 and 20% Jatropha leaf extract. However, minimum radial growth of 15.50 mm and 4.50 mm was recorded in 10 and 20% garlic bulb extract. The per cent inhibition in growth of *R. solani* after 144 hrs of incubation ranged from 25.05 to 82.75 % and 32.84 to 94.99 % respectively at 10% and 20% concentration of phytoextracts. After 144 hrs of incubation, maximum inhibition of 94.99 % in growth of *R. solani* was recorded by 20 % garlic bulb extract. However, minimum inhibition of 32.84 % was recorded in 20% Jatropha leaf extract. In this way, out of eight phytoextracts tested, three phytoextracts namely Onion bulb, Neem leaf and garlic bulb showed more than 50 per cent inhibition in growth of *R. solani* at 20% concentration after 144 hrs of incubation period. The detailed data for mean radial growth of different treatments at 10 and 20 % concentration after 144 hrs of incubation has been presented in (table 9). The graphical representation of mean radial growth of different treatments at 10 and 20 % concentration after 120 hrs and 144 hrs of incubation is presented in fig. 4 and 5. The pictorial representation of different treatments is depicted in plate 5 and 6.

Table 8: Effect of phytoextracts on mycelial growth of *Rhizoctonia solani* after 120 hrs incubation period

Treatment	Concentration				Avg. radial growth (mm)	Avg. % inhibition
	10%		20%			
	Mean radial growth (mm) *	% inhibition	Mean radial growth (mm) *	% inhibition		
Onion	22.66	72.14	17.33	78.69	20.00	75.41
Neem	28.00	65.57	24.33	70.08	26.17	67.83
Tulsi	30.66	62.30	25.50	68.65	28.08	65.47
Garlic	8.00	90.16	2.50	96.93	5.25	93.54
Karanj	36.66	54.92	30.66	62.30	33.66	58.61
Dhatura	24.33	70.08	21.00	74.18	22.67	72.13
Jatropha	39.33	51.64	34.33	57.79	36.83	54.72
Turmeric	23.50	71.11	18.83	76.85	21.17	73.98
Control	81.33	0.00	81.33	0.00	81.33	0.00
SEm±	A= 0.403, B= 0.190, A x B= 0.569					
CD @ 5 %	A= 1.159, B= 0.563, A x B= 1.639					

*Each value is a mean of three replications.

Table 9: Effect of phyto- extracts on mycelial growth of *Rhizoctonia solani* after 144 hrs incubation period

Treatment	Concentration				Avg. radial growth (mm)	Avg. % inhibition
	10%		20%			
	Mean radial growth (mm) *	% inhibition	Mean radial growth (mm) *	% inhibition		
Onion	37.50	58.25	34.00	62.15	35.75	60.20
Neem	46.33	48.42	40.66	54.74	43.50	51.58
Tulsi	56.33	37.29	51.33	42.86	53.83	40.08
Garlic	15.50	82.75	4.50	94.99	10.00	88.87
Karanj	61.00	32.09	55.66	38.04	58.33	35.07
Dhatura	52.00	42.11	47.00	47.66	49.50	44.90
Jatropha	67.33	25.05	60.33	32.84	63.83	28.94
Turmeric	56.33	37.29	51.50	42.67	53.92	39.98
Control	89.83	0.00	89.83	0.00	89.83	0.00
SEm±	A= 0.358,	B= 0.169,	A x B= 0.506			
CD @ 5 %	A= 1.031,	B= 0.486,	A x B= 1.458			

*Each value is a mean of three replications.

4.3 Effect of fungicides on mycelial growth of *Rhizoctonia solani*

A set of six fungicides namely Azoxystrobin 23% SC, Propiconazole 25% EC, Difenoconazole 25% EC, Tebuconazole 25% EC, Carbendazim 12% WP and Copper oxy chloride 50% WP were tested for their efficacy against *R. solani* under *in vitro* conditions using Poisoned food technique at five different concentrations of each fungicide (250 ppm, 500 ppm, 1000 ppm, 1500 ppm and 2000 ppm). Data were recorded for mycelial radial growth after three different incubation periods (48 hrs, 72 hrs and 96 hrs) and per cent inhibition in growth of *R. solani* was calculated above untreated control.

It was observed that after 48 hrs of incubation period, all the six fungicides significantly reduced the growth of *R. solani*. However, mycelial radial growth of *R. solani* varied from treatment to treatment. Two fungicides namely Tebuconazole 25% EC and Carbendazim 12% WP completely inhibited the growth of test fungi *R. solani* even at 250 ppm concentration and no mycelial growth of *R. solani* was recorded in these two treatments at

250 ppm concentration and above that. This showed the highest efficacy of Tebuconazole 25% EC and Carbendazim 12% WP among the tested fungicides against *R. solani*. However, maximum mycelial radial growth (7.66 mm) and minimum per cent inhibition (64.09%) of *R. solani* was recorded in Copper oxychloride 50% WP at 250 ppm concentration and after 48 hrs of incubation period. At 500 ppm concentration, average mycelial radial growth of *R. solani* ranged from 0.00 mm to 3.66 mm. However, at 1000 ppm concentration only two fungicides namely Azoxystrobin 23% SC and Copper oxy chloride 50% WP showed 1.83 mm and 2.50 mm mycelial radial growth respectively after 48 hrs of incubaition period. Further on increasing the concentrations of respective fungicides, the per cent inhibition kept on increasing and it was observed that at 1500 ppm concentration all the six tested fungicides completely inhibited the growth of *R. solani* and no mycelial growth was recorded in any treatment except control after 48 hrs of incubation period. In control plate of *R. solani*, where no fungicide was added, mycelial radial growth of 21.33 mm was recorded after 48 hrs of incubation period. The detailed data for mycelial radial growth and per cent inhibition in growth of *R. solani* in different treatments after 48 hrs of incubation period are presented in table 10 . The graphical representation for mycelial radial growth and per cent inhibition in growth of *R. solani* in different treatments after 48 hrs of incubation period are presented in Plate 7.

Further, mycelial radial growth of *R. solani* was recorded in different treatments and per cent inhibition in growth of *R. solani* was calculated after prolonged incubation of 72 hrs. It was observed that after 72 hrs of incubation period, 50.33 mm mycelial radial growth of *R. solani* was recorded in control where no fungicide was added. Among different treatments, two fungicides namely Tebuconazole 25% EC and Carbendazim 12% WP completely inhibited the growth of the test fungus *R. solani* even at 250 ppm concentration and no mycelial growth of *R. solani* was recorded in these two treatments at 250 ppm concentration and above that even after 72 hrs of incubation period. The maximum mycelial radial growth (8.83 mm) and minimum per cent inhibition (82.46%) of *R. solani* was recorded in Copper oxychloride 50% WP at 250 ppm concentration and after 72 hrs of incubation period. At 500 ppm concentration, average mycelial radial growth of *R. solani* ranged from 0.00 mm to 6.33 mm. Further, it was observed that at 1500 ppm concentration all the six tested fungicides completely inhibited the growth of *R. solani* and no mycelial growth was recorded in any treatment except control after 72 hrs of incubation period. The detailed data for mycelial radial growth and per cent inhibition in growth of *R. solani* in different treatments after 72 hrs of incubation period are presented in (table 11). The graphical representation for mycelial radial growth and per cent inhibition in growth of *R. solani* in different treatments after 72 hrs of incubation period are presented in Plate 7.

After 96 hrs of incubation period, it was observed that *R. solani* covered full mycelial radial growth of 89.33 mm in control plate. Among different treatments, maximum mycelial radial growth of 89.33 mm was recorded in Copper oxychloride 50% WP at 250 ppm concentration. However, Tebuconazole 25% EC and Carbendazim 12% WP completely inhibited the growth of *R. solani* at all the tested concentrations and no mycelial growth of *R. solani* was recorded in these two treatments. At 500 ppm and 1000 ppm concentrations, more than 95 per cent inhibition was recorded in all the fungicides except Copper oxychloride 50% WP. Further, at 1500 ppm concentration all the six tested fungicides completely inhibited the growth of *R. solani* and no mycelial growth was recorded in any treatment except control after 96 hrs of incubation period. The detailed data for mycelial radial growth and per cent inhibition in growth of *R. solani* in different treatments after 96 hrs of incubation period are presented in (table 10, 11 and 12). The graphical representation for mycelial radial growth and per cent inhibition in growth of *R. solani* in different treatments after 96 hrs of incubation period are presented in (fig. 6, 7 and 8). The pictorial representation of mycelial radial growth of *R. solani* in different treatments after 96 hrs of incubation period is depicted in plate 7.

Table 10: Effect of different fungicides on radial growth of *Rhizoctonia solani* after 48 hours incubation period

Fungicide	**Mean radial growth (mm*)**									
	Concentration (ppm)									
	250	**% inhibition**	**500**	**% inhibition**	**1000**	**% inhibition**	**1500**	**% inhibition**	**2000**	**% inhibition**
Azoxystrobin 23 % SC	4.00	81.25	2.66	87.53	1.83	91.42	0.00	100.00	0.00	100.00
Propiconazole 25 % EC	3.83	82.04	3.66	82.84	0.00	100.00	0.00	100.00	0.00	100.00
Difenoconazole 25 % EC	2.50	88.28	2.16	89.87	0.00	100.00	0.00	100.00	0.00	100.00
Tebuconazole 25 % EC	0.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00
Carbendazim 12 % WP	0.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00
COC 50 % WP	7.66	64.09	3.00	85.94	2.50	88.28	0.00	100.00	0.00	100.00
Control	21.33	0.00	21.33	0.00	21.33	0.00	21.33	0.00	21.33	0.00
SEm±	A= 0.111,			B= 0.093			C= 0.247			
CD at 5 %	A= 0.312,			B= 0.264			C= 0.699			

*Each value is a mean of three replications.

A = Treatment
B = Replication
C = Interaction (Treatment x Replication)

Table 11: Effect of different fungicides on radial growth of *Rhizoctonia solani* after 72 hours incubation period

Fungicide	Mean radial growth (mm*)									
	Concentration (ppm)									
	250	% inhibition	500	% inhibition	1000	% inhibition	1500	% inhibition	2000	% inhibition
Azoxystrobin 23 % SC	4.16	91.73	2.43	95.17	2.50	95.03	0.00	100.00	0.00	100.00
Propiconazole 25 % EC	4.00	92.05	3.00	94.04	0.00	100.00	0.00	100.00	0.00	100.00
Difenoconazole 25 % EC	3.16	93.72	2.83	94.38	0.00	100.00	0.00	100.00	0.00	100.00
Tebuconazole 25 % EC	0.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00
Carbendazim 12 % WP	0.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00
COC 50 % WP	8.83	82.46	6.33	87.42	3.66	92.73	0.00	100.00	0.00	100.00
Control	50.33	0.00	50.33	0.00	50.33	0.00	50.33	0.00	50.33	0.00
SEm±	A= 0.217,			B= 0.184			C= 0.486			
CD at 5 %	A= 0.614,			B= 0.519			C= 1.372			

*Each value is a mean of three replications.

