Studies on Downy Mildew of Pearl Millet with Special Reference to its Management through Eco-friendly Approaches

THESIS

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Jawaharlal Nehru Krishi Vishwa Vidyalaya

Jabalpur (M. P.)

in partial fulfillment of the requirement for the degree of

MASTER OF SCIENCE

IN

AGRICULTURE

(PLANT PATHOLOGY)

By

RAHUL SHARMA

Department of Plant Pathology

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M. P.)

College of Agriculture, Gwalior (M. P.)

2004-2005

CERTIFICATE – I

This is to certify that the thesis entitled **"Studies on downy mildew of pearl millet with special reference to its management through eco-friendly approaches"** submitted in partial fulfilment of the requirement for the degree of **Master of Science in Agricuiture (Plant Pathology)** of **Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur** is a record of the bonafide research work carried out by **Mr. Rahul Sharma** under my guidance and supervision. The subject of the thesis has been approved by Student's Advisory Committee and the Director of Instruction.

No part of the thesis has been submitted for any degree or diploma (Certificate awarded etc.) or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigation has been duly acknowledged by him.

Place : Gwalior
Date : 24.03.2005

Dr. R.K. Pandya
Chairman
Advisory Committee

Thesis approved by the students advisory committee

Chairman	**[Dr. R.K. Pandya]**
Member	**[Dr. L.S. Kushwah]**
Member	**[Dr. A.K. Singh]**
Member	**[Dr. V.B. Singh]**

CERTIFICATE – II

This is to certify that the thesis entitled **"Studies on downy mildew of pearl millet with special reference to its management through eco-friendly approaches"** submitted by **Mr. Rahul Sharma** to the **J. N. Krishi Vishwa Vidyalaya, Jabalpur** in partial fulfilment of the requirement for the degree of **Master of Science in Agriculture (Plant Pathology)** in the **Department of Plant Pathology, College of Agriculture, Gwalior,** has been, after evaluation, approved by the External Examiner and by the Student's Advisory Committee after an oral examination of the same.

Place : Gwalior
Date : 6.5.2005

Dr. R.K. Pandya
Chairman
Advisory Committee

Members of the students advisory committee

Chairman [Dr. R.K. Pandya]

Head of the Department [Dr. L.S. Kushwah]

Director of Instruction [Dr. R.A. Khan]

Director of Instruction
J.N. Krishi Vishwa Vidyalaya
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Jabalpur (M.P.)

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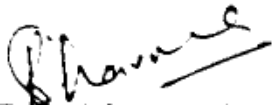
Place: Gwalior

Date:



(Rahul Sharma)

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INTRODUCTION

CHAPTER I

INTRODUCTION

Pearl millet *Pennisetum glaucum* (L.) R. Br. is the stable cereal crop best suited to the harsh climate of the seasonally hot, drought-prone, semi-arid regions of Africa and the Indian subcontinent. The most prominent pearl millet producing countries of the world are India, Pakistan, Nigeria, Sudan, Egypt, Arabia, Africa and Russia.

In India it is popularly known as 'Bajra' grown for grain and forage in the rainy season. The important pearl millet growing states of the country are Rajasthan, Gujarat, Maharashtra, Punjab, Uttar Pradesh, Tamil Nadu, Karnataka and Madhya Pradesh. In Madhya Pradesh during 2003-04 it was grown in an area of about 1.32 lakh hectares with the production of about 1.34 lakh tonnes (Anonymous 2004a). The important districts of Madhya Pradesh where pearl millet is grown are Morena, Bhind and Gwalior (Appendix-I).

More than one hundred diseases caused by fungi, bacteria, viruses and nematodes have been recorded (Pathak and Wanjekar 1980). But of these downy mildew caused by *Sclerospora graminicola* (Sacc.) Schroet. is the most wide spread and destructive disease of pearl millet in India and western Africa (Pathak and Wanjekar 1980). In India the disease was first recorded by Butler in 1907 and now it is a major limiting factor in the exploitation of the high yield potential of hybrids in the country.

Downy mildew has been recognized as a potentially important disease of pearl millet since early part of the 20th century. It attracted relatively little attention until the late 1950's since then a vast progress has been made in understanding the biology of the pathogen and its control. However the disease continues to be a major problem.

Though the disease can be managed with the foliar application of fungicides but it is uneconomical due to their high cost. Breeding for disease resistant varieties and management of the disease through botanicals are economic, eco-friendly and of wider application. On review of the literature it was observed that no work has been done so far on the management of the disease by the application of botanicals.

Plate : 1
Symptoms of downy mildew

Plate : 2
Green ear stage of the disease

Therefore, the present studies were carried out on the following lines:

1. Survey of pearl millet crop of Morena, Bhind and Gwalior districts to find out the incidence of downy mildew.
2. Symptomatology.
3. *In-vitro* evaluation of plant extracts against the pathogen.
4. Comparative efficacy of selective plant extracts, cow urine and butter milk for the control of the disease.
5. Effect of sowing dates on the incidence of downy mildew.
6. Screening of pearl millet germplasm against the disease.
7. Evaluation of promising hybrids/varieties against the disease.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Relevant literature of various works related to the present studies are briefly reviewed in this chapter.

Historical:

Downy mildew of pearl millet caused by *Sclerospora graminicola* was originally named as *Protomyces graminicola* by Saccardo in 1876 and subsequently Schroeter (1879) renamed it as *Sclerospora graminicola* from Germany. There are two distinct pathotypes of *S. graminicola*, one that attacks *Setaria* spp. and another that attacks pearl millet although they are morphologically the same (Williams, 1984). In India the earliest investigators on pearl millet downy mildew were carried out by Butler (1907) and Kulkarni (1918), but downy mildew did not become a serious problem in the national level until after the wide spread cultivation of hybrids in India during the late 1960s. The first severe major epidemic occurred in 1971 (Safeeulla, 1976 and Singh *et al.*, 1987).

Survey:

Suryanarayana (1962) observed the severe occurrence of downy mildew in Punjab, Rajasthan and Delhi and recorded 5-10 per cent damage in the pearl millet crop due to the disease.

Mathur and Dalela (1971) conducted an extensive survey of the prevalence of the disease on the pearl millet crop in the state of Rajasthan during 1962-1964 and found a range of 0-27 per cent. They also assessed the monetary loss, as worth Rs 20 million every year in Rajasthan state only.

Forty seven pearl millet fields of Morena, Shivpuri and Gwalior and 24 fields of Morena and Gwalior district were surveyed in the year 2002-2003 and 2003-04 to assess the incidence of downy mildew. All the surveyed fields were absolutely free from the disease (Anonymous, 2003-04).

Rao *et al.* (2002) conducted a field survey to monitor downy mildew (*Sclerospora graminicola*) incidence on 21 pearl millet (*Pennisetum glaucum*) hybrids in 38 fields in Gujarat in the rainy season of 2001. Downy mildew incidence was recorded in 2 m^2 subplots as the ratio of diseased to total plants at the soft-dough to hard-dough growth stage. Some seed lots were

treated with metalaxyl. Disease incidence varied with location and was very variable with 1-86% in Kheda). Of the 15 hybrid cultivars from private seed companies, seven were free from downy mildew (Amul, MRB 2210, Nandi 3, PAC 931, Proagro 7501, 9330 and Vikram, 51) and eight had mean incidences from 9 to 55%. Of the six public-sector hybrids, only GHB 235 was free from disease. the remaining five had mean incidences from 2-68%. The cropping sequence pearl millet-cowpea-maize-pearl millet reduced downy mildew incidence more than other combinations (10% downy milder incidence).

Symptomatology:

Butler (1907) was first to describe the symptoms of downy mildew of bajra in India. Ramakrishnan (1963) describe the symptoms of the disease in details which are as follows:

The symptoms of infection can be recognized even in young plants. The leaves lose their green colour and become wholly or partly yellow or whitish, later formed leaves are paler than the earlier ones. The discolouration is often evident as broad streaks extending from the base, to varying lengths or upto the tip. Such leaves turn brown prematurely. In older plants also yellowing and withering of the leaves are visible in the main shoot tillers and lateral branches. Very often some of the lateral shoots are short with reduced, distored and crinkled leaves. These turn brown quickly and tend to split into shreds at the tip. The transformation of ear, wholly or partly into a green head of small, twisted, leaf like structures is very characteristic, hence the name ' green ear' some times fertile grains may be formed in part of the ear but more often the whole ear is affected. The bristles subtending the spikelets and all its parts the glumes, palea, stamens and pistil are converted into leaf like structures. As a result of these changes, the ears appear green and the diseased plants could be easily picked out. Under humid conditions the leaves are covered by a downy white growth of the fungus. This is prominent on the lower surface. All the affected leaves and ears turn brown prematurely.

Dang (1981) reported that the downy mildew pathogen showed a great range of variability in symptoms expression due to the presence of high level of inoculum in the soil of established sick plot. Over wintered oospores induced higher downy mildew incidence than the oospores stored in laboratory conditions.

Singh and King (1988) observed that systemic symptoms generally appear on the second leaf, and once these appear, all the subsequent leaves and penicles also develop symptoms except in cases of recovery resistance where plants out grow the disease. Zoosporic inoculation of *S. graminicola* on different developmental stages of the inflorscence of *P. americanum*, resulted in malformation of floral organs that were not fully differentiated at the time of infection. "Green ear" symptoms resulting from hyperplasia and hypertrophy of the host tissues were accompanied by both sexual and asexual sporulation of the fungus on the malformed plant parts. No grain set occurred in affected florets indicating that secondary inoculum was able to cause yield reduction, even stigma led to rapid dissolution and necrosis of tissue and prevented colonization by the pathogen (Semisi and and Ball, 1989).

Gaur *et al.* (1990) reported that seeds from ear heads infected by *S. graminicola* loose their lusture and develop a violet tinge due to toxin production. Post infection differences between susceptible and resistant lines were quantitative rather than qualitative and specific (Thakur and Murty, 1992).

Effect of sowing dates:

Srivastava (2003) planted pearl millet susceptible cultivar HB_3 in four different dates (13 June 2001-24 July 2001) and observed that the incidence of downy mildew increased with the advancement of sowing dates from 23rd June to 13th July 2001 and there after it decreased.

Chahal *et al.* (1978) observed that early sowing with the onset of monsoon upto July first week reduced downy mildew incidence as compared to late sown crop.

Screening:

Singh *et al.* (1981) devised a screening strategy and implemented it for the identification of suitable resistance to downy mildew. Pearl millet germplasm and breeding materials were initially screened for downy mildew resistance at ICRISAT, Patencheru, using an efficient field screening technique. The promising materials were then exposed to variable population of pathogen at downy mildew "Hot spot" location in India and West Africa, through a cooperative multilocational testing programme. Several entries have

been consistent in five years of test. All these entries originated programmes in India and Africa. Other entries have been identified with distinct differential reactions among locations that were consistent over years.

Williams *et al.* (1981) developed an effective large scale field screening technique in pearl millet. The technique based on pre planted infector rows that provide sporangial inoculum has been successfully used to identify and improve downy mildew resistance of the technique are reliability uniformity of inoculum distribution flexibility in location and size of screening plots effectiveness through out the year (including the dry winter and post rainy season) and independence to rainfall.

Murthy *et al.* (1983) screened 318 entries of *Pennisetum americanum* against *S. graminicola* in the disease sick plot and found that 65 entries remained free from the downy mildew while HB_2 and Tift 23D 2B exhibited 86.9 per cent and 91.7 per cent infection respectively. Among the infection free entries eight are pollinated and five are male lines.

Chahal *et al.* (1987) tested 83 agronomically superior lines of *P. americanum* in the downy mildew sick plot over 5 years during rainy season. 45 showed a high level of resistance 29 were moderately resistant and 9 moderately susceptible.

