Management of chilli fruit diseases through application of new fungicide molecules and mulches

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By

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CERTIFICATE - I

This is to certify that the thesis entitled **Management of chilli fruit diseases through application of new fungicide molecules and mulches** submitted in partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE in AGRICULTUE (PLANT PATHOLOGY)** of the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by **Mr. Kumar Rakesh** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instruction.

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

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Chairperson of the Advisory Committee

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CERTIFICATE – II

This is to certify that the thesis entitled **Management of chilli fruit diseases through application of new fungicide molecules and mulches** submitted by **Mr. Kumar Rakesh** to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in partial fulfilment of the requirements for the degree of Master of Science in Agriculture in the Department of Plant Pathology has been, after evaluation, approved by the External Examiner and by the Student's Advisory Committee after an oral examination on the same.

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VITA

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INTRODUCTION

Chilli (*Capsicum annuum* L.) is used as a condiment as well as vegetable in every household in India. No Indian dish either vegetarian or non vegetarian is complete without chilli. It has an important role in our daily diet. Chillies are also used to flavour, soups, stews and souses. In India, chillies were introduced by the Portuguese.

The food value of chillies has been mentioned in the Hand Book of Indian Council of Medical Research, New Delhi (Singh, 1989). Every 100 g of edible portion of green chillies contain 85.7 per cent moisture, 2.9 g protein, 6 g fat, 3.0g carbohydrates, 30 mg calcium, 80 mg phosphorus, 1.2 mg iron, 175 µg carotenes, 0.19 mg thiamine, 0.39 mg riboflavin and 111 mg Vitamin C. Chillies are the best and cheapest source of vitamin C and A. Russian scientists have identified vitamin P in green chillies which they discovered to confer protection against damage due to secondary irradiation caused by atomic explosions (Singh, 1989), whereas vitamin A is essential for growth and reproduction and helps in resistance to infection, increases longevity and decreases senility.

Chillies are the best and cheapest source of vitamin C and A. The green chillies also contain routine which has specific medicinal value (Purseglove, 1977). The pungency of chillies is due to an alkaloid capsaicin (C18 $H_{27}NO_3$) the active hot principle which is used in pharmaceuticals, cosmetics, food and drinks (Tiwari, 1990).The red color in fruits at the ripening stage is due to the presence of pigment capsanthin (Nath, 1969). Chilli pungent principle of red pepper consists of a mixture of seven closely related alkyl vanillylamides named capsaicinoides obtained by solvent extraction of the dried fruits and the subsequent removal of the solvent (Tiwari, 1990; Govindarajan, 1985).

In India, almost all the states cultivate chillies. However, Madhya Pradesh, Tamil Nadu, Andhra Pradesh, Karnataka, Punjab, Bihar and Maharashtra are the leading chilli producers. In Madhya Pradesh, chillies are grown in all the divisions.

In Jabalpur, Chhindwara, Sagar, Khargone, Khandwa, Mandsaur, Dhar, Shajapur and Betul the crop has attained a commercial status.

The chilli crop suffers due to a number of fungal, bacterial and viral diseases that renders its production into stake (Gupta and Thind, 2006; Verma and Sharma, 1999). Among the various fungal diseases, anthracnose, dieback and fruit rot incited by *Colletotrichum* spp. is a limiting factor in Madhya Pradesh (Verma, 1966; Bhale *et al*., 2000). The pathogen has been reported from different parts of the country (Thind and Jhooty, 1990; Grover and Bansal, 1970; Mridha and Siddique, 1989). *Alternaria alternata* is also becoming a limiting factor for profitable cultivation. The pathogen has been noticed by several workers (Bhale *et al*., 2000; Verma and Bhale, 1989; Mehrotra, 1980; Verma and Sharma, 1999). The seed borne nature of this pathogen has been established (Bhale *et al*., 2001).

The fruit rot and tip drying caused by *Colletotrichum dematium* and *Alternaria alternata* have been identified as major pathogen. Exhaustive work has been done by several people. During last five years several new molecules have been developed and new combination of new generation fungicides have been developed. There is a need to identify suitable approaches for the management of the pathogens.

Hence, the present investigation was undertaken with the following objectives.

1. To determine the authentic distribution of the disease under varied intensive cultivation system.
2. To determine the influence of seasons on the development of diseases and possible correlation with weather data.
3. To determine the efficacy of new fungicide molecules on seed associated *Colletotrichum dematium* and *Alternaria alternata*.
4. To determine the efficacy of new fungicide molecules against fruit rot and tip drying diseases under natural field condition.
5. To determine the effect of mulches against the disease development.

REVIEW OF LITERATURE

Chilli (*Capsicum annuum* L.) is an important condiment crop. It belongs to family Solanaceae (2n = 24). Mexico and Guatemala are considered as the place of origin of chilli (Singh, 1989). In India the crop was introduced by Portuguese. The crop suffers due to a number of diseases (Chupp and Sherf, 1960; Mehrotra, 1980). Important diseases of chilli include wilt and seedling decay by *Phytophthora capsici, P. nicotianae, P. nicotianae* var *parasitica*, leaf spots due to *Phoma* sp., *Alternaria* sp., *Curvularia lunata, Cercospora capsici*, anthracnose *Colletotrichum* spp., root-rot, *Macrophomina phaseolina*, powdery mildew *Leveillula taurica*, leaf blight *Helminthosporium* sp., fruit rot and spots *Choanephora cucurbitarum*, daming-off *Pythium* sp., virus diseases by capsicum mosaic, cucumber mosaic, tobacco mosaic, tomato mosaic, pepper mild mosaic, bacterial leaf spots – *Xanthomonas campestris* pv. *vesicatoria* and root knot due to *Meloidogyne* spp.

Global distribution

A number of pathogens attack the crop and cause various diseases. The status of major fungal diseases is presented in Table 2.1. The vast account of fungal diseases is well documented (Mukherji and Bhasin, 1986; Gupta and Thind, 2006; Verma and Sharma, 1999; Mehrotra, 1980). Among the major fungal pathogens that attack chilli plants are ripe fruit rot, anthracnose (*Colletotrichum dematium*), leaf spots (*Alternaria alternata*), fruit rot (species of *Alternaria, Colletotrichum, Fusarium, Phoma capsici*), seedling and plant blight (*Phytophthora capsici*) and root rot (*Rhizoctonia bataticola* and *Sclerotium rolfsii*).

Distribution of chilli diseases in India

Chilli crop has attained the commercial status especially in Madhya Pradesh, Andhra Pradesh, Maharashtra, Karnataka and Gujarat. The ripe rot and anthracnose (Grover and Bansal, 1970; Thind and Jhooty, 1990), leaf blight and fruit rot by *Phytophthora capsici, Phytophthora nicotianae* var *nicotianae* (Sohi *et*

al., 1971; Sharma and Bharadwaj, 1976), frog eye leaf spot by *Cercospora capsici* (Muneem *et al*., 1995), powdery mildew by *Leveillula taurica*, *Oidiopsis taurica* (Pawar *et al*., 1985), wet rot by *Choanephora cucurbitarum* (Prabhavathy and Reddy, 1995) have been considered very important. Beside fungal pathogens, wilt caused by bacterium (*Pseudomonas = Ralstonia solanacearum*), root knot (*Meloidogyne incognita*) and mosaic virus are wide spread (Table 2.2).

Table 2.1 : Major diseases of chilli

Disease	Causal organism	Reference
Ripe fruit rot	*Colletotrichum dematium* *Cercospora capsici* *Corynospora cassicola* *Chaetomium globosum* *Gleosporium piperatum*	Thind and Gupta (2006), Verma and Sharma (1999), Mukherji and Bhasin (1986), AVRDC (1990)
Fruit infection	*Fusarium semitectum* *Choanephora cucurbitarum* *Phytophthora nicotianae* *Dreschlera tetramera* *Cladosporium oxysporum* *Curvularia lunata* *Diplodea natalensis*	
Wilt	*Fusarium* sp. *Verticillium* sp.	
Bacterial wilt	*Ralstonia solanacearum*	
Virus	*Mosaic*	

Table 2.2 : Economically important fungal diseases of chilli in India

Disease	Causal organism	Reference
Anthracnose and ripe fruit rot	*Colletotrichum capsici* *C. gleosporoides* *C. piperatum*	Grover and Bansal (1970), Thind and Jhooty (1990)
Leaf blight & fruit rot	*Phytophthora capsici* *Phytophthora nicotianae* var . *nicotianae*	Sohi *et al*. (1971), Sharma and Bharadwaj (1976)
Powdery mildew	*Leveillula taurica* *Oidiopsis taurica*	Pawar *et al*. (1985)
Frogeye leaf spot	*Cercospora capsici*	Muneem *et al*. (1995)

Incidence of *Colletotrichum dematium*

The distribution of ripe rot and anthracnose pathogen in the world and in India has been presented in Table 2.3 and 2.4.

The disease has been recorded from USA, Armenia, Canada, Bulgaria, Uganda, Japan, Pakistan, Malaysia, Korea, Sri Lanka, China, Thailand and Poland (Table 2.3).

The pathogen has been also noticed in almost from all the parts of chilli growing areas of India, including Assam, Andhra Pradesh, Bihar, Karnataka, Maharashtra, Punjab, Orissa, Rajasthan, Tamil Nadu and Jammu & Kashmir (Table 2.4).

Distribution of *Alternaria alternata*

The distribution of fruit rot and tender tip drying disease caused by *Alternaria alternata* in the world and in India is presented (Table 2.5 and 2.6).

Table 2.3 : Distribution of anthracnose and ripe rot of chili caused by *Colletotrichum* sp. in the world

Country	Reference
USA	Smith and Crossman (1958)
Armenia	Babayan and Shakhnubaryan (1970)
China	Ling and Lin (1994)
Malaysia	Mazilan and Sariah (1980)
Canada	Illman (1960)
Japan	Takano *et al*. (1985)
Sri Lanka	Park (1929)
Thailand	Juanabhanich and Chana (1975)
Uganda	Walter *et al*. (1974)
Pakistan	Sattar and Hafiz (1952)
Korea	Lee *et al*. (1986)

Table 2.4 : Distribution of fruit rot and anthracnose in India

Country	Reference
Punjab	Thind and Jhoothy (1985)
Bihar	Kumar and Mahmood (1986)
Maharashtra	Joi and Sonone (1980)
Assam	Rathaiah (1983)
Karnataka	Padaganur and Naik (1991)
Rajasthan	Chakravarti and Anil Kumar (1975)
Jammu & Kashmir	Ahmed *et al*. (1991)
Orissa	Rout and Rath (1972)
Tamil Nadu	Raja and Pillayarswamy (1972)
Andhra Pradesh	Manoharachari and Padmavati (1976)

Table 2.5 : World distribution of *Alternaria alternata* ,the cause of leaf spot and fruit rot

Country	Reference
Argentina	Walter *et al*. (1974)
Bangladesh	Mridha and Siddiqui (1989)
Nigeria and Brazil	Adisa (1985)
Mexico	Leyendecker (1954)
Italy	Sibilia (1957)
USA	Miller *et al*. (1984)
Pakistan	Sultana *et al*. (1988)
Iraq	Shawkat *et al*. (1978)
Romania	Tutunaru and Raicu (1978)

Table 2.6 : Distribution of fruit rot disease caused by *Alternaria alternata* in India

Country	Reference
Madhya Pradesh	Hasija (1987)
Maharashtra	Mali and Joi (1985)
Haryana	Chauhan and Duhan (1986)
Andhra Pradesh	Manoharachari and Padmavati (1976)
Tamil Nadu	Sujatha Bai *et al*. (1993)
Rajasthan	Mathur and Agnihotri (1961)
Uttar Pradesh	Singh and Tandon (1967)
Punjab	Bansal *et al*. (1987)

Association with seeds

Ripe rot

The seed borne nature of *Colletotrichum dematium* has been very well documented and demonstrated by several workers (Kulshrestha *et al*., 1977; Manoharachari and Padmavati, 1976; Sangehote and Janbhamich, 1984; Nobel

and Richardson, 1968; Suryanarayana and Bhombe, 1961; Shawkat *et al*., 1978; Mridha and Siddique, 1989).

Tender tip drying

The seed borne nature of *Alternaria alternata* in *Capsicum annuum* has been demonstrated (Suryanarayana and Bhombe, 1961; Monharachari and Padmavati, 1976; Mridha and Siddiqui, 1989; Dhawale and Kadmelwar, 1978).

Association of mycoflora

A number of mycoflora have been observed to be associated with chilli seeds (Suryanarayana and Bhombe, 1961; Ram Nath and Lambat, 1971; Walter *et al*., 1974; Nobel and Richardson, 1968; Sultana *et al*., 1988).

The mycoflora found associated with seeds are presented in Table 2.7.

Table 2.7 : List of major pathogens associated with chilli seeds

Seed associated pathogen	Reference
Alternaria alternata, Drechslera sarokinensis, D. tetramera, Fusarium equisetii, Fusarium moniliforme, Fusarium semitectum, Curvularia lunata, Phomopsis, Verticillium alboatrum, Aspergillus flavus, Aspergillus niger	Suryanarayana and Bhome (1961), Ram Nath and Lambat (1971), Walter *et al*. (1974), Nobel and Richardson (1968), Sultana *et al*. (1988)

Extent of damage

Losses due to *Colletotrichum dematium* and *Alternaria alternata* have been worked out. At Jorhat (Assam), about 32 per cent fruit losses have been reported by Choudhary (1957). Pearson *et al*. (1984) recorded losses up to 17.2%, whereas, Grover and Bansal (1968) and Singh *et al*. (1977) observed severe losses in Punjab and Kanpur. Suryananayana and Bhombe (1961) reported only 8-12 per cent seed germination due to the seed borne nature of *Colletotrichum* sp. Padaganur and Naik (1991) observed 75.5% seed infection due to *C. capsici* in Karnataka.