A = Treatment
B = Replication
C = Interaction (Treatment x Replication)

Table 12: Effect of different fungicides on radial growth of *Rhizoctonia solani* after 96 hours incubation period

Fungicide	Mean radial growth (mm*)									
	Concentration (ppm)									
	250	% inhibition	500	% inhibition	1000	% inhibition	1500	% inhibition	2000	% inhibition
Azoxystrobin 23 % SC	5.00	94.40	3.00	96.64	2.50	97.20	0.00	100.00	0.00	100.00
Propiconazole 25 % EC	4.33	95.15	3.33	96.27	0.00	100.00	0.00	100.00	0.00	100.00
Difenoconazole 25 % EC	3.66	95.90	3.66	95.90	0.00	100.00	0.00	100.00	0.00	100.00
Tebuconazole 25 % EC	0.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00
Carbendazim 12 % WP	0.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00
COC 50 % WP	15.00	83.21	13.33	85.08	11.66	86.95	0.00	100.00	0.00	100.00
Control	89.33	0.00	89.33	0.00	89.33	0.00	89.33	0.00	89.33	0.00
SEm±	A= 6.132			B= 5.183			C= 13.712			
CD at 5 %	A= 16.994			B= 14.364			C= 38.758			

*Each value is a mean of three replications.

A = Treatment
B = Replication
C = Interaction (Treatment x Replication)

DISCUSSION

Rhizoctonia solani is a widely distributed plant pathogen. Isolates vary considerably in pathogenicity and cultural characteristics not only from different hosts but also from the same host. Classification of *Rhizoctonia* spp. has evolved mainly from studies of isolates obtained from diseased plants. Most of the agriculturally important isolates of *Rhizoctonia* spp. were classified as *R. solani.* Fungi represented as *Rhizoctonia* spp. represents an amalgam of taxonomically diverse group that differ in many significant features, including their sexual stages, asexual stages and other characters. As a plant pathogen, *R. solani* is regarded as an unspecialized fungus. The different seed and soil-borne diseases like web blight of urd bean, sheath blight of rice and little millets, wet root rot of chick pea etc. caused by *R. solani* are among major diseases of this pathogen. Being a typical soil borne fungus, its management through chemicals is expensive and not feasible, because of the physiological heterogenicity of the soil and other edaphic factors etc. which might prevent effective concentrations of the chemical reaching to the pathogen. Integrated approaches for the disease management are paying more attentiveness in terms of sustainability. This approach mainly emphasizes on the management through eco-friendly means i.e. through the use of botanicals and bio-pesticides etc. Hence, the present investigation entitled "**Studies on *Rhizoctonia solani* (kuhn) causing web blight of urd bean and its management**" was carried out with the collection of field isolate of *R. solani* causing web blight of urd bean followed by its cultural characterization and management through botanicals and chemicals under *in vitro* conditions.

Symptoms of web blight of urd bean appeared as small circular brown spot on the primary young leaves after two months of sowing. Leaf lesions were light to dark brown with distinct zonate patterns. Dark brown lesions were also seen on petioles and branches of the plants. Further, white mycelial fungal growth was seen on under surface of infected leaves and young branches. Sclerotia were also seen as hard resting structure of the fungus on severely blighted leaves. *R. solani* was isolated from these diseased samples of web blight of urd bean and subjected to cultural characterization based on colony morphology, type, radial growth on different media, pH and temperature. Complete Petri plate growth of 90 mm was recorded after 144 hrs of incubation on Potato dextrose agar medium. However, production of sclerotia started after 10 days of incubation. Thereafter, massive irregular shaped, brown to black coloured sclerotia were produced.

Among the four tested media for colony growth of *R. solani* from urd bean, Richard's Agar medium was found most suitable and supported the growth of *R. solani*. However, Czapek's Dox Agar medium least supported the growth of *R. solani* and minimum radial growth of 71.83 mm was recorded.

To identify the optimum temperature for growth of R. solani, four different temperatures were tested for its colony growth under in vitro conditions and it was observed that *R. solani* showed maximum radial growth at 25^0C. However, it was observed that *R. solani* was not able to grow well at low temperature (15^0C and 20^0C). Further, at 30^0C colony radial growth was better than at 15^0C and 20^0C.

To identify the suitable pH for maximum growth of *R. solani*, it was grown on six different pH (4, 5, 6, 7, 8 and 9) under laboratory conditions on potato dextrose agar medium and colony radial growth was recorded. The maximum radial growth of *R. solani* was recorded a pH 7.0 after different incubation period. Further, it was observed that neutral pH 7.0 and slightly alkaline pH favours the colony growth of *R. solani* in comparision to acidic pH and maximum colony radial growth of 89.83 mm was recorded at pH 7.0 after 144 hrs of incubation period. However, minimum radial growth of 55.50 mm was recorded at pH 4.0 after 144 hrs of incubation period. In this way neutral pH 7.0 found most suitable for growth of *R. solani*. The results with respect to morphological, cultural and sclerotial characters of *R. solani* observed in the present investigations have also been recorded and described by several workers (Singh *et al.,* 2002; Srinivas, 2002, Sharma *et al.,* 2004 and Akhtar *et al.,* 2009; Dubey *et al.,* 2011; 2012;) in urd bean and other crops where findings are matching with the present investigation.

For eco-friendly management of *R. solani*, a set of eight phyto-extracts including Onion, Neem, Tulsi, Garlic, Karanj, Dhatura, Jatropha and Turmeric were used to evaluate their efficacy in inhibiting *R. solani* at 10 % and 20 per cent concentrations under *in-vitro* conditions using poisoned food technique. All the eight tested phyto-extracts significantly inhibited the growth of *R. solani* under *in vitro* conditions. The maximum per cent inhibition (90.16 %) in growth of *R. solani* was shown by garlic bulb extract followed by Onion bulb extract where 72.14 % inhibition was recorded after 120 hrs of incubation period at 10 per cent concentration. On increasing the concentration of phytoextracts from 10 to 20 %, the per cent inhibition in growth of *R. solani* also increased and maximum inhibition of 96.93 % in growth of *R. solani* was recorded by 20 % garlic bulb extract. After 144 hrs of incubation, maximum inhibition of 94.99 % in growth of *R. solani* was recorded by 20 % garlic bulb extract. However, minimum inhibition of 32.84 % was recorded in 20% Jatropha leaf extract. In this way, out of eight phytoextracts tested, three phytoextracts namely Onion bulb, Neem leaf and garlic bulb showed more than 50 per cent inhibition in growth of *R. solani* at 20% concentration after 144 hrs of incubation period. The results obtained in this experiment are close with the findings of Sehajpal *et al.,* (2009) where they evaluated forty four plant extracts for their efficacy as antifungal botanicals against *R. solani.* and found that clove extract of garlic (*Allium sativum* L.) exhibited strong fungitoxicity even at low concentration of 100 ppm. The results of present findings are also in conformity with the findings of Sinha *et al.,* (2009). In their study, ten botanicals were screened under *in vitro* condition against *R. solani* and they found that extracts of garlic and ginger recorded maximum (100 %) inhibition followed by neem (70 %). Srinivas *et al.,* (2013) studied phyto-toxic effect of thirteen plant extracts and reported highest growth inhibition of fungus by garlic at 10% concentration.

A set of six fungicides namely Azoxystrobin 23% SC, Propiconazole 25% EC, Difenoconazole 25% EC, Tebuconazole 25% EC, Carbendazim 12% WP and Copper oxychloride 50% WP was tested for efficacy against *R. solani* under *in vitro* conditions using Poisoned food technique at five different concentrations of respective fungicide (250 ppm, 500 ppm, 1000 ppm, 1500 ppm and 2000 ppm). Among the different fungicides, two fungicides namely Tebuconazole 25% EC and Carbendazim 12% WP completely inhibited the growth of test fungus *R. solani* even at 250 ppm concentration and no mycelial growth of *R. solani* was recorded in these two treatments at 250 ppm concentration and above that. This showed the highest efficacy of Tebuconazole 25% EC and Carbendazim 12% WP among the tested fungicides against *R. solani*. The similar reports have been documented for use of fungicides and botanicals for the management of web blight of urd bean by Sharma and Tripathi (2001); Jhamaria and Sharma (2002); Shailbala and Tripathi (2004); Mishra et al., (2005), Shailbala and Tripathi (2007) and Shailbala and Tripathi (2010).

SUMMARY, CONCLUSION AND SUGGESTION FOR FURTHER WORKS

Rhizoctonia solani is a multiphagous widely distributed plant pathogen. Web blight caused by *Rhizoctonia solani* causes huge yield losses in urdbean (*Vigna mungo*). All the commercially grown varieties are susceptible. Being a typical soil borne fungus, its management through chemicals is expensive and not feasible, because of the physiological heterogenicity of the soil and other edaphic factors etc. which might prevent effective concentrations of the chemical reaching the pathogen. Integrated approaches for the disease management are paying more attentiveness in terms of sustainability. Hence, the present investigation entitled "**Studies on *Rhizoctonia solani* (kuhn) causing web blight of urd bean and its management**" was carried out. The main objective of the present study was firstly to isolate and characterize *R. solani* from infected leaf samples of web blight of urd bean and secondly its management through botanicals and chemicals under *in vitro* conditions.

Symptoms of web blight of urd bean appeared as small circular brown spot on the primary young leaves after two months of sowing and white mycelial fungal growth was seen under surface of infected leaves and young branches. Sclerotia were also seen as hard resting structures of the fungus on severely blighted leaves. *R. solani* showed complete Petri plate growth of 90 mm after 144 hrs of incubation on Potato dextrose agar medium. However, production of sclerotia started after 10 days of incubation.

Among the four tested media for colony growth of *R. solani* from urd bean, Richard's Agar medium was found most suitable and supported the growth of *R. solani*. However, Czapek's Dox Agar medium least supported the growth of *R. solani*. Further, it was observed that *R. solani* showed maximum radial growth at 25^{0}C. However, it was observed that *R.solani* was not able to grow well at low temperature (15^{0}C and 20^{0}C). The maximum radial growth of *R. solani* was recorded a pH 7.0 after different incubation periods. Further, it was observed that neutral pH 7.0 and slightly alkaline pH favoured the colony growth of *R. solani* in comparision to acidic pH. However, neutral pH 7.0 found most suitable for growth of *R. solani*.

All the eight tested phyto-extracts evaluated for their efficacy in inhibiting *R. solani* at 10 % and 20 per cent concentrations under in-vitro conditions using poisoned food technique, significantly inhibited the growth of *R. solani*. The maximum per cent inhibition in growth was recorded by onion and garlic bulb extracts.

A set of six fungicides namely Azoxystrobin 23% SC, Propiconazole 25% EC, Difenoconazole 25% EC, Tebuconazole 25% EC, Carbendazim 12% WP and Copper oxychloride 50% WP were tested for their efficacy against *R. solani* under *in vitro* conditions using Poisoned food technique at five different concentrations of respective fungicide (250 ppm, 500 ppm, 1000 ppm, 1500 ppm and 2000 ppm). Among the different fungicides, two fungicides namely Tebuconazole 25% EC and Carbendazim 12% WP completely inhibited the growth of test fungus *R. solani* even at 250 ppm concentration and no mycelial growth of *R. solani* was recorded in these two treatments at 250 ppm concentration and above that.

6.2 Conclusion

The major findings of the present investigation are as following:

1. Richard's Agar medium was found most suitable and supported the growth of *R. solani*.
2. *R. solani* showed maximum radial growth at 25^0C temperature and pH 7.0.
3. Onion and garlic bulb extracts @10% and 20% significantly inhibited the growth of *R. solani* and can be used for ecofriendly management of web blight of urd bean.
4. Tebuconazole 25% EC and Carbendazim 12% WP completely inhibited the growth of test fungus *R. solani* even at 250 ppm concentration and no mycelial growth of *R. solani* was recorded in these two treatments at 250 ppm concentration and above that.

6.3 Suggestions for Further Work

Urd bean is largely grown in subsistence farming system. Besides management of the limited available resources for crop production, the farmer has to fight the onslaught of a large and diverse pest fauna and complex of the plant disease pathogens. There is need to develop reliable screening technique under controlled environmental and under field conditions and further to develop web blight resistant variety for urd bean. There is need for exploring more number of botanicals firstly under in vitro conditions followed by in vivo conditions for eco-friendly management of web blight of urd bean. There is need to devise suitable forecasting models for this disease along with appropriate control measures. There is also need of research on induced resistance, a new approach for control of plant diseases. Further, efficacy of bio control agents against the disease needs to be explored so that need based chemical control should be integrated with biological control, host resistance, physical control and cultural control in integrated disease management strategy.

