EPIDEMIOLOGY OF MUNGBEAN ANTHRACNOSE

THESIS

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Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur

in partial fulfilment of the requirements

for the Degree of

DOCTOR OF PHILOSOPHY

IN

AGRICULTURE

(PLANT PATHOLOGY)

By

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DEPARTMENT OF PLANT PATHOLOGY

JAWAHARLAL NEHRU KRISHI VISHWA VIDYALAYA

COLLEGE OF AGRICULTURE

JABALPUR, M. P.

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CERTIFICATE-I

This is to certify that the thesis entitled "EPIDEMIOLOGY OF MUNGBEAN ANTHRACNOSE", submitted in partial fulfilment of the requirements for the degree of DOCTOR OF PHILOSOPHY IN AGRICULTURE (Plant Pathology) of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of bonafied research work carried out by Shri MAHESH PRASAD THAKUR under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (certificate award etc.) or has been published. The thesis has been prepared as per the specifications prescribed by the Vishwa Vidyalaya. All the assistances and help received during the course of investigation have been duly acknowledged by him.

(Dr. M.N. Khare)
Chairman of the Advisory Committee

Date 4th September, 1987

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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Member	(Dr. Om Gupta)	4.9.87
Member	(Dr. M.P. Janoria)	
Member	(Dr. Lalchand)	

CERTIFICATE-II

This is to certify that the thesis entitled "EPIDEMIOLOGY OF MUNGBEAN ANTHRACNOSE", submitted by Shri MAHESH PRASAD THAKUR to the J.N. Krishi Vishwa Vidyalaya, Jabalpur, in partial fulfilment of the requirements for the degree of Ph.D. in the Department of PLANT PATHOLOGY has been approved by the Student's Advisory Committee and External Examiner after an oral examination on the same.

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CHAPTER I

INTRODUCTION

INTRODUCTION

Mungbean (Vigna radiata L. Wilczek) is an important pulse crop. It is grown in 231.9 thousand hectares in Madhya Pradesh (Agricultural Statistics, 1984). Among pulses, mungbean ranks second important crop grown throughout the world (Ahire, 1983). India ranks next to China in its production in the world (Trivedi, 1981).

It is mainly cultivated in kharif season in most of the states but in places with mild winter like South India it is grown in rabi too. It is also grown in summer where irrigation is available. It is cultivated as a sole, mixed or inter crop with jowar, maize, cowpea, ragi and other kharif crops.

Mungbean has been assigned second rank in nutritive value amongst the pulses (Hymowitz et al., 1975). It is proteinaceous containing 24% protein which is easy to digest and hence is ideally suited to infants (Swaminathan, 1971). It is used in several ways in human diet.

Information on diseases of pulses in general and mungbean in particular is scanty. In kharif, mungbean is exposed to all vageries of nature due to which it is a problem in obtaining high quality pathogen free seed. The crop is subjected to several diseases which are seed-borne, soil-borne and air-borne. Some of the important diseases

that affect this crop in India are : stem and root rot caused by Macrophomina phaseolina (Rae, 1929), seed rot, seedling rot, leaf, stem and pod blight due to Colletotrichum spp. and Fusarium spp. (Khare et al., 1977) and leaf blight caused by Myrothecium roridum (Munjal, 1960 and Shrivastava, 1980). These diseases result in pre-and post-emergence mortality and diseases at later stages of crop growth (Chindhalore, 1974).

Among these diseases, anthracnose caused by Colletotrichum dematium and C. lindemuthianum is very devastating. It is seed, soil as well as air-borne in nature infecting the crop at all the growth stages (Sherbakoff, 1917; Barrus, 1921 and Mazid, 1950). Saxena (1984) reported 4-21 per cent infection in green gram and black gram, in various localities by Fusarium oxysporum, F. semitectum and C. truncatum. Shao and Teri (1985) reported yield loss of 86 per cent and 27 per cent in highly susceptible and moderately susceptible varieties of Phaseolus bean due to C. lindemuthianum.

Looking to the significance of anthracnose in causing losses and lack of information on this disease, the present investigation was planned to assess the influence of various epidemiological factors on disease development.

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CHAPTER II

REVIEW OF LITERATURE

Mungbean (Vigna radiata L. Wilczek) is an important pulse crop cultivated almost in all the states of India. The major mungbean growing states are Meharashtra, Andhra Pradesh, Orissa, Rajasthan, Madhya Pradesh and Bihar. The crop is attacked by a number of pathogens causing various diseases of which anthracnose caused by Colletotrichum spp. is very important. It infects all the plant parts except roots (Tiffany, 1954). Three species of Colletotrichum : C. graminicola, C. truncatum and C. lindemuthianum are reported to attack leguminous crops particularly Phaseolus spp. (Tiffany, 1951; Tiffany and Gilman, 1954 and Nobel and Richardson, 1968). Very little information is available on various aspects of this disease.

1. Association of mycoflora with seed samples of mungbean

Ahire (1983) tested 48 samples of mungbean from different districts of Maharashtra and found the association of 23 fungi with the seeds, but he could not detect any Colletotrichum species. However, samples after 12 months storage yielded 6.5 per cent C. graminicola. Mungbean seeds collected from various locations of Madhya Pradesh were tested by Jharia (1970). He isolated 12 fungi from mungbean seeds. They were Aspergillus niger, A. flavus, A. ochraceous, Aspergillus spp., Curvularia lunata, Penicillium spp., Pestalotia sp., Rhizopus sp., Alternaria sp., Fusarium spp.,

Helminthosporium sp. and Rhizoctonia spp. Chaubey (1978) tested 13 samples of mungbean seed collected from eight districts of Madhya Pradesh. In all 15 fungi were isolated of which most predominant were the species of Fusarium.

Ramnath et al. (1970) reported 15 fungi from mungbean seed using blotter and agar plate method with and without surface sterilization. The isolated fungi were Alternaria tenuis, Botryodiplodia palmarum, Cercospra kikuchii, Choanephora sp., Colletotrichum truncatum, Corynespora cassicola, Curvularia lunata, Diaporthe phaseolorum, Drechslera rostrata, Fusarium equiseti, F. solani, F. moniliforme, F. semitectum, Macrophomina phaseoli and Myrothecium roridum. Seed health testing of mungbean was carried out by Agrawal et al. (1972) who reported several seed-borne fungi of mungbean, Alternaria longissima, Cercospora kikuchii, Chaetomium sp., Colletotrichum lindemuthianum, C. truncatum, Curvularia lunata, Drechslera tetramera, Fusarium equiseti, F. moniliforme, F. semitectum, Macrophomina phaseoli, Myrothecium roridum, Melanospora sp., Periconia sp. and Phoma sp. Suhag (1975) isolated Alternaria tenuis, Aspergillus nidulans, Cladosporium fulvum, Curvularia lunata, Fusarium spp., Rhizoctonia bataticola, Rhizopus nigricans and some unidentified fungi from mungbean seeds. Species of Alternaria, Cladosporium, Fusarium and Rhizoctonia were found to cause seed deterioration, loss in germination and

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seedling diseases. Seed-borne fungi were reported by Singh and Chouhan (1973) following blotter and agar plate methods. The fungi detected were : Aspergillus flavus, A. niger, Chaetomium olivaceus, Fusarium oxysporum, Penicillium chrysogenum, Rhizopus arhizus, Rhizoctonia bataticola and Sporotrichum sp.

Seed samples of two pulses including blackgram and green gram were examined by Khare et al. (1973) for the associated mycoflora. The important fungi reported by them were Colletotrichum dematium, C.graminearum, C.lindemuthianum, Phoma sp., Fusarium oxysporum, F. equiseti, F. solani, F. moniliforme, F. semitectum, Botryodiplodia theobromae, Macrophomina phaseolina and species of Ascochyta. Chindhalore (1973) isolated 13 fungi associated with mungbean seeds out of which Fusarium equiseti and Macrophomina phaseolina were pathogenic and internally seed-borne causing pre-and post-emergence mortality.

Finally, the most common seed-borne fungi reported by various workers are : Aspergillus flavus, A. niger, A. ochraceous, Alternaria tenuis, Botryodiplodia palmarum, Cercospora kikuchii, Collatotrichum graminearum, C. lindemuthianum, C. truncatum, Curvularia lunata, Fusarium equiseti, F. solani, F. moniliforme, F. semitectum, Macrophomina phaseolina, Myrothecium roridum and Penicillium spp.

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Baghel (1984) tested 30 mungbean varieties and found the association of ten fungi : Aspergillus niger, A. flavus Alternaria alternata, Chaetomium sp., Fusarium moniliforme, F.semitectum, F.solani, Macrophomina phaseolina, Penicillium sp. and Stachybotrys sp.

2. Incidence of anthracnose in mungbean varieties

In all 877 germplasm entries of mungbean were evaluated against serious diseases at seven centres (Chandra and Amin, 1985) out of which, entry 11/395 was found resistant to anthracnose at Ludhiana. Out of 65 entries of mungbean at Sehore 53 entries were free from anthracnose, however, 12 entries were susceptible to anthracnose (Anonymous, 1985).

3. Taxonomy of the pathogen

Colletotrichum genus was first described by Corda (1831). Tiffany and Gilman (1954) studied the species of Colletotrichum causing diseases of legumes, the important species infecting mungbean were Colletotrichum lindemuthianum and C. dematium.

Ramnath et al. (1970) reported the association of C. truncatum with mungbean seeds. They observed two types of colonies on the seed.

Type A (Large acervuli) : The whole seed was covered with acervuli of the fungus. The setae were long, dark brown

or almost black and pointed. Individual acervulus was proportionately large, circular in out line with 6-8 setae. Immature acervuli were greyish white and cushion like while the mature ones appeared dull to bright orange. The acervuli showed a tendency to coalesce, sometimes covering the whole seed showing a continuous orange coloured growth with setae arising irregularly all over the seed surface.

Type B (Small acervuli) : In the second type of growth, numerous smaller acervuli with dark setae were observed. Individual acervulus had a small, blackish, irregular area on the seed having 1-3 dark long setae. In the centre of these black areas minute dull white to dull orange spore masses were observed. The acervuli were smaller and the spore masses were not as bright as observed in A type.

Most of the seeds infected by C. truncatum did not germinate, the seedlings were distorted and many acervuli developed on infected parts.

Anthracnose caused by C. lindemuthianum was observed in 1875 by Lindemuth in Germany and was first described by Saccardo and Magnus as Gloeosporium lindemuthianum. They described the acervuli of the fungus to be scattered, surrounded by a few not very conspicuous black setae, conidiophores cylindric, simple, 45-55 µ long; conidia

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oblong with rounded ends, straight or curved and 15-19 x 3.5-5.5 u in size.

4. Symptomatology

Singh et al. (1978) described a leaf spot and blight disease of urd caused by C. dematium. The symptoms appeared as small, water soaked, greenish spots on leaflets which later enlarged becoming irregular, light brown, thin papery patches finally becoming straw coloured with narrow reddish margin. The papery portions were shed off showing 'shot-hole'. This type of symptoms were also described by Tripathi and Boniwal (1977) but the fungus identified from diseased portion was C. capsici. Saxena and Sinha (1977) isolated C. truncatum from mungbean and urdbean. They found slightly smaller conidia and poor sporulation.

Some important pathogens causing diseases resulting in severe losses to mungbean crop are given below :-

Causal organism	Name of disease	Authors
1	2	3
Alternaria alternata	Alternaria leaf blight	Gupta (1970)
Ascochyta phaseolorum	Leaf spot	Staples (1958)
Cercospora cruenta	Leaf spot	Nazid (1950) 71
C. canescens	Leaf spot	Suryanaryana (1978)
C. kikuchii	Leaf spot	Ramnath et al. (1970)

1	2	3
C. lindemuthianum	Anthracnose	Mazid (1950)
C. truncatum	Colletotrichum blight	Munjal (1960)
C. sorghi	Eye spot	Shrivastava (1980)
Corynespora cassicola	Leaf spot	Ramath et al. (1970)
Diaporthe phaseolorum	Brown spot	Ilag (1977)
Erysiphe polygoni	Powdery mildew	Ilag (1977)
Macrophomina phaseolina	Stem and root rot and leaf blight	Rae (1929) and Sakhuja (1974)
Myrothecium roridum	Leaf spot Collar rot	Suryanaryana (1978)
Phoma medicaginis	Phoma blight	Munjal (1960)
Rhizoctonia bataticola	Seed rot, seedling rot, root rot and web blight	Philip (1963)
Rhizoctonia solani	-do-	Philip (1963)
Sclerotinia sclerotiorum	Leaf blight	Shukla (1950)
Uromyces vignae	Rust	Ilag (1977)

5. Disease survey

Saxena (1984) reported the infection of Vigna radiata and Vigna mungo in various localities ranging from 4-21 per cent due to Colletotrichum truncatum, Fusarium oxysporum and F. semitectum.

Since, not much work has been done on this aspect, the survey of anthracnose in some other leguminous crops is mentioned here. In urdbean, Singh (1977) reported 17-37 per cent pre-and post-emergence mortality due to C. truncatum. In soybean, Nicholson (1973) reported 25 and 80 per cent mortality due to C. dematium f. sp. truncata and Pseudomonas glycinea at pre-and post-emergence stages respectively. In phaseolus bean, Santos et al. (1984) observed the severity, prevalence and disease index of anthracnose due to C. lindemuthianum and found anthracnose to be the most important disease in sampled areas. In bean seeds, the association of C. lindemuthianum was reported in 43-63.1 per cent samples (Tylkowsk, 1984). Shao and Teri (1985) determined the extent of losses resulting from C.lindemuthianum in three bean cultivars to be 86 per cent in the highly susceptible and 27 per cent in the moderately susceptible Mexican varieties.

6. Influence of epidemiological factors

6.1 Cultivar

Cultivar plays an important role in causing epidemic. Cultivars of the same crop vary in their capability to withstand the attack caused by the pathogen. Out of 877 germplasm entries of mungbean, entry 11/395 was resistant to anthracnose at Ludhiana (Chandra and Amin, 1985).

Reports on other leguminous crops are also available showing the effect of cultivars on the disease severity. Centro International De Agricultural Tropical (1984) evaluated different lines of Phaseolus vulgaris for resistance to anthracnose. Sohi and Rawal (1984) tested 141 varieties of cowpea and reported 21 varieties resistant to anthracnose caused by C. lindemuthianum and four varieties of Macrophomina phaseolina.

6.2 Effect of planting date

It is an important factor influencing the initiation and development of disease. Effect of dates of planting on anthracnose of urdbean was studied (Anonymous, 1983). It was reported that the disease was minimum (35%) under late sowing (23rd July 1983) and maximum (54.4%) on timely sown crop (3rd July 1983). Nicholson and Sinclair (1973) reported significantly more seedlings with Colletotrichum truncatum lesions on soybean in early dates of planting (June 1,16,July 1)

than those from late planting (July 16, 31, August 14 and September 2). On the contrary, Natti (1971) reported that out break of white mold in snap bean which occurred after mid August were more destructive than those that occurred earlier.

6.3 Effect of environmental factors

About 55 years ago, Jones (1924) attracted attention towards the relation of the environment to the inception and development of disease. The effect of environmental factors including temperature, relative humidity, wind, rain and light on plant disease has been reviewed by Colhoun (1973).

6.3.1 Temperature

Temperature is an important factor which influences the severity of diseases. Not the mean temperature but the frequency of favourable and unfavourable temperature is decisive. Thus, temperature influenced the sporulation, spore germination and disease development.

The effect of temperature upon germination of spores of Colletotrichum spp. was studied by Wollenweber and Hochapfel (1949). They reported little germination below 10°C or above 30°C at the end of 48 hours. Between 95 to 100 per cent germination occurred at temperature between 15-25°C in 24 hours. At 30°C, 100 per cent germination was observed at the end of 48 hours. Martinez Salazar and Anderson (1957) reported that the optimum temperature for

germination of spore of Colletotrichum lindemuthianum was 28°C. Mansondhar et al. (1985) reported that when conidial suspension of C. truncatum was atomised on to leaves in a mist chamber at ambient temperature (24 ± 2°C) 70 per cent of conidia germinated within four hours.

Effect of temperature on development of bean anthracnose caused by C. lindemuthianum was studied by various workers (Martinez Salazar and Anderson, 1957; Baumeyer, 1957; Rahe and Kuc, 1970 and Tu, 1981). They reported reducted anthracnose development at high temperature. It has been shown that the depressing effect of high temperature on symptom development results due to the production of phytoalexin in infected plants (Rahe and Kuc, 1970 and Rahe, 1973). They also reported that the disease on two cultivars of Phaseolus vulgaris was most severe at 20-24°C and least severe at 16°C. However, the severity was greatly reduced at 28-32°C. Tu (1982) reported 22°C to be the near optimum temperature for mycelial growth of C. lindemuthianum. The maximum temperature ranged between 32-34°C. Wollenweber and Hochapfel (1949) reported 25-30°C to be the optimum temperature for mycelial growth of Colletotrichum spp. Lautrizen (1933) observed 22-25°C as the optimum for infection by C. lindemuthianum. Optimum temperature for infection of C. lindemuthianum in French bean was 18-27°C (Sindhan, 1983).

Welty and Rawlings (1980) reported that anthracnose on Alfalfa was more severe in susceptible plants incubated at 24°C than at 16°C. Green house and growth chamber tests showed that anthracnose developed in Alfalfa at 10-30°C but it was limited at high temperature.

6.3.2 Relative Humidity

Atmospheric humidity and precipitation in the form of rain, fog and dew etc. determined disease incidence to a great extent. Humidity of the air inside the canopy especially near the leaves is much higher than that over the canopy, because of the dependence of the relative humidity upon temperature. The humidity has a typical daily pattern that is modified by wind velocity. Normally maximum humidity occurs after rise in temperature and the minimum during the afternoon (Aust, 1986). Sindhan (1983) studied the effect of relative humidity on initiation and development of anthracnose. He found maximum infection of anthracnose at 100 per cent humidity level followed by 95.6, 91.2, 85.7 and 80.5 per cent. Atleast 80.5 per cent humidity was required to cause infection. Below this humidity level infection did not occur. Frost (1964) demonstrated sporulation of C. linicola on the seedling hypocotyls at 85-100 per cent relative humidity. Sporulation at the top of the hypocotyl ceased at approximately 92 per cent relative humidity, whereas, sporulation at its base did not cease until approximately 85 per cent relative humidity was reached. At near saturated humidities acervuli were produced

on the host plant without setae. At approximately 95 per cent humidity acervuli were formed with several setae. Lautritzen (1919) also obtained similar results as Sindhan (1983).

6.3.3 Wind

The influence of wind on transport processes is very important together with the factors of temperature, water vapour and evapotranspiration. Liberation of conidia from field increased with increasing wind speed, low humidity and high temperature. Spore detachment takes place due to shaking of leaves by wind. Sedimentation of conidia required still air.

6.3.4 Rain

It has the main influence on the course of epidemics. During this phase usually rain starts abruptly and a large quantity of water in the form of rain drops hits the leaf and runs over their surfaces. Tu (1981) reported that the conidia of C. lindemuthianum on white bean could be spread to a short distance by splashing rain drops, while, long distance spread 3-4 m required wind driven rain. The fungus required 10 mm of rain to establish infection in South Ontario of U.S.A.

6.3.5 Light

Light can influence the development of disease. It probably is not usually a determining factor in the development of epidemics. Light intensity, day length, however, may affect the survival of inoculum, prepenetration processes, entrance of pathogen and abundance of sporulation. Colletotrichum lagenarium

on the host plant without setae. At approximately 95 per cent humidity acervuli were formed with several setae. Lautritzen (1919) also obtained similar results as Sindhan (1983).

6.3.3 Wind

The influence of wind on transport processes is very important together with the factors of temperature, water vapour and evapotranspiration. Liberation of conidia from field increased with increasing wind speed, low humidity and high temperature. Spore detachment takes place due to shaking of leaves by wind. Sedimentation of conidia required still air.

6.3.4 Rain

It has the main influence on the course of epidemics. During this phase usually rain starts abruptly and a large quantity of water in the form of rain drops hits the leaf and runs over their surfaces. Tu (1981) reported that the conidia of C. lindemuthianum on white bean could be spread to a short distance by splashing rain drops, while, long distance spread 3-4 m required wind driven rain. The fungus required 10 mm of rain to establish infection in South Ontario of U.S.A.

6.3.5 Light

Light can influence the development of disease. It probably is not usually a determining factor in the development of epidemics. Light intensity, day length, however, may affect the survival of inoculum, prepenetration processes, entrance of pathogen and abundance of sporulation. Colletotrichum lagenarium

(anthracnose of cucurbits) produces perfect stage on the culture if exposed to ultraviolet light. Prolonged exposure to ultreviolet light is harmful to the fungus.

6.3.6 Dispersal

Tu (1981) found that conidia of C. lindemuthianum on white bean could be spread a short distance by splashing rain drops although some plants adjacent to diseased ones were not infected. Long distance spread of 3-4 m required wind driven rain. Anthracnose of white bean spreads from an infection focus in the same direction as the prevailing wind, however, the severity of disease declined from the focus in the opposite direction of the prevailing wind. Data from Barnes et al. (1969) indicate that a dense canopy is beneficial to spread C. trifolii because it creates a moist chamber effect. Ling (1940) reported that the mycelium of the fungus give rise to conidia which are formed in abundance and are spread by rainfall, cultivation and harvesting activities and insects (Sherbakoff, 1917; Zaumeyer and Thomas 1957; Shreekumar (Abs.), 1974) stated that certain pathogens like C. lindemuthianum were found to get splashed from soil to phylloplane by rain as they were detected on filter paper trap as well as leaves.

Alicbusan et al. (1959) conducted spore trapping experiments with Alternaria porri and Erysiphe polygoni. They noted that the maximum spores (227) were trapped at 1.30-2.00 PM and minimum at 8.30-9.00 AM. Husain (1960)

could trap the maximum number of spores of A. porri between 2-4 PM under New York conditions.

According to Rotem (1963), the typical diurnal dispersal was concentrated in a few of the driest and windiest hours of the day but climax of dispersal (11 AM) preceded the hours of minimum relative humidity (1 PM) and the climax of wind velocity (3 PM). Drought prevailing for four consecutive days decreased the number of air-borne spores, whereas, dry conditions prevailing for only 1-2 days did not. Meredith (1966) observed the maximum concentration of conidia in air above diseased onions between 8 and 14 hours. Concentration of conidia was increased on windy days and by rainfall, irrigation and spraying. The amount of wind determines concentration of spores which are dispersed.

7. Influence of anthracnose on growth parameters of the host

Saxena (1984) evaluated infection percentage and crop loss estimates of seed-borne infection of green gram and black gram due to fungi in U.P. He reported 4-21 per cent damage due to Fusarium oxysporum, F. semitectum followed by C. truncatum. Factors responsible for reduced yield were affect on pod length and number/plant, seeds/pod and 100 seed weight. Barnes et al. (1969) reported severe infection of anthracnose on susceptible variety causing 25-30 per cent losses on forage yield.

8. Influence of plant population on severity of anthracnose in different varieties of mungbean

The canopy density has its influence on disease development. Increased host density needs short distance coverage of spores. It causes environmental changes within the canopy that favours disease (Burdon and Chilvers, 1982). Barnes et al. (1969) indicate that a dense canopy is beneficial to spread C. trifolii because it creates a moist chamber effect. On contrary to these results, Sivaprakasan et al. (1983) reported that plant population did not have significant effect on susceptibility to Cercospora leaf spot incidence in mungbean.

9. Survival of Colletotrichum spp.

Detailed investigations on the disease cycle of Colletotrichum spp. on legumes have been made by Tiffany (1951). Kulik (1984) reported that the anthracnose fungus can survive for upto two years on the infected plant parts and for the same period in stored seeds (Barrus, 1921). Lukezic (1974) reported that C. trifolii could survive as long as 100 days under winter conditions in Pennsylvanea. Carroll (1949) had no trouble on reisolating C. trifolii from the field after 36 winter days in Delaware probably because of milder climatic conditions in that state. Colletotrichum trifolii has been reported to over winter in hay stacks, in crop debris and on harvesting equipment stored in unheated seeds (Graham et al., 1979 and Lukezic, 1974). Tu (1983) reported that alternating wet dry cycles are detrimental to survival of C. lindemuthianum in bean.

Overseasoning of Colletotrichum spp. on soybean debris has been demonstrated by Graham et al. (1979). Hartman et al. (1986) reported that C. destructivum, C. truncatum and Glomorella glycines occurred on 22 per cent of stubble samples of soybean collected in 1984 and on 100 per cent of samples collected in 1983 in Illinois U.S.A. Colletotrichum spp. were recorded from 50 per cent soybean leaflets and from 48 per cent of either stem pieces or leaf samples of 17 weeds from 18 fields. C. truncatum was recovered from 14 genera of weed hosts. Weeds serve as collateral hosts for Colletotrichum spp. (Hepperly et al., 1986; Roy, 1982) and other soybean pathogens. As collateral hosts, weeds contribute to increased inoculum levels, allow carryover of the pathogens in crop rotation systems and provide a base for pathogenic variation.

10. Site of infection of Colletotrichum spp.

Seed-borne nature of Colletotrichum lindemuthianum on bean was reported by Kumar and Schmidt (1961). They found the pathogen to be inter and intracellular. Schneider et al. (1974) found C. truncatum within the seed coat of soybean. Nik and Lim (1984) detected mycelium of C. dematium f. sp. truncatum in all the three layers of seed coat while acervuli were present in the palisade layer.

11. Influence of fungicides on diseases

Attempts have been made by several workers to find suitable fungicides for the suppression of anthracnose.

Chacko (1977) tested a number of fungicides against C. dematium f. sp. truncata of soybean in vitro. Out of the fungicides tested, Ferbam, Penoctine C.G. 450, Thiram and Vitavax were found to inhibit the complete growth of C. dematium f. sp. truncata at 2000 ppm concentration. Complete inhibition of the fungus was also recorded by Thakur (1984) in vitro by using Forbam, Saprol and Thiram at 500 ppm concentration.

As pathogenic species of Colletotrichum attack a number of leguminous crops, studies were made to control seed-borne Colletotrichum spp. by seed treatment with Benomyl, Captan, Thiram, Orthocide, Phygon X.L., $NiCl_2$ Gramisan, Fungitax, Arasan, Ceresan etc. (Gabryl, 1961; Pall, 1963; Ramkrishna, 1965; Ahn and Cthang, 1970). Bernat and Raichu (1974) obtained good control of C. lindemuthianum on Phaseolus vulgaris with 0.2% Thiram, 0.2% Captan, 0.2% Mancozeb and Captan. Several fungicides were used by Jharia (1974) for seed treatment of mungbean, of which Benlate was reported to be the best.

In field trials, Kocide 107 (Cupric hydroxide), Perenox, Copper oxychloride and Bordeaux mixture were most effective against coffee berry disease caused by C. lindemuthianum

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(Kairu et al., 1985). Issa (1985) obtained best control of C. lindemuthianum of bean by Captafol, Benomyl and Mancozeb used singly, alternately or in combination. Systemic fungicides like Benlate and Derosal were reported to be the most effective in controlling C. lindemuthianum of bean under rainy conditions (Guzman et al., 1979). Giroto (1976) found Derosal-60, Benlate-50 and Saprol-20 to be the most effective against C. lindemuthianum of bean in spray trial at Salta.

Some reports on mungbean are also available. Sharma et al. (1971) reported that the anthracnose of mung and urd caused by C. lindemuthianum can be minimized by spray with PCNBxBenlate. The least disease index was observed in the above treatment. In a spray trial, Khare et al. (1970) reported minimum foliar diseases of mung, when treated with Captan, Zineb, Manzate-D and Fytolan.

Since, the review of literature on different aspect of the disease is scanty, therefore, the present investigation was undertaken with the following objectives :-

1. Collection of seed samples of mungbean from different locations.
2. Testing of the above seed samples by Standard Blotter Method for association of Colletotrichum spp. and other mycoflora.
3. Incidence of anthracnose in different varieties of mung.

4. Isolation, purification and maintenance of anthracnose fungus (C. dematium and C. lindemuthianum).

5. Testing pathogenicity of Colletotrichum spp. by various methods.

6. Survey of anthracnose in ten districts of M.P. with reference to the following aspects :
   (i) Season (ii) Variety (iii) Date of disease appearance
   (iv) Disease intensity (v) Stage of the crop
   (vi) Fertiliser dose (vii) Soil type.

7. To test the influence of following epidemiological factors on the incidence of anthracnose :
   (i) Effect of different varieties.
   (ii) Effect of different dates of sowing.
   (iii) Effect of temperature and humidity on sporulation and spore germination in vitro and in vivo.
   (iv) Effect of temperature, humidity and light on disease development.
   (v) Study on dispersal of spores of Colletotrichum spp. in air trapped on slides.

8. To investigate the influence of anthracnose on the following parameters of host :
   (i) Plant height (ii) Number of branches/plant
   (iii) Shoot weight (iv) Number of pods/plant
   (v) Number of seeds/pod (vi) Yield/plant.

9. Influence of plant population on the incidence of anthracnose in different varieties of mungbean.

10. To study the survival of Colletotrichum spp.

11. To locate the site of infection of Colletotrichum spp. by histopathological study.

12. Influence of fungicide :

(i) Effect of fungicides on the growth, sporulation and colony characters of C. dematium and C.lindemuthianum.

(ii) Influence of fungicide (seed treatment) on the incidence of anthracnose.

(iii) Influence of fungicides (spray trial) on the rate of disease development and yield of mungbean.

(iv) Influence of fungicides on pathogenic fungi in phylloplane.

CHAPTER III

MATERIALS AND METHODS

A. MATERIALS

1. Glasswares

Corning make glasswares were used during the investigation. These glasswares were thoroughly cleaned with detergent powder followed by washing with running tap water. Whenever required the glasswares were sterilized in hot air oven at 180°C for two hours.

The plastic petriplates used for seed health testing were sterilized with formaldehyde solution while all the metallic instruments were sterilized by heating over the flame.

2. Media

The following media were used during the investigation. The constituents of media used are given below :-

i) Potato Dextrose Agar (PDA)

Peeled and sliced potato	-	200 g
Dextrose	-	20 g
Agar Agar	-	20 g
Distilled water	-	1000 ml

ii) Potato Dextrose broth

Peeled and sliced potato	-	200 g
Dextrose	-	20 g
Distilled water	-	1000 ml

iii) Specific media for spore production of Colletotrichum

a) Glucose - 2.80 g
Magnesium sulphate ($MgSO_4.7H2O$) - 1.25 g
Potassium di phosphate (KH_2PO_4) - 2.75 g
Neopeptone - 2.00 g
Agar Agar - 20.00 g
Water - 1000 ml

(Mathur et al., 1960) ??

b) Green bean juice - 215 ml
Agar Agar - 10 g
Distilled water - 1000 ml

(Romanowski and Kuc, 1962)

Media were sterilized in autoclave at 1.05 kg/cm^2 for 15 minutes.

3. Growth chamber

Petriplates containing seeds were incubated in a wooden growth chamber during the course of study to provide optimum conditions for seed germination and growth of mycoflora associated with seeds. The dimensions of the chamber were : length-3.0 m, width-0.75 m, height-0.90 m.

The chamber was furnished inside with two sets of Philips 40 W day light tubes hanging horizontally 40 cm above the seeds. Alternating cycles of 12 hours light and 12 hours dark periods were maintained. One of the sides of the chamber

was provided with a water cooler to maintain the temperature at 28 ± 2°C during summer and to minimize the loss of water from the moist blotting papers placed in petridishes.

4. Sources of material

The seeds of two varieties of mungbean, Pusa Baisakhi and K 851, were obtained from Nucleus Seed Production Scheme, Jabalpur while one variety (J-45) was procured from Department of Plant Pathology, College of Agriculture, Jabalpur.

Seed samples of 29 varieties of mungbean were also obtained from All India Coordinated Pulse Improvement Project, RAK, College of Agriculture, Sehore and Department of Plant Pathology, College of Agriculture, Jabalpur to find the extent of association of Colletotrichum spp. and other mycoflora associated with seeds. Collected seed samples were stored at 4°C.

5. Experimental site

The field experiments were conducted at Dusty Acre Farm, Jabalpur. Observations on the disease incidence were also recorded in the experiment "Effect of different varieties and plant populations on the yield contributing characters of mungbean" conducted by Dr. V.K. Sonakia, Department of Agricultural Botany, at Livestock Farm, Adhartal, Jabalpur.

6. Meteorological data

Data on rainfall, wind velocity, sunshine, relative humidity, maximum and minimum temperature were obtained from the Meteorological Observatory at Adhartal Farm, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur.

7. Statistical analysis

The data of the experiments conducted in the laboratory, pots and field were subjected to statistical analysis. The critical difference was worked out at five per cent probability level to make out the differences between the treatments.

B. METHODS

1. Collection of mungbean seed samples

Twenty nine seed samples of mungbean were collected from different locations in Madhya Pradesh. The major source of collection was the Government Seed Testing Laboratory, Jabalpur. Seed samples from Mandla, Narsinghpur, Raipur and Sehore districts were collected directly from farmer's field.

2. Testing of seed samples for association of mycoflora

All the collected seed samples were tested for the associated mycoflora by standard blotter method as recommended by ISTA (1976). In this method, three circular pieces of white blotting papers of the size of the petridishes (9 cm) were cut. They were dipped in sterilised water, allowed to drain out the

extra water and then placed in each sterilized petridish. Twenty five seeds were placed in each petridish (16 in the outer circle, 8 in the inner circle and 1 in the centre) maintaining equal distance from each other. The petridishes were incubated in the growth chamber. Two hundred seeds were tested without any pre-treatment.

For detection and identification of seed-borne fungi, the seeds in petriplates were examined on the eighth day of incubation under a stereobinocular microscope. Whenever, needed slides were prepared and examined under the compound microscope for fungal identification. The fungi were isolated, purified and maintained as per method described elsewhere.

3. Disease severity

Disease severity of anthracnose was recorded as per cent plant infected and disease index based on the rating of the disease on foliage.

Sixty one entries from Coordinated Varietal Trial (CVT) and Initial Evaluation Trial (IET) were grown in kharif 1985. Sowing was done on eighth July 1985. Each entry was sown in 2.5 m long row with a row to row distance of 40 cm and was replicated twice. A line of anthracnose susceptible cultivar (J-45) was sown after every ten entries of CVT while Pusa Baisakhi and J-45 were used as susceptible checks in IET entries.

Diseese appeared after one month of sowing and reached the peak by 23rd August, 1985.

a) Disease incidence

Number of infected plants were recorded and the incidence of disease was calculated by using the following formula. The average of two replications was calculated :

$$A = \frac{y\ (100)}{x}$$

Where,

A = Disease incidence i.e. per cent plants exhibiting symptoms

y = Total number of infected plants

x = Total number of plants observed

b) Disease index

Disease index was calculated by using 1-9 point scale :

Numerical Ratings	Disease Intensity (%)
1	Free
2	10-20
3	21-30
4	31-40
5	41-50
6	51-60
7	61-70
8	71-80
9	> 80

$$\text{Disease index} = \frac{\text{Sum of numerical values}}{\text{Total number of observations}} \times \frac{100}{9}$$

In 1986, 49 varieties were sown of which 22 were new while rest were repeatition of previous years entries. Fifteen entries of CVT and 34 of IET were sown on 6th July, 1986. Each entry was sown in 3 m long row with 30 cm row to row distance and replicated twice. Variety J-45 was used as susceptible check for monitoring the disease severity at borders of the plot.

Disease appeared on 22nd July, 1986 and became severe by 14th August, 1986. From this period observations on percentage of plant infection and disease intensity were recorded. On the basis of disease severity cultivars were grouped into following classes :-

1. Varieties having no infection - Highly resistant (HR)
2. Disease index from 1-5% - Resistant (R)
3. Disease index from 6-10% - Moderately resistant (MR)
4. Disease index from 11-25% - Moderately susceptible (MS)
5. Disease index > 25% - Susceptible (S)

4. <u>Isolation, purification and maintenance of fungus</u>

Leaves, stems and pods exhibiting the symptoms of anthracnose were collected from experimental crop during kharif 1985 and 1986, and brought to the laboratory for isolation.

The entire work of isolation was carried out in an inoculation chamber. Prior to use, the chamber was sterilized.

The diseased plant parts were cut into small pieces, surface sterilized with 0.1 per cent mercuric chloride solution for one minute followed by three washings with sterile water and then they were placed in petridishes containing 20 ml of solidified PDA mixed with small quantity of streptomycin sulphate to avoid bacterial contamination. The plates were incubated at 25 ± 1°C. Developing fungi were subcultured, purified and identified with the help of key (Kulshreshtha et al., 1976). Fungi obtained from different plant parts as well as seed were purified by single spore technique and cultures were maintained on PDA in liquid paraffin. The culture tubes were labelled and stored in refrigerator.

5. Pathogenicity test

Pure culture was used for testing the pathogenicity by :-

i) Seed infestation

ii) Seedling inoculation

iii) Detached leaf technique

iv) Soil infestation

i) Seed infestation

Pretreated seeds of the pathogen free seed sample were soaked in sterilized water for four hours and then inoculated by rolling them on actively growing and heavily sporulated culture of the fungus. Ten infested seeds were placed in each petridish containing three moist blotters. One hundred seeds

were used in each case. Uninfested seeds were used for checks. The plates were incubated in growth chamber for seven days after which they were examined for infection.

ii) Seedling inoculation

In this method, leaves and pods of the growing plants were injured by scratching with needle after washing them with sterile water. A bit of pure culture was placed on the wounded surface which was then sealed by using cotton swab for providing moist conditions. Inoculated plants were covered by polythene bags.

iii) Detached leaf technique

The detached leaves of various age groups were washed with sterile water, placed in moist chamber and then inoculated by a 5 mm disc of C. dematium and C.lindemuthianum. The moist chambers were prepared by placing slides on glass rods kept in petridishes lined with three layers of moist blotting papers. The moist chambers with inoculated leaves were kept in incubation chamber at 25°C temperature for 10 days. The fungus was reisolated after development of symptoms on inoculated leaf.

iv) Soil infestation

Inoculum of the test fungus was grown in 250 ml Erlenmeyer conical flasks, each containing 150 ml Potato Dextrose broth. A 5 mm disc of seven day old culture of

the fungus was transferred in each flask and incubated at 25°C for 10 days. After incubation, the mycelial mat was sieved and thoroughly washed with sterilized water and then mixed in sterilized soil at the rate of growth of one flask in 200 g of soil. The infested soil was filled in sterilized plastic pots (20 cm diameter). Ten pots were used for each treatment. The fungus was allowed to grow at room temperature for two days. Ten surface sterilized seeds of the healthy seed sample were grown in each pot. Ten pots with uninfested but sterilized soil served as control. Observations were recorded on percentage emergence and pre-and post-emergence mortality after ten days. Isolations were made from the infected seeds and seedlings for the association of C. lindemuthianum for confirmation.

