ENVIRONMENTAL RELATIONSHIP OF POWDERY MILDEW OF BLACK GRAM, ITS MANAGEMENT AND DOCUMENTATION OF POWDERY MILDEW FUNGI OF CHHATTISGARH

M. Sc. (Ag.) THESIS

by

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DEPARTMENT OF PLANT PATHOLOGY

COLLEGE OF AGRICULTURE, RAIPUR

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ENVIRONMENTAL RELATIONSHIP OF POWDERY MILDEW OF BLACK GRAM, ITS MANAGEMENT AND DOCUMENTATION OF POWDERY MILDEW FUNGI OF CHHATTISGARH

Thesis

Submitted to the

Indira Gandhi Krishi Vishwavidyalaya, Raipur

by

Patil Kushavart Prakash

IN PARTIAL FULFILMENT OF THE REQUIREMENTS

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CERTIFICATE-I

This is to certify that the thesis entitled "**Environmental relationship of powdery mildew of black gram, its management and documentation of powdery mildew fungi of Chhattisgarh**" submitted in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Patil Kushavart Prakash** under my/our guidance and supervision. The subject of the thesis has been approved by Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by him/her.

Chairman

Date: 11/7/16.

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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i

CERTIFICATE-II

This is to certify that the thesis entitled "**environmental relationship of powdery mildew of black gram, its management and documentation of powdery mildew fungi of Chhattisgarh**" submitted by **Patil Kushavart Prakash** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture** in the **Department of Plant Pathology** has been approved by the external examiner and Student's Advisory Committee after oral examination.

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"Education plays fundamental role in personal and social development and teacher play a fundamental role in imparting education. Teachers have crucial role in preparing young people not only to face the future with confidence but also to build it with purpose and responsibility. There is no substitute for teacher-pupil relationship."

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%	Per cent
/	Per
@	At the rate of
ºC	Degree Celsius

LIST OF ABBREVIATIONS

CD	Critical difference
cm	Centimeter
DAS	Days after Sowing
EC	Emursifiable concentreation
et al.	*et alii*
Fig	Figure
g	Gram
hrs	Hours
i.e.	That is
kg	Kilogram
kg/ha	Kilogram per hectare
lit	Liter
m	Meter
mw	Metrological week
m2	Meter square
ml	Milliliter
No	Number
NS	Non-significant
NSKE	Neem seed kernel extract
PDC	Percent disease control
PDI	Percent disease index
ppm	Parts per million
SEm	Standard error of mean
SN	Serial Number
SMW	Standard metrological week
um	Micrometer
WP	Wettable Powder

THESIS ABSTRACT

a) Title of the Thesis	:	Environmental relationship of powdery mildew of black gram, its management and documentation of powdery mildew fungi of Chhattisgarh
b) Full Name of the Student	:	Patil Kushavart Prakash
c) Major Subject	:	Plant Pathology
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e) Degree to be Awarded	:	M. Sc. (Ag.) Plant Pathology

Signature of the Student

Signature of Major Advisor

Date: _____

Signature of Head of the Department

ABSTRACT

The present investigation was carried out during *Rabi* season in 2015-16. Disease severity was affected by dates of sowing, 7th November was found significantly superior over 10th December, 29th November and 18th November. Epidemiology (Disease development) study revealed initiation of powdery mildew in first, second, third and fourth date of sowing 30, 35, 36 and 30 DAS respectively. In second, third and fourth dates of sowing, positive correlation between maximum temperature were observed but in first date of sowing, negative correlation between disease severity and weather factors were evident. Apparent

infection rate decreased with advancement of crop age. It was maximum at flowering stage to pod development stage and negligible at maturity. Out of 12 hosts inoculated with *Erysiphe polygoni* DC, only *Lathyrus sativus L*, *Vigna radiata* (L.) Wilczek, *Glycine max, Euphorbia hirta L., Trigonella foenumgraecum* and *Pisum sativum* Wilezck received the infection, rest of the hosts showed negative response for inoculation.