REFERENCES

Abdulaziz A, Askar A and Younes R. 2010. Efficacy of Some plant extracts against *Rhizoctonia solani* on pea. Journal of Plant Protection Research 50 (3): 45-47.

Akhtar J, Jha VK, Kumar A and Lal HC. 2009. Occurrence of banded leaf and sheath blight of maize in Jharkhand with reference to diversity in *Rhizoctonia solani*. Asian Journal of Agricultural Sciences 1(2): 32-35.

Akhtar J. 2014. Multiple disease resistance in greengra and blackgram germplasm and management through chemicals under rain-fed conditions. Legume Research An International Journal (37): 101-109.

Anderson NA. 1982. The genetics and pathology of *Rhizoctonia solani*. Annual Review Phytopathology 20:329-347.

Anonymous 2003. All India Coordinated Research Project on MULLaRP 18.

Ansari MM. 1995. Control of sheath blight of rice by plant extracts. Indian Phytopathology 48: 268-270.

Bara B. 2007. Epidemiology and management of web blight disease of urdbean. M.sc. Thesis, BAU, Jharkhand. 167p.

Basandrai AK, Gartan SL, Basandrai, Daisy and Kalia V. 1999. Black gram (*Phaseolus mungo*) germplasm evaluation against different diseases. Indian Journal of Agricultural Sciences 69: 506-508.

Basandrai. 2016. Fungicidal management of web blight of urdbean caused by *Rhizoctonia solani.* Legume Research 39 (6): 1038-1042.

Boosalis MG and Scharen AL.1959. Methods for microscopic detection of *Aphanomyces euteiches* and *Rhizoctonia solani* and for isolation of *R. solani* associated with plant debris. Phytopatholology 49:192-198.

Carling DE. 1996. Grouping *Rhizoctonia solani* by hyphal anastomosis reaction. In: *Rhizoctonia* species: Taxonomy, Molecular Biology, Ecology, Pathology and Disease Control. Publishers, Netherlands. 37-47p.

Castillo F, Hernandez D, Gallegos G, Mendez M, Rodríguez R , Reyes A and Aguilar CN. 2013. *In vitro* antifungal activity of plant extracts obtained with alternative organic solvents against *Rhizoctonia solani* Kuhn. Industrial Crops and Products 32: 324-328.

Ceresini P.1999. *Rhizoctonia solani*, Pathogen Profile as one of the requirements of the course. pp.728 In Soil borne Plant Pathogens. https://www.cals. ncsu.edu/course/pp728/*Rhizoctonia* /*Rhizoctonia*. html

De Candolle AP. 1815. Uredo rouille des cereals In forafran caise, famille des champigons. Mem. Mus. D. Hist. Nat. 2: 209-216.

Dubey SC and Dwivedi RP. 1988. Chemical control of web blight of urdbean. Farm Science Journal 3: 182-183.

Dubey SC and Patel B. 2001. Evaluation of antagonists against *Thanatephorus cucumberis* causing web blight of urdbean and mungbean. Indian Phytopathology 54: 206-209.

Dubey SC, Tripathi A, Upadhyay BK and Singh B. 2012. Influence of Weather and Soil Parameters on Development of Wet Root Rot in Pulse Crops and Virulence Analysis of *Rhizoctonia solani* Isolates. Journal of Agricultural Sciences 4(11): 195-205.

Dubey SC, Tripathi A, Upadhyay BK and Thakur M. 2011. Pathogenic behaviour of leguminous isolates of *Rhizoctonia solani* collected from different Indian agro-ecological regions. Indian Journal of Agricultural Sciences 81: 64-69.

Dubey SC. 2002. Efficacy of some oil cakes and plant extracts against web blight of urd and mung bean caused by *Thanatephorus cucumeris*. Journal of Mycology and Plant Pathology 32:158-161.

Dutta S, Chaudhury A, Chaudhury AK. and Laha SK. 2004. *In vitro* fungitoxicity of plant extracts against *Pyricularia oryzae*, *Rhizoctonia solani* incident of blast and sheath blight of rice. Indian Phytopathology 12:57-344.

Dutta U and Kalha CS. 2011. *In vitro* evaluation of fungicides, botanicals and bioagents against *Rhizoctonia solani* causing sheath blight of rice and their integration for effective management of the disease under field conditions. Plant Disease Research 26 (1): 14-19.

Dwivedi RP and Saksena HK. 1974. Occurrence of web blight caused by *Thanatephorus cucumeris* on mung bean. Indian Journal of Farm Science 2: 100.

Dwivedi VB and Saksena HK. 1975. Web blight disease of arhar (*Cajanus cajan* L.) (Millsp.) caused by *Thanatephorus cucumeris.* Indian Journal of Farm Science 3:114-115.

Dwivedi, R.P. and Dubey, S.C.1986. Web blight of groundnut caused by *Thanatephorus cucumeris* .Farm Science Journal 1 (1-2) : 33-37.

Elad Y, Chet I and Katan J. 1980. *Trichiderma harzianum:* a biocontrol agent effective against *Sclerotium rolfsii* and *Rhizoctonia solani.* Phytopathology 70: 119-121.

Godoy LG, Kuninaga S, Steadman J and Powers K. 2008. Phylogenetic analysis of *Rhizoctonia solani* groups associated with web blight symptoms on common bean based on ITS-5.8s rDNA. Journal of General Plant Pathology 74: 32-40.

Goswami BK, Bhuiyan KA and Mian IH. 2010. Morphological and pathogenic variations in the isolates of *Rhizoctonia solani* in Bangladesh. Bangladesh Journal Agriculture Research 35(3): 375-380.

Grosch R and Kofoet A. 2003. Influnece of temperature, pH and inoculum density on bottom rot on lettuce caused by *Rhizoctonia solani*. Journal of Plant Diseases and Protection 110:366-378.

Haque MA. 1975. Variation in cultural characteristics, physiology, and Pathogenicity of field isolates of *Thanatephorus cucumeris* (Frank) Donk, the causal organism of rice sheath blight disease. M.Sc. Thesis, University of Philippines. 57p.

Jalali BL. 1989. Observation on *Rhizoctonia* leaf blight of rice bean from HAU, Hisar. Consolidated Report on Kharif Pulses 11:144-145.

Jhamaria SL and Sharma OP. 2002. Management of web blight of mung bean through chemicals and plant product. Indian Phytopathology 6: 55:526.

Kozaka T. 1965. Ecological of *Pellicularia sasakii* sheath blight of rice plant and its chemical control. Phytopathology 31:179-185.

Kumar P and Tripathi HS. 2007. Evaluation of bioagents against *Rhizoctonia solani* Kuhn the cause of aerial blight of soybean. Indian Phytopathology 60: 532-534.

Kumar S and Tripathi HS. 2011. Biological control strategies for management of web blight disease of urdbean (*Vigna mungo*). Journal of Mycology and Plant Pathology 41: 282-28.

Kumar S, Kumar A and Tripathi HS. 2018. Urdbean web blight and its management strategies. Indian Journal of Agriculture 10(2): 1-8.

Kumar V, Chandhary VP, Kumar D, Kumar A, Sagar S and Chandhary S. 2017. Efficacy of botanicals and fungicides against *Rhizoctonia solani* inciting sheath blight disease on Rice (*Oryza sativa* L.). Journal of Applied and Natural Science 9(4): 1916-1920.

Lakpale N, Khare N, Trimurthy VS and Agrawal KC. 1997. *In Vitro* studies on growth and sclerotial formation of *Rhizoctonia solani* Kuhn causing sheath blight of rice. Journal of Soils and Crops 7(1): 43-45.

Lakshmanan P, Nair MC and Menon MR. 1979. Collar rot and web blight of cowpea caused by *Rhizoctonia solani* in Kerala, India. Plant Disease Report 63: 410-413.

Mahadevan A. 1982. Biochemical aspects of plant disease resistance part 1 preferred inhibitory substance prohibition. Journal of Applied and Natural Science 9(5): 19 -20.

Manibushanrao K, Manian S and Zuber M. 1979. Sheath blight disease of rice. Indian Journal of Agriculture 1-101.

Meena B, Ramamoorthy V and Muthusamy M. 2001. Morphological and pathological variations in isolates of *Rhizoctonia solani* causing sheath blight of rice. Plant Disease Research 16:166–172.

Mew TW, Fabellar NG and Elazegi FA. 1980. Ecology of the rice sheath blight Pathogen: parasitic survival. International Rice Research News 6:16.

Mishra BD, Sahoo KC, Sugata G and Rout MK. 2005. *In vitro* evaluation of plant extracts, oil cakes and agrochemicals against web blight of green gram caused by *Rhizoctonia solani.* Journal of Mycopathological Research 43: 255-257.

Mubarak IIM. 2003. Control of root rot and damping-off disease of bean. Ph.D. Thesis, Tanta University Egypt. 58p.

Mukhopadhyay AN. 1994. Biocontrol of soil borne fungal plant pathogens -current status, future prospect and potential limitations. Indian Phytopathology 47: 119-126.

Nayak P, Row KVSRK and Sridhar R. 1979. Host range of *Rhizoctonia solani*, the causal organism of sheath blight disease of rice. Indian Phytopathology 32 604-605.

Nene YL and Thapliyal PN. 1973. Fungicide in Plant Diseases Control, Third Edition ; Oxford and IBH publishing Private Limited Company New Delhi, p. 325.

Ogoshi A. 1996. Introduction – The genus *Rhizoctonia.* In: Sneh B., Jabaji-Hare S., Neate S., Dijst G. (eds): *Rhizoctonia* species: Taxonomy, Molecular Biology, Ecology, Pathology and Disease Control. Kluwer Academic Publishers, Dordrecht. 1–9.

Parmeter JR and Whitney HS. 1970. Taxonomy and nomenclature the imperfect state. In Parameter IR Jr (ed.) *Rhizoctonia solani,* Biology and Pathology, London, Berkeley CA: University of California Press. 7-19.

Parmeter JR, Jr Whitney HS and Platt WD. 1967. Affinities of some *Rhizoctonia* species that resemble mycelium of *Thanatephorus cucumeris*. Phytopathology 57: 218-222.

Patole S, Salunkhe RS and Phapale AD.2016. Botanical management of *Rhizoctonia solani* in Soybean. International Journal of Plant Protection (2) :561-565.

Prasad BN and Kumar MR. 2013.Scanning Electron Microscopic Studies on Mycoparasitic Activity of *Trichoderma* spp. against *Rhizoctonia solani*, incident of sheath blight of rice. Research Journal of Pharmaceutical, Biological and Chemical Sciences 4(3): 88-96.

Purushottam and Singh D. 2015. Pulses production and productivity in India. Pulses Handbook pp 38-39.

Radha A. 1991. Effect of Mimusine on Phytopathogenic fungi M. Phil. Thesis, University of Madras. 85p.

Ray A and Kumar P. 2009. Influence of media, pH and temperature on growth and sclerotial production of *Rhizoctonia solani* Kuhn causing aerial blight of soybean. Pantnagar Journal of Research 7(1): 50-53.

Ray A, Tripathi P and Kumar HS. 2007. Evaluation of bio-agents against *Rhizoctonia solani* Kuhn the cause of aerial blight of soybean. Indian Phytopathology 60 (4): 532-534.