6. Survey

Survey to study the severity of anthracnose caused by C. dematium and C. lindemuthianum was conducted in ten districts - Betul, Hoshangabed, Jabalpur, Khargone, Khandwa, Mandla, Narsinghpur, Sehore, Seoni and Vidisha. Field of mungbean were selected randomly. Observations on diseased plants were noted at five randomly selected spots in each field. At each spot observations were made on 100 plants and number of diseased plants were noted. The infomation regarding selected field was recorded in the following proforma and representative diseased plant samples were collected for further study.

the fungus was transferred in each flask and incubated at 25°c for 10 days. After incubation, the mycelial mat was sieved and thoroughly washed with sterilized water and then mixed in sterilized soil at the rate of growth of one flask in 200 g of soil. The infested soil was filled in sterilized plastic pots (20 cm diameter). Ten pots were used for each treatment. The fungus was allowed to grow at room temperature for two days. Ten surface sterilized seeds of the healthy seed sample were grown in each pot. Ten pots with uninfested but sterilized soil served as control. Observations were recorded on percentage emergence and pre-and post-emergence mortality after ten days. Isolations were made from the infected seeds and seedlings for the association of C. lindemuthianum for confirmation.

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ANTHRACNOSE OF MUNGBEAN
(Information - Sheet)

1. Date .....
2. District .....
3. Location of field .....
4. Stage of crop .....
5. Diseased plants out of 100 plants at each of the five spots in a field
6. Fertilizer dose .....
7. Soil type .....
8. Any other information .....

The average disease incidence was calculated by applying the following formula derived by Agrawal (1985) on the basis of Naumov's formula of infection (Naumov, 1958).

i) Average disease incidence in a field = $F = \frac{PN'}{N}$

ii) Average disease incidence in a district = $D = \frac{F}{M}$

Where,

P = Degree of disease in a plant

N' = Number of diseased plants in a field at five spots

N = Total plants observed in a field at five spots

F = Sum of 'F' values of infected fields in a district

M = Total number of field having infected and uninfected plants observed in the district

7. Influence of epidemiological factors on the disease intensity

An experiment was conducted to study the effect of different varieties, dates of sowing and their interaction in relation to environmental factors on the intensity of anthracnose.

Details of the experiment

1.	Design	:	Split-plot design
2.	Treatments	:	Nine (Three varieties - J-45, Pusa Baisakhi and K 851 Three dates of sowing - 23rd June, 3rd July and 13th July 1986)
3.	Replications	:	Four
4.	Total number of plots	:	36
5.	Row to row distance	:	40 cm
6.	Total number of rows/plot	:	Five
7.	Total area	:	26.2 x 12 sq. m
8.	Net area	:	19.2 x 9 sq. m
9.	Area of the plot	:	3 x 1.6 sq. m
10.	Observation recorded:		

i) Disease index
ii) Plant height
iii) Number of branches/plant
iv) Shoot weight
v) Number of pods/plant
vi) Number of seeds/pod
vii) Yield/plant and/plot

11. Date of picking : i) 4th September 1986
ii) 10th September 1986
iii) 22nd September 1986

The progress of the disease on different varieties sown on different dates were recorded along with data on the rainfall in mm/day, intensity of rains, maximum and minimum temperatures (°C) and relative humidity (%) and average values for periods of three days were calculated.

The statistical analysis was done to find correlation between dependent variables like disease index with independent variables like rainfall, maximum and minimum temperature and relative humidity (M and N) as per standard method. Karl pearson's coefficient of correlation (r) was calculated for each. Significance of 'r' was tested by computing 't' values.

7.1 Factors affecting sporulation on host

Effect of temperature, relative humidity and age of the host was studied on sporulation of Colletotrichum spp. on host. Small leaf pieces having characteristic lesion of 10x10 mm were selected. These pieces were washed carefully in sterile water with the help of fine brush and incubated at different temperature (20, 22, 25, 27 and 30°C) and humidity levels (25, 50, 75, 90 and 100%). After 48 hours of incubation, each leaf piece was suspended in 10 ml of sterile water and number of spores/0.01 ml of suspension was recorded using haemocytometer. Effect of age of the host on sporulation was also studied. Lesion of similar size on leaves of different age

groups (22, 30, 40, 50 and 60 days old crop) were evaluated for sporulation following the procedure as described above.

7.2 Factors affecting germination of spores

Conidia taken from fungal colony growing on PDA were tested for their germination. Cavity slide method was employed for this purpose. Conidial suspension was prepared in sterile water in culture tubes and standardized so as to have about 15 conidia/microscopic field under 100x. One ml of conidial suspension was placed in each of the two cavities of each slide. Four replications were kept for each treatment, cavity slides were kept on glass rods placed in petriplates lined with moist blotters. The data on spore germination were recorded at an interval of one hour after setting the experiment.

With a view to see the effect of temperature the petridishes with cavity slides containing spore suspension were kept at 20, 22, 25, 27 and 30°c.

Five relative humidity levels 25, 50, 75, 90 and 100 per cent were used to find out the effect of relative humidity on spore germination. These humidity levels were maintained by using concentrated H_2SO_4 and distilled water in the following proportions :

Humidity level	H_2SO_4	Distilled water
25% RH	54 ml	46 ml
50% RH	42 ml	58 ml
75% RH	30 ml	70 ml
90% RH	5 ml	95 ml
100% RH	0 ml	100 ml

These mixtures were filled in dessiccators in which cavity slides with spore suspension were kept using glass rods for their support.

7.3 Factors affecting development of the disease

An experiment was conducted to study the effect of temperature, humidity and light on the development of the disease.

Leaf portions having small and developing lesions were selected and the size of each lesion was measured. They were then placed in moist chambers which were incubated at different levels of temperature - 20, 22, 25, 27 and 30°C and humidity (25, 50, 75, 90 and 100%). Increase in size of the lesion was recorded after 72 hours of incubation.

To study the effect of light the leaves with measured lesions were placed under different light intensities for 72 hours as follows :

1. Continuous darkness

2. Alternate light (having day light tube of 40 W Philips) and dark period of 12 hours each.
3. Continuous exposure to light.

After 72 hours of incubation increase in size of the lesion was recorded.

7.4 Local dissemination of the pathogen

To study the local dissemination of the pathogen, an experiment was conducted under field conditions. Microslides coated with a very thin layer of vaseline were exposed in mungbean field facing the wind direction. Slides were exposed from 7.00 AM to 12.00 Noon and 12.00 Noon to 5.00 PM, and then were observed under compound microscope. The number of spores of Colletotrichum spp. was recorded per 6 cm^2 area.

8. Effect of disease on host

Effect of anthracnose on various parameters of the host plant was studied in different varieties. Seventeen varieties of mungbean were observed for the assessment of losses caused by anthracnose. Each variety was sown in 3 m long row and observations were recorded on ten randomly selected plants in each row. Observations were also recorded on three varieties (J-45, Pusa Baisakhi and K 851) sown at different dates.

The percentage reduction in various growth parameters of host plant and reduction per unit of disease index was

observed. Observations on height, branching and fresh shoot weight were recorded on five diseased and five healthy plants selected randomly in each row. These observations were recorded at the time of pod formation.

In another set, five diseased and five healthy plants were tagged randomly in each row and used for recording number of pods/plant, number of seeds/pod and seed yield/plant.

8.1 Height of plant

Height of each plant was recorded in cm from base to tip of the main stem of the plant and mean height of five plants was calculated in each row for healthy and diseased plants separately.

8.2 Number of branches per plant

Number of branches borne on the main stem were noted and mean number of branches of five plants was calculated.

8.3 Biomass of plant

Five healthy and five diseased plants were uprooted carefully so as to avoid breakage of root. Root and shoot of each plant were separated by cutting it at the base line i.e. at the soil level. Shoots separated from roots were immediately used for further observations.

8.3.1 Shoot weight

Weight of shoot of five plants was recorded and means for healthy and diseased plants were calculated separately.

8.4 Number of pods per plant

Number of pods in each of the plant of second set were counted at the time of maturity and means of five plants were calculated.

8.5 Number of seeds per pod

Number of seeds/pod/plant were counted at maturity and means of five plants were calculated.

8.6 Yield per plant

Average yield of five plants was recorded in gram.

9. Influence of plant population on disease

Effect of plant population on the incidence of anthracnose in three varieties of mungbean was studied. Field trial was conducted with the following details :-

1.	Design	: Split-plot design
2.	Treatments	: 15 (Three varieties - J-45, Pusa Baisakhi and PS-16 and five plant populations - 4, 6, 8, 10 and 12 lacs/ha)
3.	Replications	: Three
4.	Plot size	: 5 m x 3 m
5.	Spacing	: Row to row 30 cm
6.	Fertilizer	: 20:40:0 (N:P:K)
7.	Sowing date	: 4-7-1986
8.	Picking	: i) 18-9-1986 ii) 24-9-1986

Observations

Observations on disease incidence were recorded by selecting three rows of one sq. meter area in each plot. The infection of plants caused by C. dematium and C. lindemuthianum in three varieties : Pusa Baisakhi (V_1), J-45 (V_2), PS-16 (V_3) and five plant populations : 4 lacs/ha (P_1), 6 lacs/ha (P_2), 8 lacs/ha (P_3), 10 lacs/ha (P_4), 12 lacs/ha (P_5) was estimated by counting the total number of healthy and infected plants/three rows in one sq. meter area/plot. Percentage of infection was calculated by the formula :

$$A = \frac{Y\ (100)}{x}$$

Where,

A = Per cent plants exhibiting symptoms

Y = Number of infected plants

x = Total number of plants observed

10. Survival of the pathogen on crop residues and collateral host

Survival of Colletotrichum spp. on crop residues and collateral hosts was studied.

10.1 Survival on crop residues

Survival of Colletotrichum spp. on crop residues of mungbean was studied. The crop residues i.e. leaves, stems and pods of mungbean were collected from the standing crop

sown in 1985 after harvesting. These crop residues were mixed with sterilized soil filled in the sterilized pots of 60 cm size and left as such till the commencement of next season. Suitable check was kept in which no crop residues were mixed in the soil. In each of the pot, 50 g of crop residue i.e. leaves, stems and pods were incorporated on the surface of the soil. Thus, nine pots were taken for sowing of each variety. Four varieties along with a check (J-45) were sown in 45 pots. Twenty five pretreated seeds/ pot were sown on 8th July, 1986 and observations on percentage of plant infection was recorded after one month of sowing.

10.2 Survival on pods and seeds of mungbean

Naturally infected pods of four varieties of mungbean were collected from the field during kharif 1985. Collected pods were kept in refrigerator at 4°C for one year. After completion of one year, pods and seeds were examined by agar plate method for the presence of Colletotrichum spp. Pod pieces sterilized with 0.1% $HgCl_2$ were placed on PDA medium and incubated at 25°C for seven days. Then, the plates were observed for the presence of Colletotrichum spp. seeds from the same pod were also tested by agar plate method for association of Colletotrichum spp. Observations on percentage of Colletotrichum spp. associated with pods and seeds were recorded.

10.3 Survival on collateral hosts

To find out the possibility of survival of the pathogen on collateral hosts, eight host species were inoculated with the pathogen by detached leaf technique. In this method, culture disc of 5 mm diameter was placed in the centre of upper and lower surface of the leaf on slides in petriplates. Water was added in petriplates to provide moisture to the leaves. Slides were placed in petriplates over glass rods. Petriplates were kept for incubation at 25°C for 10 days. Whenever the symptoms appeared, isolations were made from the diseased portion and infection of the leaf was recorded.

Conidial suspension was also sprayed on leaves by atomizer and the leaves were kept in petriplates. The symptoms were observed and isolation was made.

Cross inoculation study was also made. The mungbean isolate of C. dematium was inoculated on the leaves of Baugainvillea. Similarly, pure culture of C. dematium from naturally infected leaves of Baugainvillea spp. was obtained and inoculated on the leaves of mungbean.

11. Histopathological study

To locate the site of infection of C. lindemuthianum and C. dematium in mungbean seeds pods having infection of anthracnose were cut along with seeds by microtome and processed by the technique of Johanson (1940).

Pieces of infected mungbean pods were fixed in formaline aceto alcohol (FAA) and passed through the series of -

i) 70%, 90% and absolute alcohol (2 times)

ii) 15% xylene + 85% alcohol, 25% xylene + 75% alcohol, 50% xylene + 50% alcohol, 75% xylene + 25% alcohol, 85% xylene + 15% alcohol and then 2 times in pure xylene.

Infiltration, embedding, section cutting by hand rotary microtome and staining of sections with safranin and fast green was done as per standard procedure. Sections were mounted on slide in Canada balsam and examined under microscope for histopathological studies.

12. Influence of fungicides

Experiments were conducted to control the disease by using fungicides.

12.1 Fungicides

Fungicides were tested in laboratory against the pathogen *in vitro* and spray trial was conducted in field.

12.1.1 *In vitro* testing of fungicides

Poisoned food technique was followed for the study. (Falck 1930) Fungicides were incorporated in PDA after sterilization @ 1000, 1500, 2500 and 3000 ppm concentrations. Three replications were maintained. Petridishes were incubated at 25 ± 1°C. Observations on mean radial growth, inhibition

percentage sporulation and colony characters of both C.dematium and C. lindemuthianum were recorded after seven days of inoculation. Following fungicides were included in the test :

Fungicides		Chemical name
Benomyl	-	Methyl-N-(1-Butylcarbamoyl)-2-benzimidazole carbamate
Carbendazim	-	Methyl-2-benzimidazole carbamate
Captan	-	N-(Trichloromethyl) thio-4-cyclohexane-1,2-dicarboximide
Captafol	-	N-1,1,2,2-tetrachloroethyl thio-cis-4-cyclohexane-1,2 dicarboximide
Blitox-50	-	Copper oxychloride
Mancozeb	-	Zinc ions+manganese ethylenebisdithiocarbamate
Zineb	-	Zinc ethylenebisdithiocarbamate
Thiophanate-methyl	-	1,2-bis (3-methoxycarbonyl-2-thioureido) benzene
Triforine	-	N,N'-bis (1-formamido-2,2,2-trichloroethyl)-piperazine
Carboxin	-	5,6-dihydro-2-methyl 1-1,4-oxathiin-3-carboxanilide
TMTD	-	Tetramethylthiuram disulphide

12.2 Seed treatment trial

Nine fungicides - Agrozim (0.25%), Benomyl (0.15%), Captan (0.25%), Carbendazim-1 (0.1%), Carbendazim-2 (0.1%), Derosol (0.15%), TMTD (0.25%), Thiophanate methyl (0.15%) and Carboxin (0.15%) were used for treating the seeds of

mungbean (J-45). The seeds after treatment were sown in the field on 10th July, 1986 in a single row of 3 m long replicated twice with row to row distance of 30 cm. Observations on disease incidence were recorded from seedling to maturity stage.

12.3 Fungicide spray trial

An experiment was conducted to find suitable fungicides for the control of anthracnose caused by C. dematium and C. lindemuthianum in the field. The experimental details are :

1.	Design	-	Completely Randomized Block Design
2.	Treatments	-	Eight
3.	Replications	-	Three
4.	Variety	-	Pusa Baisakhi
5.	Total area	-	16.3 x 12 sq. m
6.	Net area	-	12.8 x 9 sq. m
7.	Plot size	-	3 x 1.6 sq. m
8.	Total number of plots	-	24
9.	Date of sowing	-	28.6.1986
10.	Fungicides used	-	Benomyl (0.15%), Carbendazim (0.1%), Captafol (0.25%), Copper oxychloride (0.3%), Mancozeb (0.25%), Zineb (0.25%), Triforine (0.15%)
11.	Number of sprays	-	Three (i) 27.7.1986 (ii) 12.8.1986 (iii) 27.8.1986
12.	Observations recorded	-	(i) Disease index (ii) Yield/plot (iii) Mycoflora associated with phylloplane

12.4 Influence of fungicides on the incidence of pathogenic fungi in phylloplane

Influence of fungicides on other foliar diseases was also recorded. Leaves exhibiting the symptoms of various diseases were collected from sprayed plot and observed for the presence of pathogenic fungi in phylloplane.

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CHAPTER IV

EXPERIMENTAL FINDINGS

EXPERIMENTAL FINDINGS

1. Association of Colletotrichum spp. and other fungi with mungbean seeds collected from different locations

Twenty nine seed samples of mungbean from the harvest of kharif 1985 were collected from 29 places of Madhya Pradesh and tested by standard blotter method. The seeds were tested without pre-treatment and the association of Colletotrichum spp. and other fungi was observed and presented in Table 1.

It is clear from Table 1 that none of the samples revealed the Colletotrichum spp. except Sehore-1 in which the association of C. lindemuthianum was only two per cent. As regards the other fungi, in all 21 fungi were found associated with the seed samples. The maximum number of total fungi (124) were found associated with Sehore Local-7 while sample 2, 10, 11 and 29 (Tikamgarh-1 and Indore-2) did not reveal the association of any fungus. Out of 22 fungi recorded Botrytis cinerea (654), Aspergillus niger (103), Aspergillus spp. (304), Penicillium spp. (142) and Fusarium solani (123) were predominant while some fungi such as Colletotrichum spp. (2), Fusarium moniliforme (5), Chaetomium sp. (6), Stachybotrys sp. (6), Curvularia lunata (7) and F. oxysporum (9) were less frequent. The germination percentage of seeds ranged between 28 to 98.

Table 1. Association of Colletotrichum Spp. and other fungi with mungbean seeds from different locations in Madhya Pradesh (Standard Blotter Method) (in %)

S. No.	Source of collection	Germination percentage	MYCOFLORA																						Total
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
1.	Bhopal-1	98	0	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	38
2.	Bhopal-2	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.	Khargone	96	0	0	0	3	0	16	12	0	0	0	0	0	0	0	0	0	0	0	6	0	0	4	41
4.	Khandwa-1	96	0	0	2	20	0	10	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	52
5.	Khandwa-2	95	0	0	2	13	1	8	3	0	0	1	0	0	3	2	0	0	0	0	4	1	0	6	44
6.	Narsingpur	95	0	3	0	30	4	9	4	0	0	0	0	0	2	0	0	0	0	0	5	0	0	13	70
7.	Chhindwara	88	2	0	0	13	0	8	22	0	0	0	0	0	0	0	0	3	0	0	2	0	0	10	60
8.	Raipur-1	92	0	2	0	18	0	25	10	0	0	0	0	0	0	0	0	5	0	0	0	0	0	8	68
9.	Raipur-2	57	0	0	1	23	0	0	29	0	0	0	0	0	0	0	1	10	0	0	2	1	0	9	76
10.	Teekamgarh-1	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11.	Teekamgarh-2	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.	Teekamgarh-3	78	8	6	0	20	0	6	0	0	0	3	0	0	0	16	0	0	0	4	8	0	0	8	79
13.	Teekamgarh-4	88	6	0	0	14	0	6	6	0	0	0	0	0	0	14	2	0	0	4	6	0	0	4	62
14.	Teekamgarh-5	40	4	8	1	22	0	0	6	6	0	0	0	4	8	43	4	0	0	0	8	0	0	0	114
15.	Jabalpur-1	83	1	0	3	28	0	1	5	0	0	1	0	0	2	1	1	0	2	0	6	0	0	2	53
16.	Jabalpur-2	92	0	2	0	19	1	12	6	0	0	0	0	0	0	0	0	1	0	0	6	0	0	0	47
17.	Jabalpur-3	56	0	0	0	4	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
18.	Mandla	47	0	0	0	0	0	0	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98
19.	Sehore -1	44	0	4	0	0	0	1	6	0	2	0	4	3	8	12	0	9	6	0	1	0	0	0	57
20.	Sehore Local-1	28	0	0	0	0	0	0	72	0	0	0	0	0	0	4	0	0	0	0	0	0	14	0	90
21.	Sehore Local-2	50	0	4	0	0	0	0	46	0	0	0	0	0	0	0	0	0	0	6	0	0	3	0	59
22.	Sehore Local-3	45	0	0	0	0	0	0	68	0	0	0	0	0	3	0	0	0	0	6	0	0	0	0	77
23.	Sehore Local-4	52	0	0	0	0	0	0	48	0	0	0	0	0	0	4	0	0	0	0	0	0	8	0	60
24.	Sehore Local-5	52	0	4	0	0	0	0	75	0	0	0	0	0	0	4	4	0	4	4	0	4	4	0	103
25.	Sehore Local-6	36	0	3	0	0	0	0	88	0	0	0	0	0	0	4	0	0	8	6	0	0	0	0	109
26.	Sehore Local-7	92	0	0	0	42	19	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	58	124
27.	Sehore Local-8	32	0	4	4	9	0	1	17	0	0	2	1	0	0	19	1	0	0	6	2	0	0	3	81
28.	Indore-1	66	0	0	0	4	0	0	0	0	0	0	0	2	4	0	2	0	0	3	2	0	0	1	23
29.	Indore-2	98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total		21	40	13	334	16	103	654	6	2	7	5	9	39	123	15	32	20	44	58	6	29	142	

1. Aerenomium Spp.
2. Alternaria Spp.
3. Alternaria alternata
4. Aspergillus Spp.
5. A. flavus
6. A. niger
7. Botrytis cinerea
8. Choetomium Spp.
9. Colletotrichum lindemuthianum
10. Curvularia lunata
11. F. moniliforme
12. F. Oxysporum
13. F. acuminatum
14. F. solani
15. Macrophomina phaseolina
16. Paecilomyces Spp.
17. Pithomyces Spp.
18. Phoma Spp.
19. Rhizopus Spp.
20. Stachybotrybis spp.
21. Trichothecium spp.
22. Penicillium spp. - Penicillium spp

2. Colletotrichum spp. and other fungi associated with seeds of mungbean varieties

The data on the association of Colletotrichum spp. and other mycoflora with seeds of 29 varieties of mungbean are presented in Table 2.

The data clearly indicate that Colletotrichum spp. were not associated with seeds of any of the mungbean varieties. Eighteen fungi were recorded from 29 varieties of mungbean. The maximum number of total fungi (108) was recorded in ML-325 while minimum (3) in RM-956. The data further indicate a direct relation between association of mycoflora and germination percentage. In most of the varieties as the association of mycoflora increased, there was a gradual decrease in the germination percentage of seeds.

The seeds of most of the varieties revealed the association of Aspergillus spp. as compared to other mycoflora.

3. Severity of anthracnose on mungbean varieties

3.1 Incidence and intensity of anthracnose in mungbean varieties during 1985

Thirty four varieties of mungbean sown during kharif 1985 were examined for the severity of anthracnose and the data are given in Table 3. It is evident from the data that the response of the varieties to the disease varied. Further, no variety exhibited resistant reaction. Only one variety RMG-52 was moderately resistant; 21 varieties were moderately susceptible and rest of the varieties were susceptible. The percentage of plant infection (disease incidence) ranged from 8.69 (TBU-1) to 100 (Mung-1).

Table 2. Colletotrichum Spp. and other fungi associated with seeds of mungbean varieties (Standard Blotter Method) (in %).

S. No.	Varieties	Germination percentage	Mycoflora 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
1.	GHC-47	70	0	0	0	20	0	0	0	0	0	0	10	0	0	3	3	8	0	4	49
2.	ML-5	44	0	0	0	0	0	4	0	0	0	0	8	18	0	0	6	0	0	0	35
3.	ML-31	64	0	9	0	0	0	5	0	0	0	6	12	3	4	0	16	0	0	0	57
4.	ML-131	84	0	0	0	20	0	0	4	0	0	0	7	0	0	0	0	48	0	0	79
5.	ML-370	76	0	0	4	34	8	0	9	3	0	0	12	0	0	0	0	28	0	0	96
6.	ML-323	86	0	0	0	10	8	0	0	0	0	0	8	0	0	8	0	0	0	12	46
7.	ML-325	72	0	0	0	38	18	0	7	3	0	0	0	0	0	10	8	18	0	6	108
8.	ML-382	92	3	0	0	45	4	8	0	0	0	4	2	0	0	0	0	18	0	3	87
9.	ML-371	74	6	3	0	18	0	0	0	2	0	0	3	0	0	0	0	0	0	4	30
10.	ML-384	82	0	2	0	36	0	0	2	0	0	0	3	0	0	0	4	0	0	0	47
11.	BMG-52	92	0	0	0	56	10	0	0	0	0	0	0	0	0	0	0	11	0	9	86
12.	BMG-62	78	0	0	0	48	0	0	0	0	0	0	0	0	0	0	0	0	0	14	62
13.	BMG-11	86	0	0	0	36	0	0	0	0	0	0	0	0	0	0	0	3	0	0	39
14.	BMG-70	82	0	0	0	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36
15.	PDM-84-139	80	0	0	0	12	3	12	6	0	0	3	0	0	0	4	0	0	4	0	44
16.	PDM-84-145	88	0	0	0	22	0	2	0	0	0	0	0	0	0	0	0	12	0	0	36
17.	PDM-84-146	80	0	0	0	20	4	6	0	0	0	0	0	0	0	0	0	0	0	0	30
18.	M4-956	92	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3
19.	Mung-1	62	0	0	0	28	0	0	0	0	22	0	11	0	0	0	0	8	4	0	63
20.	Mung-2	77	0	0	0	58	0	3	2	0	0	0	0	0	0	0	0	16	0	0	79
21.	MUG-140	62	0	0	0	25	0	0	3	0	0	0	2	0	0	0	3	4	0	4	43
22.	MUG-9126	78	0	0	0	36	0	6	6	0	0	0	0	0	0	0	2	3	0	26	79
23.	MH-81-7	68	0	0	0	60	0	0	0	0	0	0	2	0	0	0	2	12	0	0	76
24.	ML-395	80	0	0	0	18	0	4	0	0	0	0	2	0	0	0	0	12	0	2	38
25.	TOM-20	92	0	0	0	18	0	0	0	0	0	0	00	0	0	0	0	0	0	6	24
26.	PS-5	28	0	5	0	0	0	6	0	0	0	15	18	4	4	0	12	8	0	0	72
27.	Pant-U-2	38	0	5	0	0	4	0	0	0	0	10	18	4	0	0	18	0	0	0	55
28.	V_1-851	50	0	4	0	0	0	4	3	0	4	7	12	0	0	0	0	0	0	0	34
29.	SR-16	94	0	0	0	16	2	0	0	0	0	0	0	0	0	2	0	0	0	8	38
	Total		3	28	4	710	61	60	32	8	16	45	130	27	11	27	74	209	8	98	

1. Acremonium Spp.
2. Alternaria Spp.
3. Alternaria alternata
4. Aspergillus Spp.
5. A. niger
6. Botrytis cinerea
7. Curvularia lunata
8. Drechslera spp.
9. Fusarium oxysporum
10. F. semitectum
11. F. solani
12. Macrophomina phaseolina
13. 14 Paecilomyces Spp.
15. Phoma Spp.
16. Rhizopus Spp.
17. Trichothecium Spp.
18. Penicillium Spp.

Table 3 : Incidence and intensity of anthracnose in mungbean varieties during 1985

S. No.	Varieties	Plant infection (%)	Disease intensity	Reaction
1.	MH-85-20	66.66	18.87	MS
2.	MH-83-24	70.27	10.16	MS
3.	MH-309	65.71	12.91	MS
4.	O-UM-6	42.10	13.86	MS
5.	Pusa-100	22.22	13.63	MS
6.	RMG-56	25.00	19.36	MS
7.	RMG-62	36.00	22.61	MS
8.	RMG-52	10.63	9.67	MR
9.	RMG-70	77.27	27.66	S
10.	SR-22	41.66	21.22	MS
11.	SR-16	61.90	21.32	MS
12.	RMG-11	13.79	10.64	MS
13.	TBU-1	8.69	15.77	MS
14.	TAM-20	62.16	19.99	MS
15.	TT-2E	54.54	14.66	MS
16.	UPM-82-4	60.86	27.62	S
17.	UPM-83-3	52.38	30.61	S
18.	UPM-83-4	35.29	15.54	MS
19.	ML-47	68.96	25.67	S
20.	ML-370	46.66	19.99	MS
21.	ML-354	41.86	15.38	MS
22.	MUG-126	55.88	30.00	S
23.	Mung-1	100.00	39.66	S
24.	Mung-2	21.05	14.37	MS
25.	TOM(SRI)	85.00	18.37	MS
26.	PDM-73	45.83	23.33	MS
27.	PDM-84-128	59.37	19.80	MS
28.	PDM-84-142	63.63	31.82	MS
29.	PDM-88	60.00	27.82	S
30.	PDM-89	43.47	25.50	S
31.	PDM-94	63.33	26.66	S
32.	PDM-113	68.18	33.43	S
33.	UPM-83-10	76.92	28.77	S
34.	Pusa Baisakhi(Check)	59.67	32.44	S

3.2 Incidence and intensity of anthracnose in mungbean varieties during 1986

In kharif 1986, 22 varieties of mungbean were sown and the data on the intensity of anthracnose were recorded and presented in Table 4.

From the data it is clear that mungbean varieties showed all types of reactions for anthracnose. Four varieties- Pusa 101, Pusa 103, SR-14 and 11/395 were highly resistant to anthracnose. Pusa 108 was observed to be resistant while PDM-62 and SR-17 was moderately resistant. Eleven varieties - MH-304, PDM-84-143, Phule MX, DM-5, GM-82-4, ML-320, ML-405, ML-406, ML-408, 76/19 and 76/22 were moderately susceptible while four varieties - DM-1, MH-83-20, PDM-84 and J-45 were susceptible. In general, the incidence of anthracnose (percentage plant infection) varied from 0.00 to 87.23.

3.3 Incidence and intensity of anthracnose in mungbean varieties during 1985 and 1986

Observations on disease incidence and intensity of anthracnose caused by C. dematium and C. lindemuthianum were recorded in 27 varieties of mungbean planted during 1985 and 1986 season. The data are presented in Table 5.

The observations indicate that only one variety i.e. Pusa-109 was found highly resistant to anthracnose among 27 varieties tested during the year 1985 as well as 1986.

Table 4 : Incidence and intensity of anthracnose in mungbean varieties during 1986

S. No.	Varieties	Percentage plant infection	Disease intensity	Reaction
1.	DM-1	69.00	34.00	S
2.	MH-304	40.45	23.56	MS
3.	MH-83-20	50.55	29.11	S
4.	PDM-62	23.33	7.25	MR
5.	PDM-84-143	40.92	19.84	MS
6.	Phule MI	50.00	18.63	MS
7.	Pusa-101	0.00	0.00	HR
8.	Pusa-103	0.00	0.00	HR
9.	Pusa-108	7.08	3.03	R
10.	SR-14	0.00	0.00	HR
11.	SR-17	30.33	7.26	MR
12.	11/395	0.00	0.00	HR
13.	LM-5	32.33	15.52	MS
14.	GM-82-4	40.85	18.36	MS
15.	ML-320	60.63	20.40	MS
16.	ML-405	39.62	19.13	MS
17.	ML-406	47.82	17.28	MS
18.	ML-408	40.00	21.62	MS
19.	PDM-84	66.66	35.74	S
20.	76/19	57.63	22.50	MS
21.	76/22	55.66	17.14	MS
22.	J-45 (Check)	87.23	44.28	S

Table 5 : Incidence of anthracnose in mungbean varieties

S. No.	Varieties	Plant infection(%) 1985	Plant infection(%) 1986	Disease intensity 1985	Disease intensity 1986	Reaction 1985	Reaction 1986
1.	J-45 (Check)	98.42	80.38	43.55	43.62	S	S
2.	MH-83-21	64.47	38.33	12.43	32.30	MS	S
3.	MH-83-22	75.00	32.68	19.24	21.36	MS	MS
4.	MH-83-23	62.85	35.66	14.53	21.69	MS	MS
5.	ML-5	66.66	60.08	16.27	32.67	MS	S
6.	ML-131	65.90	15.00	10.85	16.17	MS	MS
7.	ML-322	85.71	36.66	41.78	17.19	S	MS
8.	ML-326	51.11	36.36	8.14	16.93	MR	MS
9.	ML-337	48.00	38.22	17.88	24.78	MS	MS
10.	ML-353	6.97	46.32	2.56	18.40	R	MS
11.	ML-371	40.74	68.70	14.75	30.69	MS	S
12.	MUG-125	38.23	49.33	15.33	19.23	MS	MS
13.	MUG-140	31.25	33.33	15.03	17.72	MS	MS
14.	PDM-14	12.00	35.55	13.72	20.32	MS	MS
15.	PDM-54	23.33	28.78	10.74	9.63	MS	MR
16.	Pusa-109	58.33	0.00	25.65	0.00	S	HR
17.	Pusa-115	14.28	10.00	13.63	4.53	MS	R
18.	Pusa-117	73.68	25.68	18.36	7.43	MS	MR
19.	ML-323	85.36	56.63	28.00	16.33	S	MS
20.	ML-325	83.87	20.36	22.65	16.36	MS	MS
21.	ML-382	13.33	30.63	11.12	15.38	MS	MS
22.	ML-395	60.46	70.00	17.08	26.86	MS	S
23.	MH-81-7	56.25	43.33	27.62	23.44	S	MS
24.	PDM-84-139	56.25	59.62	19.67	45.42	MS	S
25.	PDM-84-145	60.00	50.00	22.45	21.83	MS	MS
26.	PDM-84-146	82.35	49.55	27.72	30.32	MS	S
27.	PDM-116	83.33	55.03	30.84	33.69	S	S

Rest of the varieties exhibited varied reaction to anthracnose. Only two varieties (ML-353 in 1985 and Pusa-115 in 1986) were found resistant; three varieties (ML-326 in 1985 and PDM-54, Pusa-117in 1986) were moderatoly resistant; ten varieties - MH-83-22, 23, ML-131, ML-337, MUG-125, MUG-140, PDM-14, ML-325, ML-382 and PDM-84-145 were moderately susceptible; two varieties (J-45 and PDM-116) were susceptible during both the years. The varieties MH-83-21, ML-5, ML-371, ML-395, PDM-84-139 and PDM-84-146 which were moderately susceptible in 1985 were susceptible in 1986 and the varieties ML-322, ML-323 and MH-81-7 which were susceptible in 1985 were moderately susceptible in 1986. Varieties Pusa-115 and Pusa-117 which was moderately susceptible in 1985 gave moderately resistant reaction in 1986, whereas, Pusa-115 which was moderately susceptible found resistant in 1986. On the contrary ML-326 which was moderately resistant and ML-353 which was resistant in 1985 gave moderately susceptible reaction in 1986.

In general, the plant infection during 1985 was more severe than in 1986. In 1985, the incidence of anthracnose varied from 6.97 (ML-353) to 98.42 (J-45) per cent while in 1986 it varied from 0.00 (Pusa-109) to 80.38 (J-45) per cent.

4. Symptomatology

The symptoms of anthracnose due to Colletotrichum spp. in various plant parts (Plate 1,2,3,4) are as follows :

4.1 Symptoms on cotyledons

The cotyledons developed necrotic, erumpent, brittle dark black spots (Plate 1). On isolation three fungi were found associated with infected portions, i.e. Colletotrichum dematium, Fusarium oxysporum and F. semitectum.

4.2 Symptoms on leaves

The symptoms were produced in the form of small, water soaked, circular, light brown spot of 14 x 10 mm in diameter. Later these spots turned into brown colour. The diseased portion often becomes papery and drop off from the leaves due to rain drops and wind producing 'shot hole' (Plate 2 A,B,C). The shedding off of diseased tissues occurred after 12 days of infection. On isolation fungi found associated with such type of symptoms were Colletotrichum dematium, Rhizoctonia bataticola and Alternaria alternata.

In second type of symptoms, the fungus produced numerous, necrotic spots on leaves. These spots were brown, 10 x 10 mm in diameter, later they became dark brown surrounded by a dark margin. The diseased portion in the centre becomes papery and fall off producing a shot hole. The spots coalesced involving larger area of the leaf. After about a week, all the infected leaves dry and fall off causing considerable damage to the crop. The fungi found associated were Colletotrichum lindemuthianum and Rhizoctonia solani. In both the cases, infected area spreads to any direction giving irregular shape (Plate 2 A,B,D).