All the spray fungicides were found effective against the disease and significantly reduced the powdery mildew intensity. There by increased the seed yield and test weight in black gram over control. Fungicides Tebuconazole, Propiconazole, Elemental sulphur and Carbendazim at 0.1%, 0.05 %, 0.3% and 0.1% proves to be most effective fungicides in reducing the severity of disease. The botanicals neem (5%) and garlic (10%) were found effective for controlling the disease and giving better seed yield. Taxonomy of powdery mildew pathogens 30 hosts were studied in anamorph state. The genus *Erysiphe* spp. on Bawchi *(Psoralea corlifolia)* and *Sphaerotheca* spp. on Chinese Croton (*Excoecaria cochinchinensis*) hosts, were observed for the first time in India.

सारांश

रबी ऋतु 2015–16 के दौरान वर्तमान अनुसंधान को किया गया। रोग की गंभीरता बुआई की तारीखों से प्रभावित थी, 7 नवम्बर की बुवाई अन्य 10 दिसम्बर, 29 नवम्बर व 18 नवम्बर के बुआई से बेहतर पायी गयी। महामारी विज्ञान (रोग विकास) के अध्ययन मे पहले दूसरे, तीसरे और चौथे बुआई के तारीख 30, 35, 36 और 30 क्रम ाः दिन बुआई के बाद पाउडरी मिल्डयू फफूंदी की दीक्षा का पता चला। बुआई के दूसरे तीसरे और चौथे तारीखों में अधिकतम तापमान के बीच सकारात्मक संबंध पाया गया लेकिन, बुआई की पहली तारीख में रोग की गंभीरता और मौसम कारकों के बीच नकारात्मक संबंध स्पश्ट थे। स्पश्ट संक्रमण की दर फसल के बढते उम्र के साथ कम होती गयी, यह संक्रमण की दर फूलों के स्तर से फलीं विकास के स्तर तक अधिकतम और परिपक्वता पर नगण्य थी। 12 मेजबान पौधों को *इरीसाइफी पोलीगोनी* के साथ टिकाबध्द किया गया उनमें से *लेथायरस सटाइवस, विग्ना रेडियेटा, ग्लाइसिन मेक्स, यूफोरबिया हिराटा, ट्राइगोनेला फोइनमग्रेकम* और *पाइसम सटाइवस* पौधों मे संक्रमण प्राप्त किया, बाकी मेजबान पौधों मे कोही प्रतिक्रीया नहीं दिखी।

सभी फूहारे किये गये फफूंदना ाक रोग के खिलाफ प्रभावीं थे और काफी मात्रा मे पाउडरी मिल्डयू फफूंद रोग की तीव्रता को कम कर पाये जिसके कारण बीज उपज और बीज परिक्षण वजन मे बढोतरी हुई। फफूंदना ाक टेब्यूकोनाजोल (0.1%) प्रॉपीकोनाजोल (0.1%), सल्फेक्स (0.1%) और कार्बेन्डाजिम (0.1%) रोग की गंभीरता को कम करने में सबसे प्रभावी साबीत हुए। वानस्पतियों में से नींम (10%) और लहसून (10%) दूसरे वानस्पतियों के तुलना मे रोग को नियंत्रित कर पाने और बेहतर बीज उपज लेने मे साबित हुए। खस्ता फफूंदी के रोगजनकों के वर्गीकरण मे 30 मेजबान पौधों का एनामॉर्फ चरण में अध्ययन किया गया, उनमें से जीनस *इरीसाइफी* स्पी ाीज बावची के पौधे पर और *स्पॅरोथिका* स्पी ाीज चीनी क्रोटॉन के पौधे पर भारत मे पहली बार देखा गया।