Singh (1990) evaluated 3163 germplasm accessions from many pearl millet (*P. glaucum*) growing countries for resistance to downy mildew. The highest frequencies of downy mildew resistant source was detached in accession from the West Africa followed by East Africa. Forty eight selections from 37 early to medium maturity accessions showed high level of downy mildew resistance.

Rattunde and King (1993) developed a green house seedling screening technique at ICRISAT to improve efficiency of breeding for downy mildew resistance potted plants (about 50 per pot) at the coleoptyle stage to one leaf stage were spray inoculated with an aqueous suspension of sporangia incubated overnight at 20° C and >95 per cent relative humidity and returned to green house benches. After two weeks downy mildew reaction was determined based on the frequency of plants with systemic symptoms.

Govila (1994) at I.A.R.I., New Delhi initiated a major programme to incorporate downy mildew resistance into J-104 and MS 5141. A using donors P-7 and 700651. then developed a wide range of downy mildew resistant lines of MS 5141 A and J-104. Field tests and glass house screening technique were used while developing the material.

Yadav *et al.* (2001) recorded significantly higher thickness of cuticle and epidermis in the leaves of resistant cultivars, however the highly resistant cultivar had a significantly lower stomatal index and higher epicuticular wax content when compared with the highly susceptible cultivar. These anatomical characteristics seem to provide a greater degree of defence against penetration and invasion by *S graminicola* in the highly resistant cultivar.

Shivkumar *et al.* (2003) tested eight cultivars viz., IP18292, IP18294, P-310-17, MBH 110, 5141B, 81B, 23 B and HB_3 against downy mildew pathogen under green house condition IP18292 and IP18294 were categorized as highly resistant P310-17 and MBH 110 as resistant 5141B and 81B as susceptible and 23 B and HB_3 as highly susceptible.

Botanicals:

Botanicals are gaining importance in crop protection in view of their selective properties, low cost and safety to ecosystem. Many botanicals have been identified to be effective in the control of plant diseases. Among the 5280 species tested, 1134, 346, 92 plant species possessed insecticidal, fungicidal, bactericidal antiviral properties respectively (Ahmed and Grainage, 1982).

Jagnnathan and Narasimhan (1988) reported among 66-products extracts screened under *in vitro* a synthetic product from garlic oil, neem oil, neem leaf, parthenium leaf, turmeric rhizomes and garlic bulb extracts were effective in inhibiting the spore germination and mycelial growth of the two pathogens (*Helminthosporium nodulasum* and *Pyricularia orizea*) isolated from finger millet.

Kumar *et al.* (1989) reported that the aqueous extracts of different parts of the plants were tested against four plants pathogenic fungi viz; *Drechslera restrata*, *Fusarium oxysporum*, *Alternaria alternata* and *Corynespora cassicola*, *Allium cepa*, *Allium sativum*, *Parthenium historophorus*, *Gossypium arboreum* and *Phaseolus autropurpures* were

responsible for complete inhibition of spore germination while the rest either stimulated the spore germination or caused partial inhibition of spore germination.

Meena and Mariappan (1993) studied the *in vitro* leaf extract of *Azadirachta indica*, *Mentha arvonsis*, *Aegle mormelos*, *Catharanthus roseus*, *Lantana camara*, *Pongamia pinnata*, *Vitex negundo* and *Nerium odorum (Nerium olender)* and flower extracts of *Catharanthus roseus* inhibited mycelial growth and spore germination of the seed borne mycoflora of sorghum including *Alternaria tenius* (*A. alternata*) *Aspergillus flavus*, *Curvularia lunata*, *Fusarium moniliforme (Gibbrella fusikuroi)* and *Rhizophus stolonifer*. The neem extracts and those of *C. roseus* and *L. camera* were more effective than the other plant extracts tested.

Dohroo and Gupta (1995) reported that Azadirachtain and other limoids were quite effective in the control of plant diseases of diverse nature. The addition of neem cake in soil reduced incidence of damping off, wilt, blight and rot of cotton, soybean, coconut, ginger etc. The neem oil has fungicidal properties that had inhibitory effect to sclerotia of *Sclerotium*, *Rhizoctonia* and *Sclerotinia* the extract of neem was found most potent in reducing virus infectivity and nematode population.

Shivpuri et al. (1997) also reported fungitoxic effect of plant extracts from 10 plants species (*Allium cepa*, *Allium sativum*, *Azadirachta indica*, *Calotropis procera*, *Datura stramonium*, *Ocimum sanctum*, *Polyalthia longifolia*, *Tagetus erecta*, *Vinca rosea* and *Withonia somifera* against five pathogenic fungi viz. *A. brassicola*, *Colletotricum capsici*, *Fusarium oxysporum*, *Rhizoctonia solani* and *Sclerotinia sclerotiorum*, when tested under laboratory condition at two concentrations. Higher dose of few plant extracts was relatively more effective.

Gupta and Singh (1999) reported the influence of soil pH, soil bulk density, soil moisture content and addition of farm yard manure and nitrogen fixing bacteria on downy mildew incidence. The addition of *Rhizobium*, *Azospirillum* or *Azotobacter* inocula as combined seed and soil treatment also reduced disease with the best effects being from a cluster bean (*Cyamopsis tetragonoloba*) isolate of *Rhizobium* and from *Azotobacter chroococcum*.

MATERIAL AND METHODS

CHAPTER III
MATERIAL AND METHODS

Experimental Site:

The present studies were conducted in the Department of Plant Pathology and Research Farm of J.N.K.V.V. Campus, College of Agriculture, Gwalior during kharif season of 2004-05. Gwalior is situated in northern part of Madhya Pradesh at an elevation of 211.52 meters from mean sea level and lies between altitude and longitude 26°14' North and 78°15' East, respectively.

1. **Climate:**

   The climate of Gwalior is subtropical. The rainy season normally starts from middle of June after commencement of south-west monsoon and last up to September. Maximum precipitation of rains occurred in the month of July and August. Winter season runs from November to mid February and hot summer season from April to mid June. October is the transitory month between rainy and winter season.

2. **Soil:**

   The soil of experimental site was alluvial clay loam texture and pH of 7.8. The available nitrogen, phosphorus and potassium were low, medium low to medium, respectively. The water holding capacity of soils is also medium.

Preparation of downy mildew sick plot:

A large quantity of infected leaves malformed shoots and proliferated ears from downy mildew infected local susceptible and 7042S pearl millet plants were collected at the time of harvest of previous crop and were sun dried. These were then chopped into small bits and were grind in the mixture to make it in the powder from thereafter the powder was stored in the air tight container. Before the onset of first shower the powder was examined microscopically to make sure that it contained oospores. In general it was found that minimum 7-15 oospores were seen under low power. After this inoculum (powdered debris containing oospores) was uniformly mixed with the experimental soil at the time of field preparation.

Planting of infector rows:

Downy mildew susceptible cultivar "local susceptible" was used as infector rows (Inoculum doner) with a view to develop maximum disease pressure. These rows were planted three weeks earlier than the test rows.

The infector rows were sown at every ninth row through out the entire length of the experimental field. The field was also surrounded by the infector rows. The test material of the respective trial was sown about three weeks after the sowing of infector rows. The indicator rows (local susceptible and 7042S) were also planted along with the test rows to assess the level of disease pressure.

Collection of Meteorological data:

Data pertaining to average minimum-maximum temperature, relative humidity, number of rainy days and rainfall during the crop period was taken from the meteorological observatory of Research Farm, College of Agriculture, Gwalior and presented in the Appendix-II.

Survey:

Survey of downy mildew disease of pearl millet was carried out on farmers fields of Morena, Bhind and Gwalior during kharif season of 2004-05, Eight villages from Morena (Chhatar Ka Pura, Bhajpura, Dimni, Badagaon, Jigni, Mudiakheda, Morenagaon and Bagchini), eight from Bhind (Birkhadi, Manpura, Akhoda, Barakala, Soni, Siloli, Banthari and Mehadwa) and eight from Gwalior (Mohanpur, Sonsa, Utila, Bhogiram Ka Pura, Mahrajpura, Barai, Bhadroli and Nagor) were randomly selected and from each three fields were randomly selected. From each field four 1 m^2 patches were randomly selected. The downy mildew incidence on the plants of selected patches was recorded with the help of following formula:

$$\text{Downy mildew incidence (\%)} = \frac{\text{Downy mildew infected plants}}{\text{Total number of plants}} \times 100$$

The village wise incidence of downy mildew was worked out by calculating the mean of three fields of respective village. District wise incidence of downy mildew was worked out by calculating the average of eight villages of respective districts.

In-vitro evaluation of plant extracts against the pathogens:

The fresh leaves of six botanicals viz., *Eucalyptus* leaf extract, *Neem*, *Datura*, *Calotropis*, *Parthenium* and *Lantana were* collected, washed and dried in an oven at 60° C. The respective dried botanicals were grind by the mixer to make them into the powdered form and were stored in the plastic bottles. These botanicals in the form of powder were evaluated against *Sclerospora graminicola* @ 10 and 20% by adopting detached leaf technique, apart from leaf extract the Neem and Eucalyptus were also evaluated in the form of oil at the concentration of 1% against the pathogen.

The fresh healthy leaves of downy mildew susceptible cultivar HB_3 were brought from the experimental field for the evaluation of botanicals. The leaves were cut into two pieces. So that it can easily be kept in the polythene bags. These leaves were surface sterilized by dipping them into 0.1% solution of $HgCl_2$ for one minute then these leaves were washed thrice by passing them in three beakers containing sterilized distilled water to remove the effect of $HgCl_2$. These leaves were kept in between the blotting paper to remove the free moisture present on the leaf surface. These detached leaves were dipped in the sporangial suspension of *Sclerospora graminicola* and than these were sprayed by the desired concentration of respective botanicals. For individual treatment fifteen cut leaves were used and were placed in three polythene bags (four leaves in each bag) to make three replication. The polythene bags containing the inoculated leaves were marked by the marker, stappled and were kept in the incubator at 25° C for 24 hours and thereafter the leaves were brought out from the polythene bags and kept at room temperature. After three days of inculation the observations were recorded by measuring the per cent area covered by the fungal growth.

Evaluation of botanicals, cow urine and butter milk against the disease:

Three botanicals viz., *Eucalyptus* leaf extract, *Datura* leaf extract, and *Neem* leaf extract were found effective against *Sclerospora graminicola* under detached leaf technique were further evaluated in the pots along with cow urine, butter milk, oil cakes and recommended fungicides with a view to generate an effective, economical and eco-friendly alternate of chemical for the management of downy mildew.

The details of the experiment are as follows:

Cultivar	:	HB_3
Design	:	R.B.D.
Treatment	:	11
		T_1 : Eucalyptus @ 10%
		T_2 : Neem leaf extract @ 10%
		T_3 : Datura leaf extract @ 10%
		T_4 : Cow urine @ 3%
		T_5 : Cow urine @ 5%
		T_6 : Butter milk @ 5%
		T_7 : Mustard cake @ 5%
		T_8 : Linseed cake @ 5%
		T_9 : Seed dressing with Metalaxyl @ 6 g/kg seed
		T_{10} : Seed dressing with Metalaxyl @ 6 g/kg followed by spray of mancozeb @ 0.2%
		T_{11} : Control
Replication	:	3
Number of plants per p ot	:	4

Procedure:

Soil collected form the field was sterilized in the autoclave at the pressure of 15 pond per square inch for 15 minutes. ¾ height of the pot was filled with the sterilized soil. The extract of oil cakes was prepared by soaking the 5 gm of respective cake in 100 ml of water (5%) for 24 hours after this the extracts were incorporated into the respective pot. Leaf extract were used at the concentrations of 10% for this 10 gm powder of respective botanicals was poured in 100 ml of water and left for 24 hours and thereafter the extract of

Plate : 3
Experimental field view

Plate : 4
View of pot screening trial

the botanicals was incorporated in to the soil. Cow urine was incorporated into the soil at the concentrations of 3% and 5%. Seven days old butter milk was used at the concentrations of 5% and the same was also incorporated into the soil apart from above seeds of pearl millet susceptible hybrids "HB_3" were also treated with recommended fungicide Metalaxyl (Apron SD 35) for their comparison with non chemicals. The seeds downy mildew susceptible hybrid treated with oosporic powder of *Sclerospora graminicola* and 15 seeds were placed in each plot the oosporic treatment was common for all the treatment. After emergence the seedlings were thinned and only four seedlings were left in each pot. The foliar application of botanicals, oil cakes extracts, cow urine, butter milk and mancozeb @ 0.2% was done at 20, 35 and 50 days after sowing. The concentration of botanicals, cow urine, butter milk and oil cake extract for foliar application was the same as it was used for the soil treatment. The downy mildew incidence was recorded at 30 and 65 days after sowing.