Plate 1 : Symptoms of anthracnose exhibited on cotyledons of mungbean

1

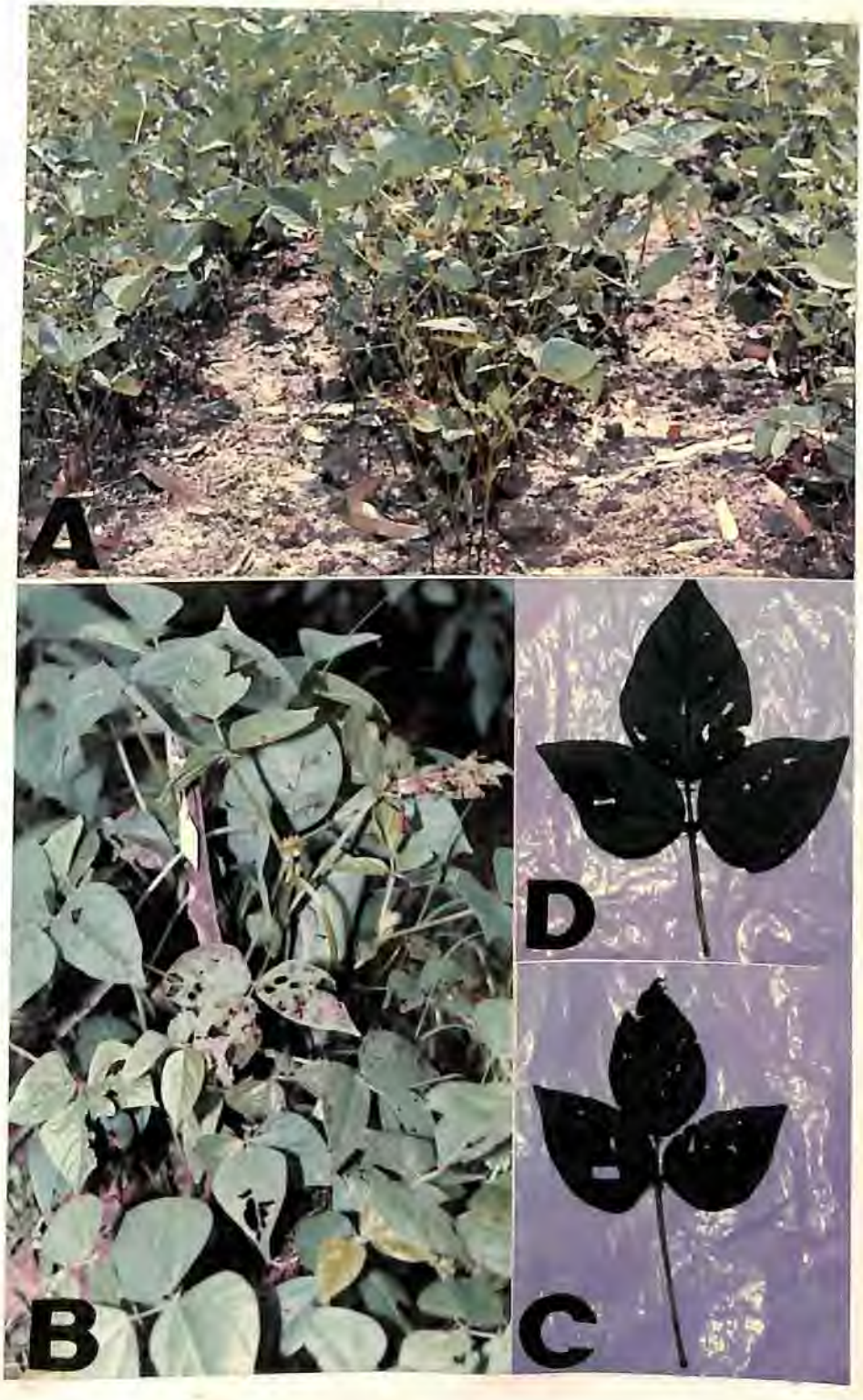
Plate 2 : Symptoms of anthracnose on mungbean plant

A. Mungbean field exhibiting the symptoms of anthracnose on leaves

B. Enlarged view showing the symptoms of anthracnose on foliage

C. Leaves exhibiting the symptoms of *Colletotrichum dematium*

D. Leaves exhibiting the symptoms of *Colletotrichum lindemuthianum*


A
B
C
D

4.3 Symptoms on stem

On stem, the fungus produced dark brown, cankerous spots or lesions. Later, the fungus developed acervuli. These structures are clearly evident even by naked eye. The fungus associated with the infected portion was Colletotrichum lindemuthianum and C. dematium (Plate 3).

4.4 Symptoms on pod

Dark brown necrotic spots appeared on pods at the early stage of its formation. When the plants were infected after the pod formation had started, the young pods were infected and the mycelium was observed growing on such pods. Within the pods, mycelium was found growing around the seeds and in slightly matured seeds, brown spots developed on the seeds. The fungi associated with pod surface were C. dematium, Phoma sp., Rhizoctonia solani and Curvularia lunata. On seed C. dematium, C. lindemuthianum and many other fungi were associated. Acervuli are observed on the seed coat (Plate 4 E,F).

Identification

Cultures of C. dematium and C. lindemuthienum were identified on the basis of morphological characters.

Colletotrichum dematium (Pers. ex Fr.) Grove

On PDA, colonies were pinkish white, thick with branched mycelium.

Plate 3 : Stem exhibiting the acervuli and setae of *Colletotrichum dematium*

On seed

The whole seed was covered with acervuli of the fungus. Acervuli were numerous in number. Individual acervuli were proportionately big, circular in outline with 6-8 setae in each acervulus (Plate 4 F). Acervuli were pinkish when young and became brownish later, oval shaped, waxy in appearance. Conidial masses were white to dull white, pale orange or bright orange.

Conidia

Conidia were hyaline, simple, single celled, curved with rounded tips 18-22 u x 3.4 u in diameter (Plate 5 H).

Setae

Numerous, blackish brown to dark black, longer than the conidial mass. Swollen at the base multi-septate and 40-94 u in length.

Colletotrichum lindemuthianum (Sacc. et Magm) Briet Cav.

On seed

Acervuli mostly in groups coalescing and covering the seed, rarely single. Conidial mass orange to bright orange, mycelium scanty, white.

Conidia

Conidia hyaline, oblong to dumble shaped, one celled, straight, ends rounded, measuring 9-15 x 3-4 u (Plate 5 G).

Plate 4 : Symptoms of Colletotrichum spp. exhibiting on germinating seed of mungbean

E. Acervuli of Colletotrichum lindemuthianum

F. Acervuli of Colletotrichum dematium


E


F

Plate 5 : Conidia of two species of Colletotrichum

G. Conidia of Colletotrichum lindemuthienum

H. Conidia of Colletotrichum dematium


G
H

5. Pathogenicity test

The pathogenicity of C. dematium and C. lindemuthianum was tested by the following methods.

5.1 Seed infestation method

Pathogenicity of C. dematium and C. lindemuthianum was conducted by seed infestation technique. On blotter infested seeds resulted in 95 per cent and 27 per cent infection of germinating seeds by C. dematium and C. lindemuthianum, respectively as compared to no infection in control. The germination of seeds was reduced from 96 in control to 56 and 63 per cent due to C. dematium and C. lindemuthianum, respectively. The seeds infested with C. dematium produced symptoms on cotyledons, primary leaves as well as roots. The symptoms on roots appeared as brown discolouration, where the acervuli along with setae were produced. On tenth day, 32 per cent post-emergence mortality was recorded.

5.2 Seedling inoculation method

Plants 30, 40 and 50 days old were used for pathogenicity of C. dematium and C. lindemuthianum in pots. The symptoms on leaves and pods appeared after 12 days of inoculation. Young plants (30 days old) infected earlier than the older plants (50 days old). The isolation revealed the association of both the Colletotrichum spp.

5.3 Detached leaf technique

Leaves from the plantings of 23rd June, 4th and 30th July of kharif 1986 were inoculated with the culture of both the species of Colletotrichum on the upper and lower surface. The symptoms appeared on the eighth day of inoculation on the lower surface followed by upper surface. Symptoms on leaves taken from 4th and 30th July sown plants appeared first than in 23rd June sown plants. This is because younger leaves are more susceptible to infection than older leaves. No symptoms were observed in the control. The two fungi were confirmed by reisolation from the affected portion.

5.4 Soil infestation technique

Pathogenicity of C. lindemuthianum was tested by soil infestation method. The observations on pre-and post-emergence mortality were recorded. The pre-emergence mortality was 31 per cent while the post-emergence mortality was 17 per cent as compared to only 6 per cent pre-emergence mortality in control. No post-emergence mortality was recorded in control. The final stand was less (52%) in comparison to control (94%). On isolation the ungerminated diseased seeds and seedlings yielded C. lindemuthianum.

6. Survey of anthracnose in ten districts of Madhya Pradesh

During kharif 1986, a survey of anthracnose of mungbean caused by C. dematium and C. lindemuthianum was made in ten districts of Madhya Pradesh. The data are presented in Table 6.

Table 6 : Survey of anthracnose of mungbean in ten districts of Madhya Pradesh

S. No.	District	Season	Variety	Date of disease appear-ance	Disease incidence (%)	Stage of the crop	Fertilizer doses (N:P:K)	Soil type
1.	Jabalpur	Kharif	J-45, Pusa Baisakhi K 851, PS-16	13.7.86	23.43	Seedling stage	20:40:0	Sandy loam
			-do-	13.7.86	45.65	Vegetative stage		
			-do-	13.7.86	75.67	Flowering stage		
			-do-	13.7.86	57.28	Pod formation		
		Rabi	Pusa Baisakhi	No disease	0.00	At all stages	20:40:0	Sandy loam
2.	Mandla	Kharif	Pusa Baisakhi and J-45	5.7.86	23.52	Seedling stage	0:0:0	Sandy loam
		Rabi	Kopergaon	No disease	0.00	Vegetative growth stage	10:30:0	Clay loam
3.	Seoni	Kharif	J-45, PIMS-2	12.7.86	10.15	Pre-flowering	0:0:0	Light soil
		Rabi	Pusa Baisakhi	No disease	0.00	Vegetative stage	20:40:0	Silty soil
4.	Khargone	Kharif	PS-16	22.7.86	32.66	Maximum vegetative growth stage	20:40:0	Clay loam
		Rabi	Pusa Baisakhi	No disease	0.00	-do-	10:30:0	Clay loam
5.	Khandwa	Kharif	PS-16, Krishna	25.7.86	27.72	Flowering stage	20:40:0	Clay loam
		Rabi	Pusa Baisakhi	No disease	0.00	Flowering stage	10:30:0	Clay loam
6.	Betul	Kharif	Local variety	15.7.86	37.21	Flowering stage	10:30:0	Sandy soil
7.	Sehore	Kharif	Local variety	3.7.86	28.48	Pre-flowering	20:40:0	Heavy soil
8.	Vidisha	Kharif	ML-33, PIMS-2	12.7.86	20.18	Vegetative growth	10:30:0	Sandy loam
9.	Narsinghpur	Kharif	Local variety	No disease	0.00	Flowering stage	20:40:0	Heavy soil
10.	Hoshangabad	Kharif	PS-16 and Local variety	No disease	0.00	Flowering stage	10:30:0	Heavy soil

Out of ten districts surveyed for anthracnose infection in eight districts mungbean was found infected with C. dematium and C. lindemuthianum while in Hoshangabad and Narsinghpur districts the crop was found free from the disease. The infection of the disease was recorded only in kharif season. No incidence of the disease was recorded in rabi season. The date of appearance and incidence of disease varied from 3rd July and 25th July 1986 being 0 and 75.67 per cent respectively. The disease is known to attack the crop at all growth stages right from seedling upto pod formation.

The incidence of the disease was recorded at two doses of N:P:K i.e. 10:30:0 (37.21 and 20.18% at Betul and Vidisha respectively) and 20:40:0 (23.43, 45.65, 75.67 and 57.28% at Jabalpur, 32.66% at Khargone, 27.72% at Khandwa and 28.48% at Sehore). Disease incidence was also recorded where no fertilizer was given (23.52 and 10.15% at Mandla and Seoni respectively). As regards the soil, the incidence of anthracnose in sandy loam soil varied from 20.18-75.67 per cent, in clay loam 27.72-32.66 per cent, in heavy soil 28.48 per cent, in light soil 10.15 per cent, in sandy soil 37.21 per cent and in silty soil no incidence of anthracnose was observed.

7. Influence of environmental factors

7.1 Effect of varieties and dates of sowing on the incidence of anthracnose

An experiment was conducted to study the effect of different varieties and different dates of sowing on the

Table 7 : Average intensity of anthracnose in three varieties of mungbean sown on various dates and their effect on yield

Variety	Date of sowing	Disease index	Yield (g/plot)
J-45	23.6.1986	21.18	104.80
J-45	3.7.1986	21.36	61.65
J-45	13.7.1986	17.69	52.62
Pusa Baisakhi	23.6.1986	22.13	68.80
Pusa Baisakhi	3.7.1986	23.68	137.60
Pusa Baisakhi	13.7.1986	16.27	65.67
K 851	23.6.1986	23.27	67.92
K 851	3.7.1986	32.72	99.47
K 851	13.7.1986	19.60	75.67
F - test			
1. Varieties		NS	S
2. Dates of sowing		S	S
3. Interaction		NS	S
C.D. at 5% level			
1. Varieties		-	8.51*
2. Dates of sowing		5.29*	11.44*
3. Interaction		-	19.82*

23.60
22.13
1.55

32.72
23.27
8.45

7.2 Influence of environmental factors on the development of anthracnose of mungbean (J-45)

It is evident from Table 6 that the disease index on 23rd June sown crop was negatively correlated with maximum and minimum temperature, whereas, positive correlation was observed with humidity percentage (morning and noon) and rainfall. As the temperature increased, there was significant decrease in the disease index but no significant decrease was observed with minimum temperature. The first appearance of the disease was recorded on 13th July 1986. It was significantly increased with increase in humidity percentage (morning and noon) and rainfall. The disease index was maximum (32.02) on 6th August1986 when the maximum and minimum temperatures were 28.9°C and 23.2°C respectively, humidity levels were 98.0 and 87.6 per cent during morning and noon respectively and rainfall was 29.8 mm. No disease was noted on 8th September when there was no rain, maximum and minimum temperatures were higher in 33.4 and 24.4°C respectively and humidity percentage was low being 82.3 and 51.6 during morning and noon respectively. The progress of the disease development was completely checked after 20th September 1986 (Fig. 1).

On the crop which was sown on 3rd July 1986, the correlation between disease index and environmental factors was made. The results were similar to the crop sown on 23rd June. The first incidence of the disease was recorded

on 19th July. The disease index was maximum (30.38) on 25th July when the temperatures were 29.03°C and 22.5°C (maximum and minimum), humidity percentages were 94.0 and 82.3 and rain was 5.3 mm. No increase in disease index was recorded from 5th to 8th September. The progress of the disease was stopped after 20th September due to unfavourable conditions (Fig. 2).

In 13th July sowing, the disease was negatively correlated with maximum and minimum temperatures, whereas, positive correlation was observed with humidity percentage and rainfall. Significant increase in the disease was observed with decrease in maximum temperature while no significant increase in the disease was observed with minimum temperature. Statistically significant increase in disease was noted with increase in humidity percentage but it was not so with rainfall. In this case, the appearance of the disease was late in the season. The intensity of the disease increased from 22nd July to 31st July with deviation in temperatures from 27.2-29.2°C maximum, 22.1-23.8°C minimum, humidity percentage 92.0-95.3 during morning and 77.3-89.6 per cent in the noon and rainfall from 3.4-60.3 mm. The disease was not observed after 2nd September onwards due to absence of rain. As soon as the rain started, the plants got infected and hence there was disease on 14th and 17th September 1986 with 53.5 and 2.5 mm rains (Fig. 3, 4).

FIG.2: CORRELATION OF ENVIRONMENTAL FACTORS WITH PROGRESS OF ANTHRACNOSE IN J-45 VARIETY OF MUNGBEAN SOWN ON 3rd JULY 86

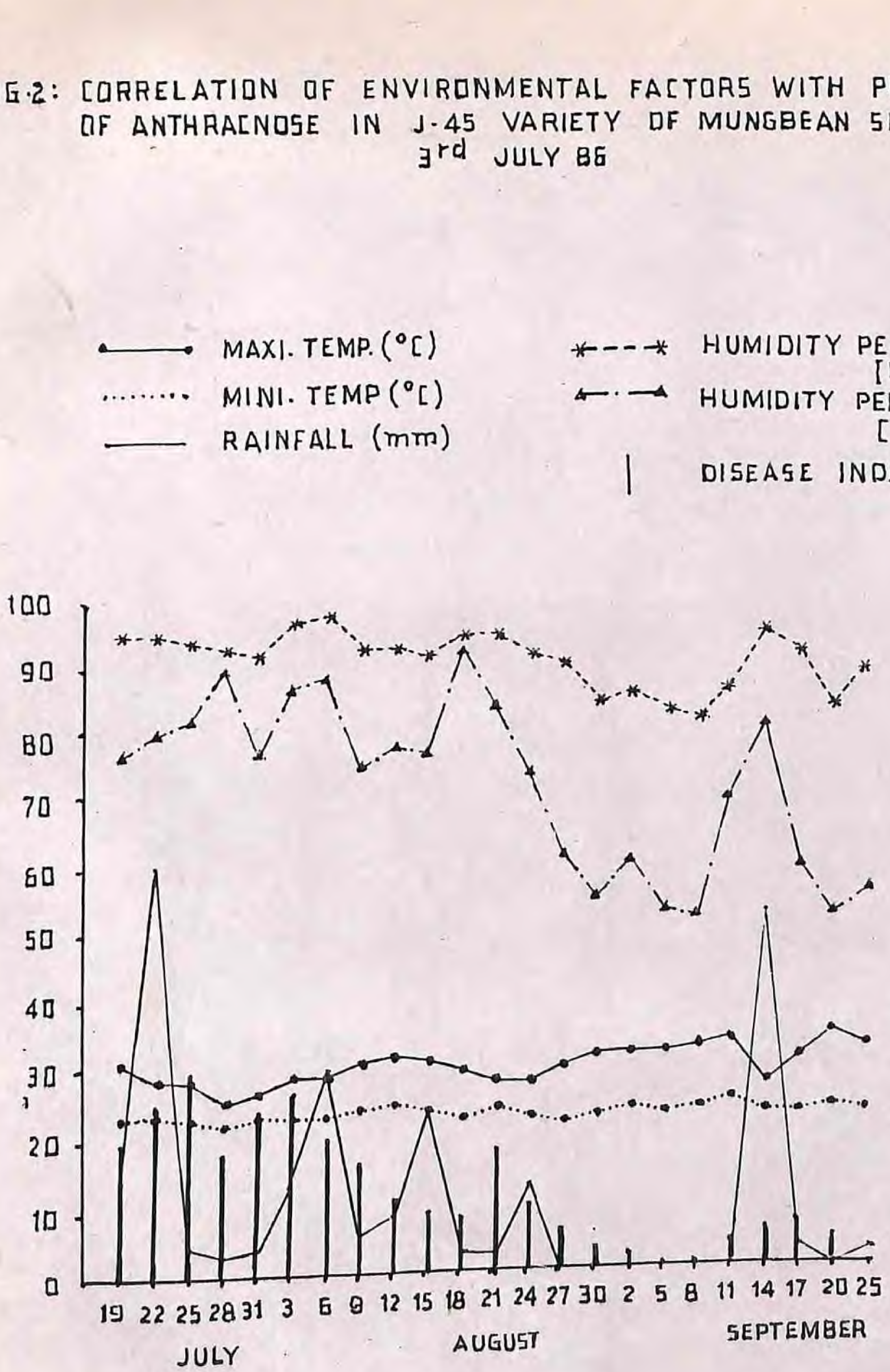


FIG.3: CORRELATION OF ENVIRONMENTAL FACTORS WITH PROGRESS OF ANTHRACNOSE IN J-45 VARIETY OF MUNGBEAN SOWN ON 13th JULY 86

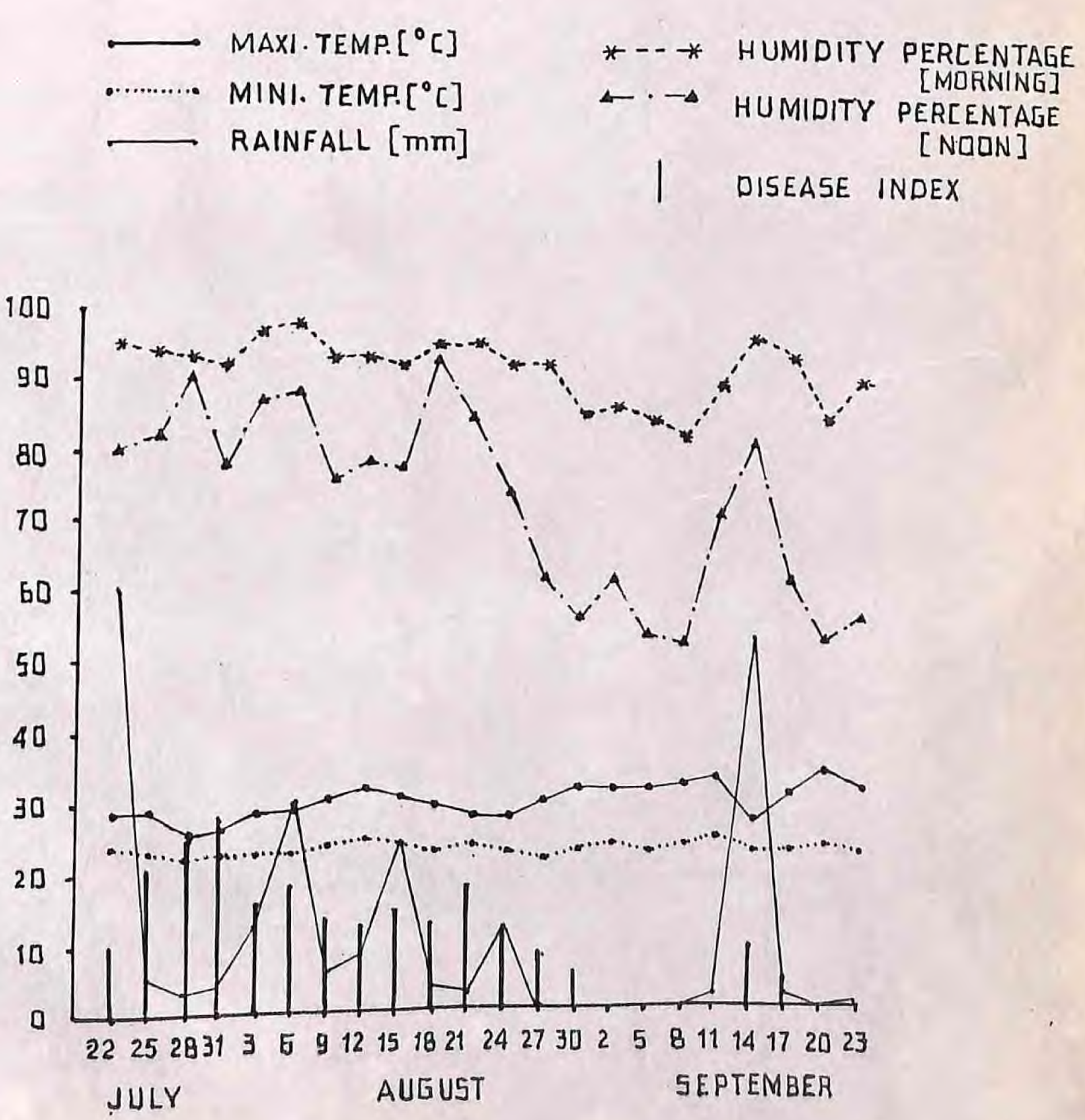
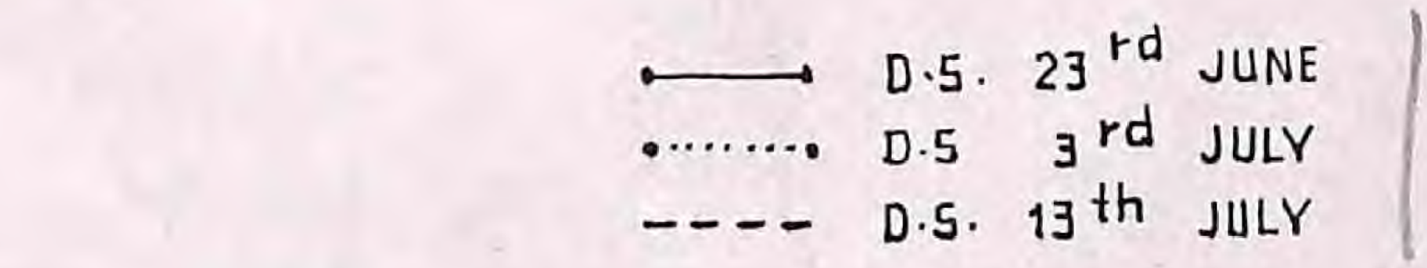


FIG.4: PROGRESS OF ANTHRACNOSE IN J-45 VARIETY OF MUNGBEAN SOWN ON DIFFERENT DATES 1986-87



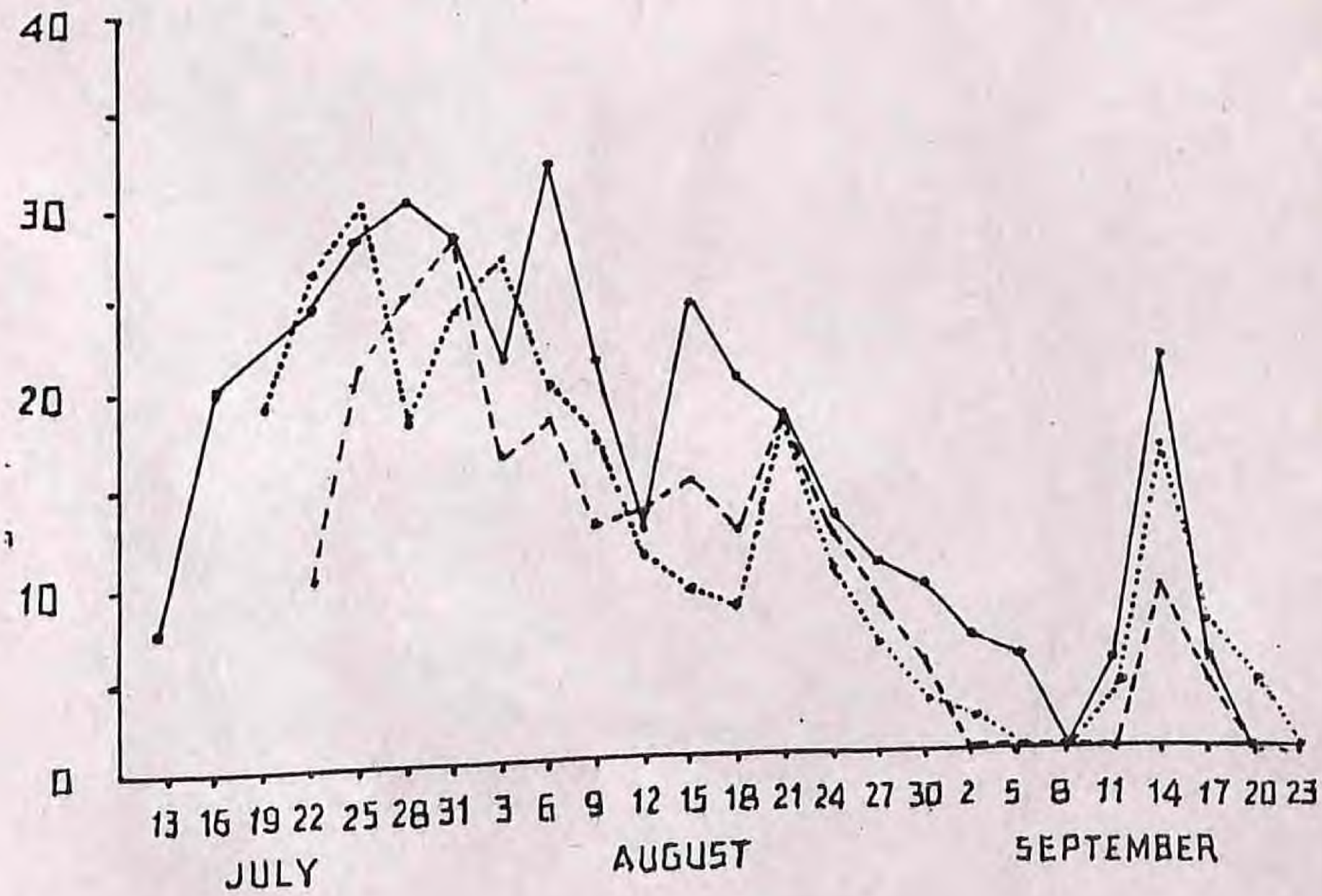


Table 8 : Influence of environmental factors on the development of anthracnose in J-45 of mungbean

Date	Maximum temperature (°C)	Minimum temperature (°C)	Humidity per cent (Morning)	Humidity per cent (Noon)	Rain (mm)	Disease index at three dates of planting		
						23rd June	3rd July	13th July
13.7.86	30.6	24.3	88.3	65.0	1.6	8.01	-	-
16.7.86	31.5	24.0	96.3	76.0	18.8	20.20	-	-
19.7.86	32.0	24.9	95.3	77.3	15.5	21.79	18.19	-
22.7.86	29.2	23.8	95.3	79.6	60.3	23.99	25.69	10.12
25.7.86	29.0	22.5	94.0	82.3	5.3	28.49	30.38	21.23
28.7.86	28.0	22.1	92.6	89.6	3.4	30.32	17.83	25.45
31.7.86	27.2	23.2	92.2	77.3	4.5	28.44	23.52	27.62
3.8.86	28.6	23.1	96.6	86.6	13.4	21.12	27.10	15.86
6.8.86	28.9	23.2	98.0	87.6	29.8	32.02	20.32	17.60
9.8.86	31.2	24.4	93.3	95.3	6.2	21.03	16.95	15.43
12.8.86	32.2	24.9	93.0	77.6	8.4	11.80	10.75	12.32
15.8.86	31.4	24.5	92.0	77.3	24.4	24.35	8.75	14.62
18.8.86	30.0	22.9	95.3	93.0	3.4	19.75	7.66	11.62
21.8.86	27.7	23.6	95.0	84.0	2.5	18.22	18.42	18.32
24.8.86	27.9	23.0	92.3	73.0	12.8	13.27	9.77	12.12
27.8.86	30.1	22.0	91.0	61.3	0.0	10.12	6.32	7.84
30.8.86	31.6	22.7	85.0	55.0	0.0	8.55	3.17	5.32
2.9.86	32.4	24.2	86.0	61.0	0.0	6.20	2.42	0.00
5.9.86	32.4	23.0	83.6	52.6	0.0	4.55	0.00	0.00
8.9.86	33.4	24.4	82.3	51.6	0.0	0.00	0.00	0.00
11.9.86	33.6	24.5	88.6	71.6	2.3	5.40	3.42	0.00
14.9.86	27.4	22.7	96.3	81.3	53.5	21.22	16.12	8.92
17.9.86	31.2	22.9	93.0	60.6	2.5	4.88	6.66	4.32
20.9.86	34.5	24.4	84.3	52.6	0.0	0.00	4.00	0.00
23.9.86	33.1	22.7	90.3	56.0	1.2	-	0.00	0.00
Value of 'r' for disease index								
23.6.86	-0.71*	-0.29	0.78*	0.85*	0.48*			
3.7.86	-0.72*	-0.14	0.75*	0.75*	0.46*			
13.7.86	-0.79*	-0.26	0.66*	0.65*	0.17			

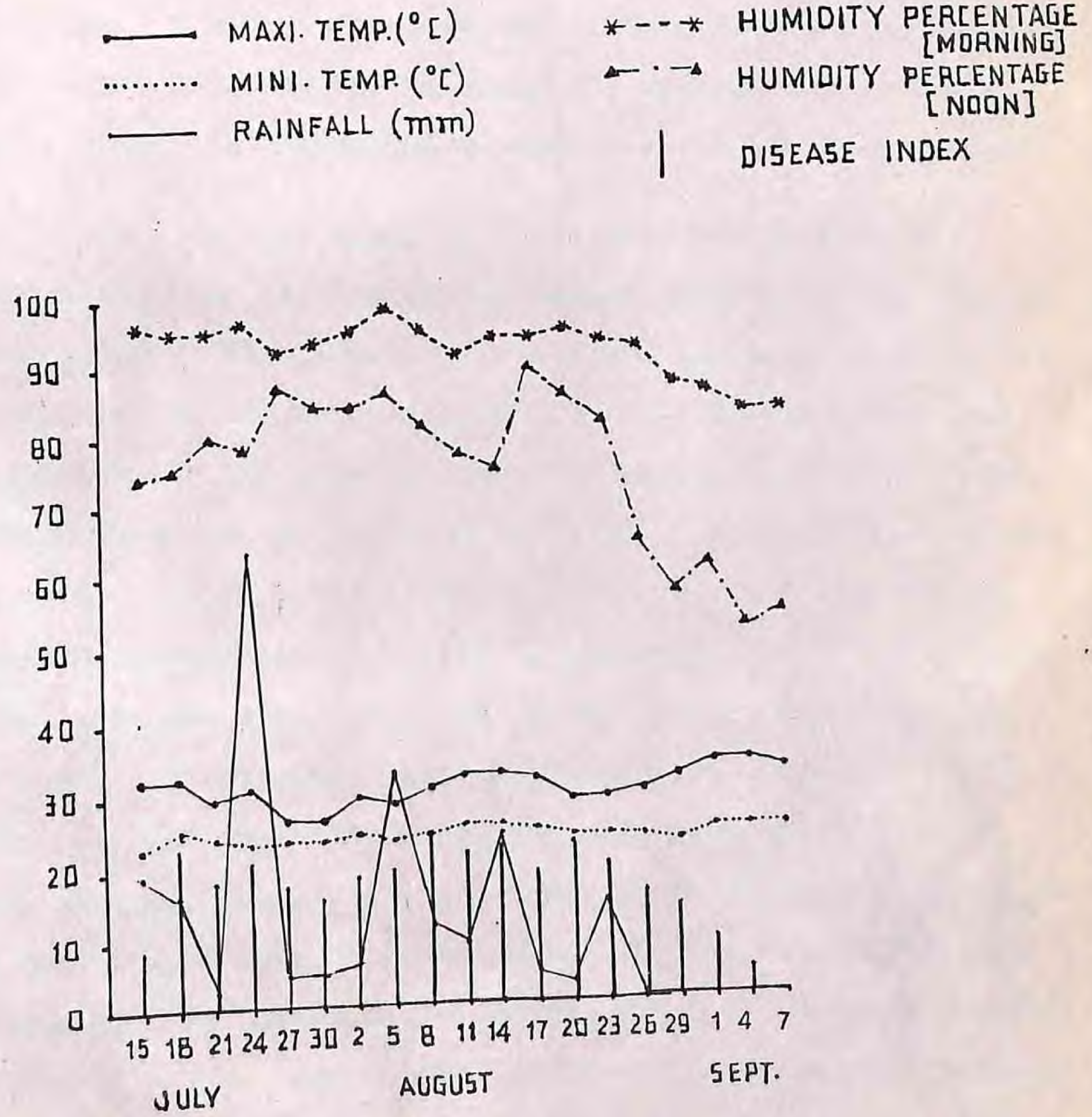
*Significant at 5% level

7.3 Influence of environmental factors on the progress of anthracnose on Pusa Baisakhi mungbean

It is clear from the data in Table 9 that the development of the disease was negatively correlated with maximum temperature. Increase in maximum temperature decreased the intensity of disease, however, it was not statistically significant. Positive correlation between disease index and environmental factors including minimum temperature, humidity percentage and rainfall was observed. The correlation coefficient 'r' was statistically significant with humidity percentage (morning and noon) but it was non-significant with minimum temperature and rainfall at 5 per cent level of significance. The disease appeared on 15th July 1986 and reached its maximum (23.66) by 8th August at 30.1 and 23.9°C (maximum and minimum), 95.3 and 81.3 per cent humidity (morning and noon) and 10.5 mm rainfall. The proportion of increase in disease incidence continuously decreased from 20th August to 4th September due to no rains during the period of increased temperature and decreased humidity percentage (Fig.5).

Negative correlation was found in the disease index and temperatures on 3rd July sown crop. It was significant with maximum temperature. The disease index was positively correlated with humidity percentage and rainfall. Humidity percentage with reference to disease development was statistically significant but it was not significant with rainfall, although increase in disease increases with increase in rains. Maximum disease

FIG.5: CORRELATION OF ENVIRONMENTAL FACTORS WITH PROGRESS OF ANTHRACNOSE IN PUSA BAISAKHI VARIETY VARIETY SOWN ON 23rd JUNE 86



intensity (38.42) was recorded at 26.4 and 22.5°C (maximum and minimum temperature), 92.6 and 84.3 per cent humidity (morning and noon) and 4.1 mm rainfall. The disease index was reduced from 20th August 1986 till 4th September with increase in temperatures, decrease in humidity and absence of rains. The prevalence of the disease from 30th July to 5th August was observed to touch the maximum limit with no acute change in temperatures, humidity and rainfall (Fig.6).

In late sown crop, disease index was positively correlated with all the environmental factors except minimum temperature. With increase in minimum temperature there was a decrease in the disease index but this decrease was non-significant. The disease index was highly significant with humidity percentage (morning and noon). However, it was non-significant with maximum temperature and rainfall. As the maximum temperature and rainfall increased the disease index also increased but it was not statistically significant at 5% level. First anthracnose symptoms were noted on 21st July 1986 and the disease obtained its peak (28.33) by 11th August. There was great fluctuation in the development of the disease. It decreased after 23rd August and further development was completely stopped from 1st September because of no rain after 23rd August and relative humidity percentage decreased (Fig. 7,8).