CHAPTER – I
INTRODUCTION

Black gram or urd bean is one of the important pulse crop in India. Black gram (*Vigna mungo* L.) reported to be originated in India, belongs to family Leguminoseae. Its references have also been found in Vedic texts such as Kautilya's 'Arthasasthra' and in 'Charak Samhita' lends support to the presumption of its origin in India. Black gram is a rich protein food. It contains about 26 percent protein, which is almost three times that of cereals. The biological value improves greatly, when wheat or rice is combined with black gram because of the complementary relationship of the essential amino acids such as Arginine, Leucine, Lysine, Isoleucine, Valine and Phenyl Alanine etc. It is consumed in the form of split pulse as well as whole pulse, which is an essential supplement of cereal based diet. The chemical composition of black gram given as under, crude protein 26.2%, Carbohydrate 36.6%, nutrients like (mg/100 gm): Ca: 185, Fe: 8.7, P: 34.5, Vitamins: B: 0.42, B2: 0.37 and Niacine: 2. (Anonymous, 2015) In addition, being an important source of human food and animal feed**,** it also plays an important role in sustaining soil fertility by improving soil physical properties and fixing atmospheric nitrogen. Being a drought resistant crop, it is suitable for dry land farming and predominantly used as an intercrop with other crops.

All over the country, the black gram is mainly cultivated in kharif and rabi season in plains and in the hills, this crop is grown in most part of the year. Black gram is mostly grown on loam or clay loam soil. This crop prefers dry whether condition with ideal temperature range between 25º C to 35º C (Anonymous, 2015). Maturity crop period should coincide with the dry whether condition for high yield and good quality seeds, this is one of the main criteria to decide time of planting.

In about 70% world`s black gram production come from India, it was shared 8.60% in total production of pulses in India. The area under this crop in

India during the year 2013-14 was 3.5 million ha of area and production was 1700 thousands of tones, with an average yield of 470 kg/ha (Anonymous, 2015). In

Thousands of tones, with an average yield of 470 kg/ha (Anonymous, 2015). In Chhattisgarh state, the production and productivity of black gram is restricted to few districts and contribute 29.93 thousand MT annually and 269 kg/ha respectively with an area of 96.92 thousand hectare during the year 2013 (Anonymous, 2014).

Powdery mildew has long been known as important disease of plants in all parts of world the disease noticed generally on all aerial parts of the plants. In black gram powdery mildew caused by *Erysiphe polygoni* DC is one of the major constraints in the production of black gram, which cause both qualitative and quantitative loss of grains. The reduction in photosynthetic activity and physiological changes are considerable, which lead to potential decrease in yield (40-90%) depending on stage and time at which the disease appears. However, the disease has favorable in warm and humid weather. The disease has world-wide importance, occurring wherever it is grown, particularly in the Indian sub-continent and Southeast-Asian countries (Butler, 1918).

Powdery mildew pathogens belong to the family Erysiphaceae, order - *Erysiphales* and subdivision Ascomycotina characterised by dark, spherical closed ascocarps formed on external white mycelium, bitunicate, one to several asci (Yen & Wang, 1973). Apart from low temperature perithecia formation is a characteristic of the species of powdery mildew and host (Yarwood, 1973). Host range and geographic distribution of family Erysiphaceae had been reviewed by Hirata in 1971.

Powdery mildew was reported for the first time in 1753 by Linnaeus and used binomial *Mucor erysiphe* to a shile fungus on the leaves of *Humulus, Acer, Lamium, Galeopsidis* and *Lithospermnm.*

De Candolle (1805, 1815) dropped name *Mucor* and use *Erysiphe* at generic level and named 25 species of *Erysiphe.*

Braun (1987) summarized concepts regarding subfamilies, tribes, and genera based on morphological features. He recognized the subfamilies

Erysiphoideae and Phyllactinioideae, distinguished largely on the basis of whether mycelia were external or internal to the host. Within the subfamily Erysiphoideae were the tribes Erysipheae, with multiascal ascocarps, and Cystotheceae, with ascocarps each producing a single ascus. Tribe Erysipheae was further subdivided into subtribes based on ascocarp appendages. Leveille's (1851) divided Erysiphe into six genera namely *Calocladia, Erysiphe, Phyllactinia, Podosphaera, Sphaerotheca* and *Uncinula.* This was the land marks in taxonomy of powdery mildew pathogens. A world monograph of Erysiphaceae was published by Salmon (1900) in which *Calocladia* was replaced by *Microsphaera*.

