Studies on banded leaf and sheath blight of finger millet caused by *Rhizoctonia solani* Kuhn

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Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur

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By

SMITA PRAJAPATI
(I.D. No. 170218005)

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

2019

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This is to certify that the thesis entitled, "**Studies on banded leaf and sheath blight of finger millet caused by *Rhizoctonia solani* Kuhn**." submitted in partial fulfillment 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 **Miss Smita Prajapati** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

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

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Place:
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Place:

Date:

(Dr. A. K. Jain)
Chairman of the
Advisory Committee

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Committee	**Name**	**Signature**
Chairman	(Dr. A. K. Jain)	……..
Member 1	(Dr. K. S. Baghel)	……..
Member 2	(Dr. M. R. Dhingra)	……...
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Major Advisor — Signature of the student

Name and Signature — Smita Prajapati

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Place : Rewa (M.P.) **(Smita Prajapati)**
Date ----------

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LIST OF ABBREVIATIONS

Words	Abbreviations
Banded leaf and sheath blight	BLSB
Cultivars	cv
Centimeter	cm
Percentage	%
Co-workers	*et al.*
Critical difference	C.D.
Degree centigrade	°C
Degree of Freedom	d.f.
Figure	Fig.
Fisher's value	"F"value
Gram	g
Hour	H
Kilogram(s)	Kg
Mean sum of square	M.S.S.
Meter	M
Millimeter	Mm
Non-significant	N.S.
Number	No.
Per	/
Per cent	%
Relative lesion height	RLH
Serial No.	S.No.
Source of variation	S.V.
Species	Spp.
Square	sq.
Standard error of difference	S.Ed±
Standard error of means	S.Em±
Sum of square	S.S.
Days after sowing	DAS

INTRODUCTION

Finger millet (*Eleusine coracana* L. Gaertn.) commonly known as ragi is one of the hardiest small seeded crop suited for rainfed farming. It is a principal member of small millet group. It can be grow under conditions of very low rainfall, can with stand in severe drought and can revive again with a good shower of rain. Finger millet is the staple food grain for majority of the population in India since it is economical and very nutritious. In India, crop is cultivated over an area of 1.14 m ha with a production of 1.82 m. tons and productivity of 1601 kg/ha during 2015-16 (Anon, 2018). Karnataka, Andhra Pradesh, Tamil Nadu, Gujarat, Maharashtra, Jharkhand, Chattisgarh are major finger millet growing states. In Madhya Pradesh, crop is grown in erratic pockets by tribal farmers. It contains a large proportion of carbohydrates and thus provides bulk of energy in diets. It is also rich in proteins, sulphur containing amino acids and because of its low glycemic index with high fibre, it is recommended for diabetic patients. Apart from the major nutrients, the calcium content of finger millet is higher than all the cereals and millets.). In India, grains are used in many food preparations like cakes, porridge and sweetmeat. Germinating grains are malted and fed to infants also. It is also good for pregnant women. The finger millet flour is consumed by mixing with milk, boiled water or yoghurt. It is non acid forming food and easy to digest. It is considered to be one of the least allergic and most digestible foods (Pragya and Rita Singh, 2012).

A number of diseases occurs in finger millet at different stages of plant growth and reported to cause qualitative and quantitative loss (Anilkumar et

al, 2003). Banded leaf and sheath blight caused by *Rhizoctonia solani* (basidial stage : *Thanatephorus cucumeris* (Fr.) Donk) is an important disease which occurs at different stages of plant growth. In India, the disease was first reported from Vellayani in Kerala in a severe form by Das and Girija (1989). Later on the disease was also reported from Bihar (Dubey, 1995) and Karnataka (Nagaraja and Anjaneya Reddy, 2010). The disease was more severe on exotic genotypes of finger millet. A description of the symptoms of disease on finger millet was given and pathogen was identified as *Rhizoctonia solani* AG-I (Dubey, 1995). Finger millet was also reported susceptible to highly susceptible to rice isolates of *Rhizoctonia solani* (Kanaiyan and Prasad, 1978, Meena and Muthuswamy, 1998) and moderate to maize isolate (Rathore et al, 1998). Earlier, the disease was minor but recently the disease is becoming a major disease in all the finger millet growing areas under favourable environmental conditions (Nagaraja et al 2016). *Rhizoctonia solani* is reported to cause severe banded leaf and sheath blight diseases in cereals including all the small millets (Kumar and Dinesh, 2009 & 2010, Jain and Gupta, 2010, Jain and Tiwari, 2013, Lenka et al, 2014). The disease is characterized by oval to irregular, light grey to dark brown lesions on the lower leaf sheath. The central portion of the lesions subsequently turns white to straw with narrow reddish brown border. Under favourable environmental conditions, the disease was characterized by a series of copper or brown coloured bands across the leaves giving banded appearance (Nagaraja and Anjaneya Reddy, 2010). Studies on cultural and sclerotial characteristics of *Rhizoctonia. solani* isolated from infected finger millet are meager in the literature. However, lot of work on rice and few studies in kodo millet (Kahar, 2017), foxtail millet (Patro and Madhuri, 2014),

barnyard mieelt (Kumar,2016) and little millet (Chouhan, 2014, Jain et al ,2017 and Kumar, 2018) had been carried out. Vulnerability of plant age against BLSB is important for estimation of avoidable crop losses and economical management of the disease. Use of resistant cultivars is the best way to combat with any soil borne disease. But very little reports are available in identification of resistant sources in finger millet against BLSB. Fungicides namely propiconazole, hexaconazole, validamycin, carbenazim and combination of biocontrol agents *Pseudomonas fluorescence* + *Trichoderma harzianum* were reported effective against BLSB in finger millet (Patro and Madhuri, 2014, Kukreti et al, 2017). Hence, the present study was proposed with the following objectives.

Objectives

1. Isolation, purification and characterization of *Rhizoctonia solani* causing banded leaf and sheath blight in finger millet
2. Effect of plant age on development of banded leaf and sheath blight in finger millet.
3. Identification of host plant resistance in finger millet against banded leaf and sheath blight.

REVIEW OF LITERATURE

The available literature pertaining to the studies on banded leaf and sheath blight of Finger millet and other cereal crops caused by *Rhizoctonia solani* Kunh in the proposed objectives has been compiled and presented in this chapter under following subheads:

Objectives

2.1 The Pathogen (*Rhizoctonia solani)*

2.2 Symptoms produced by pathogen in cereal crops

2.3 Cultural characteristics of *Rhizoctonia solani*

2.4 Plant age on development of banded leaf and sheath blight in cereals

2.5 Identification of host plant resistance in finger millet against banded leaf and sheath blight.

2.1 The Pathogen (*Rhizoctonia solani)*

The genus *Rhizoctonia* was created by De Candolle (1815) for the non-sporulating root pathogen *Rhizoctonia crocorum* D.C. ex.fr. Later, Julis kuhn, a German scientist described it as *Rhizoctonia solani* isolated from diseased potato tubers. *Rhizoctonia solani* [telomorph-*Thanatephorus cucumeris* (Frank) Donk] causal agent of banded leaf and sheath blight is one of the most wide spread, destructive and versatile pathogen prevalent in most parts of the world with a wide host range (Oghasi, 1987).

Isolates of *Rhizoctonia solani* one morphologically grouped based on the number of nuclei per cell and by hyphal anastomosis reactions. Singh *et al* (1999) reported

that there was no relationship between cultural / morphological characteristics of an isolates with its anastomosis behavior. Further, in addition to four types of earlier reported reactions i.e. 0 – neutral, 1- parallel growth but no fusion, 2- incompatible fusion and 3- compatible fusion, an additional category-1 (minus one) has also been also reported. Based on anastomosis reactions, at least 13 anastomosis groups (AGs) of R. solani have been identified (Gonzalez et al, 2006) and sheath blight causing fungus has been placed in AG-1 I A group (Gonzalez-Vera et al , 2010). The pathogen has a wide host range of 250 plant species including commercially grown crops. (Chahal *et al*, 2003).

2.2 Symptoms produced by R. solani on finger millet

Symptoms of banded leaf and sheath blight are visible and characterized with presence of peculiar bands on leaf sheath and sclerotial bodies on affected parts of the plants. Very few reports are available of symptoms produced by *R. solani* on finger millet.

Dubey (1995) reported irregular to oval, dark brown to purplish brown necrotic lesions on peduncles, glumes and fingers. Early infection on peduncle or near finger base is some what similar to neck rot resulting in poor grain filling. If the sheath is infected before peduncle emergence, then the fingers are discoloured and reduced in size.Infected glumes produce smaller and shiveled grains. Thus the symptoms produced on every part of the plant give a very characteristic banded appearance, due to which the disease has been named as banded blight.

Nagaraja and Reddy (2010) observed oval to irregular, light to dark brown lesion on the lower leaf sheath of finger millet. Later, central portions of lesions turned white

to straw with narrow reddish brown border. Spots were observed on leaf blades, under favourable conditions. The lesions enlarged rapidly and coalesced to cover large portions of the sheath and leaf lamina.

Nagaraja et al (2016) reported that temperature range from 23-300C and a relative humidity of 80% or above favours rapid disease development, where these enlarge rapidly and coalesce to cover large proportions of the sheath and leaf lamina. They also reported mycelia growth along with white to brown sclerotia around the lesions. Later on, the leaves dry up and plants appear blighted.

2.3 Cultural characteristics of *Rhizoctonia solani*

Singh et al (1974) reported that PDA was found best for radial growth. The maximum number of sclerotia and weight was recorded on Czapek Dox Agar medium.

Das and Girija (1989) observed severe sheath blight of *Eleusine coracana* from Vellayani, Kerala and thought to be the first report of *Rhizoctonia. solani* on *Eleusine coracana* from India. The causal organism was isolated, identified as *Rhizoctonia. solani* and pathogenicity was confirmed.

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.

Lakpale *et al* (1997) studied the mycelial growth and sclerotial formation of rice isolates of *Rhizoctonia solani* and reported that 300C temperature is best for optimum growth. Desiccation of sclerotia and compactness of basal medium did not influence mycelia growth and sclerotial formation.

Singh *et al* (1999) taken 8 isolates of *Rhizoctonia solani* collected from rice, maize, soybean, mungbean and 22 additional rice isolates for the testing 4 anastomosis behavior and pathogencity. They reported that there was no relationship between cultural/morphological characteristics of an isolates with its anastomosis behavior. Further, in addition to four types of earlier reported reactions i.e. 0 – neutral, 1- parallel growth but no fusion, 2- incompatible fusion and 3- compatible fusion, an additional category-1 (minus one) has also been also reported.

Meena *et al* (2001) studied the variability in morphological and cultural characteristics of *Rhizoctonia solani* isolates collected from rice in Tamil Nadu, India. The mycelia and sclerotial characters varied greatly among the isolates. Potato dextrose agar medium supported the maximum mycelia 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 sclerotia production. Sclerotial colour grouped into two: dark brown and light brown and sclerotial formation pattern grouped in 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 solution agar, water agar, PDA and maltose agar were found the best media for*Rhizoctonia solani*, while beef extract peptone agar was the worst medium.Richards's agar was the best for sclerotial formation. Maximum sclerotialnumbers and mass were obtained in this medium.

Sunder et al (2003) reported that colony colour ranged from brown, light brown, dark brown and yellowish brown in *R. solani* isolated from rice. The discolourations of the growth media is mainly attributed to the production of pigments by the pathogen.

The differences in the intensity of the colour may also correspond to the amount of pigments released by respective isolate in the media. On the basis of growth pattern, the isolates were categorized in three groups viz. abundant, moderate and slight. Eight isolate showed abundant growth, four isolate were moderate and 13 isolates showed only slight growth.

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

Akhtar *et al* (2009) reported wide spread occurrence of banded leaf and sheath blight of maize caused by *Rhizoctonia solani in* Jharkhand with disease severity ranging from 30.30 to 80.46 percent. Five isolates from five different locations showed variation in their morphological characters such as abundance of mycelium, colour and location, distribution, size and density of sclerotia etc.

Lal and Kandhari (2009) studied the cultural and morphological variability in *Rhizoctonia solani* isolates causing sheath blight of rice and reported great diversity in colony size, growth, colour and sclerotial formation (central, peripheral or scattered), location (aerial or surface) and texture (smooth or rough). Based on the colony pigmentation, all the isolates were assigned into 5 groups: Light brown, yellowish brown, whitish brown, dark brown and very pale brown. Characteristically hyphal branching at right angle, constriction at the point of branching of the mycelium and presence of a septum near the branching junction were recorded in all the tested 25 isolates.

Ray and Kumar (2009) reported that Czapek's dox agar supported best mycelial growth and sclerotial production of *Rhizoctonia solani* followed by Potato dextrose

agar, Richard's medium and Corn meal agar media. Maximum colony diameter, sclerotial production was recorded at 30^0C and maximum mycelia dry weight at pH 7.0, while minimum at pH 3.0

Nagaraja and Anjaneya Reddy (2010) reported the banded blight of finger millet from Karnataka disease and described the symptoms. The disease appeared as oval to irregular, light to dark brown lesions on the lower leaf sheath. Later, the central portions of the lesion turned white to straw with narrow, reddish brown border. Spots were also observed on leaf blade. The lesion enlarged rapidly and coalesced to cover large portions of the sheath and leaf lamina. At this stage, the disease was characterized by a series of copper or brown coloured bands across the leaves giving a very characteristic banded appearance.

Sharma et al (2013) studied the culture characteristics of R. solani isolated from soybean in Asthana and Hawkers, PDA, Czapek's dox agar, corn meal agar and Richards agar medium. PDA was found best for growth and development followed by Czapek's dox agar and corn meal agar. The maximum number of sclerotia and weight were also recorded in by Czapek's dox agar and corn meal agar.

Mishra et al (2014) collected isolates of *Rhizoctonia solani* from rice, maize and green gram and studied the cultural, morphological characters and pathogenicity. Colour appearance of the isolates was sparse, sparse fluffy, cottony and cottony fluffy. Most of the isolates were sparse and light brown in colour. Out of the three patterns of radial growth namely fast, medium and slow, twelve isolates were medium growing where growth completed within 72 h, eight isolates were fast growing and two were slow growing. Sclerotia of the isolates were light brown, brown, dark brown and black in colour and formed as central, sub-central ring, scattered and irregular manner.

Kumar et al (2014) effect of different culture media (cultural), temperature, pH (physiological), carbon and nitrogen sources (biochemical) were evaluated in vitro against Rhizoctonia solani Kuhn.

Husain et al (2016) collected the sheath blight infected samples of rice from six states of India and isolated in PDA. Colont colour, growth pattern and diameter growth showed great diversity in all the isolates. Based on the colony pigmentation all the isolates were assigned into 4 groups: dark brown, dirty white, milky white and yellowish brown. Isolates were grown on five different media. PDA was found the best media for growth and development in comparison to others. The fourteen days old broth culture of oat meal broth of different isolate of *R. solani* significantly reduced the radical length and plumule length of the germinated seeds of Pusa Basmati-1 and Tepek as compared to check.

Jain *et al* (2017) studied the cultural characteristics of *Rhizoctonia. solani* from little millet in four culture media viz. potato dextrose agar, czapek's dox agar, Richards agar and corn meal agar media. Cottony, regular and fast growing whitish colony without pigmentation was reported in potato dextrose agar medium. Whereas mycelia growth were transparent, submerged, slow and without pigmentation in corn meal agar.

Hase and Nasreen (2017) suggested that culture media differentially influenced the growth and colony characters of *R. solani*. Maximum colony diameter was recorded in corn meal agar (91.3±0.3) followed by Czapek's dox agar (82.6±0.5) and potato dextrose agar (72.3±0.4) medium. Least mycelia growth was found in nutrient agar and sabouraud agar.

2.4 Plant age on development of banded leaf and sheath blight in cereals.

Yoshimura and Nishizawa (1954) reported that inoculation of rice plant with *Rhizoctonia solani* at the maximum tillering stage was the most suitable for varietal testing.

Kozaka (1961) found that rice plants become more susceptible to sheath blight as they grow older to an adequate microclimate within the crop canopy, which greatly affects the incidence and the damage caused by this disease.

Tsai (1974) reported that yield loss due to sheath blight was maximum, when infection started 60 days after sowing (tillering stage) and continues to subsequent booting stage.

Roy (1979) reported that *Rhizoctonia solani* causes maximum disease and consequently yield loss on rice plants inoculated at the maximum tillering stage, less at exertion of tillering and least at booting stage.

Chang and Dath (1995) found significant interaction between *R. solani* isolates, rice cultivars and stages of the plant growth thereby indicating that everyone of the combination of these factors influenced sheath blight severity. However, the disease severity in many cultivars was, in general, more at flowering than at seedling and maximum tillering stages.

Cu et al (1996) demonstrated that the incidence of sheath blight was great when plants were inoculated at panicle exertion, booting or flowering stage and significantly lower at tillering and grain filling stage.

Lakpale et al (1996) observed that transplanted rice seedlings 20 and 30 days old showed the highest severity of sheath blight compared with seedlings of 40,50 and 60 days old. Maximum tillering stage was more susceptible for disease development compared with booting and milk stage.

Sharma and Teng (1996) observed that rice was more susceptible to sheath blight at booting and flowering stages than at tillering and panicle exertion stages.

Vanitha *et al.* (1996) observed that plants are more susceptible to infection at booting and flowering stages. The average percentage of infected tillers and average disease severity are increased as plant age increased.

Saxena (1997) observed symptoms of the BLSB on all aerial parts of maize plant except tassel. Under natural conditions, disease appeared at pre-flowering stage on 30 to 40 days old plants but infection can also occur on young plants which may subsequently result in severe blighting and death of apical region of growing plants

Rodrigues et al (2003) inoculated the rice plants with *Rhizoctonia solani* at 45 (four leaf stage), 65 (eight leaf stage, 85 (tillering), 117 (booting) and 130 (panicle exertion) days of emergence. The total number of sheath blight lesions on sheath and total area under the relative lesion extension curve decreased at all plant growth stages when rate of Si increased in the soil. The severity of sheath blight was lower at booting and panicle exertion stage. In general, plants inoculated with *R. solani* were more vulnerable to infection at all growth stages, especially at 45 days after emergence.

Thind et al (2008) found crop age as an important factor in sheath blight development and reported that tillering to panicle emergence stage were the most susceptible stages. A temperature range of 25 to 30^0C and relative humidity between 80 to 100 percent were the most favourable for disease development.

Kumar (2018) studied disease progression and development of banded leaf and sheath blight in terms of relative lesion height in 19 cultivars of little millet artificially inoculated at 20, 30, 40 and 50 days old crop. Significant linear increase in relative

lesion height at crop age of 20, 30, 40 and 50 days of sowing was recorded, but progression and development of BLSB was maximum in 20 and 30 days old little millet crop.

2.5 Identification of host plant resistance in finger millet against banded leaf and sheath blight.

Kannaiyan and Prasad (1978) studied the reaction of certain cereal crop plant to sheath blight of rice causing pathogen. *Eleusine coracana* (finger millet) was found highly susceptible to *Rhizoctonia solani*

Dubey (1995) observed disease in a severe form in 1993 at Ranchi, Bihar (now Jharkhand) with more severity on exotic genotypes. Isolation of the pathogen yielded *Rhizoctonia. solani* AG-I.

Patro (2008) evaluated finger millet varieties against banded leaf and sheath blight and observed the disease in a very severe form on finger millet variety KM 252 and RAU 8 at ARS, Vizianagaram.

Nagaraja and Anjaneya Reddy (2010) reported banded leaf and sheath blight on popular finger millet variety GPU 28 and found susceptible to the disease.

Chouhan *et al*. (2014) screened 21 released and pre-released genotypes of little millet. None was found completely free from banded leaf and sheath blight. However, five genotypes namely KRI 10-03, RLM 186, OLM 203, DLM 103 and BL 4 were found resistant with 0.082 to 0.119 cm per day infection rate under artificial inoculations.

Kahar (2017) reported that soil application of value added Trichoderma viride @ 1kg formulation mixed in 25 kg FYM, incubated for 15 days and applied over an area of 1 acre at the time of sowing was found best to reduce banded leaf and sheath blight incidence in kodo millet. Soil application of value added *Pseudomonas fluorescens* + *Trichoderma viride* + *Bacillus subtilis* @ 335 g each of formulation was at par with the application of T. viride.

Thakur et al (2017) studied the epidemiological aspect of sheath blight disease of rice. Sheath blight disease progression and apparent infection rate were maximum during1 to 15 and 16 – 30 th October in over the four years *kharif* season. Year wise correlation analysis between weather parameters and sheath blight disease severity suggest that T max and sun shine hours had positive effect in the development of sheath blight of rice.

Jain and Joshi (2018) evaluated 48 entries of finger millet against banded leaf and sheath blight from 2014-15 to 2017-18 under artificial inoculations. BLSB incidence ranging from 0.0 to 51.6% was recorded in the evaluated entries. Seven entries namely VL 352, VL 384, GPU 91, GPU 92, VR 708, TNEC 1234 and GPU 45 are resistant to banded leaf and sheath blight.

MATERIALS AND METHODS

Banded leaf and sheath blight is an emerging disease of finger millet and causes significant reduction in grain yield under favourable conditions. The present investigation entitled **Studies on banded leaf and sheath blight of finger millet caused by Rhizoctonia solani Kuhn** was carried out during 2018-19 at Jawaharlal Nehru Krishi Vishwa Vidyalaya, College of Agriculture, Rewa (M.P.) and the field experiments were conducted at experimental area of All India Coordinated Small Millets Improvement Project (voluntary center), College of Agriculture, Rewa (M.P.). The details of the material used and methodologies adopted during the course of present study are described below.

3.1 Experimental site

The field experiments were carried out at the experimental area of All India Coordinated Small Millets Improvement Project (voluntary center), JNKVV, College of Agriculture, Rewa (M.P.) during *Kharif* 2018. The laboratory studies were done in the Department of Plant Pathology, College of Agriculture, Rewa (M.P.).

3.2 Climate and Weather Conditions

Rewa is situated at $24^0$31' North latitude, $80^0$15' East longitude and 365 meter above the sea level. It is located at the North-Eastern part of Madhya Pradesh. It has sub-tropical climate. Hot and dry summer and cold winter are the main features of this region. The onset of monsoon is expected by the end of June to beginning of July and cessation by September. The minimum and maximum temperature occasionally reaches 17.66^0C and 44.66^0C, respectively. The average annual rainfall of this tract

ranged between 900 to 1200 mm, which mostly occurs during July to October.

The weekly rainfall, rainy days, maximum, minimum temperature and maximum and minimum relative humidity for the entire crop season of finger millet (June to November) are presented in Appendix Ist and illustrated through Fig. 3.1

The total rainfall received from 4th June to 31st December, 2018 was 966.2 mm and distributed over a period of 48 rainy days. The maximum temperature 44.0^{0}C was recorded during 27th standard week and minimum temperature 11.4^{0}C was recorded during 51st standard week. The maximum relative humidity 87.14% was recorded during 30th standard week and minimum relative humidity 11.6% was recorded during 23rd standard week.

3.3 Equipment used

The following equipments were used in the present study

I. Autoclave for sterilization of culture media.
II. BOD incubator for incubation.
III. Hot air oven for sterilization of glass wares.
IV. Laminar air flow for isolation and purification of the test pathogen
V. Electronic weighing balance
VI. Spirit lamp
VII. Forceps, needles, incubation needles, cork borer etc
VIII. Refrigerator

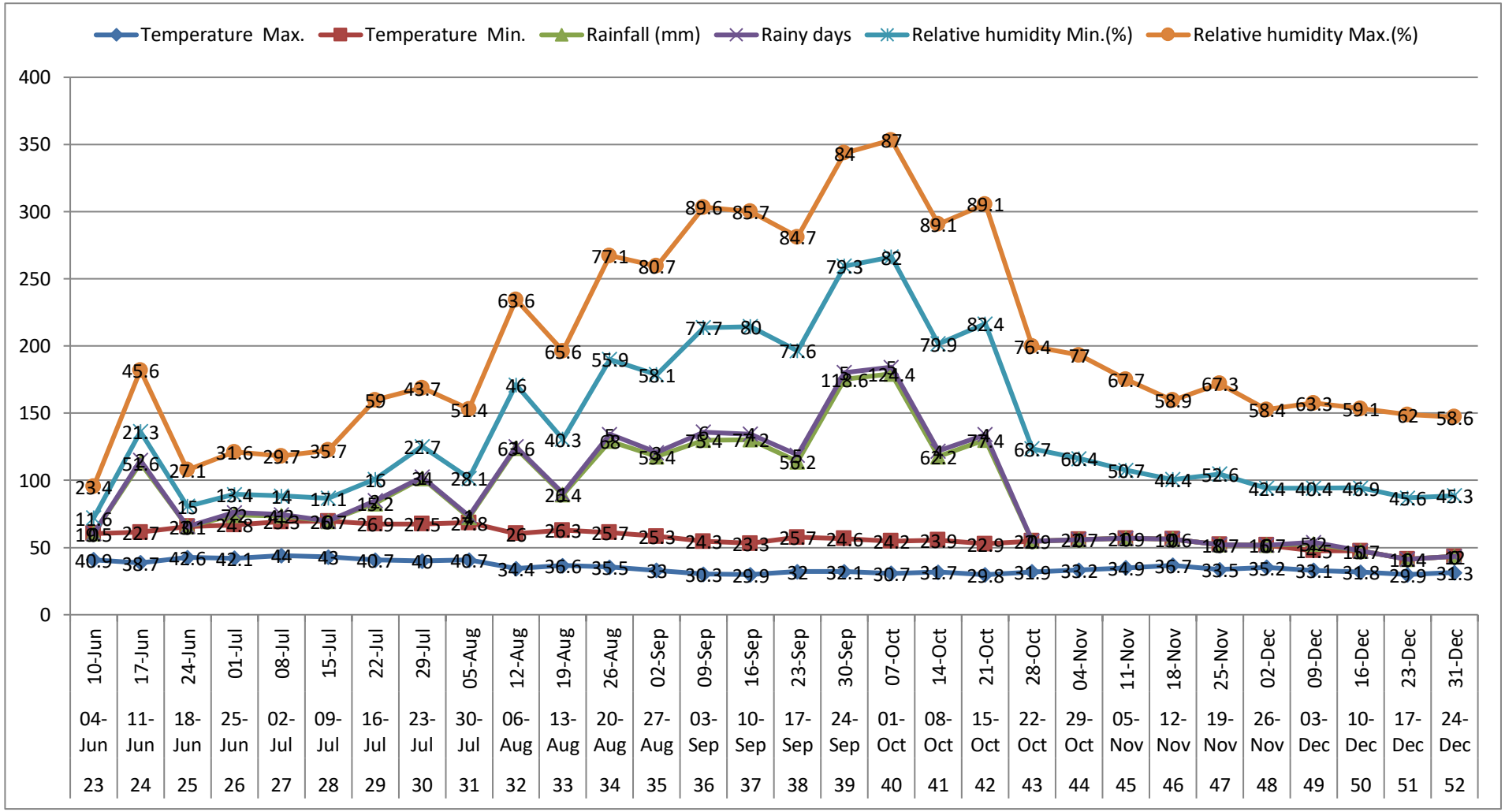


Fig. 3.1 Weekly meteorological data in standard week 23 to 52 (2018-19)

3.4 Cleaning and sterilization of glass wares

For the laboratory studies, Borosil glass wares were used. The glass wares were washed with detergent powder and kept for I hour in cleaning solution made with 60 g potassium dichromate, 60 ml of concentrated sulphuric acid in one litre of water followed by washing under running tap water and rinsing twice in distilled water. Glass wares further air dried and sterilized in hot air oven at 180^0C for one hour.