FIG.6: CORRELATION OF ENVIRONMENTAL FACTORS WITH PROGRESS OF ANTHRACNOSE IN PUSA BAISAKHI SOWN ON 3rd JULY 86

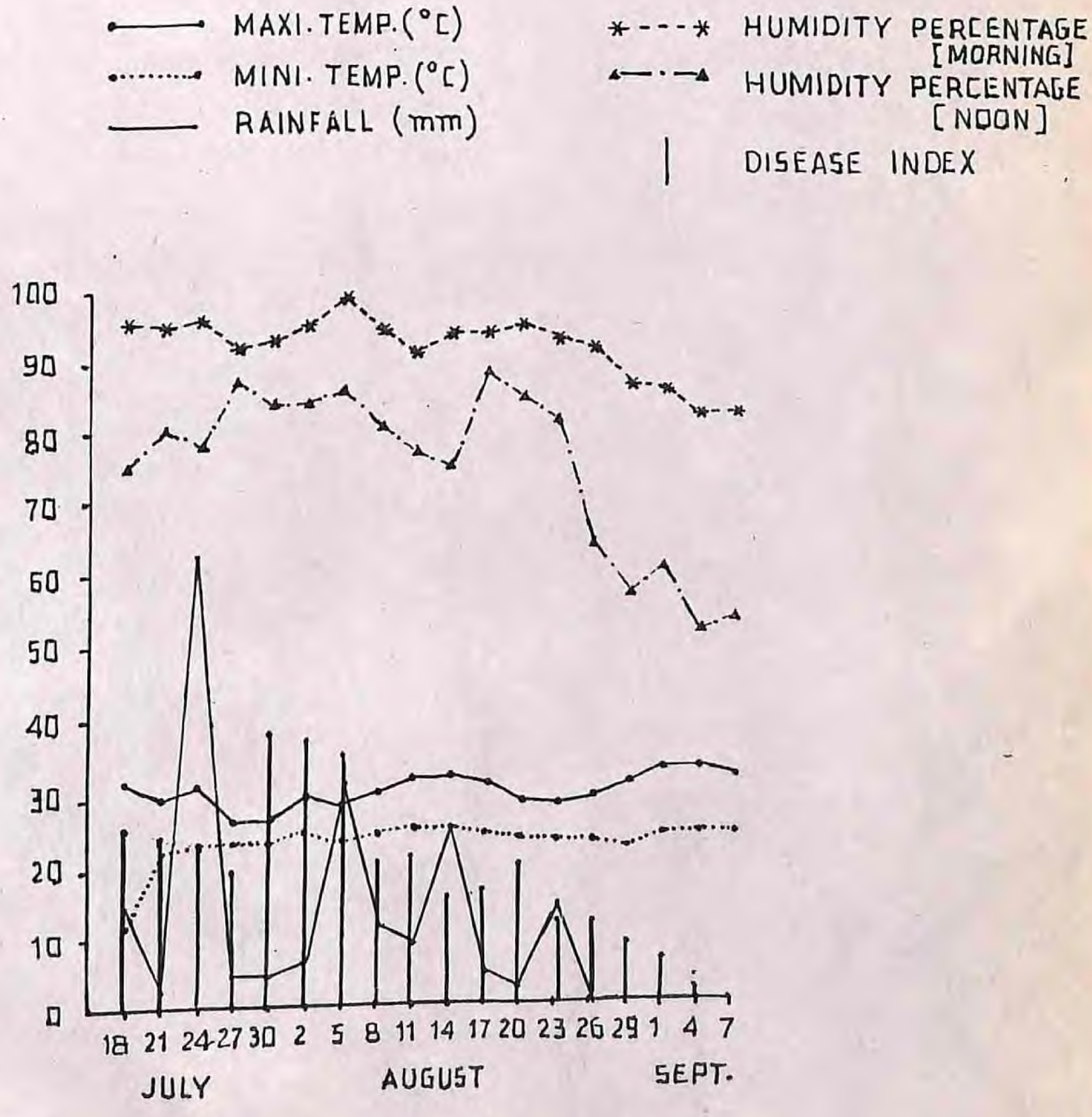


FIG.7: CORRELATION OF ENVIRONMENTAL FACTORS WITH PROGRESS OF ANTHRACNOSE IN PUSA BAISAKHI VARIETY OF MUNGBEAN SOWN ON 13th JULY 86

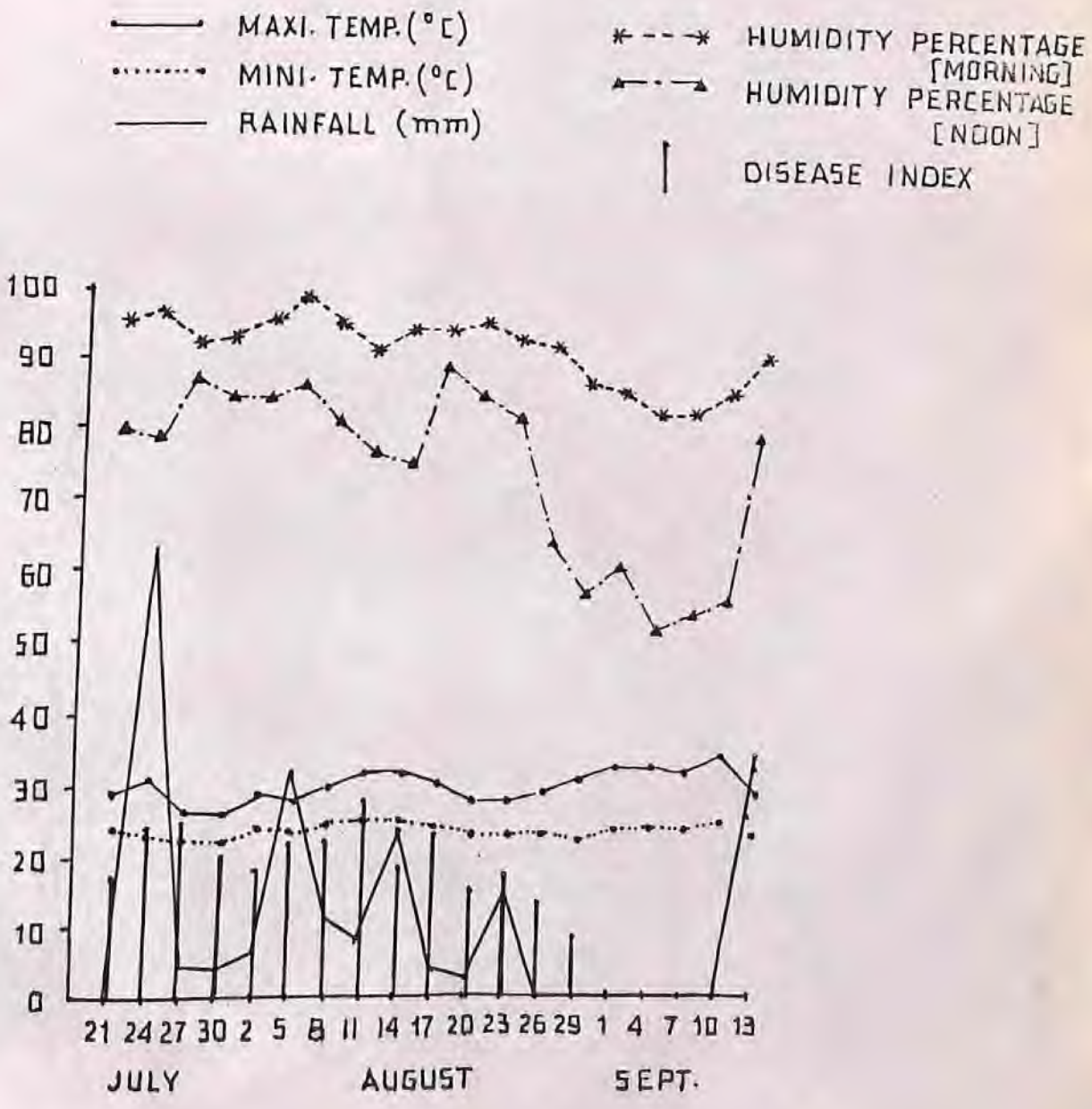


FIG. 8 : PROGRESS OF ANTHRACNOSE IN PUSA BAISAKHI VARIETY OF MUNGBEAN SOWN ON DIFFERENT DATES 1986-87

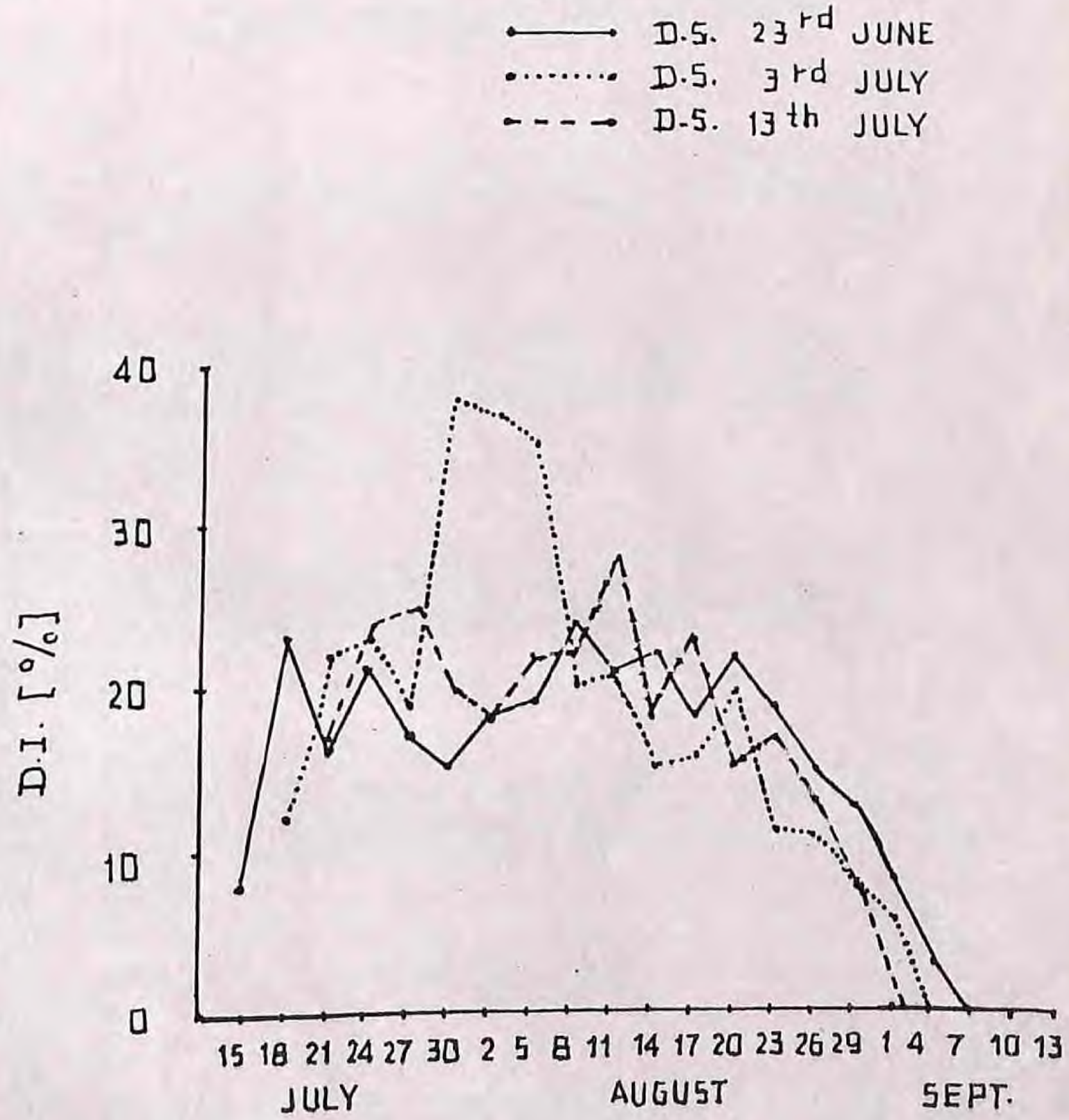


Table 9 : Influence of environmental factors on the development of anthracnose in Pusa Baisakhi of mungbean

Date	Maximum temperature (°C)	Minimum temperature (°C)	Humidity per cent (Morning)	Humidity per cent (Noon)	Rain (mm)	Disease index at three planting dates		
						23rd June	3rd July	13th July
15.7.86	31.7	23.4	95.6	74.3	16.8	7.82	-	-
18.7.86	32.4	24.9	94.6	74.6	15.5	22.70	12.36	-
21.7.86	29.2	24.3	94.6	80.3	1.9	15.70	22.43	16.69
24.7.86	30.7	23.4	96.0	77.6	62.5	21.32	23.27	23.76
27.7.86	26.2	22.5	91.6	87.0	4.1	16.68	19.30	25.42
30.7.86	26.4	22.5	92.6	84.3	4.1	15.32	38.42	20.22
2.8.86	29.2	23.6	94.6	84.0	6.2	18.42	36.72	18.33
5.8.86	28.4	22.9	98.6	86.0	32.5	10.45	35.05	22.32
8.8.86	30.1	23.9	95.3	81.3	10.5	23.66	20.12	21.62
11.8.86	31.9	24.7	91.3	77.0	7.6	20.81	20.96	28.33
14.8.86	32.1	24.5	94.3	75.0	23.6	21.52	14.50	18.00
17.8.86	31.0	23.8	93.6	89.3	3.5	17.52	15.60	23.42
20.8.86	27.7	23.3	95.0	85.3	2.0	22.32	20.32	15.32
23.8.86	27.7	23.3	93.0	82.0	14.2	19.45	11.42	17.32
26.8.86	29.4	22.5	92.3	64.3	0.0	15.21	10.82	12.63
29.8.86	31.0	22.1	86.6	57.0	0.0	13.33	7.52	7.63
1.9.86	32.5	23.9	86.0	60.0	0.0	8.00	6.43	0.00
4.9.86	32.7	23.5	83.3	52.6	0.0	2.50	0.15	0.00
7.9.86	32.3	23.9	82.6	54.0	0.0	0.00	0.00	0.00
10.9.86	34.7	24.5	86.3	56.3	0.0	-	0.00	0.00
13.9.86	28.7	23.3	95.6	87.6	34.8	-	-	0.00
Value of 'r' for disease index								
23.6.86	-0.37	0.16	0.78*	0.73*	0.29			
3.7.86	-0.67*	-0.23	0.76*	0.79*	0.34			
13.7.86	0.19	-0.05	0.68*	0.71*	0.27			

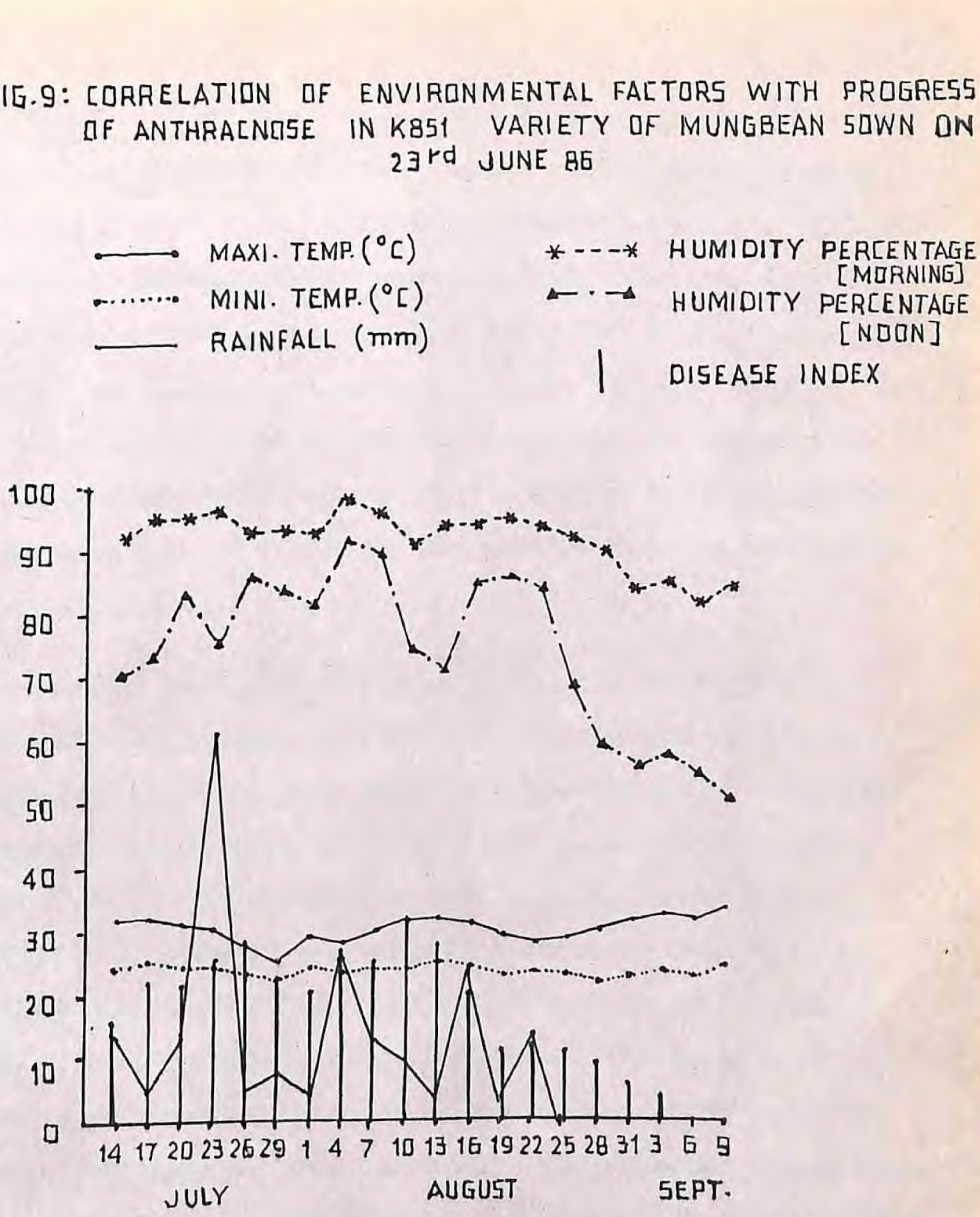
*Significant at 5% level

7.4 Influence of environmental factors on the incidence of anthracnose in K-851 mungbean

It is clearly evident from Table 10 that the disease index had negative correlation with maximum temperature but the correlation was non-significant. Positive correlation between disease index and minimum temperature, humidity percentage and rainfall was observed. It was statistically significant with relative humidity but non-significant with rainfall. In this case, the disease was reported on 14th July and was maximum (31.78) on 10th August when the environmental conditions, temperatures, humidity and rainfall were 31.5, 24.4°C, 91.0, 75.0 per cent and 9.9 mm respectively. After 22nd August the disease index decreased with gradual increase in maximum temperature, decrease in humidity percentage and complete absence of rain. The progress of the disease was completely checked from 6th September (Fig. 9).

In the crop sown on 3rd July, the disease development was negatively correlated with maximum and minimum temperature while positively correlated with relative humidity (morning and noon) and rainfall. The correlation between disease index and maximum temperature was statistically significant, however, it was non-significant with minimum temperature. The disease progress decreased with maximum and minimum temperature. Significant positive correlation was also observed with humidity percentage and rainfall. This is the only case where increase in disease severity was significantly correlated with increase

FIG.9: CORRELATION OF ENVIRONMENTAL FACTORS WITH PROGRESS OF ANTHRACNOSE IN K851 VARIETY OF MUNGBEAN SOWN ON 23rd JUNE 86



in rainfall. No significant correlation of disease index and rainfall was observed in other cases. The disease progress was simply correlated with increase in rainfall. At 28.2 and 23.0°C (maximum and minimum temperatures), 98.0, 90.0 per cent RH (humidity per cent of morning and noon) and 26.90 mm rain, maximum infection of anthracnose (27.39) was worked out. But there was fall in disease progress when all the factors, temperature, humidity percentage and rainfall, decreased after 22nd August. The progress of the disease was not there after 3rd September (Fig. 10).

Disease index on 13th July was again negatively correlated with maximum and minimum temperature. Significant correlation was found with maximum temperature, whereas, non-significant correlation was found with minimum temperature. The progress of the disease was markedly influenced by fluctuation in maximum temperature. Relative humidity percentage and rainfall had the positive correlation with disease index. Statistically significant correlation was observed with humidity percentage of morning while humidity percentage of noon and rainfall had nonsignificant correlation with disease index. Observations on the disease progress were recorded for one month only as later no disease was noted. The range of disease index varied from 11.32 to 20.32 under 28.5, 23.0°C temperature, 95.3, 85.6 per cent humidity (morning and noon) and 2.7 mm rainfall to 28.2, 23.0°C, 98.0, 90.0 per cent RH, 26.90 mm rains respectively (Fig. 11, 12).

FIG·10: CORRELATION OF ENVIRONMENTAL FACTORS WITH PROGRESS OF ANTHRACNOSE IN K851 VARIETY OF MUNGBEAN SOWN ON 3rd JULY 86

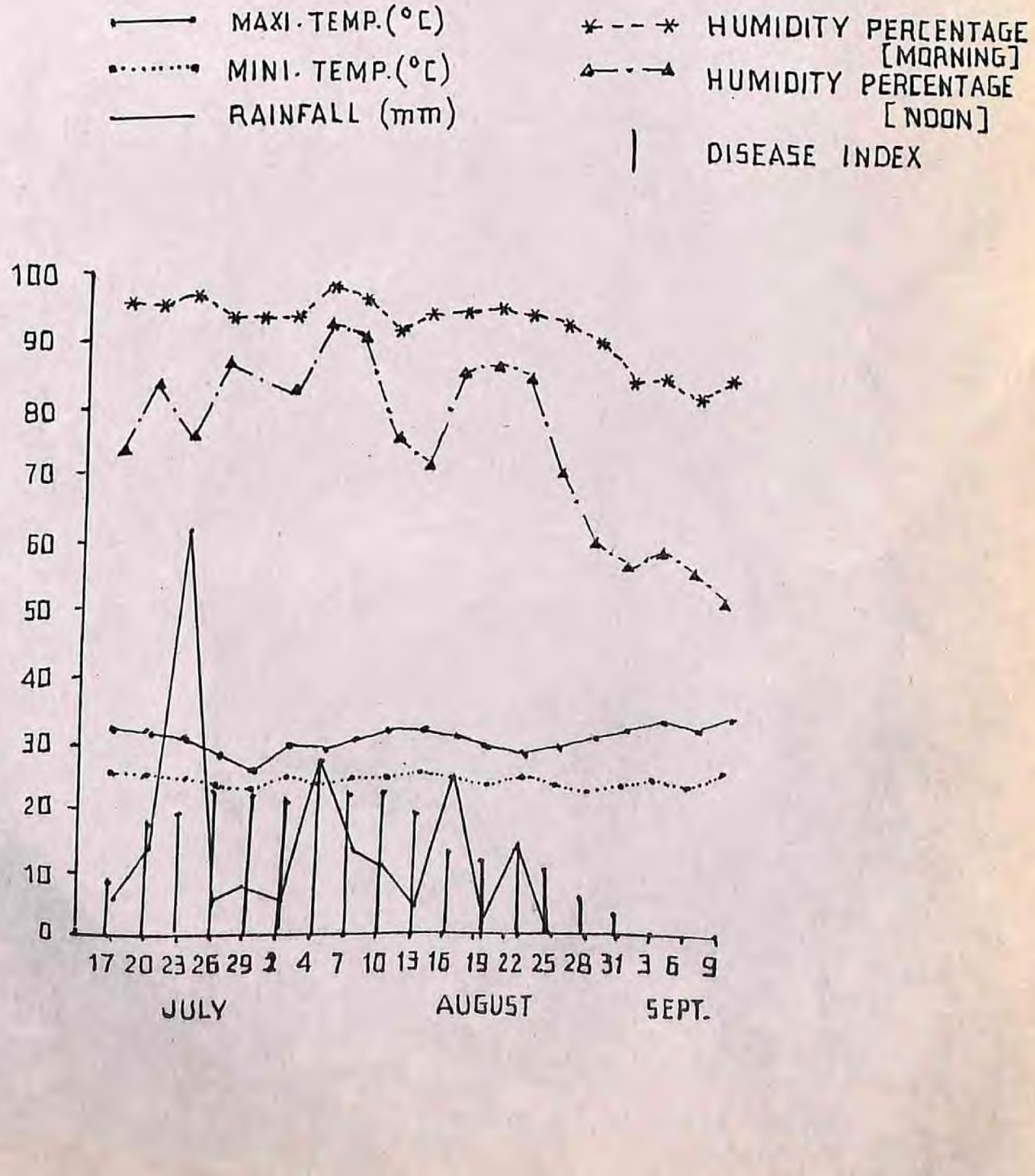


FIG.11: CORRELATION OF ENVIRONMENTAL FACTORS WITH PROGRESS OF ANTHRACNOSE IN K851 VARIETY OF MUNGBEAN SOWN ON 13th JULY 86

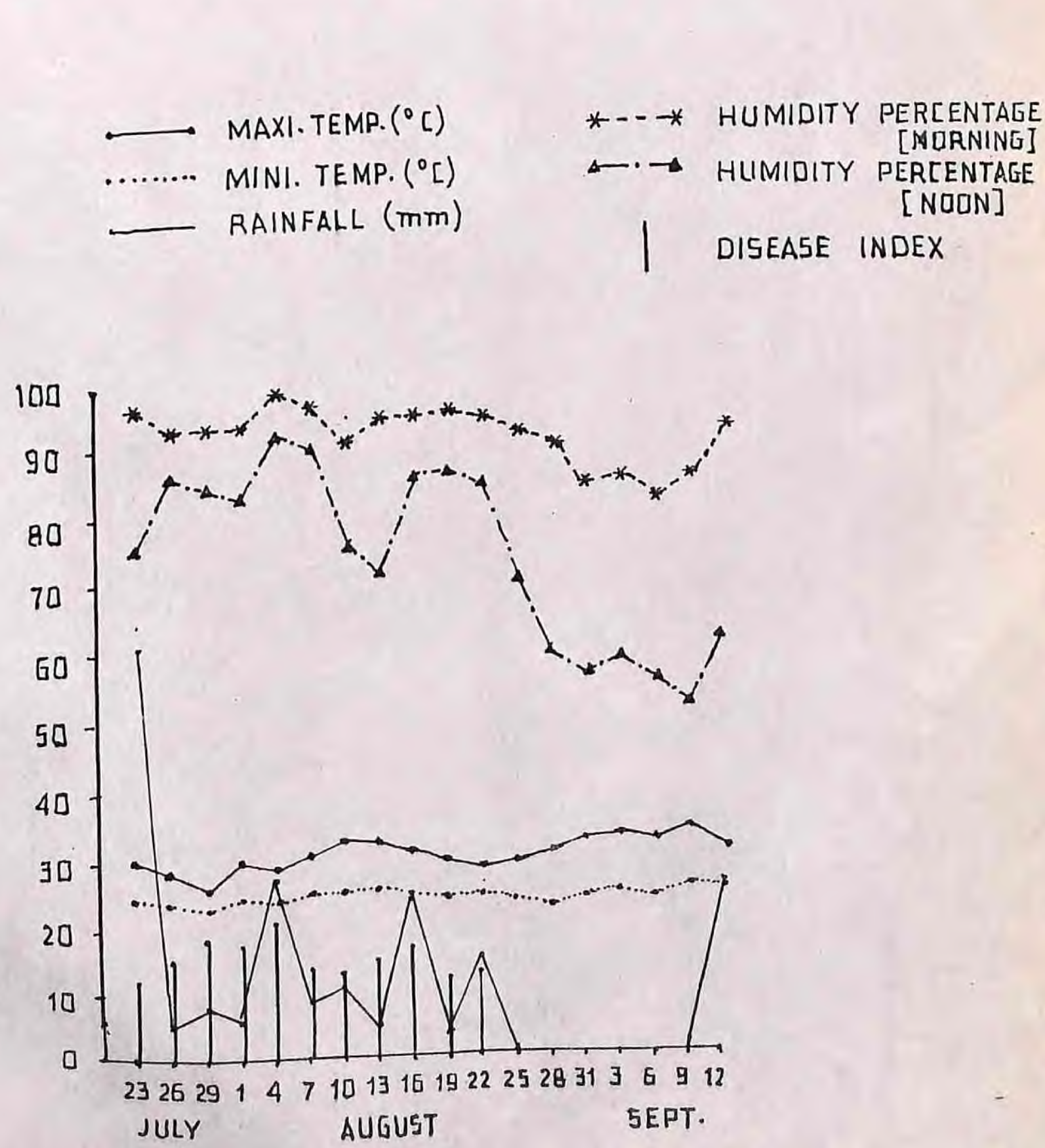


FIG.12: PROGRESS OF ANTHRACNOSE IN K851 VARIETY OF MUNGBEAN SOWN ON DIFFERENT DATES 1986-87

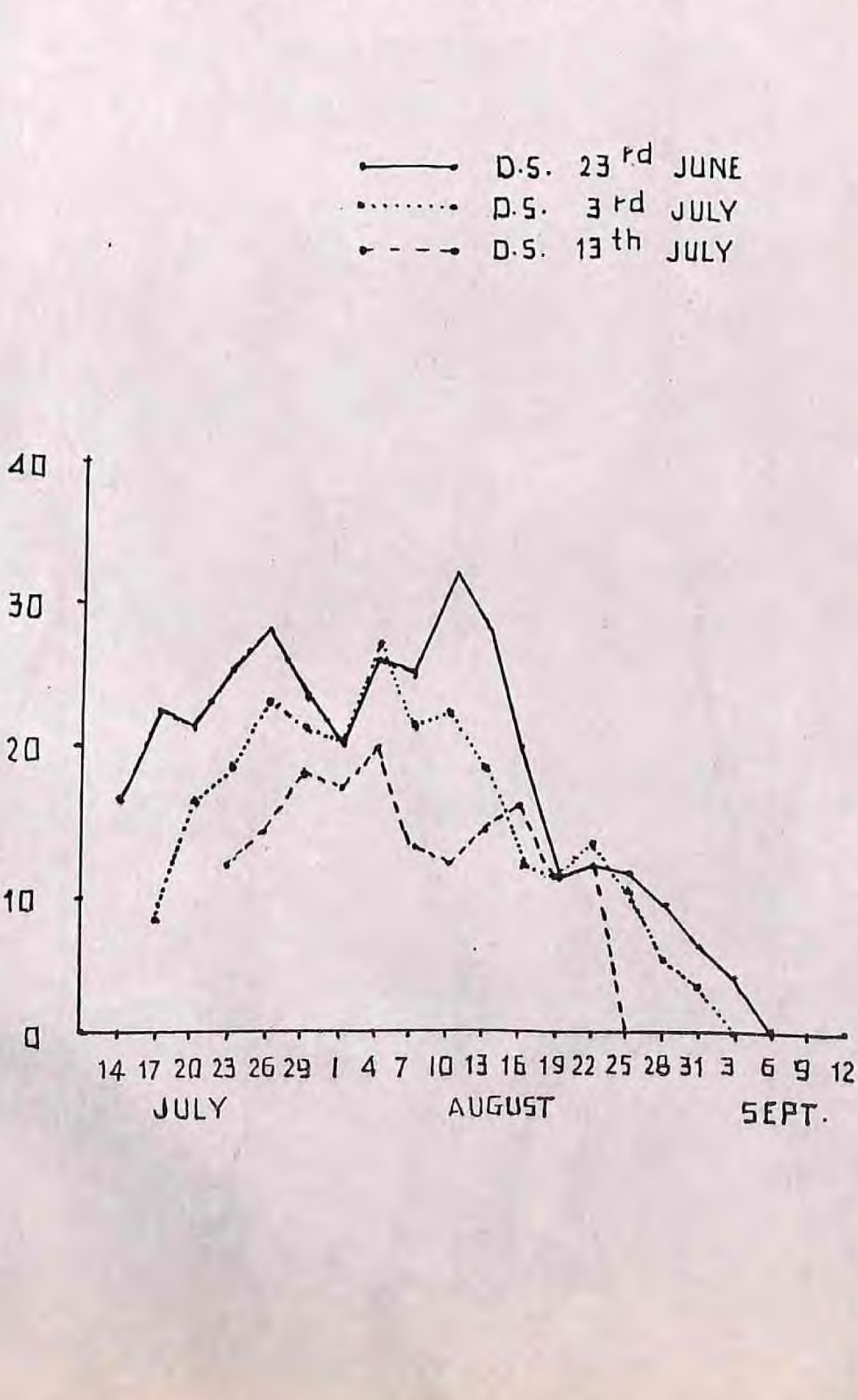


Table 10 : Influence of environmental factors on the development of anthracnose in K 851 mungbean

Date	Maximum temperature (°C)	Minimum temperature (°C)	Humidity per cent (Morning)	Humidity per cent (Noon)	Rain (mm)	Disease index at three dates of planting		
						23rd June	3rd July	13th July
14.7.86	32.1	23.6	92.0	70.0	14.1	15.53	-	-
17.7.86	31.8	24.9	95.3	73.3	4.6	22.13	7.86	-
20.7.86	30.5	24.3	94.6	82.6	12.9	20.83	16.25	-
23.7.86	30.1	23.7	96.0	74.6	60.5	25.43	18.04	12.43
26.7.86	27.7	23.0	92.6	86.3	5.0	28.32	22.50	13.52
29.7.86	24.9	21.9	93.3	84.3	5.5	23.47	20.82	18.42
1.8.86	29.3	23.5	93.0	81.6	4.7	20.32	20.23	16.63
4.8.86	28.2	23.0	98.0	99.0	26.9	26.42	27.39	20.32
7.8.86	29.7	23.7	96.3	90.3	13.3	25.02	21.32	13.42
10.8.86	31.5	24.4	91.0	75.0	9.9	31.78	22.18	12.00
13.8.86	32.1	24.9	93.6	71.0	4.4	28.32	18.24	14.22
16.8.86	30.9	23.8	94.3	85.3	24.1	20.12	12.23	15.68
19.8.86	28.5	23.0	95.3	85.6	2.7	11.13	11.12	11.32
22.8.86	27.9	23.6	94.3	84.3	14.2	12.32	13.43	12.03
25.8.86	28.9	22.8	91.6	69.0	0.0	11.42	9.76	0.00
28.8.86	30.4	21.8	90.3	59.3	0.0	8.72	5.43	0.00
31.8.86	32.3	23.4	84.3	56.3	0.0	6.42	3.36	0.00
3.9.86	32.6	24.0	85.3	58.3	0.0	4.02	0.00	0.00
6.9.86	32.2	23.3	81.6	55.3	0.0	0.00	0.00	0.00
9.9.86	34.3	24.5	85.3	50.6	0.0	0.00	0.00	0.00
12.9.86	30.7	23.7	92.0	80.6	24.8	-	-	0.00
Value of 'r' for disease index								
23.6.86	-0.41	0.15	0.75*	0.73*	0.41			
3.7.86	-0.63*	-0.08	0.77*	0.84*	0.45*			
13.7.86	-0.60*	-0.01	0.77*	0.46	0.37			

*Significant at 5% level

7.5 Progress of anthracnose in three varieties of mungbean

Disease index in three varieties of mungbean J-45, Pusa Baisakhi and K-851 was determined. Each variety is the average of three dates of sowing. Observations on progress of disease are presented in Table 11.

It is evident from Table 11 that the range of infection of anthracnose caused by C. dematium and C. lindemuthianum varied from 0-26.69 per cent in J-45. In Pusa Baisakhi, it ranged from 0.88 to 25.60 per cent and 1.34 to 24.71 per cent in K-851. The maximum intensity of the disease was almost the same in all the varieties. In J-45 the disease index was nil on 8th September and then started increasing by 11th September and totally stopped by 23rd September while in other two varieties the disease was completely stopped by 6th and 7th September due to complete maturity of the crop (Fig. 13).