Hirata (1966) listed the host plants of powdery mildew fungi as 9838 Angiosperm species dispersed in 44 orders, 169 families and 1617 genera of the total host species, 9176 dicotyledons and 669 monocotyledons, 684 are members of graminae and remaining 28 dispersed among seven other families. The powdery mildews are recognised as parasite chiefly of dicot having exceptional relations with graminae among the monocots.

The effects of various environmental factors on powdery mildews vary with the species studied and the conditions under which it is studied. This variation has led to considerable confusion as to the effect of environment on the development of powdery mildews in general. The factors that will be treated are temperature, moisture, light, and wind. Other factors such as atmospheric pressure, smoke, air circulation, and soil fertility have been reviewed by Yarwood. Although the powdery mildews initiate infection from ascospores, conidia, and overwintering mycelia in dormant buds the conidial stage is the most important spore form in secondary spread. Most of the studies on environmental effects have been made with this spore form.

At present there are no varieties that are resistant to the powdery mildew disease in the locality, hence, fungicide application is the only means of control. Unfortunately, the intensive use of chemicals against powdery mildews often resulted in the development of resistance, this happened in the case of most of the groups of chemicals applied (Mcgrath, 2001). The use of eco-friendly products like botanicals control to disease is one of possible alternatives to reduce chemical use that has been proposed and evaluated in numerous patho-systems, with different

degrees of success. (Anonymous, 2012). The fungus that causes powdery mildew is usually host specific. Thus, by controlling the diseases through a suitable control measure is essentially required for present farming. However many researchers tried to control the diseases chemically worldwide (Rahman *et al.* 2005, Ahmed *et al.* 2006).

Keeping in view of wide spread, occurrence, severity and losses caused by powdery mildew, present investigation entitled **"Environmental Relationship of Powdery Mildew of Black Gram, Its Management and Documentation of Powdery Mildew Fungi of Chhattisgarh"** was undertaken with the following objectives:

- Epidemiological studies of black gram powdery mildew.
- Host range study of *Erysiphe polygoni* DC.
- Studies of management of powdery mildew of black gram.
- Documentation of powdery mildew pathogens of Raipur.

CHAPTER – II

REVIEW OF LITERATURE

2.1 Effect of Sowing Dates on Powdery Mildew Severity

Powdery mildew generally appears from the early flowering to pod maturity stage and its development depends upon the cultivars used, date of sowing and prevailing weather conditions. The disease can be managed by spraying fungicides. By adjusting sowing dates one can avoid susceptible stage of the crop to the powdery mildew disease which is an obviously good strategy.

Sivaprakasam *et al.* (1981) found higher incidence of *Erysiphe polygoni* in *vigna radiata and v. mungo* in 60 and 80 days old crops sown on 1st and 20th august compared to 40 days old crops sown on 10th September. Compared to black gram, the disease incidence is more in green gram.

Moghe and Utikar (1981) observed minimum incidence of powdery mildew in green gram by sowing the crop in mid august. Crops sown in late July showed maximum diseases.

Kunkalikar and Padagnur (1991) recorded lowest percentage disease index and highest grain yield in early sown crop of green gram than late. In the late sown crop, disease develop most quickly when minimum temperature was 20 ºC and relative humidity 82.5%-83.5%. Early sowing was thus found to reduce disease incidence and crop losses.

Shukla and Amin (1991) observed lower incidence of powdery mildew in pea with increased yield by sowing the crop between late October and early November compared to late November to December sowing.

Thakur (1992) observed higher severity (66.84%) of powdery mildew (*Erysiphe polygoni)* in 60 days old mungbean compared to lower severity (8.76%) in 30 days old crop. Similarly, disease severity was maximum (45-67%) in sole crop of mungbean than in intercrop with sesamum and bean.