Effect of sowing dates:

Downy mildew susceptible cultivar HB_3 was sown under five different dates in the downy mildew sick field. The details of the experiment are as follows:

Treatment (Sowing dates)	:	5 D_1: 9.7.2004 D_2: 20.7.2004 D_3: 2.8.2004 D_4: 14.8.2004 D_5: 24.8.2004
Design	:	R.B.D.
Replication	:	4
Plot size	:	2m × 2m
Fertilizer	:	60 kg N, 40 kg P_2O_5/ha
Spacing (row to row)	:	50 cm

Screening of pearl millet germplasm:

Identification of disease resistant lines and their utilization is resistance breeding program is the most effective method for the management of the disease. Therefore pearl millet germplasm consisting of 188 lines were

evaluated against downy mildew in the downy mildew sick soil by adopting a field screening technique which was developed by Williams *et al.* (1981).

The observations on total number of plants and plant affected by downy mildew were recorded at 30 days and 65 days (dough stage) after sowing. The percentage of diseased plants was then calculated

Details of the experiment are as follows

Experimental details:

Entries	188
Design	R B D
Replication	2
Row length	5m
Spacing	50×10 cm
Fertilizer	60 kg N, 40 kg P_2O_5/ha
Date of sowing	2nd Aug 04
Thinning	16 8 2004
Interculture (hoeing)	29 8 2004
Weeding	23 8 2004 & 21 9 2004
Harvesting	26 10 2004

Evaluation of promising hybrids/varieties:

Many hybrids released in past succumbed to downy mildew therefore screening of released pre related and locally cultivated hybrids/varieties was done during kharif 2004. Forty hybrids/varieties were screened by adopting a field screening technique which were develop by Williams *et al.* (1961).

The details of the experiment was as follows

Entries	40
Replication	2
Plot size	5m length single row
Spacing	10 cm (plant to plant)
Fertilizer	60 kg N, 40 kg P_2O_5/ha
Irrigation	2
Weeding	23 8 2004 21 9 2004
Thining	15 8 2004
Harvesting	26 10 2004

Statistical Analysis:

The per cent downy mildew incidence was transformed using angular transform values as per method suggested by Fisher (1935) then these transformed values were statistically analysed

Plate : 5
Evaluation of promising hybrids/varieties

Plate : 6
View of germplasm trial

EXPERIMENTAL FINDINGS

CHAPTER IV

EXPERIMENTAL FINDINGS

Survey:

A total of 24 villages of Morena, Bhind and Gwalior district (eight villages from each district) were surveyed to assess the incidence of downy mildew in these major pearl millet growing districts of the state. The data summarized in the Table 4.1 shows that three villages of Morena (Bhojpura, Badagaon and Bagchini), one of Bhind (Birkhadi) and three of Gwalior (Sonsa, Utila, Maharajpura) were free from downy mildew. The maximum incidence of downy mildew was recorded in Manpura of Bhind district (8.23%) followed by Mohanpur (5.9%) of Gwalior district. In Morena district the maximum incidence of downy mildew was recorded in Jigni (2.2%) followed by Mudiakheda (1.9%), Chhatar Ka Pura (1.7%), Morena gaon (1.53%) and Dimni (0.83%). In Bhind district the maximum disease incidence was recorded in Manpura (8.23%) followed by Banthari (5.03%), Soni (4.36%), Akhoda (2.9%), Siloli (1.1%), Barakala (0.86%) and Mehdwa (0.4%). In Gwalior district, the maximum incidence was recorded in Mohanpur (5.9%) followed by Barai (4.67%), Bhadroli (3.74%), Nagor (0.8%) and Bhogiram Ka Pura (0.43%). It is also clear from the above table that the maximum incidence of downy mildew was recorded in Bhind district (2.86%) followed by Gwalior (1.94%) and the minimum incidence (1.02%) was recorded in Morena district (Fig. 1).

Table 4.1: Downy mildew incidence on pearl millet crop of Morena, Bhind and Gwalior during kharif 2004-05.

	Downy mildew (%)			Mean
District- Morena				
Chhatar Ka Pura	0.0	1.0	4.1	1.7
Bhajpura	0.0	0.0	0.0	0.0
Dimni	2.5	0.0	0.0	0.83
Badagaon	0.0	0.0	0.0	0.0
Jigni	4.5	2.1	0.0	2.2
Mudiakheda	4.8	0.0	0.9	1.9
Morenagaon	0.0	0.0	4.6	1.53
Bagchini	0.0	0.0	0.0	0.0
Mean				**1.02**

Fig. 1: Districts wise mean incidence of downy mildew in Morena, Bhind and Gwalior

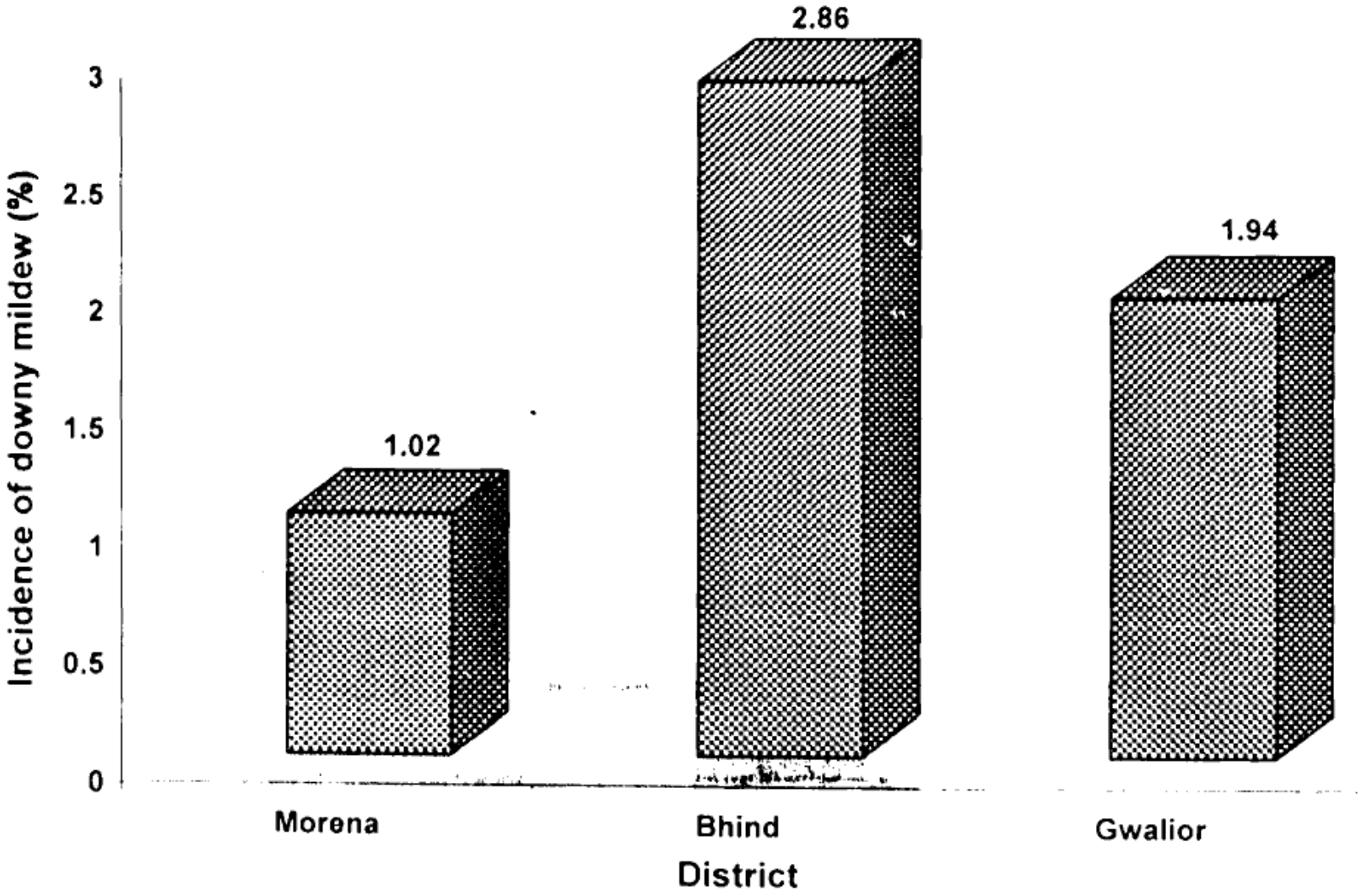


Plate : 7

Green ear on farmer field

District- Bhind				
Birkhadi	0.0	0.0	0.0	0.0
Manpura	5.2	19.5	0.0	8.23
Akhoda	0.0	4.8	3.9	2.9
Barakala	2.1	0.0	0.5	0.86
Soni	9.6	0.0	3.5	4.36
Siloli	0.0	1.5	1.8	1.1
Banthari	7.8	1.9	5.4	5.03
Mehadwa	1.2	0.0	0.0	0.4
Mean				**2.86**
District- Gwalior				
Mohanpur	16.4	1.3	0.0	5.90
Sonsa	0.0	0.0	0.0	0.00
Utila	0.0	0.0	0.0	0.00
Bhogiram Ka Pura	0.0	1.3	0.0	0.43
Mahrajpura	0.0	0.0	0.0	0.00
Barai	0.0	12.4	1.6	4.67
Bhadroli	8.2	0.0	3.0	3.74
Nagor	1.8	0.6	0.0	0.80
Mean				**1.94**

Symptomatology:

The first symptom of the disease was observed in eleven days old seedlings of pearl millet susceptible hybrid "7042S". The leaf symptoms initiated as chlorotic streaks which started from the base of leaf *lamina* of the upper surface gradually progresses towards the tip (Plate 8). The corresponding lower surfase of the leaf showed whitish, cottony growth (Plate 9). Later on the chlorotic leaves turned yellowish brown. Finally redish brown and split of vertically from the tip (Plate 10). Infected plants remain stunted with profused tillering (Plate 11). In older plants whitening and curling of younger leaves (Plate 12) and sometimes twisting of newly emerging leaves was also observed (Plate 13). Transformation of earheads into different types of leafy and/or needle like structures were commonly observed (Plate 14). In some cases instead of forming normal or green ear the stunted plant also produces a bunch of chlorotic leafy structure (Plate 15). At the maturity stage of the crop the infected splited brown leaves and malformed earheads contain oospores which serve as the source of primary infection for the next year crop.