7.6 Progress of anthracnose on three dates of sowing irrespective of varieties

The progress of the disease on the crop at three dates of sowing i.e. 23rd June, 3rd July and 13th July was observed during kharif 1986. The data are the average of three varieties J-45, Pusa Baisakhi and K 851. The data on disease index in each date of sowing are presented in Table 12. It is evident that the disease index was higher in majority of the observations recorded on 23rd June sowing in comparison to 3rd July and 13th July sown crop. Ten observations had more than 20 per cent

FIG: 13 : PROGRESS OF ANTHRACNOSE IN THREE VARIETIES OF MUNGBEAN 1986-87

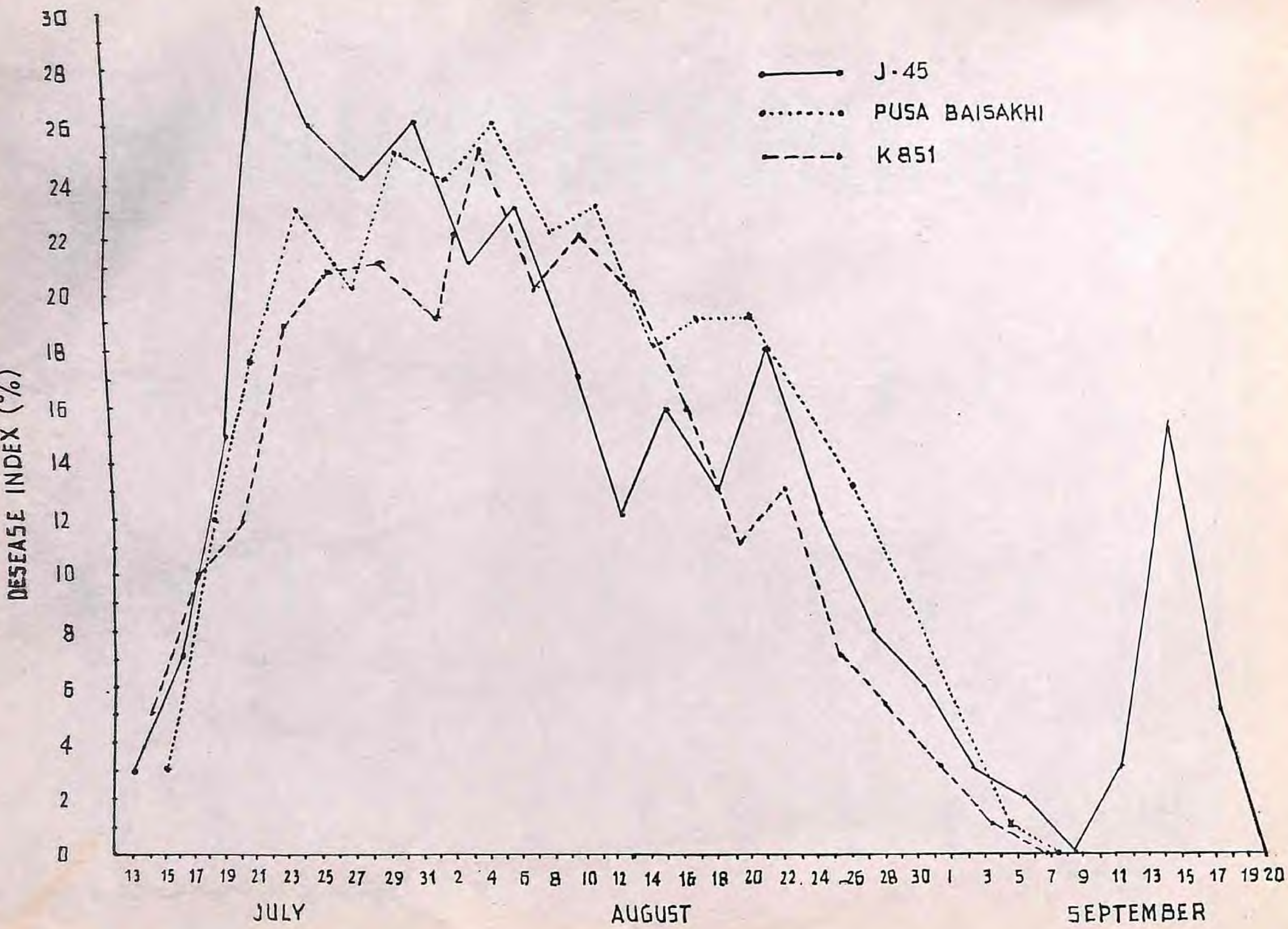


Table 11 : Progress of anthracnose in three varieties of mungbe

Date	Disease index		
	J-45	Pusa Baisakhi	K 851
1	2	3	4
13.7.86	2.67		
14.7.86			5.17
15.7.86		2.60	
16.7.86	6.73		
17.7.86			9.99
18.7.86		11.68	
19.7.86	13.52		
20.7.86			12.36
21.7.86		18.27	
22.7.86	19.93		
23.7.86			18.63
24.7.86		20.78	
25.7.86	26.69		
26.7.86			21.44
27.7.86		20.46	
28.7.86	24.53		
29.7.86			20.90
30.7.86		24.65	
31.7.86	26.52		
1.8.86			19.06
2.8.86		24.49	
3.8.86	21.34		
4.8.86			24.71
5.8.86		25.68	
6.8.86	23.31		
7.8.86			19.92
8.8.86		21.18	
9.8.86	17.80		
10.8.86			21.98
11.8.86		23.26	
12.8.86	11.62		
13.8.86			20.26
14.8.86		18.05	
15.8.86	15.90		

Contd....

1	2	3	4
16.8.86			16.01
17.8.86		18.84	
18.8.86	13.01		
19.8.86			11.19
20.8.86		19.32	
21.8.86	18.32		
22.8.86			12.59
23.8.86		11.06	
24.8.86	11.70		
25.8.86			7.06
26.8.86		12.88	
27.8.86	8.09		
28.8.86			4.71
29.8.86		9.49	
30.8.86	5.68		
31.8.86			3.26
1.9.86		4.81	
2.9.86	2.87		
3.9.86			1.34
4.9.86		0.88	
5.9.86	1.51		
6.9.86			0.00
7.9.86		0.00	
8.9.86	0.00		
9.9.86			0.00
10.9.86		0.00	
11.9.86	2.94		
12.9.86			
13.9.86			
14.9.86	15.42		
15.9.86			
16.9.86			
17.9.86	5.28		
18.9.86			
19.9.86			
20.9.86	1.33		
21.9.86			
22.9.86			
23.9.86	0.00		

Table 12 : Progress of anthracnose on three date of sowing irrespective of varieties

Date	Disease index (Sum of three varieties)		
	23rd June	3rd July	13th July
15.7.1986	10.6	-	-
18.7.1986	21.6	13.0	13.0
21.7.1986	19.4	21.4	19.5
24.7.1986	23.5	23.8	23.0
27.7.1986	24.4	19.8	21.4
30.7.1986	23.0	27.5	18.1
2.8.1986	22.3	28.0	17.7
5.8.1986	22.3	27.5	16.3
8.8.1986	26.9	19.4	18.2
11.8.1986	24.5	17.9	16.1
14.8.1986	20.5	13.8	15.4
17.8.1986	20.6	13.4	15.2
20.8.1986	17.7	16.6	9.8
23.8.1986	16.6	11.5	6.8
26.8.1986	13.2	8.9	4.3
29.8.1986	10.7	5.3	0.0
1.9.1986	7.6	1.9	0.0
4.9.1986	4.0	0.0	0.0
7.9.1986	1.5	0.0	0.0
10.9.1986	0.0	1.1	2.9
13.9.1986	1.8	5.3	1.4
16.9.1986	7.0	2.2	0.0
19.9.1986	1.6	0.0	0.0
22.9.1986	0.0	0.0	0.0

disease index ranging from 20.5-26.9 per cent (23rd June). In 3rd July sown crop five observations consisted more than 20 per cent disease index varying from 21.4-28.0 per cent and 21.4-23.0 per cent in two observations in late sown crop (13th July). However, the maximum intensity (28.0) of the disease was recorded in mid sowing while early sowing had the higher disease in ten observations (Fig. 14).

7.7 Factors affecting sporulation on the host

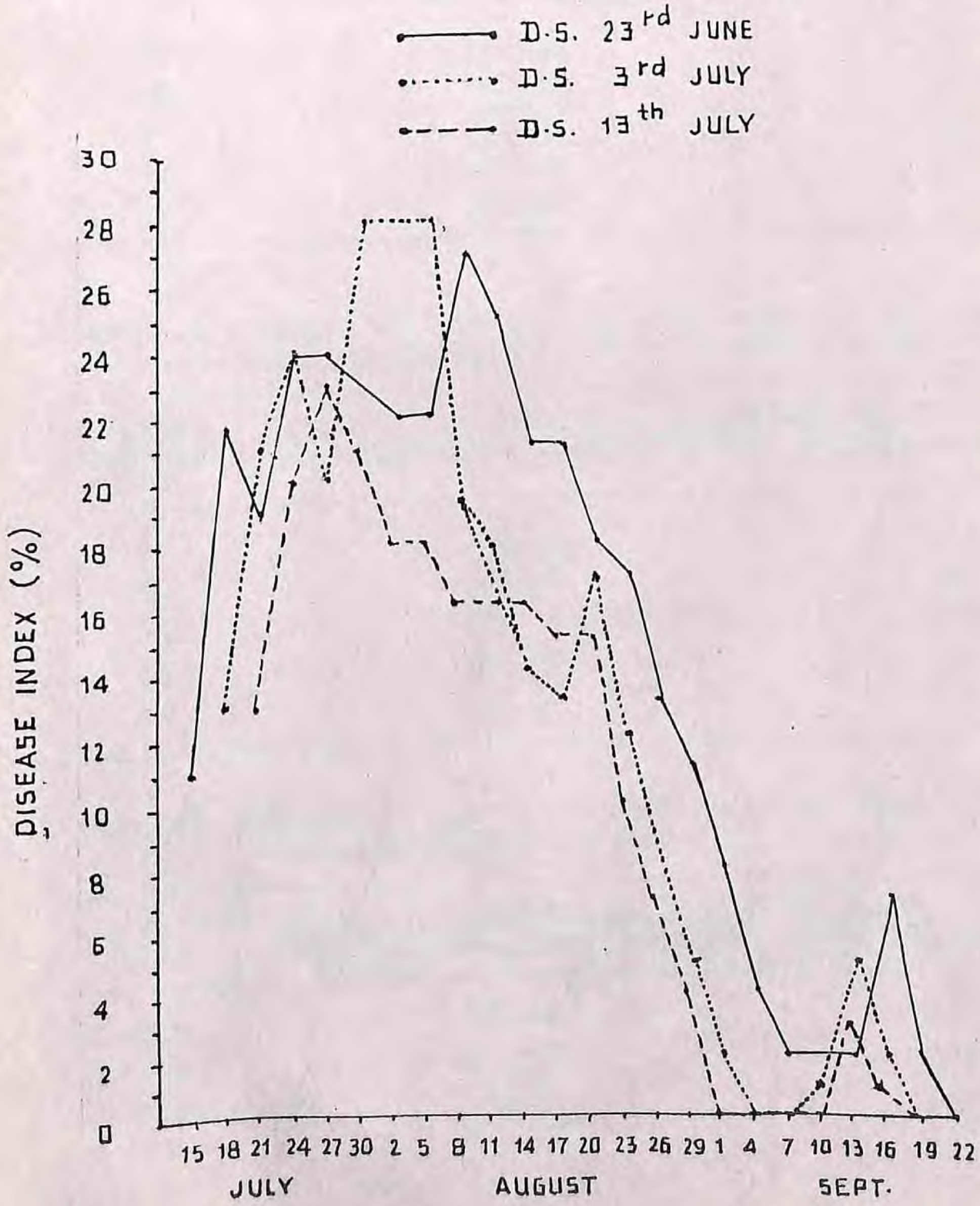
7.7.1 Temperature

It is evident from Table 13 that the maximum number of spores of C. lindemuthianum and C. dematium were observed at 25°C temperature. In C. lindemuthianum, the maximum number of spores were 293.32/mm^2 lesion area followed by 261.12, 201.03, 195.35 and 190 spores/mm^2 lesion area at 25, 22, 27, 20 and 30°C temperature respectively. On the other hand C. dematium had its maximum sporulation 250.63 spores/mm^2 followed by 215.52, 178.30, 159.67 and 140.42 at 25, 22, 20, 27 and 30°C temperature respectively. The number of spores in C. lindemuthianum were more than number of spores in C.dematium at all temperatures (Fig. 15).

7.7.2 Humidity

The sporulation per mm^2 were recorded at five relative humidity levels - 25, 50, 75, 90 and 100 per cent. The results are given in Table 14.

FIG. 14 : INFLUENCE OF DATE OF SOWING ON THE PROGRESS OF ANTHRACNOSE IN THREE VARIETIES OF MUNGBEAN - 1986-87



The maximum number of spores/mm^2 area were noted at 100 per cent humidity level in both the species of Colletotrichum. The maximum number of spores of C. lindemuthianum and C.dematium were 286.36 and 248.34, followed by 260.67 and 257.52, 139.28 and 147.02, 60.15 and 90.63, 30.32 and 57.40 at 100, 90, 75, 50 and 25 per cent humidity. The number of spores in C. dematium were more 147.02, 90.63 and 57.40 spores/mm^2 lesion area as compared to C. lindemuthianum at 75, 50 and 25 per cent humidity level. At 90 and 100 per cent humidity level, the number of spores of C. dematium were almost at par. It indicates that the optimum humidity is between 90-100 per cent (Fig. 16).

7.7.3 Host age

The sporulation on leaves of different age groups - 22, 30, 40, 50 and 60 days were examined and the results are given in Table 15.

The maximum number of spores of C. lindemuthianum was noted in the leaves of 40 days old plant followed by 269.64, 240.05, 201.15 and 184.56 spores/mm^2 area in 30, 22, 50 and 60 days old plant respectively. The maximum number of spores of C. dematium were 294.25 followed by 279.37, 265.63, 190.3 and 140.15 spores/mm^2 in the leaves of 30 days old plant followed by 22, 40, 50 and 60 days old plant respectively. In both the species the maximum number of spores were recorded in 30 days and 40 days old plants but the number of spores/mm^2 area declined as the host age increased (Fig. 17).

FIG. 15: FACTORS AFFECTING SPORULATION OF *Colletotrichum* Spp. ON MUNGBEAN LEAVES

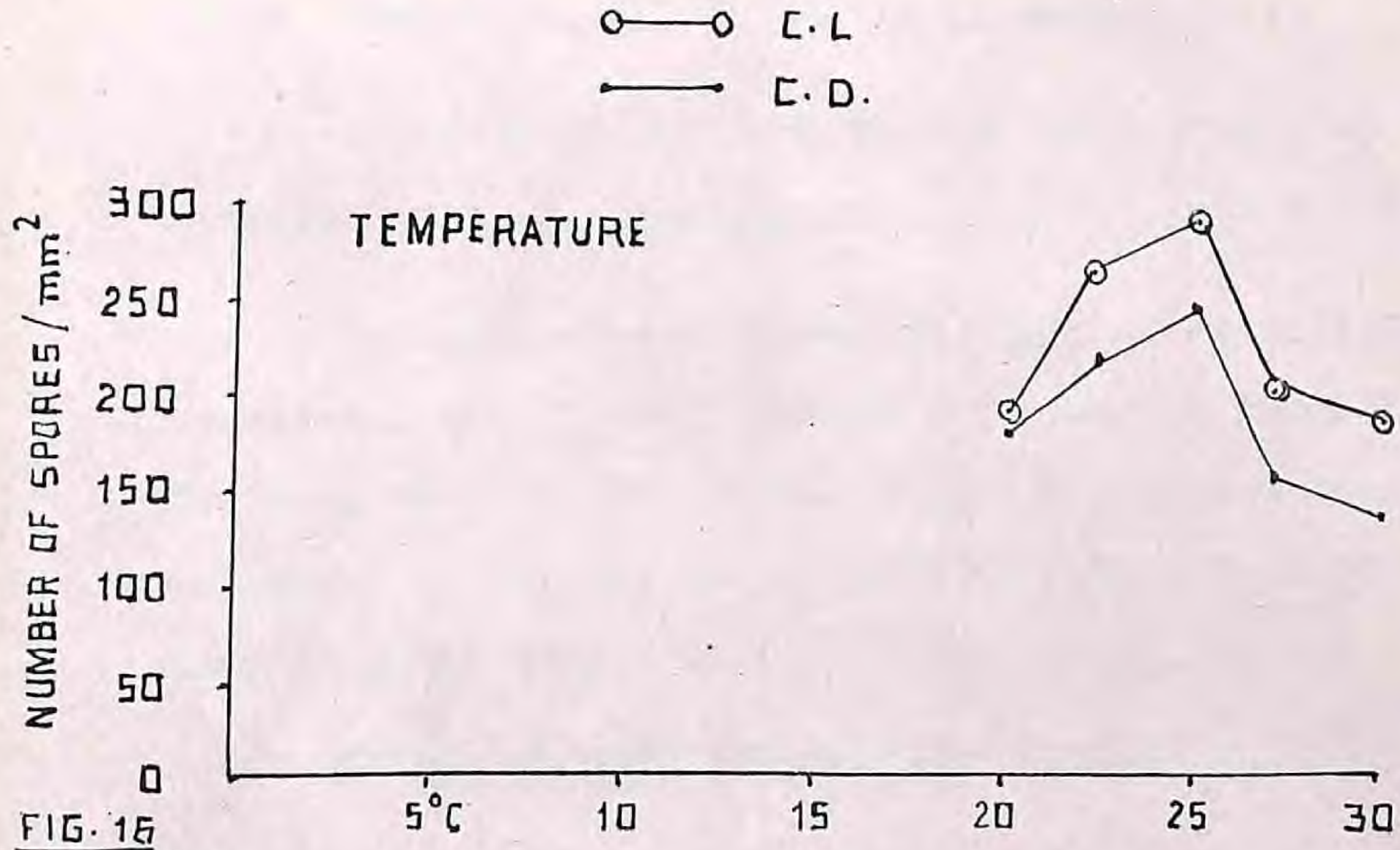


FIG. 16

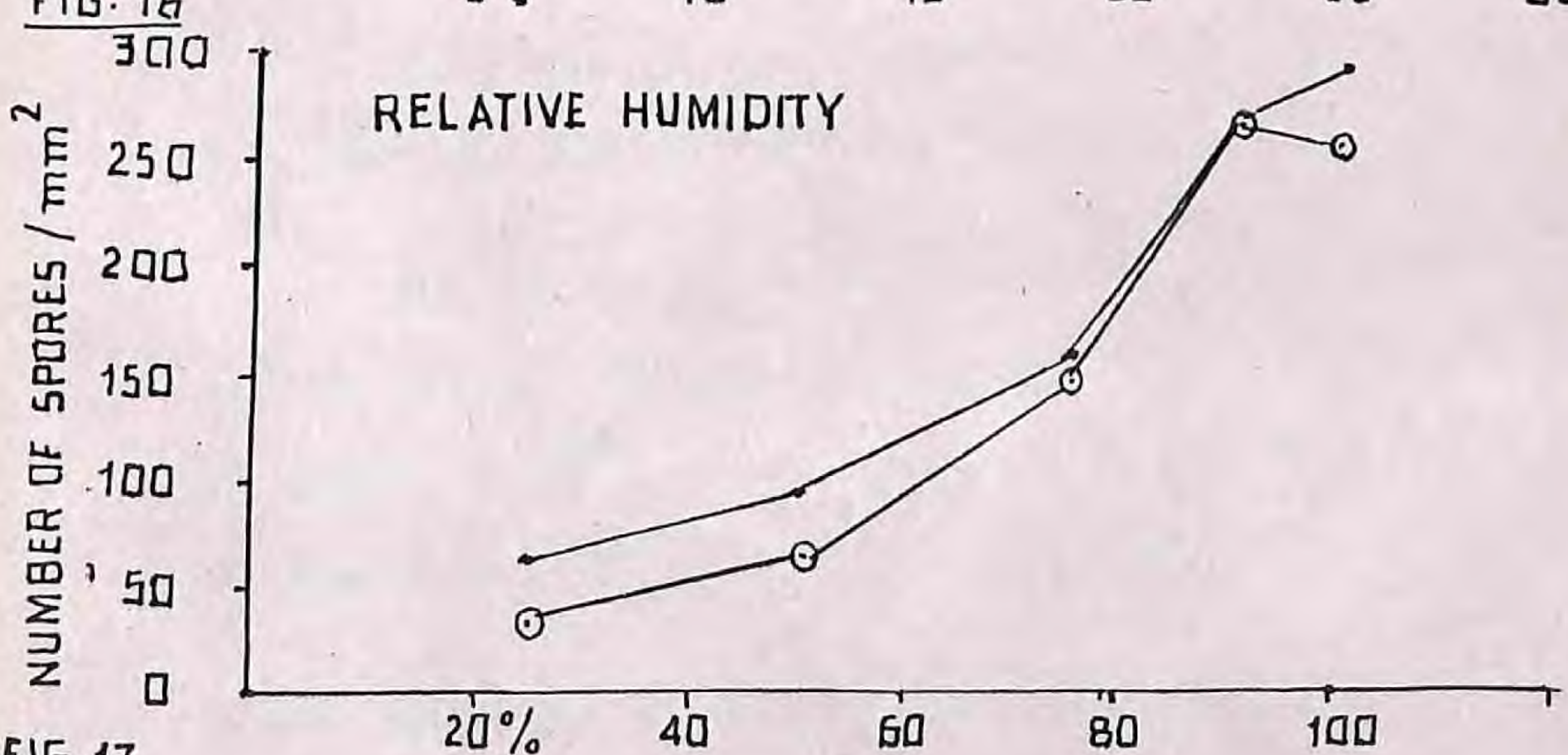
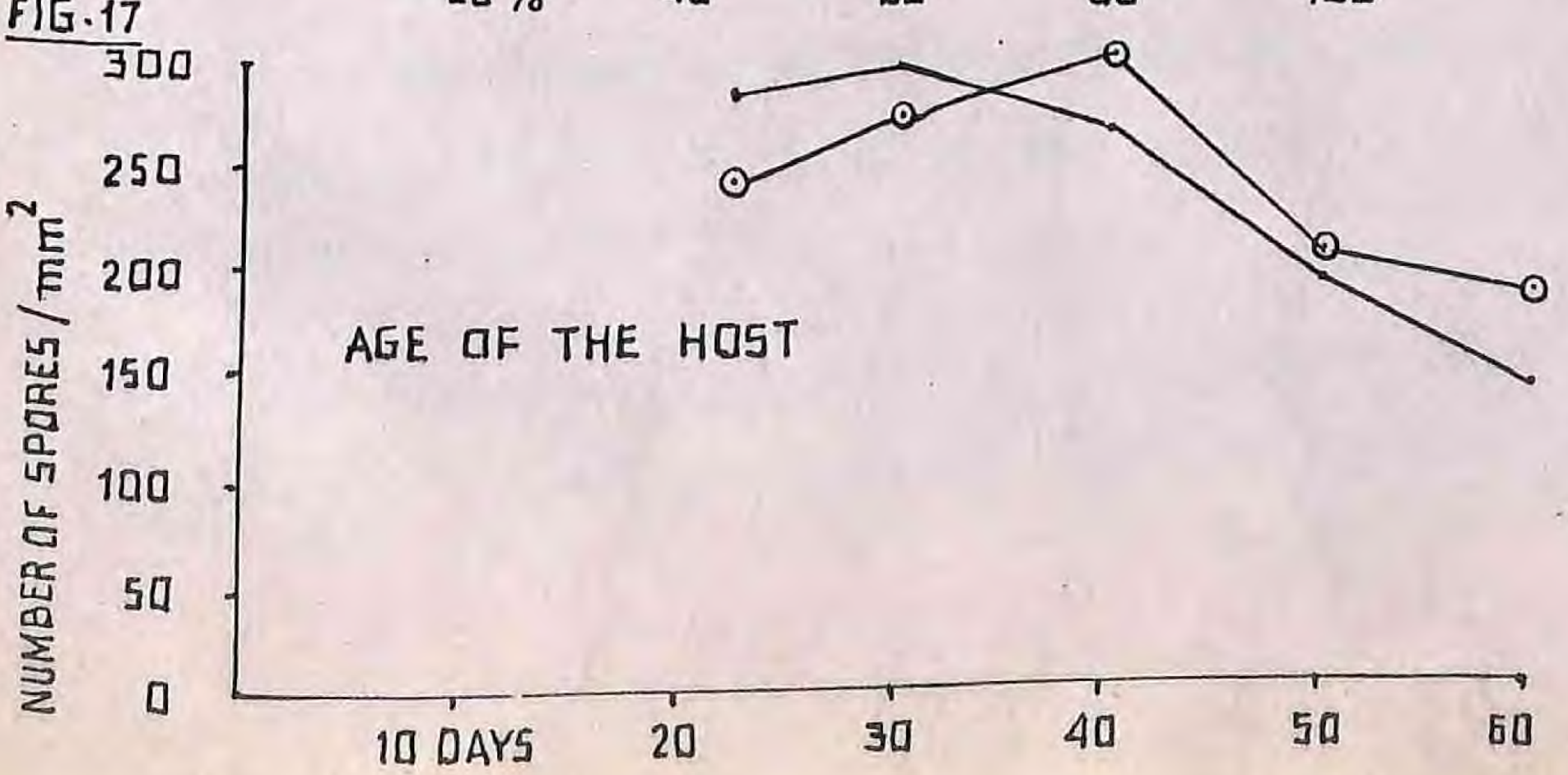


FIG. 17



7.8 Factors affecting spore germination

7.8.1 Effect of temperature on C. dematium

The data on the influence of temperature on spore germination of C. dematium are presented in Table 16.

The spores were placed in drops of distilled water in cavity slides. Spores germinated within 16 hours at 25°C followed by 82.2, 79.3, 65.4 and 56.3 per cent germination of spores at 22, 20, 27 and 30°C temperature within 16 hours time interval (Fig. 18).

7.8.2 Effect of temperature on C. lindemuthianum

The data on spore germination of C. lindemuthianum as affected by temperature are given in Table 17.

The spores were placed in drops of distilled water in cavity slide. Spores germinated within 12 hours at 25°C, 14 hours at 22°C, 15 hours at 20°C and 92.3 per cent germination of spores was noted at 30°C (Fig. 18).

7.8.3 Effect of humidity on C. dematium

The effect of different relative humidity levels on spore germination of C. dematium was studied and the data are given in Table 18.

The spores were kept dry and placed at different humidity levels. Maximum germination of spores i.e. 87.32 per cent was

FIG. 18 : EFFECT OF TEMPERATURE ON SPORE GERMINATION OF Colletotrichum spp. IN VITRO

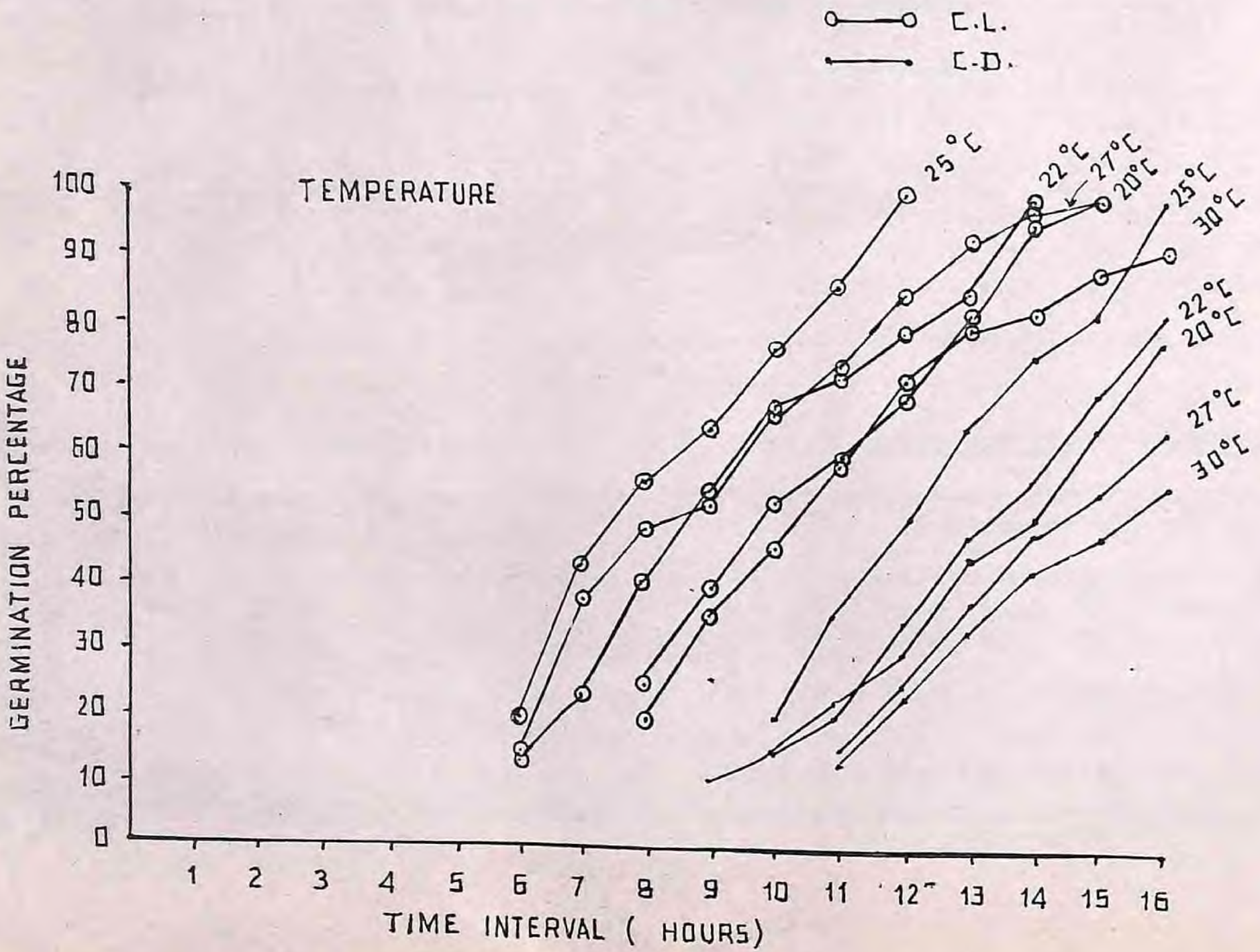


Table 16 : Effect of temperature on spore germination of Colletotrichum dematium

Temperature (°C)	Time interval (Hours)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Germination percentage															
20	0	0	0	0	0	0	0	0	11.2	15.4	23.3	30.4	44.5	50.5	64.3	79.3
22	0	0	0	0	0	0	0	0	0	15.3	21.1	35.4	48.4	57.3	69.7	82.2
25	0	0	0	0	0	0	0	0	0	20.3	38.4	50.3	65.2	75.7	82.4	100
27	0	0	0	0	0	0	0	0	0	0	16.1	25.2	38.3	49.2	55.3	65.4
30	0	0	0	0	0	0	0	0	0	0	12.6	23.3	34.4	42.7	48.3	56.3

Table 17 : Effect of temperature on spore germination of Colletotrichum lindemuthianum

Temperature (°C)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
20	0	0	0	0	0	0	0	20.2	35.6	45.9	58.7	69.3	82.4	96.0	100	-
22	0	0	0	0	0	13.3	24.4	40.5	55.3	68.2	72.2	79.3	84.5	100	-	-
25	0	0	0	0	10.5	20.3	43.4	55.7	63.6	75.6	86.3	100	-	-	-	-
27	0	0	0	0	0	15.2	38.1	49.4	52.8	67.0	74.4	85.2	93.1	98.0	100	-
30	0	0	0	0	0	0	0	25.3	40.4	53.3	60.2	72.1	79.6	82.3	89.4	92.3

Table 18 : Effect of relative humidity on germination of spores of Colletotrichum dematium

Relative humidity (%)	Time interval (Hours)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Germination percentage															
100	0	0	0	0	0	0	0	0	0	0	0	17.8	30.4	56.7	70.3	87.32
90	0	0	0	0	0	0	0	0	0	0	0	0	0	20.1	32.3	45.50
75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.60
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 19 : Effect of relative humidity on germination of spores of Colletotrichum lindemuthianum

Relative humidity (%)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
100	0	0	0	0	0	0	0	14.5	20.8	31.2	44.4	55.7	65.2	75.5	91.1	100.0
90	0	0	0	0	0	0	0	0	0	13.2	25.4	50.3	61.8	69.6	73.4	83.4
75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15.3
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

noted at 100 per cent RH followed by 45.5 and 16.6 per cent at 90 and 75 per cent RH level respectively. No spore germinated at 50 and 25 per cent humidity level. The germination of spore started within 12 hours at 100 per cent RH, 14 hours at 90 per cent RH and within 16 hours at 75 per cent RH (Fig. 19).

7.8.4 Effect of humidity on C. lindemuthianum

Effect of different relative humidities on spore germination of C. lindemuthianum in vitro is presented in Table 19.

The germination of spore started within 8 hours and completed within 16 hours at 100 per cent RH. At 90 per cent RH, 83.4 per cent germination was observed followed by 15.3 per cent at 75 per cent RH level. No germination took place at 50 and 25 per cent RH level. At 90 per cent RH, spore started germination within 10 hours (Fig. 19).

7.9 Factors affecting disease development

7.9.1 Temperature

Leaves with single lesions were collected from the experimental area. The lesion was measured, washed with sterile water. Then, the leaves were incubated in moist chamber at different temperatures. The increase in lesion size after 72 hours at each temperature was recorded and given in Table 20.

FIG-19 : EFFECT OF RELATIVE HUMIDITY ON GERMINATION OF SPORES *Colletotrichum* spp. IN VITRO

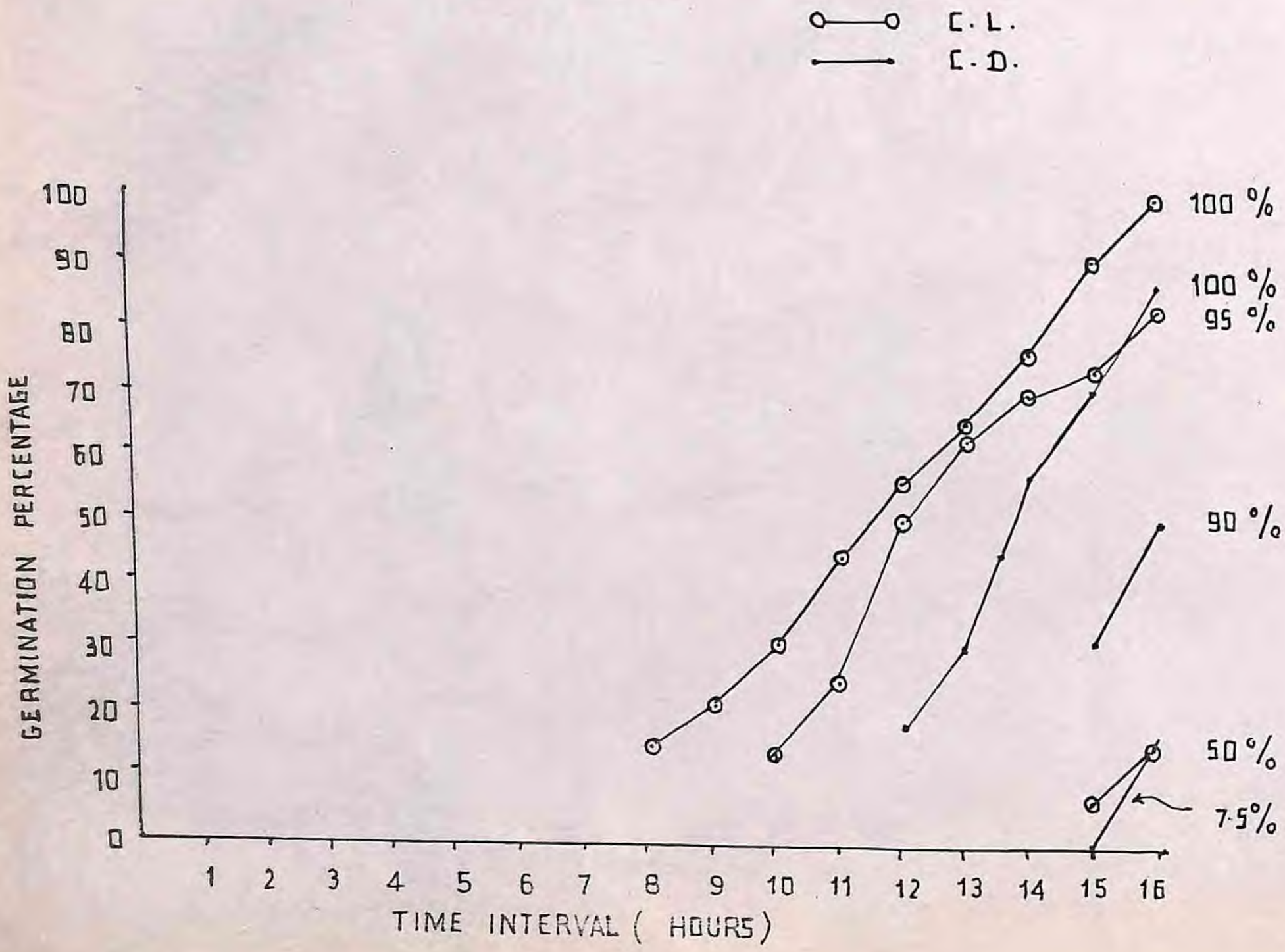


Table 20 : Effect of temperature on development of anthracnose of mungbean (72 hours)

Temperature (°C)	Increase in area (mm^2)	
	Colletotrichum lindemuthianum	Colletotrichum dematium
20	9.79	12.00
22	12.45	16.31
25	15.59	18.26
27	16.25	10.21
30	7.89	8.76

Table 21 : Effect of relative humidity on development of anthracnose of mungbean (72 hours)

Relative humidity (%)	Increase in area (mm^2)	
	Colletotrichum lindemuthianum	Colletotrichum dematium
100	18.76	22.21
90	15.63	16.36
75	4.60	7.53
50	0.00	0.00
25	0.00	0.00

Table 22 : Influence of light intensity on development of anthracnose of mungbean (72 hours)

Light intensity	Increase in area (mm^2)	
	Colletotrichum lindemuthianum	Colletotrichum dematium
1. Darkness (72 hours)	2.20	3.43
2. Alternate light and darkness (12 hours each)	5.45	6.22
3. Continuous light (72 hours)	6.94	7.07

The maximum increase (16.25 mm^2) in lesion size was noted at 27°C temperature in C. lindemuthianum while it was maximum (18.26 mm^2) at 25°C in C. dematium. Minimum increase in size of lesion was associated with both the species of Colletotrichum at 30°C temperature. At 20°C in C.lindemuthianum and 30°C in both the species, the increase in lesion area was very poor (Fig. 20).