Singh (1987) reported the losses ranging from 19.0 to 47.89% while Sanz (1970) observed between 30-40% fruit infection due to *Alternaria* sp. In New Mexico, losses upto 90.0% were recorded due to internal infection of *Alternaria* sp. (Leyendecker, 1954). Reduced seed germination and seed rot due to *Alternaria* sp. has been also recorded by several workers (Adiver *et al*, 1987; Dhawale and Kodmelwar, 1978).

Pathogenicty

Pathogenicty is the ability of a pathogen to cause disease. *Colletotrichum dematium* and *Alternaria alternata* have been recorded on a number of host plants, indicating the ability to produce disease under natural conditions.

Various methods for testing the virulence of seed associated mycoflora have been documented (Agarwal, 2006; Vishnavat, 2009). Roll on culture method, pin prick method; soil inoculation method and fruit injection methods have been used in different crops for testing virulence of a range of seed associated mycoflora (Bhale, 1993).

Management

The association of *Colletotrichum dematium* and *Alternaria alternata* with fruit rot, twig drying, tender tip drying and leaf spots has been reported. The seed borne nature of both the fungi have been observed by several workers. The pathogens are transmitted through seed and is responsible for seed rot, seedling decay. The pathogen survives in the plant debris and secondary infection takes place through air borne inoculum that multiplies on the plant lefts in the soil (Agrios, 2009).

Attempts have been made by several workers to find suitable fungicides for the control of anthracnose pathogen (*Colletotrichum dematium*) including Takano *et al*. (1985), Thind and Jhooty (1980), Rathore (2006), Sharma and Thakre (2004) and fruit rot and twig drying pathogen. *Alternaria alternata*, Khare *et al*. (2002), Parwez *et al*. (1968), Singh and Tandon (1967), Miller *et al*. (1984), Jharia *et al*. (1997).

Management of seed associated mycoflora

Management of seed associated *Colletotrichum dematium* and *Alternaria alternata* has been attempted by Srinivas *et al*. (2006), Thippeswamy (2007), Prasanna *et al*. (2009), Rahman *et al*. (2004), Mali and Joi (1985), Dhyani *et al*. (1990), Siddarmaiah *et al*. (1980), Prasad and (1985), Sultana *et al*. (1988).

Effectiveness of seed treatment with Thiram plus captan (0.3%) in checking the pre- and post-emergence losses and mortality at adult stage was observed by Jharia *et al*. (1977). Seed treatment with methoxyethyl-mercury chloride at 0.16 per cent provided complete control of *Colletotrichum capsici* (Juanbhanich and Chana, 1975) at Bangkok. Among 12 seed dressers tested thiram was the best against seed borne *Colletotrichum* sp. (Kumar and Mahmood, 1986). Better emergence and vigour was also recorded. Efficacy of thiram (0.2%) was also observed by Chakravarti and Anil Kumar (1975) and Siddiqui *et al*. (1977). The ripe rot pathogen was controlled by the application of zineb to the chilli seeds (Boswell *et al*., 1952), Panigarahi and Narain (1971) recorded the efficacy of Vitavax, plantvax and ziram.

The efficacy of ferbam, maneb and captan @ 0.5% was confirmed by Crisam and Mesechu (1970) while investigating the leaf spot caused by *Alternaria* sp. on red pepper.

Efficacy of seed treatment with thiram has been reported against *Alternaria* sp. by Mali and Joi (1985) and Dhyani *et al*. (1990) while Kannaaiyan *et al*. (1980) recorded the best results with Benlate-T (0.3%) in pigeon pea.

In Bangladesh, Mridha and Chaudhary (1990) observed the efficacy of benomyl, Mancozeb and Vitavax 200 against the seed borne natural infection of *A. alternata* and *C. capsici* at 0.45% after 6 days, Siddaramaiah *et al*. (1980) recommended the use of thiram (0.3%) while Prasad (1985) observed triforine (0.15%) the best, as seed treatment against A*lternaria carthemi* in safflower.

Foliar application of fungicides

Management of *Colletotrichum dematium (=Colletotrichum capsici)* and *Alternaria alternata* through foliar application of fungicides has been attempted by number of workers throughout the world.

Anthracnose and ripe rot

Extensive studies have been carried out in all the chilli growing areas against this disease (Kumawat, 1997; Ushakiran *et al*., 2006; Rathore, 2006; Sharma and Thakare, 2004, Rathore, 2004, Udit Narain *et al*., 2006; Mani *et al*., 2005, Chander Mohan, 2004; Hegde and Anahosur, 2001; Hingole and Kurandikar, 2009; Jayasekar *et al*., 1987, Raju and Rao, 1985; Deshmukh *et al*., 2004; Reddy, 2004; Ekbote, 2005).

Significant reduction due to Mancozeb plus Thiophenate methyl and Carbendazim was noticed (Kumawat, 1997; Ushakiran *et al*., 2006). Efficacy of application of Carbendazim has been observed (Sharma and Thakare, 2004; Thippeswamy, 2007; Udit Narayan *et al*., 2006; Ekbote, 2005; Reddy, 2004; Rao *et al*., 2000; Jayasekar *et al*., 1987). Efficacy of Mancozeb was noticed by Rathore (2004), Raju and Rao (1985), Natrajan and Subramanian (1976), Kodu *et al*. (1977), Kashyap *et al*. (2008).Fungicide, thiophenate-methyl has been used for the effective control of ripe rot pathogen by Sharma and Thakare (1999), Kumawat (1997) Sharma and Thakare (2004), Thippeswamy (2007),and Udit Narayan *et al*. (2006), whereas, the efficacy of hexaconozole was reported by Hegde and Anahosur (2001).

Alternaria fruit rot

Very few references on chilli fruit rot caused by *Alternaria alternata* are available however, on other crops, information is available. Khare *et al*. (2002) recorded the efficacy of Mancozeb (0.2%) chlorothalonil (0.2%) and Carbendazim (0.1%) against Alternaria leaf spot of chilli. Ghosh *et al*. (2002) reported effectiveness of tridemorph (0.1%) and Mancozeb on gerbera. In

marigold, minimum disease was noticed after application of propiconazole (0.1%) by Patil *et al*. (2005).

Effect of mulch

Primarily practices of mulching were employed for the conservation of soil moisture. The practice had exhibited some additional advantages in different situations of agricultural systems. Stimulated early root growth and efficient nutrient uptake of transplanted tomatoes is reported by Wien *et al.* (1993). Beside the moisture conservation mulching has resulted in weed management (Aulakh and Sur, 1999) in pomegranate. Considering the varied advantages, use of plant residues has also been a good practice (Jalota *et al*., 2001; Mauraya and Lal, 1981; Sekhon *et al*., 2005). Paddy straw (Chakraborty, 2000), sugarcane straw (Shinde *et al.*, 1999), pine needles (Igbokwe, 1996), grass (*Panicum maximum*) (Palada *et al*., 2003), organic mulch consisting chopped and composed cocoa pods , grass and sweet potato vines (Gollifer, 1993) have been used by various workers for deriving the mulch advantages in various crops. Effect of cultural practices on the capsaicin and ascorbic content of chili has been investigated (Panchal *et al*., 2001). No systematic study has been undertaken on the influence of mulches on the incidence of diseases in our conditions, however, reduction in insect pests and increase yields have been reported (Ibrra *et al*., 2004) in Mexico. The use of white plastic mulch for chillies resulted in a doubling of yield compared to traditional methods.

MATERIAL AND METHODS

The management of fruit rot, dieback and powdery mildew disease of chilli was undertaken by employing a combination of new molecules of fungicides. The effect of mulching on disease inhibition was studied in the present investigation. The distribution of diseases was also determined .The material used and methods followed are described herewith.

General

Cleaning and sterilization of apparatus

The glassware used during the course of investigation was of Corning and Borosil make. Prior to use, each glassware was cleaned with chromic acid solution.

Preparation of chromic acid solution

Sulphuric acid	300 ml
Potassium dichromate	80 g
Distilled water	400 ml

The glassware was cleaned with chromic acid solution followed by thorough washing with detergent powder and finally rinsed with normal tap water/ distilled water as per need. The air dried glassware were sterilized in an autoclave at 1.05 kg/cm² (15 lb per square inch) for 15 minutes, whereas, soil at 1.05 kg/cm² for 180 minutes. Plastic trays were surface disinfested with 0.1% NaOCl (Sodium hypochlorite solution) followed by thorough washing with sterilized water.

The inoculation needle, forceps and biological needle were surface disinfested by dipping in alcohol and there after heating over a flame.

The inner surface of the growth chamber and clean-air-system was disinfested by using ultra violet lamps and spray of formaldehyde solution. Prior to use safety precaution were adopted while using ultra violet lamp and formaldehyde solution.

Media

The ingredients of media used during the course of investigation are as follows:

Potato Sucrose Agar (PSA)

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

Incubation chamber

The incubation chamber was used to provide optimum condition for the isolated mycoflora from seed and different plant parts including stem and fruits of chilli. The internal dimensions of the chamber were length 3.0 m, width 0.75m and height 0.90m. Two sets of Philips 40 W day light tubes were provided in the chamber, horizontally at the height of 40 cm. Alternative cycles of 12 hr light and dark periods were maintained.

Seed germination chamber

To provide the optimum conditions for the chilli seed germination, the walk-in-seed germination chamber was used, the internal dimensions of the chamber were 6.1 feet height, length 8.7 feet and width 5.7 feet. The chamber was provided with light sources and the system of the maintaining the temperature and humidity.

The temperature was adjusted with the help of two air conditioners (1.0 ton) capacity. The humidity was created with the help of rotor-humidity creator where the water molecules were broken in to the small particles resulting in the fog. The wall of the chamber are made of stainless steel and provided with insulation by PUF. The insulation maintained the inside temperature during peak variations.

Meteorological data

The data on rainfall, relative humidity, minimum-maximum temperature were obtained from the Meteorological Observatory, College of Agricultural Engineering, JNKVV, Jabalpur for the period of investigation.

Table 3.1 : The weekly weather condition data from July 2010-April 2011

Standard weeks		Temperature (°C)		Relative humidity (%)		Rainfall (mm)
		Max.	Min.	Morn.	Eve.	
June 2010	22	43.2	30.0	36	18	0.0
	23	40.8	27.5	41	23	1.0
	24	43.2	26.0	56	26	3.9
	25	38.9	25.5	70	43	58.4
July	26	37.4	25.4	76	42	44.0
	27	33.1	24.8	86	71	82.4
	28	31.7	24.2	89	75	148.2
	29	33.5	25.2	88	63	41.0
August	30	30.7	24.5	89	75	170.3
	31	31.5	23.5	88	75	122.0
	32	31.9	23.1	88	63	102.5
	33	33.3	23.3	8	64	128.0
	34	32.9	23.7	86	73	24.0
September	35	33.5	23.6	84	70	95.0
	36	33.0	23.3	93	70	312.7
	37	31.9	2.6	90	69	80.0
	38	30.4	22.5	93	69	118.5
October	39	32.0	20.6	88	47	0.0
	40	32.3	20.8	89	51	0.0
	41	31.7	19.7	86	45	0.0
	42	31.8	19.8	94	60	79.4
	43	30.9	18.1	92	42	0.0
November	44	29.3	15.3	91	42	0.4

Standard weeks		Temperature (°C)		Relative humidity (%)		Rainfall (mm)
		Max.	Min.	Morn.	Eve.	
	45	30.3	16.3	91	48	0.0
	46	31.5	19.4	92	58	1.4
	47	29.7	14.5	90	38	0.0
December	48	29.2	16.3	91	55	0.0
	49	23.7	11.5	89	47	7.6
	50	24.8	8.9	91	32	0.0
	51	24.7	4.9	89	24	0.0
	52	27.0	8.7	81	36	0.0
Jan. 2011	1	21.0	3.1	95	35	0.0
	2	23.8	3.5	87	25	0.0
	3	24.6	6.1	87	25	0.0
	4	26.3	8.7	85	36	0.0
February	5	26.3	8.5	88	37	0.0
	6	29.0	9.9	85	36	0.0
	7	29.5	12.7	79	35	0.0
	8	26.2	10.1	83	38	1.4
March	9	29.5	12.6	86	40	4.2
	10	32.1	13.6	82	34	0.0
	11	32.2	11.2	73	20	0.0
	12	36.3	17.9	47	14	0.0

Location of the site

The field experimentations were conducted at Research Experimental Area, Department of Horticulture, JNKVV, Jabalpur. The investigation were conducted the crop grown during kharif 2010 at Jabalpur. The location site lies between 22°49’ and 22°80’ North latitude and 78°21’ and 80°58’ East longitude at an altitude of 411.78 meter above the mean sea level.

Status of the disease

The status of chilli diseases was determined at Jabalpur in the experimental area, near by back yard gardens / kitchen gardens and commercial crop fields. The distribution and occurrence of chilli diseases was recorded at Maharajpur Farm, Krishi Nagar and farmers' field.

Incidence of disease

The incidence of major diseases was recorded on randomly selected 100 plants in a particular field. The diseases were identified initially on the basis of typical field symptoms. During the study, total and infected plants were counted to calculate the disease incidence as per the formula given by Singh and Singh (2000).

$$PDI = \frac{TIP}{TPO} \times 100$$

Where,

PDI = Percent disease incidence i.e. per cent plant exhibiting symptoms

TIP = Total number of infected plants

TPO = Total number of plants observed

Collection of chilli plant parts

During study infected fruits and stem were collected in paper envelopes and brought to the laboratory. The samples shows collected were numbered and stored in paper envelops at 4°C to avoid any further deterioration.

Isolation, purification, identification and maintenance of fungi

Fruits, twigs, leave and seeds from infected plants/fruits were collected from different locations. Isolations were made to determine the associated mycoflora. The diseased plant parts were cut into small pieces. Surface sterilized with 0.1% NaOCl for 30 seconds followed by three washings with sterilized water

and there after placed in Petri dishes containing 17-20ml of solidified PSA mixed with small quantity of streptopencillin to avoid bacterial contamination. The Petri dishes were incubated at 25 ± 2°C. After 4 to 7 days incubation the developing fungi were subcultured on PSA medium and purified by using hyphal tip method.

The isolated fungi were identified with the help of available fungi identification keys and on the basis of morphological characteristics of the colony, mycelium and conidia.