3.5 Isolation and identification of the pathogen

The diseased leaf sheaths (Plate-1) of finger millet collected from previous crop season showing characteristic symptoms were thoroughly washed repeatedly in tape water. Thereafter, small bits measuring about 5 mm were cut for isolation. Care was taken to ensure that each bit should have healthy as well as diseased parts. The sheath bits were surface sterilized with 0.1 per cent mercuric chloride ($HgCl_2$) solution for 30 second followed by three change of sterilized water. The surface sterilized sheath bits were aseptically transferred to the petriplates containing potato dextrose agar (PDA) medium and incubated at 28 ± 2^0 C. After 48 hours of incubation, the growing mycelium from the margin of apparently distinct colonies was sub cultured aseptically on fresh PDA plates. In this way, pure culture of *R. solani* was maintained. The sub culturing was done at an interval of 15 days and preserved at low temperature (4 ± 1^0 C) in refrigerator. Temporary slides of the culture were prepared in lacto phenol cotton blue and examined under compound microscope for the mycelia characters. The confirmation and identification of the fungus was done on the basis of the mycelia and colony characters.

3.6 Cultural characterization of *Rhizoctonia solani* causing banded leaf and sheath blight in different media

Cultural characteristics of *Rhizoconia solani* were studied in eight culture media namely Potato Dextrose Agar (PDA), Oat meal agar (OMA), Corn Meal Agar (CMA), Czapek's Dox Agar (CDA), Richards medium, Finger millet Leaf extract agar (30%), Finger millet seed extract agar (10%), Finger

millet seed extract agar(10%) + 2% sucrose agar purchased from Hi-media laboratories pvt. Ltd. The composition of the used media was as under:

Potato Dextrose Agar (PDA)

Composition	Quantities (g / liter)
Potato (peeled and sliced)	200
Dextrose	20
Agar-agar	15

Oat Meal Agar (OMA)

Composition	Quantities (g / liter)
Oatmeal	10g
Agar powder	15g
$M_gSO_4.7H_2O$	1.0g
KH_2PO_4	1.5g
$NaNO_3$	1g

Corn Meal Agar (CMA)

Composition	Quantities (g / liter)
Corn meal infusion from	50.00
Dextrose	2.00
Agar-agar	15.00

Czapek's Dox Agar (CDA)

Composition	Quantities (g / liter)
Sucrose	30.00
Sodium nitrate	2.00
Dipotassium phosphate	1.00
Magnesium sulphet	0.500
Potassium chloride	0.500
Ferrous sulphate	0.010
Agar - agar	15.00

Richards Agar medium (RA)

Composition	Quantities (g / liter)
Potassium nitrate(KNO3)	10.00
Mono potassium dihydrogen phosphate(KH2PO4)	5.00
Magnesium sulphet (MgSO4.7H2O)	2.50
Ferric chloride (FeCl3)	0.02
Sucrose	50.00
Agar-agar	15.0

Finger millet Leaf extract agar. (30%)

Composition	Quantities (g / liter)
Finger millet leaf	300
Agar-agar	20

Finger millet seed extract agar (10%)

Composition	Quantities (g / liter)
Finger Millet seed	100
Agar-agar	20

Finger millet seed extract agar (10%) + 2% sucrose agar

Composition	Quantities (g / liter)
Finger Millet seed	100
Agar-agar	20
Sucrose	20

For measuring the radial growth rate, 2 days old culture of *Rhizoctonia solani* was inoculated in triplicate at the centre of 90 mm media plate. Inoculum was done in the form of 5 mm mycelial discs taken from margin of colonies grown on 3 plates of each culture media The plates were incubated at ambient temperature (25^0C) and the radial growth was measured (in mm) 24, 48 and 72 hrs after incubation. Colony characteristics (Growth rate, growth pattern, colony

colour etc.) and sclerotial characteristics (size, colour, weight, number etc) were observed by visual observation of the growth pattern of *Rhizoctonia solani* after 98 hrs of inoculation.

3.7 Host plant

Ten early and medium maturing entries in advanced varietal trials and 26 entries in initial varietal trials received from Project Co-ordinating Unit (Small millets) Bengaluru were used for screening against banded leaf and sheath blight, The pedigree of finger millet cultivars used in the study are given in table 3.1 and 3.2

Table 3.1 Pedigree of early and medium maturing finger millet entries used in the present study

S. No.	Genotypes	Centre	Pedigree
1.	BR-14-3	Jagadalpur	PR 202 X GPU 48
2.	KOPN 942	Kolhapur	Selection from IEC 190
3.	VL 387	Almora	VL 324 x L 540
4.	VR 1101	Vizianagaram	VL 330 x GE 532
5.	OEB 602	Berhampur	APK 7 x Purna
6.	VL 352	Almora	VR 708 x VL 149
7.	PR 202	Peddapuram	Pure Line Selection from Mettachodi ragi of Arakku valley
8.	GPU 45	Bengaluru	Selection from GPMR 1153
9.	GPU 67	Bengaluru	CO 2 x MS 4729
10.	REC 69	Rewa	Selection from local germplasm

Table 3.2 Pedigree of finger millet entries received under initial varietal trial.

S. No.	Genotypes	Centre	Pedigree
1	WN 591	Waghai	Derivative of GN 4 x Ratnagiri local
2	WN 562	Waghai	Derivative of GPU 48 x GFM 493 local
3	VL 394	Almora	GPU 28 x VL 324
4	VL 382	Almora	WR 2 x VL 201
5	KMR 650	Mandya	Indaf 5 x IE 2936
6	KMR 652	Mandya	L 5 x IE 2924
7	OEB 604	Berhampur	Neelachal x Suvra
8	HR-13	Hagari	ML 365 x GE 18
9	VR 1110	Vizianagaram	GE 5331 x GPU 48
10	VR1117	Vizianagaram	GE 5331 x GPU 48
11	BR-14-27	Jagdalpur	PR 202 x GPU 48
12	PR 1639	Peddapuram	GPU 28 x PR 202
13	GPU 98	Bengaluru	PS 1 x MR 6-8-1
14	GPU 99	Bengaluru	PS 1 x HR 911-11
15	RAUF 17	Dholi	RAU 8 x RAU 3
16	TNEc 1297	Athiyandal	CO 14 x KMR 346
17	TNEc 1299	Athiyandal	CO 15 x KMR 346
28	IIMRFM-8023-17	IIMR, Hyderabad	Selection from GEC 283
19	IIMRFM-8011-17	IIMR, Hyderabad	Selection from GE 4671
20	GSMC-1	Gossaigaon	Local collection from Kokrajhar district of Assam
21	GPU 67	Bengaluru	CO 2 x MS 4729
22	GPU 45	Bengaluru	Selection from GPMR 1153
23	VL 376	Almora	GE 4172 x VL 149
24	PR 202	Peddapuram	Pure Line Selection from Mettachodi ragi of Arakku valley
25	REC 69	Rewa	Selection from local germplasm
26	Uduru Mallige	Vizianagaram	Selection from local germplasm

3.8 Effect of plant age on development of banded leaf and sheath blight in entries (IVT).

Twenty six entries of finger millet consisting of different maturity group were sown in ten rows of 3.0 m length with 22.5 cm row to row and 10.0 cm plat to plant distance in randomized block design with three replications on 5th July, 2018. Fertilizer application i.e.40:20:0 kg NPK per hectare was given for optimum plant growth and susceptibility for diseases. Ten plants of each entry from each replications were artificially inoculated at 40, 50, 60 and 70 days old crop by leaf bit method. Observations on number of lesions, lesion length and vertical disease spread in terms of relative lesion height (RLH) were recorded 10 days after inoculations using following formula given by Ahn et al, (1986).:

$$\text{RLH (\%)} = \frac{\text{Total lesion length}}{\text{Total length of sheath}} \times 100$$

3.9 Identification of host plant resistance in finger millet against banded leaf and sheath blight.

Ten genotypes of early and medium maturity (AVT-I & II) and 26 genotypes from initial varietal trial (IVT) were sown on 5th July, 2018 in randomized block design in three replications at experimental area of AICRP on Small Millets, College of Agriculture, Rewa (M.P.) during *Kharif* 2018. The seeds of finger millet genotypes were sown in 10 rows with 22.5 cm row to row and 10.0 cm plant to plant spacing. Recommended doses of fertilizers i.e. 50 kg N and 40 kg P_2O_5 per hectare and package of practices were adopted for optimum plant growth. Ten plants of each genotype from each replication were artificially inoculated with sclerotia of *Rhizoctonia solani* at 40 days after sowing. Sclerotia were inserted between the stem of the middle tiller of each plant and leaf sheath of basal node. High humidity was maintained during disease development by frequent watering. The inoculated plants were observed daily for development of symptoms. Observations on vertical disease spread were recorded at 10 days interval in each genotype till 70 DAS. Disease progression and disease severity were recorded.

Incubation period

The incubation period (days) was recorded from time of inoculation to the appearance of the disease in all the screened finger millet entries.

Apparent infection rate (r)

Apparent infection rate (r) is the increase and decrease in disease per unit time. This was calculated using relative lesion height adopting the formula given by Van der Plank (1963).

$$r = \frac{1}{t_2 - t_1} \text{Log}_e \frac{X_2}{X_1}$$

Where,

r is the apparent infection rate per day

t_1 and t_2 is the initial and final time for disease recorded

X_1 and X_2 are the proportions of lesion height at time t_1 and t_2, respectively.

Area under Disease Progress Curve

Area under Disease Progress Curve (AUDPC) was calculated using a simple midpoint formula as described by Madden *et al* (2007).

$$\text{AUDPC} = \sum_{i=1}^{n-1} \left(\frac{y_i + y_{i+1}}{2} \right) (t_{i+1} - t_i)$$

Where, "t" is time in days of each observation,
"y" is the percentage of lesion height at each reading
"n" is the number of observation.

The screened genotypes were grouped into different categories of reaction according to standard evaluation system (SES).

SES scale for banded leaf and sheath blight of Finger millet

Infection category	Description	Host reaction
0	No infection	Highly resistant (HR)
1	Vertical spread of the lesions up to 20% of plant height.	Resistant (R)
3	Vertical spread of the lesions up to 21-30% of plant height.	Moderately resistant (MR)
5	Vertical spread of the lesions up to 31-45% of plant height.	Moderately susceptible (MS)
7	Vertical spread of the lesions up to 46-65% of plant height.	Susceptible (S)
9	Vertical spread of the lesions more than 65% of plant height.	Highly susceptible (HS)

Experimental details

Design	RBD
Replication	03
Plot size	2.25 x 3.0 m
Spacing	Row to Row 22.5cm, Plant to Plant 10.0 cm
No. of rows	10
Fertilizer	50:40:0 kg NPK ha^{-1}
Treatment	10 entries
Date of sowing	05/7/2018

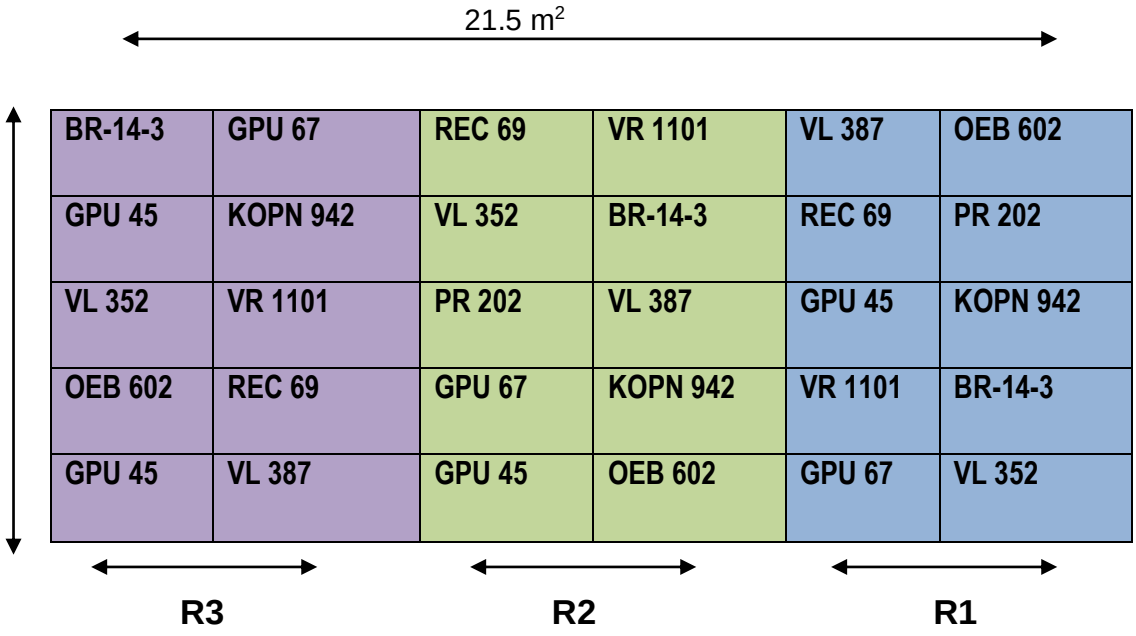


Fig.3. 2 Field lay out for Identification of host plant resistance in finger millet (AVT I & II)

Experimental details

Design	RBD
Replication	03
Plot size	2.25 x 3.0 m
Spacing	Row to Row 22.5cm, Plant to Plant 10.0 cm
No. of rows	10
Fertilizer	50:40:0 kg NPK ha^{-1}
Treatment	26 entries
Date of sowing	05/7/2018

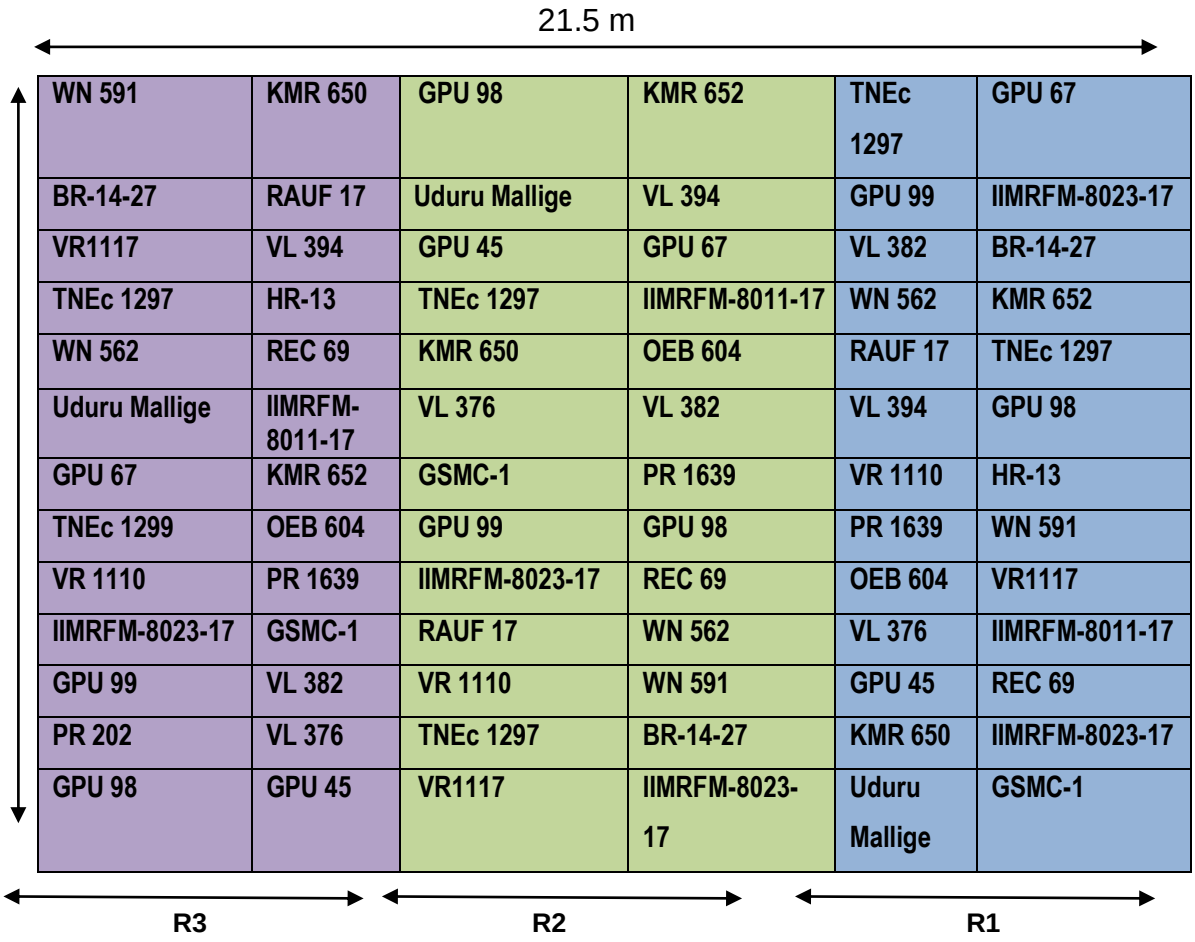


Fig.3. 3 Field lay out for Identification of host plant resistance in I finger millet (IVT)

3.10. Statistical analysis

The data were analyzed statistically using Randomized Block Design (RBD). The data obtained from different experiments were analyzed by the "F" test significance and treatments were compared by mean of critical differences at 5% probability levels. If the F test is not significant it was indicated by letters NS. The values expressed in percentage were transformed to angular (Arc-sine) values before analysis.

Analysis of Variance (ANOVA)

The mean of each replication was used for the analysis of data following the procedure of RBD analysis of variance for each character as given by **Panse** and **Sukhatme (1976)**. The total variance was divided into three components *viz.*, replications, genotypes, error and significance of 'F' was determined

Analysis of variance was done under the fixed effect model given below:

$$Y_{ij} = \mu + g_i + r_j + e_{ij}$$

Where,

Y_{ij} = phenotypic observation in the i^{th} treatment and j^{th} replication

μ = overall mean

g_i = effect of the i^{th} treatment

r_j = effect of the j^{th} replication

e_{ij} = random error associated with the i^{th} treatment and j^{th} replication

Here, i =1, 2, 3……30

j =1, 2

$H_o = g_1 = g_2 \ldots\ldots g_{30}$

The sum of squares was arranged in the following manner to test the significance of difference between treatments.

Skeleton of Analysis of variance (ANOVA)

Source of variation	Degree of freedom (d.f.)	Sum of squares (S.S.)	Mean sum of squares (M.S.S).	Variance ratio
Replications	(r-1)	RSS	RSS/(r-1) = V_r	V_r/EMS
Treatments	(t-1) = n_1	TSS	TSS/(t-1) = V_t	V_t/EMS
Error	(r-1) (t-1) = n_2	ESS	ESS/(r-1) (t-1) = EMS	
Total	(rt -1)			

Where,

r = Number of replications, t = Number of genotypes / treatments

EMS = Error mean sum of squares.

3.6.2 Standard error of mean:

Standard error of mean was calculated by the following formula.

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

3.6.3 Critical difference:

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

C.D. = S.Em × $\sqrt{2}\times$ 't' at 5% for error d.f.

Critical difference was calculated by the following formula.

C.D. = $\sqrt{2EMS/r}$ x tedf at 5%

Where,

r = Number of replications, EMS = Error mean sum of squares

t = Table value of 't' at error degrees of freedom at 0.05 level of significance.

Test of significance:

If the variance ratio (calculated F) was greater than the tabulated F value at 5% level of significance the difference between the different genotypes in terms of different character was considered to be significant and if it was lower than the tabulated value, it was considered to be non-significant.

RESULTS

The results of present study entitled **Studies on banded leaf and sheath blight of finger millet caused by *Rhizoctonia solani* Kuhn.** are presented under the following heads:

4.1 Isolation, purification and characterization of *Rhizoctonia solani* causing banded leaf and sheath blight in finger millet

4.2 Effect of plant age on development of banded leaf and sheath blight in finger millet.

4.3 Identification of host plant resistance in finger millet against banded leaf and sheath blight.

4.1 Isolation, purification and characterization of *Rhizoctonia solani* causing banded leaf and sheath blight in finger millet.

The sheath and leaves of finger millet infected with *Rhizoctonia solani* showing typical banded leaf and sheath blight symptoms were collected from the field for isolation of the fungus in the laboratory. The pathogen was isolated in potato dextrose agar medium and apparently distinct colonies were sub cultured aseptically on fresh PDA. The fungus was identified on the basis of mycelia and colony characters.

4.1.1 Effect of different culture media on radial growth of *R. solani*

The cultural characteristics of *Rhizoctonia solani isolated from finger millet were* studied in eight culture media and data are presented in table 4.1.1 fig no.4.1, 4.2, 4.3, 4.4 and plate 4.1.1. Significant differences in colony diameter (mm) of *R. solani* after 24, 48 and 72 hrs of incubation were recorded in different media. Average colony diameter ranging from 27.6 to 38.0 mm with a mean of 32.8 mm was recorded after 24 hrs of incubation. Whereas it was 42.4 to 69.3 mm with a mean of 58.0 mm and 71.4 to 91.3 mm with a mean of 79.7 mm after 48 and 72 hrs, respectively. The maximum radial growth of *R. solani* (91.3 mm) was recorded on Potato Dextrose Agar (PDA), which was significantly at par in Czapek dox agar (85.8 mm) medium. Oat meal agar (81.7 mm) and Corn meal agar (81.3 mm) were next best

medium for growth of *R. solani*. Colony diameter was 77.7 mm in Finger millet leaf extract agar +2% sucrose , 76.2 mm in Finger millet leaf extract agar, 72.3 mm in Richard's agar and least growth 71.4 mm was in Finger millet seed extract agar and these are statistically at par with each other.

4.1.2 Culture characteristics of *Rhizoctonia solani* on different culture media

The culture characteristics i.e. colour, growth pattern and growth rate of *Rhizoctonia solani* were studied in eight culture media and observations are presented in table 4.1.2 and plate 4.1.1. Differentiation in colour of culture viz. White, Pale brown, Yellowish brown was recorded. White colony was observed in Potato dextrose agar, Richard's agar and Corn meal agar media. Whereas Pale brown colony was recorded in Oat meal agar, Czapek dox agar, Finger millet seed extract agar and Finger millet leaf extract agar +2% sucrose. Yellowish brown colony was found in Finger millet leaf extract agar medium. Abundant growth pattern was recorded in Potato dextrose agar, Oat meal agar, Richard's agar, Czapek dox agar media and moderate was in Finger millet leaf extract agar media. Slight growth pattern was observed in Corn meal agar, Finger millet seed extract agar and Finger millet leaf extract agar +2% sucrose. Fast growth rate was recorded in Potato dextrose agar and Czapek dox agar media. Moderate growth rate was in Oat meal agar, Corn meal agar, Finger millet leaf extract agar, Finger millet seed extract agar and Finger millet leaf extract agar +2% sucrose. Whereas slow growth rate was recorded in Richard's agar media.

Table 4.1.1 Colony diameter (mm) of *Rhizoctonia solani* in different culture media.

S. No.	Media	Colony diameter (mm)			
		24 hrs	48 hrs	72 hrs	Mean
1	Potato dextrose agar	36.0	68.7	91.3	65.3
2	Oat meal agar	28.7	57.6	81.7	56.0
3	Richard's agar	30.0	42.4	72.3	48.2
4	Corn meal agar	27.6	66.5	81.3	58.5
5	Czapek dox agar	37.3	69.3	85.8	64.1
6	Finger millet leaf extract agar	31.3	50.0	76.2	52.5
7	Finger millet seed extract agar	33.3	48.8	71.4	51.2
8	Finger millet leaf extract agar +2% sucrose	38.0	60.7	77.7	58.8
	Mean	32.8	58.0	79.7	
	SEm±	1.04	1.28	1.68	
	CD (5%)	5.48	6.73	8.83	

Table 4.1.2 Culture characteristics of *Rhizoctonia solani* on different culture media.