Plate : 8

Chlorotic streaks starting from the base of the upper surface of infected leaf

Plate : 9

Whitish cottony growth on the lower surface of leaf

Plate : 10
Browning and spliting of infected leaves

Plate : 11
Stunted plant with profused tillering

Plate : 12
Whitening & curling of emerging leaf

Plate : 13
Twisting of newly emerging leaf

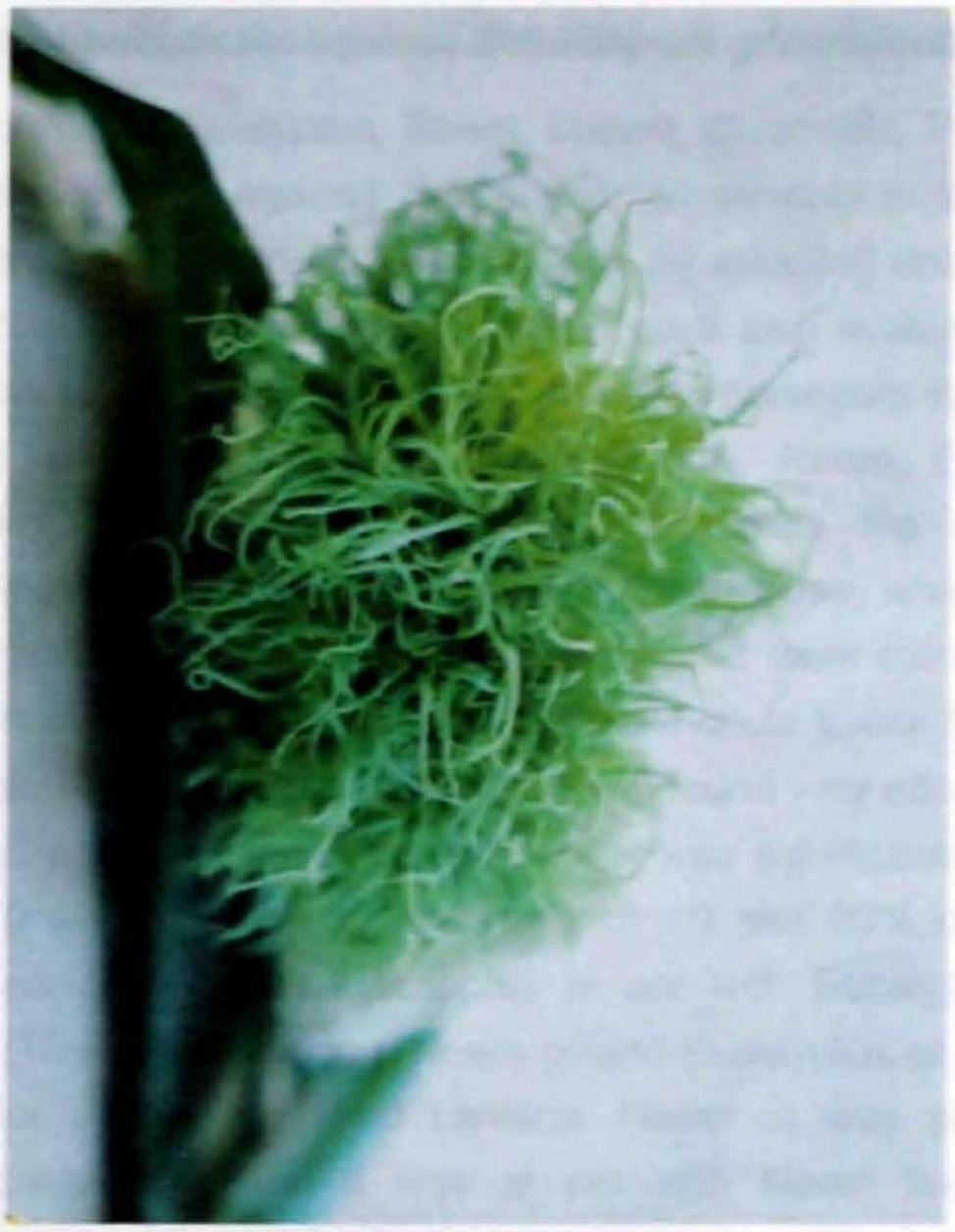


Plate : 14 (a)

Transformation of ear head into leafy and/or needle like structure

Plate : 14 (b)

Transformation of ear head into leafy and/or needle like structure

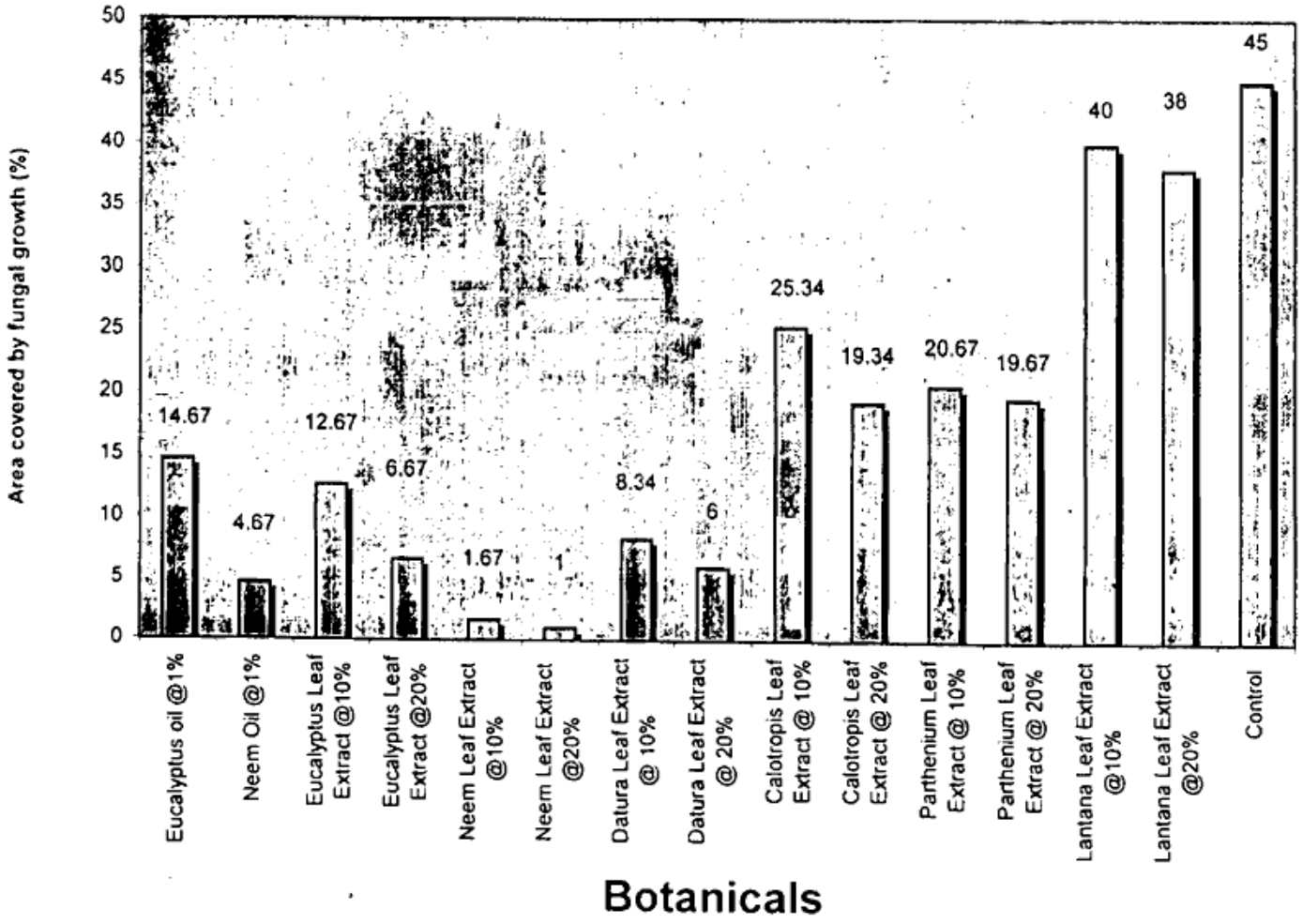
***In-vitro* evaluation of botanicals against *Sclerospora graminicola*:**

Six botanicals viz., *Eucalyptus, Neem, Datura, Calotropis, Parthenium,* and *Lantana* were evaluated against *Sclerospora graminicola* in the form of leaf extracts at the concentration of 10% and 20% by adopting detached leaf technique, apart from this Neem and Eucalyptus were also evaluated in the form of oil extract at the concentration of 1%. The data presented in the Table 4.2 indicates that leaf extracts of five botanicals viz., Neem, Eucalyptus, Datura, Parthenium and Calotropis significantly checked the growth of *Sclerospora graminicola* under both the tested concentrations, while Lantana was statistically at par with control. The above botanicals were more effective under higher concentration (Fig. 2) but none of them could check the growth absolutely. However, Neem leaf extract @ 10% was found very effective (only 1.7% leaf area was covered by the growth) and it was significantly superior over Calotropis (10 and 20% conc.), Parthenium (10 and 20% conc.) and Eucalyptus (10% conc.) but was statistically at par with Eucalyptus (20% conc.) and Datura (10 and 20% conc.). Neem oil and Eucalyptus oil were also significantly superior over control and Lantana. Neem oil was significantly superior over Eucalyptus oil but it was at par with Neem leaf extract, Eucalyptus leaf extract and Datura leaf extract.

Table 4.2: *In-vitro* evaluation of botanicals against *Sclerospora graminicola* by adopting detached leaf technique.

S. No.	Botanicals	Conc. (%)	Area covered by fungal growth (%)			
			RI	RII	RIII	Mean
1.	Eucalyptus oil	1.0	16.0	18.0	10.0	14.67
2.	Neem oil	1.0	0.0	8.0	6.0	4.67
3.	Eucalyptus leaf extract	10.0	15.0	6.0	17.0	12.67
4.	Eucalyptus leaf extract	20.0	9.0	3.0	8.0	6.67
5.	Neem leaf extract	10.0	0.0	2.0	3.0	1.67
6.	Neem leaf extract	20.0	0.0	3.0	0.0	1.00
7.	Datura leaf extract	10.0	7.0	10.0	8.0	8.34
8.	Datura leaf extract	20.0	9.0	3.0	6.0	6.00
9.	Calotropis leaf extract	10.0	25.0	28.0	23.0	25.34
10.	Calotropis leaf extract	20.0	24.0	15.0	19.0	19.34
11.	Parthenium leaf extract	10.0	19.0	17.0	26.0	20.67
12.	Parthenium leaf extract	20.0	24.0	15.0	20.0	19.67
13.	Lantana leaf extract	10.0	37.0	39.0	44.0	40.00
14.	Lantana leaf extract	20.0	33.0	49.0	32.0	38.00
15.	Control		42.0	38.0	55.0	45.00
	S.E. (m)±					**2.840**
	C.D. (at 5%)					**8.22**

Fig-2: In-vitro evalution of botanicals against Sclerospora graminocola



Evaluation of selected botanicals cow urine and Butter milk against downy mildew of pearl millet:

It is evident from the Table 4.3 that Metalaxyl seed treatment @ 6 g/kg followed by three sprays of Mancozeb (0.2%) at 20, 35 and 50 days after sowing absolutely checked the incidence of downy mildew at 30 and 65 days after sowing and it was significantly superior over all other treatments at 65 days after sowing but at 30 days after sowing it was statistically at par with Metalaxyl seed treatment (T_9). Other than chemical treatment the Neem leaf extract @ 10% was found most effective and it was significantly superior over control at 30 and 65 days after sowing. Metalaxyl seed dressing was significantly superior over Neem leaf extract at 30 days after sowing but it was at par at 65 days after sowing. Except T_{10} (Metalaxyl seed treatment followed by foliar spray of Mancozeb) the minimum incidence of downy mildew at 65 days after sowing was recorded in Neem leaf extract and Metalaxyl seed treatment (41.67%) followed by cow urine @ 5% (50.00%), Cow urine @ 3% Datura leaf extract and mustard cake (66.67%), Eucalyptus leaf extract (75%) and Linseed cake (83.3%), while a maximum of 91.67% downy mildew incidence was recorded in control (Fig. 3). Cow urine at both the tested concentrations also significantly controlled the disease.

Table 4.3: Evaluation of botanicals, cow urine and butter milk against downy mildew of pearl millet.