Test of virulence

The pathogenicty test of isolated *Colletotrichum dematium* and *Alternaria alternata* was conducted under field condition. The test was performed by fruit inoculation.

Technique under natural field conditions

Fruit inoculation technique

On semi-ripe and complete ripe chilli fruits, the cultures of *Colletotrichum dematium* and *Alternaria alternata* were inoculated by pin prick, injection and tooth pick method. Observations on symptom development were recorded. In pin prick and tooth-pick method, the pricks were made with the help of sterile needles and sharpen tooth picks and later the needles and tooth picks were loaded with inoculum. The needles and tooth picks were touched, separately and individually with the fungal culture plates, so that the mycelial bits and spores were sticked / adhered on the surface of the needles/tooth picks, and then inserted to the skin (pericarp) of the fruits. The spore and mycelial bit suspension was prepared in the culture tube and 2 ml of the spore suspension was injected in the fruits with the help of disposable syringe using the needle number 22.

Symptoms

The symptoms of diseases were noticed under field conditions and the progressive development of the diseases, including Anthracnose and Alternaria leaf spot were recorded.

Management

The following fungicides and their combination were used for the management studies under lab condition. The fungicides included Mancozeb + Carbendazim, Carbendazim, , Carboxin + Thiram, Copper oxy chloride,Mancozeb, Mancozeb + Thiophenate methyl. Untreated chilli seeds served as control. Pre-determined seed samples with known infection were used.

Treatment of chilli seeds

The required quantity of fungicide was measured and sprinkled over the chilli seeds already kept in polythene bags. The fungicide and seeds were gently shacked for uniform coating. The fungicides treated seeds were spread over a butter paper and the air dried chilli seed was placed on the top of the blotter (standard blotter method), between the blotter (Standard Ragdoll method) and sown in the sterile sand (Grow Out Test).

Management of seed associated mycoflora

The seeds of pre tested variety Jawahar Mirch 283 (JM 283) having maximum natural infection of *Colletotrichum dematium* and *Alternaria alternata* was used. The seeds were treated with individual fungicides and observations were recorded on the associated mycoflora adopting Standard Blotter method (ISTA, 1996) and Standard Ragdoll method (ISTA, 1996).

Standard blotter method

Fungicide treated seeds were used .Untreated seeds served as control. In this method, three circular blotter papers of the size of the Petri dish were cut and dipped in sterilized water. Excess water was removed and soaked sheets were placed in each Petri dish. Twenty five chilli seeds were placed in each Petri dish with the help of sterilized forceps under aseptic conditions of inoculation chamber. In the outer circle, 6 seeds were placed, 8 in the inner circle and one in the center so as to allow in the equal distance between the seeds. Seeded plates were kept for the incubation in the chamber. Fungi were identified by making

slides and observing under microscope on eight day of incubation with the help of identification manuals.

Standard Ragdoll method

Two sheets of standard germination testing method (paper towel) were soaked in sterilized distilled water. Excess water was removed and one sheet was stretched over clean top of working table. On the stretched sheet 50 fungicide treated seeds were placed in 5 rows of 10 seeds at equal distance. The second pre soaked sheet was placed covering the first sheet having the 50 seeds, without disturbing already arranged sheets. Both the sheets were rolled out and tide with rubber band at both the ends. At one end, butter coated paper was used to avoid water losses. The rolled paper towels containing seeds were placed in the germinator with slightly tilting the bunch of the towels. The seeded towels were incubated in the dark for 14 days. The seeds were examined for associated mycoflora and germination after removing one sheet. Continued wetness of the towels was maintained during the incubation.

Grow Out Test

Well cleaned sterilized sand was used in a plastic tray to determine the influence of fungicidal seed treatment on the germination. Counted seeds were sown in the tray at equal distance. There after the seeded trays were placed in the walk-in-germination chamber. Seed emergence was recorded after eight days.

Management of fruit and plant diseases

Management of fruit rot and leaf spot, dieback caused by *Colletotrichum capsici* and *Alternaria alternata* was attempted under field conditions at Maharajpur Farm, JNKVV, Jabalpur.

Treatment details

Chilli variety	Jawahar Mirch 283
Date of nursery sowing	16 August 2010
Date of planting	27 September 2010

Plot size 2 x 2 m

Plot to plot distance 40 x 40 cm

Row to row distance 40 x 40 cm

Number of plants/plot 25 plants

Fungicide combination and doses

Fungicide 5

Replication 6

Soil type Vertisols

Fungicides

Fungicide	Formulation	Dosage ml / 100 L water
Difenoconazole 25%	EC	25
Difenoconazole 25%	EC	50
Difenoconazole 25%	EC	75
Difenoconazole 25%	EC	100
Difenoconazole 25%	EC	200
Kitazin 48% +	EC	200
Tebuconazole 25%	EC	100
Azoxystrobin 23%	SC	50
Azoxystrobin 23%	SC	100
Azoxystrobin 23%	SC	150
Azoxystrobin 23%	SC	200
Azoxystrobin 23%	SC	400
Kitazin 48%	EC	200
Tebuconazole 25%	EC	100
Control	-	No spray

Influence of mulch

Treatment details

Chilli variety Jawahar Mirch 283

Date of nursery sowing	16 August 2010
Date of planting	27 September 2010
Plot size	2 x 2 m
Plot to plot distance	40 x 40 cm
Row to row distance	40 x 40 cm
Number of plants/plot	25 plants
Replication	06
Mulch	
Colorless Transparent sheet	200 gauge
Black plastic sheet	200 gauge
Paddy (Rice) straw	
Control without mulch	
Soil type	Vertisols

Effect of colorless transparent plastic 200 gauge, black plastic 200 gauges and paddy straw was determined as mulch. These were used in transplanted chilli crop after 20 days of establishment. The colorless and black plastic sheets were spread over around the plants after 20 days of transplanting of chilli seedling under field condition as mulch. The corners and edges of the plastic sheets were covered with natural field soil to protect from disturbance of the air currents. A thin layer of paddy straws was placed in between the plants. A little space was provided for irrigation. The movement of persons was restricted between the plots. Observation on progressive development of *Colletotrichum dematium* and *Alternaria alternata* was recorded. Observations were recorded from the side of the bunds on the development of diseases based on typical symptoms.

RESULTS

The fruit rot and dieback caused by *Colletotrichum dematium* and fruit rot and tender tip drying incited by *Alternaria alternata* were investigated. The distribution of the disease, status, development and management aspects were studied. The results of the investigation are presented here with.

Status of diseases of chilli

The incidence of chilli diseases was recorded at different locations during September & October 2010 and first fortnight of January 2011. The incidence of diseases was recorded at commercial fields located near by Jabalpur city, the kitchen garden (back yard) and research experimental fields where the vegetable cultivation is undertaken throughout the year.

Measurement of disease

The incidence of major diseases was recorded on randomly selected 100 plants in a particular field. The diseases were identified on the basis of typical field symptoms. The incidence was calculated as per the formula advocated by Singh and Singh (2000).

Incidence of chilli diseases

Location wise

During September – October

Incidence of diseases was recorded at 34 location during the period, that include 17 location of commercial fields, 13 location of backyard / kitchen garden and 4 location of research experimental field.

The data presented in Table 4.1 indicate that during September, October incidence of fruit rot, dieback and tender tip drying was widespread in variable proportions. At 17 location in farmers field the average fruit rot caused by *Colletotrichum* was 10.18%, in the ranged of 2.0 to 19.0%. Maximum fruit rot disease was recorded at Ranital and Amkhera village. At farmers fields'

maximum dieback disease (40.0%) was observed in Amkhera village while the least (4.0%) was recorded in the fields towards Katni road. The average incidence of dieback was 25.71%. At farmer fields tender tip drying due to *Alternaria alternata* ranged from 2.0 to 13.0%, with average incidence of 7.29%. Maximum disease incidence was recorded in Amkhera village while least disease incidence was noticed in the fields towards Gwarighat. The fruit rot caused by *Alternaria alternata* was observed in the range 2.0 to 9.0, being maximum at Gohalpur near Amkhera, with an average incidence of 4.41% (Table 4.1).

The distribution of fruit rot and tip drying and dieback was also investigated in backyard / kitchen garden of Krishi Nagar (5 location), Suhagi village (3 locations) and Maharajpur village (5 location). The fruit rot incidence ranged between 2.0 to 11.0, being minimum at Maharjpur and maximum at Krishi Nagar. The dieback disease incidence was in the range from 5.0 to 22.0%. The average incidence of fruit rots was 7.15 and dieback 12.15% in 13 location of kitchen garden during September, October 2010. Average incidence of fruit rot due to *Alternaria alternata* was 7.2% and tender tip drying 9.5% in 13 location. The Alternaria fruit rot incidence range from 3.0 to 12.0% whereas, the tender tip drying incidence ranged from 2.0 to 17.0%. Maximum tender tip drying incidence was noticed in backyard gardens of Suhagi village (Table 4.1).

In four location of research field at Maharajpur farm the fruit rot disease was 15.5% while the dieback ranged from 22.0 to 44.0% with average 29.25% at Maharajpur. The fruit due to *Alternaria alternata* ranged from 5.0 to 9.0 with average 5.0% whereas, the tender tip drying incidence was in the range of 11.0 to 20.0% with an average 14.0%.

During January 2011

Incidence of fruit rot ranged from 2.0 to 15.0 and dieback 3.0 to 28.0% with an average incidence 7.11 and 15.76% was recorded in 17 locations in the commercial farmers' fields. The Alternaria fruit rot incidence ranged from 4.0 to 22.0 whereas, the tender tip drying incidence ranged from 5.0 to 37.0% with an

average of 21.06% in the farmers fields. Maximum disease incidence was recorded at Ranital and Amkhera fields (Table 4.2).

Table 4.1 : Incidence of chilli diseases at Jabalpur during September 2010

Location & number	Percent disease incidence				
	Colletotrichum Die back		Alternaria Dry tip		Powdery mildew
	Fruit Rot	Die back	Fruit rot	Tender tip drying	
Farmers Field					
Ranital (1)	19	32	02	08	0.0
Ranital (2)	05	30	02	06	3.0
Ranital (3)	11	21	05	05	0.0
Gohalpur (1)	13	31	02	05	7.0
Gohalpur (2)	11	22	05	09	7.0
Gohalpur (3)	02	19	09	08	11.0
Amkhera (1)	17	40	09	09	15.0
Amkhera (2)	12	42	06	11	3.0
Amkhera (3)	08	32	02	12	5.0
Amkhera (4)	10	35	02	05	19.0
Katni road (1)	12	28	05	13	0.0
Katni road(2)	05	04	07	10	0.0
Katni road(3)	05	09	03	10	0.0
Tilwarghat road(1)	11	29	05	05	5.0
Tilwarghat road(2)	10	20	02	04	5.0
Gwarighat road(1)	10	12	04	02	0.0
Gwarighat road(2)	12	31	05	02	0.0
Average	10.18	25.71	4.41	7.29	
Kitchen Garden					
Krishi Nagar(1)	10	22	11	13	0.0
Krishi Nagar(2)	11	11	12	11	0.0
Krishi Nagar(3)	10	17	09	05	0.0
Krishi Nagar(4)	09	20	07	02	0.0
Krishi Nagar(5)	08	20	09	04	0.0
Suhagi(1)	09	11	05	17	7.0
Suhagi (2)	08	10	04	11	7.0
Suhagi(3)	09	10	03	14	8.0
Maharajpur(1)	07	09	09	15	0.0
Maharajpur(2)	05	08	10	10	0.0
Maharajpur(3)	02	09	10	05	0.0
Maharajpur(4)	02	05	08	03	0.0
Maharajpur(5)	03	06	06	09	0.0
Average	7.15	12.15	7.92	9.15	
Research Fields					
Maharajpur(1)	12	22	05	15	0.0
Maharajpur(2)	18	24	06	10	3.0
Maharajpur(3)	15	27	09	20	5.0
Maharajpur(4)	17	44	05	11	0.0
Average	15.5	29.25	5.0	14.0	

Table 4.2 : Incidence of chilli diseases at Jabalpur during January 2011

Location & number	Percent disease incidence				
	Colletotrichum Die back		Alternaria Dry tip		Powdery mildew
	Fruit Rot	Die back	Fruit rot	Tender tip drying	0.0
Farmers Field					
Ranital (1)	06	19	22	37	0.0
Ranital (2)	03	10	15	25	0.0
Ranital (3)	05	10	17	22	0.0
Gohalpur (1)	05	18	19	29	4.0
Gohalpur (2)	04	05	20	22	3.0
Gohalpur (3)	02	03	05	21	0.0
Amkhera (1)	15	27	06	35	5.0
Amkhera (2)	05	11	18	21	5.0
Amkhera (3)	02	05	15	22	2.0
Amkhera (4)	09	22	12	15	0.0
Katni road (1)	08	11	09	22	0.0
Katni road(2)	10	28	05	11	0.0
Katni road(3)	10	12	04	10	0.0
Tilwarghat road(1)	07	22	06	23	0.0
Tilwarghat road(2)	10	20	07	05	0.0
Gwarighat road(1)	10	20	08	09	0.0
Gwarighat road(2)	10	25	11	29	0.0
Average	7.11	15.76	11.70	21.06	
Kitchen Garden					
Krishi Nagar(1)	02	15	11	22	0.0
Krishi Nagar(2)	05	12	12	18	0.0
Krishi Nagar(3)	03	12	10	11	0.0
Krishi Nagar(4)	05	10	07	22	0.0
Krishi Nagar(5)	02	05	04	05	0.0
Suhagi(1)	08	10	12	15	0.0
Suhagi (2)	11	02	10	10	0.0
Suhagi(3)	02	05	14	10	5.0
Maharajpur(1)	15	07	20	19	2.0
Maharajpur(2)	10	06	15	14	0.0
Maharajpur(3)	02	02	12	14	0.0
Maharajpur(4)	04	10	10	05	0.0
Maharajpur(5)	05	05	03	04	0.0
Average	5.69	7.78	10.77	12.92	
Research Fields					
Maharajpur(1)	13	14	12	32	2.0
Maharajpur(2)	10	20	10	30	0.0
Maharajpur(3)	22	15	03	25	2.0
Maharajpur(4)	05	03	05	12	0.0
Average	12.5	13.0	7.5	24.75	

In 13 location of kitchen garden of Krishi Nagar, Suhagi and Maharajpur the fruit rot incidence ranged from 2.0 to 15.0% with average incidence 5.69. The dieback incidence was average 7.78% in the range of 2.0 to 15.0%. The Alternaria fruit rot incidence was maximum at Maharajpur and it ranged from 4.0 to 20.0% whereas, the tender tip drying incidence was 5.0 to 22.0% with an average 12.92% incidence (Table 4.2).