Saikia UN and Roy AK. 1975. Natural occurrence of *Corticium sasakii* on few plants in Jorhat. Assam Sciences Culture 42(4) : 228-229.

Saksena HK and Dwivedi RP. 1973. Web blight of black gram caused by *Thanatephorus cucumeris*. Indian Journal Farm Science 1:58-61.

Seema M, Sreenivas SS, Rekha ND and Devaki NS. 2011. *In vitro* studies of some plant extracts against *Rhizoctonia solani* Kuhn infecting FCV tobacco in Karnataka light soil, Karnataka, India. Journal of Agriculture Technology 7(5):1321-1329.

Sehajpal A, Arora S and Kaur P. 2009. Evaluation of plant extracts against *Rhizoctonia solani* causing sheath blight of rice. The Journal Plant Protection Sciences 1(1): 25-30.

Shailbala 2010.Biological and chemical management of web blight disease of urdbean caused by *Rhizoctonia solani* Kuhn. Journal Plant Disease Science 54: 121-125.

Shailbala and Tripathi HS. 2004. Fungicidal management of web blight of urdbean. Indian Phytopathology 57: 99-100.

Shailbala and Tripathi HS. 2007. Current status of research on web blight disease of urdbean: a review. Agriculture Review 28: 1-9.

Sharma J and Tripathi HC. 2001. Biological and chemical control of web blight disease of urdbean. Indian Phytopathology 54: 267-269.

Sharma L, Goswami S and Nagrale DT. 2013. Culture and physiological variability in *Rhizoctonia solani*, responsible for foliar and lesions on aerial part of soybean. Journal of Applied and Natural Science 5(1): 41-46.

Sharma R, Mohammod H, Surapareddy, Sreenivasa P, Muthu M Nitya. 1999. Morphological and Genetical Study on *Rhizoctonia* Sheath Disease Complex of Rice in Bangladesh Universal Journal of Agricultural Research . 5(6): 344-349.

Sharma RR, Gour HN and Rathore RS. 2004. Etiology of banded leaf and sheath blight symptoms on maize. Journal of Mycology and Plant Pathology 34 (1): 56-59.

Shukla RP, Singh PK and Dwivedi RS. 1990. Toxicity of essential oils against *Rhizoctonia solani* Kuhn fungus sheath blight in Rice. International Rice Research 15-27.

Singh A and Malhotra SK. 1994. Pathological and physiological studies on some root disease of soybean. Bhartiyakrishi Anusadhan Patrika 9: 113-116.

Singh BP. 2006. Effect of carbon and nitrogen sources on *Rhizoctonia solani* and its integrated management. M.Sc. (Ag.) Thesis. Plant Pathology, NDUAT, Faizabad. 72p.

Singh PK and Singh AK. 2007. Studies on the Suitability of different agar media on the growth of *Rhizoctonia solani* Pathogen of rice. Flora Fauna 13(2): 300-302.

Singleton LL, Mihail JD and Rush CM. 1992. Methods for Research on Soil borne Phytopathogenic Fungi. APS Press, St. Paul, Minnesota, USA., ISBN-13: 978-0890541272, Pages: 266.

Sinha, Kishan KS,Vijay A, Patil, Jitendar KS and Akhilesh KK. 2009. *In vitro* Evaluation of Botanicals against *R. solani* Causing Sheath Blight of Paddy International Journal *of* Current Microbiology and Applied Sciences 7: 3316-3322.

Srinivas P, Ratan V, Patel AP and Bindu MG. 2013. *In-vitro* evaluation of fungicides, biocontrol agents and plant extracts against rice Sheath blight pathogen *Rhizoctonia solani.* International Journal of Applied Biology and Pharmaceutical Technology 5(1): 121-126.

Tewari SN and Dath AP. 1984. Effect of leaf extract media of some plants on the growth of three fungal Pathogens of Rice. Indian Phytopathology 37: 458-461.

Tewari SN and Mandakini N. 1991. Activity of four plant extracts against the three fungal Pathogens of Rice. Tropical Agriculture 68:373-375.

Thakur RS, Sugha SK and Sharma BM. 1992. Morphological grouping of different isolates of *Rhizoctonia solani* Kuhn. Plant Disease Research 7(1): 58-60.

Tiwari A and Khare MN. 2002. Conditions inducing imperfect and perfect stages in *Rhizoctonia solani* causing diseases of mungbean. Journal of Mycology and Plant Pathology 32(2): 176-180.

Tripathi HS. 2001. Host rang of *Rhizoctonia solani* Kuhn, of urdbean causal agent of web blight of Urdbean [*Vigna mungo* (L)]. Journal of Mycology and Plant Pathology 31: 81-82.

Tsai WH. 1970. Studies on the relations between weeds and Rice diseases Observations on the host range of Rice sheath blight fungus (*Pellicularia sasakii*) on weeds. Journal of Taiwan Agricultural Research 19:48-51.

Upmanyu S and Paul YS. 2013. Cultural, morphological and physiological variations among different anastomosis groups of *Rhizoctonia solani* Kuhn. Plant Disease Research 28(2): 113-120.

Verma HS and Thapliyal PN. 1976. *Rhizoctonia* aerial blight of soybean. Indian Phytopathology 29: 389-391.

Vincent JM. 1947. Distortion of fungal hyphae in presence of certain inhibitors. Nature 154:850.

Wiese MV Ed. 1987. Compendium of wheat diseases, 2nd ed., American Phytopathological society, St. Paul, MN.112 pp.

Yoon MY**,** Byeongjin Cha and Jin-Cheol Kim**.** 2013. Recent Trends in Studies on Botanical Fungicides in Agriculture Plant Pathology Journal 29 (1): 1–9.

Zhou, ERXun, Yang Mei Li Lin and Zeng WeiDa. 2002. The effects of media on the mycelia growth and sclerotial formation of *Rhizoctonia solani* AG-1 IA. Journal of South China Agricultural University 23(3):33-35.

APPENDICES

Analysis Table of Variance (*in vitro*)

Table 1

Linear growth of *Rhizoctonia solani* on different media for table

Source of Variation	DF	SS	MSS	F-Calculated	Significance
Treatment (A)	6	28,591.713	9,530.571	10,944.196	-0.00000
Concentrations (B)	4	1,864.317	466.079	535.211	0.00000
Intraction A X B	24	2,870.850	239.238	274.722	0.00000
Error	70	34.833	0.871		
Total	104	33,361.713			

Table 2

Linear growth of *Rhizoctonia solani* on different PH for table

Source of Variation	DF	SS	MSS	F-Calculated	Significance
Treatment (A)	5	44,290.489	8,858.098	10,259.024	0.00000
Concentrations (B)	4	1,528.879	382.220	442.668	-0.00000
Interaction A X B	20	10,184.866	509.243	589.781	0.00000
Error	60	51.807	0.863		
Total	89	56,056.040			

Table 3

Linear growth of *Rhizoctonia solani* on different Temperature for

Source of Variation	DF	SS	MSS	F-Calculated	Significance
Treatment (A)	3	20,883.646	6,961.215	6,709.605	0.00000
Concentrations (B)	4	2,110.833	527.708	508.635	0.00000
Intraction A X B	12	7,593.833	632.819	609.946	0.00000
Error	40	41.500	1.038		
Total	59	30,629.813			

Table 4

Linear Effect of phytoextracts on mycelial growth of *Rhizoctonia solani* after 120 hrs incubation period

Source of Variation	DF	SS	MSS	F-Calculated	Significance
Treatment (A)	8	6,739.537	842.442	866.512	0.00000
Concentrations (B)	1	3.130	3.130	3.219	0.08119
Intraction A X B	8	14,876.537	1,859.567	1,912.698	0.00000
Error	36	35.000	0.972		
Total	53	21,654.204			

Table 5

Linear Effect of phytoextracts on mycelial growth of *Rhizoctonia solani* after 144 hrs incubation period

Source of Variation	DF	SS	MSS	F-Calculated	Significance
Treatment (A)	8	8,599.000	1,074.875	1,398.633	-0.00000
Concentrations (B)	1	5.352	5.352	6.964	0.01221
Intraction A X B	8	14,160.315	1,770.039	2,303.184	0.00000
Error	36	27.667	0.769		
Total	53	22,792.333			

Table 6

Linear Effect of Fungicides on mycelial growth of *Rhizoctonia solani* after 48 hrs incubation period

Source of Variation	DF	SS	MSS	F-Calculated	Significance
Treatment (A)	6	449.562	74.927	408.693	-0.00000
Concentrations (B)	4	18.967	4.742	25.864	0.00000
Intraction A X B	24	5,084.867	211.869	1,155.652	0.00000
Error	70	12.833	0.183		
Total	104	5,566.229			

Table 7

Linear Effect of Fungicides on mycelial growth of *Rhizoctonia solani* after 72 hrs incubation period

Source of Variation	DF	SS	MSS	F-Calculated	Significance
Treatment (A)	6	2,129.028	354.838	508.364	-0.00000
Concentrations (B)	4	34.680	8.670	12.421	0.00000
Intraction A X B	24	29,403.064	1,225.128	1,755.197	0.00000
Error	70	48.860	0.698		
Total	104	31,615.632			

Table 8

Linear Effect of Fungicides on mycelial growth of *Rhizoctonia solani* after 96 hrs incubation period

Source of Variation	DF	SS	MSS	F-Calculated	Significance
Replication	6	4,844.348	807.391	1.431	0.21502
Treatment	4	498.986	124.746	0.221	0.92577
Error	24	54,302.581	2,262.608	4.011	0.00000
Total	70	39,482.833	564.040		
	104	99,128.748			