S. No.	Botanicals	Conc.	Downy mildew incidence (%)	
			At 30 DAS	At 65 DAS
T_1	Eucalyptus leaf extract	10%	33.34 (35.00)	75.00 (65.00)
T_2	Neem leaf extract	10%	25.00 (30.00)	41.67 (40.00)
T_3	Datura leaf extract	10%	41.67 (40.00)	58.34 (60.00)
T_4	Cow urine	3%	41.67 (40.00)	66.67 (50.00)
T_5	Cow urine	5%	33.34 (35.00)	50.00 (45.00)
T_6	Butter milk	5%	33.34 (35.00)	58.34 (55.00)
T_7	Mustard cake	5%	50.00 (45.00)	66.67 (55.00)
T_8	Linseed cake	5%	58.34 (50.00)	83.34 (70.00)
T_9	Seed dressing with Metalaxyl (Recommended practice)	6 g/kg	08.34 (10.00)	41.67 (40.00)
T_{10}	Seed dressing with Metalaxyl + Foliar spray of Mancozeb	6g/kg 0.2%	00.00 (00.00)	00.00 (00.00)
T_{11}	Control (Untreated)		58.34 (50.00)	91.67 (80.00)
	S.E. (m)±		**5.307**	**10.012**
	C.D. (at 5%)		**15.655**	**29.53**

Fig. 3: Evolution of botanicals, cow urine and buttermilk against downy mildew

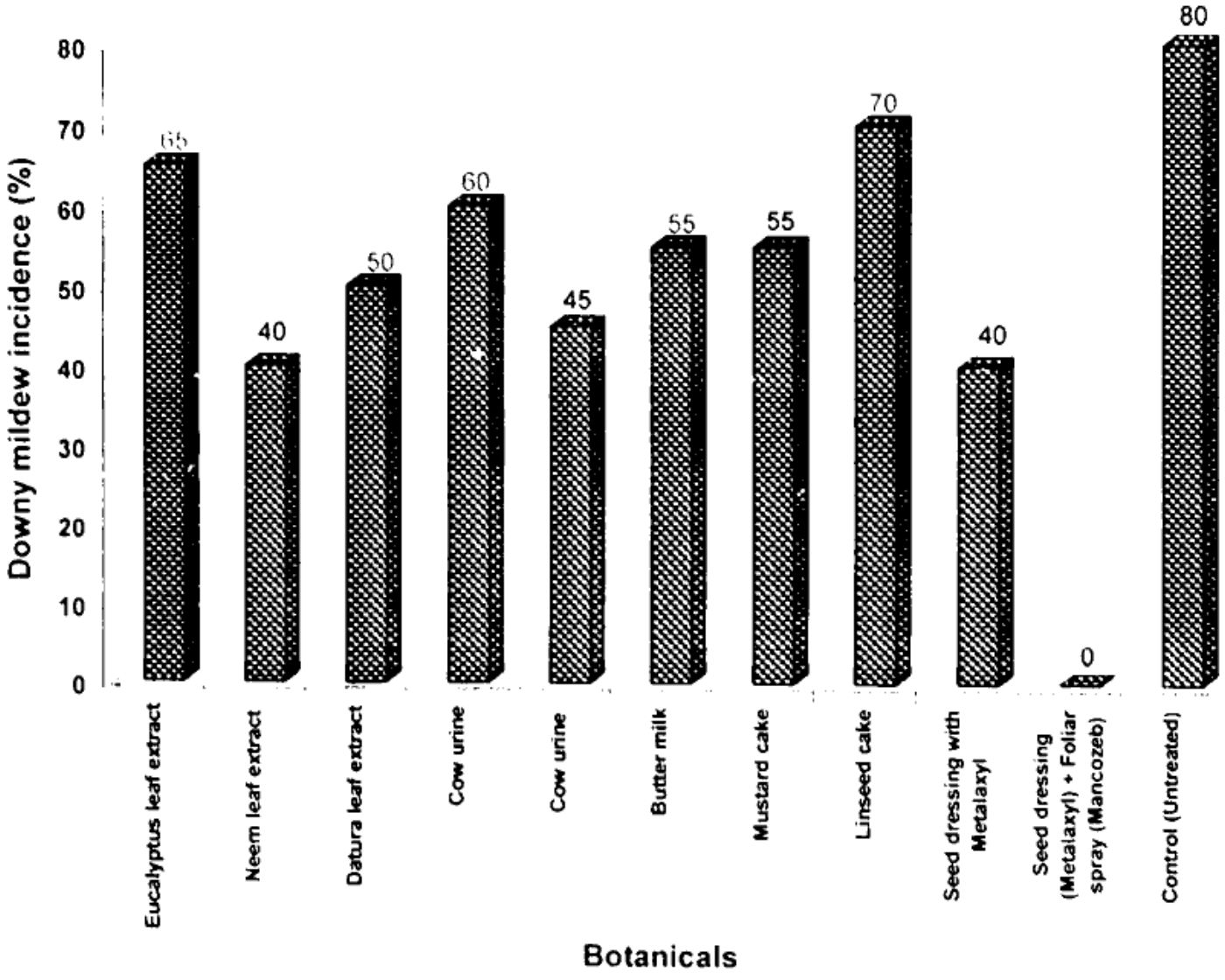


Plate : 15

Infected plant sowing a bunch of chlorotic leafy structure

Plate : 16

Green ear on the pot experiment

Effect of sowing dates:

Downy mildew susceptible pearl millet hybrid "HB_3" was planted in five different dates started from 9 July, 2004 to 24 August, 2004 to find out the influence of sowing dates on the incidence of downy mildew. The data presented in the Table 4 indicates that sowing dates plays a significant role on the incidence of downy mildew. At 30 days after sowing the minimum incidence of downy mildew (19.09%) was recorded in the crop sown on 9th July (D_1) followed by 27.30% in the crop sown on 20th July but there after it was increased sharply and significantly in third sowing date i.e. on 2nd August sown crop (54.21%) and thereafter on 14th August and 24th August sown crop. Its incidence was 38.78 per cent and 28.14 per cent which cleary indicates a gradual and significant decrease of disease incidence in later sown crop.

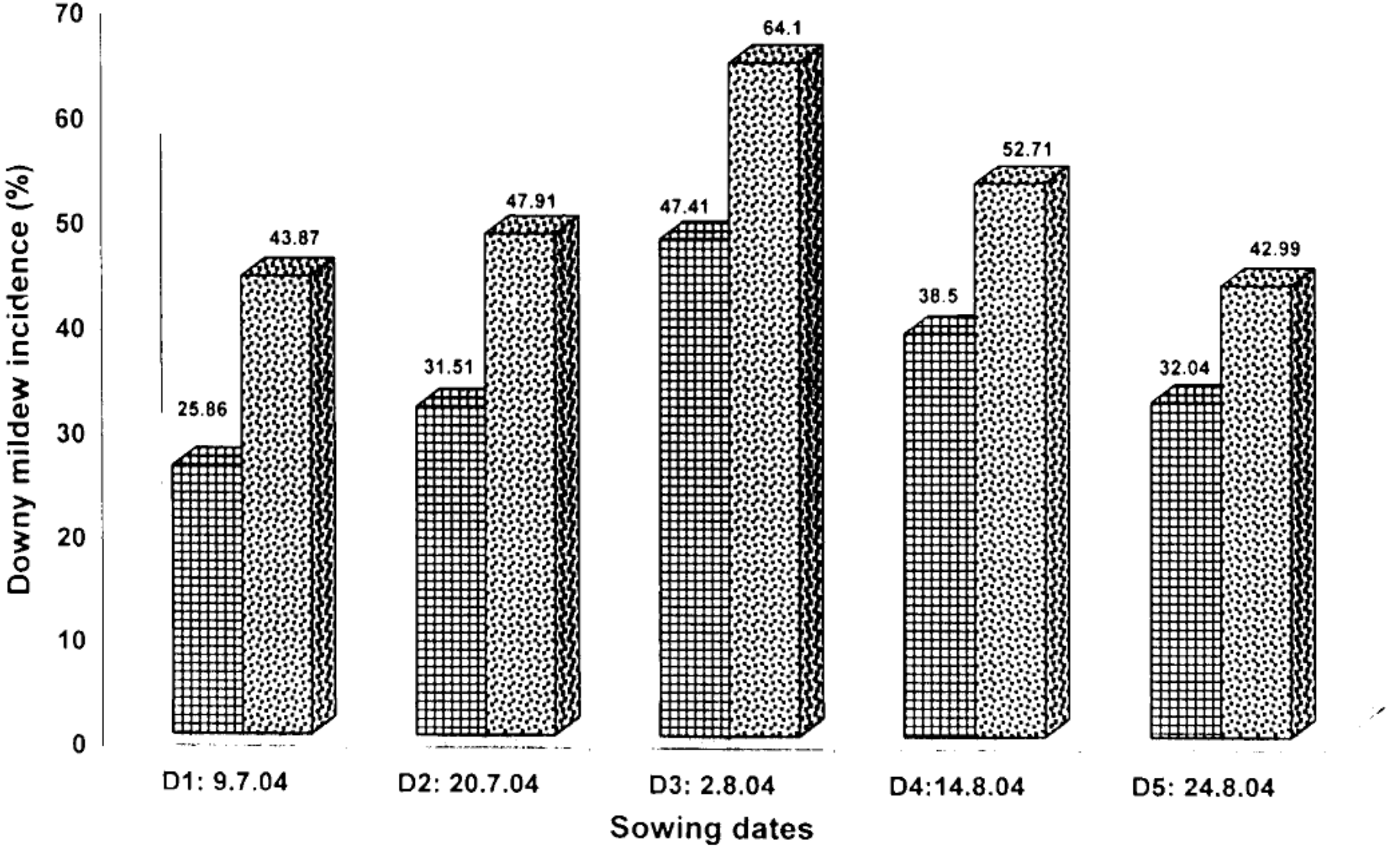
Similar trend of downy mildew incidence was also observed at 65 days after sowing. The maximum incidence (80.83%) was recorded in the crop sown on 2nd August followed by 63.26 in the crop sown of 14th August. The minimum incidence of the disease at 65 days after sowing (46.5%) was recorded in the crop sown on 24th August followed by 9th July sown crop (48.07%). These two dates were significantly at par which indicates less downy mildew under early and very late sown crop than the normal and late sown crop. Among the above five dates the incidence of downy mildew was significantly higher on 2nd August sown crop. The downy mildew incidence at 65 days after sowing was statistically at par with the crop sown on 9th July, 20th July and 24th August, 2004 (Fig. 4).

Table 4.4: Effect of sowing dates on the incidence of downy mildew of pearl millet.

S.No.	Treatment (sowing date)	Downy mildew incidence (%)	
		At 30 DAS	At 65 DAS
1.	D_1: 9 July, 2004	19.09	48.07
		(25.86)	(43.87)
2.	D_2: 20 July, 2004	27.30	54.65
		(31.51)	(47.93)
3.	D_3: 2 August, 2004	54.20	80.83
		(47.41)	(64.10)
4.	D_4: 14 August, 2004	38.78	63.26
		(38.50)	(52.71)
5.	D_5: 24 August, 2004	28.14	46.50
		(32.04)	(42.99)
	S.E. (m)±	**1.168**	**1.479**
	C.D. (at 5%)	**3.598**	**4.200**

- Data in parenthesis are angular transformed value on which statistical analysis is based
- Data are the mean of four replication

Fig. 4: Effect of sowing dates on the incidence of downy mildew



Screening of pearl millet germplasm against the downy mildew:

The data presented in Table 4.5 shows that total of 188 pearl millet lines were evaluated against downy mildew. Out of these 72 lines were free from the disease at 30 days after sowing but out of these lines, only 15 lines viz., IHT 110, IHT 119, IHT 145, IHT 151, HPT 712, IPT 406, IPT 411, IPT 420, IPT 423, IPT 424, PAT 211, PAT 230, PAT 242, PAT 251 and PAT 257 were free from downy mildew at 30 and 65 days after sowing while 79.14 and 98.39 per cent incidence was recorded in 7042S (check) at 30 and 65 days after sowing respectively. 20.6 and 31.75 per cent incidence was recorded in local susceptible at 30 and 65 days after sowing, respectively. All the tested lines were significantly superior over 7042S and local susceptible. More than 10 per cent downy mildew was recorded in two entries viz., PAT 201 (11.87%) and PAT 207 (10.85%) at 65 days after sowing, the other entries except 15 free lines showed <10% downy mildew.