7.9.2 Humidity

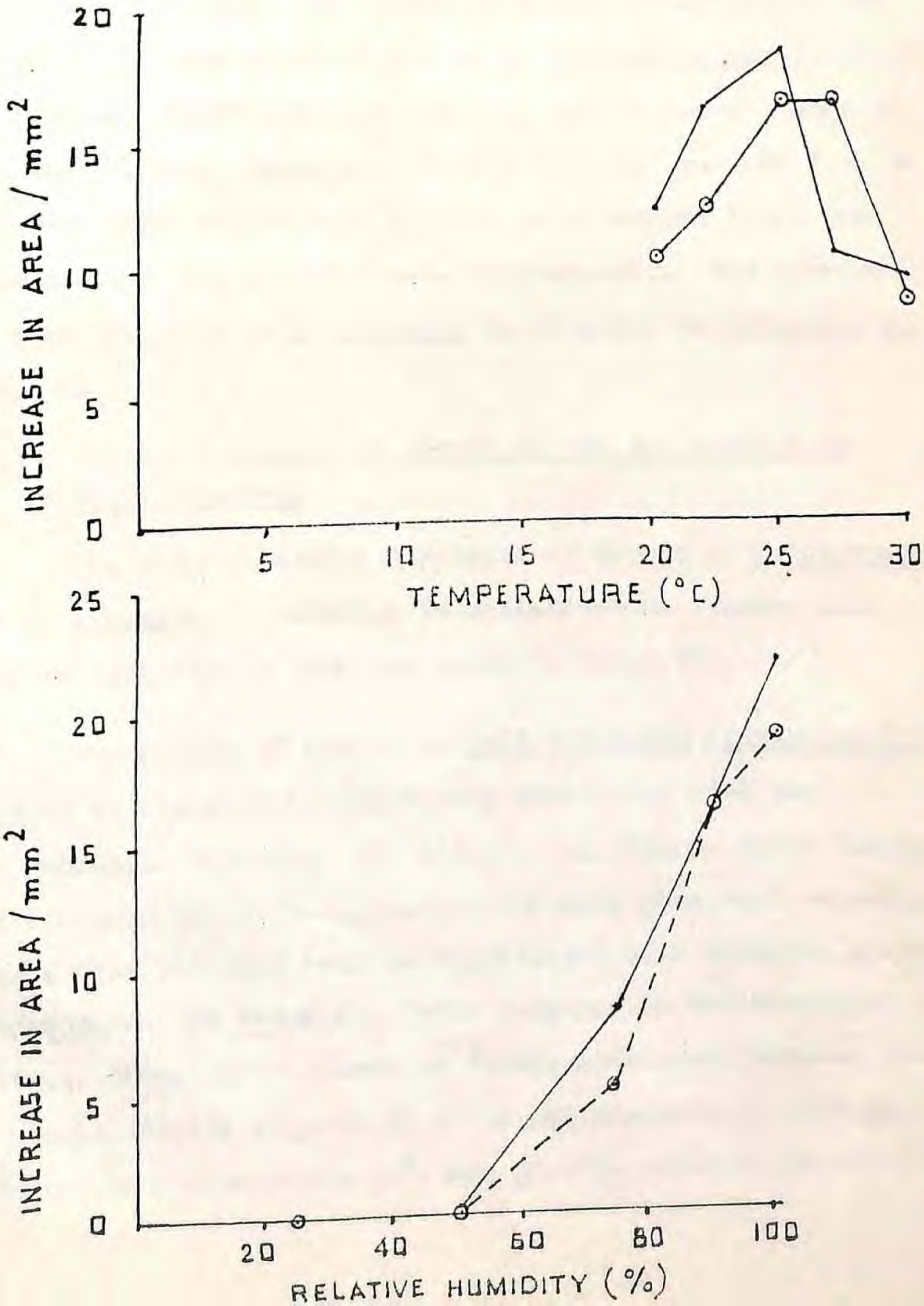
The increase in lesion was recorded at five relative humidity levels - 25, 50, 75, 90 and 100 and data on C. lindemuthianum and C. dematium are given in Table 21.

Increase in area within 72 hours was maximum in C. lindemuthianum and C. dematium at 100 per cent RH level. The increased lesion area was 18.76 mm^2 in C. lindemuthianum followed by 15.63 and 4.60 mm^2 at 100, 90 and 75 per cent RH respectively while, in C. dematium, the area was 22.21, 16.36 and 7.53 mm^2 at 100, 90 and 75 per cent RH respectively. No increase in area was noted at 25 and 50 per cent RH in both the species (Fig. 20).

7.9.3 Light

The effect of complete darkness, alternate light and darkness for 12 hours each, and continuous light exposure for 72 hours on disease development of C. lindemuthianum and C. dematium was studied and data are presented in Table 22.

FIG. 20: EFFECT OF TEMPERATURE AND RELATIVE HUMIDITY ON THE DEVELOPMENT OF ANTHRACNOSE CAUSED BY TWO SPECIES OF COLLETOTRICHUM



The data revealed that there was maximum (6.94 and 7.07 mm^2) increase in area of lesions in C. lindemuthianum and C. dematium when the leaves were exposed to continuous light for 72 hours. In alternate light and darkness, the increase in area was 5.45 mm^2 in C. lindemuthianum followed by 2.20 mm^2 under complete darkness for 72 hours. Same is the case with C. dematium, the increase in area was 6.22 and 3.43 mm^2 when leaves were exposed to alternate light and darkness and complete darkness respectively. The increase in area was more in C. dematium as compared to C.lindemuthianum (Fig. 21).

7.10 Aerial dispersal of spores of the two species of Colletotrichum

The data on aerial dispersal of spores of C.lindemuthianum and C. dematium in relation to environmental factors from 13th July to 13th August 1986 are given in Table 23.

The number of spores of Colletotrichum lindemuthianum trapped on slides were negatively correlated with the environmental factors. The correlation between spore trapping and relative humidity at morning and noon were statistically significant but they were nonsignificant with maximum, minimum temperatures and rainfall. With decrease in environmental factors, trapping of spores on slides increased. Maximum number of spores (98.42) trapped on slide was observed on 30th July when the temperature was 29°C and 23.1°C, relative humidity was

Table 23 : Spore trapping of two species of Colletotrichum in relation to different environmental factors from 13th July to 13th August 1986

Date	Maximum temperature (°C)	Minimum temperature (°C)	Humidity per cent (Morning)	Humidity per cent (Noon)	Rain (mm)	Number of spores trapped on slide (6 cm^2)	
						Colletotrichum lindemuthianum	Colletotrichum dematium
13.7.86	33.0	24.0	91	63	-	10.70	5.20
14.7.86	32.7	22.1	98	85	42.4	5.80	1.20
15.7.86	29.4	24.2	98	75	14.0	6.30	7.50
16.7.86	32.5	25.7	93	68	0.0	12.50	8.60
17.7.86	33.7	25.0	95	77	9.7	17.00	10.00
18.7.86	31.2	24.2	96	79	36.8	4.60	5.20
19.7.86	31.2	24.2	95	76	0.0	22.36	25.30
20.7.86	29.2	24.7	93	93	2.0	21.56	15.10
21.7.86	27.4	24.0	96	72	3.8	8.64	13.15
22.7.86	32.0	22.8	97	74	175.5	3.60	2.20
23.7.86	30.9	24.5	95	78	2.3	13.82	25.62
24.7.86	29.2	23.0	96	81	9.7	39.52	56.71
25.7.86	27.9	23.0	91	88	4.1	82.20	30.37
26.7.86	26.2	23.0	91	90	1.3	70.50	60.70
27.7.86	24.5	21.5	93	83	7.1	45.50	19.30
28.7.86	26.2	22.0	94	96	1.8	38.40	18.10
29.7.86	24.0	22.4	93	74	10.7	30.30	28.41
30.7.86	29.0	23.1	91	83	0.0	98.42	85.20
31.7.86	28.7	24.2	92	75	0.0	86.42	68.70
1.8.86	30.7	23.2	96	87	14.2	25.68	53.20
2.8.86	28.7	23.5	96	90	4.6	45.43	61.00
3.8.86	27.0	22.8	98	83	21.6	20.42	35.40
4.8.86	29.0	22.8	100	82	54.6	5.60	7.30
5.8.86	29.3	23.3	98	93	21.3	86.78	80.30
6.8.86	28.5	23.5	96	88	13.5	68.68	74.34
7.8.86	31.3	24.5	95	90	5.3	78.68	80.67
8.8.86	30.5	23.7	95	66	12.7	55.56	64.30
9.8.86	32.2	25.0	90	70	0.8	45.43	55.30
10.8.86	32.2	24.7	88	89	16.3	67.36	47.70
11.8.86	31.7	24.5	96	72	5.8	58.63	56.67
12.8.86	32.7	25.5	95	72	3.3	45.26	44.50
13.8.86	32.0	24.7	90	69	4.1	38.43	25.36

Value of 'r' for two species of Colletotrichum					
Colletotrichum lindemuthianum	-0.2229	-0.2572	-0.4217*	-0.5738*	-0.3429
Colletotrichum dematium	-0.1293	-0.2494	-0.1705	0.2839	-0.3290

*significant at 5% level

91 and 83 per cent and there was no rain. Cloudy weather and drizzling was also observed during this period. Number of spores trapped on slides were generally less when heavy rains occurred (14th, 18th, 22nd July and 4th August). The spores might be washed off due to heavy rains but the number soon increased as the rains receded (19th, 30th July, 5th and 7th August). Number of spores were less when the maximum temperature was higher (14th, 17th and 22nd July) (Fig. 22).

Spore trapping of C. dematium was also negatively correlated with environmental factors except relative humidity during noon. Correlation between spores trapped and relative humidity of noon was positive. No correlation was found to be statistically significant. Increase in relative humidity of noon was related with increase in spores trapped on slides (Fig.22).

Number of spores (98.42 and 85.20) trapped on slides (6 cm^2) on 30th July were more in C. lindemuthianum as well as in C. dematium. On the days with heavy rains, lesser number of spores were trapped in C.lindemuthianum and C.dematium. The relation of environmental factors with number of spores trapped were similar in C. lindemuthianum and C. dematium.

7.10.1 Presence of spores of two species of Colletotrichum in air in field

The data on spore trapping of C. lindemuthianum and C. dematium within 10 hours from 7.00 AM to 5.00 PM are given in Table 24.

FIG. 22: CHANGES IN DAILY CONCENTRATION OF SPORES OF TWO SPECIES OF *Colletotrichum* TRAPPED ON SLIDES

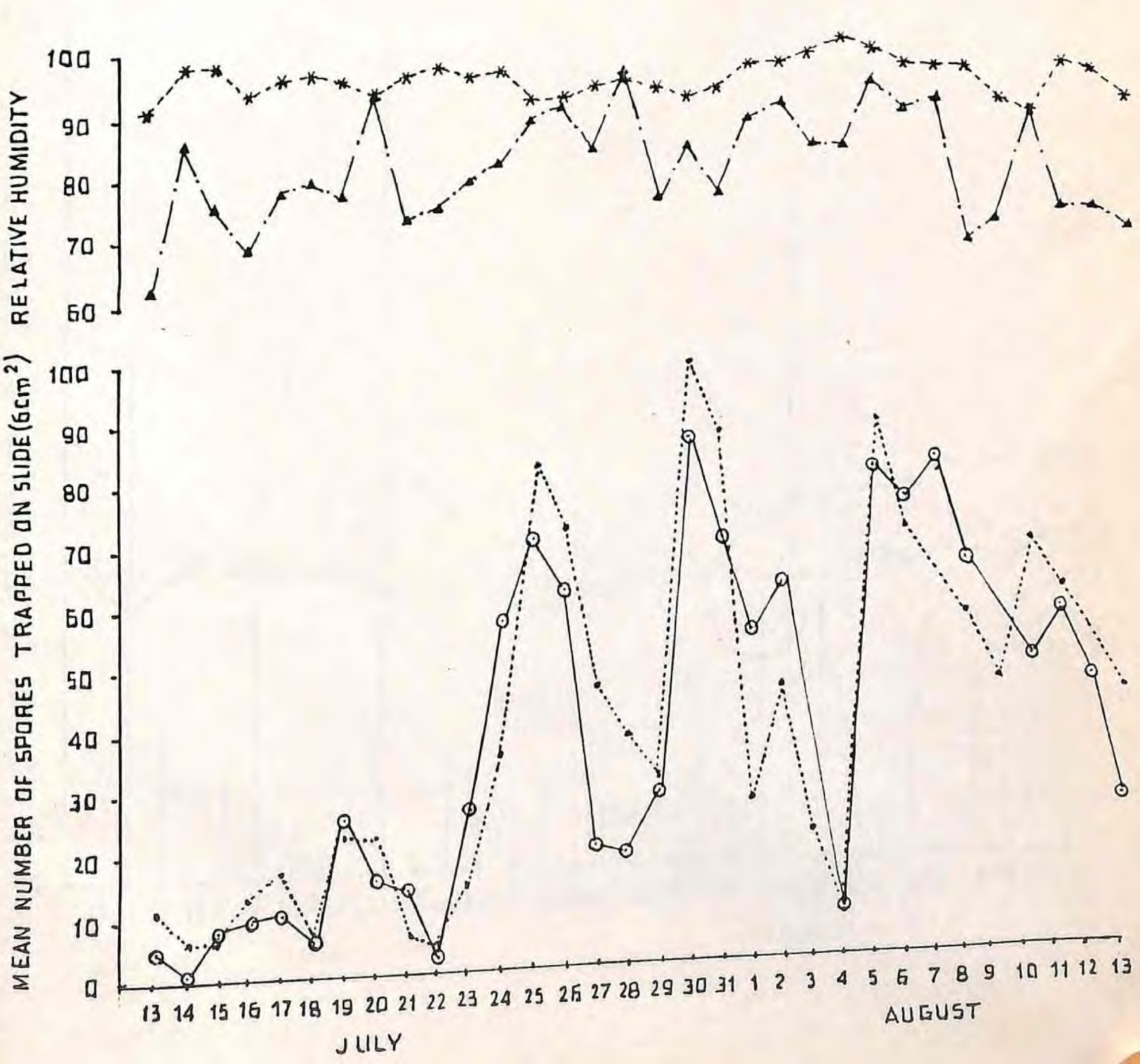


FIG. 22 : CHANGES IN DAILY CONCENTRATION OF SPORES OF Colletotrichum SPP. TRAPPED ON SLIDES

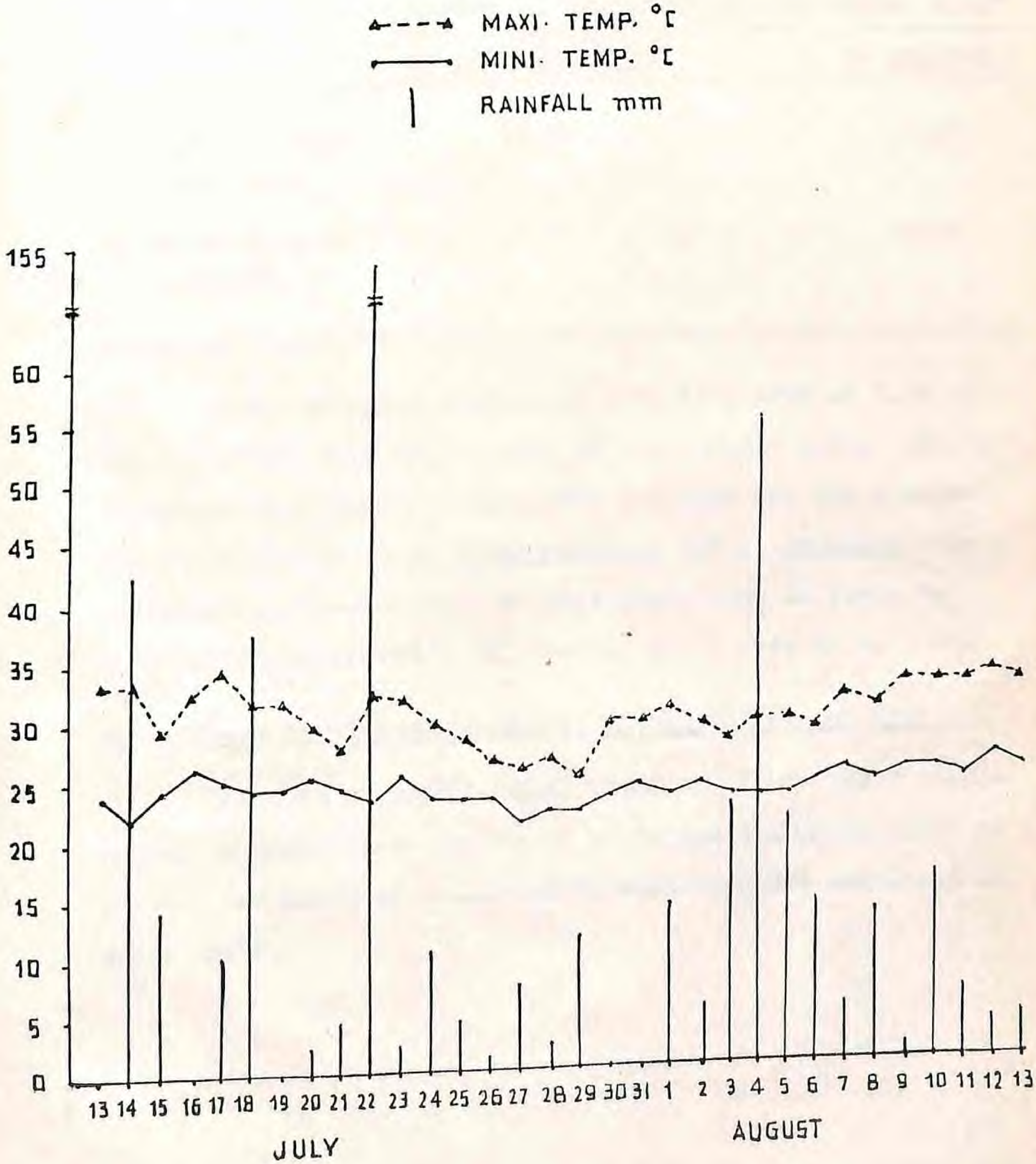


Table 24 : Presence of spores of the two species of Colletotrichum in air under field conditions (Mean of 32 days)

Time	Number of spores trapped on slide (6 cm^2)	
	C. lindemuthianum	C. dematium
1. 7.00 AM to 12.00 Noon	17.85	14.64
2. 12.00 Noon to 5.00 PM	8.94	10.78

Spore trapping started on 13th July 1986 at 7.00 AM and continued till the evening of 13th August 1986. Counts of spores were made at 12.00 Noon and 5.00 PM. The maximum number of spores of C. lindemuthianum and C. dematium were collected in between 7.00 AM till 12.00 Noon followed by 8.94 and 10.78 spores/6 cm^2 between 12.00 Noon to 5.00 PM.

8. Affect of disease on growth parameters of the host

The data on mean height, branches/plant, shoot weight, number of pods/plant, number of seeds/pod and yield/plant of healthy and diseased plants of 17 varieties are presented in Table 25-30.

8.1 Plant height

Average disease intensity of five diseased plants was determined in 17 varieties of mungbean. Mean height of five diseased and five healthy plants was also measured in all the 17 varieties and difference between healthy and diseased plants was observed to determine the percentage reduction in height. Reduction per unit disease was determined by dividing the percentage reduction to the average disease intensity. The data on percentage reduction and reduction per unit disease in 17 varieties are given in Table 25.

It is evident from Table 25 that the maximum reduction (2.30 cm) in height per unit disease was observed in variety ML-323 followed by GM-82-4 (2.12 cm) and MH-304 (1.97 cm). The least reduction in plant height was associated with Phule MI being 0.17 cm. The reduction in height of six varieties namely DM-5, ML-131, ML-395, PDM-84-145 and 76/22 was almost similar. The percentage reduction in height was maximum (46.55 cm) in MH-304 and minimum in Phule MI (3.43 cm) in which reduction per unit disease was also least. Affect of disease on eight varieties - GM-82-4, ML-5, ML-323, ML-320, ML-395, ML-405, PDM-84-145 and DM-1 was almost equal.

8.2 Number of branches/plant

Influence of anthracnose caused by C. lindemuthianum and C. dematium on number of branches per plant was studied. Average number of branches of five healthy and five diseased

Table 25 : Effect of anthracnose on plant height of mungbean

Variety	Diseased / Healthy	Disease intensity	Mean plant height (cm)	Percentage reduction in height	Reduction in height/unit disease index
DM-5	D	15.52	30.78	24.01	1.54
	H		40.51		
GM-82-4	D	18.36	32.76	39.09	2.12
	H		53.79		
ML-5	D	27.18	33.95	33.54	1.23
	H		51.10		
ML-131	D	19.19	33.65	29.33	1.52
	H		47.62		
ML-323	D	16.33	34.92	37.58	2.30
	H		55.95		
ML-320	D	20.40	35.56	34.39	1.68
	H		54.20		
ML-395	D	26.86	34.59	36.76	1.36
	H		54.71		
ML-405	D	19.13	32.38	34.34	1.79
	H		49.32		
ML-406	D	17.28	39.03	29.58	1.71
	H		55.44		
ML-408	D	21.62	34.36	25.82	1.19
	H		46.32		
PDM-84	D	35.74	35.22	21.72	0.60
	H		45.00		
PDM-84-145	D	21.93	30.78	35.56	1.62
	H		47.77		
Phule MI	D	19.65	44.39	3.43	0.17
	H		45.97		
76/19	D	22.50	38.81	29.65	1.31
	H		55.16		
76/22	D	17.14	38.81	25.68	1.49
	H		52.22		
DM-1	D	34.01	31.62	32.22	0.94
	H		46.65		
MI-304	D	23.56	30.91	46.55	1.97
	H		57.83		

plants was recorded and difference between healthy and diseased plants was calculated. The percentage reduction and reduction per unit disease was calculated and the data are presented in Table 26.

It is clear from the data that the reduction per unit disease was maximum (2.14) in DM-5 with 33.33 per cent reduction while minimum reduction (0.33) was in ML-408 with 7.14 per cent. The reduction per unit disease was almost at par with maximum (2.14) reduction in varieties namely GM-82-4 (2.04), 76/19 (1.94), PMD-84-145 (1.92) and ML-323 (2.09). In remaining 11 varieties, the reduction per unit disease was at par with minimum reduction (0.33). The percentage reduction was highest (43.75) in 76/19 and lowest (7.14) in ML-408 which was similar to reduction per unit disease. In other varieties, the percentage reduction in number of branches was similar as in case of reduction in number of branches per unit disease.

8.3 Shoot weight

Influence of anthracnose on shoot weight was recorded and data on percentage reduction in shoot weight and reduction in shoot weight per unit disease was calculated and presented in Table 27.

Reduction in shoot weight between healthy and diseased plant was clearly evident from Table 27. This host parameter was markedly influenced by the disease. Maximum reduction in

Table 26 : Effect of anthracnose on number of branches/plant of mungbean

Variety	Diseased / Healthy	Disease intensity	Mean number of branches per plant	Percentage reduction	Reduction per unit disease index
DM-5	D	15.52	4.00	33.33	2.14
	H		6.00		
GM-82-4	D	18.16	5.00	37.50	2.04
	H		8.00		
ML-5	D	27.18	5.00	20.00	0.73
	H		6.25		
ML-131	D	19.19	4.50	28.00	1.45
	H		6.25		
ML-323	D	16.33	5.75	34.28	2.09
	H		8.75		
ML-320	D	20.40	5.00	25.92	1.27
	H		6.75		
ML-395	D	26.86	5.50	26.66	0.99
	H		7.50		
ML-405	D	19.13	6.25	13.79	0.72
	H		7.25		
ML-406	D	17.28	8.00	13.51	0.70
	H		9.25		
ML-408	D	21.62	6.50	7.14	0.33
	H		7.00		
PDM-84	D	35.74	4.75	36.66	1.02
	H		7.50		
PDM-84-145	D	21.83	4.50	41.93	1.92
	H		7.75		
Phule MI	D	19.65	5.25	19.23	0.97
	H		6.50		
76/19	D	22.50	4.50	43.75	1.94
	H		8.00		
76/22	D	17.14	7.50	9.09	0.53
	H		8.25		
DM-1	D	34.01	4.25	22.72	0.66
	H		5.50		
MH-304	D	23.56	5.00	28.57	1.21
	H		7.00		

Table 27 : Effect of anthracnose on shoot weight of mungbean

Variety	Diseased / Healthy	Disease intensity	Mean shoot weight (g)	Percentage reduction in weight	Reduction in weight/unit disease index
DM-5	D	15.52	7.77	61.96	3.99
	H		20.43		
GM-82-4	D	18.36	9.00	65.85	3.58
	H		26.36		
ML-5	D	27.18	6.62	70.65	2.59
	H		22.56		
ML-131	D	19.19	9.60	30.58	1.59
	H		13.83		
ML-323	D	16.23	14.80	52.08	3.20
	H		30.89		
ML-320	D	20.40	10.70	59.48	2.91
	H		26.41		
ML-395	D	26.86	8.50	63.47	2.36
	H		23.27		
ML-405	D	19.13	14.20	48.93	2.55
	H		27.81		
ML-406	D	17.28	18.80	22.53	1.30
	H		24.27		
ML-408	D	21.62	12.52	40.71	1.88
	H		21.12		
PDM-84	D	35.74	10.80	39.66	1.10
	H		17.90		
PDM-84-145	D	21.83	7.46	55.06	2.52
	H		16.60		
Phule MI	D	19.65	14.95	27.14	1.38
	H		20.52		
76/19	D	22.50	13.43	49.01	2.17
	H		26.34		
76/22	D	17.14	14.27	26.29	1.33
	H		19.36		
DM-1	D	34.01	8.62	38.82	1.14
	H		14.09		
MH-304	D	23.56	11.15	55.09	2.33
	H		24.83		

shoot weight per unit disease was noted in DM-5 (3.990 g) followed by 3.58 g reduction in GM-82-4. Minimum effect 1.10 g of disease on shoot weight was seen in PDM-84. Seven varieties - ML-323 (3.20 g), ML-320 (2.91 g), ML-405 (2.55 g), ML-5 (2.59 g), MH-304 (2.33 g), PDM-84-154 (2.52 g) and ML-395 (2.36 g) had almost similar reduction in shoot weight per unit disease. Remaining varieties were at par with DM-1.

The percentage reduction in weight was maximum (70.65 g) in ML-5 followed by 65.85 g in GM-82-4, 63.47 g in ML-395, 61.96 g in DM-5 while it was minimum (26.29 g) in 76/22. Five varieties namely ML-320, MH-304, PDM-84-145, 76/19 and ML-405 were influenced by the disease in a similar way. Rest of the varieties were at par with 76/22.

8.4 Number of pods per plant

The effect of disease on pod formation varied from variety to variety. In some of the varieties, plants were heavily infected with the disease. In such cases, no pod formation was observed. It was adversely affected with the disease (Table 28). If pod formation took place, then the size of the pods reduced to the great extent and number of pods/plant was also reduced. Maximum reduction (5.08) in pod formation per unit disease was noted in variety ML-323, whereas, minimum in variety PDM-84. The varieties DM-1 and Phule MI were at par with PDM-84. Percentage reduction in number of pods/plant was maximum (91.42) in variety GM-82-4, whereas,

Table 28 : Effect of anthracnose on number of pods/plant of mungbean

Variety	Diseased / Healthy	Disease intensity	Mean number of pods/ plant	Percentage reduction in number of pods/plant	Reduction in pods/unit disease index
DM-5	D	15.52	3.00	65.71	4.23
	H		8.75		
GM-82-4	D	18.36	0.75	91.42	4.97
	H		8.75		
ML-5	D	27.18	2.75	65.62	2.41
	H		8.00		
ML-131	D	19.19	3.00	63.63	2.34
	H		8.25		
ML-323	D	16.23	2.50	82.45	5.08
	H		14.25		
ML-320	D	20.40	7.25	47.27	2.31
	H		13.75		
ML-395	D	26.86	5.50	65.07	2.42
	H		15.75		
ML-405	D	19.13	4.25	69.09	3.61
	H		13.75		
ML-406	D	17.28	6.25	63.23	3.65
	H		17.00		
ML-408	D	21.62	5.25	61.81	2.85
	H		13.75		
PDM-84	D	35.74	7.75	49.18	1.37
	H		15.25		
PDM-84-145	D	21.83	7.50	60.00	2.74
	H		18.75		
Phule MI	D	19.65	7.50	37.50	1.90
	H		12.00		
76/19	D	22.50	3.75	71.15	2.16
	H		13.00		
76/22	D	17.14	4.50	57.14	3.33
	H		10.50		
UM-1	D	34.01	4.50	48.57	1.42
	H		8.75		
MH-304	D	23.56	0.75	89.28	3.78
	H		7.00		

minimum in variety Phule MI. The number of pods per plant (%) in variety GM-82-4 was reduced to the great extent than the other varieties. Other varieties namely MM-5, ML-5, ML-131, ML-395, ML-405, ML-406, ML-408, PDM-84-145 and 76/19 were equally affected due to the disease.

8.5 Number of seeds per plant

Diseased pods contained less number of seeds as compared to healthy ones. Generally, 1/4th reduction in number of seeds per pod was observed in diseased plants (Table 29). Maximum reduction (5.14) in number of seeds per pod per unit disease was recorded in variety GM-82-44 while it was minimum (1.61) in PDM-84. Seven varieties MH-304, ML-131, ML-408, ML-405, PDM-84-145, 76/19 and 76/22 were in between the range of minimum and maximum. The percentage of seeds per pod was reduced in different varieties. The number of seeds per pod (%) were greatly reduced in variety GM-82-4 i.e. 94.49 while least reduction was observed in variety Phule MI i.e. 40.31.

8.6 Yield per plant

The data in Table 30 indicate reduction in yield of the plant per unit disease. The maximum reduction in yield per unit disease was noted in variety GM-82-4 (15.15 g), whereas, minimum reduction was in variety PDM-84 (1.59 g). Two varieties MM-5 (4.54 g) and ML-323 (4.55 g) were at par with GM-82-4. Severe reduction in yield/plant was recorded. It was maximum (94.00) in variety GM-82-4, whereas, minimum in variety Phule MI.

Table 29 : Effect of anthracnose on number of seeds/pod of mungbean

Variety	Diseased / Healthy	Disease intensity	Mean number of seeds/ pod	Percentate reduction	Reduction in number of seeds/unit disease index
DM-5	D	15.52	24.00	65.95	4.24
	H		70.50		
GM-82-4	D	18.36	4.50	94.49	5.14
	H		81.75		
ML-5	D	27.18	19.25	71.37	2.62
	H		67.25		
ML-131	D	19.19	21.25	68.40	3.56
	H		67.25		
ML-323	D	16.33	20.00	78.66	4.81
	H		93.75		
ML-320	D	20.40	54.75	56.54	2.77
	H		126.00		
ML-395	D	26.86	47.25	67.52	2.51
	H		145.50		
ML-405	D	19.13	34.25	61.29	3.20
	H		88.50		
ML-406	D	17.28	45.25	74.93	4.33
	H		180.50		
ML-408	D	21.62	41.50	65.48	3.02
	H		120.25		
PDM-84	D	35.74	56.50	57.83	1.61
	H		134.00		
PLM-84-145	D	21.83	57.00	65.61	3.00
	H		165.75		
Phule MI	D	19.63	57.00	40.31	2.05
	H		95.50		
76/19	D	22.50	24.00	74.12	3.29
	H		92.75		
76/22	D	17.14	29.75	67.83	3.95
	H		92.50		
DM-1	D	34.01	28.75	64.17	1.88
	H		80.25		
MH-304	D	23.56	6.50	88.69	3.76
	H		57.50		

Table 30 : Effect of anthracnose on yield/plant of mungbean

Variety	Diseased / Healthy	Disease intensity	Mean yield per plant (g)	Percentage reduction	Reduction/ unit disease index
DM-5	D	15.52	0.63	70.56	4.54
	H		2.14		
GM-82-4	D	18.36	0.15	94.00	5.11
	H		2.50		
ML-5	D	27.18	0.62	71.68	2.63
	H		2.19		
ML-131	D	19.19	0.74	60.84	3.17
	H		1.89		
ML-323	D	16.33	0.72	74.37	4.55
	H		2.81		
ML-320	D	20.40	1.39	59.11	2.89
	H		3.40		
ML-395	D	26.86	1.25	69.00	2.56
	H		4.13		
ML-405	D	19.13	0.95	60.90	3.18
	H		2.43		
ML-406	D	17.28	1.29	55.36	3.20
	H		2.89		
ML-408	D	21.62	1.34	61.60	2.84
	H		3.49		
PDM-84	D	35.74	1.62	57.14	1.59
	H		3.78		
PDM-84-145	D	21.83	1.66	59.21	2.71
	H		4.07		
Phule MI	D	19.65	1.74	33.33	1.69
	H		2.61		
76/19	D	22.50	0.72	72.93	3.24
	H		2.66		
76/22	D	17.14	0.88	67.64	3.94
	H		2.72		
DM-1	D	34.01	0.77	66.22	1.94
	H		2.28		
MI-304	D	23.56	0.17	88.27	3.74
	H		1.45		

8.7 Effect of disease on host parameters under different dates of sowing and varieties

Reduction per unit disease and percentage reduction on various growth parameters of the host in three varieties sown on different dates were determined.

8.7.1 Effect of disease on plant height and number of branches

The data on the influence of disease on mean plant height and number of branches per plant of five healthy and five diseased plants are given in Table 31.

Table 31 showed that the reduction in mean height and number of branches per unit disease was maximum (2.64 cm and 3.62) in V_3D_3 and minimum (6.37 cm and 0.49) in V_1D_2 and V_2D_2. Percentage reduction in height was maximum (41.78) in V_3D_3 and minimum in V_1D_2. Reduction in height (%) was almost similar in V_1D_1, V_2D_1, V_2D_2, V_2D_3, V_3D_1 and V_3D_2.

As regards the reduction in number of branches (%), maximum reduction (58.26) was recorded in V_1D_3 followed by 57.32, 50.8, 47.59, 47.41, 46.73, 38.49, 34.12 and 21.44 in V_3D_3, V_1D_1, V_3D_2, V_1D_2, V_3D_1, V_2D_1, V_2D_3 and V_2D_2 respectively.

8.7.2 Shoot weight and number of pods per plant

The observations in Table 32 displayed that the reduction in shoot weight per unit disease was maximum (1.63 g) in V_1D_3 followed by 1.46 g in V_1D_2. In other cases, the variation in shoot weight was extended to the wider limit. The least reduction

Table 31 : Influence of anthracnose on plant height and number of branches in different varieties and sowing date of mungbean

Variety	Date of sowing	Diseased / Healthy	Disease intensity	Mean plant height (cm)	Percentage reduction	Reduction per unit disease index	Mean number of branches	Percentage reduction	Reduction/ unit disease index
J-45 (V_1)	23.6.86 (D_1)	D	30.56	43.33	33.25	1.08	12.20	50.80	1.66
		H		64.92			24.80		
	3.7.86 (D_2)	D	30.38	52.22	20.98	0.69	13.84	47.41	1.56
		H		66.09			26.32		
	13.7.86 (D_3)	D	25.60	53.34	21.83	0.85	10.15	58.26	2.27
		H		68.24			24.32		
Pusa Baisakhi (V_2)	23.6.86 (D_1)	D	23.66	24.63	36.61	1.54	7.75	38.49	1.62
		H		38.86			12.60		
	3.7.86 (D_2)	D	43.05	28.44	36.01	0.83	7.73	21.44	0.49
		H		44.45			9.84		
	13.7.86 (D_3)	D	20.33	24.13	33.65	1.65	8.32	34.12	1.67
		H		36.37			12.63		
K 851 (V_3)	23.6.86 (D_1)	D	27.39	27.94	39.28	1.43	18.07	46.73	1.70
		H		46.02			15.15		
	3.7.86 (D_2)	D	18.25	31.29	35.16	1.92	9.80	47.59	2.60
		H		48.26			18.70		
	13.7.86 (D_3)	D	15.82	23.95	41.78	2.64	7.51	59.32	3.62
		H		41.14			17.60		

Table 32 : Effect of anthracnose on shoot weight and number of pods/plant in three varieties and sowing date on mungbean

Variety	Date of sowing	Diseased / Healthy	Disease intensity	Mean shoot weight (g)	Percentage reduction	Reduction per unit disease index	Mean number of pods/ plant	Percentage reduction	Reduction/ unit disease index
J-45 (V_1)	23.6.86 (D_1)	D	30.52	25.62	36.95	1.21	18.10	45.51	1.49
		H		40.64			33.32		
	3.7.86 (D_2)	D	30.38	28.05	44.61	1.46	21.10	30.91	1.01
		H		50.65			30.54		
	13.7.86 (D_3)	D	25.60	26.22	41.77	1.63	16.21	38.50	1.50
		H		45.03			26.36		
Pusa Baisakhi (V_2)	23.6.86 (D_1)	D	23.66	19.41	26.19	1.10	9.89	50.02	2.11
		H		26.30			19.79		
	3.7.86 (D_2)	D	43.05	22.32	19.13	0.44	12.54	39.21	0.91
		H		27.60			20.63		
	13.7.86 (D_3)	D	20.33	21.43	27.42	1.34	7.89	52.03	2.55
		H		29.53			16.45		
K 851 (V_3)	23.6.86 (D_1)	D	27.39	20.92	18.88	0.68	4.31	78.98	2.88
		H		25.79			20.51		
	3.7.86 (D_2)	D	18.25	23.49	15.62	0.85	7.59	62.51	3.42
		H		27.84			20.25		
	13.7.86 (D_3)	D	15.82	23.50	11.15	0.70	5.31	73.30	4.63
		H		26.45			19.89		

in shoot weight (0.44 g) was noted in V_2D_2. The range of percentage reduction in shoot weight varied from 11.15 (V_3D_3) to 44.61 (V_1D_2).

Anthracnose infection mainly affects the bearing of pods per plant. Reduction in number of pods per plant per unit disease was maximum (4.63) in V_3D_3, whereas, it was minimum (0.91) in V_2D_2. Reduction in number of pods (%) also varied from 30.91 (V_1D_2) to 78.98 (V_2D_2).

8.7.3 Number of seeds per pod and yield per plant

In infected plants, less number of pods formed resulted in lesser number of seeds (Table 33). Reduction in number of seeds per pod per unit disease was highest (4.73) in V_3D_3 and lowest (0.93) in V_2D_3. The range of percentage reduction was maximum (85.69) in V_3D_1 and minimum (37.30) in V_1D_2.

Reduction in yield per plant per unit disease was maximum in V_3D_3 (4.96) followed by 3.98, 2.81, 2.62, 2.27, 1.36, 0.93, 0.86 and 0.69 g in V_3D_2, V_2D_3, V_3D_1, V_2D_1, V_1D_3, V_2D_2, V_1D_1 and V_1D_2 respectively. Maximum reduction in percentage of yield in V_3D_3, V_3D_2, V_3D_1 and V_2D_3 followed the same sequence as in case of reduction/unit disease. Percentage reduction in yield per plant was least in case of V_1D_2 (21.26).