In research field during January 2011, the incidence of tender tip drying ranged from 12.0 to 32.0% with an average incidence of 24.75%. The average dieback incidence was 18.0% in the range 3.0 to 20.0% whereas *Colletotrichum* fruit rot incidence ranged from 5.0 to 22.09% with an average of 1.5%.

Variety wise

The data presented in Table 4.3 indicate that at farmer fields maximum fruit rot (12.0%) and dieback (21.0%) was recorded in unidentified farmer's variety which has been used locally. Least fruit rot (1.0%) was noticed in Pusa Jyoti while 9.8% fruit rot was observed in Ankur. The dieback incidence ranged from 7.0 to 17.0%, being minimum in Pusa Jwala and maximum in Ankur variety. The Alternaria fruit rot was maximum 16.0 while the tender tip drying ranged 5.0 to 17.0%, it was maximum in Pusa Jyoti (Table 4.3). In research field fruit rot incidence was maximum (13.0%) in Pant C1 and dieback 22.0% in JM 283. The Alternaria fruit rot was minimum 2.0% and maximum 11.0% in Pant C1. The tender tip drying incidence ranged from 7.0% to 19.0% in kitchen garden the incidence of dieback was maximum Mayhco (1.5%). The tender tip drying incidence ranged from 21.0 to 25.0% (Table 4.3).

Table 4.3 : Incidence of chilli diseases in different varieties at Jabalpur during January 2011

Variety	Percent disease incidence				
	Colletotrichum Die back		Alternaria	Dry tip	Powdery mildew
	Fruit Rot	Die back	Fruit rot	Tender tip drying	
Farmers Field					
Mayhco	05	12	05	09	2
Ankur	09	17	03	12	0
No721	06	10	04	05	7
Local	12	21	08	05	11
Pusa Jwala	05	07	05	10	5
Pusa Jyoti	01	08	16	17	4
Kitchen Garden					
J M 218	10	13	02	22	2
J M 283	07	10	08	21	0
Mayhco	09	15	03	25	2
Research Fields					
J M 218	08	19	02	12	5
J M 283	07	22	07	07	0
Pusa Jwala	10	21	06	09	0
Pant C1	13	05	11	19	5

Germ line wise

The incidence of diseases was recorded in 26 germ line/variety. The incidence of fruit rot was below 5% I JM 283, Usha Mukti, Usha Sadabahar, JNS, JNS-5, SKS-1, SKS-3, SUMU 506-1, JM 218, Amulya, VNR and SKS-2. The incidence of dieback caused by *Colletotrichum dematium* was less than 5% in Pusa Mukti, Pusa hot, SKS-1, 2, 3 and K-1-4. Maximum dieback was recorded in KDSG-210-4. The incidence of Alternaria fruit rot was less than 5% in JM 283, Pusa Jawala, Pusa Mukti, JM 218, KA 2, Pusa hot, V 9600, SKS 2, SKS 3, SUMU 506-1, K-1-4. The incidence of tender tip drying was maximum in variety Ujala (22%), the incidence was less than 5% in Utkl, Abha, Pusa Jawala, Pusa Jyoti, Pusa Sadabahar, JNS 5, KA 2, SKS 1, and K-1-4 (Table 4.4).

Table 4.4 : Incidence of chilli diseases in different varieties germ lines at Jabalpur during January 2011

Varieties	Percent disease incidence				
	Colletotrichum Die back		Alternaria Dry tip		Powdery mildew
	Fruit Rot	Die back	Fruit rot	Tender tip drying	
JM 218	05	14	05	11	2
JM 283	02	16	03	13	5
Utkal Abha	07	15	07	05	2
Pusa Jwala	09	06	02	03	0
Pusa Jyoti	11	05	06	05	0
Pusa Mukti	02	05	05	07	0
Pusa Sadabahar	03	07	06	05	0
Ujala	11	07	10	22	0
Amulya	05	10	11	14	0
JNS	02	17	10	17	0
JNS 5	02	15	13	02	0
KA2	15	17	05	05	0
Pusa Hot	12	03	05	06	5
VNR	05	11	05	11	0
GUC	07	15	07	14	0
V 9608	04	08	03	08	0
SKS 1	02	03	02	05	3
SKS 2	05	02	01	08	3
SKS 3	03	05	01	08	7
SUMU 506 -17	05	11	05	09	0
SUMU 506 -1	04	12	02	10	0
K-1- 4	08	05	02	02	2
K- 413 -1	08	19	05	05	0
KDSG-210 -10 - 4	10	25	08	10	2
BVC -1	18	20	08	12	0
M-25- F	12	11	06	07	5

Status of diseases

The overall status of fruit rot, dieback, and tender tip drying disease is presented in Table 4.5. The fruit rot due to *Colletotrichum dematium* incidence ranged from 2.0 to 19.0% in farmer fields, 2.0-11.0% in kitchen garden and 12.0 to 18.0% in experimental fields. The dieback incidence was 4.0 to 14.0 % in farmer field, 5.0 to 22.0% in kitchen garden and 22.0 to 44.0% in experimental fields. The Alternaria fruit rot incidence was in the range 4.0 to 22.0% in farmers' fields, 3.0 to 15% in kitchen garden and 3.0 to 12.0% in experimental fields. The tender tip drying disease incidence was up to 37.0 in farmers fields 22.0% in kitchen garden and 32% in experimental field. Maximum dieback incidence was recorded in experimental field whereas maximum tender tip drying was recorded in farmer fields (Table 4.5).

Table 4.5 : Incidence of dieback and fruit rot of chilli at Jabalpur during 2010-11

Location	Percent disease incidence				
	Colletotrichum Die back		Alternaria Dry tip		Powdery mildew
	Fruit Rot	Die back	Fruit rot	Tender tip drying	
Farmers field	2.0-19.0	4.0-40.0	4.0-22.0	5.0-37.0	
Kitchen garden	2.0-11.0	5.0-22.0	3.0-15.0	4.0-22.0	
Experimental field	12.0-18.0	22.0-44.0	3.0-12.0	12.0-32.0	

Symptoms

The *Colletotrichum dematium* cause variable symptoms that include fruit rot of ripe fruits and downward death of twigs (dieback). Tender tip drying, fruit and leaf spot are incited by *Alternaria alternata.* The symptomatology of both the diseases was critically analyzed and studied.

Colletotrichum dematium

On fruits

The infection of *Colletotrichum dematium* changed the colour of full ripe fruits. It changes to straw colour from normal red colour. At initial stage small

black brown spots appeared and latter spread in the direction of long axis, thus becoming more as less elliptical. In certain cases the acervuli were arranged in circular fashion. Numerous black infected seed with profuse mycelium and stromatic bodies were observed where the infected fruit was cut open. On semi ripe fruit the symptoms were confusing, necrotic spots appeared at initial period that covered the entire fruit. Just beneath the pericarp (fruit wall) stromatic bodies with profuse mycelium of *Colletotrichum dematium* was recorded. The infected seeds were brown and rusty. Due to infection the seeds were shrinked. Black mass of scattered acervuli was noticed on rotted portion (Plate I).

On stem

Death of the chilli plant tissues from the tip of twigs to downward was noticed, just after the rains. A brown demarcation line reported the infected portion from the healthy ones. Under field condition the dieback symptoms was conspicuous. Circular to irregular shaped spots appeared on leaf lamina. The dead portion of the plant contained numerous acervuli, the fruiting bodies of the fungus (Plate I).

Alternaria alternata

On fruits

Irregular concentric rings of necrotic tissue were developed on chilli fruit that contained fungal bodies (mycelium with spores). The fruit wall (pericarp) turned grey in colour. In severally infected fruits the seeds were also infected. The pericarp became very thin and papery. The necrotic portion of the fruit was completely covered with dark. Grey brown to black velvety moldy growth of *Alternaria alternata*. The size of the fruit remained almost unchanged as compared to the infection by *Colletotrichum dematium* (Plate I).

On stem and leafs

The badly affected plants exhibited the tender tip drying symptoms which were conspicuous. It could be distinguished on the basis of white-wash symptoms. The tender tips of twigs became silvery white in contrast of brown

chocolate colour tender tips in case of plants infected with *Colletotrichum dematium*. Irregular brown specks were common. On leaves, at initial stage, the lesions were small isolated, scattered and pale brown. The infection was initiated from downward to upward. In the necrotic tissues concentric rings developed to produced target board effect. There was a narrow yellow halo zone around the spots. In severe cases the grey mycelium was observed on the infected portions at young stems pale brown discoloration was noticed (Plate I).

Identification

The identification of *Colletotrichum dematium* and *Alternaria alternata* was made on the basis of reports and key provided by Sutton (1973) and Kulshreshtha *et al*. (1976). Initially the fungal colony was pink while, later became black brown on potato sucrose agar medium. The mycelium was brown, septate and branched. The fruiting bodies, acervuli were dark brown black, globose and abundantly scattered on the host surface that contained numerous conidia and setae. The setae were black to brown, broader at base and pointed at tips. The setae were lager than conidial mass. The length of setae was in the range of 60.5 to 190.5 µm. The conidia were hyaline, single celled, curved with both ends, pointed and were pink in mass. The size of the conidia ranged from 22.8-27.50 x 3.5-6.3 µ.

Alternaria alternata

On the basis of morphological and cultural character on described by Ellis (1971) and Subramanian (1971), the identification of isolated *Alternaria* sp. was done. The mycelium was aerial varying from fluffy, cottony to closely tuft. The pigmentation was gray, olive green and almost black in old culture. Mycelium was closely septate. The conidia were light, olive brown to dark brown smooth, muriform with 3-6 transverse septa and 1-3 longitudinal septa. The conidia were variable in shape and size. It ranged from 30.2-42.8 x 10.6-13.2 µ. The conidia were observed in chain, the size of the beak ranged from 10.20 x 2.6 µm. The conidiophores were simple, erect live brown, septate often with scars and swellings.

On the basis of symptoms, morphological and conidial characteristics, the isolated fungi were identified as *Alternaria alternata* (Fr.) Keissler and *Colletotrichum dematium* (Pers ex Fr.) Grove.

Colletotrichum capsici (Sydow) Butler and Bisby is the well adopted and known name assigned to the fungus, however, Kulshreshtha *et al*. (1976) and Nobel and Richardson (1968) have listed and considered as *Colletotrichum dematium*.

Test of virulence

The pathogenicty test of isolated *Colletotrichum dematium* and *Alternaria alternata* was conducted under field conditions. The test was performed by fruit inoculation technique under natural field condition.

Fruit inoculation technique

On semi ripe and completely ripe fruits, the inoculum (culture) of *Colletotrichum dematium* and *Alternaria alternata* were placed by pin prick, injection, tooth pick method on two varieties JM 218 and JM 283. Observations on symptoms development were recorded and data are presented in Table 4.6 and 4.7.

Inoculum insertion through tooth pick method was the best, as the symptoms expressed after six days in the ripe fruit of JM 218 and JM 283. When the spore suspension was injected by hypodermal needle (no22), the symptom appeared after 12-15 days in ripe fruit whereas; it took about 7-8 days when the inoculum was inserted through pin prick in ripe fruit. When the inoculum was placed on the fruit surface (without injury) the symptoms appeared between 11-12 days in ripe fruits. In semi ripe fruit the symptoms expressed by *Colletotrichum dematium* between 7-15 days in JM 218 and JM 283. Inoculum insertion through tooth pick method exhibited the symptoms after 7 days in semi ripe fruit (Table 4.6).

Table 4.6 : Efficacy of methods for testing the pathogenicty of *Colletotrichum dematium* on intact fruits of chilli

Method	Symptoms expressed after days							
	Fruits of Jawahar Mirch 218				Fruits of Jawahar Mirch 283			
	Semi Ripe	Ripe	Av Temp	Av RH	Semi ripe	Ripe	Av Temp	Av RH
Spore suspension injection	13	15	26.5° C	75	13	12	26.5° C	75
Inoculum insertion through pin pricks	11	08			10	07		
Inoculum insertion through tooth pick	07	06			07	06		
Surface placement of spores and wrapping with moist cotton	15	12			15	11		
No Inoculum	0	0			0	0		

For testing the pathogenicty of *Alternaria alternata* on infected fruits similar sets of methods was employed. The symptoms due to *Alternaria alternata* appeared in 7 days when the inoculum was inserted through the tooth pick methods (in semi ripe fruits). The symptoms were expressed after 15 days when the spore suspension was injected in semi ripe fruit of JM 218 and 19 days in JM 283, respectively. In pin prick method symptoms were expressed after 10 days in semi ripe fruit of both the varieties. In uninjured fruits where the inoculum (spores + mycelial bits) were placed on the surface of the fruit and rapped with moist cotton, the symptoms expressed in 17-18 days in semi ripe fruit and 10-11 in ripe fruits.

It is concluded that tooth pick method was the best for the testing the virulence of *Colletotrichum dematium* and *Alternaria alternata* in ripe intact fruit under natural field conditions. It was also observed that upon provision of injury on the fruit surface, the expression of symptoms was earlier as compared to uninjured fruit (Table 4.6 and 4.7).