S. No.	Media	Culture characteristics		
		Colour	Growth pattern	Growth rate
1	Potato dextrose agar	White	Abundant	Fast
2	Oat meal agar	Pale brown	Abundant	Moderate
3	Richard's agar	White	Abundant	Slow
4	Corn meal agar	White	Slight	Moderate
5	Czapek dox agar	Pale brown	Abundant	Fast
6	Finger millet leaf extract agar	Yellowish brown	Moderate	Moderate
7	Finger millet seed extract agar	Pale brown	Slight	Moderate
8	Finger millet leaf extract agar +2% sucrose	Pale brown	Slight	Moderate

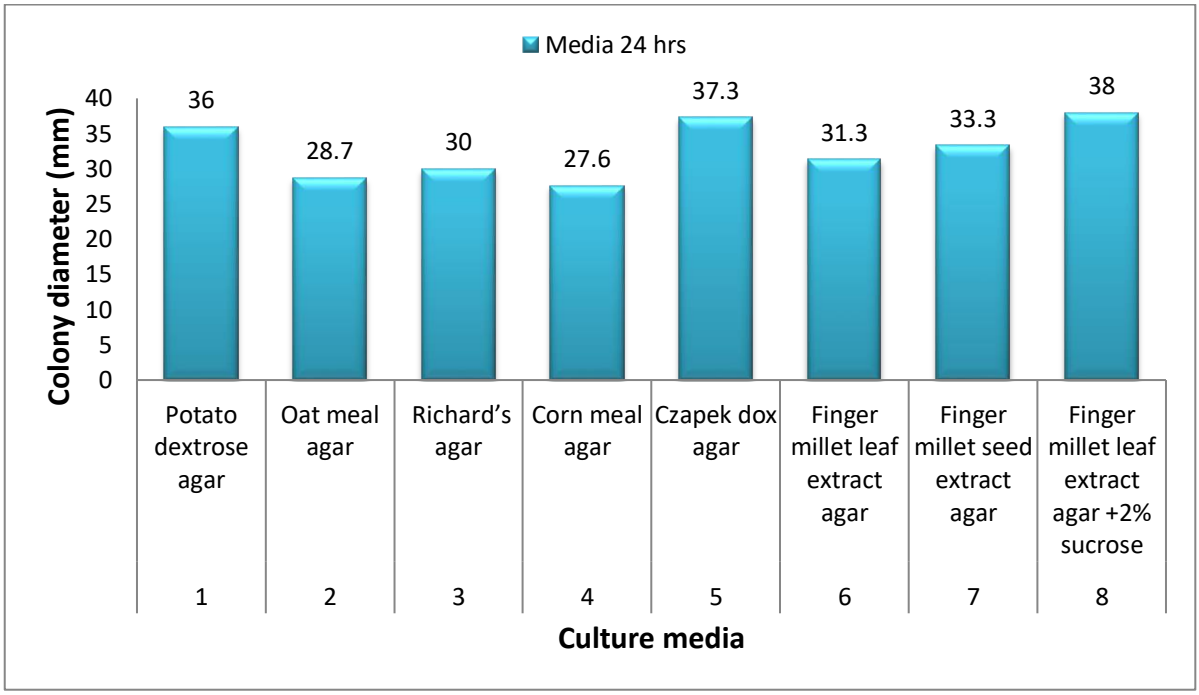


Fig 4.1 Colony diameter of *Rhizoctonia solani* in 24hrs on different culture media.

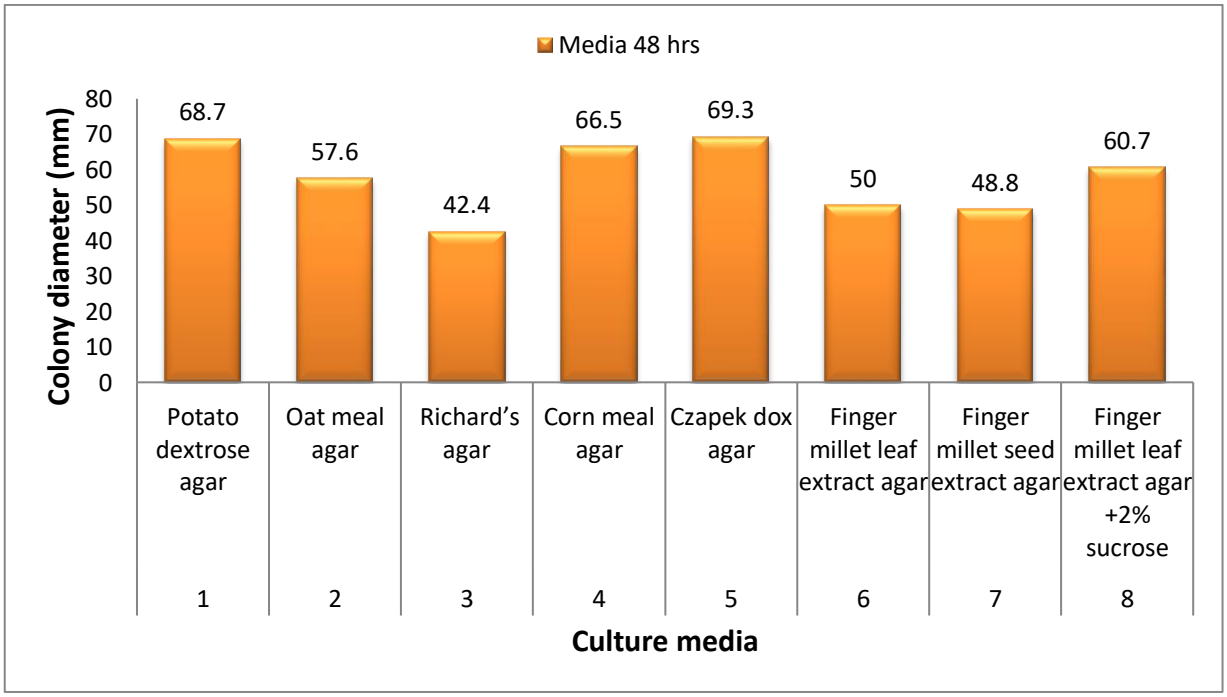


Fig 4.2 Colony diameter of *Rhizoctonia solani* in 48hrs on different culture media

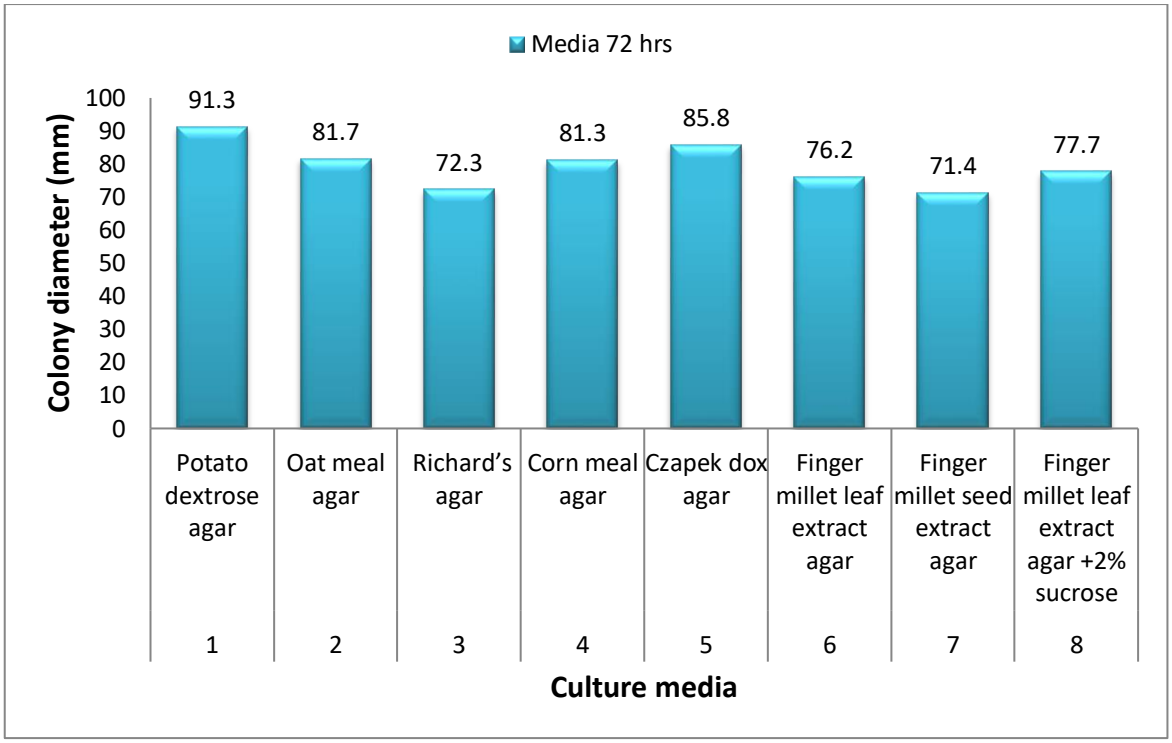


Fig 4.3 Colony diameter of *Rhizoctonia solani* in 72 hrs on different culture media.

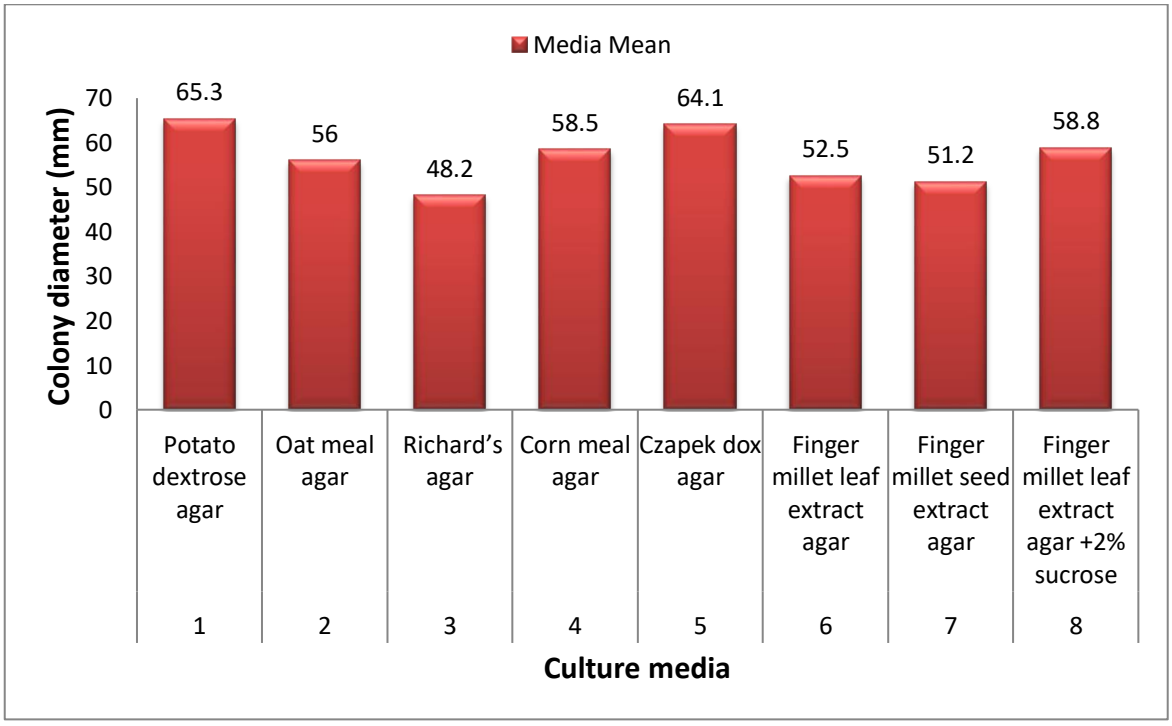


Fig 4.4 Average colony diameter of *Rhizoctonia solani* on different culture media.

4.1.3 Effect of different culture media on sclerotial formation of *Rhizoctonia solani*

Data of sclerotial characteristic viz. Time taken for initiation of sclerotia, number of sclerotia, weight of sclerotia and size of sclerotia on eight culture media are presented in Table 4.1.3 fig no. 4.4, 4.5, 4.6, 4.7, 4.8 and Plate No.4.1.2 .Sclerotia formation was initiated within 2 to 3 days in different tested media. Sclerotia formation was started in two days on Potato dextrose agar (PDA), Oat meal agar (OMA), Czapek dox agar (CDA), Richard's agar (RA) and Finger millet seed extract agar (FMSEA). Whereas sclerotial formation initiated in 3 days on Corn meal agar (CMA), Finger millet leaf extract agar (FMLEA) and Finger millet leaf extract agar +2% sucrose. Significant differences in number of sclerotia formed on different media ranging from 11.0 to 57.3 were recorded. Highest number of sclerotia were formed in OMA (57.3) followed by PDA (55.0) and CDA (48.7) and these results are at par with each other. Number of sclerotia formed in CMA and RA were 36.3 and 30.3, respectively. Least number of sclerotai were formed in FMSEA (11.0) followed by FMLEA (12.7) and FMLEA+ 2% sucrose (13.3). Weigh of 10 sclerotia ranged from 132.0 to 1040.7 mg produced on different media. Highest weight of sclerotia was recorded produced on PDA (1040.7 mg) followed by CDA (925.7 mg), OMA (899.7 mg). Whereas lowest weight of sclerotia was recorded on CMA (132.0 mg) followed by RA (213.3 mg) and FMLEA+ 2% sucrose (341.0 mg). Significant variation in size of sclerotia ranging from 0.3 to 1.2 mm was recorded. Maximum scletotial size was recorded in Potato dextrose agar (1.2 mm) followed by Finger millet seed extract agar (1.0 mm). Average size of sclerotia was recorded on Corn meal agar (0.9 mm), Oat meal agar (0.7 mm), Finger millet leaf extract agar (0.6 mm) and Finger millet leaf extract agar +2% sucrose (0.6 mm). Minimum size of sclerotia was recorded on Czapek dox agar (0.4 mm), Richard's agar (0.3 mm).

4.1.4 Sclerotial pattern of *Rhizoctonia solani* on different culture media

Observation on sclerotial formation was recorded on 8 culture media and data of sclerotial topography, colour, arrangement and clump formation are presented in table 4.1.4 and plate 4.1.2. Sclerotia pattern was superficial

in Potato dextrose agar, Richard's agar, Corn meal agar, Finger millet seed extract agar and Finger millet leaf extract agar +2% sucrose. Whereas immersed sclerotia were formed in Oat meal agar, Czapek dox agar and Finger millet leaf extract agar media. Variation in sclerotial colour from light brown, brown to dark brown was recorded. Light brown sclerotia were formed in Potato dextrose agar, Oat meal agar, Richard's agar, Corn meal agar, Finger millet leaf extract agar and Finger millet leaf extract agar +2% sucrose. Whereas brown sclerotia was formed on Finger millet seed extract agar and dark brown on Czapek dox agar. Peripheral, central and scattered arrangements of sclerotia were observed in tested media. All three patterns were recorded in Richard's agar and Czapek dox agar media. Central and scattered pattern was observed in oat meal agar, peripheral and scattered pattern was observed in corn meal agar. Only scattered pattern was observed in potato dextrose agar, central in Finger millet leaf extract agar and peripheral pattern in Finger millet seed extract agar and Finger millet leaf extract agar + 2% sucrose were recorded.

Table 4.1.3 Sclerotial formation of *Rhizoctonia solani* on different culture media.

S. No.	Media	Time taken for initiation of sclerotia	Number of sclerotia	Weight of sclerotia (mg)	Size of sclerotia (mm)
1	Potato dextrose agar	2	55.0(7.41)	1040.7	1.2
2	Oat meal agar	2	57.3(7.56)	899.7	0.7
3	Richard's agar	2	30.3(5.50)	213.3	0.3
4	Corn meal agar	3	36.3(6.01)	132.0	0.9
5	Czapek dox agar	2	48.7(6.98)	925.7	0.4
6	Finger millet leaf extract agar	3	12.7(3.55)	534.3	0.6
7	Finger millet seed extract agar	2	11.0(3.29)	540.7	1.0
8	Finger millet leaf extract agar +2% sucrose	3	13.3(3.63)	341.0	0.6
	Mean SEm± CD (5%)		33.1(5.49) 0.14 0.73	578.4 10.10 53.09	0.7 0.06 0.30

Figures in parentheses are square root transformed values.

Table 4.1.4 Sclerotial pattern of *Rhizoctonia solani* on different culture media

Media	Sclerotial pattern			
	Topography	Colour	Arrangement	Clump formation
Potato dextrose agar	Superficial	Light brown	Scattered	Less
Oat meal agar	Immersed	Light brown	Centre, Scattered	More
Richard's agar	Superficial	Light brown	Peripheral, Centre, Scattered	Medium
Corn meal agar	Superficial	Light brown	Peripheral, Scattered	Less
Czapek dox agar	Immersed	Dark brown	Peripheral, Centre, Scattered	More
Finger millet leaf extract agar	Immersed	Light brown	Centre,	Medium
Finger millet seed extract agar	Superficial	Brown	Peripheral,	Less
Finger millet leaf extract agar +2% sucrose	Superficial	Light brown	Peripheral,	Less

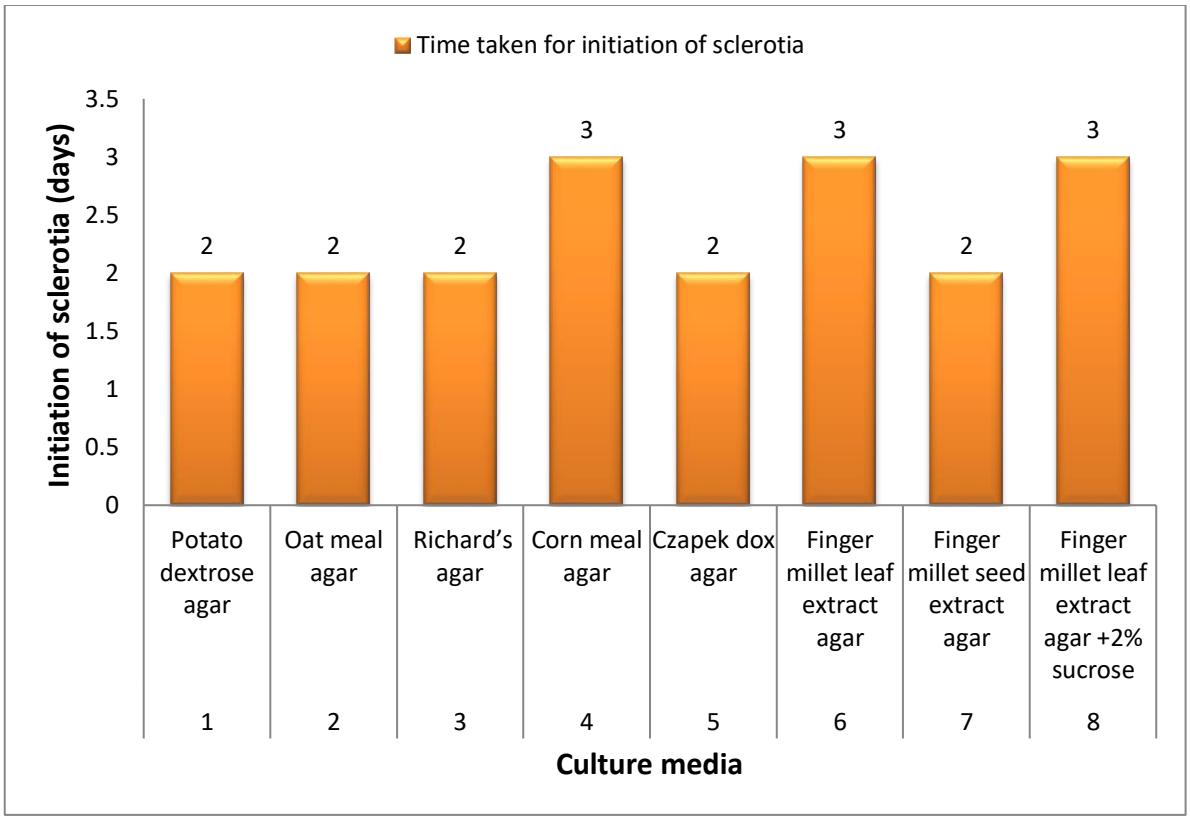


Fig 4.5 Sclerotia initiation of *Rhizoctonia solani* in different culture media.

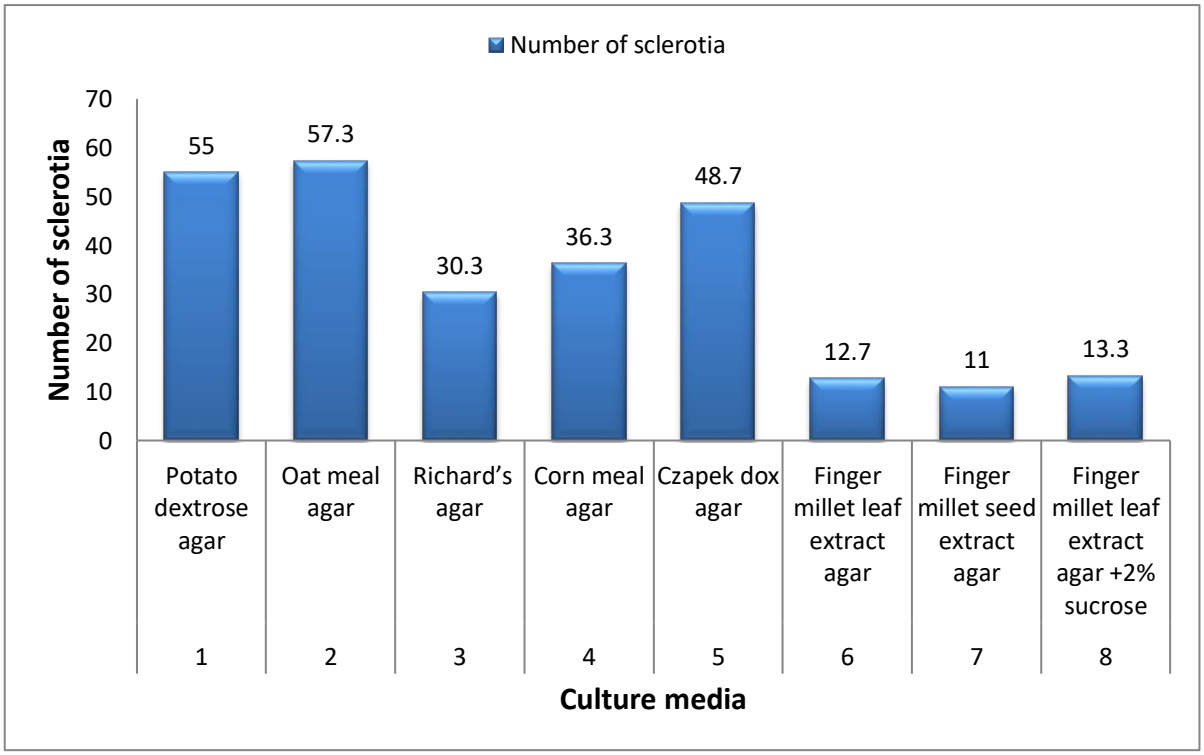


Fig 4.6 Number of sclerotia produced in different culture media

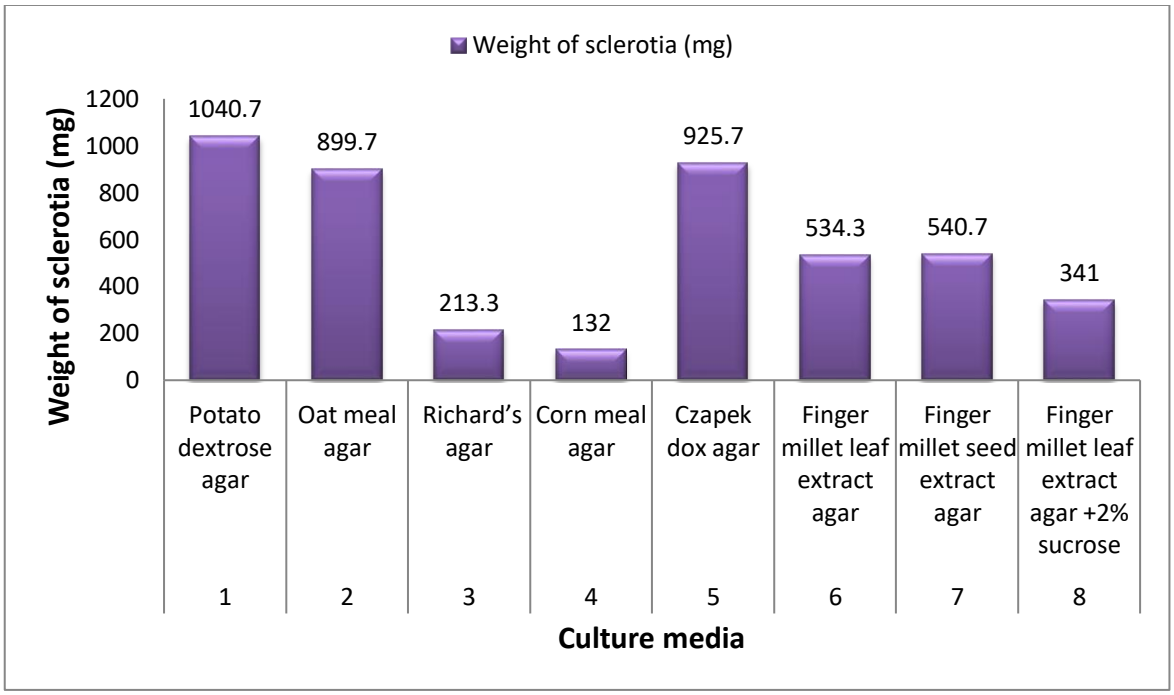


Fig 4.7 Weight of sclerotia (mg) produced in different culture media.