Table 33 : Effect of anthracnose on number of seeds/pod and yield/plant in three varieties and dates of sowing on mungbean

Variety	Date of sowing	Diseased / Healthy	Disease intensity	Mean number of seeds per plant	Percentage reduction	Reduction/ unit disease index	Mean yield per plant (g)	Percentage reduction	Reduction per unit disease index (g)
J-45 (V_1)	23.6.86 (D_1)	D	30.52	108.00	60.91	1.99	3.75	26.32	0.86
		H		276.32			5.09		
	3.7.86 (D_2)	D	30.38	188.33	37.30	1.22	4.48	21.26	0.69
		H		300.40			5.69		
	13.7.86 (D_3)	D	25.60	105.42	46.76	1.82	3.69	35.03	1.36
		H		198.02			5.68		
Pusa Baisakhi (V_2)	23.6.86 (D_1)	D	23.66	81.42	55.07	2.32	2.23	53.73	2.27
		H		181.25			4.82		
	3.7.86 (D_2)	D	43.05	107.51	40.21	0.93	3.10	40.38	0.93
		H		179.03			5.20		
	13.7.86 (D_3)	D	20.33	63.82	43.27	2.12	2.00	57.17	2.81
		H		112.50			4.67		
K 851 (V_3)	23.6.86 (D_1)	D	27.39	28.32	85.69	3.12	1.34	71.79	2.62
		H		198.00			5.53		
	3.7.86 (D_2)	D	28.25	72.32	67.17	3.68	1.62	72.77	3.98
		H		220.32			5.95		
	13.7.86 (D_3)	D	15.82	45.20	74.87	4.73	1.06	78.62	4.96
		H		179.88			4.96		

9. Influence of population density of the crop on anthracnose disease

Influence of plant population on the incidence of anthracnose caused by C. dematium and C. lindemuthianum in three varieties (Pusa Baisakhi, J-45 and PS-16) of mungbean was studied and the observations on disease incidence (%) are presented in Table 34.

It is clearly evident from Table 34 that the incidence of the disease significantly varied from variety to variety. In J-45, the incidence of disease ranged from 39.06 (V_2P_2) to 51.51 per cent (V_2P_4) followed by 12.46 (V_3P_4) to 22.43 per cent (V_3P_2) in PS-16 and 11.86 (V_1P_4) to 17.56 per cent (V_1P_5) in Pusa Baisakhi respectively. As regards the plant population, there was no significant difference among the different levels of population density (P_1-P_5). However, maximum incidence of the disease (53.51) was recorded at 10 lac/ha plant population in J-45 followed by 22.43 per cent at 6 lac/ha in PS-16 and 17.56 per cent at 12 lac/ha in Pusa Baisakhi. Least disease incidence 39.06, 12.46 and 11.86 per cent was noted in P_2V_2, P_4V_3 and P_3V_1 respectively. Interaction of varieties and plant population was also nonsignificant.

10. Survival of the pathogen

Survival of the pathogen on crop residues and collateral host was studied and data are given in Table 36, 36 and 37.

Table 34 : Influence of plant population on the incidence of anthracnose in three mungbean varieties

Variety	Plant population (lac/ha)	Disease incidence*
Pusa Baisakhi (V_1P_1)	4	12.66 (18.91)
Pusa Baisakhi (V_1P_2)	6	13.04 (19.51)
Pusa Baisakhi (V_1P_3)	8	14.96 (21.65)
Pusa Baisakhi (V_1P_4)	10	11.86 (19.59)
Pusa Baisakhi (V_1P_5)	12	17.56 (23.20)
Jawahar-45 (V_2P_1)	4	42.19 (40.34)
Jawahar-45 (V_2P_2)	6	39.06 (38.53)
Jawahar-45 (V_2P_3)	8	48.75 (44.27)
Jawahar-45 (V_2P_4)	10	53.51 (47.01)
Jawahar-45 (V_2P_5)	12	38.19 (37.95)
PS-16 (V_3P_1)	4	13.62 (20.85)
PS-16 (V_3P_2)	6	22.43 (28.21)
PS-16 (V_3P_3)	8	21.51 (27.20)
PS-16 (V_3P_4)	10	12.46 (19.42)
PS-16 (V_3P_5)	12	22.00 (27.94)

'F' test	Variety	S	10.50
	Plant population	NS	0.78
	Interaction (VxP)	NS	1.48
C.D. at 5%	Variety	13.47	
	Plant population	-	
	Interaction	-	

*Figures in parentheses are transformed values

10.1 Survival on crop residues

To study the survival of the pathogen on crop residues, an experiment was conducted with four varieties. The incidence of disease (%) on various plant parts such as leaves, stem and pods was observed and presented in Table 35.

The maximum incidence of disease (30.03) was recorded in J-45 (Table 35). It was followed by 20.39, 16.07 and 15.03 per cent in Pusa Baisakhi, PS-16 and K 851 respectively. The least incidence (2.71%) of disease was noted in control without crop residues. Average disease incidence (%) was more (21.00) on stem than on leaves (18.76) and pods (10.79).

10.2 Survival on pods and seeds

Infected pods containing seeds were collected from the experimental area during kharif 1985 and tested during kharif 1986 for the presence of the two species of Colletotrichum by agar plate method. The data on percentage Colletotrichum spp. associated with seeds and pod pieces of four varieties are presented in Table 36. The average percentage association of C. dematium and C. lindemuthianum on seed and pod was maximum (28.54) in J-45 followed by 17.70, 16.20 and 10.35 per cent in Pusa Baisakhi, PS-16 and K 851 respectively. The association of both the species on pod was higher (29.55 and 27.64 per cent) in comparison to seed (8.55 and 7.05%). Association of C.dematium on pod was 29.55 per cent, whereas, on seed it was 8.55 per cent. The percentage association of C. lindemuthianum on seed was 7.05 and on pod it was 27.64.

Table 35 : Survival of two species of Colletotrichum on crop residues of mungbean

Variety \ Plant parts	Leaves	Stem	Pod	Mean
Pusa Baisakhi	24.38	25.51	11.30	20.39
J-45	33.63	34.20	22.28	30.03
PS-16	16.62	21.13	10.46	16.07
K 851	16.50	20.35	8.26	15.03
Control (J-45)	2.69	3.81	1.65	2.71
Mean	18.76	21.00	10.71	

Table 36 : Survival of two species of Colletotrichum on pods and seeds within the same pods (PDA method)

Variety	Pod		Seed		Mean
	Colletotrichum dematium	Colletotrichum lindemuthianum	Colletotrichum dematium	Colletotrichum lindemuthianum	
Pusa Baisakhi	29.12	31.13	6.23	4.32	17.70
J-45	46.60	39.20	15.16	13.23	28.54
PS-16	23.34	26.82	9.63	5.03	16.20
K 851	19.15	13.43	3.20	5.62	10.35
Mean	29.55	27.64	8.55	7.05	

10.3 Possibility of survival on collateral host

Table 37 exhibits the fact that some of the host like Achanthosperman hispidum, Eclypta alba, Cyperus rotendus and Baugainvillea spp. were infected with the pathogen i.e. C. dematium. No host was infected with C. lindemuthianum. In cross inoculation test, C. dematium from mungbean infected the leaves of Baugainvillea spp. and the same infected the leaves of mungbean.

Table 37 : Possibility of survival of Colletotrichum spp. on collateral host

Hosts	Colletotrichum dematium	Colletotrichum lindemuthianum
1. Celossia argentia	-	-
2. Achanthosperman hispidum	+ ✓	-
3. Alternauthera sessalis	-	-
4. Ageratum conyzoides	-	-
5. Eclypta alba	+ /	-
6. Cyperus rotendus	+ /	-
7. Baugainvillea spp.	+ /	-

- Absent
+ Present

10.4 Disease cycle

Anthracnose caused by C. dematium and C. lindemuthianum survived on seed, crop residues, collateral hosts and soil. The two fungi over winters on the crop debris and during dry periods, it remains dormant and survives as mycelium in host tissues. In case of seed-borne infection, the fungal spores adhering with seed cause infection to the seed before or after emergence. The mycelium present on seed coat gets activated and cause infection to the cotyledons and primary leaves. Seed coat with mycelium may also left in the soil during germination which builds up soil-borne inoculum. Abundant spores are produced. These spores then get dispersed and disseminated to distant places by rain and run off water over the soil. Raindrops splash spores of C. lindemuthianum from the soil on to the plants, from leaf to leaf and from plant to plant. Spore dispersal results into deposition of the spores on the host surface. Upon landing on the surface of the host, they start to germinate, formed acervuli in which conidia are produced on conidiophores upon infection to the various plant parts. The setae are also produced. Thus, the inoculum builds up to epidemic proportions.

Further movement to the various plant parts results through local infection. Spores dispersed from primary leaves may cause infection to the pod. Spores spread by various means to the pod but mycelium do not grow sequentially to the upper part. Thus, infection to pod occurred by formation of necrotic

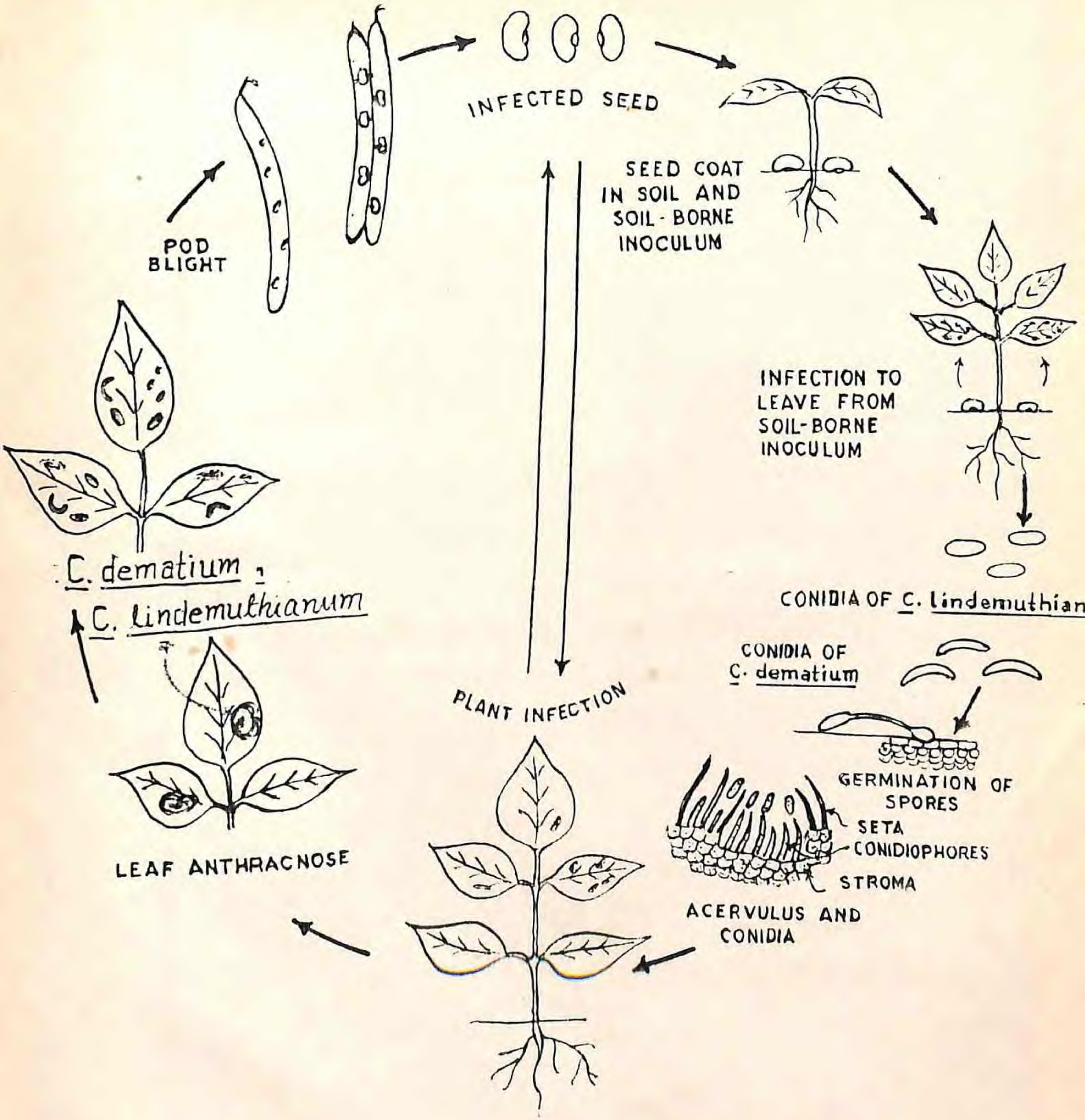


FIG.23: DISEASE CYCLE OF ANTHRACNOSE OF MUNGBEAN

Plate 6 : Sections exhibiting the symptoms of *Colletotrichum dematium* on pod and seed

I. Acervuli and setae of *Colletotrichum dematium* on pericarp

J. Acervuli of *Colletotrichum dematium* on seed coat

K. Infection of *Colletotrichum dematium* on hilum region

L. Disruption of seed tissues

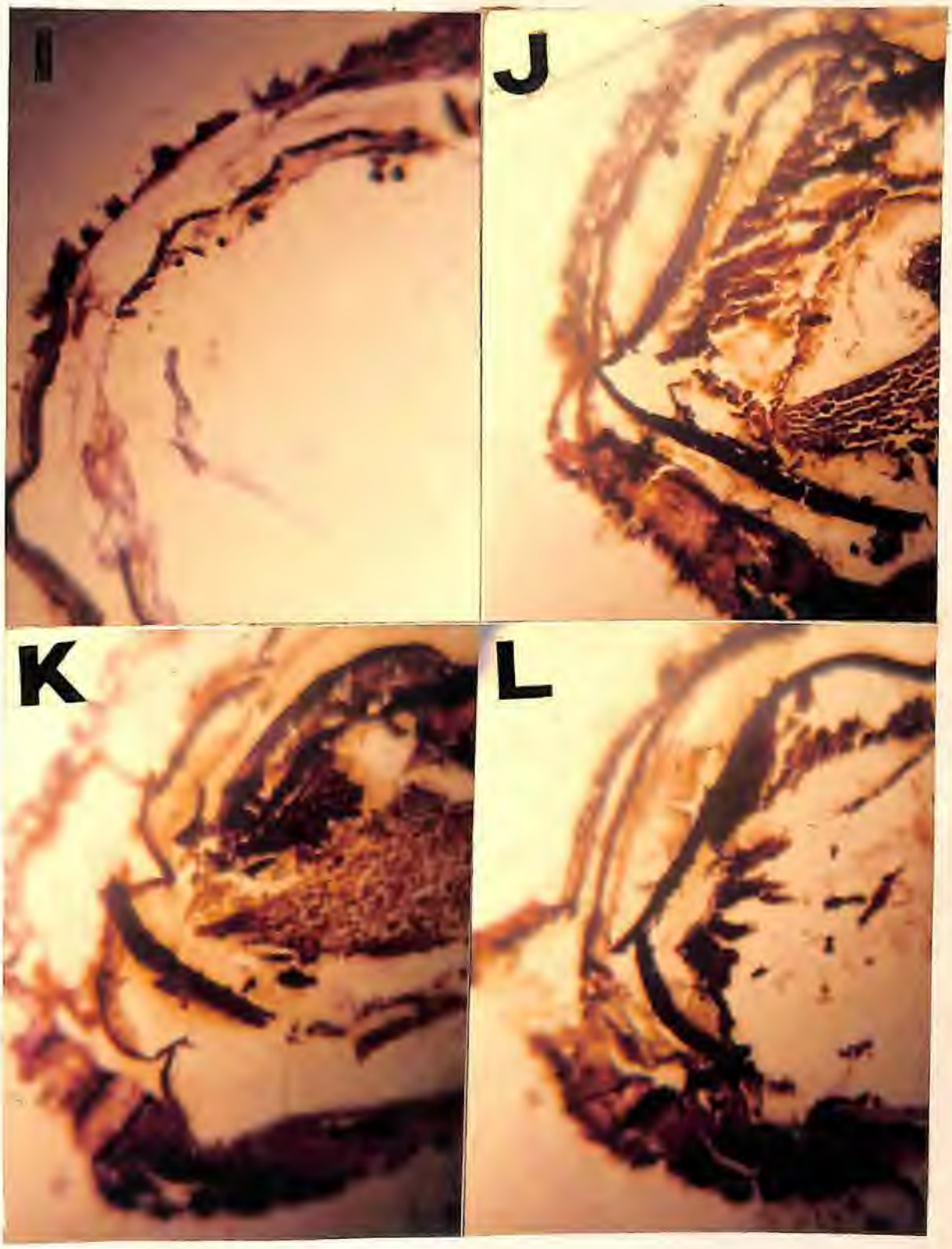
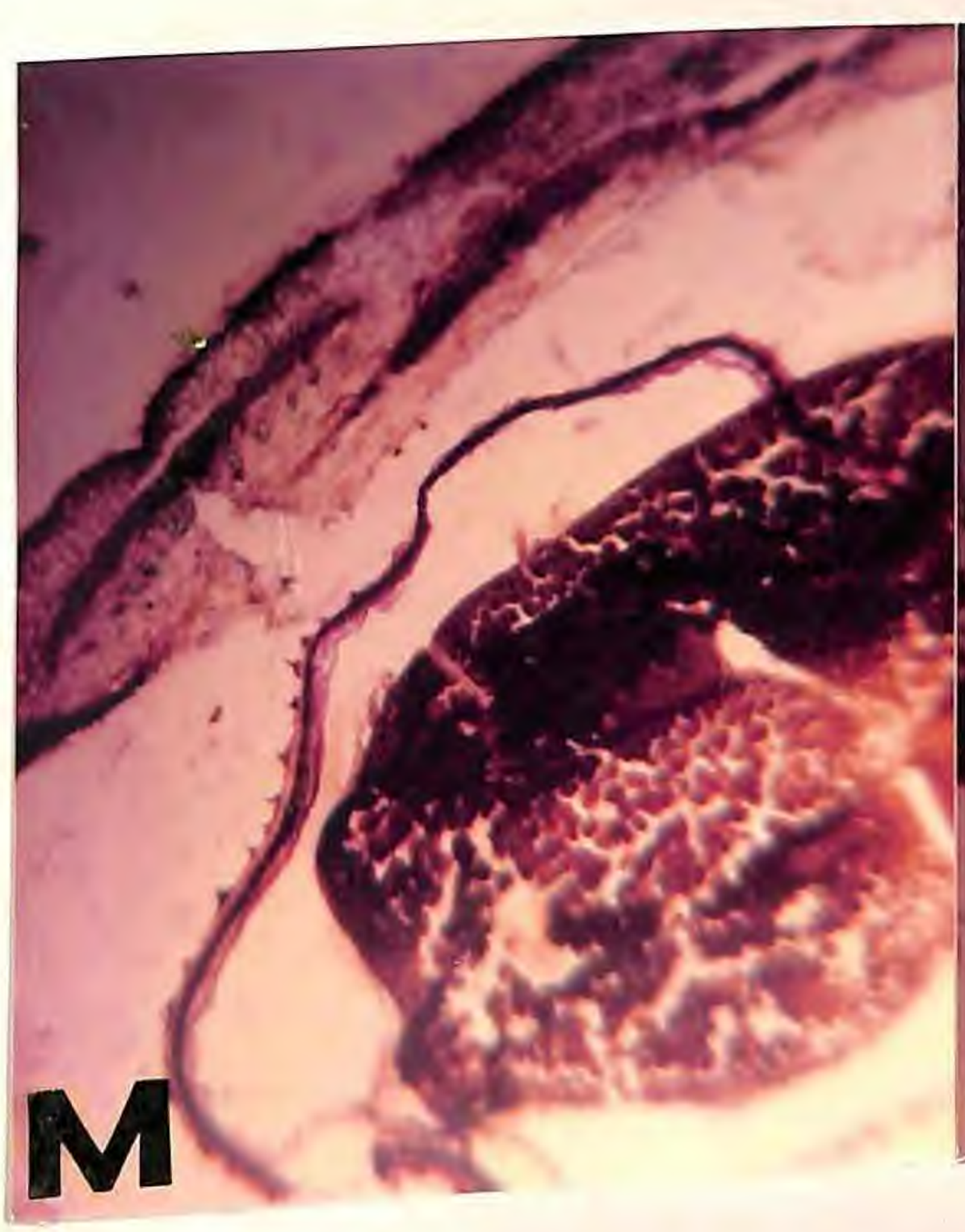
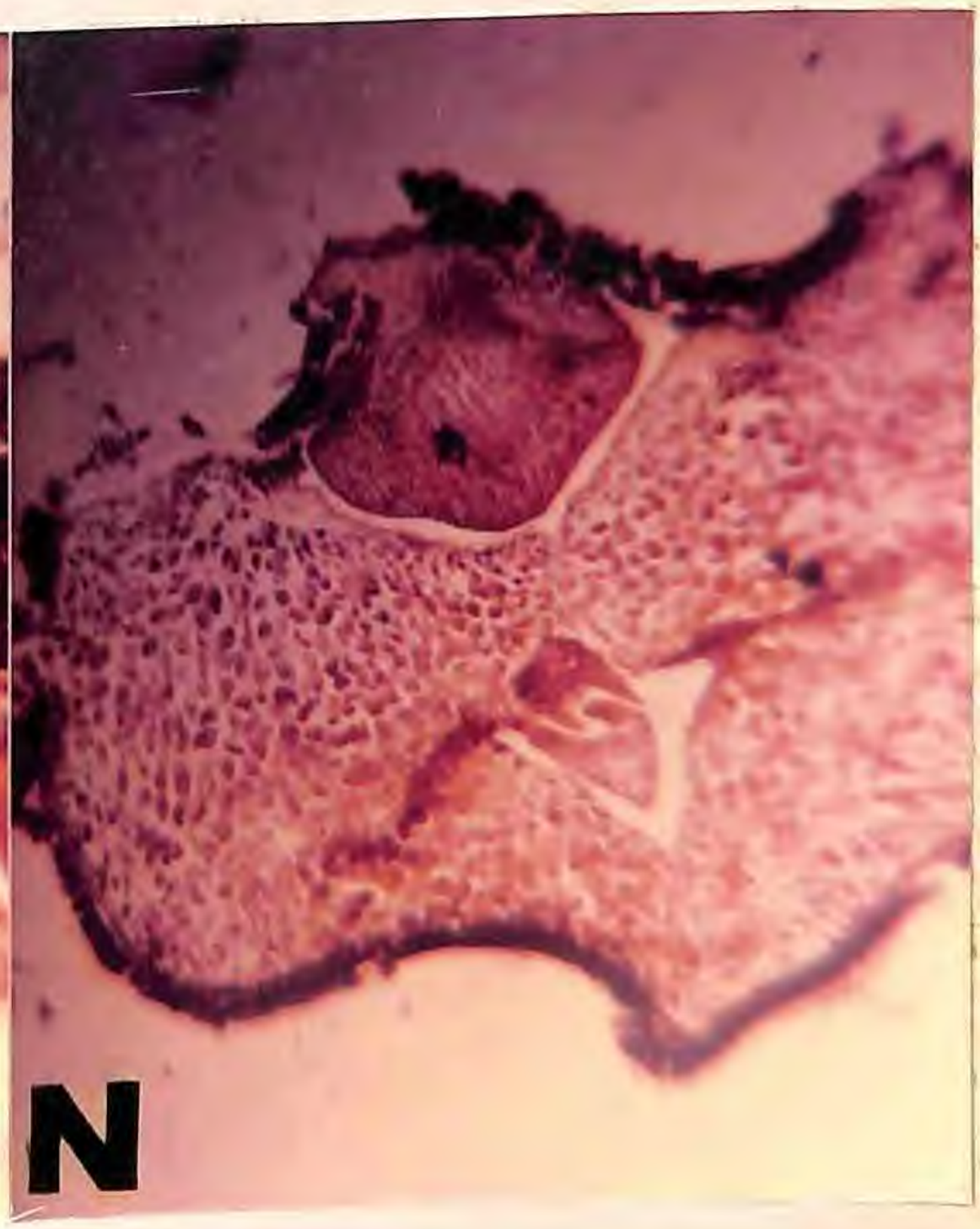

I
J
K
L

Plate 7 : Section of mungbean seed and pod

M. Section of healthy seed within the pod

N. Section of healthy seed


M


N

C. dematium was studied in vitro. The data on inhibition percentage at different concentrations, sporulation per microscopic field and colony characters at 1000 ppm concentration are recorded in Table 38. The observations indicate complete inhibition of C. dematium at 3000 ppm of Benomyl, Captafol, Carbendazim and Triforine, at 2500 ppm by Captafol and at 1000 ppm by Carbendazim. The percentage of inhibition was least in Mancozeb at 1000 ppm (8.88) and 1500 ppm (15.55), whereas, in Zineb it was least at 2500 ppm (13.33%) and 3000 ppm (53.33%). In fungicides such as Benomyl, Captafol, Carbendazim, Copper oxychloride and Triforine, no sporulation of the fungus was recorded at 2500 and 3000 ppm. Similar results were obtained with Captafol, Carbendazim and Copper oxychloride at 1500 ppm and Carbendazim alone at 1000 ppm. Minimum sporulation was recorded in Captafol (2) followed by Benomyl (3), Copper oxychloride (4), Mancozeb (28), Triforine (36) and Zineb (56) at 1000 ppm in comparison to control (102). At 1500 ppm, least number of spores per microscopic field were observed in Benomyl (2) followed by Triforine (13), Mancozeb (22) and Zineb (44) as compared to control (89). Least sporulation in Mancozeb i.e. 14 and 10 were recorded at 2500 and 3000 ppm followed by 30 and 27 spores in Zineb at 2500 and 3000 ppm in comparison to control i.e. 101 and 108 respectively.

No growth was observed in Carbendazim and Captafol. In Benomyl, Mancozeb, Zineb and Triforine the growth was appressed.

Table 38 : Influence of fungicides on growth, sporulation and colony characters of *Colletotrichum dematium* from mungbean

Fungicide	Mean Radial Growth				Inhibition percentage				Sporulation				Colony characters
	1000 ppm	1500 ppm	2500 ppm	3000 ppm	1000 ppm	1500 ppm	2500 ppm	3000 ppm	1000 ppm	1500 ppm	2500 ppm	3000 ppm	1000 ppm
1. Benomyl	22	10	0	0	75.55	88.88	100	100	3	2	0	0	Appressed, fluffy growth
2. Carbendazim	0	0	0	0	100	100	100	100	0	0	0	0	No growth
3. Captafol	12	0	0	0	86.66	100	100	100	2	0	0	0	No growth
4. Copper oxychloride	46	44	42	38	48.88	51.11	53.53	57.77	4	0	0	0	Suppressed, thinly scattered growth
5. Mancozeb	82	76	74	36	8.88	15.55	17.77	60.00	28	22	14	10	Appressed, fluffy mycelial growth
6. Triforine	52	29	20	0	42.22	67.77	77.77	100	36	13	0	0	White, appressed, fluffy growth
7. Zineb	80	74	78	42	11.11	17.77	13.33	53.33	56	44	30	27	Appressed growth and very thin mycelial mats at the growing zone
8. Control	90	90	90	90	0	0	0	0	102	89	101	108	Appressed growth, dull white and evenly distributed, pinkish spore mass appeared

spots which later become deep seated and infection reaches the seed. It has not been observed in placenta or xylem vessels. Finally, it can be said that the fungus follows both cycles of systemic and local infection (Fig. 23).

11. Histopathological study

The histopathological studies of mungbean seeds within the pod revealed that C. dematium is extraembryonal (Plate 6). The fungus grows on pod surface upon infection and forms acervuli and setae (Plate 6I). Due to the formation of these structures, different layers of the pod get distorted and infection becomes deep seated. It reaches the seed coat (Plate 6J). As a result of infection, seed coat separated and further infection was noted in the hilum region (Plate 6K). The tissues got macerated. The growth of the fungus continued to the cotyledons. In severe cases, all the tissues of the seeds were disrupted (Plate 6L). No growth was observed in control (Plate 7M,N).

12. Influence of fungicides

In vitro testing of seven fungicides was carried out to find the best one to control anthracnose disease in mungbean. Seed treatments and foliar spray trial was also conducted to choose a suitable fungicide based on the field performance.

12.1 In vitro testing against C. dematium

Influence of fungicides on the mean radial growth, inhibition percentage, sporulation and colony characters of

Fluffy growth was in Benomyl, Mancozeb and Triforine. Suppressed, thinly scattered growth was associated with copper oxychloride. In control, the growth was appressed, dull white and evenly distributed all over the plate. Pinkish pigmentation appeared within the mycelial growth of the fungus.

12.2 In vitro testing against C. lindemuthianum

Data on the influence of fungicides on growth, sporulation and colony characters of C. lindemuthianum are given in Table 39. It is apparent that the inhibition percentage of fungus varied from 11.11 (Mancozeb) to 100 per cent (Captafol) at 1000 ppm concentration. Complete inhibition was observed with Benomyl, Captafol and Carbendazim at 1500, 2500 and 3000 ppm. Triforine also inhibited complete growth of the fungus at 3000 ppm. Least inhibition was noted in Mancozeb at all the concentrations used.

Sporulation per microscopic field in Benomyl, Captafol, Carbendazim and Copper oxychloride was zero at 1500, 2500 and 3000 ppm. No sporulation was recorded with Captafol at 1000 ppm and Triforine at 3000 ppm. The presence of spores per microscopic field in Benomyl (5), Carbendazim (3) and Copper oxychloride (2) at 1000 ppm was almost similar and attained the range of minimum as compared to control (120). In contrast, the sporulation per microscopic field in Triforine was least at 1500 and 2500 ppm in comparison to control, 108 and 115 respectively. Minimum sporulation was noted with Mancozeb at 3000 ppm concentration.

Table 39 : Influence of fungicides on growth, sporulation and colony characters of *Colletotrichum lindemuthianum* in vitro

Fungicide	Mean radial growth (mm)				Inhibition percentage				Sporulation/Micro field				Colony characters
	1000 ppm	1500 ppm	2500 ppm	3000 ppm	1000 ppm	1500 ppm	2500 ppm	3000 ppm	1000 ppm	1500 ppm	2500 ppm	3000 ppm	1000 ppm
1. Benomyl	10	0	0	0	88.8	100	100	100.0	5	0	0	0	Suppressed growth
2. Captafol	0	0	0	0	100.0	100	100	100.0	0	0	0	0	No growth
3. Carbendazim	12	0	0	0	86.6	100	100	100.0	3	0	0	0	Suppressed growth
4. Copper oxychloride	30	23	18	15	66.6	74.4	80.0	83.3	2	0	0	0	Submerged pattern of growth
5. Mancozeb	80	71	69	42	11.1	21.1	23.3	53.3	30	22	17	10	Irregularly spread all over the plate
6. Triforine	43	26	10	0	52.2	71.0	88.8	100.0	12	8	3	0	Compact growth
7. Zineb	75	62	54	40	16.6	31.1	40.0	55.5	28	19	19	15	Irregularly spread
8. Control	90	90	90	90	0	0	0	0	120	108	115	100	Evenly distributed, fluffy mycelial growth, whitish spore mass

No growth was seen in Captafol. Suppressed growth pattern was observed in Benomyl and Carbendazim. In Copper oxychloride, submerged growth was visible. Mancozeb and Zineb showed the irregular growth while compact growth was observed in Triforine. In control, evenly distributed, fluffy mycelial growth with whitish pigmentation was clearly viewed.

12.3 Seed treatment trial

Effect of seed treatment with fungicides on the incidence of anthracnose was studied. The observations on disease incidence were recorded from seedling to maturity stage and the average incidence is given in Table 40.

Table 40 : Effect of seed treatment on the incidence of anthracnose of mungbean

Fungicide	Concentration (%)	Disease incidence (%)
1. Agrozim	0.15	12.50
2. Benomyl	0.15	12.00
3. Captan	0.25	9.52
4. Carbendazim-1	0.10	0
5. Carbendazim-2	0.10	0
6. Derosol	0.15	0
7. Thiram	0.25	0
8. Topsin-M	0.15	0
9. Vitavax	0.15	8.33
10. Control	-	16.66

It is clear from the Table 40 that no disease was there in Carbendazim-1, Carbendazim-2, Derosol, TMTD and Thiophanate methyl treated seeds at the respective dosages. In Vitavex, 8.33 per cent infection was recorded followed by Captan (9.52%), Benomyl (12.0%) and Agrozim (12.50%) in comparison to control (16.66%).

12.4 Fungicidal spray trial to control anthracnose

An experiment was conducted to select suitable fungicide for the control of anthracnose. Seven fungicides were evaluate against anthracnose. Suitable checks were maintained. Three spray of fungicides were given. The first spray was done after one month of sowing when the disease just appeared in the field Second spray was given after 15 days of the first spray and third spray was given at the same interval. Data on mean disease index, yield per plot and yield per hectare were recorded which are given in Table 41.

There was significant difference in occurrence of the disease from treatment to treatment. The mean disease index was minimum (5.17) in Triforine followed by Carbendazim (8.51%), Captafol (9.96%), Copper oxychloride (13.68%), Benomyl (14.40%), Zineb (17.75%) and Mancozeb (18.47%) as compared to control (28.78). Disease index in Benomyl, Mancozeb and Zineb was not much different. However, the intensity of disease was statistically significant among different fungicides after first,

Table 41 : Influence of fungicides on the intensity of anthracnose and yield of mungbean

Fungicide	Concentration (%)	Disease intensity* After 1st Spray	2nd Spray	3rd Spray	Mean	Yield** (g/plot)	Yield (kg/ha)
1. Benomyl	0.15	11.03 (19.33)	15.23 (22.91)	16.96 (24.19)	14.40 (22.14)	48.33	100.68
2. Captafol	0.25	5.70 (13.77)	11.94 (20.10)	12.25 (20.31)	9.96 (18.06)	60.00	125.00
3. Carbendazim	0.10	5.44 (13.31)	11.76 (19.97)	8.35 (16.63)	8.51 (16.63)	85.00	177.08
4. Copper oxychloride	0.30	8.49 (16.83)	15.73 (23.12)	16.83 (24.13)	13.68 (21.36)	52.00	108.33
5. Mancozeb	0.25	14.44 (22.31)	19.12 (25.87)	21.86 (27.86)	18.47 (25.34)	48.33	100.68
6. Triforine	0.15	4.96 (10.50)	4.28 (9.76)	6.27 (14.41)	5.17 (11.55)	67.00	139.58
7. Zineb	0.25	15.30 (22.94)	15.38 (22.97)	22.58 (28.27)	17.75 (24.72)	44.33	92.35
8. Control	-	28.52 (32.24)	24.17 (31.56)	33.66 (35.39)	28.78 (33.06)	35.00	72.91
C.D. at 5% level		8.73*	8.77*	6.17*		18.93*	

* Mean of three replications

** Mean of three replications

Figures in parentheses are transformed values

second and third spray. Least disease index, 4.96, 4.28 and 6.27 was recorded in Triforine after each subsequent spray. Maximum disease intensity was found in Zineb (15.30 and 22.58) in comparison to control (28.52 and 33.66) after first and third application of fungicides respectively. At 2nd spray, maximum disease index (19.12) was recorded in Mancozeb in comparison to control (24.17).

Maximum yield per plot was obtained with Carbendazim (85 g) followed by Triforine (67 g), Captafol (60 g), Copper oxychloride (52 g), Benomyl and Mancozeb (48.33 g) and Zineb (44.33 g) in comparison to control (35 g). Similarly, the sequence of yield per hectare did not change (Fig. 24).

12.5 Effect of fungicides on pathogenic fungi in phylloplane

To study the incidence of pathogenic fungi in phylloplane in different treatments, infected leaves showing symptoms of disease were collected, brought to the laboratory and examined under microscope. Isolations were made from the infected portions and fungi associated were confirmed. The percentage of different pathogenic fungi in different treatments were recorded and given in Table 42.