Table 4.7 : Efficacy of methods for testing the pathogenicty of *Alternaria alternata* on intact fruits of chilli

Method	Symptoms expressed after days							
	Fruits of Jawahar Mirch 218				Fruits of Jawahar Mirch 283			
	Semi ripe	Ripe	Av Temp	Av RH %	Semi ripe	Ripe	Av Temp	Av RH %
Spore suspension injection	15	14	26.5° C	75	19	13	26.5° C	75
Inoculum insertion through pin pricks	10	09			10	09		
Inoculum insertion through tooth pick	07	07			06	09		
Surface placement of spores and wrapping with moist cotton	18	10			17	11		
No Inoculum	0	0			0	0		

Development of diseases

Dieback caused by *Colletotrichum dematium*

The development of die back was recorded on fixed plant method basis. Randomly 10 plants were selected and tagged for incremental development of the disease. The observation on the incidence of the diseases was recorded at weekly interval starting from 2nd week of August 2010. Observations were recorded on the initiation of the disease till maximum incidence. The data presented in Table 4.8 indicate that the die back was initiated in 2nd week of 2010 (32nd standard week) when the temperature ranged from 23.1 to 31.9 with humidity 88 to 63 in morning and evening. Maximum die back disease incidence was 47% during 38th and 39th standard week, coinciding the last week of the September and the 1st week of October. During this period the temperature ranged between 20.6 - 30.4 (av 25.5°C) with 93% humidity in morning and 69% humidity in evening. The maximum disease appeared after the rain during 38th week. The rainfall was 118.5 mm.

It was concluded that the die back incidence was initiated during 2nd week of August and maximum disease incidence was observed in the 4th week of September and 1st week of October under Jabalpur condition and 118.5 mm rains (Table 4.8).

Table 4.8 : Development of dieback caused by *Colletotrichum dematium* in chilli

Month	Week	Standard Week	Disease Incidence		Temp(°C)		Rain (mm)	%Relative Humidity	
			JM 218	JM283	Min	Max		Morn	Eve
August 2010	II	32	02	00	23.1	31.9	102.5	88	63
	III	33	15	03	23.3	33.3	128.0	85	64
	IV	34	18	10	23.7	32.9	24.0	86	73
September 2010	I	35	19	21	23.6	33.5	95.0	84	70
	II	36	35	40	23.3	33.0	312.4	93	70
	III	37	37	42	23.6	31.9	80.0	90	69
	IV	38	47	42	22.5	30.4	118.0	93	69
October 2010	I	39	47	42	20.6	32.0	0	88	47
	II	40	45	41	20.8	32.3	0	89	51
	III	41	45	41	19.7	32.7	0	86	45
	IV	42	43	40	19.8	31.8	79.4	94	60

Tender tip drying by *Alternaria alternata*

The tender tip drying was initiated in the 4th week of the November when the temperature ranged 19.4-31.5 (av 25.45) with morning humidity 92 and evening humidity 18 (av humidity 75%) with 1.4 mm rainfall. The tender tip drying disease was maximum during 2nd and 3rd week of January training average maximum temperature 24.2 °C with 87% morning and 25% evening humidity.

Powdery mildew

The incidence of powdery mildew was observed in the last week of the September when the average temperature was 26.45°C and average relative

humidity 81% with the rainfall 118.5 mm. The maximum incidence of powdery mildew disease was in 2nd and 3rd week of October when the average temperature was 26.55°C.

Based upon the data presented in Table 4.8, 4.9 and 4.10, it was concluded that the die back and fruit rot was maximum during last week of September and 1st week of October whereas the tender tip drying was maximum during 2nd and 3rd week of January. Powdery mildew infection was recorded during 2nd and 3rd week of October (Table 4.11).

Table 4.9 : Development of tender tip drying caused by *Alternaria alternata* in chilli

Month	Week	Standard Week	Disease Incidence		Temp(°C)		Rain (mm)	%Relative Humidity	
			JM 218	JM283	Min	Max		Morn	Eve
November 2010	II	44	00	00	15.3	29.3	0.4	91	42
	III	45	00	00	16.3	30.3	0	91	48
	IV	46	02	00	19.4	31.5	1.4	92	58
December 2010	I	47	02	05	14.5	29.7	0	90	38
	II	48	07	05	16.3	29.2	0	91	55
	III	49	13	09	11.5	23.7	7.6	89	47
	IV	50	15	12	8.9	24.8	0	91	32
January 2011	I	1	38	35	3.1	21.0	0	95	35
	II	2	35	41	3.5	23.8	0	87	25
	III	3	35	41	6.1	24.6	0	87	25
	IV	4	32	41	8.7	23.6	0	85	36

Table 4.10 : Development of powdery mildew in chilli under natural field conditions

Month	Week	Standard Week	Disease Incidence		Temp(°C)		Rain (mm)	%Relative Humidity	
			JM 218	JM283	Min	Max		Morn	Eve
September 2010	II	36	00	00	23.3	33.0	312.7	93	70
	III	37	00	00	23.6	31.9	80.0	90	69
	IV	38	00	05	22.5	30.4	118.5	93	69
October 2010	I	39	10	05	20.6	32.0	00	88	47
	II	40	25	17	20.8	32.3	00	89	51
	III	41	20	17	19.7	32.7	00	86	45
	IV	42	10	10	19.8	31.8	79.4	94	60

Table 4.11 : Incidence of diseases of chilli under natural filed conditions

Month	Week	Standard Week	Maximum Disease Incidence		Temp(°C)		Rain (mm)	% Relative Humidity	
			JM 218	JM283	Min	Max		Morn	Eve
Dieback and fruit rot									
Sept.	IV	38	47	42	22.5	30.4	118.0	93	69
Oct.	I	39	47	42	20.6	32.0	00	88	47
Tender tip drying									
Jan.	I	1	38	35	3.1	21.0	00	95	35
Jan.	II	2	35	41	3.5	23.8	00	87	25
Powdery mildew									
Oct.	II	40	25	17	20.8	32.3	00	89	51
Oct.	III	41	20	17	19.7	32.7	00	82	45

Management

Management of seed associated *Colletotrichum dematium* and *Alternaria alternata*

Management of seed associated *Colletotrichum dematium* was attempted by seed dressing with fungicides and employing Standard Blotter method (on top of the paper) and Standard Ragdoll method (between the papers). The seeds from naturally infected sample were used and predetermined seed sample with known infection were used.

Standard blotter method

Seeds (200) derived from the pre-identified seed lot having maximum natural infection of *Colletotrichum dematium* and *Alternaria alternata* were placed on top of the blotters.

Colletotrichum dematium

Data presented in Table 4.12 indicate that association of *Colletotrichum dematium* was 28% in untreated-undressed seeds (control). The percent infection of the fungus in different fungicidal tretment ranged from 1.0-3.0% as observed under stereo binocular microscope after incubation of 7 days. Copper oxychloride (2.5 g/kg of seed, Mancozeb (2.5 g), Carboxin + Thiophenate methyl (2.0 and 2.25 g) completed eliminated the seed associated *Colletotrichum dematium*. Practically no association of *Colletotrichum dematium* was observed. The chilli seed germination ranged from 79.0-89.0% in fungicide treated seed as compared to 70.0% in untreated seed (control). The seed dressing with fungicides eliminated the infection of the fungus and improved the germination (Table 4.12).

Alternaria alternata

A similar trend was observed. The fungicide treated seed effectively eliminated the *Alternaria alternata*. No infection of *Alternaria alternata* with chilli seeds was observed on 7 days incubated seeds that were dressed with copper oxy chloride, Carbendazim, Mancozeb, Carboxin + Thirum, Mancozeb +

Carbendazim, Mancozeb + Thiophenate methyl (1.75, 2.0 and 2.25 g/kg of seed). In untreated seeds, 21% infection of *Alternaria alternata* was observed. In fungicide treated seed, germination ranged from 79-89% as compared to 73% in untreated control. The fungicide treated seed reduced the fungal infection and improved the seed germination (Table 4.13).

Table 4.12 : Influence of seed dressing with fungicides on the associated *Colletotrichum dematium* with chilli seeds using the Standard Blotter method (ISTA, 1996)

Fungicide	Concentration (g per Kg of seed)	Per cent infection of *Colletotrichum dematium*	Per cent Seed germination
Copper oxy chloride	2.5	00	88
Carbendazim	2.0	1.0	86
Mancozeb	2.5	00	88
Carboxin + Thirum	2.0	00	89
Mancozeb + Carbendazim	2.5	00	89
Mancozeb + Thiophanate methyl	1.0	1.0	79
Mancozeb + Thiophanate methyl	1.25	3.0	80
Mancozeb + Thiophanate methyl	1.50	2.0	80
Mancozeb + Thiophanate methyl	1.75	2.0	81
Mancozeb + Thiophanate methyl	2.0	00	86
Mancozeb + Thiophanate methyl	2.25	00	85
Control	0.0	28.00	70

Table 4.13 : Influence of seed dressing with fungicides on the associated *Alternaria alternata* with chilli seeds using the Standard Blotter method (ISTA, 1996)

Fungicide	Concentration (g per Kg of seed)	Per cent infection of *Colletotrichum dematium*	Per cent Seed germination
Copper oxy chloride	2.5	0.0	89
Carbendazim	2.0	0.0	89
Mancozeb	2.5	0.0	88
Carboxin + Thirum	2.0	0.0	89
Mancozeb + Carbendazim	2.5	0.0	89
Mancozeb + Thiophanate methyl	1.0	5.0	79
Mancozeb + Thiophanate methyl	1.25	3.0	80
Mancozeb + Thiophanate methyl	1.50	3.0	81
Mancozeb + Thiophanate methyl	1.75	0.0	86
Mancozeb + Thiophanate methyl	2.0	0.0	85
Mancozeb + Thiophanate methyl	2.25	0.0	86
Control	00	21.0	73

Standard Ragdoll method

Chilli seeds (200) were derived from the same seed lot, naturally infected with target fungi. The seeds were placed, between the blotters and rolled blotters, were incubated in seed germinator. Observation on seed germination and associated microflora were recorded on 14 day of incubation.

Colletotrichum dematium

In untreated seeds 28% infection of *Colletotrichum dematium* was observed on 14th day of incubation, whereas in fungicides treated seeds the infection ranged from 1.0-3.0%. No association of the fungus was observed in seeds treated with copper oxy-chloride, Carbendazim, Carboxin + Thirum, Mancozeb + Carbendazim, Mancozeb + Thiophenate methyl (2.25 g). In fungicide treated seed the seed germination was in the range of 76-89% as compared to 74% in untreated control (Table 4.14).

Table 4.14 : Influence of seed dressing with fungicides on the associated *Colletotrichum dematium* with chilli seeds using the Standard Ragdoll method (ISTA, 1996)

Fungicide	Concentration (g per Kg of seed)	Per cent infection of *Colletotrichum dematium*	Per cent Seed germination
Copper oxy chloride	2.5	0.0	89
Carbendazim	2.0	0.0	89
Mancozeb	2.5	1.0	90
Carboxin+ Thirum	2.0	0.0	91
Mancozeb + Carbendazim	2.5	0.0	90
Mancozeb + Thiophanate methyl	1.0	3.0	76
Mancozeb + Thiophanate methyl	1.25	2.0	82
Mancozeb + Thiophanate methyl	1.50	3.0	81
Mancozeb + Thiophanate methyl	1.75	1.0	82
Mancozeb + Thiophanate methyl	2.0	1.0	87
Mancozeb + Thiophanate methyl	2.25	0.0	88
Control	00	28.0	79

Alternaria alternata

Complete absence of *Alternaria alternata* was recorded on seeds treated with copper oxy-chloride, Mancozeb, Carboxin + Thirum, Mancozeb + Carbendazim, Mancozeb + Thiophenate methyl (2.0, 2.25 g). In untreated seeds the infection of the fungus was 21%. In untreated seed, seed germination was 78.0% while it ranged from 81 to 90% in treated seed (Table 4.15).

Table 4.15 : Influence of seed dressing with fungicides on the associated *Alternaria alternata* with chilli seeds using the Standard Ragdoll method (ISTA, 1996)

Fungicide	Concentration (g per Kg of seed)	Per cent infection of *Alternaria alternata*	Per cent Seed germination
Copper oxy chloride	2.5	0.0	89
Carbendazim	2.0	1.0	90
Mancozeb	2.5	0.0	90
Carboxin+ Thirum	2.0	0.0	90
Mancozeb + Carbendazim	2.5	0.0	89
Mancozeb + Thiophanate methyl	1.0	4.0	80
Mancozeb + Thiophanate methyl	1.25	3.0	82
Mancozeb + Thiophanate methyl	1.50	0.0	81
Mancozeb + Thiophanate methyl	1.75	1.0	86
Mancozeb +Thiophanate methyl	2.0	0.0	84
Mancozeb +Thiophanate methyl	2.25	0.0	86
Control	00	21.0	78

Influence of fungicides seed treatment on seed emergence

The influence of seed dressing with fungicides on the emergence of chilli seedlings was observed. The same seed lot having the natural infection of *Colletotrichum dematium* and *Alternaria alternata* was used. Counted seeds were sown in the well cleaned sterilized sand. The plastic trays containing seeds where placed in walking seed germination chamber.

In untreated chilli seeds, the emergence was 60% as observed on a 8 day of incubation. Maximum 79% seed emergence was observed in seed treated with Carboxin + Thiram (at the rate of 2 g/kg of seed). The seed emergence ranged from 68.0 to 79.0% in fungicides treated seeds. Seed treatment with Carbendazim (2.0 g), Mancozeb + Thiophenate methyl (2.0, 2.25 g) resulted in 76% emergence (Table 4.16).

Table 4.16 : Influence of seed dressing with fungicides on the emergence of chilli seedling

Fungicide	Dose(g per Kg of seed)	Per cent seed emergence	Per cent reduction
Copper oxy chloride	2.5	75	25.0
Carbendazim	2.0	76	26.6
Mancozeb	2.5	70	16.6
Carboxin+ Thirum	2.0	79	31.6
Mancozeb+ Carbendazim	2.5	75	25.0
Mancozeb+ Thiophanate methyl	1.0	68	13.3
Mancozeb+ Thiophanate methyl	1.25	69	15.0
Mancozeb+ Thiophanate methyl	1.50	68	13.3
Mancozeb+ Thiophanate methyl	1.75	75	25.0
Mancozeb+ Thiophanate methyl	2.0	76	26.6
Mancozeb+ Thiophanate methyl	2.25	76	26.6
Control	00	60	-

Management through foliar application of fungicides

The effect of fungicides (Difenoconazole, Azoxystrobin Kitazin and Tebuconazole) was investigated under natural field conditions. The fungicides application was made on the initiation of disease symptoms as observed by visual method. Chilli seedlings of about 41 days age were transplanted on 27 September 2010. The plant-plant and row-row distance is 40 cm. The five fungicides were used in 6 replications. Overall 25 chilli plants were accommodated in one plot.