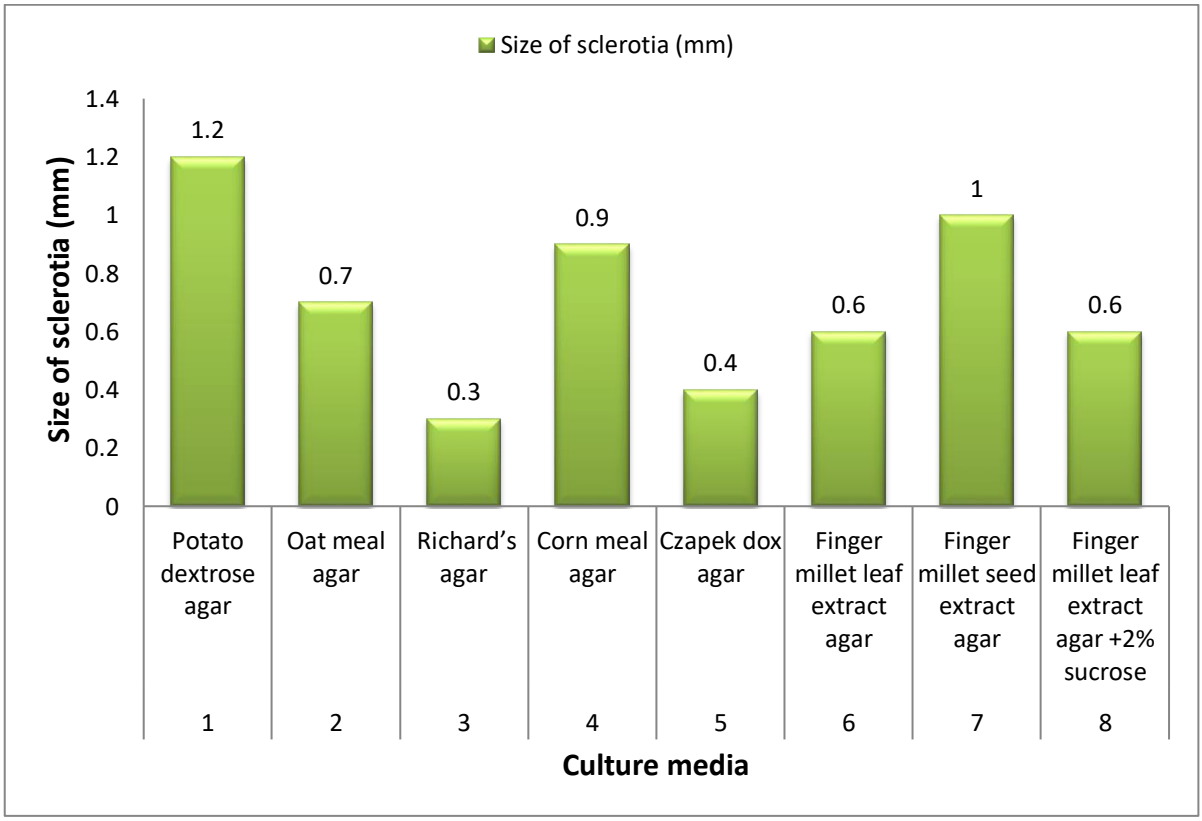


Fig 4.8 Size of sclerotia (mm) produced in different culture media

4.2 Effect of plant age on development of banded leaf and sheath blight in finger millet.

Results of BLSB development in early, medium and late duration finger millet genotypes at different crop age i.e. 40, 50, 60 and 70 days are presented in table 4.2.1 and 4.2.2. In early maturing 5 finger millet genotypes, average number of lesions were 7.4 in a range of 4.7 to 9.3 , 3.2 in a range of 2.0 to 5.0, 2.4 in a range of 1.3 to 4.7 and 0.6 in a range of 0.0 to 1.5 at crop age of 40, 50, 60 and 70 days, respectively. RLH (%) was 12.2% in a range of 9.0 to 13.3%, 11.2% in a range of 4.9 to 22.8%, 8.4% in a range of 5.3 to 11.5% and 2.4% in a range of 0.0 to 8.2% at crop age of 40, 50, 60 and 70 days, respectively. In medium maturing 12 finger millet genotypes, average number of lesions were 7.6 (2.0 to 11.0), 3.5 (1.0 to 5.3), 2.6(1.5 to 4.0) and 1.0 (0.0 to 3.0) and RLH (%) was 11.5 (4.6 to 16.4) , 10.1 (6.8 to 13.1) , 8.7 (1.4 to 16.8) and 3.8% (0.0 to 8.1) at crop age of 40, 50, 60 and 70 days, respectively. In late maturing 9 genotypes, average number of lesions were 7.9 (3.7 to 11.3) , 4.1 (2.0 to 12.0) , 1.9 (1.0 to 2.5) and 0.9 (0.0 to 2.0) and RLH (%) was 12.5 (7.9 to 17.9) , 9.1 (5.6 to 16.6) , 7.0 (5.0 to 11.3) and 3.9% (0.0 to 10.6) at crop age of 40, 50, 60 and 70 days, respectively. Average number of lesion was 7.6 in 40 days old crop, where as 3.3 was in 50 days, 2.6 in 60 days and 0.8 in 70 days old crops. Average RLH (%) was 12.1% in 40 days, 9.4% in 50 days, 8.7% in 60 days and 3.4% in 70 days old finger millet crop. It is inferred from the data that 40 and 50 days old crops are more susceptible to BLSB as compared to 60 and 70 days old crops.

Table 4.2.1 Effect of plant age on development of banded leaf and sheath blight in finger millet.

S. No.	Genotypes	40 days		50 days		60days		70 days	
		No. of lesions	RLH (%)	No. of lesions	RLH (%)	No. of lesions	RLH (%)	No. of lesions	RLH (%)
Early maturing									
1	VL 382	9.3	13.2	2.0	11.3	4.7	8.1	1.5	8.2
2	IIMRFM-8011-17	8.0	13.6	4.5	22.8	2.3	7.8	0.0	0.0
3	VL 376	4.7	9.0	2.5	7.7	1.3	9.4	0.0	0.0
4	REC 69	7.3	11.3	5.0	9.1	1.3	5.3	0.0	0.0
5	UM	7.7	13.9	2.0	4.9	2.3	11.5	1.5	4.0
	MEAN	**7.4**	**12.2**	**3.2**	**11.2**	**2.4**	**8.4**	**0.6**	**2.4**
Medium maturing									
1	WN 591	8.0	15.8	4.7	11.7	2.0	6.9	1.0	4.8
2	VL 394	11.0	16.4	3.3	13.1	2.5	6.7	1.5	5.0
3	HR-13	5.7	6.5	4.0	8.5	2.5	7.1	1.5	7.5
4	VR 1110	10.7	14.6	5.3	6.8	1.5	7.3	3.0	8.1
5	VR1117	10.0	14.2	4.7	8.8	3.0	9.5	1.5	4.7
6	BR-14-27	8.3	14.1	2.3	10.8	3.5	5.5	0.5	2.4
7	GPU 45	2.0	4.6	1.0	8.0	4.0	1.4	0.0	0.0
8	RAUF 17	9.0	11.4	4.0	12.0	1.5	14.0	0.0	0.0
9	TNEc 1297	6.3	9.5	3.3	8.6	2.5	16.0	0.5	2.4
10	IIMRFM-8023-17	4.0	6.8	3.0	12.5	3.5	16.8	1.0	5.2
11	PR 202	5.0	8.7	1.3	12.2	3.5	4.8	0.0	0.0
12	KMR 650	11.0	15.2	5.0	8.1	1.5	8.2	1.5	5.0
	MEAN	**7.6**	**11.5**	**3.5**	**10.1**	**2.6**	**8.7**	**1.0**	**3.8**
Late maturing									
1	KMR 652	10.0	14.2	2.3	5.7	2.0	11.3	1.0	9.4
2	TNEc 1299	10.0	17.9	12.0	5.6	1.0	6.6	0.0	0.0
3	GSMC-1	4.3	8.6	2.0	16.6	1.5	5.6	2.0	5.8
4	GPU 67	3.7	7.9	2.0	12.8	2.5	6.8	0.0	0.0
5	GPU 98	5.7	9.0	2.3	4.6	1.5	6.5	2.0	10.6
6	GPU 99	9.7	9.1	3.0	8.7	2.5	8.6	0.0	0.0
7	WN 562	11.3	17.1	5.3	11.9	1.5	6.0	1.0	3.3
8	OEB 604	9.3	15.2	2.3	6.5	2.5	6.5	1.0	1.5
9	PR 1639	7.3	13.5	5.3	9.5	2.0	5.0	1.5	4.8
	MEAN	**7.9**	**12.5**	**4.1**	**9.1**	**1.9**	**7.0**	**0.9**	**3.9**

Table 4.2.2 Number of lesions and RLH (%) in early, medium and late maturing genotypes of finger millet at different crop age.

Duration		Crop age (days)			
		40	50	60	70
Early	No. of lesions	7.4 (4.7-9.3)	3.2 (2.0-5.0)	2.4 (1.3-4.7)	0.6 (0.0-1.5)
	RLH(%)	12.2 (9.0-13.3)	11.2 (4.9-22.8)	8.4 (5.3-11.5)	2.4 (0.0-8.2)
Medium	No. of lesions	7.6 (2.0-11.0)	3.5 (1.0-5.3)	2.6 (1.5-4.0)	1.0 (0.0-3.0)
	RLH(%)	11.5 (4.6-16.4)	10.1 (6.8-13.1)	8.7 (1.4-16.8)	3.8 (0.0-8.1)
Late	No. of lesions	7.9 (3.7-11.3)	4.1 (2.0-12.0)	1.9 (1.0-2.5)	0.9 (0.0-2.0)
	RLH(%)	12.5 (7.9-17.9)	9.1 (5.6-16.6)	7.0 (5.0-11.3)	3.9 (0.0-10.6)
Over all average	No. of lesions	7.6	3.3	2.6	0.9
	RLH(%)	12.1	9.4	8.7	3.4

4.3. Identification of host plant resistance in finger millet against banded leaf and sheath blight.

4.3.1 Evaluation of early and medium maturing finger millet entries.

4.3.1.1 Number of lesions

Number of lesions were recorded in 10 early and medium maturing entries of finger millet at 40, 50, 60 and 70 days after sowing and data are presented in table 4.3.1 and depicted in Fig. 4.9 Mean number of lesions ranging from 3.3 to 9.0 with an average of 5.6, 4.0 to 10.0 with an average of 6.9, 4.0 to 10.0 with an average of 7.0 and 4.0 to 10.7 with an average of 7.2 were recorded in 10 entries of finger millet at 40, 50, 60 and 70 days after sowing, respectively. Least number of lesions were recorded in VL 352 (4.0) followed by VR 1101 (5.0) and OEB 602 (5.3). whereas highest number of lesions were recorded in REC 69 (10.7) followed by GPU 45 (10.0) and GPU 67 (9.3).

4.3.1.2 Length of lesions

Observations on lesions length (cm) were recorded in 10 early and medium maturing entries of finger millet at 40, 50, 60 and 70 days after sowing and data are presented in table 4.3.2 and depicted in Fig. 4.10 Mean length of lesions ranging from 3.7 to 9.8 cm with an average of 6.4 cm , 4.8 to 11.1 cm with an average of 7.8 cm, 5.9 to 11.8 cm with an average of 8.6 cm and 5.9 to 11.8 cm with an average of 9.0 cm were recorded in 10 entries of finger millet at 40, 50, 60 and 70 days after sowing, respectively. Least lesion length were recorded in VL 352 (5.9 cm) followed by VR 1101 (6.3 cm) and KOPN 942, VL 387 (7.6 cm). Whereas highest lesion length were recorded in REC 69 (11.8 cm) followed by GPU 45 (11.4 cm) and GPU 67 (10.5 cm).

4.3.1.3 Incubation period and Relative lesion height (%)

Incubation period (days) and vertical spread of the disease in terms of percentage relative lesion height (RLH) was recorded in 10 early and medium maturing entries of finger millet at 40, 50, 60 and 70 days after sowing and data are presented in table 4.3.3 and depicted in Fig 4.11 and

4.12 Incubation period in early and medium maturing entries varied from 2.6 to 4.0 days was minimum in REC 69 and maximum in VR 1101. In rest of the genotypes it varied from 3.0 to 3.8 days. Mean RLH (%) ranging from 4.9 to 14.2% with an average of 8.8% , 7.9 to 15.1 % with an average of 10.4%, 11.2 to 31.5% with an average of 20.0% and 15.3 to 46.1% with an average of 26.5% were recorded in 10 entries of finger millet at 40, 50, 60 and 70 days after sowing, respectively. Lowest value of RLH were recorded in VR 1101 (15.3%) followed by VL 352 (21.7%) and PR 202 (22.3%). Whereas highest value of RLH were recorded in REC 69 (46.1%) followed by, GPU 45 (31.2%), GPU 67 (27.5%) and OEB 602 (26.5%).

Table 4.3.1 Number of lesions at different days after sowing in advanced varietal trial of finger millet

S. No.	Entry	Days to 50% flowering	Number of lesions			
			40 DAS	50 DAS	60 DAS	70 DAS
1	BR-14-3	57	5.0 (2.206)	8.3 (2.878)	8.3 (2.878)	8.3 (2.878)
2	KOPN 942	88	4.7 (2.096)	6.3 (2.481)	6.3 (2.506)	6.7 (2.545)
3	VL 387	82	5.3 (2.296)	6.0 (2.447)	6.7 (2.578)	6.7 (2.578)
4	VR 1101	80	4.3 2(.019)	4.7 (2.132)	5.0 (2.225)	5.0 (2.206)
5	OEB 602	58	3.3 (1.791)	4.3 (2.076)	4.3 (2.076)	5.3 (2.299)
6	VL 352*	58	3.3 (1.807)	4.0 (1.983)	4.0 (1.983)	4.0 (1.983)
7	PR 202*	82	5.3 (2.265)	6.0 (2.410)	6.0 (2.410)	6.0 (2.410)
8	GPU 45*	73	9.0 (2.991)	10.0 (3.156)	10.0 (3.156)	10.0 (3.156)
9	GPU 67*	82	7.7 (2.755)	9.3 (3.043)	9.3 (3.043)	9.3 (3.043)
10	REC 69	57	7.7 (2.768)	9.7 (3.095)	9.7 (3.104)	10.7 (3.262)
	Mean		**5.6**	**6.9**	**7.0**	**7.2**
	CD (5%)		**0.741**	**0.589**	**0.496**	**0.615**

Table 4.3.2 Length of lesions at different days after sowing in advanced varietal trial of finger millet

S. No.	Entry	Days to 50% flowering	Length of lesion (cm)			
			40 DAS	50 DAS	60 DAS	70 DAS
1	BR-14-3	57	5.0 (5.033)	8.20 (8.200)	8.9 (8.866)	9.9 (9.866)
2	KOPN 942	88	3.7 (3.733)	4.80 (4.800)	5.6 (5.566)	7.6 (7.633)
3	VL 387	82	3.7 (4.966)	5.10 (5.833)	6.2 (6.333)	7.6 (6.333)
4	VR 1101	80	5.0 (3.666)	5.83 (5.100)	6.3 (6.200)	6.3 (7.633)
5	OEB 602	58	7.8 (4.066)	9.20 (5.000)	9.9 (5.900)	9.9 (5.900)
6	VL 352*	58	4.1 (7.400)	5.00 (8.933)	5.9 (9.533)	5.9 (9.533)
7	PR 202*	82	7.4 (7.766)	8.93 (9.200)	9.5 (9.900)	9.5 (9.900)
8	GPU 45*	73	9.3 (9.300)	10.30 (10.300)	11.4 (11.366)	11.4 (11.366)
9	GPU 67*	82	7.9 (7.866)	9.40 (9.400)	10.5 (10.466)	10.5 (10.466)
10	REC 69	57	9.8 (9.833)	11.07 (11.066)	11.8 (11.833)	11.8 (11.833)
	Mean		**6.4**	**7.78**	**8.6**	**9.0**
	CD (5%)		**3.709**	**3.327**	**3.193**	**2.958**

Table 4.3.3 Relative Lesion Height (%) at different days after sowing in advanced varietal trial of finger millet

S. No.	Entry	Incubation period (days)	Relative Lesion Height (%)			
			40 DAS	50 DAS	60 DAS	70 DAS
1	BR-14-3	3.3	6.8 (14.677)	10.69 (18.993)	21.8 (27.809)	25.2 (30.062)
2	KOPN 942	3.3	4.9 (12.538)	6.16 (14.146)	16.1 (23.604)	26.1 (30.695)
3	VL 387	3.4	6.6 (14.617)	7.47 (15.713)	19.9 (26.441)	22.7 (28.421)
4	VR 1101	4.0	6.9 (13.740)	7.9 (16.288)	11.2 (21.373)	15.3 (25.130)
5	OEB 602	3.1	6.0 (14.099)	7.12 (15.373)	15.6 (23.234)	26.5 (30.955)
6	VL 352	3.8	9.4 (17.832)	11.31 (19.572)	17.6 (24.781)	21.7 (27.769)
7	PR 202	3.6	10.6 (18.639)	11.81 (19.888)	19.3 (26.020)	22.3 (28.113)
8	GPU 45	3.0	14.2 (22.146)	15.06 (22.801)	21.1 (27.309)	31.2 (30.449)
9	GPU 67	3.1	9.6 (18.000)	11.08 (19.416)	23.9 (29.236)	27.5 (31.639)
10	REC 69	2.6	13.4 (21.462)	14.50 (22.364)	31.5 (34.120)	46.1 (36.187)
	Mean		**8.8**	**10.4**	**20.0**	**26.5**
	CD (5%)		**6.039**	**4.794**	**2.795**	**3.787**

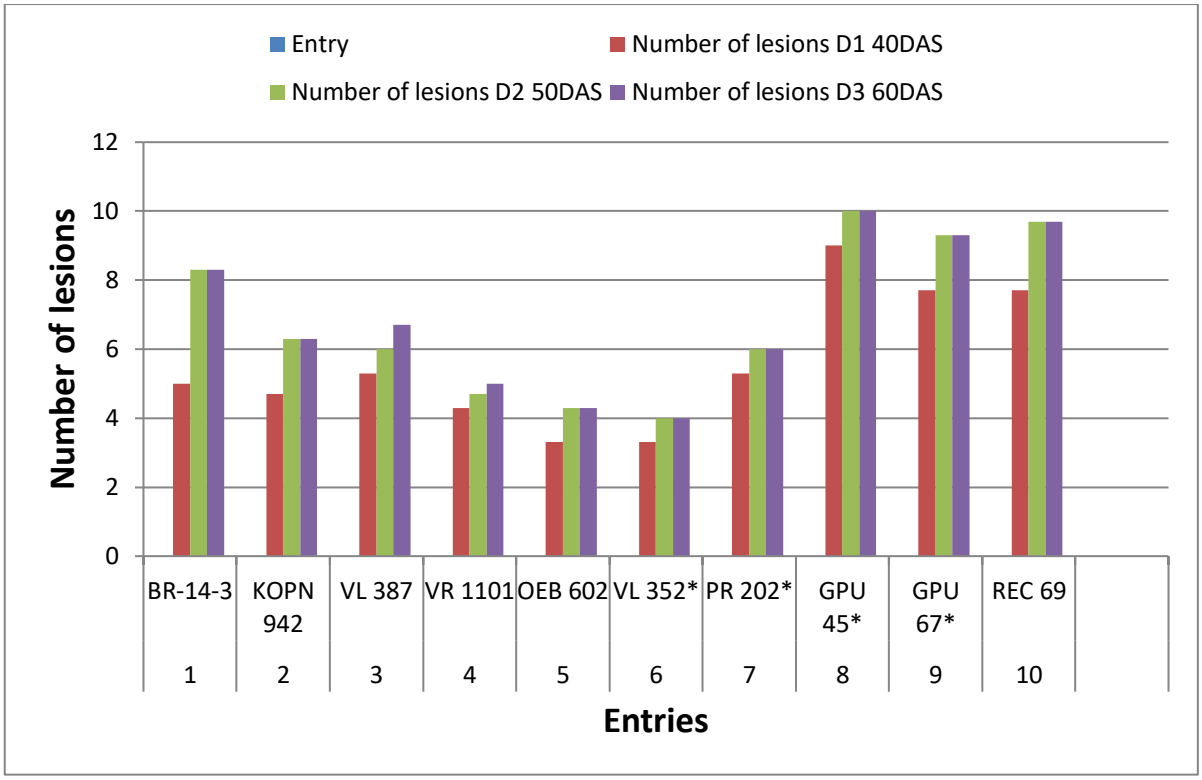


Fig. 4.9. Number of lesions at different days after sowing in early and medium maturing entries of finger millet

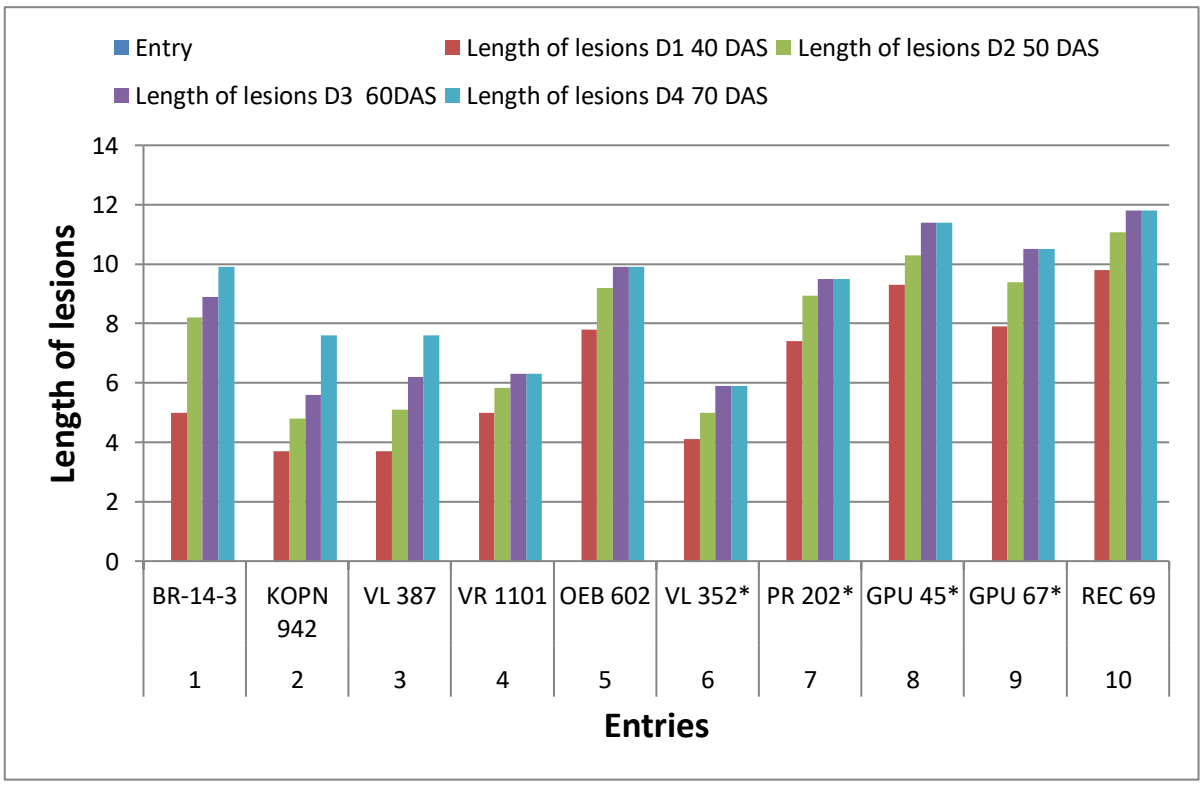


Fig 4.10 Length of lesions (cm) at different days after sowing in early and medium maturing entries of finger millet

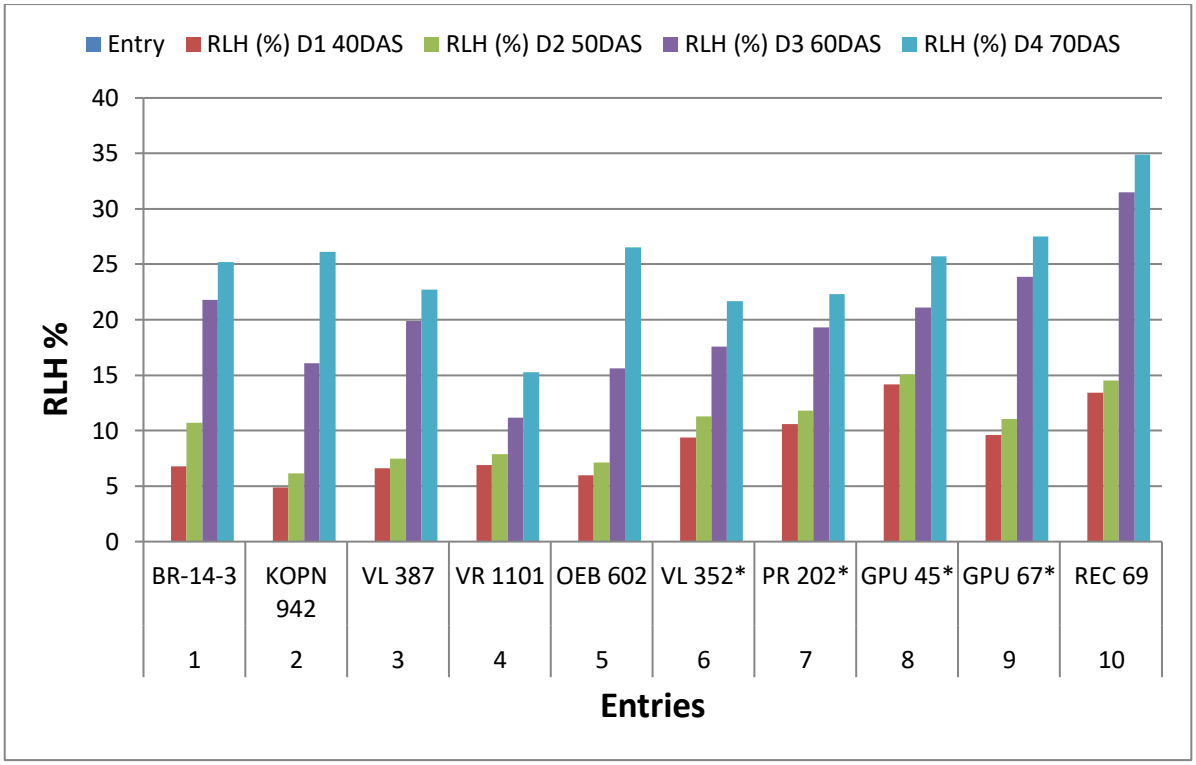


Table 4.11 Relative Lesion Height (%) at different days after sowing in early and medium maturing entries of finger millet

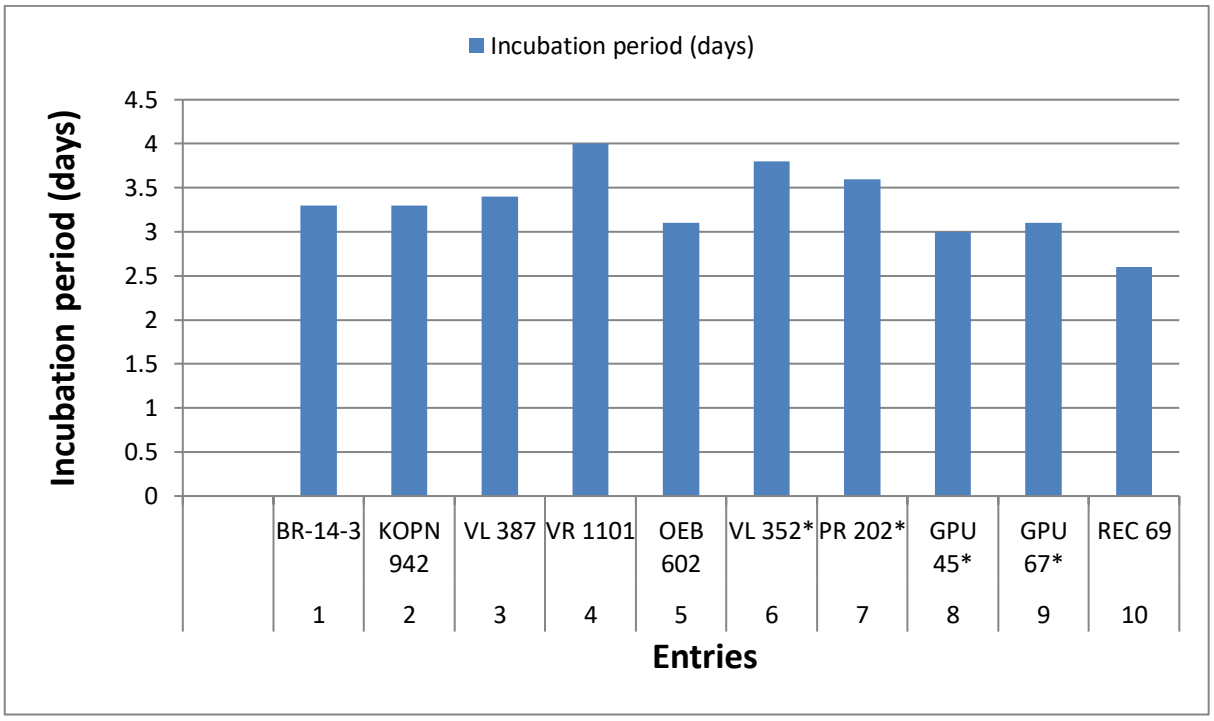


Fig. 4.12 Incubation period in 10 early and medium maturing entries of finger millet

4.3.1.4 Apparent infection rate and area under disease progress curve in AVT 10 entries of finger millet.

The values of apparent infection rate (r) and area under disease progress curve (AUDPC) were estimated in 10 early and medium maturing cultivars of finger millet and results are presented in Table 4.3.4 and Fig.4.13, 4.14. The mean apparent infection rate was 0.007 between 40 to 50 DAS, 0.028 between 50 to 60 DAS and 0.010 between 60 to 70 DAS with an average of 0.015 percent per day. Apparent infection rate was lowest between 40 to 50 DAS (0.007) indicates the less favourable conditions for disease development. Highest value of apparent infection rate (0.028) was found between 50 to 60 DAS indicates the favourable period for disease development.