Table 4.5: Screening of pearl millet germplasm against downy mildew.

S.No.	Entries	Downy mildew incidence (%)	
		At 30 DAS	At 65 DAS
1	IHT 101	3.24 (10.38)	4.75 (12.54)
2	IHT 102	1.78 (5.47)	7.73 (16.09)
3	IHT 103	1.93 (5.69)	8.01 (16.43)
4	IHT 104	0.00 (0.00)	3.44 (7.62)
5	IHT 105	5.42 (13.06)	9.67 (18.08)
6	IHT 106	3.85 (8.05)	6.34 (14.52)
7	IHT 107	2.70 (6.72)	5.33 (12.91)
8	IHT 108	0.00 (0.00)	2.56 (9.19)
9	IHT 109	0.00 (0.00)	1.47 (4.91)
10	IHT 110	0.00 (0.00)	0.00 (0.00)
11	IHT 111	2.50 (6.46)	3.75 (15.56)
12	IHT 112	1.21 (4.46)	2.53 (13.55)
13	IHT 113	0.00 (0.00)	4.44 (12.03)
14	IHT 114	1.56 (5.07)	3.23 (10.31)
15	IHT 115	3.89 (11.27)	3.89 (11.27)

16	IHT 116	2.70 (9.46)	2.7 (9.46)
17	IHT 117	3.78 (11.11)	7.56 (15.75)
18	IHT 118	6.38 (14.6)	7.69 (10.11)
19	IHT 119	0.00 (0.00)	0.00 (0.00)
20	IHT 120	1.72 (5.39)	6.47 (14.65)
21	IHT 121	0.00 (0.00)	1.72 (5.39)
22	IHT 122	2.86 (9.72)	5.57 (13.21)
23	IHT 123	1.42 (4.91)	3.99 (11.43)
24	IHT 124	1.52 (4.99)	4.50 (12.05)
25	IHT 125	2.95 (9.89)	7.46 (15.77)
26	IHT 126	1.25 (4.5)	5.63 (13.73)
27	IHT 127	0.00 (0.00)	6.85 (15.12)
28	IHT 128	2.38 (6.33)	8.81 (16.34)
29	IHT 129	6.67 (14.35)	9.92 (18.15)
30	IHT 130	0.00 (0.00)	4.36 (11.89)
31	IHT 131	0.00 (0.00)	3.6 (10.9)
32	IHT 132	1.39 (4.82)	2.78 (6.84)
33	IHT 133	3.89 (11.21)	5.13 (13.12)
34	IHT 134	2.53 (9.19)	7.56 (15.76)
35	IHT 135	1.22 (4.45)	3.86 (11.3)
36	IHT 136	1.78 (5.47)	4.48 (12.19)
37	IHT 137	1.22 (4.45)	1.22 (4.45)
38	IHT 138	1.22 (4.45)	2.44 (6.39)
39	IHT 139	1.39 (4.82)	1.39 (4.82)
40	IHT 140	2.67 (9.46)	3.95 (11.33)
41	IHT 141	1.73 (9.39)	8.85 (17.26)
42	IHT 142	0.00 (0.00)	4.89 (12.69)
43	IHT 143	3.57 (7.62)	4.17 (11.66)
44	IHT 144	0.00 (0.00)	0.00 (0.00)
45	IHT 145	0.00 (0.00)	2.81 (9.62)

46	IHT 146	3.45 (7.62)	7.58 (15.76)
47	IHT 147	0.00 (0.00)	1.67 (5.24)
48	IHT 148	2.08 (5.92)	4.17 (8.37)
49	IHT 149	1.35 (4.73)	4.47 (12.00)
50	IHT 150	0.00 (0.00)	3.23 (10.31)
51	IHT 151	0.00 (0.00)	0.00 (0.00)
52	IHT 152	1.67 (5.24)	3.45 (10.72)
53	IHT 153	1.25 (4.55)	1.25 (4.55)
54	IHT 154	0.00 (0.00)	3.85 (8.05)
55	IHT 155	0.00 (0.00)	2.89 (9.79)
56	IHT 156	1.31 (4.64)	1.31 (4.64)
57	IHT 157	1.39 (4.82)	4.45 (12.05)
58	IHT 158	1.73 (5.39)	3.34 (10.54)
59	IHT 159	1.32 (4.64)	4.64 (12.14)
60	IHT 160	1.78 (5.47)	1.78 (5.47)
61	IHT 161	0.00 (0.00)	2.17 (5.98)
62	IHT 162	2.00 (5.77)	2.00 (5.77)
63	IHT 163	0.00 (0.00)	1.93 (5.69)
64	IHT 164	0.00 (0.00)	1.35 (4.73)
65	IHT 165	2.87 (9.71)	7.32 (15.58)
66	IHT 166	3.13 (10.23)	3.13 (10.23)
67	IHT 167	0.00 (0.00)	1.32 (4.64)
68	IHT 168	0.00 (0.00)	5.53 (9.54)
69	IHT 169	1.73 (5.32)	3.45 (7.62)
70	IHT 170	0.00 (0.00)	2.27 (6.13)
71	IHT 171	0.00 (0.00)	1.52 (4.99)
72	IHT 172	1.93 (5.69)	3.39 (10.6)
73	IHT 173	0.00 (0.00)	5.62 (13.37)
74	IHT 174	0.00 (0.00)	4.35 (11.97)
75	IHT 175	2.86 (6.91)	2.86 (6.91)

76	IHT 176	1.32 (4.64)	2.56 (9.19)
77	HPT 701	0.00 (0.00)	2.93 (9.85)
78	HPT 702	0.00 (0.00)	4.16 (8.37)
79	HPT 703	2.00 (5.78)	3.56 (10.84)
80	HPT 704	0.00 (0.00)	1.32 (4.64)
81	HPT 705	2.79 (9.63)	5.36 (13.04)
82	HPT 706	1.32 (4.64)	2.56 (9.19)
83	HPT 707	0.00 (0.00)	3.70 (7.87)
84	HPT 708	0.00 (0.00)	7.02 (14.98)
85	HPT 709	1.25 (4.55)	3.89 (11.27)
86	HPT 710	1.43 (4.91)	2.85 (6.91)
87	HPT 711	0.00 (0.00)	5.21 (13.18)
88	HPT 712	0.00 (0.00)	0.00 (0.00)
89	HPT 713	1.52 (4.99)	3.03 (7.15)
90	HPT 714	1.62 (5.16)	3.23 (7.38)
91	HPT 715	0.00 (0.00)	1.79 (5.47)
92	HPT 716	0.00 (0.00)	5.54 (13.07)
93	HPT 717	5.00 (12.57)	7.58 (15.84)
94	HPT 718	5.00 (12.92)	5.0 (12.92)
95	HPT 719	0.00 (0.00)	2.64 (9.36)
96	IHT 177	0.00 (0.00)	3.3 (10.46)
97	IHT 178	8.02 (16.26)	9.27 (17.38)
98	IHT 179	1.19 (4.46)	4.13 (11.48)
99	IHT 180	1.38 (4.82)	1.38 (4.82)
100	IHT 181	0.00 (0.00)	1.35 (4.73)
101	IHT 182	5.02 (12.89)	5.02 (12.89)
102	IHT 183	3.98 (11.36)	5.3 (13.24)
103	IHT 184	0.00 (0.00)	1.39 (4.82)
104	IHT 185	0.00 (0.00)	2.78 (6.84)
105	IPT 401	0.00 (0.00)	2.82 (9.72)

106	IPT 402	1.78 (5.47)	3.26 (10.37)
107	IPT 403	0.00 (0.00)	1.52 (4.99)
108	IPT 404	1.66 (5.21)	1.66 (5.21)
109	IPT 405	1.78 (5.47)	5.23 (12.94)
110	IPT 406	0.00 (0.00)	0.00 (0.00)
111	IPT 407	0.00 (0.00)	3.24 (10.38)
112	IPT 408	1.62 (5.16)	1.62 (5.16)
113	IPT 409	2.99 (9.03)	4.42 (11.97)
114	IPT 410	0.00 (0.00)	3.14 (10.2)
115	IPT 411	0.00 (0.00)	0.00 (0.00)
116	IPT 412	0.00 (0.00)	2.7 (9.46)
117	IPT 413	0.00 (0.00)	1.43 (4.91)
118	IPT 414	7.86 (16.13)	10.71 (19.08)
119	IPT 415	1.52 (4.99)	3.03 (7.15)
120	IPT 416	1.35 (4.73)	2.63 (9.37)
121	IPT 417	0.00 (0.00)	1.52 (4.99)
122	IPT 418	2.95 (7.03)	4.42 (11.94)
123	IPT 419	0.00 (0.00)	1.43 (4.91)
124	IPT 420	0.00 (0.00)	0.00 (0.00)
125	IPT 421	1.43 (4.91)	1.43 (4.91)
126	IPT 422	2.38 (6.33)	3.81 (11.24)
127	IPT 423	0.00 (0.00)	0.00 (0.00)
128	IPT 424	0.00 (0.00)	0.00 (0.00)
129	IPT 425	1.73 (5.39)	3.45 (7.62)
130	PAT 201	5.75 (13.78)	11.87 (20.11)
131	PAT 202	0.00 (0.00)	3.13 (7.27)
132	PAT 203	2.95 (9.89)	4.52 (12.09)
133	PAT 204	0.00 (0.00)	1.67 (5.24)
134	PAT 205	0.00 (0.00)	3.24 (10.38)
135	PAT 206	1.85 (5.45)	3.46 (10.7)

136	PAT 207	1.85 (5.45)	10.85 (13.29)
137	PAT 208	0.00 (0.00)	4.35 (8.58)
138	PAT 209	1.35 (4.73)	3.35 (10.5)
139	PAT 210	5.00 (9.22)	6.73 (14.61)
140	PAT 211	0.00 (0.00)	0.00 (0.00)
141	PAT 212	7.98 (16.95)	9.84 (18.26)
142	PAT 213	1.62 (5.16)	4.50 (12.03)
143	PAT 214	0.00 (0.00)	3.17 (10.29)
144	PAT 215	0.00 (0.00)	1.22 (4.46)
145	PAT 216	1.42 (4.91)	2.85 (9.81)
146	PAT 217	4.44 (11.91)	4.44 (11.91)
147	PAT 218	1.42 (4.91)	5.42 (13.43)
148	PAT 219	2.64 (8.41)	5.28 (13.31)
149	PAT 220	0.00 (0.00)	3.97 (11.36)
150	PAT 221	0.00 (0.00)	3.39 (10.60)
151	PAT 222	0.00 (0.00)	4.45 (11.84)
152	PAT 223	2.78 (6.85)	4.21 (11.75)
153	PAT 224	3.13 (7.27)	4.59 (12.18)
154	PAT 225	4.17 (8.37)	6.67 (14.37)
155	PAT 226	3.85 (8.06)	5.09 (12.61)
156	PAT 227	2.00 (5.78)	4.00 (14.74)
157	PAT 228	6.47 (14.13)	6.47 (14.13)
158	PAT 229	6.45 (14.13)	9.00 (17.4)
159	PAT 230	0.00 (0.00)	0.00 (0.00)
160	PAT 231	0.00 (0.00)	2.63 (6.67)
161	PAT 232	3.03 (7.15)	4.59 (12.22)
162	PAT 233	4.34 (11.85)	5.73 (13.6
163	PAT 234	7.14 (15.43)	8.57 (15.72
154	PAT 235	4.29 (11.92)	7.29 (15.57)
165	PAT 236	0.00 (0.00)	2.5 (6.45