Sanger and Singh (1994) conducted a field experiment on pea Cv. Khaparkheda, Rachna and JP-789 sown on 5th or 25th Oct., 14th Nov. or 4th Dec. They found delay in sowing after 5th October increased the incidence of powdery

mildew they found delay in sowing after 5th October increased the incidence of powdery mildew infection and decreased yield. Khaparkheda showed lowest incidence of the disease. Delay in sowing after 5th October also decreased the grain yield.

Singh *et al.* (1995) studied effect of 4 different sowing dates i.e. 20th October, 5th and 21st November and 6th December on the occurrence and severity of the powdery mildew in pea and found that October sown crop had a minimum infection there by given more seed yield December sown crop however, shoe maximum disease leading to low yield.

Bhardwaj and Sharma (1996) conducted an experiment on pea on five different dates of sowing with four varieties and recorded that variety Arkel and VL-7 gave higher pod yield (4.34 and 4.22 tones ha-1) with lowest disease index of powdery mildew.

Nayak and Patra (2000) conducted an experiment to determine the effect of cultivars to dates of sowing. Eight improved and 4 local green gram (*Vigna radiata*) cultivars were sown on 1st and 16th November during winter seasons. Time to flowering averaged 50 and 57 days with sowing on 1st and 16th November, respectively, but there was no effect of sowing date on yield or yield components. Incidence of powdery mildew (*Erysiphe polygoni*) was higher in the improved than the local cultivars.

Thakur *et al*. (2004) conducted an experiment to determine the effect of cultivars (PS 16, RUM 1, No. 89047 and TARM 18) and sowing dates (17th November, 2nd and 17th December, 1995) on the severity and development of mungbean powdery mildew (*Erysiphe polygoni*). The average mildew severity was significantly lower (41.99 and 41.83%) in early- and mid-sown crop whereas, it was significantly higher (59.70%) in late-sown crop. Among the cultivars, RUM 1 exhibited the least severe (14.39%) disease, while PS 16 recorded the most severe (84.25%) disease. Mildew severity in interaction of sowing dates cultivars was lowest (1.33%) on RUM 1 and highest (93.33%) on PS 16 both planted on 17th November 1995. The first appearance of powdery mildew was noticed at 35 days after sowing (DAS) in early-sown crop, 33 DAS in mid-sown crop and 24 DAS in late-sown crop.

Khatri and Gangopadhyay (2008) conducted an experiment to determine the effect of cultivars (Varuna, Pusa Bold and Bio-902) and sowing dates (21st October, 31st October and 10th November) on the severity and development of mustard powdery mildew (*Erysiphe cruciferarum*). The average mildew intensity was significantly lower (24-26% and 29-31%) in early and mid-sown crop whereas; it was significantly higher (33-35%) in late-sown crop. Average seed yield was higher (11.2 to 12 q/ha) in crops sown early (Oct 21), While it was low (7.2 to 8.4 q/ha) in late sown crop (Nov.10). Seed yields were between 10 to 10.5 q/ha in crops sown on the second date of sowing (Oct 31). All the three varieties i.e. Varuna, Pusa Bold and Bio 902, showed disease incidence but gave maximum yields in the early sowing. The disease intensity in varieties was significant, whereas, seed yields reduced in the second and the third dates of sowing.

Wadje *et al.* (2008) studied to minimize the diseases and obtain better yields. Three mungbean varieties viz. BPMR-145, Kopergaon and Latur local were sown at four different dates (July 7th, 14th, 21st, and 28th) under natural condition to study the effect of sowing dates on powdery mildew incidence and seed yields. The result indicates that disease intensity was minimum (35.80%) in early sown, moderate (41.98 to 44.79%) in mid-late and maximum (50.25%) in late sown mungbean, whereas in varieties disease was lower in BPMR-145 (35.97) and higher in Kopergaon (45.21%) and Latur local (48.46%). The grain yields and test weight of mungbean was found to differ significantly with respect to sowing dates and varieties.