Fruit rot and die back (*Colletotrichum dematium*)

Data presented in Table 4.17 indicate that in untreated-unsprayed plots of JM 283, the incidence of fruit rot was 28.66% whereas the dieback incidence was 43%. All the fungicides significantly controlled the disease as observed after 3 applications of fungicides made at 15-day interval. Difenoconazole 25% applied at the rate of 50 ml/liter of water exhibited the least 5.43% fruit rot and 7.3% dieback. Among the various concentration of Difenoconazole 25% (i.e. 25-200 ml/100 L of water) the incidence of fruit rot ranged from 5.43-9.96% whereas the dieback incidence ranged from 7.3-8.5%. Among the various concentrations of Azoxystrobin 23% (at the rate 50-400 ml/100 L of water), the incidence of fruit rot ranged from 6.56-8.56% whereas, the incidence of dieback ranged from 8.32-9.5%. The Azoxystrobin applied at 50 ml/100 L of water exhibited lest fruit rot 6.56% and dieback (8.3%) as compared to control 28.66 and 43%, respectively. The fungicides Kitazin 48% where applied with tebuconazole 23% (200 and 100/100 L of water) was more effective as expressed by the incidence of fruit rot (6.13%) and dieback 8.0% (Table 4.17).

Table 4.17 : Incidence of die back and fruit rot by *Colletotrichum dematium* after foliar application of fungicides under natural field conditions

	Fungicide	Dosage (ml) per 100 Lit of water	Percent disease incidence and disease control in parenthesis	
			Fruit rot	Die back
T1	Difenoconazole 25%	25	9.96	8.5
T2	Difenoconazole 25%	50	5.43	7.3
T3	Difenoconazole 25%	75	5.53	7.5
T4	Difenoconazole 25%	100	6.70	7.5
T5	Difenoconazole 25%	200	6.83	7.9
T6	Azoxystrobin 23%	50	6.56	8.3
T7	Azoxystrobin 23%	100	6.76	8.4
T8	Azoxystrobin 23%	150	6.56	8.9
T9	Azoxystrobin 23%	200	8.43	8.9
T10	Azoxystrobin 23%	400	7.73	9.4
T11	Kitazin 48%	200	12.13	15.0
T12	Tebuconazole 23%	1000	9.36	10.5
T13	Kitazin 48% + Tebuconazole 23%	200 + 100	6.13	8.0
T14	Control	00	28.66	43.0
	CD			
	SED			

Fruit rot and tender tip drying (*Alternaria alternata*)

The incidence of fruit rot was 19.5% while the tip drying was 31% in untreated-unsprayed control plot. The data presented in Table 4.18 indicate that least (6.5%) tip drying and 5.2% fruit rot was observed in the chilli plants that were protected by the application of fungicides Difenoconazole 25% @ 50 ml/500 L of water. The incidence of fruit rot ranged from 5.2 to 5.9% where Difenoconazole 25% was applied @ 25, 50, 75, 100 and 200 ml/100 L of water.

Azoxystrobin 23% applied at the rate of 100 ml/100 L of water exhibited minimum fruit rot 6.5% and tip drying 6.9%. Application of Kitazin and tebuconazole was effective as compared to alone application of Kitazin. All the fungicides applied were effective against fruit rot and tip drying caused by *Alternaria alternata*.

Table 4.18 : Incidence of tender tip drying and fruit rot by *Alternaria alternata* after foliar application of fungicides under natural field conditions

	Fungicide	Dosage (ml) per 100 Lit of water	Percent disease incidence and disease control in parenthesis	
			Tip drying	Fruit rot
T1	Difenoconazole 25%	25	6.9	5.6
T2	Difenoconazole 25%	50	6.5	5.2
T3	Difenoconazole 25%	75	7.9	5.3
T4	Difenoconazole 25%	100	7.9	5.3
T5	Difenoconazole 25%	200	6.8	5.9
T6	Azoxystrobin 23%	50	7.0	6.2
T7	Azoxystrobin 23%	100	7.0	6.5
T8	Azoxystrobin 23%	150	6.9	6.5
T9	Azoxystrobin 23%	200	7.2	6.9
T10	Azoxystrobin 23%	400	7.5	6.9
T11	Kitazin 48%	200	10.5	8.5
T12	Tebuconazole 23%	1000	11.0	9.5
T13	Kitazin 48% + Tebuconazole 23%	200 + 100	7.3	5.9
T14	Control	00	31.0	19.5
	CD			
	SED			

Management through different mulches

Effect of mulch

Influence of colorless and black plastic sheets and paddy straw used as mulch was determined on the development of dieback, tender tip drying and fruit rot incited by *Colletotrichum dematium* and *Alternaria alternata* in chilli crop. The colorless and black plastic sheets were spread over around the plants after 20 days of transplanting of chilli seedling under field condition. The corners and edges of the plastic sheets were covered with natural field soil to protect from the disturbances of the air currents. A thin layer of paddy straws of was used as mulch , placed in between the plants. A little space was provided for irrigation. The movement of persons was restricted between the plots. Observation were recorded from the side of the bunds on development of disease based are typical symptoms.

Development of dieback and fruit rot caused by *Colletotrichum dematium*

Data presented in Table 4.19 indicate that least (10%) incidence of dieback was in plots covered with colorless transparent plastic sheets of 200 gauge and 8.0% fruit rot as compared to 43% dieback and 22% fruit rot in control (Table 4.19) after 80 days. An incremental increase in incidence of dieback, 3.0, 19.0, and 45.0% was observed at 20, 40 and 60 days respectively. Similarly the fruit rot was 5.0, 10.0 and 11.0 % was observed at 20, 40 and 60 days respectively.

Development of tender tip drying and fruit rot by *Alternaria alternata*

Data presented in Table 4.20 indicate the development of tender tip drying and fruit rot of *Alternaria alternata* in mulched chilli crop under natural field conditions. The incidence of tender tip drying was 3.0, 30.0, 35.0 and 38.0% in control plots at 20, 40, 60 and 80 days, respectively. The fruit rot due to Alternaria was 2.0, 13.0, 15.0 and 17.0%, respectively at 20, 40, 60 and 80 days in untreated un-mulch control. Faster development of tender tip drying and fruit

rot was noticed during 60-80 days. Least tender tip drying and fruit rot (7.0 and 8.0) was observed in plots mulched with colorless transparent plastic sheets (200 gauges) as compared to un-mulched (control) and rest of the two treatments. Mulching with paddy straw resulted in 8.0 and 5.0 tender tip drying and fruit rot respectively (Table 4.20).

Table 4.19 : Development of die back and fruit rot caused by *Colletotrichum dematium* in mulched chilli crop

Mulch	Percent disease incidence after days							
	20		40		60		80	
	DB	FR	DB	FR	DB	FR	DB	FR
Colorless transparent plastic 200 gauge	00	00	02	00	06	03	10	08
Black plastic 200 gauge	00	05	04	09	13	13	15	17
Paddy straw	02	00	12	05	12	06	14	10
Control	03	05	19	10	45	11	43	22

DB: Die back; FR: Fruit Rot

Table 4.20 : Development of tender tip drying and fruit rot by *Alternaria alternata* in mulched chilli crop

Mulch	Percent disease incidence after days							
	20		40		60		80	
	TTD	FR	TTD	FR	TTD	FR	TTD	FR
Colorless transparent plastic 200 gauge	00	00	00	02	03	04	07	08
Black plastic 200 gauge	03	00	03	02	04	09	12	09
Paddy straw	00	00	02	02	08	05	08	05
Control	03	02	13	13	35	15	38	17

TTD: Tender Tip Drying; FR: Fruit Rot

Among the three types of mulches least dieback (10%) and 7% tender tip drying was noticed in colorless transparent plastic coverage as compared to 43% and 38% in un-mulched crop, respectively. Least fruit rot 8 and 5.0% was recorded in plots mulched with paddy straw. It was observed that reduction in fruit rot and drying of the twigs was noticed in mulched crop as compared to un-mulched crop (Table 4.21).

Table 4.21 : Incidence of die back and fruit rot after 80 days in chilli

Type of mulch	Percent disease			
	Fruit rot		Drying	
	Colletotrichum Fruit Rot	Alternaria Fruit Rot	Die back	Tender Tip Drying
Colorless transparent plastic 200 gauge	10	08	10	07
Black plastic 200 gauge	17	09	15	12
Paddy straw	08	05	14	08
Control	22	17	43	38

DISCUSSION

Chilli (*Capsicum annuum* L.) is an important condiment crop. It belongs to family Solanaceae (2n = 24). Mexico and Guatemala are considered as the place of origin of the crop (Singh, 1989). The crop suffers due to a number of diseases (Mukherji and Bhasin, 1986; Gupta and Thind, 2006; Verma and Sharma, 1999; Mehrotra, 1980). A number of pathogen attack the crop and cause various diseases at various growth stages. Dieback & fruit rot caused by *Colletotrichum dematium* (Pers. ex Fr.) Grove (= *Colletotrichum capsici* (Syd.) Butler & Bisby) and tender tip drying & fruit rot incited by Alternaria *alternata* are the major problem identified that limit the profitable cultivation of chilli in Madhya Pradesh. The distribution of the diseases, status, development and management aspects were studied in this investigation during 2010-2011.

Jabalpur is a semi humid region having subtropical climate with hot dry summer and cold winters. It is situated on 23.9' North latitude 79.58 east longitude and 411.78m above mean sea level.

Chilli is an important indispensable condiment. Red and green chillies have an important role in our daily diet. No Indian dish is complete without chillies. It is the major and cheapest source of vitamin C, A and P (Singh, 1989). Unique crop among all the spice being the only source of capsaicin ($C_{18}H_{27}No_3$), an alkaloid the active hot principle which is a mixture of seven closely related alkylvanillyamides named capsicinoids (Tiwari, 1990; Govindrajan, 1985; Maya, 1975; Rogers, 1966).The red color of the fruits is due to the pigment capsanthin (Nath, 1969).Chilli fruits are used as irritant for rheumatism or neuritis, presence of rustine in the fruits provides it a unique medicinal value (Purseglove, 1977; Singh, 1989).

The distribution and status of dieback & fruit rot caused by *Colletotrichum dematium* and tender tip drying & fruit rot incited by *Alternaria alternata* was determined. Two-time survey were conducted at farmers field (commercial fields), research experimental fields, Maharajpur Farm, kitchen garden (back yard gardens) first during August - September and second in January. The

incidence of diseases was recorded on the basis of visual symptoms as per the formula advocated by Singh and Singh (2000).The sample size was 100 plants. Incidence of diseases was recorded at 34 location during the period, that include 17 location of commercial fields, 13 location of backyard / kitchen garden and 4 location of research experimental field. During September, October incidence of fruit rot, dieback and tender tip drying was widespread in variable proportions. At 17 location in farmers field the average fruit rot caused by *Colletotrichum* was 10.18%, in the ranged of 2.0 to 19.0%. Maximum fruit rot diseases was recorded at Ranital and Amkhera village. At farmers fields' maximum dieback disease (40.0%) was observed in Amkhera village while the least (4.0%) was recorded in the fields towards Katni road. The average incidence of dieback was 25.71%. At farmer fields tender tip drying due to *Alternaria alternata* ranged from 2.0 to 13.0%, with average incidence of 7.29%. Maximum disease incidence was recorded in Amkhera village while least disease incidence was noticed in the fields towards Gwarighat.

The distribution of fruit rot and tip drying and dieback was also investigated in backyard / kitchen garden of Krishi Nagar (5 locations), Suhagi village (3 locations) and Maharajpur village (5 locations). The fruit rot incidence ranged between 2.0 to 11.0, being minimum at Maharajpur and maximum at Krishi Nagar. The average incidence of fruit rots was 7.15 and dieback 12.15% in 13 location of kitchen garden during September-October 2010. Average incidence of fruit rot due to *Alternaria alternata* was 7.2% and tender tip drying 9.5% in 13 locations. The Alternaria fruit rot incidence range from 3.0 to 12.0% whereas, the tender tip drying incidence ranged from 2.0 to 17.0%. In four location of research field at Maharajpur farm the fruit rot disease was 15.5% while the dieback ranged from 22.0 to 44.0% with average 29.25% at Maharajpur. The fruit due to *Alternaria alternata* ranged from 5.0 to 9.0 with average 5.0%.The incidence of *Colletotrichum dematium* and *Alternaria alternata* has been reported (Verma, 1966; Chourasia, 1976; Harne and Nema ,1967; Verma and Bhale ,1989; Mali and Joi, 1985; Sujatha Bai *et al*., 1993; Sreekantiah *et al*., 1973).