166	PAT 237	5.42	5.42
		(13.42)	(13.42)
167	PAT 238	1.43	1.43
		(4.91)	(4.91)
168	PAT 239	0.00	3.23
		(0.00)	(7.39)
169	PAT 240	1.61	1.61
		(5.16)	(5.10)
170	PAT 241	4.02	6.65
		(11.36)	(14.94)
171	PAT 242	0.00	0.00
		(0.00)	(0.00)
172	PAT 243	3.23	3.23
		(10.31)	(10.31)
173	PAT 244	1.43	4.52
		(4.91)	(12.14)
174	PAT 245	2.57	4.04
		(6.5)	(11.41)
175	PAT 246	2.86	5.8
		(6.91)	(13.94)
176	PAT 247	3.96	3.96
		(11.36)	(10.41)
177	PAT 248	1.52	3.13
		(4.99)	(10.32)
178	PAT 249	1.52	2.77
		(4.99)	(9.54)
179	PAT 250	4.06	6.22
		(11.48)	(16.43)
180	PAT 251	0.00	0.00
		(0.00)	(0.00)
181	PAT 252	3.29	4.85
		(10.46)	(12.56)
182	PAT 253	3.3	4.82
		(10.46)	(12.62)
183	PAT 254	1.43	1.423
		(4.91)	(4.91)
184	PAT 255	3.45	3.45
		(7.62)	(7.62)
185	PAT 256	1.62	3.05
		(5.10)	(10.36)
186	PAT 257	0.00	0.00
		(0.00)	(0.00)
187	PAT 258	3.13	3.13
		(7.27)	(7.27)
188	PAT 259	0.00	3.34
		(0.00)	(10.54)
	Local susceptible	20.6	31.75
		(26.96)	(33.36)
	7042S	79.14	98.39
		(62.84)	(82.36)
	S.E. (m)±	3.71	3.58
	C.D. (at 5%)	10.28	9.97

Note: Data are the mean of two replications.
The figures in parenthesis are angular transformed value on which statistical analysis was carried out.
DAS- Days after sowing

Evaluation of pearl millet hybrids/varieties against downy mildew:

Forty promising hybrids/varieties were evaluated against downy mildew. Local susceptible and 7042S were used as check and the data are summarized in Table 4.6 It is clear from the table that five entries viz., PAC 931, 7688, Anmol, JBV 3 and hybrid Bajra AG SUN B-38 were completely free from downy mildew at 30 days after sowing. Out of these five, two entries viz., PAC 931 and JBV-3 were also free at 65 days after sowing while entries viz., IPI 8293, 834 B, 8113, ICMP-451-P6, JK-592, 852 B, showed >10% downy mildew incidence at 65 days after sowing. <10% downy mildew was recorded in the remaining 32 entries. However, all the forty entries were significantly superior over both the checks at 30 and 65 days after sowing.

Table 4.6: Evaluation of promising hybrids/varieties of pearl millet against downy mildew.

S.No.	Entries	DM incidence (%)	
		At 30 DAS	At 65 DAS
1	JKBH-26	1.2 (4.36)	2.3 (6.13)
2	PAC 938	2.9 (6.9)	5.9 (13.59)
3	PAC 931	0.0 (0.0)	0.0 (0.0)
4	7688	0.0 (0.0)	1.6 (5.07)
5	Nitya BJ-16	3.1 (10.13)	4.4 (11.91)
6	Nitya BJ-09	4.4 (8.58)	7.7 (15.02)
7	Anmol	0.0 (0.0)	1.4 (4.73)
8	Akash Prabha	1.3 (4.64)	8.2 (11.56)
9	8421	4.7 (12.45)	6.6 (14.8)
10	HC-20	2.6 (6.52)	2.6 (6.53)
11	Pusa 23	3.6 (7.72)	4.8 (12.27)
12	Pusa 383	3.7 (11.05)	5.9 (13.65)
13	Pusa 605	4.45 (11.91)	5.7 (13.79)
14	Mahyco 2210	3.7 (11.04)	3.7 (11.04)
15	GHB 558	1.6 (5.07)	5.0 (12.68)
16	RHB 121	2.85 (9.72)	4.25 (11.72)

17	Raj 171	1 3 (5 47)	3 45 (10 7)
18	JBV-2	0.75 (3 52)	* 45 (6 92)
19	JBV-3	0 0 (0 00)	0 0 (0 00)
20	JBV-4	0.7 (3 4)	1 4 (5 92)
21	WCC-75	2 2 (8 45)	3 0 (9 97)
22	ICTP-8203	2 3 (8 63)	3 1 (10 14)
23	IP 18292	1 5 (4 99)	4 96 (12 6)
24	IP 18293	5 1 (12 71)	11.1 (19 46)
25	P-310-17	4 9 (12 66)	8 2 (16 54)
26	P-7-4	3 0 (9 97)	7 5 (15 81)
27	843B	4 1 (11 56)	6 8 (15 06)
28	834B	8 5 * (16 47)	11.9 (20 84)
29	81B	16 3 (23 67)	23 4 (28 94)
30	ICMB 99022	2 8 (9 69)	7 8 (15 15)
31	ICMP 451-P6	3 1 (10 06)	15 3 (22 97)
32	Pioneer 86M32	1 7 (5 32)	4 8 (12 53)
33	Pioneer 85M34	1 8 (5 47)	3 6 (7 73)
34	ICMV 221	2 6 (9 27)	5 1 *(12 66)
35	ICMV 155	2 5 (6 46)	5 2 (13 17)
36	JK 592	6 4 (13 91)	10 2 (18 43)
37	Gopalagrittak	1 9 (5 62)	1 9 (5 62)
38	Hybrid bajra AG Sun B-38	0 (0 00)	1 6 (5 15)
39	852 B	6 8 (15 09)	13 6 (21 67)
40	Kushwahdhar local	4 2 (11 73)	5 8 (13 94)
	Local susceptible (check)	48 0 (43 85)	82 7 (65 41)
	7042S (check)	54 5 (47 50)	85 5 (67 64)
	S.E. (m)±	**3.78**	**3.29**
	C.D. (at 5%)	**10.69**	**9.30**

DISCUSSION

CHAPTER V

DISCUSSION

Survey:

In the present study a total of 24 villages of Morena, Bhind and Gwalior district were surveyed to assess the incidence of downy mildew. Out of these three villages of Morena (Bhajpura Badagaon and Bagchini) three of Gwalior (Sonsa, Utila and Maharajpura) and one of Bhind (Birkhadi) were found free from downy mildew. The maximum incidence of downy mildew was recorded in Marpura of Bhind district (8.23%) followed by Morarpur (5.9%) of Gwalior district. In Morena district. The maximum incidence of downy mildew was recorded in Jigni (2.2%) followed by Mudiakheda (1.9%), Chhatar Ka Pura (1.7%), Morenagaon (1.53%) and Dimni (0.83%). In Bhind district the maximum disease incidence was recorded in Marpura (8.23%) followed by Banthar (5.03%), Soni (4.36%), Akoda (2.9%), Silodi (1.1%), Barakala (0.86%) and Mehgwa (0.4%). In Gwalior district the maximum incidence was recorded in Morarpur (5.9%) followed by Sarai (4.67%), Bhadroli (3.74%), Nagor (0.8%) and Bhojram Ka Pura (0.43%). Earlier 47 pearl millet fields of Morena and Gwalior district were surveyed in the year 2002-2003 and in the year 2003-04 in which all the surveyed fields in both the years were absolutely free from downy mildew (Anonymous 2003-2004b). Now it is clear from the above record and present study that the problem of downy mildew initiated recently in the cultivators fields of Morena, Bhind and Gwalior districts which gives us an alarm to recommend the cultivation of downy mildew resistant entries in these localities because the pathogen *"Sclerospora graminicola"* is a soil borne hence the cultivation of downy mildew susceptible hybrids/varieties will rapidly promote the problem in these areas.

Symptomatology:

The symptoms of downy mildew appeared in seven days old seedlings of pearl millet susceptible hybrid 7042S. The disease starts as chlorotic streaks from the base of upper surface of leaf and the corresponding lower surface showed whitish growth of fungal mycelium. Later on the leaves turned brown and split off vertically from the tip. The infected plant remained

stunted with profused tillering. Whitening, curling and twisting of younger leaves was observed on older plants. Transformation of earhead into different types of leafy or needle like structures was commonly observed. In some cases instead of forming normal or green ear the stunted plant also produced a bunch of chlorotic leafy structure.

Present finding is in conformity with those of Butler (1907) Rama Krishnan (1963) and Dang (1981) who also described similar types of symptoms and structural variations.

In-vitro evaluation of Plant extract against *Sclerospora graminicola*:

In the present study six botanicals viz., *Eucalyptus*, *Neem*, *Datura*, *Calotropis*, *Parthenium* and *Lantana* were evaluated against *Sclerospora graminicola* by adopting detached leaf technique. Neem leaf extract 10% conc. was found very effective in controlling the growth of *Sclerospora graminicola* and it was significantly superior over Calotropis (10 and 20% conc.), Parthenium (10 sand 20% conc.) and Eucalyptus (10% conc.) but statistically at par with Datura (10% and 20% conc.) and Eucalyptus (20%) Neem oil and Eucalyptus oil were significantly superior over control.

Present finding is supported by Dohroo and Gupta (1995) who also reported that Azadiractin and other limoids are quite effective in the control of plant disease of diverse nature. They also reported that Neem oil has fungicidal properties that had inhibitory effect to sclerotia of *Sclerotium*, *Rhizoctinia* and *Sclerotinia*. The extract of Neem was found most potent in reducing virus infectivity and nematode population. In the present study it was also observed that the extract of botanicals are more effective under higher concentration. Shivpuri *et al.* (1997) also reported that some plant extract were most effective under higher concentration.

Evaluation of selected botanicals, cow urine and butter milk against downy mildew:

In the present study seed treatment of pearl millet with Metalaxyl (Apron SD-35 @ 6 g/kg) followed by three sprays of Mancozeb @ 0.2% absolutely checked the incidence of downy mildew in the susceptible hybrid HB_3. Seed treatment with Apron alone also checked the incidence of downy mildew at 30 days after sowing but was less effective at 65 days after sowing. Among the tested plant extracts, oil cakes, cow urine and butter milk the

Neem leaf extract was found best as its soil treatment @ 10% followed by three sprays at 20, 35 and 50 days after sowing significantly checked the incidence of downy mildew and it was also statistically at par with the seed treatment of Apron SD-35. This clearly indicates that it can act as an alternative to the Metalaxyl seed treatment which is currently recommended for the management of downy mildew. In the present study Cow urine and Eucalyptus leaf extract also significantly checked the disease but they were less effective than the Neem leaf extract. The present finding is supported by those of Jagannathan and Narsimhan (1988), Meena and Mariappan (1993), Dohroo and Gupta (1995) and Shivpuri *et al.* (1997) who also reported the fungicidal properties of botanicals against different pathogens.