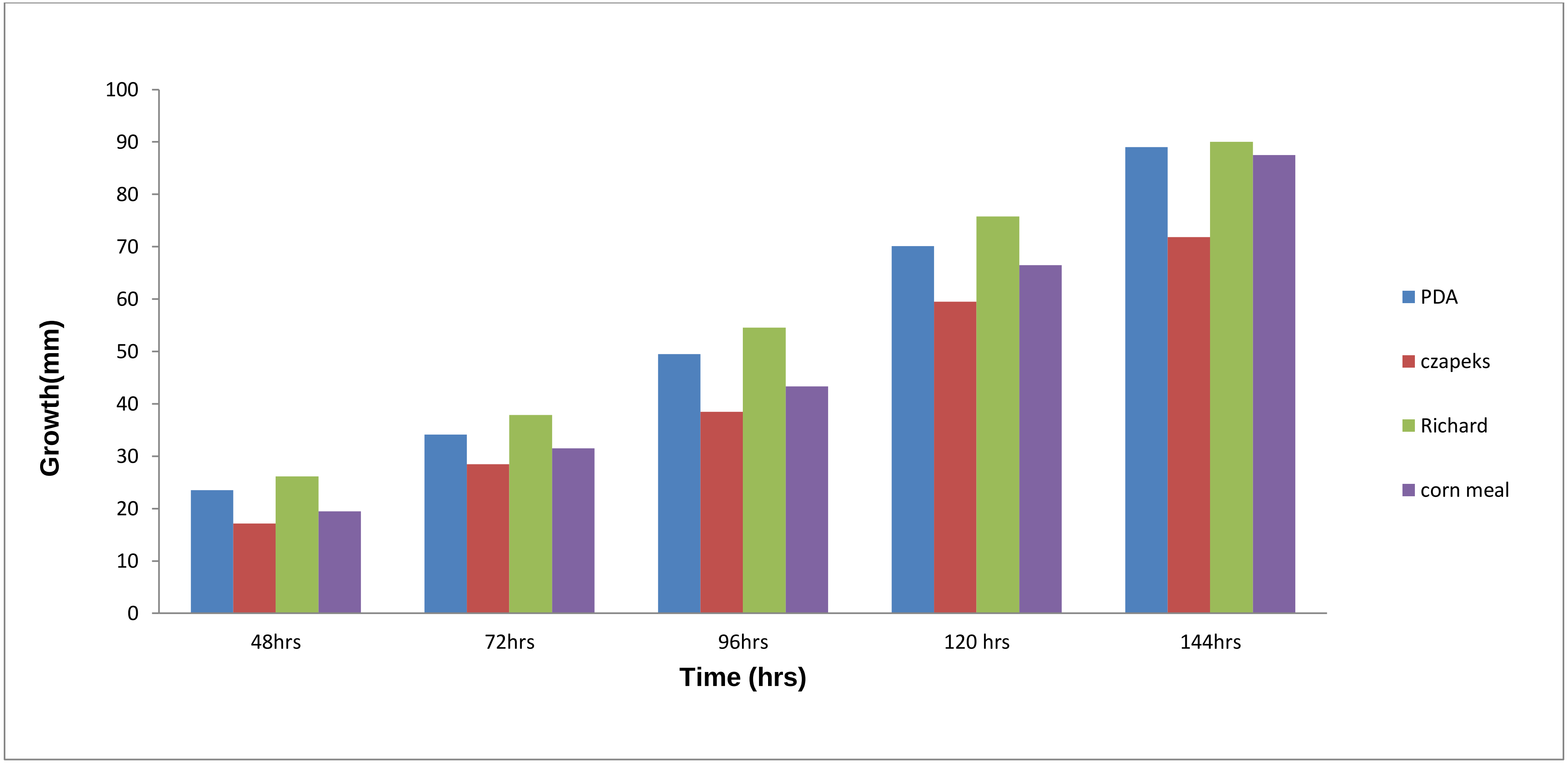


Fig. 1: : Graphical representation of effect of different media on mycelial growth of *Rhizoctonia solani* after different incubation periods

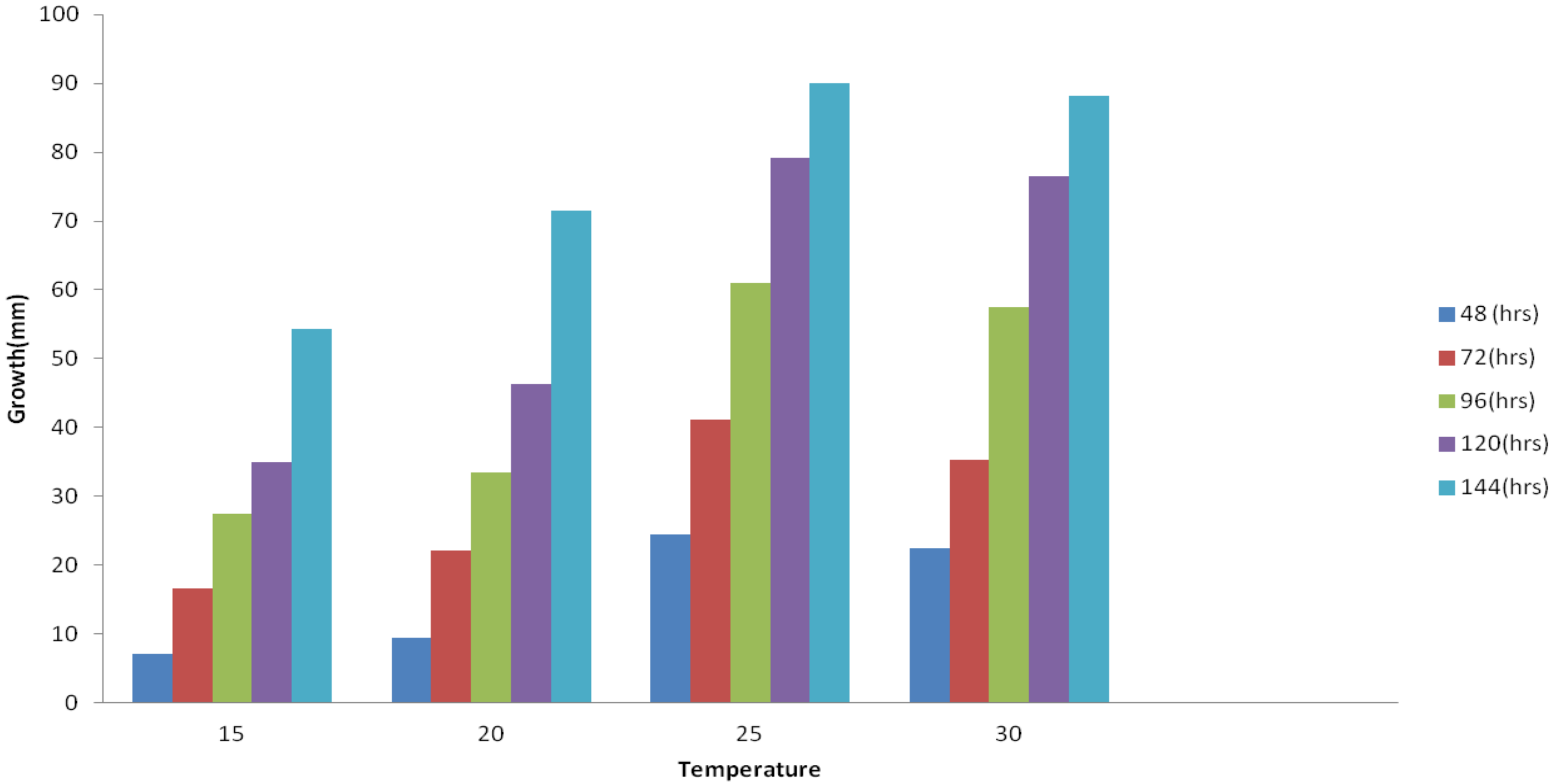


Fig. 3: : Graphical representation of effect of different temperature on mycelial growth of *Rhizoctonia solani* after different incubation periods

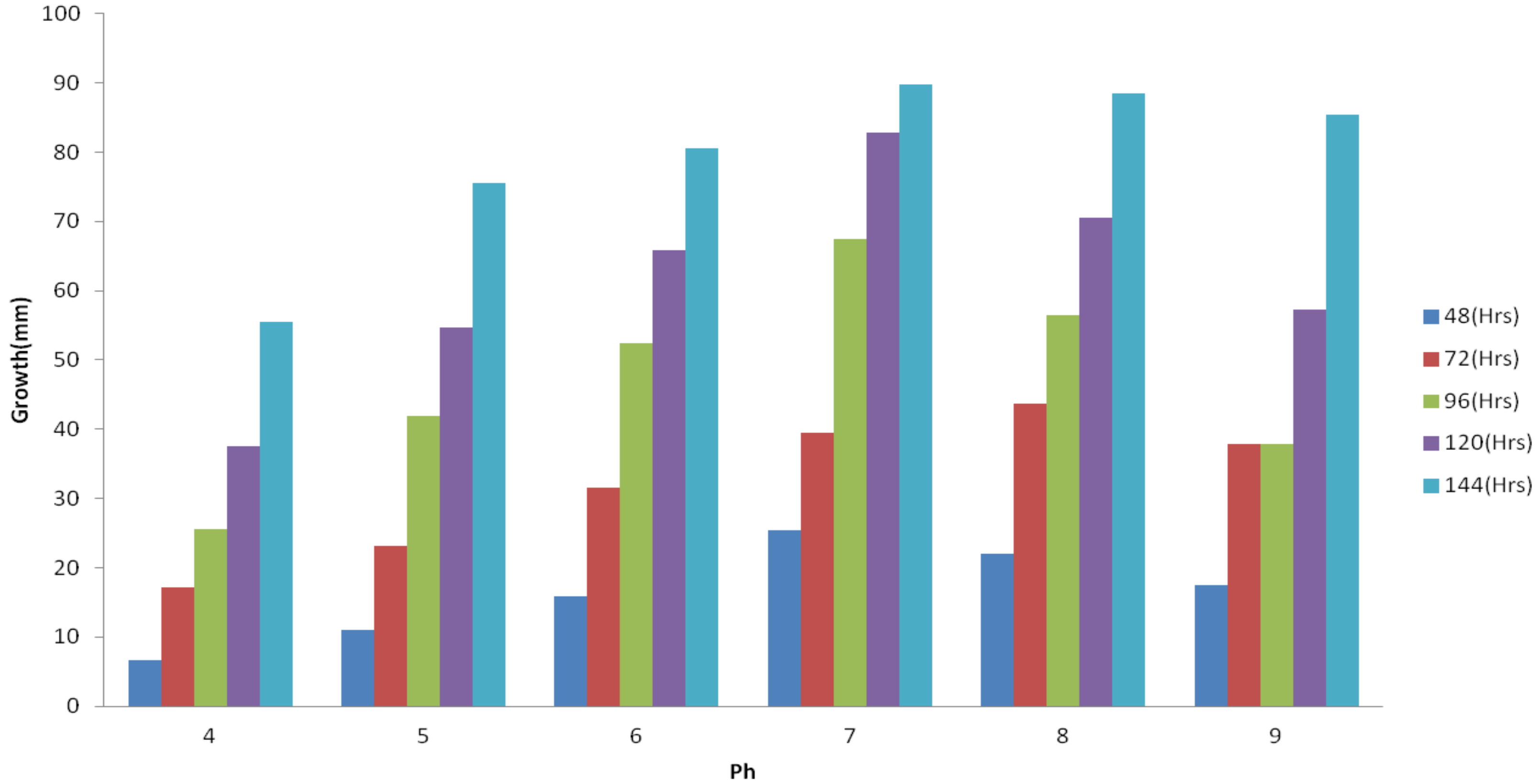


Fig. 4: : Graphical representation of effect of different pH on mycelial growth of *Rhizoctonia solani* after different incubation periods