The incidence of diseases was also recorded on different varieties grown in farmers' fields and experimental area. At farmer fields maximum fruit rot (12.0%) and dieback (21.0%) was noticed in unidentified farmer's variety which has been used locally. Least fruit rot (1.0%) was noticed in Pusa Jyoti while 9.8% fruit rot was observed in var. Ankur. The dieback incidence ranged from 7.0 to 17.0%, being minimum in Pusa Jwala and maximum in Ankur variety. The Alternaria fruit was maximum 16.0% while the tender tip drying ranged 5.0 to 17.0%, it was maximum in Pusa Jyoti. In research field fruit rot incidence was maximum (13.0%) in Pant C1 and dieback 22.0% in JM 283. The Alternaria fruit rot was minimum 2.0% and maximum 11.0% in Pant C1. The tender tip drying incidence ranged from 7.0% to 19.0% in kitchen garden the incidence of dieback was maximum Mayhco (1.5%). The tender tip drying incidence ranged from 21.0 to 25.0%. The incidence of diseases was recorded in 26 germ line/variety. The incidence of fruit rot was below 5% I JM 283, Usha Mukti, Usha Sadabahar, JNS, JNS-5, SKS-1, SKS-3, SUMU 506-1, JM 218, Amulya, VNR and SKS-2. The incidence of dieback was less than 5% in Pusa Mukti, Pusa hot, SKS-1, 2, 3 and K-1-4. Maximum dieback was recorded in KDSG-210-4. The incidence of Alternaria fruit rot was less than 5% in JM 283, Pusa Jawala, Pusa Mukti, JM 218, KA 2, Pusa hot, V 9600, SKS 2, SKS 3, SUMU 506-1, K-1-4. The incidence of tender tip drying was maximum in variety Ujala (22%), the incidence was less than 5% in Utkl, Abha, Pusa Jawala, Pusa Jyoti, Pusa Sadabahar, JNS 5, KA 2, SKS 1, and K-1-4.

The overall status of fruit rot, dieback, and tender tip drying was computed and the fruit rot due to *Colletotrichum dematium* incidence ranged from 2.0 to 19.0% in farmer fields, 2.0-11.0% in kitchen garden and 12.0 to 18.0% in experimental fields. The dieback incidence was 4.0 to 14.0 % in farmer field, 5.0 to 22.0% in kitchen garden and 22.0 to 44.0% in experimental fields. The Alternaria fruit rot incidence of 4.0 to 22.0% in farmers' fields, 3.0 to 15% in kitchen garden and 3.0 to 12.0% in experimental fields. The tender tip drying disease incidence was up to 37.0 in farmers fields 22.0% in kitchen garden and 32% in experimental field.

The *Colletotrichum dematium* cause variable symptoms that include rot of ripe fruits and downward death of tissues of twigs (dieback). Tender tip drying, fruit and leaf spot are incited by *Alternaria alternata.* The symptomatology of both the diseases was critically analyzed and studied. Progressive downward necrosis of tender twig was noticed in both the cases Symptoms incited by *C. dematium* and *Alternaria alternata* have been recorded critically on seeds, seedlings, leaves twigs and fruits. Infected seeds were rusty brown with shrinked seed coat. In badly infected fruits seeds were covered with mycelium that was evident after removing the pericarp. On infected and dead seedlings numerous fungal fruiting bodies were recorded symptoms produced by *Colletotrichum dematium* are in close agreement to those described by Thind and Jhooty (1990), Kardale (1990), Dattar and Manale (1989), Dastur (1921). The badly affected plants exhibited the tender tip drying symptoms which were conspicuous. It could be distinguished on the basis of white-wash symptoms. The tender tips of twigs(*Alternaria alternata*) became silvery white in contrast to brown chocolate colour tender tips in case of plants infected with *Colletotrichum dematium*

Identification of the fungi was made on the basis of information of Sutton (1973), Kulshreshtha *et al*. (1976). *Colletotrichum capsici* (Sydow) Butler & Bisby is the well known nomenclature assigned to the fungus causing anthracnose of chillies. However, after critical examination, Kulshreshtha *et al*. (1976) have listed and considered it as a synonym of *Colletotrichum dematium*, based upon the grouping of curved spores. The morphological cultural characteristics of *Alternaria alternata* (Fr.) Keissler have been described by several workers (Haware *et al*., 1986; Gupta and Karwasra, 1983; Singh and Suhag, 1983). Upon repeated isolation *C. dematium* and *A. alternata* was obtained on potato sucrose agar medium. The colony of *C. dematium* was initially pink, later becoming black brown. Acervuli were dark brown abundant conidia and numerous setae. Setae were larger than conidial mass, conidia were hyaline, and single celled, curved at both ends, pointed, pinkish in mass and measured 22.8-27.50 x 3.5-6.3 µ in size. The colony of *Alternaria alternata* on PSA was light gray, later turning black; ultimately olivaceous green-black conidia were light brown, olive, smooth

muriform with 3-6 transverse septa and 1 to 3 longitudinal septa. Conidia were variable in shape-size measured from 13.2-42.8 x 10.6 x 13.2 µ and were in chains and with single beak. The characters are in close agreement with Haware *et al*. (1986) and Singh and Suhag (1983).

The test of virulence of isolated *Colletotrichum dematium* and *Alternaria alternata* was performed on two varieties under field conditions on intact chilli fruits(ripe and semi-ripe) through spore suspension injection, inoculum insertion through pin pricks, inoculum insertion through tooth pick, surface placement of spores and wrapping with moist cotton. It was concluded that tooth pick method was the best for the testing the virulence of *Colletotrichum dematium* and *Alternaria alternata* in ripe intact fruit under natural field conditions. The average temperature was 26.5°C with 75% relative humidity. Inoculum insertion through tooth pick method was the best, as the symptoms expressed after six days in the ripe fruit of JM 218 and JM 283. Upon provision of injury on the fruit surface, the expression of symptoms was faster as compared to uninjured fruit.

Seeds play a vital role in the production of healthy crop. They are known to carry pathogens which cause yield losses (Agarwal and Sinclair, 1997; Neergaard, 1977). The seed borne nature of *Alternaria alternata* in *Capsicum annuum* has been demonstrated (Suryanarayana and Bhombe, 1961; Monharachari and Padmavati, 1976; Mridha and Siddiqui, 1989; Dhawale and Kadmelwar, 1978). The seed borne nature of *Colletotrichum dematium* has been very well documented and demonstrated by several workers (Kulshreshtha *et al*., 1977; Manoharachari and Padmavati, 1976; Sangehote and Janbhamich, 1984; Nobel and Richardson, 1968; Suryanarayana and Bhombe, 1961; Shawkat *et al*., 1978; Mridha and Siddique, 1989).

With a view to determine the correlation between weather parameters and development of the *Colletotrichum dematium* that cause variable symptoms including rot of ripe fruits and downward death of tissues of twigs (dieback), tender tip drying, fruit and leaf spot incited by *Alternaria alternata, studies* were undertaken on the development of diseases under natural field conditions. The

development of die back was recorded on fixed plant method basis. Randomly 10 plants were selected and tagged for incremental development of the disease. The observation on the incidence of the diseases was recorded at weekly interval starting from 2nd week of August 2010. Observations were recorded on the initiation of the disease till maximum incidence. The die back was initiated in 2nd week of August 2010 (32nd standard week) when the temperature ranged from 23.1 to 31.9 with humidity 88 to 63 in morning and evening. Maximum die back disease incidence was 47% in during 38th and 39th standard week, coinciding the last week of the September and the 1st week of October. During this period the temperature ranged between 20.6 - 30.4°C (av. 25.5°C) with 93% humidity in morning and 69% humidity in evening. The maximum disease appeared after the rain during 38th week. The rainfall was 118.5 mm. It was concluded that the die back incidence was initiated during 2nd week of August and maximum disease incidence was observed in the 4th week of September and 1st week of October under Jabalpur condition and 118.5 mm rains.

The tender tip drying was initiated in the 4th week of the November when the temperature ranged between 19.4-31.5°C (av. 25.45) with morning humidity 92 and evening humidity 18 (av humidity 75%) with 1.4 mm rainfall. The tender tip drying disease was maximum during 2nd and 3rd week of January training average maximum temperature 24.2 °C with 87% morning and 25% evening humidity.

The incidence of powdery mildew was observed in the last week of the September when the average temperature was 26.45°C and average relative humidity 81% with the rainfall 118.5 mm. The maximum incidence powdery mildew disease was in 2nd and 3rd week of October when the temperature was average 26.55°C.

It was concluded that the die back and fruit rot was maximum during last week of September and 1st week of October whereas the tender tip drying was maximum during 2nd and 3rd week of January. Powdery mildew infection was recorded during 2nd and 3rd week of October.

Management of seed associated *Colletotrichum dematium* and *Alternaria alternata* was attempted by seed dressing with fungicides and employing Standard Blotter method (on top of the paper) and Standard Ragdoll method (between the papers). The seeds from naturally infected sample were used and predetermined seed sample with known infection were used.

Association of *Colletotrichum dematium* was 28% in untreated-undressed seeds (control). The percent infection of the fungus ranged from 1.0-3.0% as observed under stereo binocular microscope after incubation of 7 days. Copper oxychloride (2.5 g/kg of seed, Mancozeb (2.5 g), Carboxin + Thiophenate methyl (2.0 and 2.25 g) completed eliminated the seed associated *Colletotrichum dematium*. Practically no association of *Colletotrichum dematium* was observed. The chilli seed germination ranged from 79.0-89.0% in fungicide treated seed as compared to 70.0% in untreated seed (control). A similar trend was also observed. The fungicide treated seed effectively eliminated the *Alternaria alternata*. No infection of *Alternaria alternata* with chilli seeds was observed on 7 days incubated seeds that were dressed with copper oxy chloride, Carbendazim, Mancozeb, Carboxin + Thirum, Mancozeb + Carbendazim, Mancozeb + Thiophenate methyl (1.75, 2.0 and 2.25 g/kg of seed). In untreated seeds, 21% infection of *Alternaria alternata* was observed. In fungicide treated seed, germination ranged from 79-89% as compared to 73% in untreated control. The fungicide treated seed reduced the fungal infection and improved the seed germination.

In Standard Ragdoll method, in untreated seeds 28% infection of *Colletotrichum dematium* was observed on 14^{th} days of incubation, whereas in fungicides treated seeds the infection ranged from 1.0-3.0%. No association of the fungus was observed in seeds treated with copper oxy-chloride, Carbendazim, Carboxin + Thirum, Mancozeb + Carbendazim, Mancozeb + Thiophenate methyl (2.25 g). In fungicide treated seed the seed germination was in the ranged of 76-89% as compared to 74% in untreated control .Complete

absence of *Alternaria alternata* was recorded on seeds treated with copper oxy-chloride, Mancozeb, Carboxin + Thirum, Mancozeb + Carbendazim, Mancozeb + Thiophenate methyl (2.0, 2.25 g). In untreated seeds the infection of the fungus was 21%. In untreated seed, seed germination was 78.0% while it ranged from 81 to 90% in treated seed

Attempts have been made by several workers to find suitable fungicides for the control of *Colletotrichum dematium* (Takano *et al*., 1985; Thind and Jhooty, 1980; Rathore, 2006; Sharma and Thakre, 2004) and fruit rot and twig drying pathogen. For *Alternaria alternata* by Khare *et al*. (2002), Parwez *et al*. (1968), Singh and Tandon (1967), Miller *et al*. (1984), Jharia *et al*. (1997).

Management of seed associated *Colletotrichum dematium* and *Alternaria alternata* has been attempted by Srinivas *et al*. (2006), Thippeswamy (2007), Prasanna *et al*. (2009), Rahman *et al*. (2004), Mali and Joi (1985), Dhyani *et al*. (1990), Siddarmaiah *et al*. (1980), Prasad (1985), Sultana *et al*. (1988).

Effectiveness of seed treatment with Thiram plus captan (0.3%) in checking the pre- and post-emergence losses and mortality at adult stage was observed by Jharia *et al*. (1977). Seed treatment with methoxyethyl-mercury chloride at 0.16 per cent provided complete control of *Colletotrichum capsici* (Juanbhanich and Chana, 1975) at Bangkok. Among 12 seed dressers tested thiram was the best against seed borne *Colletotrichum* sp. (Kumar and Mahmood, 1986). Better emergence and vigour was also recorded. Efficacy of thiram (0.2%) was also observed by Chakravarti and Anil Kumar (1975) and Siddiqui *et al*. (1977). The ripe rot pathogen was controlled by the application of zineb to the chilli seeds (Boswell *et al*., 1952), Panigarahi and Narain (1971) recorded the efficacy of Vitavax, plantvax and zirum. Efficacy of seed treatment with Thirum has been reported against *Alternaria* sp. by Mali and Joi (1985), Dhyani *et al*. (1990) while Kannaaiyan *et al*. (1980) recorded the best results with Benlate-T (0.3%) in pigeon pea. In Bangladesh, Mridha and Chawdhary (1990) observed the efficacy of benomyl, Mancozeb and Vitavax 200 against the seed borne natural infection of *A. alternata* and *C. capsici* at 0.45% after 6 days, Siddaramaiah *et al*. (1980) recommended the use of thiram (0.3%) while Prasad

(1985) observed triforine (0.15%) the best, as seed treatment against A*lternaria carthemi* in safflower. A number of fungicides have been used to obtain effective control of these diseases under diverse agro climatic conditions. The efficacy of ferbam, maneb, captan, vitavax, plantvax and ziram has been verified (Grisam and Mesechu, 1970; Jharia *et al*., 1977; Kumar and Mahmood, 1986; Panigrahi and Narain, 1971; Boswell *et al*., 1952; Srinivas *et al*., 2006; Thippeswamy, 2007; Prasanna *et al*., 2009; Rahman *et al*., 2004; Mali and Joi, 1985; Sultana *et al*., 1988; Dhyani *et al*., 1990; Mridha and Chaudhary, 1990; Prasad ,1985)

The influence of seed dressing with fungicides on the emergence of chilli seedlings was observed. The same seed lot having the natural infection of *Colletotrichum dematium* and *Alternaria alternata* was used. Counted seeds were sown in the well cleaned sterilized sand. The plastic trays containing seeds where placed in walking seed germination chamber. In untreated chilli seeds, the emergence was 60% as observed on a day of incubation. Maximum 79% seed emergence was observed in seed treated with Carboxin + Thirum (at the rate of 2 g/kg of seed). The seed emergence ranged from 68.0 to 79.0% in fungicides treated seeds. Seed treatment with Carbendazim (2.0 g), Mancozeb + Thiophenate methyl (2.0, 2.25 g) resulted in 76% emergence.