Effect of sowing dates:

In the present study a downy mildew susceptible pearl millet hybrid "HB_3" was planted on five different dates starting from 9 July –24 August to find out the influence of sowing date on the incidence of downy mildew. The minimum incidence of downy mildew at 30 days after sowing was recorded in the crop sown on 9th July (D_1) followed by 27.30% in the crop sown on 20th July but there after on 2nd August sown crop it was increased sharply and significantly (54.20%). The disease incidence was gradually and significantly declined in the crop sown on 14th August (38.78%) and 24th August (28.14%). Similar trend of downy mildew incidence was also observed at 65 days after sowing. The maximum incidence (80.83%) was recorded in the crop sown on 2nd August followed by 63.26 in the crop sown of 14th August. The minimum incidence of the disease at 65 days after sowing (46.5%) was recorded in the crop sown on 24th August followed by 9th July sown crop (48.07%). These two dates were significantly at par which indicates less downy mildew under early and very late sown crop then the normal and late sown crop. The possible reason of higher susceptibility of downy mildew on 2nd August sown crop is that it receives higher humidity and slightly lower temperature which is more favourable for disease development as compared to early sown crop. Apart from this 2nd August sown crop was also exposed to receive secondary inoculum (infection) from the earlier sown infected crop. Whereas the early sown crop did not get this opportunity and in that case the infection is only primary that is through oospores. 14th August and 24th August sown crop was

also exposed for infection from earlier infected crop but could not get higher humidity which is essential for infection and development, hence it was less infected. The present finding is also in support by Chahal *et al.* (1978) who reported that early sowing with the onset of monsoon upto July first weak reduced downy mildew incidence as compared to late sown crop. Similarly Shrivastava (2003) also planted downy mildew susceptible cultivar "HB_3" on four different dates starting from 13th June to 24th July and observed that the incidence of downy mildew increased with the advancement of sowing dates form 23 June to 13 July and there after it decreased.

Screening of pearl millet germplasm against the disease:

Pearl millet germ plasm consisting of 188 lines was evaluated in the present study to select out the downy mildew resistant lines. 15 lines (IHI 110, IHT 119, IHT 145, IHT 151, HPT 712, IPT 406, IPT 411, IPT 420, IPT 423, IPT 424, PAT 211, PAT 230, PAT 242, PAT 251, PAT 257) were free from downy mildew at 30 and 65 days after sowing while 79.14 and 98.39% incidence was recorded in 7042S at 30 and 65 days after sowing respectively Singh (1990) also evaluated 3163 germplasm accessions from many pearl millet growing countries for resistance to downy mildew. The highest frequencies of downy mildew resistant source was detached in accession from the west Africa followed by east Africa. Forty eight selections from 37 early to medium maturity accession showed high level of downy mildew resistance.

Evaluation of promising hybrids/varieties against the disease:

Forty promising hybrids/varieties were evaluated in the present study against downy mildew. Local susceptible and 7042S were used as check. Five entries viz., PAC 931, 7688, Anmol, JBV-3 and hybrid Bajra AGSun B38, were completely free from downy mildew at 30 days after sowing and out of these fives, two entries viz., PAC 931 and JBV-3 were also free from the disease at 65 days after sowing. The present finding is supported by the work of Rao *et al.* (2002) who conducted a field survey of Gujarat to monitor downy mildew incidence on 21 pearl millet hybrids and observed that the seven hybrids viz., PAC 931, Amul, MRB 2210, Nandi-3, Proagro 7531, 9330 and Vikram 51, were free from the disease.

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

CHAPTER VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

Summary:

Pearl millet (*Pennisetum glaucum* (L.) R. Br.) also known as Bajra is an staple cereal crop of India. Northern Madhya Pradesh comprising Morena, Bhind and Gwalior is the major pearl millet producing area of the state.

Downy mildew incited by *Sclerospora graminicola* (Sacc.) Schroet is the most wide spread and destructive disease of pearl millet in India. Though the disease can be managed with the foliar application of fungitoxicants. It is uneconomical due to their high cost. Breeding for disease resistant varieties and management of the disease through botanicals are economic, eco-friendly and of wider application. Therefore, the present studies were carried out in the Department of Plant Pathology and Research Farm of J.N.K.V.V. Campus, College of Agriculture, Gwalior during kharif season of 2004-05 and the results are summarized as below:

Twenty four villages of Morena, Bhind and Gwalior districts were surveyed to assess the incidence of downy mildew. Out of these three villages of Morena (Bhajpura, Badagaon and Bagchini), three of Gwalior (Sonsa, Utila and Maharajpura) and one of Bhind (Birkhadi) were found free from downy mildew. The maximum incidence of downy mildew was recorded in Manpura of Bhind district (8.23%) followed by Mohanpur (5.9%) of Gwalior district. District wise mean incidence indicates that the maximum incidence of downy mildew was recorded in Bhind (2.86%) followed by Gwalior (1.94%) and Morena (1.04%).

The first symptom of the disease was observed in eleven days old seedlings of pearl millet susceptible hybrid "7042S". The leaf symptoms initiated as chlorotic streaks, which started from the base of leaf lamina of the upper surface and gradually progressed towards the tip. The corresponding lower surface of the leaf showed whitish cottony growth. Transformation of earheads into different types of leafy and/or needle like structure were commonly observed

Six botanicals viz., Eucalyptus, Neem Datura, Calotropis, Parthenium and Lantana were evaluated against *Sclerospora graminicola* in the form of leaf extracts at the concentration of 10 and 20 per cent by adopting detached leaf technique. None of them could check the growth absolutely. However, Neem leaf extract @ 10% was found very effective (only 1.7% leaf area was covered by the growth) and it was significantly superior over calotropis (10 and 20% conc.), Parthenium (10 and 20% conc.) and Eucalyptus (10% conc.).

Metalaxyl seed treatment @ 6 g/kg followed by three sprays of mancozeb (0.2%) at 20, 35 and 50 days after sowing absolutely checked the incidence of downy mildew at 30 and 65 days after sowing and it was significantly superior over all other treatment at 65 days after sowing but at 30 days after sowing it was statistically at par with Metalaxyl seed treatment. Other than chemical treatment, Neem leaf extract @ 10% was found most effective and it was significantly superior over control at 30 and 65 days after sowing. Metalaxyl seed dressing was statistically at par with Neem leaf extract (10% conc.) of 65 days after sowing.

Downy mildew susceptible pearl millet hybrid "HB_3" was planted in five different dates started from 9 July, 2004 to 24 August, 2004 to find out the influence of sowing dates on the incidence of downy mildew. The maximum incidence (80.83%) was recorded in the crop sown on 2nd August followed by 63.26 in the crop sown of 14th August. The minimum incidence of the disease at 65 days after sowing (46.5%) was recorded in the crop sown on 24th August followed by 9th July sown crop (48.07%).

Out of 188 pearl millet lines were evaluated against downy mildew. Out of these only 15 lines viz., IHT 110, IHT 119, IHT 145, IHT 151, HPT 712, IPT 406, IPT 411, IPT 420, IPT 423, IPT 424, PAT 211, PAT 230 PAT 242 PAT 251 and PAT 257 were free from downy mildew at 30 and 65 days after sowing while 79.14 and 98.39 per cent incidence was recorded in 7042S at 30 and 65 days after sowing respectively.

Forty promising hybrids and varieties were evaluated against downy mildew. Out of these two entries viz., PAC 931 and JBV-3 were completely free from downy mildew at 30 and 65 days after sowing.

Conclusions:

The entire study so carried out was successful in meeting its objectives as reflected in following conclusions drawn there from:

1. Survey report shows that the problem of downy mildew initiated on the cultivators field of Morena, Bhind and Gwalior districts. Which gives us an alarm to use downy mildew resistant cultivar.
2. The disease starts as chlorotic streaks from the base of upper surface of leaf with the whitish cottony growth on the corresponding lower surface of the leaf.
3. Neem leaf extract @ 10% was found very effective in controlling the growth of *Sclerospora graminicola* in the detached leaf technique.
4. Seed dressing with Metalaxyl (Apron SD35 @ 6 g/kg seed) followed by three sprays of mancozeb 0.2% at 20, 35 and 50 days after sowing absolutely controlled the incidence of downy mildew in a highly susceptible cultivar.
5. Soil treatment with Neem leaf extract (10% conc.) followed by three sprays of this extract at 20, 35 and 50 days after sowing showed a significant control of the disease and it was also statistically at par with the Metalaxyl seed treatment (recommended practices) at 65 days after sowing. Therefore Neem leaf extract may act as an alternative of the chemical treatment.
6. Early sowing of pearl millet (in the first fort night of July) reduces downy mildew incidence as compare to late sown crop (first fort night of August).
7. Out of 188, fifteen lines of pearl millet viz., IHT 110, IHT 119, IHT 145, IHT 151, HPT 712, IPT 406, IPT 411, IPT 420, IPT 423, IPT 424, PAT 211, PAT 230, PAT 242, PAT 251 and PAT 257 were found free from downy mildew.
8. PAC 931 and JBV-3 were found free from downy mildew, hence, these two may be promoted for their cultivation on the farmers fields.

Suggestions for further work:

1. In the present study six botanicals were evaluated against *Sclerospora graminicola* by adopting detached leaf technique. Now, there is a need to test a large number of botanicals in the different form under variable concentrations.
2. The entries which were identified resistant may also be tested under artificial inoculation and thereafter the resistant source may be utilize in the resistance breeding programme.
3. JBV-3 was found free from downy mildew under the downy mildew sick plot condition. May also by promoted for cultivation on the farmers fields.

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APPENDICES

APPENDIX-I

Area, production and productivity of pearl millet in northern Madhya Pradesh during kharif 2004

Districts	Area (ha)	Production (mt)	Productivity (kg/ha)
	Chambal Division		
Morena	76803	131103	1707
Bhind	44778	48114	1080
Sheopur	22282	31979	1435
Total	133863	211128	1577
	Gwalior Division		
Gwalior	13151	36356	2764
Shivpuri	16431	21846	1329
Datia	444	464	1045
Ashok Nagar			
Datia	1141	1213	1063
Total	30058	49869	1659
M.P.	202409	281045	1388

Source: Basic Agriculture Statistics Report (M.P.) published by Commissioner, Land Records and Settlement, Madhya Pradesh

APPENDIX-II

Meteorological data from July to October, 2004, recorded from Meteorological Obeervatory, College of Agriculture, Gwalior

Standard week	Temperature (°C)**		Humidity (%)**		Rainfall (mm)*
Number with dates	Maximum	Minimum	Maximum	Minimum	
July 2-8	37.4	24.6	74	50	124.5
July 9-15	37.2	26.0	60	37	000.0
July 16-22	38.5	24.8	76	44	004.4
July 23-29	35.2	24.0	85	50	005.1
July-August 30-5	34.4	24.0	89	63	032.5
August 6-12	32.5	22.5	85	68	174.8
August 13-19	31.9	22.7	87	75	016.3
August 20-26	30.2	21.9	89	70	063.5
August-September 27-2	33.3	22.9	75	53	000.0
September 3-9	35.5	22.5	72	43	000.0
September 10-16	35.2	22.9	78	58	031.4
September 17-23	31.1	19.8	89	70	008.2
September 24-30	36.1	19.8	79	39	000.0
October 1-7	40.4	20.5	81	49	000.0
October 8-14	31.3	17.8	83	54	051.7
October 15-21	30.3	12.4	86	49	000.0
October 22-28	31.5	12.2	74	45	000.0

* Total rainfall (mm) per week

** Average minimum and maximum temperature and humidity over the week

VITA

VITA

The author of the thesis **Mr. Rahul Sharma** S/o Shri J.P. Sharma was born on 15th August, 1979 at Gwalior, M.P.

He passed his High School in the year 1994 from Kendriya Vidhyalaya No. 3 with 48% per cent marks. After that he passed Higher Secondary in the year 1996 acquiring 54 per cent marks from Govt. Higher Secondary School, No. 2 Morar, Gwalior (M.P.).

He completed his B.Sc. (Ag.) from College of Agriculture, Gwalior, JNKVV, Jabalpur in the year 2002 achieving 6.48 OGPA.

After completing graduation he was selected for M.Sc. (Ag.) degree programme in Plan Pathology and was admitted in College of Agriculture, Gwalior (M.P.). He has passed all required courses in M.Sc. by obtaining approximately 7.02 OGPA.

Rahul Sharma