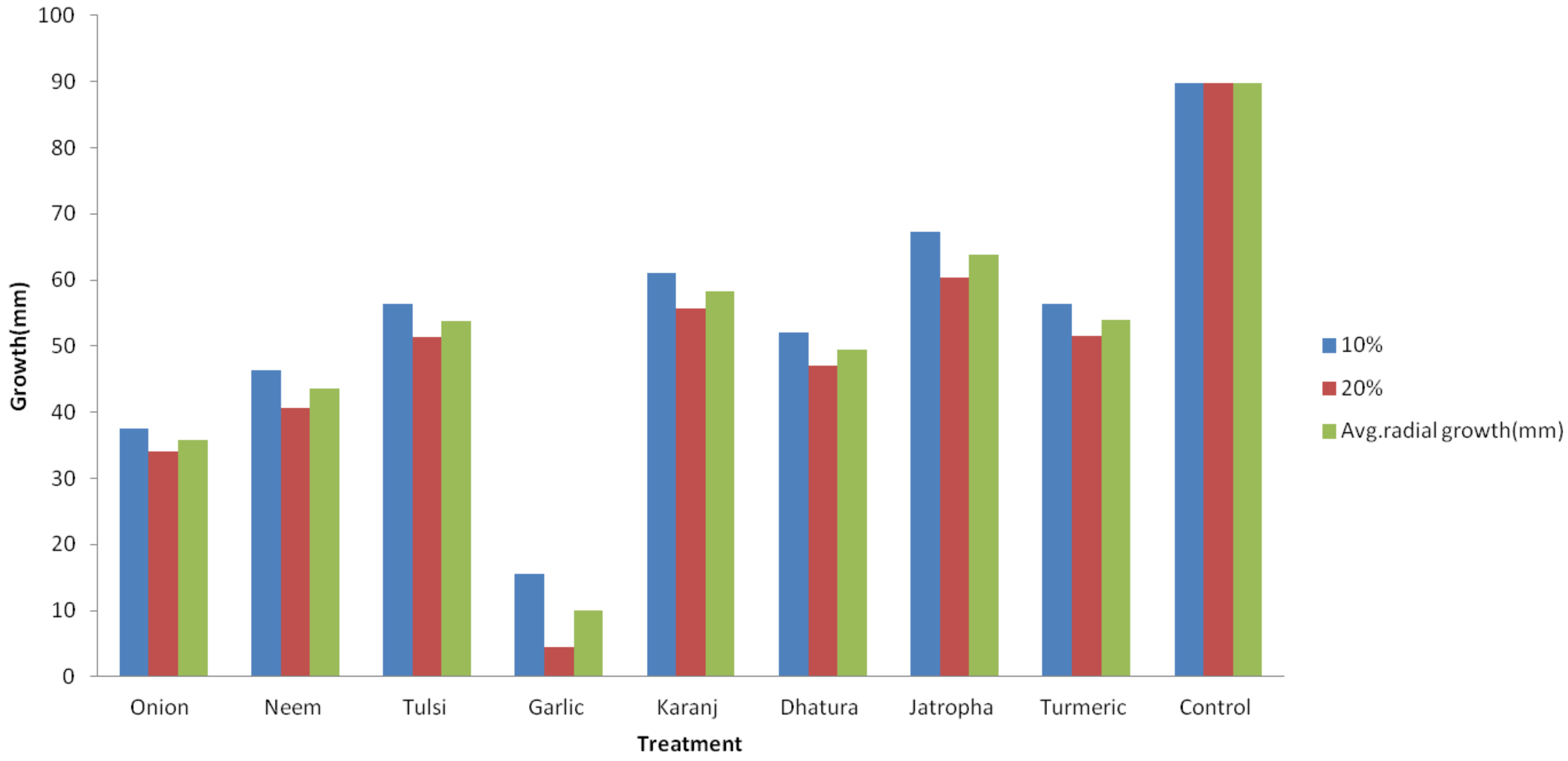


Fig. 5: : Graphical representation of effect of phyto-extracts on mycelial growth of *Rhizoctonia solani* after 144 hrs incubation period.

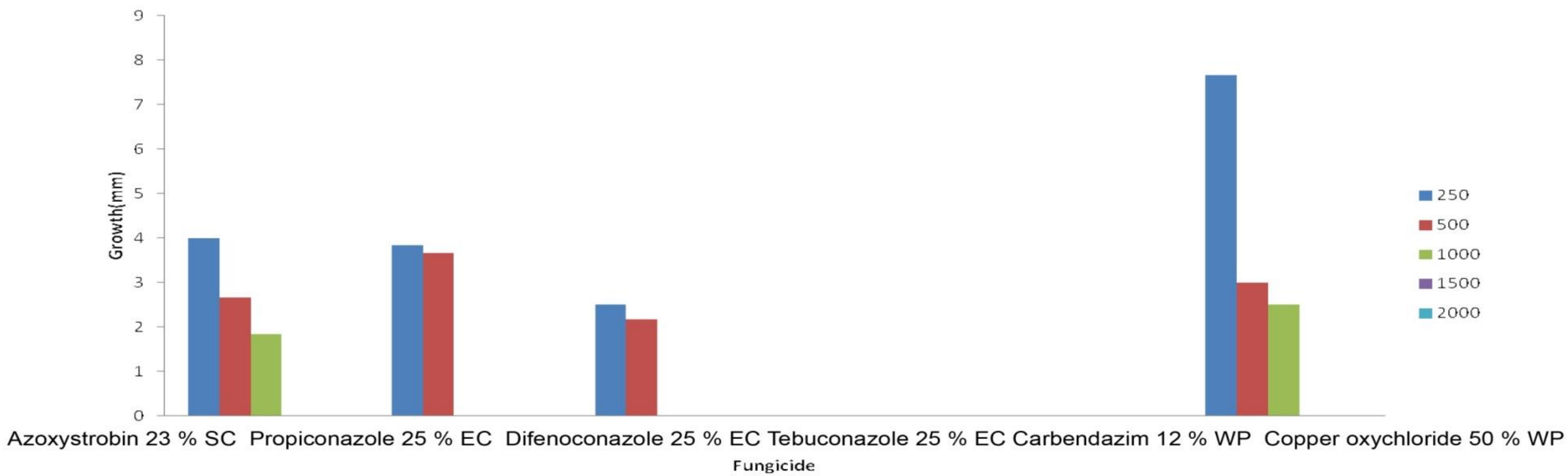


Fig. 6: : Graphical representation of effect of fungicides on mycelial growth of *Rhizoctonia solani* after 48 hrs of incubation period

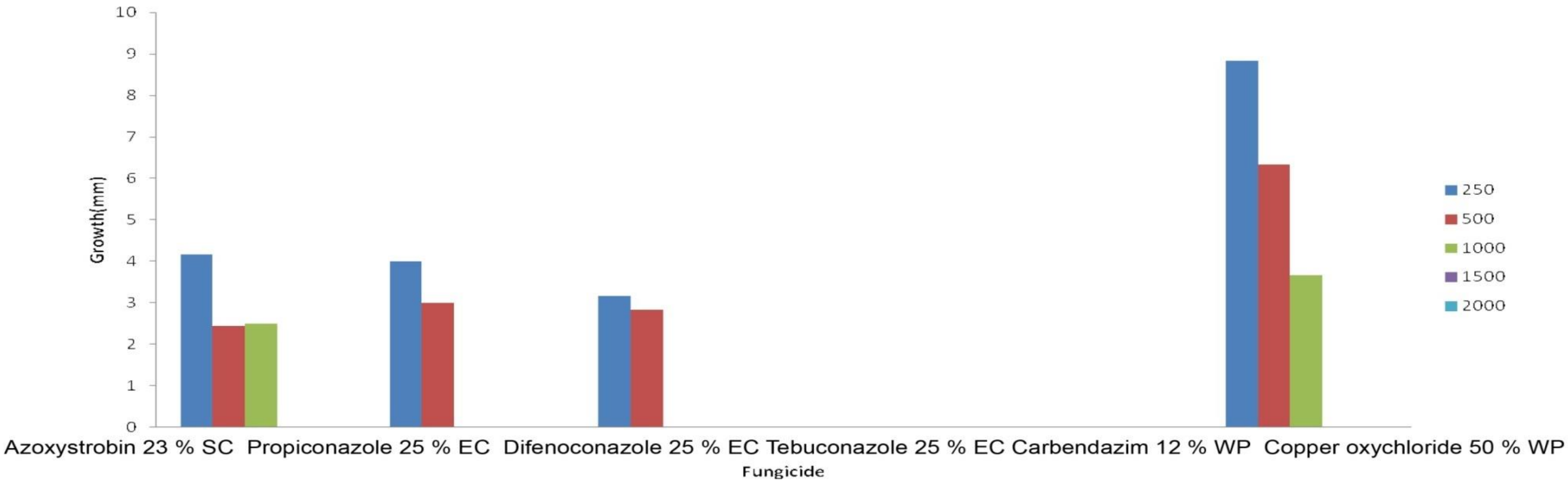


Fig. 7: : Graphical representation of effect of fungicides on mycelial growth of *Rhizoctonia solani* after 72 hrs of incubation period

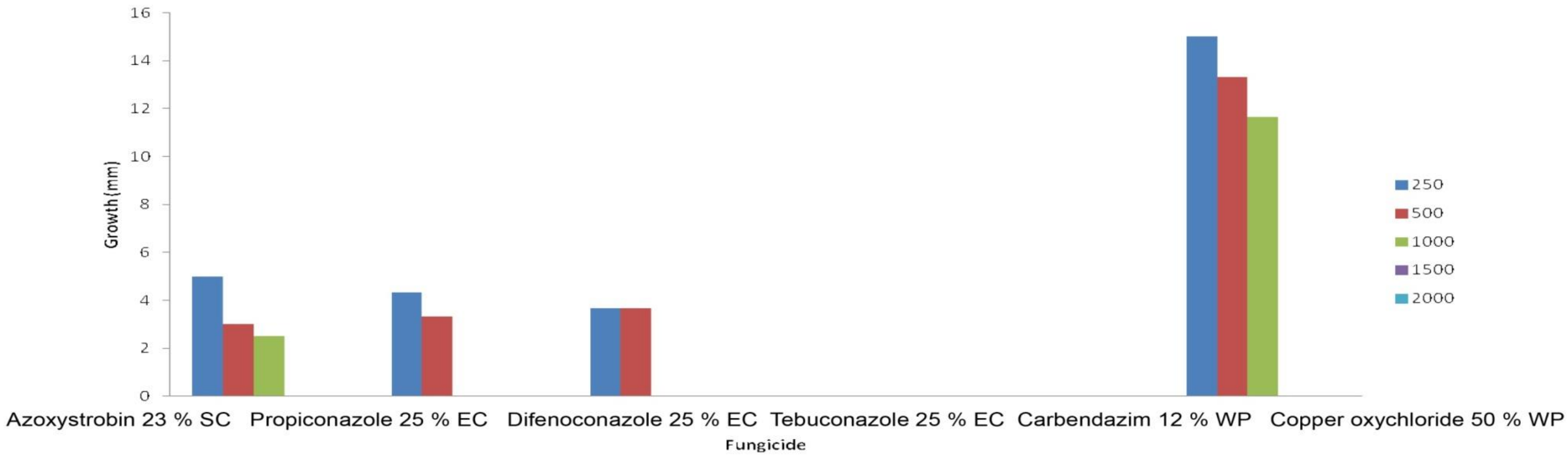


Fig. 8: : Graphical representation of effect of fungicides on mycelial growth of *Rhizoctonia solani* after 96 hrs of incubation period