Management through foliar application of fungicides was attempted. The effect of fungicides (Difenoconazole, Azoxystrobin Kitazin and Tebuconazole) was investigated under natural field conditions. The fungicides application was made on the initiation of disease symptoms as observed by visual method. Chilli seedlings of about 41 days age were transplanted on 27 September 2010. The plant-plant and row-row distance is 40 cm. The five fungicides were used in 6 replications. Overall 25 chilli plants were accommodated in one plot. In untreated-unsprayed plots of JM 283, the incidence of fruit rot was 28.66% whereas the dieback incidence was 43%. All the fungicides significantly controlled the disease as observed after 3 applications of fungicides made at 15-day interval. Difenoconazole 25% applied at the rate of 50 ml/liter of water exhibited the least 5.43% fruit rot and 7.3% dieback. Among the various concentration of Difenoconazole 25% (i.e. 25-200 ml/100 L of water) the

incidence of fruit rot ranged from 5.43-9.96% whereas the dieback incidence ranged from 7.3-8.5%. Among the various concentrations of Azoxystrobin 23% (at the rate 50-400 ml/100 L of water), the incidence of fruit rot ranged from 6.56-8.56% whereas, the incidence of dieback ranged from 8.32-9.5%. The Azoxystrobin applied at 50 ml/100 L of water exhibited lest fruit rot 6.56% and dieback (8.3%) as compared to control 28.66 and 43%, respectively. The fungicides Kitazin 48% where applied with tebuconazole 23% (200 and 100/100 L of water) was more effective as expressed by the incidence of fruit rot (6.13%) and dieback 8.0%.

The incidence of fruit rot (*Alternaria alternata*) was 19.5% while the tip drying was 31% in untreated-unsprayed control plot. The data presented in Table 4.18 indicate that least (6.5%) tip drying and 5.2% fruit rot was observed in the chilli plants that were protected by the application of fungicides Difenoconazole 25% @ 50 ml/500 L of water. The incidence of fruit rot ranged from 5.2 to 5.9% where Difenoconazole 25% was applied @ 25, 50, 75, 100 and 200 ml/100 L of water. Azoxystrobin 23% applied at the rate of 100 ml/100 L of water exhibited minimum fruit rot 6.5% and tip drying 6.9%. Application of Kitazin and tebuconazole was effective as compared to alone application of Kitazin. All the fungicides applied were effective against fruit rot and tip drying caused by *Alternaria alternata*.

Efficacy of Carbendazim was recorded by (Sharma and Thakare, 2004; Thippeswamy, 2007; Udit Narain *et al*., 2006). Hegde and Anahosur (2001) observed the efficacy of hexaconozole where Thiophenate methyl has been used by Kumavat (1997). Significant reduction due to Mancozeb plus Thiophenate methyl and Carbendazim was noticed (Kumavat, 1997; Ushakiran *et al*., 2006). The combination of Thiophenate methyl and Mancozeb was first attempted at Jabalpur. Extensive studies have been carried out in all the chilli growing areas of the country against diseases incited by *Colletotrichum dematium* and *Alternaria alternata* (Ushakiran *et al*., 2006; Rathore, 2006; Sharma and Thakare, 2004, Udit Narain *et al*., 2006; Chander Mohan, 2004, Hegde and Anahosur, 2001; Hingole and Kurandikar, 2009). Significant reduction due to Mancozeb plus

Thiophenate methyl and Carbendazim was noticed (Kumawat, 1997). Efficacy of Carbendazim was recorded by (Sharma and Thakre, 2004; Thippeswamy, 2007). Hedge and Anahosur (2001) observed the efficacy of hexaconozole.

In the present investigation ,among the three types of mulches least dieback (10%) and 7% tender tip drying was noticed in colorless transparent plastic coverage as compared to 43% and 38% in un-mulched crop, respectively. Least fruit rot 8 and 5.0% was recorded in plots mulched with paddy straw. The reduction in fruit rot and drying of the twigs was noticed in mulched crop as compared to un-mulched crop

Primarily practices of mulching were employed for the conservation of soil moisture. The practice had exhibited some additional advantages in different situations of agricultural systems. Stimulated early root growth and efficient nutrient uptake of transplanted tomatoes is reported by Wien *et al.* (1993). Beside the moisture conservation (Chakraborty, 2000) mulching has resulted in weed management (Shinde *et al.*, 1999) in capsicum with higher returns (Ibarra *et al*., 2004) due to reduction of insect pests .Effect of cultural practices on the capsaicin and ascorbic content of chili has been investigated (Panchal *et al*., 2001). No systematic study has been undertaken on the influence of mulches on the incidence of diseases under our conditions.

SUMMARY, CONCLUSION AND SUGGESTION FOR FUTURE WORK

The chilies are preferred and valued for pungency which is due to an alkaloid compound called capsaicin. Chilli (*Capsicum annuum* L.) is an important vegetable crop. Several pharmaceutical and medicinal values of the chilli crop are well documented. The capsanthin pigment is responsible for red color in chilli. A number of fungal, bacterial, viral and nematode diseases have been reported as a limiting factor for the profitable cultivation. *Colletotrichum dematium* (Pers. ex Fr.) Grover (= *Colletotrichum capsici* (Sydow) Butler & Bisby) and *Alternaria alternata* (Fr.) Keissler have been identified as the major pathogen under conditions of Jabalpur, Madhya Pradesh. The pathogens are responsible for seed rot, seedling decay, stem blackening, leaf spots and fruit rot and twig drying. The incidence studies were conducted on commercial farmers fields (17 location), backyard and kitchen gardens (13 locations). The disease survey were conducted in September and October 2010 and 1st fortnight of January 2011. The Colletotrichum fruit rot incidence was 10.18, 7.15 and 15.5% in farmers' field, kitchen garden and research fields, respectively. The die back problem due to *Colletotrichum dematium* was 25.71, 12.15, and 29.25% respectively, in farmers' field, kitchen garden and research field. The incidence of fruit rot and die back was higher during September and October. The average Alternaria fruit rot was 11.70, 10.77 and 7.5% in farmers' field, kitchen garden and research field, respectively. The incidence of tender tip drying was 21.06, 12.92, and 24.75% respectively, in farmers' fields, kitchen garden and research field. The incidence of tender tip drying was higher during first fortnight of January as compared to September-October. The incidence Colletotrichum fruit rot was maximum (9.0%) in variety Ankur grown on farmers fields and 17% dieback was recorded in the same variety. The incidence of Alternaria fruit rot and tender tip drying was maximum 16.0 and 17.0% in variety Pusa Jyoti grown on farmers field. In kitchen garden, 15% dieback and 25% tender tip drying was noticed in Mayhco variety.

The incidence of fruit rot was below 5% in 13 varieties whereas the dieback was observed in 6 germ lines. The incidence of Alternaria fruit rot was less than 5% in 11 germ line whereas the tender tip drying in 8 lines. Overall incidence of dieback ranged from 4.0 to 40.0% in farmers fields, 5.0-22.0% in kitchen garden and 22.0-44.0% in experimental fields. The range of tender tip drying due to *Alternaria alternata* was 5.0-37.0% in farmers' fields, 4.0-22.0% in kitchen garden and 12.0-32.0% in research field. The critical study of symptomatology indicate that tender tip drying and dieback could be differentiated due to the presence of silver and white wash symptoms (due to *Alternaria alternata*) and chocolate brown blackening of affected part due to *Colletotrichum dematium* under natural field conditions. Upon repeated isolation *Colletotrichum dematium* and *Alternaria alternata* were found associated with seeds, twigs and fruits. The infected seeds were brown rusty with shrinked seed coat. The test of virulence of *Colletotrichum dematium* and *Alternaria alternata* was verified through injection of spore suspension, inoculum insertion through pin pricks, inoculum insertion through tooth picks and surface placement of spore & rapping with moist cotton. The inoculum insertion through tooth pick method was the best for testing the virulence for the both the fungi under natural field condition. The typical symptoms were expressed in 6-7 days in ripe and semi ripe chilli fruit. The fruit rot and dieback caused by *Colletotrichum dematium* was initiated during the 2nd week of August when the temperature 23.1°C (minimum) and maximum 31.9°C with 88% humidity in morning and 68% in evening with weekly rainfall 102.5 mm were noticed. Maximum fruit rot and dieback disease was observed during 4th week of September to 1st week of October with average 26.45 temperature (22.5°C minimum-30.4°C maximum) and average temperature. Relative humidity 8.1% (93% in morning – 69% in evening) with 118.5 mm rainfall. The Alternaria fruit rot and tender tip drying was initiated and first observed in the 1st week of December. The disease was maximum in 2nd and 3rd week of January with maximum temperature 23.8°C and humidity 87% in morning 25% in evening. Management of seed associated *Colletotrichum dematium* and *Alternaria alternata* was investigated with pre-tested seed sample having maximum natural

infection. Fungicide treated seeds were placed on top of the blotter and in between the blotter methods. The seed associated *Alternaria alternata* and *Colletotrichum dematium* were effectively eliminated by the dressing with copper oxychloride (2.5 g/kg of seed), Carbendazim (2.0 g/kg of seed), Mancozeb 2.5 g/kg of seed), Carboxin + Thirum (2.0 g/kg of seed), Mancozeb + Carbendazim (2.5 g/kg of seed) and Mancozeb + Thiophenate methyl (2.0 g/kg of seed). The fungicides treated seeds exhibited superior seed germination (79-89%) as compared to 70% in untreated seed. Standard blotter method was superior as compared to Standard Rag doll method. The seed dressing with fungicides also improved the seed emergence. All the fungicides improved the seed emergence, however, seed dressing with Carboxin + Thirum (e.g. Vitavax power) resulted in79.0% seed emergence as compared to 60.0% in control. The fungicides treated seeds resulted in 68-79% emergence as compared to 60% in control. Three applications of Difenoconazole 25% applied at the rate of 50 ml/100 L of water resulted in the least fruit rot (5.43%) and dieback (7.3%) and compared to 28.66% fruit rot in control and 43% dieback symptoms in unsprayed plots. Azoxystrobin 23% applied at the rate 50 ml/100 L of water was also promising in reducing the fruit rot and dieback. All the fungicides reduced the incidence of dieback as compared to control. Reduction in Alternaria fruit rot and tender tip drying was noticed in Difenoconazole applied at the rate of 50 ml/100 L of water (2.0-6.5% disease). Azoxystrobin applied at 50 ml/10 L of water (6.2-7.0% disease), Kitazin and tebuconazole applied at 200 ml/100 L of water (5.9-7.3% disease) as compared to control 19.5% fruit rot and 31.0 % tip drying, respectively. Use of colourless transparent and black plastic 200 gauge sheet and paddy straw used as mulch, significantly reduced the incidence of fruit rot and tip drying. Colletotrichum fruit rot incidence was 22% and dieback 43% in non-mulched crop whereas only 10% disease was recorded in colourless transparent sheet. Mulching also reduced the fruit rot infection and Alternaria tip drying.

Suggestions for future work

- Standardization of dosage and time of application of specific chemical molecules and combination of fungicides under varied agro climatic and farming situations.
- Refinement of application technology regulation by power spray and precise application time, based upon the accurate epidemiological studies.
- Extensive search for biopesticides, its mode of application, time of application and compatibility studies with effective fungicide dose and combinations..
- Influence of foliar application of fungicides on the phyllosphere microflora and its implications on subsequent development.

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ABSTRACT

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Abstract

Beside several pharmaceutical and medicinal values, Chilli (*Capsicum annuum* L.) is preferred and valued for pungency which is due to an alkaloid capsaicin. The red color is due to capsanthin pigment. Among the seven diseases noticed pathogens, *Colletotrichum dematium* (Pers. ex Fr.) Grover = *Colletotrichum capsici* (Sydow) Butler & Bisby) and *Alternaria alternata* (Fr.) Keissler have been identified as the most wide spread problem under conditions of Jabalpur, Madhya Pradesh .The pathogens are responsible for seed rot, seedling decay, stem blackening, leaf spots, fruit rot and twig drying. The incidence studies conducted in research experimental fields (10), kitchen garden (10) and commercial fields (truck garden) (5) indicate the presence of diseases in the range of 2.0 to 40.0%. The distribution of diseases was recorded in August-September and December-January at 21 locations and on 11 varieties. Maximum ripe rot (27%) was observed on Jawahar Mirch 283. The die back problem ranged from 10.0% (Pusa Jawala) to 17.0% in Pant C-1. The seeds collected from experimental fields, kitchen garden and truck garden revealed the presence of 6 major pathogens as detected by Standard Blotter method. The association of *C. dematium* ranged from 11.0 to 20.0% while *A. alternata* from 11.0 to 18.0% was recorded. Among 3 methods, tooth pick method was the best for testing the virulence of isolated fungi. Management of *C. dematium* and *A. alternata* was attempted through different combinations and dosages of mancozeb, mancozeb plus thiophenate methyl, copper oxychloride and carbendazim, available under different trade names. The new combinations were evaluated. The influence of these combination and fungicide on seed associated mycoflora, seed vigour, emergence and germination was determined through seed dressing and plating on top of the blotters (Standard blotter), between blotters (Standard Ragdoll method) and sowing in sand and soil medium. In fungicide treated seeds, association of *C. dematium* (1.0 to 3.0%) *A. alternata* (1.0 to 2.0%) was noticed as compared to untreated seeds (23.0% and 17.0%, respectively). The

combinations of mancozeb plus carbendazim (0.25%), mancozeb plus thiophenate methyl (0.175%, 0.200%, and 0.225%) and mancozeb (0.25%) were very effective in elimination of seed associated mycoflora. The fungicide treated seeds exhibited superior seed germination (75.0% in untreated and 78.0 to 84.0% in treated seeds) was recorded. The fungicide treated seeds had better emergence in sand and soil. Better seed emergence was noticed in sand as compared to sterile soil. It ranged from 80.0 to 84.0 in sand and 74.0 to 82.0% in soil, whereas, in field conditions it ranged from 75.0 to 83.0% as compared to 70.0% in untreated seeds. Three foliar applications of fungicides on chilli crop raised from untreated and treated seeds indicate that fruit rot in control plot was 18.5% whereas the incidence ranged from 4.0 to 10.0%. In fungicide treated plots, the most effective treatment was the application of mancozeb plus carbendazim (2.50 g/L water) while mancozeb plus thiophenate methyl (1.75 g/L water) also provided good control.