Average apparent infection rate of consecutive observation period was ranged from 0.008 to 0.023 percent per day in 10 entries of finger millet. Lowest apparent infection was recorded in VR 1101 (0.008) followed by PR 202 (0.010), KOPN 942 (0.011) and VL 352 (0.012), Where as highest values were recorded in REC 69 (0.023) followed by GPU 45 (0.020) and BR-14-3 (0.018).

The value of AUDPC ranged between 106.7 to 233.8 with a mean of 157.6 in different finger millet entries. Minimum values were found in VR 1101(106.7) followed by KOPN 942 (125.9) and OEB 602 (129.9). Maximum values were found in REC 69 (233.8) followed by GPU 45* (187.03) and GPU 67* (178.4).

4.3.1.5 Grouping of early and medium maturing finger millet entries against banded leaf and sheath blight (BLSB)

Based on the vertical spread of the disease in terms of RLH (%), 10 early and medium maturing entries of finger millet are grouped into different categories of resistance/ susceptibility and data are presented in table 4.3.5 and Fig 4.15 None of the evaluated entries were highly resistant to BLSB. VR 1101 was found resistant against BLSB. Seven entries namely BR 14-3, KOPN 942, VL 387, OEB 602, VL 352, PR 202 and GPU 67 were

moderately resistant and one entry GPU 45 was moderately susceptible and one entry REC 69 was susceptible to BLSB.

Table 4.3.4 Apparent infection rate and area under disease progress curve in 10 entries of finger millet.

S. No.	Entry	Apparent infection rate (r)				AUDPC
		40 –50 DAS	50 –60 DAS	60 –70 DAS	Mean	
1	BR-14-3	0.019	0.030	0.006	0.018	161.6
2	KOPN 942	0.005	0.015	0.013	0.011	125.9
3	VL 387	0.005	0.040	0.006	0.017	140.1
4	VR 1101	0.002	0.014	0.008	0.008	106.7
5	OEB 602	0.003	0.033	0.004	0.013	129.9
6	VL 352	0.008	0.019	0.009	0.012	148.2
7	PR 202	0.004	0.021	0.006	0.010	158.5
8	GPU 45	0.007	0.030	0.023	0.020	187.0
9	GPU 67	0.006	0.033	0.006	0.015	178.4
10	REC 69	0.009	0.040	0.020	0.023	233.8
	Mean	**0.007**	**0.028**	**0.010**	**0.015**	**157.6**

Table 4.3.5 Grouping of early and medium maturing finger millet genotypes against banded leaf and sheath blight (BLSB) disease

Reaction	BLSB severity (RLH %)	No. of entries	Genotypes
Highly resistant	0	0	Nil
Resistant	Up to 20	1	VR 1101
Moderately resistant	20 – 30	7	BR 14-3, KOPN 942, VL 387, OEB 602, VL 352, PR 202, GPU 67
Moderately susceptible	31 – 45	1	GPU 45
Susceptible	46 – 65	1	REC 69
Highly susceptible	Above 65	Nil	-

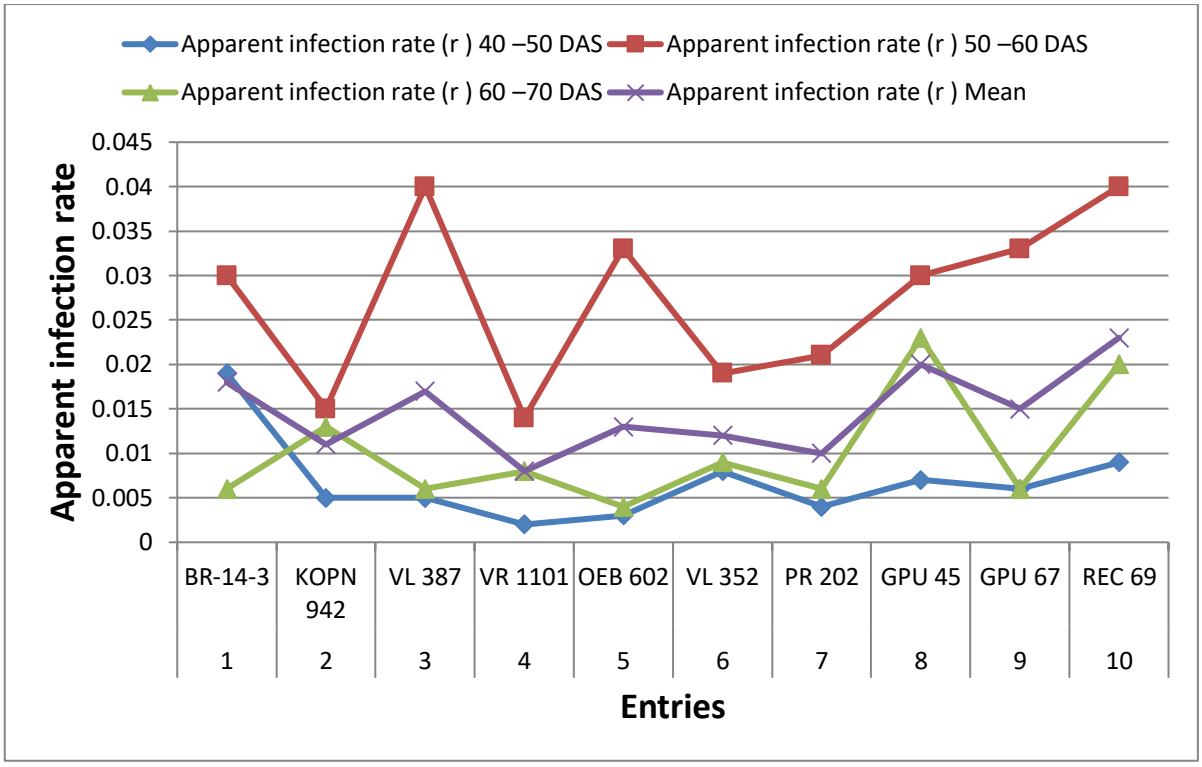


Fig. 4.13 Apparent infection rate in early and medium maturing entries entries of finger millet.

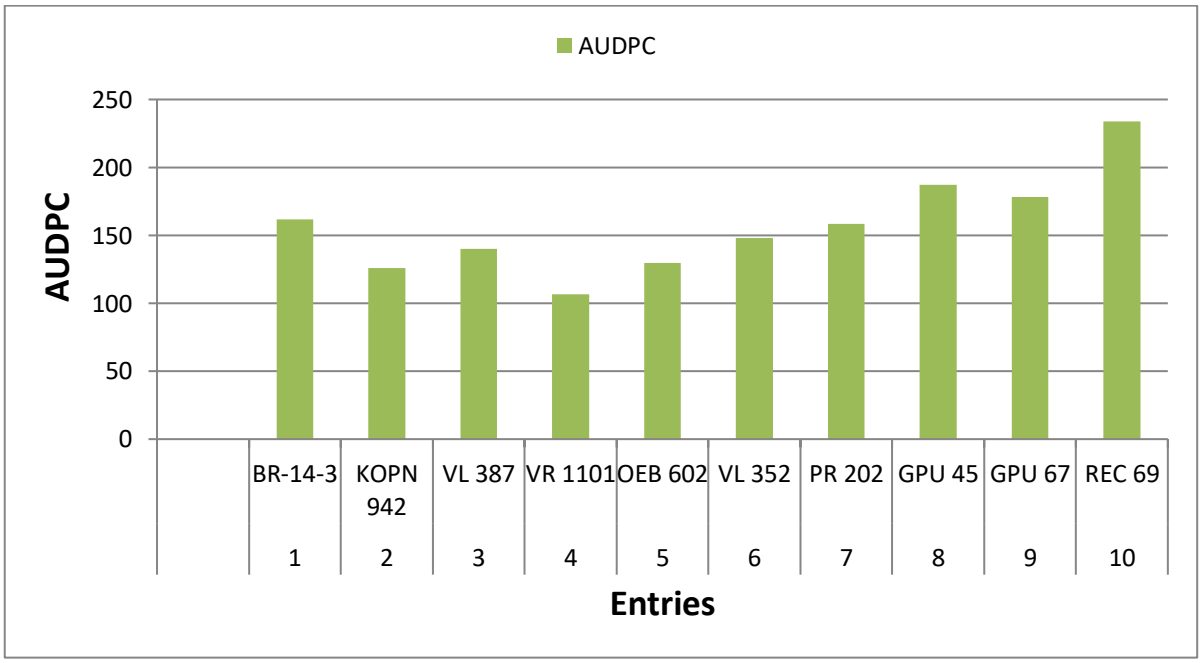


Fig 4.14 Area under disease progress curve in early and medium maturing entries of finger millet.

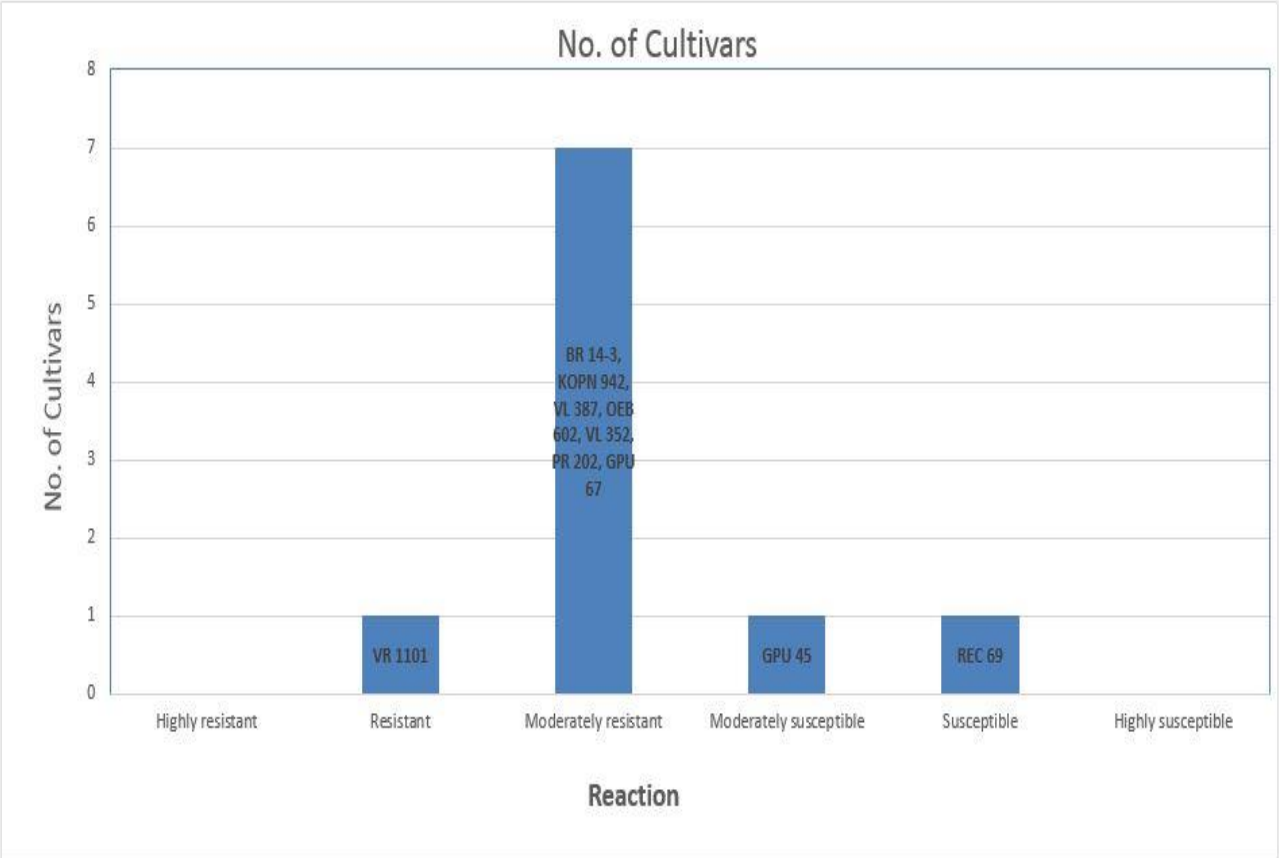


Fig 4.15 Grouping of early and medium maturing finger millet genotypes against banded leaf and sheath blight (BLSB) disease

4.3.2 Evaluation of finger millet entries under Initial Varietal Trial

4.3.2. Number of lesions

Significant differences in number of lesions were recorded in 26 entries of finger millet at 40, 50, 60 and 70 days after sowing and data are presented in table 4.3.6 and depicted in Fig 4.16. Mean number of lesions ranging from 0.7 to 8.3 with an average of 5.3, 1.7 to 10.7 with an average of 6.6, 2.0 to 11.1 with an average of 7.2 and 4.3 to 11.4 with an average of 8.3 were recorded in 26 entries of finger millet at 40, 50, 60 and 70 days after sowing, respectively. Lowest number of lesions were recorded in IIMRFM-8023-17 (4.3) followed by GSMC-1 (4.7), PR 202 (5.1) , KMR 650 and GPU 99 (5.7). Highest number of lesions were recorded in WN 562 (11.4) followed by VL 394 (11.1), VR 1110 (10.7) and TNEc 1299 (10.3). Entries showing less number of lesions may be categorized as resistant to moderately resistant to BLSB. Whereas entries exhibiting more number of lesions may be categorized as susceptible to the disease.

4.3.2.2 Length of lesions

Significant differences in lesion length were recorded among 26 entries of finger millet at 40, 50, 60 and 70 days after sowing and results are presented in table 4.3.7 and depicted in Fig 4.17. Average lesion length ranging from 0.5 to 9.0 cm with mean of 6.0 cm was recorded at 40 DAS in 26 finger millet entries. At 50 DAS, average lesion length ranged from 1.9 to 10.5 cm with mean of 7.2 cm was recorded. Average lesion length varied from 3.7 to 11.3 cm with mean of 8.3 cm at 60 DAS and 3.9 to 11.7 cm with mean of 8.7 cm at 70 DAS in 26 entries of finger millet. Lowest lesion length was recorded in GPU 45 (3.9 cm) followed by IIMRFM-8023-17 (5.2 cm), HR-13 (5.7 cm) and GPU 98 (6.7 cm), while highest lesion length was recorded in BR-14-27 (11.7 cm) followed by VL 394 (11.6 cm), VR 1117 (11.3 cm), KMR 652 and PR 1639 (10.9 cm). Entries showing lower lesion length may be categorized as resistant to moderately resistant to BLSB. Whereas entries exhibiting higher lesion length may be categorized as susceptible to the disease.

4.3.2.3 Relative lesion height (%)

Relative lesion height (%) was calculated in 26 finger millet entries at 40, 50, 60 and 70 days after sowing and results are presented in table 4.3.8 and Fig 4.18. Significant variation in RLH (%) was recorded in the evaluated finger millet entries. The value of RLH ranged from 0.8 to 15.6 with a mean of 9.2% was minimum in GPU 48 and maximum in TNEc 1299 at 40 DAS. RLH varied from 4.6 to 17.9% with a mean of 12.3% was recorded in 26 entries at 50 DAS. GPU 45 showed lowest RLH and TNEc 1299 exhibited highest RLH. At 60 DAS, RLH ranging from 11.1 (GPU 99) to 36.7 (REC 69) with a mean of 24.1% was recorded. RLH values ranging from 15.4 to 47.1% with a mean of 35.6% were recorded at 70 DAS. Lowest value was recorded in KMR 650 and highest in Uduru Mallige .

Table 4.3.6 Number of lesions at different days after sowing in initial varietal trial of finger millet

S. No.	Entry	Number of lesions			
		40 DAS	50 DAS	60 DAS	70 DAS
1	WN 591	6.3	8.0	8.3	9.1
2	WN 562	7.0	10.7	11.1	11.4
3	VL 394	6.3	9.3	10.6	11.1
4	VL 382	5.7	8.0	8.3	9.3
5	KMR 650	3.7	4.7	5.3	5.7
6	KMR 652	7.3	9.7	9.9	10.0
7	OEB 604	7.0	8.3	9.0	9.4
8	HR-13	4.0	5.3	7.5	11.3
9	VR 1110	7.9	9.7	10.1	10.7
10	VR1117	8.3	9.7	10.0	10.1
11	BR-14-27	6.3	7.3	8.3	8.4
12	PR 1639	5.7	7.1	7.3	9.7
13	GPU 98	4.0	5.2	5.7	7.3
14	GPU 99	3.3	3.9	4.7	5.7
15	RAUF 17	4.7	5.3	5.9	6.6
16	TNEc 1297	5.3	6.0	6.3	9.1
17	TNEc 1299	8.3	8.9	10.0	10.3
18	IIMRFM-8023-17	3.0	3.3	4.0	4.3
19	IIMRFM-8011-17	6.7	7.0	7.8	8.3
20	GSMC-1	3.4	4.0	4.3	4.7
21	GPU 67	3.0	3.8	4.7	6.9
22	GPU 45	0.7	1.7	2.0	7.2
23	VL 376	2.7	4.7	5.7	6.7
24	PR 202	3.7	4.7	5.0	5.1
25	REC 69	6.3	7.0	7.3	8.3
26	Uduru Mallige	6.3	7.0	7.7	8.9
	Mean	**5.3**	**6.6**	**7.2**	**8.3**
	CD (5%)	0.964	0.800	0.974	0.828

Table 4.3.7 Length of lesions at different days after sowing in initial varietal trial of finger millet

S. No.	Entry	Length of lesions (cm)			
		40 DAS	50 DAS	60 DAS	70 DAS
1	WN 591	5.7	6.7	8.9	9.1
2	WN 562	7.7	9.2	9.7	9.9
3	VL 394	9.0	10.5	11.3	11.6
4	VL 382	7.1	8.2	9.2	9.3
5	KMR 650	3.7	4.6	5.5	5.7
6	KMR 652	5.7	6.6	7.4	7.9
7	OEB 604	7.2	8.3	9.2	9.3
8	HR-13	6.3	7.9	8.3	9.9
9	VR 1110	7.5	9.1	10.4	10.7
10	VR1117	7.5	9.8	10.9	11.3
11	BR-14-27	9.0	9.7	10.5	11.7
12	PR 1639	8.5	9.5	10.6	10.9
13	GPU 98	4.1	5.0	6.6	6.7
14	GPU 99	3.0	3.6	4.9	5.2
15	RAUF 17	5.8	8.2	8.8	9.1
16	TNEc 1297	5.3	6.1	7.3	7.4
17	TNEc 1299	7.7	8.4	9.6	10.2
18	IIMRFM-8023-17	3.5	6.2	7.3	7.7
19	IIMRFM-8011-17	8.0	8.6	9.5	9.8
20	GSMC-1	4.2	4.8	6.2	6.3
21	GPU 67	3.8	4.7	6.4	6.8
22	GPU 45	0.5	1.9	3.7	3.9
23	VL 376	5.2	5.9	6.7	7.1
24	PR 202	4.3	5.0	6.2	6.6
25	REC 69	8.5	9.6	10.6	10.9
26	Uduru Mallige	7.2	8.0	9.6	10.7
	Mean	**6.0**	**7.2**	**8.3**	**8.7**
	CD (5%)	4.030	3.579	3.916	4.387

Table 4.3.8 Relative lesion height at different days after sowing in initial varietal trial of finger millet

S. No.	Entry	RLH (%)			
		40 DAS	50 DAS	60 DAS	70 DAS
1	WN 591	11.0(19.22)	15.8(23.36)	23.3(28.81)	34.7(36.07)
2	WN 562	13.9(21.83)	17.1(24.40)	27.3(31.49)	37.1(37.52)
3	VL 394	14.5(22.26)	16.4(23.84)	24.4(29.59)	34.4(35.91)
4	VL 382	10.6(18.84)	13.2(21.04)	17.3(24.38)	31.7(34.24)
5	KMR 650	9.2(17.61)	12.9(21.02)	15.2(22.87)	15.4(23.07)
6	KMR 652	12.1(20.23)	14.2(22.04)	24.3(29.49)	38.3(38.23)
7	OEB 604	13.0(21.01)	15.2(22.87)	25.3(30.19)	33.3(35.19)
8	HR-13	4.6(12.41)	16.5(23.92)	29.7(32.97)	39.7(39.02)
9	VR 1110	11.1(19.20)	14.6(22.42)	25.59(30.30	35.5(36.56)
10	VR1117	10.5(183.88	14.2(22.06)	21.6(27.63)	31.6(34.17)
11	BR-14-27	12.7(20.81)	14.1(22.02)	26.8(31.16)	38.6(38.40)
12	PR 1639	11.4(19.69)	13.5(21.34)	29.9(33.09)	39.9(39.13)
13	GPU 98	5.9(13.96)	9.0(17.46)	16.7(24.07)	33.1(35.10)
14	GPU 99	4.6(12.35)	9.1(17.42)	11.1(19.30)	16.7(24.07)
15	RAUF 17	7.9(15.84)	11.4(19.64)	19.3(25.8/3)	29.3(32.67)
16	TNEc 1297	7.4(15.67)	9.5(17.89)	24.4(29.56)	44.4(41.77)
17	TNEc 1299	15.6(23.18)	17.9(24.94)	26.3(30.82)	46.3(42.86)
18	IIMRFM-8023-17	4.3(11.66)	6.8(14.91)	21.5(27.59)	31.5(34.13)
19	IIMRFM-8011-17	12.4(20.52)	13.6(21.55)	23.9(29.21)	33.9(35.59)
20	GSMC-1	6.1(13.94)	8.6(16.61)	27.6(31.70)	36.7(37.27)
21	GPU 67	4.8(12.45)	7.9(16.29)	28.8(32.44)	38.8(38.53)
22	GPU 45	0.8(4.17)	4.6(12.27)	22.3(28.09)	39.6(38.96)
23	VL 376	7.5(15.82)	9.0(17.18)	17.5(24.66)	37.5(37.73)
24	PR 202	6.5(14.63)	8.7(16.94)	24.4(29.56)	34.4(35.90)
25	REC 69	9.2(17.53)	11.3(19.32)	36.7(37.25)	46.7(43.10)
26	Uduru Mallige	11.4(19.66)	13.9(21.73)	35.2(36.37)	47.1(43.32)
	Mean	**9.2**	**12.3**	**24.1**	**35.6**
	CD (5%)	4.484	5.020	4.203	3.779