Six fungi were associated with different types of symptoms in different treatments. The lowest percentage of total fungi was recorded in Carbendazim (2.04) followed by Triforine (6.7), Benomyl (10.58), Copper oxychloride (23.26),

FIG. 23 : INFLUENCE OF FUNGICIDES ON THE RATE OF GROWTH OF ANTHRACNOSE CAUSED BY TWO SPECIES OF COLLETOTRICHUM

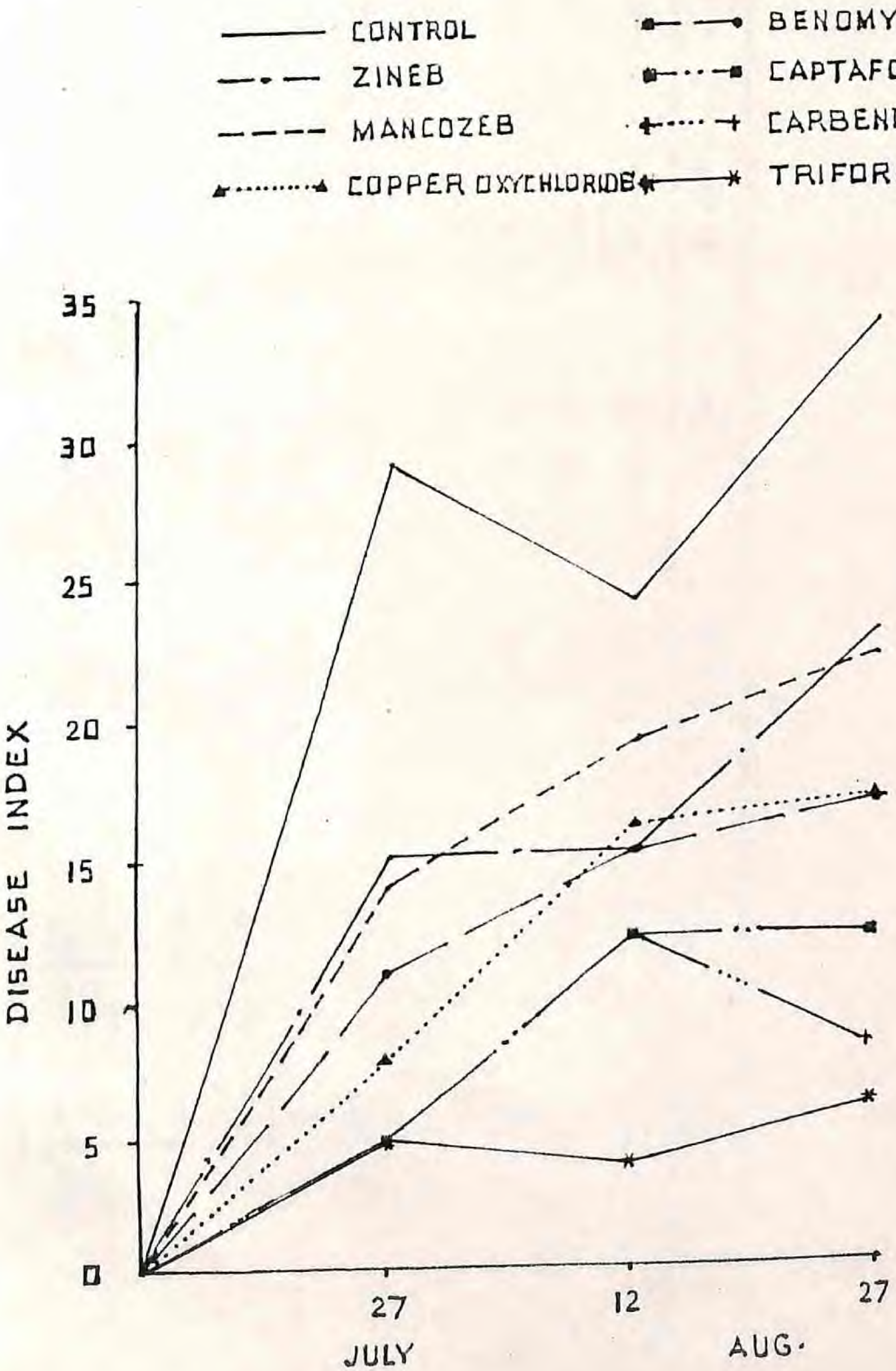


Table 42 : Influence of fungicides on the incidence of phylloplane pathogenic fungi (%)

Fungicide	Alternaria alternata	Cercospora canescens	Colletotrichum spp.	Sphaerotheca fuliginea	Rhizoctonia solani	Sclerotium rolfsii	Total fungi
Benomyl	1.01	2.02	3.30	0.00	1.00	3.25	10.58
Captafol	0.00	4.15	10.10	46.62	3.30	0.00	64.17
Carbendazim	1.04	0.00	1.00	0.00	0.00	0.00	2.04
Copper Oxychloride	3.03	9.12	7.64	0.82	2.65	0.00	23.26
Dithane M-45	0.00	3.62	8.00	12.33	4.27	0.00	28.22
Triforine	1.79	3.02	1.03	0.00	0.86	0.00	6.70
Zineb	2.07	3.33	5.68	29.33	0.38	2.06	42.85
Control	0.00	9.45	25.61	26.66	10.34	0.00	72.06
Total	8.94	34.71	62.36	115.76	22.80	5.31	

Mancozeb (28.22), Zineb (42.85) and Captafol (64.17) in comparison to control (72.06). The percentage of other fungi i.e. Sphaerotheca fuliginea causing powdery mildew of mungbean was highest (115.76) followed by Colletotrichum spp. (62.36) causing anthracnose, whereas, Sclerotium rolfsii was the least (5.31).

CHAPTER V

DISCUSSION

DISCUSSION

The present investigation was undertaken with the objective to study the epidemiology of anthracnose of mungbean which is influenced by various environmental factors, host factors and virulence of the pathogen.

The association of species of Colletotrichum and other fungi in 29 seed samples of mungbean collected from different places of Madhya Pradesh was examined by standard blotter method. Out of 29 seed samples tested, only in Sehore-1 Colletotrichum lindemuthianum was found associated. Ahire (1983) found 6.5 per cent C. graminicola in mungbean seed sample tested after 12 months of storage period. Association of C. truncatum with mungbean seeds was reported by Ramnath et al. (1970). Khare et al. (1977) reported the association of three species of Colletotrichum : C. dematium, C. graminicola and C. lindemuthianum from seed samples of green gram and black gram. Agrawal et al. (1972) also reported C. lindemuthianum and C. dematium associated with mungbean seeds besides other fungi. In the present investigation no species of Colletotrichum was found associated with seeds. Ahire (1983) tested 48 samples of mungbean from different districts of Maharashtra and found the association of several fungi with the seed but he could not detect any species of Colletotrichum. Association of Colletotrichum with mungbean seeds was also not observed by Jharia (1970) and Chindhalore (1974) from Madhya Pradesh.

The present findings were similar to the findings of Suhag (1975) and Chaubey (1978) and Singh and Chauhan (1973). It was further observed that seeds free from the association of fungi had maximum percentage of seed germination (98) while the minimum percentage germination was found in seeds with maximum number of fungi. The important fungi recorded during seed testing were - Botrytis cinerea (654), Aspergillus spp. (304), Penicillium spp. (142), Fusarium solani (123) and Aspergillus niger (103). These fungi were also reported by Baghel (1984), Suhag (1978) and Singh and Chauhan (1973).

The seeds of 29 varieties of mungbean procured from Madhya Pradesh and Uttar Pradesh were tested for the association of Colletotrichum and other fungi. But, not a single seed in any of the variety exhibited the presence of Colletotrichum. Baghel (1984) tested 30 mungbean varieties, he also could not isolate Colletotrichum from the seeds of any variety. Association of other ten fungi - Aspergillus niger, A. flavus, Alternaria alternata, Chaetomium globosum, Fusarium moniliforme, F. semitectum, F. solani, Macrophomina phaseolina, Penicillium spp. and Stachybotrys reported by Baghel (1984) were in confirmation with the present findings. Association of seed-borne fungi influenced the germination percentage of seed to the greater extent. Thakur (1984) reported that higher the association of seed-borne fungi, lower the germination percentage of seed in soybean and vice versa. The range of

association of fungi in the present study were 28-94 per cent. These findings indicate no or very little role of seed transmission of the pathogen from seed to plant. Only a very little number of seeds carrying the pathogen help in build up of the inoculum contributing towards epidemic.

The severity of anthracnose in 34 varieties of mungbean was worked out during Kharif 1985. All the 34 varieties exhibited anthracnose, however, they differed in disease severity and were classified in susceptible to moderately resistant groups. The percentage of plant infection in these varieties varied from 8.69-100.

In Kharif 1986, 22 varieties of mungbean were evaluated for observing severity of anthracnose. The disease developed in the field. Four varieties - Pusa-101, Pusa-103, SR-14 and 11/395 were found highly resistant to anthracnose while other varieties possessed resistant to susceptible host reactions. Chandra and Amin (1985) reported the reaction of 877 germplasm entries of mungbean against serious diseases at seven centres. Out of which, entry 11/395 was found resistant to anthracnose at Ludhiana. This confirmed the result of present findings. The incidence of anthracnose ranged from 0.00-87.23 per cent.

Twenty seven varieties of mungbean sown during 1985 and 1986 were observed for the occurrence of anthracnose. Out of 27 varieties, only one variety, Pusa 109 was highly

resistant against anthracnose. However, two varieties, ML-353 and Pusa-115 were resistant while three varieties, ML-326, PDM-54 and Pusa-11 were moderately resistant. Ten varieties were moderately susceptible and two varieties susceptible during 1985 kharif. It has been observed that the varieties which remained susceptible, moderately susceptible and moderately resistant in 1985 had different reactions in 1986. In certain varieties the reaction was reversed. The percentage plant infection in 1985 was generally higher than during 1986. In 1985, it varied from 0.00-98.42 per cent, whereas, in 1986 it ranged from 0.00 to 80.38 per cent. In all, five varieties, Pusa-101, Pusa-103, Pusa-109, SR-14 and 11/395 out of 83 varieties were highly resistant during both the years of testing.

Fungi associated with different plant parts of mungbean viz. cotyledons, leaves, stems, pods and seeds were isolated. Colletotrichum dematium and C. lindemuthianum were found associated mainly with leaves as compared to other plant parts. The important fungi obtained from different plant parts during isolation were - C. dematium, C. lindemuthianum, Rhizoctonia bataticola, Alternaria alternata, Fusarium oxysporum, Fusarium semitectum, Phoma sp., Curvularia lunata and others. The two species of C. dematium and C. lindemuthianum were identified on the basis of morphological characters. Other fungi were also identified with the help of keys.

Pathogenicity of C. dematium and C. lindemuthianum was tested by different methods. Out of which, wound inoculation

and seed infestation method was most effective against C.dematium, whereas, soil infestation method was effective against C. lindemuthianum.

Survey of anthracnose of mungbean was carried out in ten districts of Madhya Pradesh. Among those, the crop in Narsinghpur and Hoshangabad was free from anthracnose while eight districts were found to have the anthracnose. The incidence of anthracnose was observed in kharif only and varied from 0.00-75.67 per cent. Saxena (1984) reported the infection on mung and urid in various localities which ranged between 4-21 per cent due to C.truncatum, Fusarium oxysporum and F. semitectum. In urid alone, Singh (1977) reported 17 and 37 per cent mortality at pre-and post-emergence stage due to C. truncatum. In Phaseolus vulgaris, yield loss of 86 and 27 per cent in highly susceptible and moderately susceptible varieties respectively was reported by Shao and Teri (1985) due to C. lindemuthianum. The above three findings are in support of the present result. During survey, incidence of the disease was recorded on two doses of N:P:K. At 20:40:0, the incidence of disease was higher as compared to 10:30:0 (N:P:K). Less incidence was recorded where no fertilizer was given. Incidence of the disease was also recorded in different soil types including sandy loam, clay loam, heavy, light and sandy soil except silty soil. In survey, no infection of anthracnose was seen on mungbean which was sown with Jowar, Kodon, Kutki and Soybean.

Effect of different dates of sowing and different varieties on disease index was studied. It is clear from the result that the disease index on different dates of sowing differed significantly. The disease index in early planting (23rd June and 3rd July) was more as compared to late planting (13th July). Minimum disease (35%) has been reported under late sowing (23rd July 1983) and maximum disease (54.4%) on timely sown crop (3rd July 1983) of urid (Anonymous, 1983). Soybean seeds harvested from early planting dates (June 1, 16, July 1) had significantly more seedlings with C. truncatum lesions as compared to late planting dates (July 16, 31, August 14 and September 2). The disease index in different varieties and interaction did not differ significantly. However, yield/plot differ significantly from treatment to treatment. Thus, the early sowing is harmful as the intensity of the disease was more.

The progress of anthracnose in J-45 was studied which was sown on 23rd June, 3rd and 13th July. It was observed that the disease index was negatively correlated with maximum and minimum temperature. There was increase in progress of the disease as the temperature decreased, while, increase in temperature decreased the progress of the disease. It can further be stated from the values of 'r' (correlation coefficient) that the disease index was positively correlated with humidity percentage (morning and noon) and rainfall. There was significant

increase in disease intensity with increase in humidity percentage and rainfall except rainfall of 13th July.

The first appearance of the disease was recorded on 13th July in 23rd June sown crop after heavy rainfall continued since 20th June. Allen et al. (1985) observed the first symptoms of anthracnose 1-2 week after a large amount of rainfall. The disease index was maximum on 6th July when the temperature was 28.9°C (maximum) and 23.2°C (minimum), relative humidity was 98 and 87.6 per cent and rainfall was 29.8 mm. Mollenweber and Hochapfel (1949) also reported 25-30°C to be the optimum temperature for mycelial growth of Colletotrichun. Temperature between 22-25°C was observed as the optimum level for infection by C. lindemuthianum (Lauritzen, 1933). The findings of these two workers are in support of the present experiment. No disease was observed on 8th September 86 when there was no rain, high temperature (33.4 and 22.4°C) and low humidity percentage (82.3 during morning and 51.6 during noon). The disease progress was totally stopped after 20th September. It may be due to high temperature, low humidity level and absence of rain. Reduction in anthracnose development due to high temperature was reported by various workers (Martinez Salazar and Anderson, 1957; Zaumeyer, 1957; Rahe and Kuc, 1970 and Tu, 1981), which confirmed the present results.

In mid (3rd July) and late sown crop (13th July), the deviation in pattern of the disease remained the same as in 23rd June sowing.

The disease index in three dates of sowing was recorded. It ranged from 0.00-30.32 on 23rd June, 0.00-30.38 on 3rd July and 0.00-27.62 on 13th July sown crop. On 23rd June sown crop, the disease index on majority of observations was more as compared to 3rd July and 13th July. From this, it can be explained that the crop sown before July is prone to attack more than that sown on 3rd and 13th July.

Influence of environmental factors on the progress of anthracnose in Pusa Baisakhi sown on 23rd June, 3rd and 13th July was undertaken. The value of 'r' showed that the disease index had negative correlation with maximum temperature (23rd June and 3rd July) and minimum temperature (3rd and 13th July). But, the disease index had positive correlation with humidity percentage (morning and noon) and rainfall. Disease index of 13th July and 23rd June also had positive correlation with maximum and minimum temperature. It means, increase in temperature, humidity percentage and rains increased the disease. Increase in disease index also occurred due to decrease in temperature.

On 23rd June sown crop, disease appeared on 15th July and reached the maximum by 8th August under favourable conditions. But, soon the conditions deviated from favourable to unfavourable and the disease severity was greatly reduced and was even fully checked between 20th August and 4th September. Similar disease pattern was observed on 3rd and 13 July sown crop

under similar environmental conditions. In Pusa Baisakhi, the disease index on 23rd June and 3rd July sown crop was almost similar but on 13th July sown crop, it was comparatively less.

In K 851 sown on 23rd June, 3rd and 13th July, the progress of disease index remained the same as observed in J-45 and Pusa Baisakhi.

From the results on the influence of different dates of sowing, different varieties and environmental conditions on the disease severity, it is observed that the disease intensity was maximum at 26-30°C temperature. It was further observed that the increase in temperature did not appreciably decrease the disease but decrease in disease intensity was related with continuous increase in temperature for prolonged period. Tu (1982) reported that the prolonged and continuous high temperature suppressed symptom development of anthracnose by inhibiting germination and appressoria formation in Phaseolus bean which confirms the present findings. At continuous high temperature for longer period, severee reduction in disease intensity was recorded. It may be possible that the conidia faced the scarcity of water at the time of germination and penetration. Silker (1981) supported this view. He reported the susceptibility of conidia of C. lindemuthianum to drying. Before drying, 94 per cent of the conidia germinated but after drying of 6 hours only, 7 per cent conidia got germinated. No germination was observed after 12 hours.

As regards the humidity, it was observed as an important factor restricting the disease development. In all the cases, when the relative humidity during morning was 90-100 per cent, maximum disease was recorded and as the percentage of relative humidity declined below 90 per cent decrease in the disease was recorded. Relative humidity of noon which varied from 80-93 per cent was most favourable for the development of disease. As the relative humidity declined, there is reduction in disease index. The findings of Sindhan (1983) are in confirmity with the present investigations. He studied the effect of relative humidity on initiation and development of anthracnose and found maximum infection of anthracnose at 100 per cent humidity level followed by 95.6, 91.2, 85.7 and 80.5 per cent.

Rainfall is the most important factor which has been observed to inhibit the disease progress. On rainy days, when the rains were supported with high wind velocity (13 kg/hour) caused maximum spread of the disease and made the primary inoculum ready to spread from diseased plant to healthy plant. Tu (1981) also reported long distance (3-4 m) spread of C. lindemuthianum in french bean by rain drops blown by gusting wind. Raindrops falling on the diseased spots dispersed the conidia of the fungus to the neighbouring plants which led to the initiation of the disease. The conidia from soil were also found to get splashed to the leaves by raindrops. That is why, the maximum disease was observed on rainy days and when there was no rain, no disease was recorded. Drizzling rains were

observed to be most favourable for maximum disease intensity. However, heavy rains for continued longer periods caused the washing off of conidia from leaves and shedding off of the diseased spots from the leaves. If heavy rains continued for 2-3 days, lower disease index was observed but as the rains became light, maximum disease severity was noted. Soon after rains, no disease spread was observed but 2-3 days later, heavy incidence was noticed. It is possible that the conidia take that much time to settle and cause further infection and therefore heavy incidence is recorded after 2-3 days of rainfall.

Light intensity and its duration is also equally important for infection. Bright sunshine for the entire day resulted in reduction of the disease, whereas, sunshine for zero hours predisposed the plant to the disease.

Weather conditions recorded at 7 and 14 hours showed that there was extreme reduction in disease intensity, when the weather was clear (0). Overcast (2) and partially cloudy (1) weather was most suitable for the development of the disease. It was most favourable for the pathogen. Rain at thunder (6) and drizzling (5) weather were the most desirable for quick dissemination of the pathogen.

Wind velocity was observed to be more during the entire period of the disease progress. Maximum disease intensity was recorded at 9.13 km/hour wind velocity, while, the minimum

disease was noted below the above range (3-4 km/hour). High wind velocity was known to play an effective role in quick delivery, long distance spread and quick infection of the disease

Thus, combination of all these environmental factors including temperature, relative humidity, rainfall, light, intensity, wind, weather conditions together with the suitable host and virulent pathogens cause the epidemic of the disease.

Disease index on three varieties of mungbean revealed that the anthracnose was more severe in J-45 than in Pusa Baisakhi and K 851. In J-45, maximum intensity of anthracnose (26.69) was recorded on 25th July followed by Pusa Baisakhi (25.60) on 5th August and K 851 (24.71) on 4th August.

The effect of temperature, relative humidity and host age on sporulation of C. dematium and C. lindemuthianum were studied. The result of all these factors showed that the 25°C and 90-100 per cent relative humidity were optimum for sporulation of C. dematium (90%) as well as C. lindemuthianum (100%). Frost (1964) reported sporulation of C. linicola on flax hypocotyls at 85-100 per cent relative humidity level. The present result is in confirmity with the result of Frost (1964). The sporulation was abundant on younger plants as compared to older plants in C. lindemuthianum and C. dematium.

The effect of temperature and relative humidity on spore germination of C. dematium and C. lindemuthianum was studied.

Colletotrichum dematium had 100 per cent germination at 25°C within 16 hours while least germination (56.3%) was observed at 30°C. No reports are available on the effect of temperature on spore germination of C. dematium from mungbean. However, Manandhar et al. (1985) reported 70 per cent germination of C. truncatum on soybean leaves at 24 ± 2°C temperature within four hours. Wollenweber and Hochapfel (1949) reported lesser germination of Colletotrichum spp. below 10°C and above 30°C at the end of 48 hours. This confirms the present results.

Spores of C. lindemuthianum started germinating within five hours and had complete germination within 12 hours at 25°C. In this case also, least germination was observed at 30°C. Lauritzen (1933) observed 22-25°C temperature as optimum for infection by C. lindemuthianum. Infection establishment in 12 hours at 25°C was reported by Martinez Salazar (1957). The findings of the above two workers are in confirmation with the present results. Alpha, beta and gamma strains of C.lindemuthianum started to germinate in nine hours at 28°C. The percentage germination of alpha strains after two hours at 16, 20, 24, 28 and 32°C was 0, 8, 5, 90 and 9 respectively, that of beta strain was 19, 39, 32, 25 and that of gamma strain was 6, 24, 62, 96 and 25 respectively. In the present experiment C. lindemuthianum started to germinate within 6 hours at 20°C and within 8 hours at 22-27°C. Complete germination occurred within 15 hours.

As regards the relative humidity, maximum germination (87.32%) of C. dematium was noted at 100% RH within 16 hours.

But, no germination was recorded at 25 and 50% RH within the same period of time. Significant value of positive 'r' (correlation coefficient) with disease index further indicate the importance of maximum relative humidity i.e. 100% in creating maximum disease.

Effect of relative humidity on germination of spores of C. lindemuthianum was studied. The present study showed the complete germination of spores within 16 hours at 100% RH, but no germination was observed at 25 and 50% RH. The present result was similar to that of Sindhan (1983) who reported 100% RH for maximum infection of C. lindemuthianum in Phaseolus bean.

The study on the effect of temperature, relative humidity and light on the development of anthracnose revealed that the maximum lesion size was obtained at 27°C in C. lindemuthianum (16.25 mm^2), at 25°C (18.26 mm^2) in C. dematium with 100% RH in both the cases. Sindhan (1983) recorded maximum disease development at 21°C followed by 24, 18, 27, 15 and 30°C which is slightly different from the present result but Lauritzen (1933) fully support the present result by concluding 22-25°C to be the optimum for the infection by C. lindemuthianum and 100% RH was optimum for disease development. Maximum disease development was observed when the inoculated plants were exposed to continuous light for 24 hours each day while least development was noted when they were kept in complete darkness. Thus, it is apparent from the present observations that the maximum disease development

occurred between 22-28°C temperature, 90-100% RH during light rains (10 mm), cloudy wet weather and high wind velocity (10-12 km/hours). These conditions were existing from 15th July to 20th August 1986 under which maximum incidence of the disease was recorded. In 1985, maximum intensity of the disease was recorded under the same set of environmental conditions. Boelema and Ehlers (1967) reported that the disease is favoured by wet weather and temperature between 21-30°C. Tu (1981) reported the spread of secondary inoculum under wet weather conditions. It supported the development of anthracnose in mungbean.

Dispersal of spores collected on slide indicated that the spores of C. lindemuthianum and C. dematium were abundently trapped when the normal rains were supported with high wind velocity (7-10 km/hour). Many workers emphasized the importance of rain in dispersal of the spores. Tu (1981) found that conidia of C. lindemuthianum on white bean could be spread to a short distance by splashing raindrops. This supports the involvement of rains for spread of conidia as observed in the present study. Long distance spread of 3-4 m required wind driven rain. Shree kumar (1974) stated that C. lindemuthianum got splashed from soil to phyllosphere by rain as detected on filter paper and leaves. Ling (1940) reported the role of rainfall in the spread of conidia. It was observed that the higher number of spores were trapped after 2-3 days of heavy rains. Absence of rains followed by heavy rains also resulted in maximum trapping of spores. Maximum trapping of spores of both the species was recorded on 30th July following

suitable environmental conditions (temperature 29 and 23.1°C, RH 91 and 83% and no rains). Meredith (1966) observed maximum concentration of conidia in air above diseased onion crop during windy days. He reported an increase in conidial dispersal by rainfall, irrigation and spraying. Thus, maximum trapping of spores was closely related with suitability of the atmospheric conditions as observed during present investigation.

Average trapping of spores of C. dematium and C. lindemuthianum continued for 32 days revealed that the collection of spores was more in early part of the day i.e. from 7 AM to 12 Noon than the late part of the day i.e. from 12 Noon to 5 PM. On the contrary to this, Alicbusan et al.(1959) trapped maximum spores (227) of Alternaria porri and Erysiphe polygoni at 1.30-2.00 PM and minimum at 8.30-9.00 AM. Husain (1960) also trapped maximum number of spores of Alternaria porri between 2-4 PM under New York conditions. However, Meredith (1966) confirmed the present results by reporting maximum concentration of conidia in air between 8-14 hours.

Effect of severity of anthracnose on various yield parameters of mungbean was studied. It was observed that per unit disease reduction of seeds/pod was 1.61-5.14, in yield was 1.59-5.11, number of pods was 1.37-4.97, shoot weight was 1.10-3.99, plant height was 0.17-2.30 and number of branches/plant was 0.33-2.14. The percentage reduction in various yield parameters also followed the same sequence.

The range of reduction in various host parameters varied from 3.43-94.49 per cent. Saxena (1984) studied the infection percentage and crop loss of seed-borne infection of green gram and black gram due to C. truncatum and other fungi. He found the factors contributing to reduced yield were number of pods/ plant, pod length, number of seeds/pod and 100 seed weight. Reduction in seed weight (22.4-61.7%) of soybean due to C. dematium f. sp. truncata was studied by Verma et al.(1973). Barnes et al. (1969) reported severe infection of anthracnose causing 25-30 per cent losses on forage yield and in plant vigour. These findings are in agreement with the present observations.

Influence of varieties and dates of sowing on various host parameters due to C. dematium and C. lindemuthianum was studied. Reduction in number of pods/plant, number of seeds/ pod and yield/plant/unit disease were almost similar in all the cases. It varied from 0.69-4.96 per cent. Shoot weight reduction was minimum/unit disease. The percentage reduction in number of pods/plant and yield/plant were same i.e. 21.26 to 78.98. Minimum reduction was found in height of the plant (20.98-41.78). It was further noted that the reduction in different yield parameters were more pronounced in K 851 planted on 13th July followed by J-45 planted on 13th July.

Influence of plant population on the incidence of anthracnose in different varieties denotes that the incidence of disease was significantly influenced in different varieties.

Out of three varieties sown, J-45 was highly susceptible to anthracnose as compared to PS-16 and Pusa Baisakhi. Different levels of plant population did not significantly affect the disease incidence. Sivaprakasam et al. (1983) reported that the plant population did not significantly affect the susceptibility of plant to Cercospora leaf spot of mungbean. His result was in confirmity with the present findings. However, maximum disease incidence was recorded at maximum plant density level (12 lac/ha) in Pusa Baisakhi. The findings of Burdon and Chilvers (1982) were also similar as increased host density resulted in a short distance transmission of spores. A dense canopy was beneficial for the spread of Colletotrichum trifolii because it creates a moist chamber effect (Barnes et al., 1969).

Possibility of survival of Colletotrichum spp. on crop residues and different host plants was studied. The survival of Colletotrichum spp. on one year old crop residues of stems, leaves and pods of four varieties indicate that the pathogen survived in all plant parts. Hartman et al. (1986) also reported the survival of Colletotrichum spp. from 50 per cent of soybean leaflets and from 48 per cent of either stem pieces or leaf samples of 17 weeds from 18 fields. Overseasoning of Colletotrichum spp. on soybean debris by Graham et al. (1979) further correlates the present findings. In addition to this, C. trifolii has been reported to over winter in crop debris.

hay stacks and on harvesting equipment (Graham et al., 1979 and Lukezic, 1974). Out of four varieties of mungbean, J-45 was noted to be highly susceptible, whereas, others were similar in their capacity of infection to Colletotrichum spp. Infection to all these varieties showed the survival of pathogen in one year old plant parts burried in soil. Kulik (1984) reported the survival of anthracnose fungus for as long as two years in infected plant material. Anthracnose of soybean caused by C. destructivum, C. truncatum and Glomerella glycines were reported to survive on 22 per cent stubble samples of soybean collected in 1984 and on 100 per cent of samples collected in 1983 in three Illinois counties (Hartman et al., 1986). These findings are similar to the present observation.

Survival study on Colletotrichum spp. associated with pods and seeds within the same pods was carried out. The pods were more vulnerable to the attack by Colletotrichum spp. than the seeds. The infection percentage of seeds was lower than the pods. Barrus (1921) reported survival of the pathogen in stored seeds of bean for two years while survival of the pathogen in stored seeds of one year old was recorded in the present investigation.

The possibility of survival of Colletotrichum spp. on different host was tested. It has been shown that some of the hosts are susceptible to infection by C. dematium. These host species are of perennial nature; some are of annual nature which may offer the chance for survival of C. dematium being infecting

them. Weeds were reported to serve as collateral hosts for Colletotrichum spp. (Roy, 1982 and Happerly et al., 1986) and other soybean pathogens. As collateral hosts, weeds were found to contribute to increase inoculum levels and allow carryover of the pathogen.

The histopathological study revealed that C. dematium is extraembryonal. The fungus was observed on seed coat, hilum region. Schneider et al. (1974) found C. truncatum within the seed coat of soybean. The mycelium of C.dematium f. sp. truncatum was also detected in all the three layers of seed coat of soybean.(Nik and Lim, 1984). He also reported the presence of acervuli in the palisade layer. These findings are in confirmity with the present result.

In the in vitro study, Carbendazim (1000 ppm), Captafol (2500 ppm), Benomyl and Triforine (3000 ppm) were most effective in inhibiting the complete growth of C. dematium. Thakur (1984) confirmed the efficacy of Triforine (500 ppm) to be the best for complete inhibition of C. dematium f. sp. truncata of soybean. No sporulation/microscopic field was observed in case of Carbendazim at 1000 ppm, Captafol, Copper oxychloride at 1500 ppm and Benomyl at 3000 ppm concentration. The growth pattern was fluffy in Benomyl, Mancozeb, Triforine and Zineb. Suppressed, thinly scattered growth was associated with Copper oxychloride. In control, appressed dull white, even growth with pinkish spore mass appeared.

Captafol inhibited complete growth of C.lindemuthianum at all concentrations. Benomyl and Carbendazim too resulted in cent percent inhibition of growth at each concentration except 1000 ppm. Sporulation per microscopic field was zero at 1000 ppm in case of Captafol, Carbendazim and Copper oxychloride at all the concentrations except 1000 ppm. The growth was suppressed in Benomyl and Carbendazim while submerged in Copper oxychloride. Mancozeb and Zineb showed irregular growth. In check plates, fluffy mycelial growth with whitish spore mass was viewed.

Seeds of mungbean were treated with nine fungicides to record their effect on incidence of anthracnose. The results indicate that no disease incidence occurred when the seeds were treated with Carbendazim-1, Carbendazim-2 (0.1%), Derosol (0.15%), Thiram (0.25%) and Thiophanate methyl (0.15%). Captan (0.25%) and Vitavax (0.15%) were also effective as less incidence was recorded. Bernat and Raichu (1974) also obtained good control of C. lindemuthianum on Phaseolus vulgaris with 0.2% Thiram, 0.2% Captan, 0.2% Mancozeb and Captan. Sharma et al. (1971) reported maximum emergence in mungbean in seed treatment. Captan seed treatment in mungbean also resulted in 92.5 per cent emergence of seedling (Khare et al., 1970).

In a fungicide spray trial, Triforine (0.15%) proved best against anthracnose of mungbean as the least disease index was noted in this treatment. Giroto (1976) also reported similar

result. He found Triforine-20, Benomyl-50 and Derosol-60 to be most effective against C. lindemuthianum of bean in spray trial at Salta. Other fungicides such as Carbendazim, Captafol, Copper oxychloride and Benomyl were also effective in minimizing the infection due to Colletotrichum spp. on mungbean. Kairu et al. (1985) reported Copper oxychloride to be the effective fungicide against berry disease (C. lindemuthianum) further confirmed the present result. Best control of C. lindemuthianum of bean was obtained by Benomyl, Captafol and Mancozeb used singly, alternately or in mixture. This finding of Issa (1985) was again in confirmation with the present result. Guzman et al. (1979) supported the present view by reporting Benomyl to be the most effective against C. lindemuthianum of bean under rainy conditions. Kotasthane and Agrawal (1976) controlled foliar disease of mungbean including leaf spot by Bavistin followed by Benomyl. Maximum yield per plot was obtained with Carbendazim followed by Triforine and Captafol. They also reported higher yield and 100 seed weight with the use of Carbendazim.

Influence of fungicides on phylloplane pathogenic fungi revealed the association of six fungi on leaves of mungbean. Among which, powdery mildew of mungbean caused by Sphaerotheca fuliginea was predominantly present in plots sprayed with Captafol, Zineb and Maneb. The incidence

of other fungi - Alternaria alternata, Cercospora canescens, Colletotrichum spp., Rhizoctonia solani and Sclerotium rolfsii were less in all the treatments. The total fungi in Carbendazim and Triforine were less, being 2.04 and 6.70 per cent as compared to which was control, 72.06 per cent.

CHAPTER VI

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The epidemiological studies on anthracnose of mungbean revealed that there is great influence of environment, host, pathogen and time on the build up of epidemics in mungbean.

Twenty nine seed samples of mungbean collected from different locations of Madhya Pradesh and 29 varieties collected from Madhya Pradesh and Uttar Pradesh indicated the minimum possibility of association of the two species of Colletotrichum with seeds. Only two per cent Colletotrichum spp. was found associated with 29 seed sample while none of the species of Colletotrichum was found associated with 29 varieties of mungbean. However, some other fungi namely - Aspergillus spp., Penicillium spp., Fusarium solani, F. semitectum, F. oxysporum, Macrophomina phaseolina were predominantly present with the seeds. Considering the host as a factor in causing epidemics of anthracnose, 34 varieties in 1985, 22 varieties in 1986 and 27 varieties in 1985 and 1986 were examined for the severity of anthracnose. Anthracnose was observed on different varieties to a varied extent. In two years testing, four varieties - Pusa-101, Pusa-103, SR-14 and 11/395 in 1986 and one variety i.e. Pusa-109 in 1985 and 1986 was found highly resistant to anthracnose. The percentage of plant infection in general varied from 0.00 to 100 per cent in two years testing.

In a disease survey of ten districts of Madhya Pradesh, anthracnose was observed on mungbean in eight districts during kharif 1986. Performance of different varieties in different

dates of sowing was tested for knowing the anthracnose severity. It was found that the varieties do not have any significant effect on the incidence of disease. However, sowing at different dates could significantly affect the disease severity.

The relative humidity of morning and noon, rainfall, maximum and minimum temperature were found to effect the development of the disease. Significant positive correlation was observed with humidity percentage and rainfall while significant negative correlation was found with maximum temperature. Among different varieties, J-45 in early sowing (23rd June 1986) was most susceptible to infection by the disease.

Effect of temperature and humidity on sporulation and spore germination of C. dematium and C. lindemuthianum revealed 25°C temperature and 100 per cent relative humidity to be most suitable. Sporulation of the above two species in young plant was more than in older plants. Anthracnose spots developed more at 27°C temperature, 100 per cent relative humidity and continuous light for 72 hours. Trapping of spores of C. dematium and C. lindemuthianum was negatively correlated with different environmental factors. Number of spores trapped on slide were more in between 7 AM to 12 Noon than 12 Noon to 5 PM.

Effect of anthracnose on various host yield parameters was studied. Infection of anthracnose was more destructive in reducing the number of seeds/pod, yield/plant and number of pods/plant. Reduction/unit disease index and percentage reduction in above

parameters varied from 1.31-5.14 and 33.33-94.49 respectively. Apart from this, the overall reduction per unit disease and percentage reduction in various parameters ranged from 0.17-5.11 and 3.43-94.49 respectively. Anthracnose in different varieties and dates of sowing also followed the same sequence in reduction of various parameters.

Influence of plant population on the incidence of anthracnose in three varieties revealed the significant difference among three varieties, whereas, nonsignificant difference was observed among different levels of plant population. The incidence of anthracnose in varieties and plant population varied from 11.86-53.51 per cent.

Survival of Colletotrichum spp. on crop residues i.e. stem was maximum in J-45. The survival of C. dematium (29.55%) on pod was also maximum in J-45 and in C. lindemuthianum (27.64%). The possibility of survival in Achanthosperm spp., Eclypta alba, Cyperus rotendus and Baugainvillea spp. was recorded.

Carbendazim (1500 ppm), Captafol (1500 ppm), Benomyl (2500 ppm) and Triforine (3000 ppm) completely inhibited the growth of C. dematium and C. lindemuthianum. Sporulation per microscopic field was zero in the above fungicides. Sporulation/ microscopic field in Copper oxychloride was also zero at 1500 ppm onward in C. dematium as well as in C. lindemuthianum. No growth was recorded in Carbendazim and Captafol. In seed treatment trial, Carbendazim-1 (0.1%), Carbendazim-2 (0.1%), Derosol (0.1%), Topsin-M (0.15%) and Thiram (0.25%) were most effective as the

incidence of disease was completely checked. In fungicide spray trial, Triforine (0.15%), Carbendazim (0.10%) and Captafol (0.30%) were most effective as the disease intensity was less, 5.17, 8.51 and 9.96 respectively as compared to control (28.78). Yield per plot was also higher, 85 g in Carbendazim, 67 g in Triforine and 60 g in Captafol as compared to control (35 g). Similarly, the sequence of yield per hectare did not change. Influence of Carbendazim and Triforine on the incidence of phylloplane pathogenic fungi was much less than other fungicides. The total fungi in all the fungicides varied from 2.54-64.17 per cent in comparison to control (72.06%).

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APPENDIX

APPENDIX-I

Tables of statistical analysis

(a) Analysis of variance for table 7 (Disease index)

Source	D.F.	M.S.S.	'F' cal.
Main plot :			
Varieties	2	93.75	4.59
Replication	3	36.69	1.79
Error (a)	6	20.41	-
Sub plot :			
Date of sowing	2	195.62	5.11*
Date x Variety	4	32.93	0.86
Error (b)	18	38.26	-

(b) Analysis of variance for table 7 (Yield)

Source	D.F.	M.S.S.	'F' cal.
Main plot :			
Varieties	2	938.25	12.77*
Replication	3	98.19	1.33
Error (a)	6	73.47	-
Sub plot :			
Date of sowing	2	3667.76	20.56*
Date x Variety	4	3569.01	20.01*
Error	18	178.35	-

(c) Analysis of variance for table 34

Source	D.F.	M.S.S.	'F' cal.
Main plot :			
Varieties	2	1864.46	10.50*
Replication	2	326.84	1.84
Error (a)	4	177.40	-
Sub plot :			
Plant population	4	22.74	0.78
Variety x plant population	8	43.18	1.48
Error (b)	24	29.06	-

(d) Analysis of variance for table 34 (1st spray)

Source	D.F.	M.S.S.	'F' cal.
Fungicides	7	145.02	9.72*
Replication	2	4.37	0.29
Error	14	14.91	-

(e) Analysis of variance for table 34 (2nd spray)

Source	D.F.	M.S.S.	'F' cal.
Fungicides	7	144.44	9.60*
Replication	2	12.58	0.83
Error	14	15.04	-

(f) Analysis of variance for table 34 (3rd spray)

Source	D.F.	M.S.S.	'F' cal.
Fungicides	7	138.35	18.57*
Replication	2	3.29	0.44
Error	14	7.45	-

(g) Analysis of variance for table 34 (Yield)

Source	D.F.	M.S.S.	'F' cal.
Fungicides	7	720.28	10.27*
Replication	2	57.12	0.81
Error	14	70.12	-