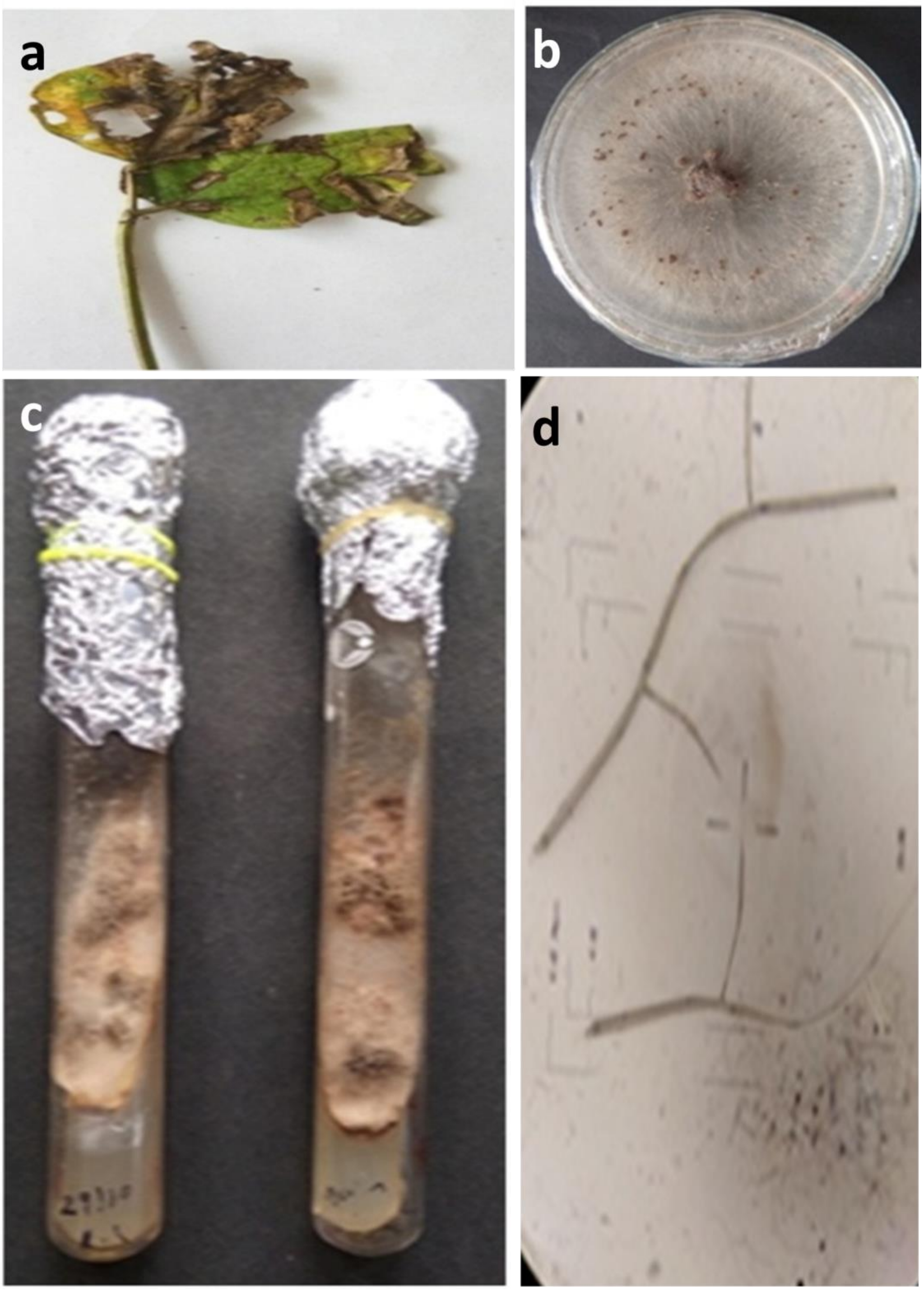


Plate 1: Collection, isolation and purification of *Rhizoctonia solani*

a) Diseased sample showing symptoms of web blight of urd bean
b) Pure culture of *Rhizoctonia solani*
c) Culture of *Rhizoctonia solani* in slants
d) Mycelia of *Rhizoctonia solani*

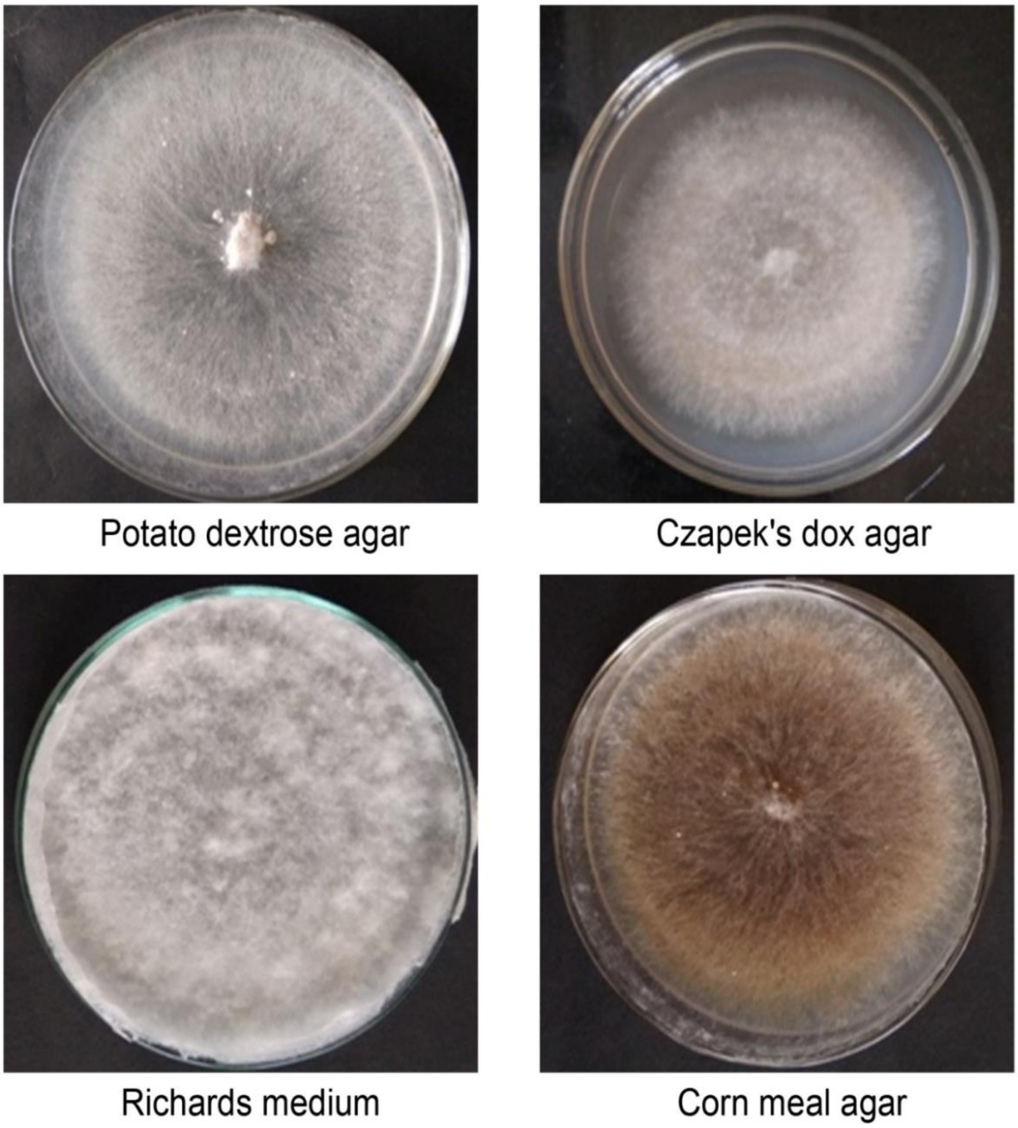
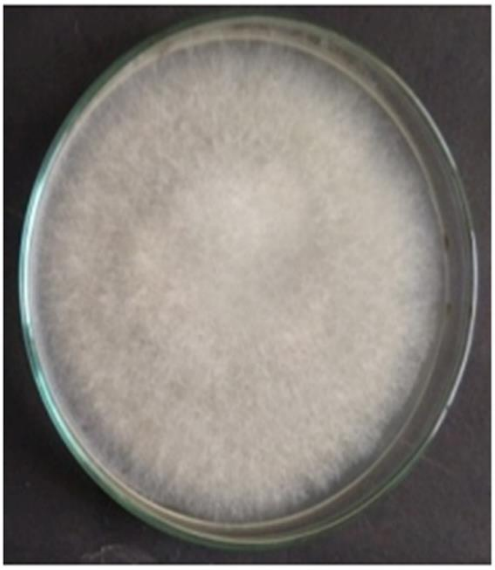


Plate 2: Effect of different media on mycelial growth of *Rhizoctonia solani* on different media

15 ^{O}c

20 ^{O}c



25 ^{O}c

30 ^{O}c

Plate 3: Effect of different temperature on mycelial growth of *Rhizoctonia solani* on different media

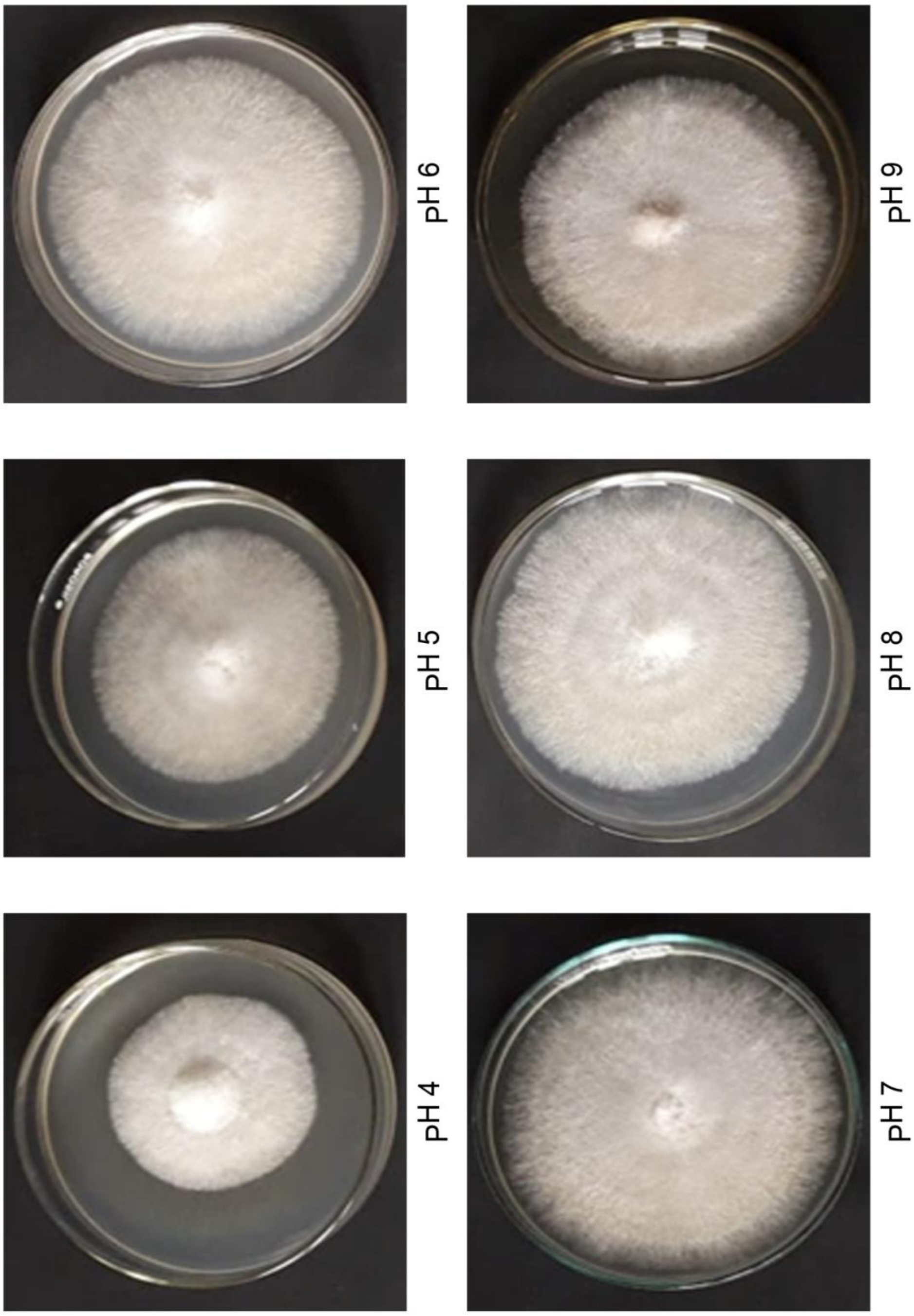
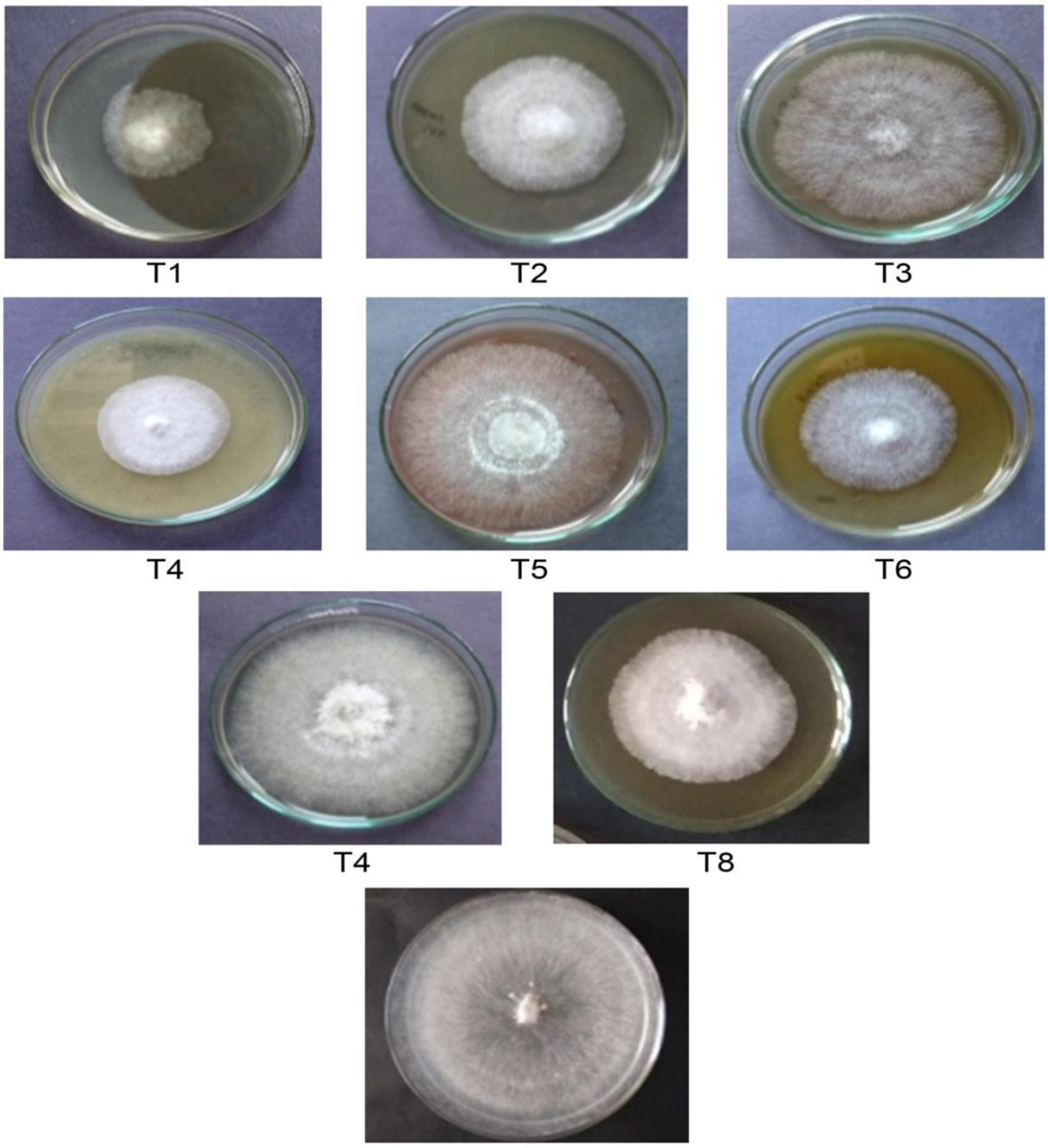