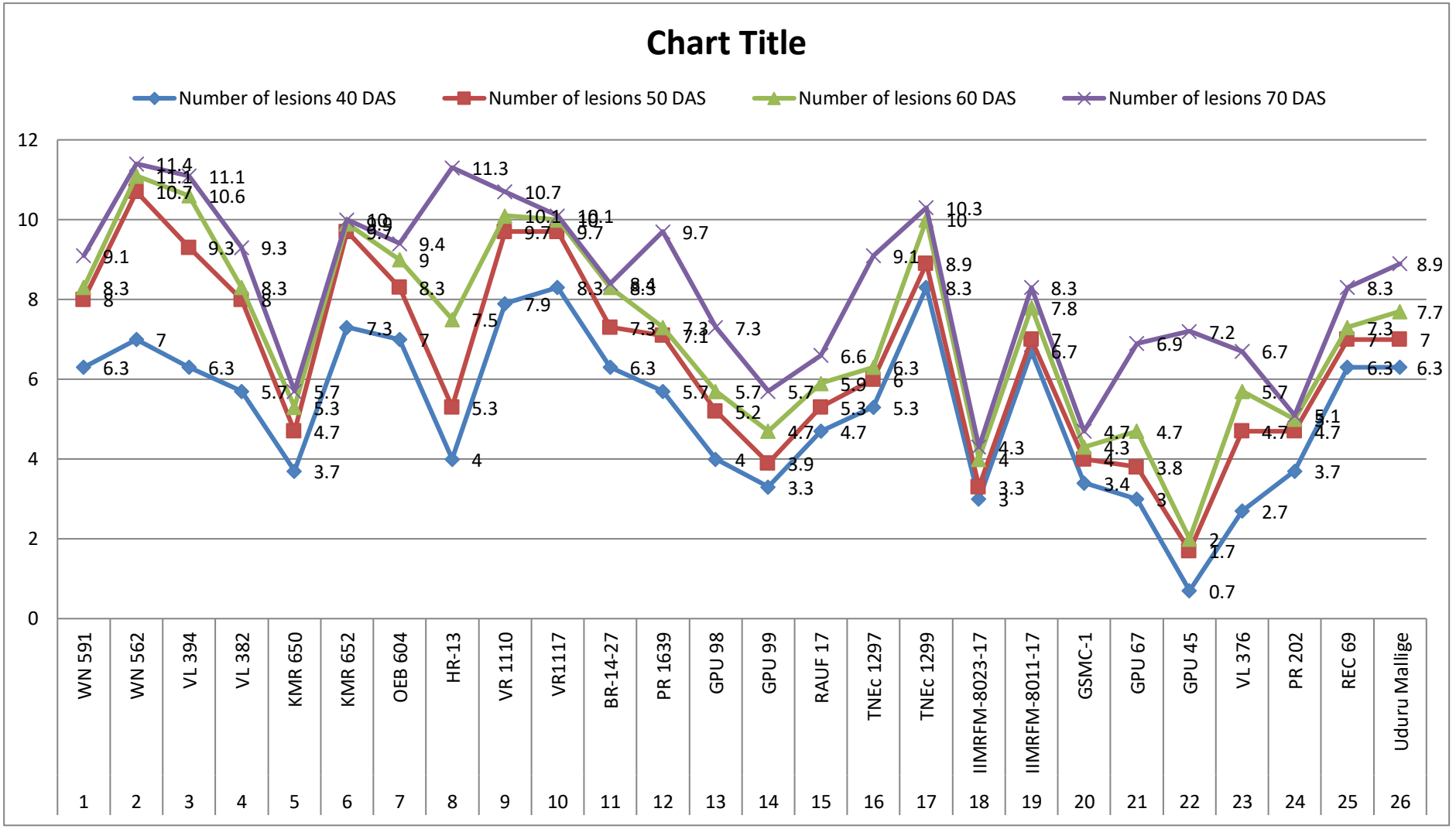


Fig. 4.16 Number of lesions at different days after sowing in initial varietal trial of finger millet (26 entries)

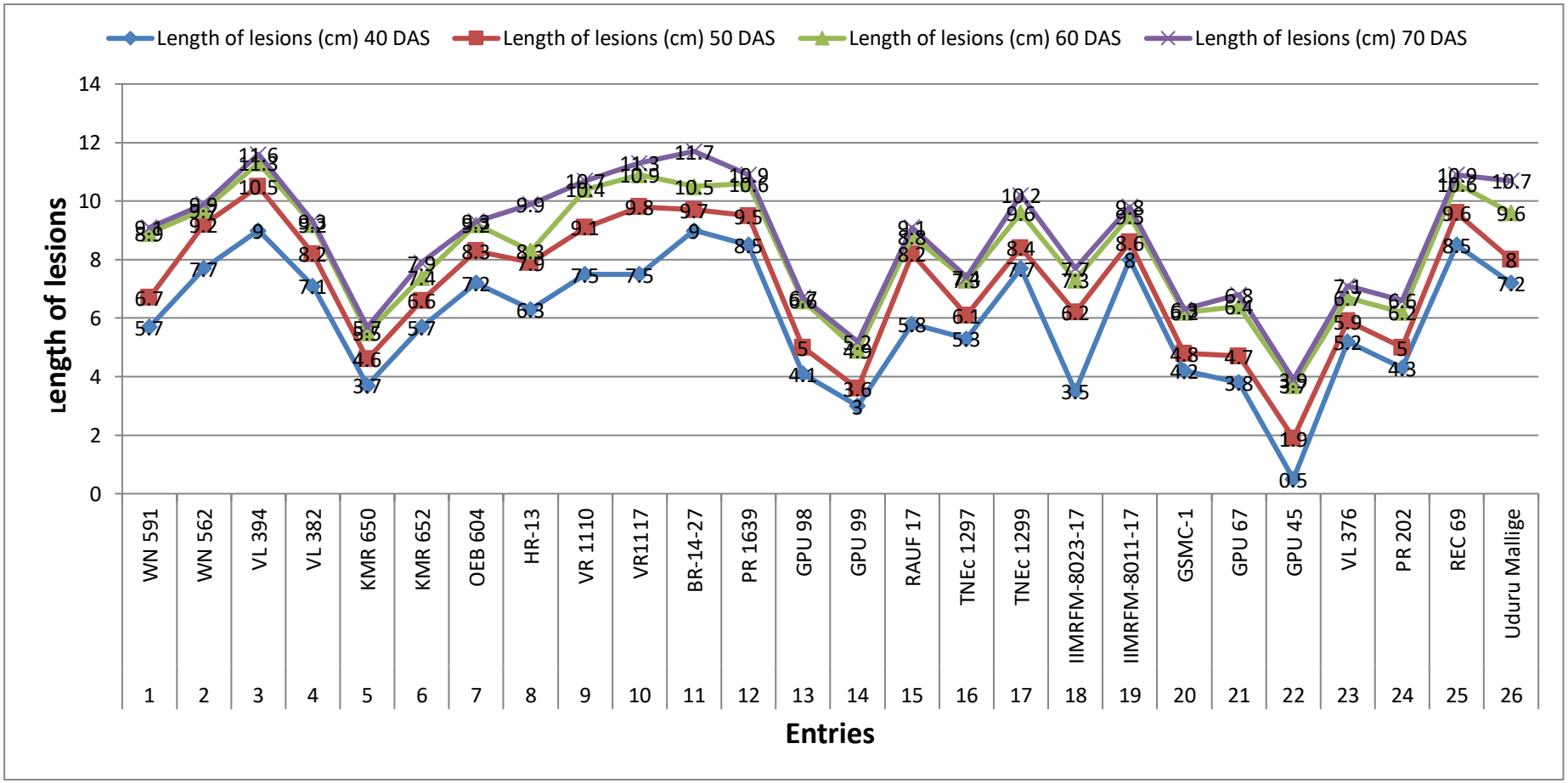


Fig 4.17 Length of lesions at different days after sowing in initial varietal trial of finger millet (26 entries)

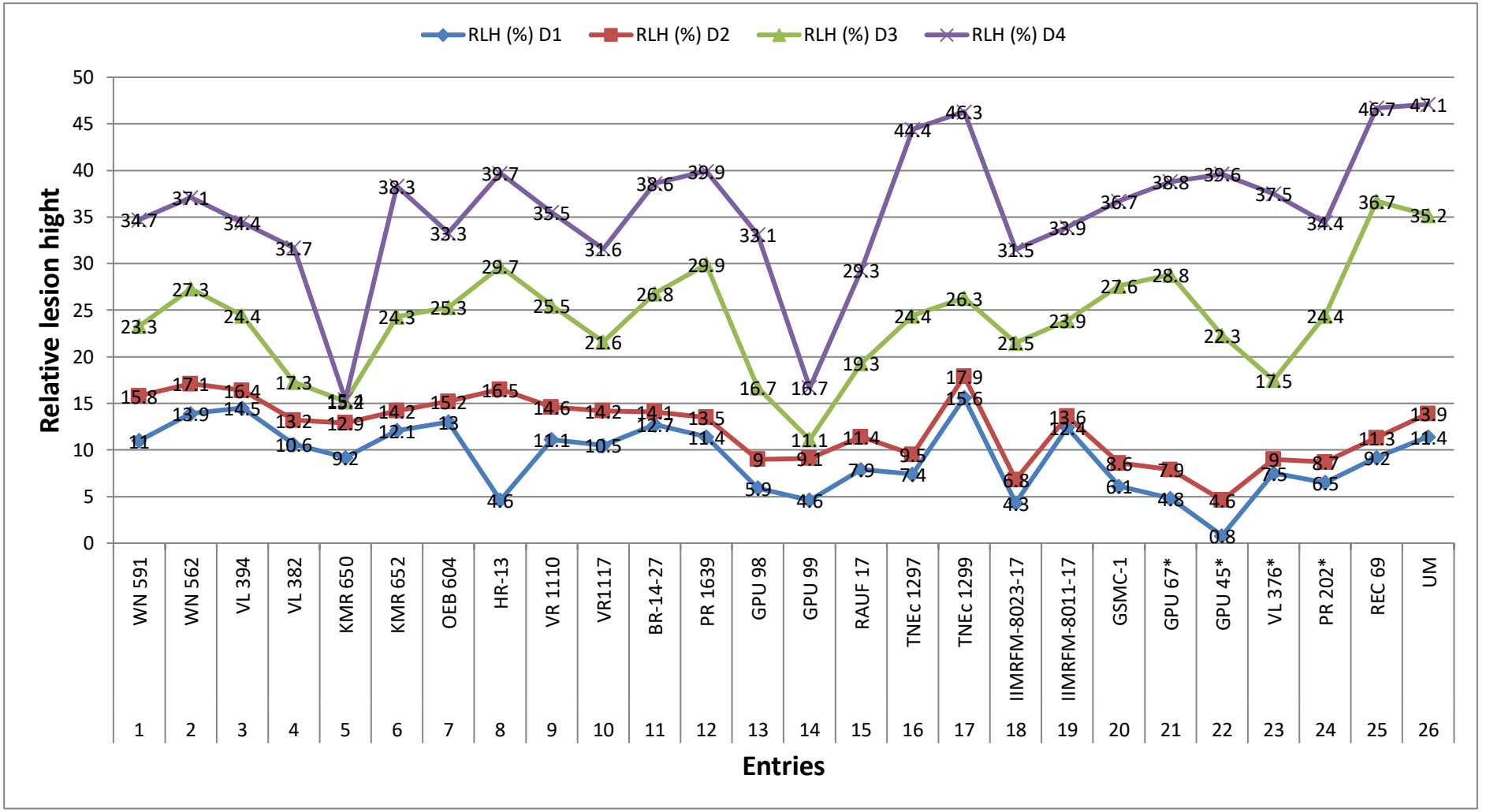


Fig 4.18 Relative lesion height at different days after sowing in initial varietal trial of finger millet (26 entries)

4.3.2.4 Incubation period, apparent infection rate and area under disease progress curve in 26 entries of finger millet.

Results of incubation period, the values of apparent infection rate (r) and area under disease progress curve (AUDPC) were estimated in 26 entries of finger millet and data are presented in Table 4.3.9 and Fig. 4.19, 4.20, 4.21 . Incubation period ranging from 2.3 to 4.5 days was recorded in finger millet entries. The lowest incubation period was recorded in REC 69 and Uduru Mallige (2.3 days) followed by TNEc 1299 (2.4 days) , TNEc 1297 (2.5 days) and HR 13 (2.9 days), whereas highest incubation period was recorded in KMR 650 (4.5 days) followed by GPU 99 (4.3 days) and RAUF 17 (4.1 days). In rest of the entries it varied 3.0 to 3.8 days. The mean apparent infection rate was 0.015 between 40 to 50 DAS, 0.029 between 50 to 60 DAS and 0.017 between 60 to 70 DAS with an average of 0.020 percent per day. Apparent infection rate was lowest between 40 to 50 DAS (0.015) indicates the less favourable conditions for disease development. Highest value of apparent infection rate (0.029) was found between 50 to 60 DAS indicates the favourable period for disease development. Average apparent infection rate of consecutive observation period was ranged from 0.009 to 0.056 percent per day in 26 entries of finger millet. Lowest apparent infection was recorded in KMR 650 (0.008) followed by VL 394 (0.012), OEB 604 (0.013), WN 562 and IIMRFM 8011-17 (0.014), Where as highest values were recorded in GPU 45 (0.056) followed by HR 13 (0.031) and IIMRFM 8023-17 (0.028). The value of AUDPC varied from 102.8 to 261.2 with a mean of 195.9 was found in different finger millet entries. Minimum values were found in GPU 99 (102.8) followed by KMR 650 (134.7) and GPU 99 (150.7). Maximum values were found in Uduru Mallige (261.2) followed by REC 69 (253.2) and TNEc 1299 (250.5).

4.3.2.5 Grouping of finger millet entries against banded leaf and sheath blight (BLSB) screened under initial varietal trial.

Based on the vertical spread of the disease in terms of RLH (%), 26 entries of finger millet are grouped into different categories of resistance/ susceptibility and data are presented in table 4.3.10 and Fig 4.22 None of

the evaluated entries were highly resistant to BLSB. Two entries namely KMR 650 and GPU 99 were found resistant against BLSB. RAUF 17 was moderately resistant and 20 entries namely WN 591, WN 562, VL 394, VL 382, KMR 652, OEB 604, HR 13, VR 1110, VR 1117, BR 14-27, PR 1639, GPU 98, TNEc 1297, IIMRFM 8023-17, IIMRFM 8011-17, GSMC 1, GPU 67, GPU 45, VL 376, PR 202 were moderately susceptible and 3 entries namely TNEc 1299, REC 69, Uduru Mallige were susceptible to BLSB showing more than 45% vertical spread of the disease.

Table 4.3.9 Apparent infection rate and area under disease progress curve in 26 entries of finger millet.

S. No.	Entry	Incubation period (days)	Apparent infection rate (r)				AUDPC
			40-50 DAS	50-60 DAS	60-70 DAS	Mean	
1	WN 591	3.0	0.015	0.016	0.017	0.016	206.5
2	WN 562	3.1	0.008	0.020	0.013	0.014	233.0
3	VL 394	3.0	0.005	0.017	0.014	0.012	217.5
4	VL 382	3.4	0.009	0.011	0.026	0.015	172.2
5	KMR 650	4.5	0.014	0.007	0.005	0.007	134.7
6	KMR 652	3.2	0.006	0.023	0.019	0.016	212.3
7	OEB 604	3.3	0.006	0.022	0.011	0.013	212.2
8	HR-13	2.9	0.055	0.025	0.012	0.031	227.8
9	VR 1110	3.0	0.011	0.024	0.014	0.016	211.3
10	VR1117	3.7	0.013	0.018	0.016	0.016	189.5
11	BR-14-27	3.1	0.004	0.027	0.015	0.015	221.8
12	PR 1639	3.1	0.007	0.034	0.012	0.018	230.2
13	GPU 98	3.3	0.018	0.026	0.029	0.024	150.7
14	GPU 99	4.3	0.029	0.008	0.017	0.018	102.8
15	RAUF 17	4.1	0.015	0.022	0.018	0.018	164.3
16	TNEc 1297	2.5	0.010	0.040	0.025	0.025	199.3
17	TNEc 1299	2.4	0.005	0.016	0.024	0.015	250.5
18	IIMRFM-8023-17	3.8	0.012	0.044	0.014	0.023	154.0
19	IIMRFM-8011-17	3.7	0.004	0.024	0.015	0.014	202.2
20	GSMC-1	3.5	0.014	0.050	0.012	0.025	192.0
21	GPU 67	3.4	0.021	0.056	0.012	0.030	195.0
22	GPU 45	3.1	0.008	0.040	0.012	0.020	157.0
23	VL 376	3.2	0.007	0.028	0.033	0.023	163.3
24	PR 202	3.2	0.019	0.049	0.016	0.028	178.5
25	REC 69	2.3	0.008	0.051	0.010	0.023	253.2
26	Uduru Mallige	2.2	0.075	0.068	0.024	0.056	261.2
	Mean		0.015	0.029	0.017	0.020	195.9

Table 4.3.10 Grouping of finger millet entries against banded leaf and sheath blight (BLSB) screened under initial varietal trials.

Reaction	BLSB severity (RLH %)	No. of entries	Genotypes
Highly resistant	0	0	Nil
Resistant	Up to 20	2	KMR 650, GPU 99
Moderately resistant	20 – 30	1	RAUF 17
Moderately susceptible	31 – 45	20	WN 591, WN 562, VL 394, VL 382, KMR 652, OEB 604, HR 13, VR 1110, VR 1117, BR 14-27, PR 1639, GPU 98, TNEc 1297, IIMRFM 8023-17, IIMRFM 8011-17, GSMC 1, GPU 67, GPU 45, VL 376, PR 202
Susceptible	46 – 65	3	TNEc 1299, REC 69, Uduru Mallige
Highly susceptible	Above 65	Nil	-

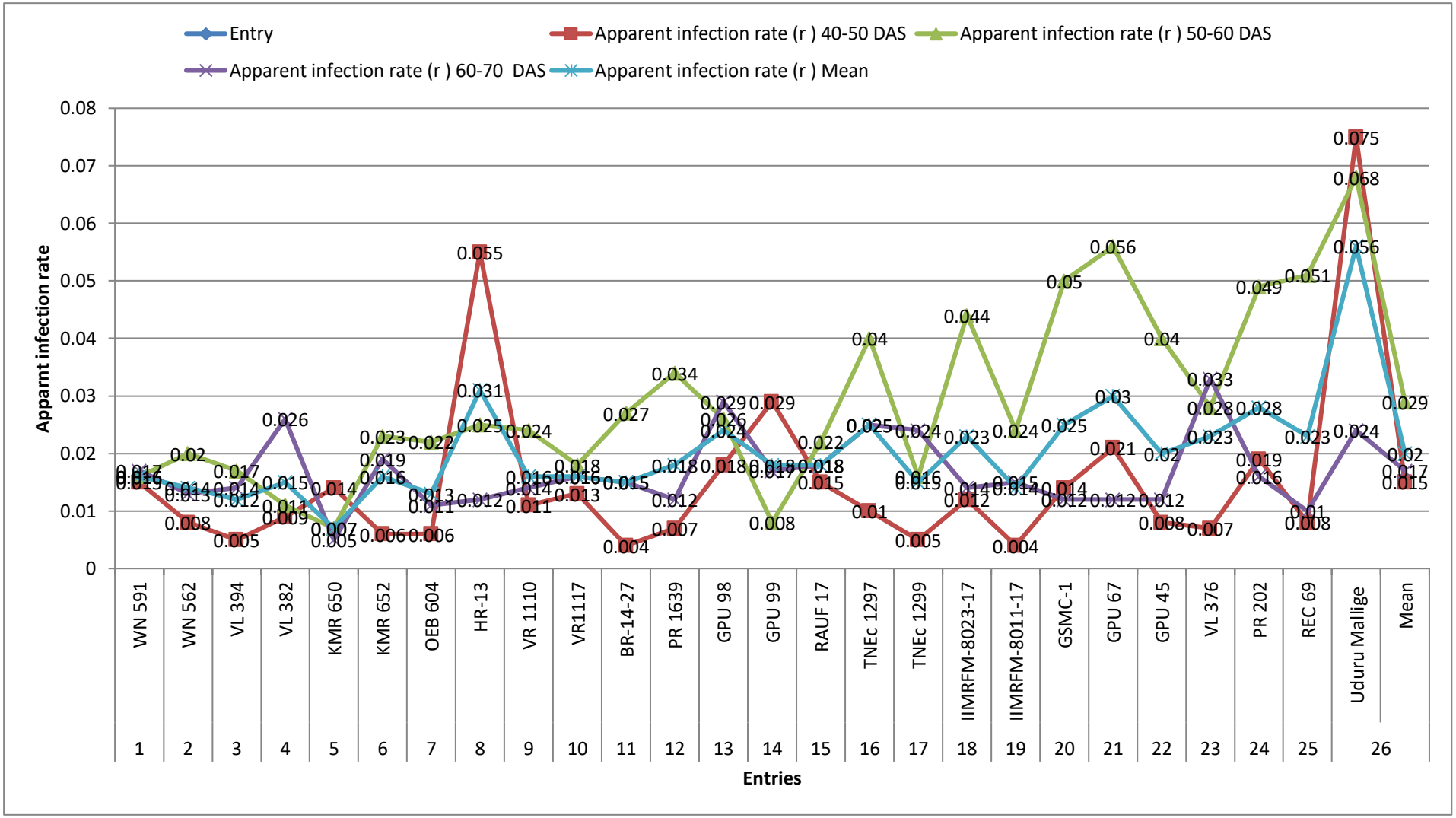


Fig. 4.19 Apparent infection rate in 26 entries of finger millet tested under initial varietal trial

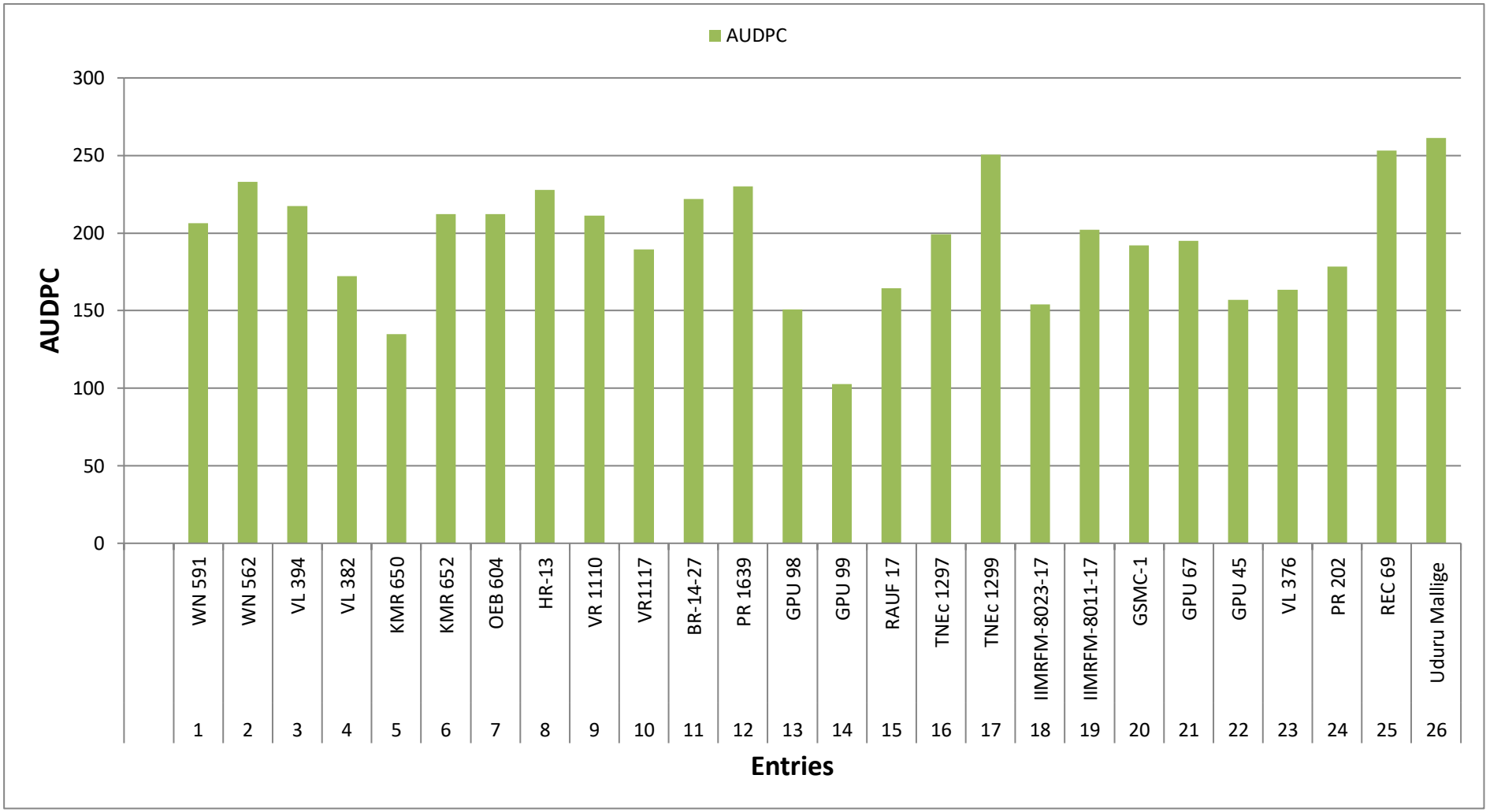


Fig 4.20 Area under disease progress curve in 26 entries of finger millet tested under initial varietal.

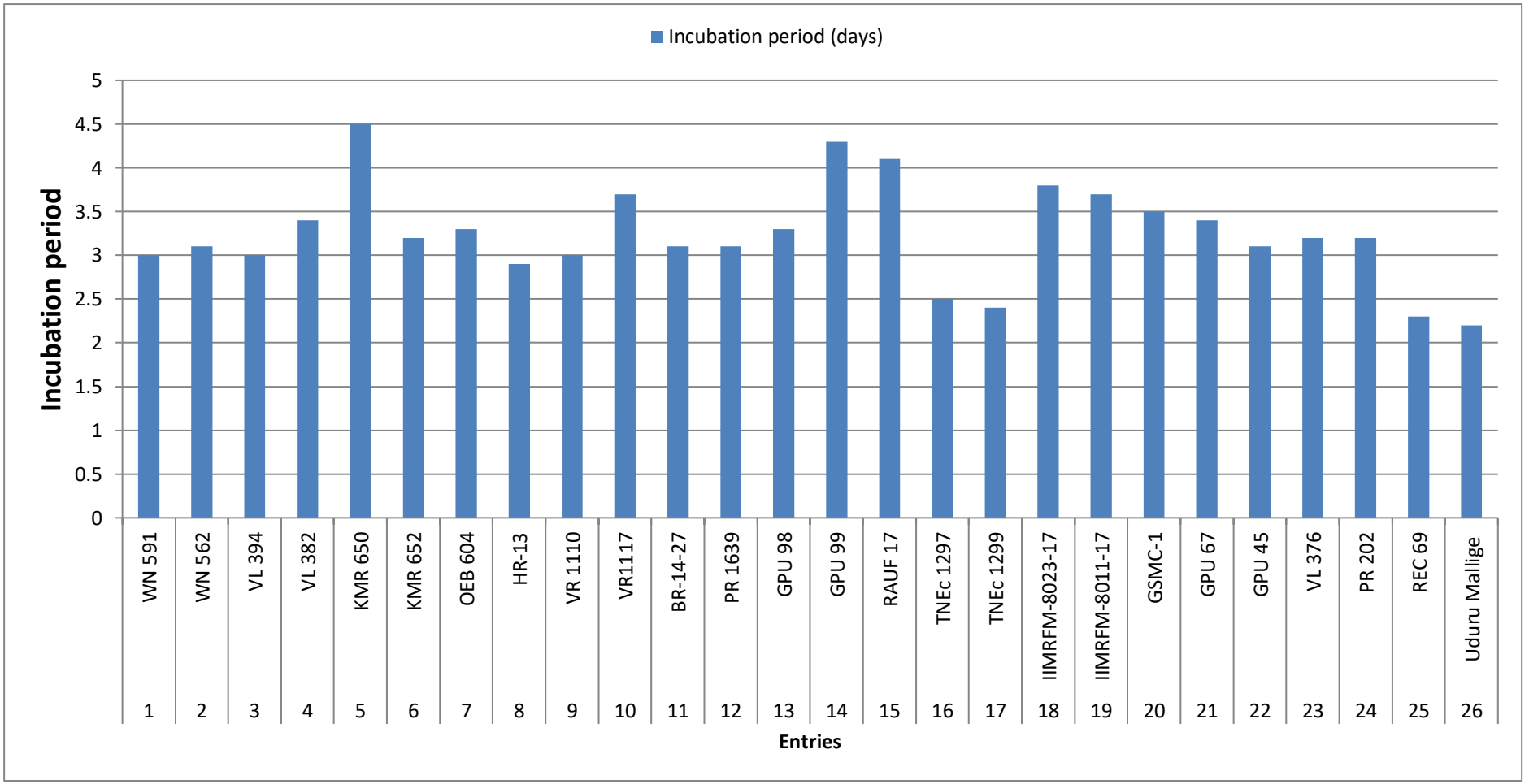


Fig. 4.21 Incubation period in 26 entries of finger millet tested under initial varietal trial.

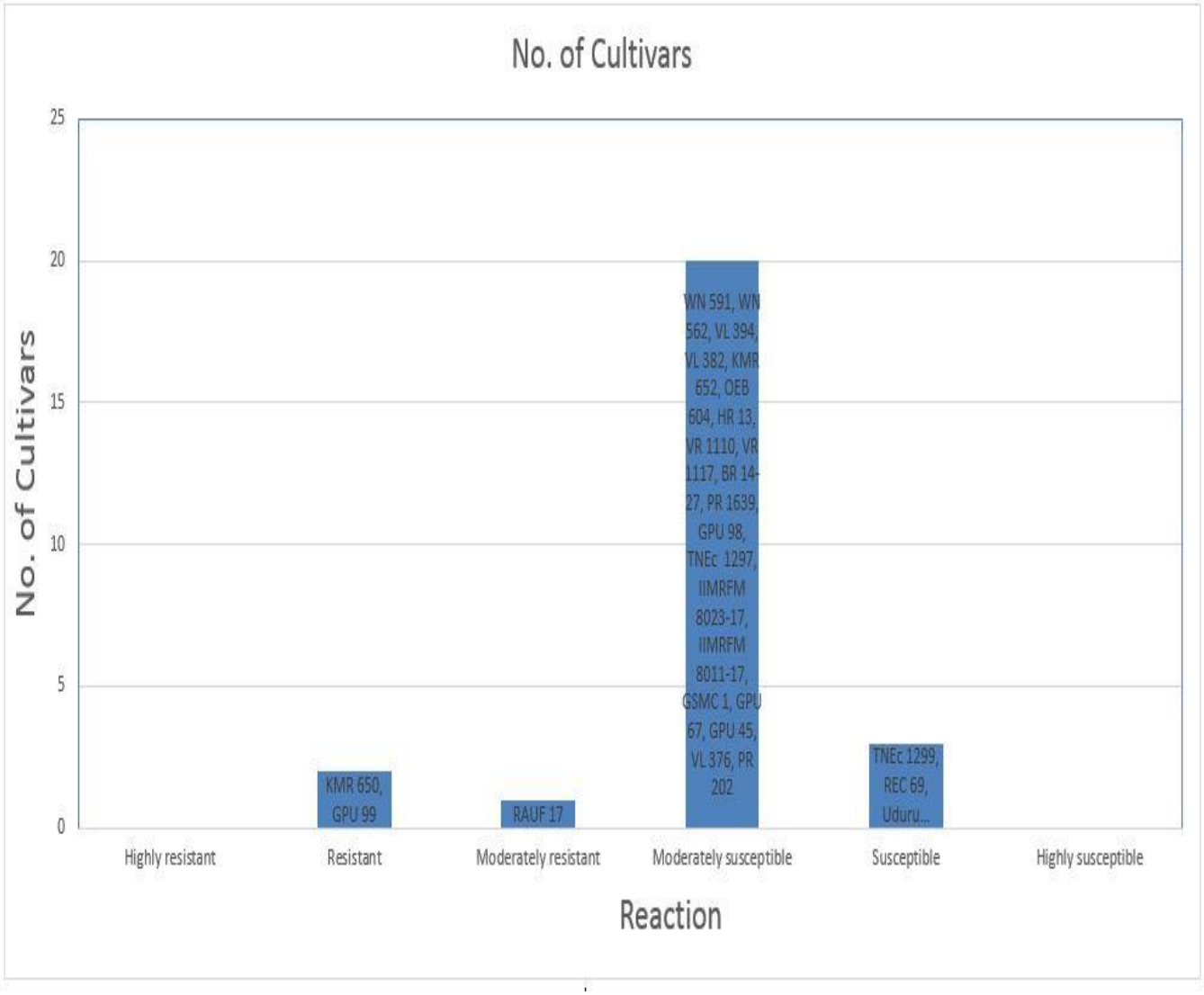
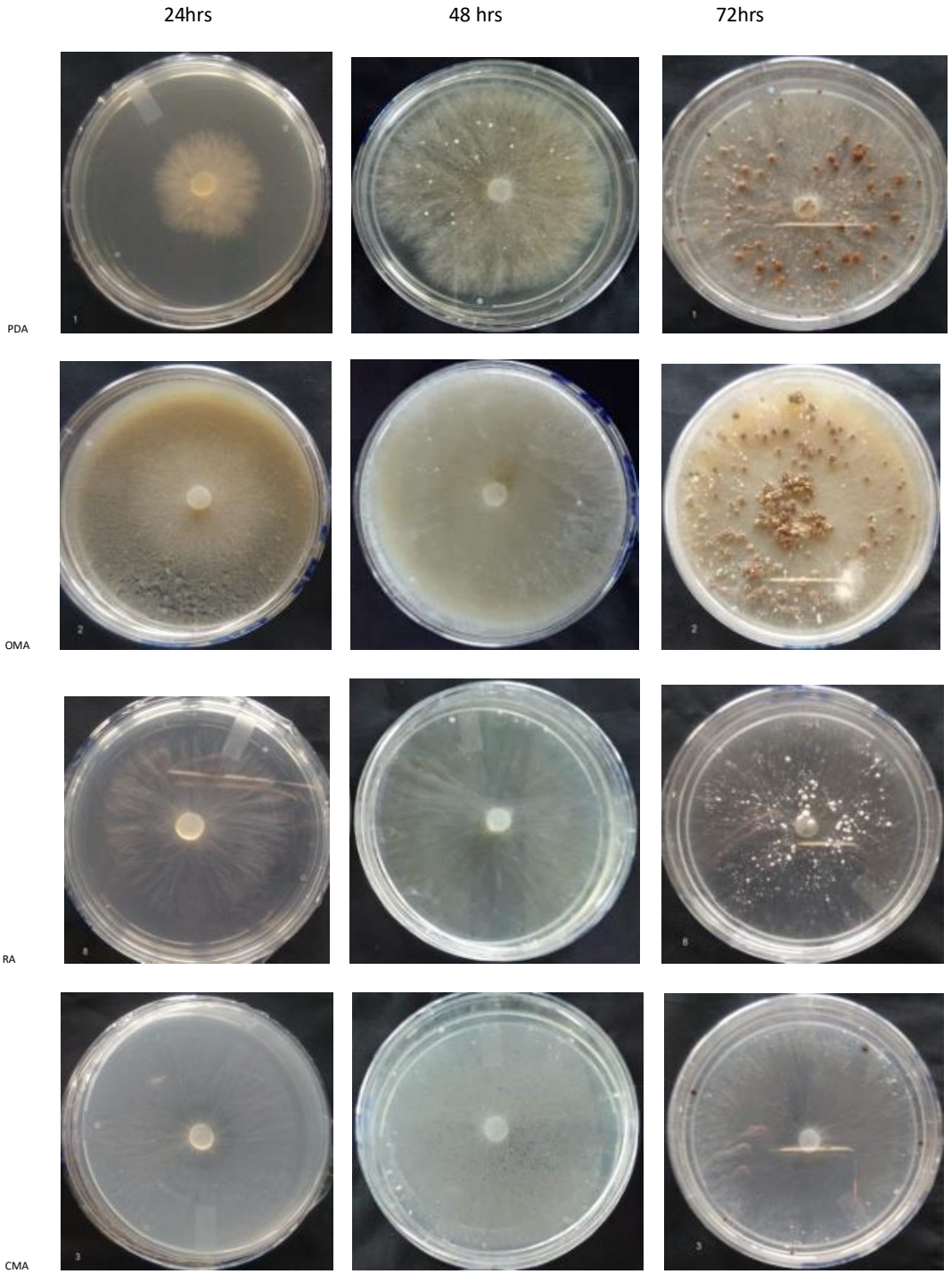


Fig 4.22 Grouping of little millet genotypes against banded leaf and sheath blight disease

Plate 2 Field view of Finger millet trials (*Kharif* 2018)

Plate 1

A. Healthy Finger millet cro
B. Symptom initiation
C. Measurment of lesions on sheath
D. Development of lesions on sheath



PDA = Potato dextrose agar, OMA = Oat meal agar

RA = Richard's agar, CMA = Corn meal agar medium

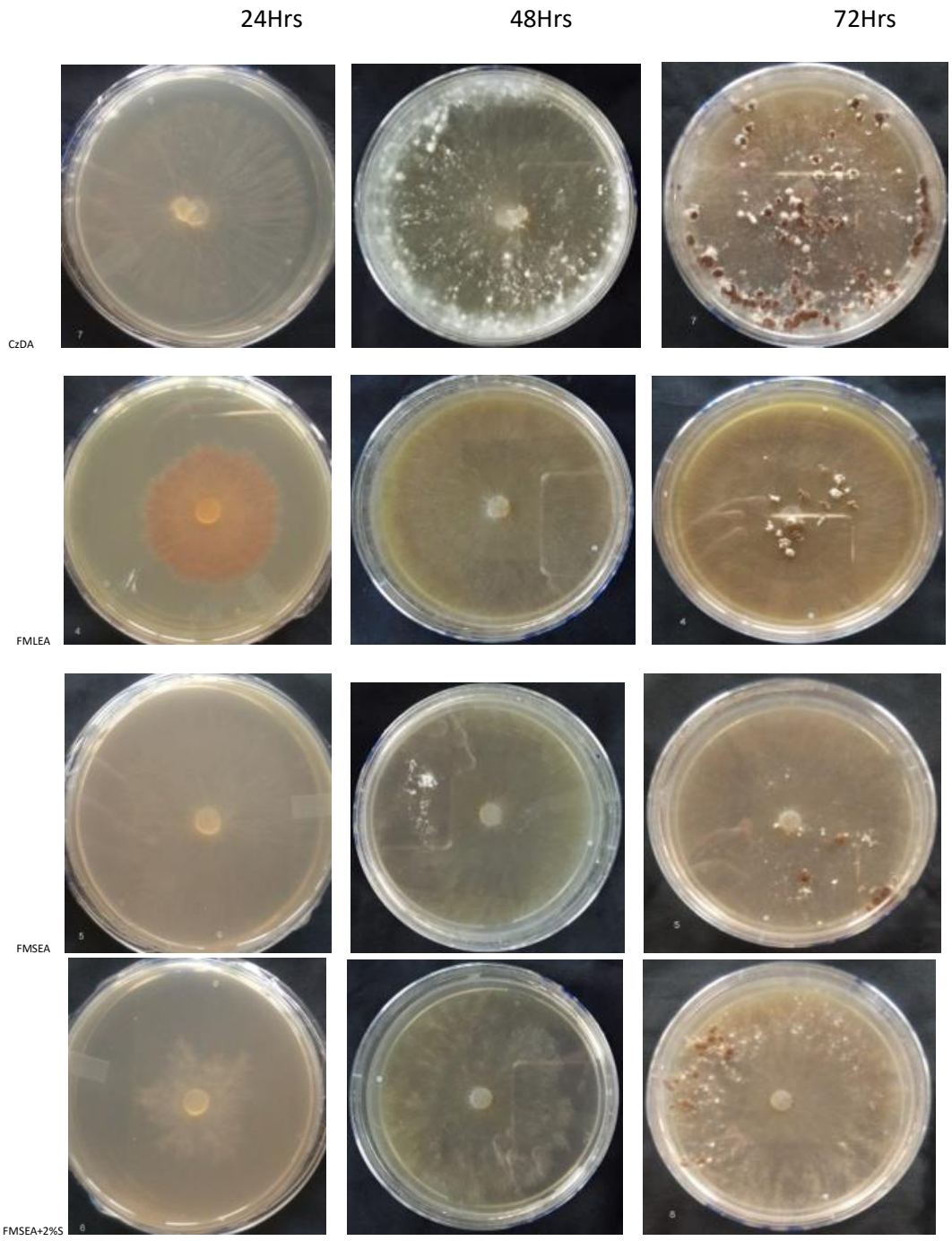


Plate 3 Mycelial growth of *Rhizoctonia solani* on different culture media

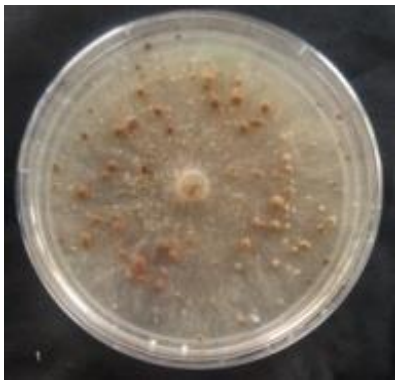
CzDA = Czapek's dox agar, FMLEA = Finger millet leaf extract agar

FMESA = Finger millet seed extract agar, FMSEA+2%S = Finger millet seed extract agar+2% sucrose

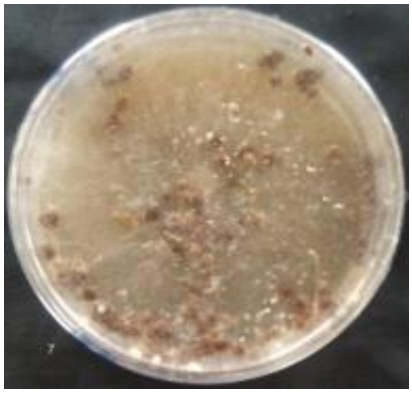
98hrs

98hrs

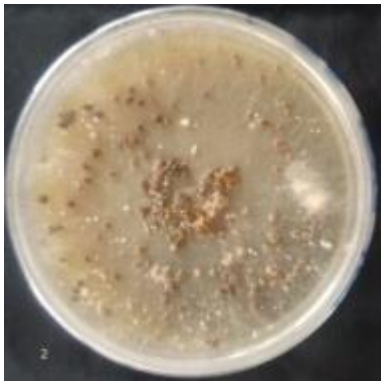
PDA



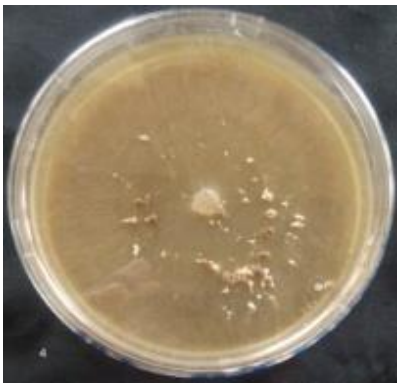
CzDA



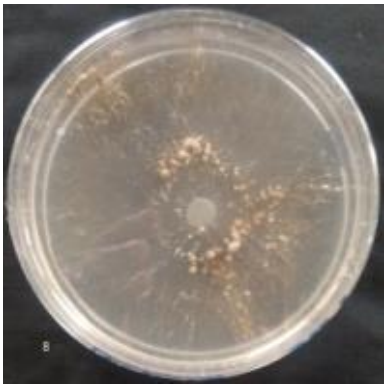
OMA



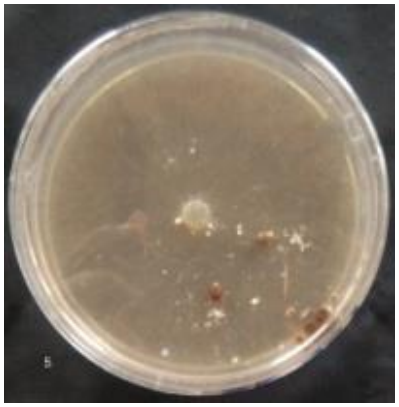
FMLEA



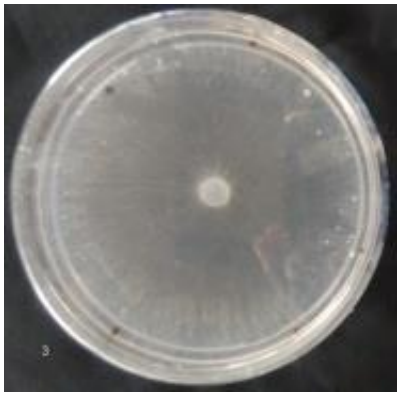
RA



FMSEA



CMA



FMSEA+2% S

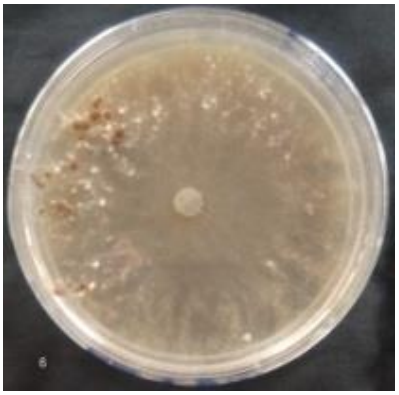


Plate 4 Sclerotial pattern on different culture media

DISCUSSION

Finger millet (*Eleusine coracana* L. Gaertn), commonly known as *ragi* is a widely cultivated small millet crop of Asia and Africa. The crop is grown by resource poor farmers in low fertile soils. Banded leaf and sheath blight of finger millet caused by *Rhizoctonia solani* is an emerging disease and occurs at all the stages of plant growth. The yield losses depend mainly on cultivars, crop stage, cultivation practices and environmental conditions prevailed during the crop growth. Very little work has been carried out on this disease of finger millet particularly on host resistance, hence present study was undertaken with the following objectives:

4. Isolation, purification and characterization of *Rhizoctonia solani* causing banded leaf and sheath blight in finger millet.
5. Effect of plant age on development of banded leaf and sheath blight in finger millet.
6. Identification of host plant resistance in finger millet against banded leaf and sheath blight.

Banded leaf and sheath blight of finger millet is caused by an ubiquitous soil borne fungus and produced oval to irregular, light grey to dark brown lesions on the lower leaf sheath. The disease was characterized by a series of copper or brown coloured bands across the leaves giving banded appearance. The lesions and characteristic bands were also formed on leaf blades. The banded blight symptoms were observed more severe on close planted and lodged plant due to excessive growth or higher rains. Oval to oblong sclerotia initially white and turning brown on maturity were also observed under moist conditions.

In the present study, colony characteristics of *Rhizoctonia solani* were studied in eight solid culture media namely Potato dextrose agar (PDA), oat meal agar (OMA), richard's agar (RA), corn meal agar (CMA), czapek dox agar (CDA), finger millet leaf extract agar(FMLEA), Finger millet seed extract agar (FMSEA) and Finger millet leaf extract agar (FMLEA) +2% sucrose . Average colony diameter ranged from 27.6 to 38.0 mm with

a mean of 32.8 mm after 24 hrs of incubation, 42.4 to 69.3 mm with a mean of 58.0 mm after 48 hrs of incubation and 71.4 to 91.3 mm with a mean of 79.7 mm after 72 hrs of incubation, respectively. The maximum mycelial growth of *R. solani* was observed on PDA (91.3 mm) closely followed in CDA (85.8 mm), OMA (81.7 mm) and CMA (81.3 mm). Least growth was recorded in FMSEA (71.4 mm) and RA (72.3 mm). This may be due to presence of antifungal substances in seeds of finger millet. Maximum mycelia growth of *R. solani* on PDA and CDA was also reported by Sharma et al. (2013) in soybean, Chouhan (2014) and Jain et al (2017) in little millet, Singh and Vishwanath (2016) in rice and maize. Kumar et al (2014) found maximum growth of *R. solani* isolated from urd bean in PDA as well as in CDA and least growth in richard's medium. Hase and Nasreen (2017) reported maximum growth of *R. solani* in CMA and CDA. All these results are in agreement with the present findings.

Variation in colour, growth pattern and growth rate of *Rhizoctonia solani* on different culture media was observed. Colour of the culture varied from white, pale brown to yellowish brown with abundant, moderate to slight growth pattern and fast, moderate to slow growth rate of the fungus in tested media. The excellent fast, abundant and white mycelia growth was recorded on PDA. Where as fast, abundant and pale brown growth was observed on CDA. In OMA, fungal growth rate was moderate, abundant and pale brown, while moderate growth rate, slight growth pattern and white colony was observed in CMA. Moderate growth rate, slight growth pattern and pale brown colony was observed in FMSEA and FMSEA+2% sucrose. In Richards agar medium growth rate was slow, growth pattern was abundant and white colony was recorded. Lal and Kandhari (2009) nreported great diversity in colony colour, growth pattern and colony diameter of *R. solani.*

Sclerotial characteristics and pattern was studied in eight culture media and significant variation was recorded. Time taken for initiation of sclerotia varied 2 to 3 days in different culture media. Variation in number of sclerotia , weight of 10 sclerotia and size of sclerotia was 11.0 to 57.3, 132.0 to 1040.7 mm and 0.3 to 1.2 mm, respectively. Maximum number of

sclerotia was recorded in OMA (57.3) closely followed by PDA (55.0) and CDA (48.7). whereas least sclerotia were formed in FMSEA (11.0) followed by FMLEA (12.7) and FMLEA + 2% sucrose (13.3). Maximum weight of 10 sclerotia was recorded in PDA (1040.7 mg) followed by CDA (925.7 mg) and OMA (899.7 mg). Minimum weight of sclerotia was observed in CMA (132.0 mg) followed by RA (213.3 mg) and FMLEA + 2% sucrose (341.0 mg). Significant variation in size of sclerotia was observed, which ranged 0.3 mm to 1.2 mm with maximum size in PDA followed by FMSEA (1.0 mm) and CMA (0.9 mm), Smallest sclerotia were formed in Ra (0.3 mm) followed by CDA (0.4 mm). Sharma et al (2013), Kumar et al (2014) and Raja Husain et al (2016) also reported maximum sclerotial formation of *R. solani* in OMA, PDA and CDA. These result confirms the present findings.

Plant growth stages differed significantly on development of BLSB in early, medium and late maturing genotypes of finger millet. Average number of lesions was 7.6 and RLH (%) was 12.1% at 40 days old crop. In 50 days old crop, average number of lesions and RLH (%) was 3.3 and 9.4%. Average lesion number and RLH (%) was 2.6 and 8.7% in 60 days old crop, where as average number of lesions was 0.8 and RLH (%) was 3.4% in 70 days old crop. The results showed that 40 and 50 days old crop of finger millet is more susceptible to BLSB as compared to 60 and 70 days old crops. Number of lesions and vertical spread of the disease in terms of RLH (%) were decreased as the crop approaches to maturity. Tillering to maximum tillering stage was reported more susceptible to sheath blight as compared to flowering and booting stages in rice (Yashimura and Nishizawa,1954, Tsai,1974, Roy ,1979, Lakpale et al,1996, Rodrigues et al ,2003, Thind et al, 2008, Thakur et al , 2017) These results confirm the present findings. On the contrary, Kozaka (1961), Cu et al (1996), Sharma and Teng (1996), Vanitha et al (1996) found flowering, panicle exertion and booting stage more susceptible to sheath blight compared to seedling and tillering stage in rice. Chang and Dath (1995) found significant interaction between *R. solani* isolates, rice cultivars and stages of the plant growth thereby indicating that everyone of the combination of these factors influenced sheath blight severity. However, the disease severity in many

cultivars was, in general, more at flowering than at seedling and maximum tillering stages.