Plate 4: Effect of different pH on mycelial growth of *Rhizoctonia solani* on different media

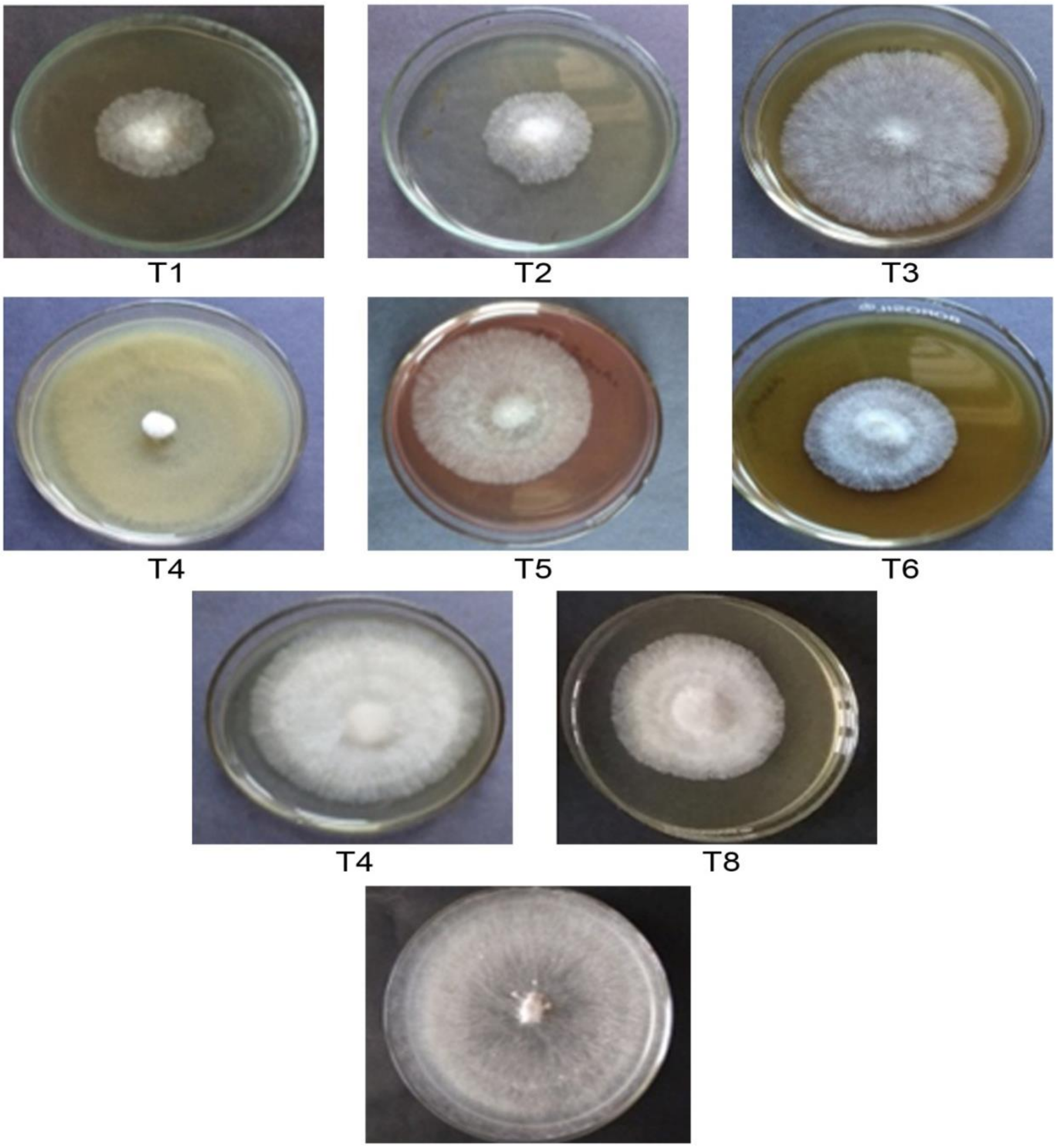


T1- Onion T2- Neem T3- Tulsi

T4- Garlic T5-Karanj T6- Dhatura

T7- Jatropha T8 -Turmeric T9- Control

Plate 5: Effect of phyto-extracts @10% on mycelial growth of *Rhizoctonia solani*



T1- Onion　T2- Neem　T3- Tulsi

T4- Garlic　T5-Karanj　T6- Dhatura

T7- Jatropha　T8 -Turmeric　T9- Control

Plate 6: Effect of phyto-extracts @20% on mycelial growth of *Rhizoctonia solani*

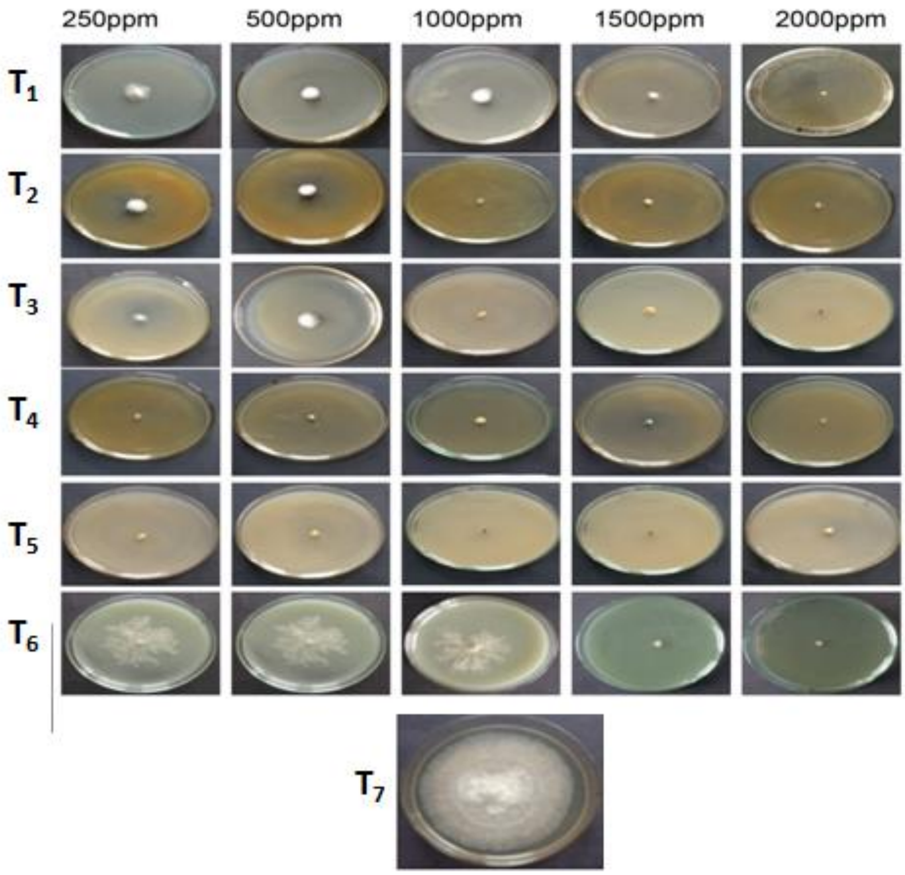


Plate 7: Effect of fungicides on mycelial growth of *Rhizoctonia solani* after 96 hrs of incubation period

T_1=Azoxystrobin 23% SC,
T_2=Propiconazole 25% EC,
T_3=Difenoconazole 25% EC,
T_4=Tebuconazole 25% EC,
T_5=Carbendazim 12% WP
T_6=Copper oxy chloride 50% WP
T_7= Control

CURRICULUM VITAE

Name of the author : Babli verma

Place : Near by ram mandier Dhaboti,Post – Bamulia Teh or Dist-Sehore, 466001, (M.P)

Date of Birth : 01/01/1993

The author of this thesis **Babli Verma**, D/o Sooraj Singh and Sheela Verma, born on 1 January 1993 at (Madhya Pradesh). She joined the following institutions and successfully completed the degree of M.Sc. (Ag.) during the year 2018-19 with 6.55 OGPA out of 10-point scale.

S.No.	**Institution**	**Degree awarded**	**Year**
1	JNKVV, Jabalpur (M.P.)	M.Sc. (Ag)	2019
2	RVSKVV, Gwaliar (M.P.)	B.Sc. (Ag)	2017
3	NBVMHS School, Sehore	12th	2012
4	SCH School, Sehore	10th	2010

For the partial fulfillment of the master's degree programme, she was allotted a research problem on **"Studies on *Rhizoctonia solani* (Kuhn) causing web blight of urd bean and its management** which was successfully conducted by her and being submitted in the form of the thesis.