Use of host plant resistance is the most economical and feasible way for the management of any soil borne disease. In finger millet very few studies were under taken to find out the resistant sources against BLSB. Ten early and medium maturing finger millet entries and 26 entries from initial varietal trials were screened against BLSB under artificial inoculations. A significant variation in number of lesions, length of lesions and relative lesion height (RLH) was recorded in all the screened finger millet entries. In early and medium maturing finger millet entries, number of lesions, length of lesions and RLH (%) varied from 4.0 to 10.7, 5.9 to 11.8 cm and 15.3 to 46.1%, respectively. Incubation period ranged from 2.6 to 4.0 days. Average apparent infection rate (r) ranged from 0.008 to 0.023 percent per day. Average maximum infection rate (0.028) was recorded between 50 to 60 DAS indicating the favourable conditions for disease development. Minimum infection rate (0.007) was found between 40 to 50 DAS showing less favourable conditions for disease development. The area under disease progress curve is commonly used to quantify the disease severity over time and is an important component for identification of slow blighting genotypes. The values of AUDPC ranged from 106.7 to 233.8 with a mean of 157.6 in 10 finger millet entries. Finger millet entry VR 1101 was found resistant to BLSB exhibiting low number of lesions (5.0), small length of lesions (6.3 cm), less than 20% (15.3%) RLH and higher (4.0 days) incubation period. Low values of apparent infection rate (0.008 percent per day) and AUDPC (106.7) were recorded in VR 1101.Seven entries namely BR 14-3, KOPN 942, VL 387, OEB 602, VL 352, PR 202 and GPU 67 were moderately resistant. GPU 45 was found moderately susceptible with 10.0 number of lesions, 11.4 cm lesion length and more than 30.0% (31.2%) RLH. Moderate values of apparent infection rate (0.020 percent per day) and AUDPC (187.0) was recorded. Finger millet entry REC 69 shown susceptibility against BLSB and more number of lesions (10.7), length of lesion (11.8 cm) and more than 45% RLH (46.1%) and lower incubation period (2.6 days) were recorded. Higher values of apparent infection rate (0.023 percent per day) and AUDPC (233.8) were estimated in REC 69.

In 26 finger millet entries, number of lesions varied from 4.3 to 11.4 with a mean of 8.3, lesion length varied from 3.9 to 11.7 cm with a mean of 8.7 and RLH from 15.4 to 47.1% with a mean of 35.6%. Incubation period varied from 2.3 to 5.4 days in the screened entries. Values of apparent infection rate varied from 0.009 to 0.056 with a mean of 0.020 percent per day. Higher values of apparent infection rate (0.029 percent per day) was observed between 50 to 60 DAS followed by 0.017 between 60 to 70 DAS and 0.015 between 40 to 50 DAS. It indicates that time period between 50 to 60 DAS was more congenial for BLSB development as compared to others. In finger millet entries, the values of AUDPC varied from 102.8 to 261.2 with a mean of 195.9. Two entries of finger millet namely KMR 650 and GPU 99 were found resistant to BLSB showing less number of lesions (5.7), low lesion length (5.2 &5.7 cm) , less than 20% RLH (15.4 & 16.7%) and higher incubation period (4.3 & 4.5 days). In KMR 650 apparent infection rate was 0.007 percent per day and AUDPC values was 134.7. whereas in GPU 99, number of lesions, length of lesions, RLH, apparent infection rate and AUDPC values were 5.7, 5.2 cm, 16.7%, 0.018 percent per day and 102.8, respectively. Finger millet entry RAUF 17 was found moderately susceptible by showing moderate number of lesions (6.6), length of lesion (9.1 cm), less than 30% RLH (29.3%), moderate incubation period (4.1 days), low values of apparent infection rate (0.018) and moderate values of AUDPC (164.3). Three entries namely TNEc 1299, REC 69 and Uduru Mallige were found susceptible to BLSB with higher number of lesions (8.3 to 10.3), length of lesions (10.2 to 10.9 cm), RLH (46.3 to 47.1%), apparent infection rate (0.015 to 0.023 percent per day) and higher values of AUDPC (250.5 to 261.2) and lower values of incubation period (2.3 to 2.4 days). Kahar (2017) in kodo millet and Kumar (2018) in little millet also reported that low values of apparent infection rate as well as AUDPC and high incubation period contributed towards resistance and for identification of slow blighting genotypes against *Rhizoctonia solani* causing banded leaf and sheath blight. Earlier finger millet entry PR 10-35 (Anon, 2017) and BR 14-3 (Anon., 2018) were reported resistant to BLSB. However, BR 14-3 was found moderately resistant to BLSB in the present study. Jain and Joshi (2018) reported that finger millet cultivars namely VL

352, VL 384, GPU 91, GPU 92, VR 708, TNEC 1234 and GPU 45 are resistant to banded leaf and sheath blight. On the contrary, in the present study GPU 45 was found moderately susceptible to BLSB under artificial inoculations.

SUMMARY, CONCLUSION AND SUGGESSIONS FOR FUTURE RESEARCH WORK

The present investigation entitled **Studies on banded leaf and sheath blight of finger millet caused by *Rhizoctonia solani* Kuhn was** carried out at Jawaharlal Nehru Krishi Vishwa Vidyalaya, College of Agriculture, Rewa (M.P.) and the field experiments were conducted at experimental area of All India Coordinated Small Millets Improvement Project (voluntary centre), College of Agriculture, Rewa (M.P.) during 2018-19. The results obtained from the present study are summarized below:

6.1 Summary

Banded leaf and sheath blight (BLSB) of finger millet is an emerging disease and may cause substantial yield losses under favourable environmental conditions. The disease occurs at all the stages of plant growth and characteristic bands are formed on the leaf sheath and leaf blade.

The pathogen *Rhizoctonia solani* was isolated in potato dextrose agar (PDA) medium and apparently distinct colonies were sub cultured aseptically on fresh PDA for getting pure culture. Colony characteristics of *R. solani* were studied in eight solid culture media. The maximum mycelial growth was recorded on potato dextrose agar (91.3 mm) closely followed in czapek's dox agar (85.8 mm), oat meal agar (81.7 mm) and corn meal agar (81.3 mm). Whereas least growth was recorded in finger millet seed extract agar (71.4 mm) and richards agar (72.3 mm) medium. Colour of the culture varied from white, pale brown to yellowish brown with abundant, moderate to slight growth pattern and fast, moderate to slow growth rate of the fungus in tested media were observed. The excellent fast, abundant and white mycelial growth was recorded on PDA. Where as fast, abundant and pale brown growth was observed on czapek's dox agar (CDA). In oat meal agar (OMA), fungal growth rate was moderate, abundant and pale brown with moderate growth rate, slight growth pattern and white colony was observed in corn meal agar. Moderate growth rate, slight growth pattern and pale brown colony was observed in finger millet seed extract agar and finger

millet seed extract agar +2% sucrose. In Richards agar medium mycelia growth rate was slow, growth pattern was abundant and white colony was recorded.

Time taken for initiation of sclerotia varied 2 to 3 days in different culture media. Maximum number of sclerotia was recorded in OMA (57.3) closely followed by PDA (55.0) and CDA (48.7). Maximum weight of 10 sclerotia was recorded in PDA (1040.7 mg) followed by CDA (925.7 mg) and OMA (899.7 mg). Significant variation in size of sclerotia was observed, which ranged 0.3 mm to 1.2 mm with maximum size in PDA followed by FMSEA (1.0 mm) and CMA (0.9 mm), Smallest sclerotia were formed in Richards agar (0.3 mm) followed by CDA (0.4 mm).

Plant growth stages differed significantly on development of BLSB in early, medium and late maturing genotypes of finger millet. The results showed that 40 and 50 days old crop of finger millet is more susceptible to BLSB as compared to 60 and 70 days old crop. Number of lesions and vertical spread of the disease in terms of RLH (%) were decreased as the crop approaches to maturity.

Ten early and medium maturing entries and 26 entries from initial varietal trial were screened against BLSB. A significant variation in number of lesions, length of lesions and relative lesion height (RLH) was recorded in all the screened finger millet entries. In early and medium maturing entries, number of lesions, length of lesions and RLH (%) varied from 4.0 to 10.7, 5.9 to 11.8 cm and 15.3 to 46.1%, respectively. Incubation period ranged from 2.6 to 4.0 days. Average maximum infection rate (0.028) was recorded between 50 to 60 DAS indicating the favourable conditions for disease development. Minimum infection rate (0.007) was found between 40 to 50 DAS showing less favourable conditions for disease development. Finger millet entry VR 1101 was found resistant to BLSB exhibiting low number of lesions (5.0), small length of lesions (6.3 cm), less than 20% (15.3%) RLH and higher (4.0 days) incubation period. Low values of apparent infection rate (0.008 percent per day) and AUDPC (106.7) were recorded in VR 1101.Seven entries namely BR 14-3, KOPN 942, VL 387, OEB 602, VL 352,

PR 202 and GPU 67 were moderately resistant. GPU 45 was found moderately susceptible with 10.0 number of lesions, 11.4 cm lesion length and more than 30.0% (31.2%) RLH. Moderate values of apparent infection rate (0.020 percent per day) and AUDPC (187.0) was recorded. Finger millet entry REC 69 shown susceptibility against BLSB and more number of lesions (10.7), length of lesion (11.8 cm) and more than 45% RLH (46.1%) and lower incubation period (2.6 days) were recorded. Higher values of apparent infection rate (0.023 percent per day) and AUDPC (233.8) were estimated in REC 69 susceptible to BLSB.

Two entries of finger millet namely KMR 650 and GPU 99 were found resistant to BLSB showing less number of lesions (5.7), low lesion length (5.2 &5.7 cm) , less than 20% RLH (15.4 & 16.7%) and higher incubation period (4.3 & 4.5 days). In KMR 650 apparent infection rate was 0.007 percent per day and AUDPC values was 134.7. whereas in GPU 99, number of lesions, length of lesions, RLH, apparent infection rate and AUDPC values were 5.7, 5.2 cm, 16.7%, 0.018 percent per day and 102.8, respectively. Finger millet entry RAUF 17 was found moderately susceptible by showing moderate number of lesions (6.6), length of lesion (9.1 cm), less than 30% RLH (29.3%), moderate incubation period (4.1 days), low values of apparent infection rate (0.018) and moderate values of AUDPC (164.3). Three entries namely TNEc 1299, REC 69 and Uduru Mallige were found susceptible to BLSB with higher number of lesions (8.3 to 10.3), length of lesions (10.2 to 10.9 cm), RLH (46.3 to 47.1%), apparent infection rate (0.015 to 0.023 percent per day) and higher values of AUDPC (250.5 to 261.2) and lower values of incubation period (2.3 to 2.4 days).

6.2 Conclusion

The following conclusions could be drawn from the present study.

1. *Rhizoctonia solani* produced characteristic symptoms of banded leaf and sheath blight in finger millet as irregular to oval, light to dark brown lesions with narrow reddish brown margins on the lower leaf sheath,

which gradually spread on upper leaf sheaths with characteristic bands on leaf sheath and leaf blades.

2. The maximum radial growth of *R. solani* (91.3 mm) was recorded on potato dextrose agar, which was significantly at par in czapek dox agar (85.8 mm) medium. Least growth (71.4 mm) was observed in finger millet seed extract agar and richards agar.
3. The excellent fast, abundant and white mycelial growth of *R. solani* was recorded on potato dextrose agar. Where as fast, abundant and pale brown growth was observed on czapek dox agar.
4. Initiation of sclerotia formation varied 2 to 3 days in different culture media. Maximum number of sclerotia was produced in oat meal agar (57.3) closely followed by potato dextrose agar (55.0) and czapek dox agar (48.7). Maximum weight of 10 sclerotia was recorded in potato dextrose agar (1040.7 mg) followed by czapek dox agar (925.7 mg) and oat meal agar (899.7 mg). Maximum size of sclerotia were formed in potato dextrose agar followed by finger millet seed extract agar (1.0 mm) and corn meal agar (0.9 mm),
5. Development and spread of banded leaf and sheath blight was more in 40 and 50 days old crop of finger millet as compared to 60 and 70 days old crops.
6. Early maturing finger millet entry VR 1101 was found resistant to banded leaf and sheath blight exhibiting less number (5.0) and length of lesions (6.3 cm) , less than 20% relative lesion height (15.3%), lower apparent infection rate (0.008 percent per day), low AUDPC (106.7) and higher (4.0 days) incubation period. Seven early and medium maturing entries namely BR 14-3, KOPN 942, VL 387, OEB 602, VL 352, PR 202 and GPU 67 were found moderately resistant to banded leaf and sheath blight.
7. Two entries of finger millet from initial varietal trial namely KMR 650 and GPU 99 were found resistant to banded leaf and sheath blight (BLSB) showing less number and length of lesions, less than 20% relative lesion height, lower apparent infection rate and AUDPC values with higher incubation period. RAUF 17 was found moderately resistant to BLSB under artificial inoculations.

6.3 Suggestions for future research work

Based on the present findings, following suggestions can be made for future work.

I. Survey and surveillance of banded leaf and sheath blight (BLSB) in finger millet at farmers field is essential to know the status and management of the disease.

II. Standardization of artificial inoculation technique , host range and cross inoculation studies for banded leaf and sheath blight of finger millet.

III. Estimation of avoidable losses due to BLSB in finger millet for planning of management strategies.

IV. Studies of host plant resistance in cultivated varieties of finger millet and development of low cost integrated disease management practices for BLSB in finger millet.

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Appendix - I

Weekly weather data (2018), College of Agriculture, Rewa (M.P.)

Standard Week	Period		Temperature (0^c)		Rainfall (mm)	Rainy days	Relative humidity	
	From	To	Max.	Min.			Min.(%)	Max.(%)
23	04-Jun	10-Jun	40.9	19.5	0.0	0.0	11.6	23.4
24	11-Jun	17-Jun	38.7	22.7	51.6	2.0	21.3	45.6
25	18-Jun	24-Jun	42.6	23.1	0.0	0.0	15.0	27.1
26	25-Jun	01-Jul	42.1	24.8	7.2	2.0	13.4	31.6
27	02-Jul	08-Jul	44.0	25.3	4.2	1.0	14.0	29.7
28	09-Jul	15-Jul	43.0	26.7	0.0	0.0	17.1	35.7
29	16-Jul	22-Jul	40.7	26.9	15.2	2.0	16.0	59.0
30	23-Jul	29-Jul	40.0	27.5	34.0	1.0	22.7	43.7
31	30-Jul	05-Aug	40.7	27.8	4.0	1.0	28.1	51.4
32	06-Aug	12-Aug	34.4	26.0	63.6	1.0	46.0	63.6
33	13-Aug	19-Aug	36.6	26.3	26.4	1.0	40.3	65.6
34	20-Aug	26-Aug	35.5	25.7	68.0	5.0	55.9	77.1
35	27-Aug	02-Sep	33.0	25.3	59.4	3.0	58.1	80.7
36	03-Sep	09-Sep	30.3	24.3	75.4	6.0	77.7	89.6
37	10-Sep	16-Sep	29.9	23.3	77.2	4.0	80.0	85.7
38	17-Sep	23-Sep	32.0	25.7	56.2	5.0	77.6	84.7
39	24-Sep	30-Sep	32.1	24.6	118.6	5.0	79.3	84.0
40	01-Oct	07-Oct	30.7	24.2	124.4	5.0	82.0	87.0
41	08-Oct	14-Oct	31.7	23.9	62.2	4.0	79.9	89.1
42	15-Oct	21-Oct	29.8	22.9	77.4	4.0	82.4	89.1
43	22-Oct	28-Oct	31.9	22.9	0.0	0.0	68.7	76.4
44	29-Oct	04-Nov	33.2	22.7	0.0	0.0	60.4	77.0
45	05-Nov	11-Nov	34.9	21.9	0.0	0.0	50.7	67.7
46	12-Nov	18-Nov	36.7	19.6	0.0	0.0	44.4	58.9
47	19-Nov	25-Nov	33.5	18.7	0.0	0.0	52.6	67.3
48	26-Nov	02-Dec	35.2	16.7	0.0	0.0	42.4	58.4
49	03-Dec	09-Dec	33.1	14.5	5.2	1.0	40.4	63.3
50	10-Dec	16-Dec	31.8	15.7	0.0	0.0	46.9	59.1
51	17-Dec	23-Dec	29.9	11.4	0.0	0.0	45.6	62.0
52	24-Dec	31-Dec	31.3	12.0	0.0	0.0	45.3	58.6

Gross Total Rainfall, (mm)	966.2 mm
Total no. of Rainy days	57 days
Rainfall from 1st June	867.2 mm
Total no. of Rainy days from 1st June	48 days
Average rainfall, mm	1200 mm
Deficit %	27.7
Latitude:	$24^0$31'N
Longitude:	$80^0$15' E
Altitude (m) (above MSL):	365

Appendix - II

I. Analysis of variance for characterization of *Rhizoctonia solani* causing banded leaf and sheath blight in finger millet on different culture media.

Colony diameter of *R. solani* in different culture media : Radial growth after 24 h

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	F tab.
Replications	2	24.60	12.30	1.26	
Treatments	7	336.79	48.11	4.92*	**3.57**
Error	14	136.85	9.77		-
Total	23				-

*significant at 5%

Colony diameter of *R. solani* in different culture media : Radial growth after 48 h

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	F tab.
Replications	2	7.62	3.81	0.26	
Treatments	7	2141.53	305.93	20.74*	**3.57**
Error	14	206.46	14.75		-
Total	23				-

*significant at 5%

Colony diameter of *R. solani* in different culture media : Radial growth after 72 h

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	F tab.
Replications	2	18.14	9.07	0.36	
Treatments	7	951.23	135.89	5.34*	**3.57**
Error	14	356.25	25.45		-
Total	23				-

*significant at 5%

Sclerotial formation of *R. solani* in different culture media : Number of sclerotia

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	F tab.
Replications	2	27.09	13.54	0.67	
Treatments	7	7873.43	1124.78	55.93*	**3.57**
Error	14	281.57	20.11		-
Total	23				-

*significant at 5%

Sclerotial formation of *R. solani* in different culture media : Weight of sclerotia

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	F tab.
Replications	2	4593.58	2296.79	2.50	
Treatments	7	2489303.83	355614.83	387.07*	**3.57**
Error	14	12862.42	918.74		-
Total	23				-

*significant at 5%

Sclerotial formation of *R. solani* in different culture media : Size of sclerotia

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	F tab.
Replications	2	0.02	0.01	0.27	
Treatments	7	2.00	0.29	9.75*	**3.57**
Error	14	0.41	0.03		-
Total	23				-

*significant at 5%

Appendix - III

I. Analysis of variance for Identification of host plant resistance in finger millet against banded leaf and sheath blight

Number of lesions at 40 DAS in AVT-I & II

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	0.414	0.202	1.086	0.351
Treatments	9	4.577	0.508	2.691*	0.039
Error	18	3.390	0.186	-	-
Total	29	-	-	-	-

*significant at 5%

Number of lesions at 50 DAS in AVT-I & II

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	0.026	0.013	0.096	0.905
Treatments	9	5.286	0.585	5.101*	0.006
Error	18	2.075	0.110	-	-
Total	29	-	-	-	-

*significant at 5%

Number of lesions at 60 DAS in AVT-I & II

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	0.038	0.019	0.191	0.828
Treatments	9	5.019	0.553	6.731*	0.003
Error	18	1.493	0.087	-	-
Total	29	-	-	-	-

*significant at 5%

Number of lesions at 70 DAS in AVT-I & II

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	0.042	0.026	0.166	0.842
Treatments	9	5.025	0.555	4.380*	0.007
Error	18	2.291	0.125	-	-
Total	29	-	-	-	-

*significant at 5%

Length of lesions at 40 DAS in AVT-I & II

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	9.236	4.613	0.990	0.392
Treatments	9	147.453	16.380	3.521*	0.010
Error	18	83.776	4.653	-	-
Total	29	-	-	-	-

*significant at 5%

Length of lesions at 50 DAS in AVT-I & II

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	8.506	4.253	1.136	0.344
Treatments	9	152.646	16.961	4.522*	0.001
Error	18	67.493	3.745	-	-
Total	29	-	-	-	-

*significant at 5%

Length of lesions at 60 DAS in AVT-I & II

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	8.656	4.323	1.249	0.314
Treatments	9	154.843	17.207	4.960*	0.008
Error	18	62.336	3.461	-	-
Total	29	-	-	-	-

*significant at 5%

Length of lesions at 70 DAS in AVT-I & II

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	5.206	2.603	0.877	0.439
Treatments	9	114.183	12.688	4.265*	0.002
Error	18	53.546	2.979	-	-
Total	29	-	-	-	-

*significant at 5%

Relative lesion height (%) at 40 DAS in AVT-I & II

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	41.453	20.726	1.674	0.213
Treatments	9	300.896	33.437	2.704*	0.037
Error	18	222.840	12.382	-	-
Total	29	-	-	-	-

*significant at 5%

Relative lesion height (%) at 50 DAS in AVT-I & II

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	32.677	16.333	2.093	0.152
Treatments	9	236.757	26.309	3.374*	0.015
Error	18	140.481	7.807	-	-
Total	29	-	-	-	-

*significant at 5%

Relative lesion height (%) at 60 DAS in AVT-I & II

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	34.331	17.160	6.470	0.005
Treatments	9	348.998	38.775	14.634*	1.427
Error	18	47.697	2.649	-	-
Total	29	-	-	-	-

*significant at 5%

Relative lesion height (%) at 70 DAS in AVT-I & II

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	0.658	0.329	0.066	0.938
Treatments	9	231.569	25.725	5.279	0.003
Error	18	87.847	4.884	-	-
Total	29	-	-	-	-

*significant at 5%

Number of lesions at 40 DAS in IVT

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	0.171	0.085	0.259	0.770
Treatments	25	16.831	0.674	1.950*	0.021
Error	50	17.256	0.340	-	-
Total	77	-	-	-	-

*significant at 5%

Number of lesions at 50 DAS in IVT

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	0.158	0.079	0.333	0.710
Treatments	25	28.627	1.140	4.772*	1.309
Error	50	11.986	0.236	-	-
Total	77	-	-	-	-

*significant at 5%

Number of lesions at 60 DAS in IVT

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	0.045	0.022	0.055	0.941
Treatments	25	17.480	0.694	1.989*	0.018
Error	50	17.649	0.358	-	-
Total	77	-	-	-	-

*significant at 5%

Number of lesions at 70 DAS in IVT

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	0.159	0.079	0.303	0.730
Treatments	25	11.386	0.453	1.807*	0.033
Error	50	12.642	0.258	-	-
Total	77	-	-	-	-

*significant at 5%

Length of lesions at 40 DAS in IVT

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	7.796	3.898	0.646	0.521
Treatments	25	348.956	13.953	2.309*	0.009
Error	50	302.403	6.040	-	-
Total	77	-	-	-	-

*significant at 5%

Length of lesions at 50 DAS in IVT

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	1.442	0.726	0.158	0.856
Treatments	25	373.853	14.950	3.156*	0.002
Error	50	237.097	4.748	-	-
Total	77	-	-	-	-

*significant at 5%

Length of lesions at 60 DAS in IVT

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	2.329	1.169	0.206	0.815
Treatments	25	318.021	12.728	2.230	0.007
Error	50	284.323	5.685	-	-
Total	77	-	-	-	-

*significant at 5%

Length of lesions at 70 DAS in IVT

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	13.758	6.874	0.967	0.385
Treatments	25	354.786	14.192	1.985	0.017
Error	50	357.917	7.152	-	-
Total	77	-	-	-	-

*significant at 5%

Relative lesion height (%) at 40 DAS in IVT

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	33.669	16.839	1.920	0.159
Treatments	25	1377.753	55.110	6.316*	1.767
Error	50	436.362	8.722	-	-
Total	77	-	-	-	-

*significant at 5%

Relative lesion height (%) at 50 DAS in IVT

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	1.855	0.922	0.097	0.901
Treatments	25	800.474	32.019	3.419*	0.001
Error	50	468.679	9.374	-	-
Total	77	-	-	-	-

*significant at 5%

Relative lesion height (%) at 60 DAS in IVT

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	16.725	8.362	0.375	0.684
Treatments	25	1139.892	45.599	2.050*	0.018
Error	50	1107.195	22.148	-	-
Total	77	-	-	-	-

*significant at 5%

Relative lesion height (%) at 70 DAS in IVT

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F cal	**F prob**
Replications	2	10.572	5.281	0.157	0.855
Treatments	25	2654.429	106.171	3.191*	0.002
Error	50	1664.120	33.284	-	-
Total	77	-	-	-	-

*significant at 5%

CURRICULUM VITAE

Name – Smita Prajapati

Place – Village- Ghurehata Post - Mauganj

Teh. + Dist. – Mauganj, Rewa, (M.P.)

Date of birth – 30 April 1994

Institution	Degree	University	Year	OGPA
College of Agriculture Rewa, (MP)	**M.Sc. (Ag.) Plant Pathology**	**JNKVV, Jabalpur**	**2019**	**7.45**
College of Agriculture Rewa, (MP)	**B.Sc. (Ag.)**	**JNKVV, Jabalpur**	**2017**	**7.04**
Saraswati Higher Secondary School, Unchehra, Satna (M.P.)	**12th**	**BSEMP, Bhopal**	**2011**	**65.6**

For the partial fulfillment of the master's degree programme she was allotted a field research experiment on**,** - "**Studies on banded leaf and sheath blight of finger millet caused by *Rhizoctonia solani* Kuhn.**" which was successfully conducted by her and being submitted in the form of this thesis.