Rakhonde *et al.* (2013) Studied at to determine effect of sowing dates (1st July, 8th July, 15th July and 22nd July) on the severity and development of green gram powdery mildew. Crop sown on July 22nd showed higher disease intensity (38.79%) observed in the peak period i.e. on 27th August whereas comparatively low disease severity was observed when the crop sown on 8th July (27.46%), 1st July (27.99%). The crop sown on 15th July exhibited higher disease intensity (36.49%). As regards the grain yield the crop sown at 1st July recorded highest grains. 750 kg/ha which was significantly superior to the crop sown on 15th and 22nd July.

2.2 Role of Environmental Factors on Development of Powdery Mildew

Yarwood (1936) reported passive dissemination of conidia of *Erysiphe polygoni* DC depending on maturity of the conidia, dryness of plant and fungus surfaces and wind. Reduction in liberation of conidia at night has been predicted because of higher relative humidity and less wind.

Yarwood *et al.* (1954) reported infection of powdery mildew to a plants within a temperature range of 10-28 ºC with an average about 21 ºC.

Yarwood (1957) observed favourable effects of rains, dews, fog and sprinkler irrigation on the development of powdery mildew, but little role of atmospheric relative humidity. The disease appeared more in shade than fully natural light condition. The epidemic development of powdery mildew is very fast and its progress as compound interest.

Soria and Quebral (1973) concluded that powdery mildew of *P. aureus* caused by *Erysiphe polygoni* DC occurred in January when monthly temperature, relative humidity, wind velocity total solar radiation and rainfall were 26.6°C, 85%, 1.8 mph, 9976 g cal-cm 2 days and 1.61 inch, respectively.

Deshpande and Dake (1978) noticed the epidemics of Erysiphales at 25 ºC temperature.

Findings of Moghe and Uttikar (1981) inferred that powdery mildew of mungbean caused by *Erysiphe polygoni* DC was favoured by weekly maximum temperature (31.34-31.67°C) and RH (90%) during pod formation.

Agrawal and Philip (1983) recorded incidence of powdery mildew in urid *(phaselous mungo)* 60 days after sowing. The infection there after continued till harvest i.e. for 40 more days.

Paul and Kaushal (1985) based on the effect of relative humidity (RH) on their conidial germination, grouped powdery mildews in 4 categories (a) those requiring 70% RH e.g. *Erysiphe berberidis* and *Oidium sp.* (b); those requiring 70-100% e.g. *Erysiphe martii, E. cichoracearum, E. graminis, Sphaerotheca macularis, S. fulginea* and *Oidium sp.* (c); those requiring 70-100% RH e.g. *E.cruciferarum, E. betae, E. pisi, Oidium amaranthi* and *O.oxalidis* and (d) those in the different RH range e.g. *E.pisi* on *vigna mungo* and *vicia faba.*

Kunkalikar and Padagnur (1989) observed that for *Erysiphe polygoni* to cause powdery mildew development in mungbean minimum mean temperature 20 ºC and relative humidity 82.5% to 83.5% are essential.

Mittal and Sharma (1992) studied development and spread of powdery mildew of green gram and black gram in the kumaon hills of India and noted the disease appearance 90 days after sowing when the crops were in post flowering and pod formation stages. During this period, average maximum temperature was 28.8 ºC, minimum temperature 17.2 ºC, RH above 75% and weekly rainfall 5.8 mm spread over 1 to 2 days.

Abbaiah (1993) inferred that powdery mildew appearance in the first week of January when the crops was 45 days old. Fast mildewing was found to be correlated with weather parameter and positive correlation were observed with maximum temperature and wind velocity whereas, negative correlation with minimum temperature.

Khare *et al.* (1994-1996) reported that, the development of powdery mildew *(Erysiphe polygoni)* of urd bean (*Vigna mungo*) in relation to environmental conditions, and the effect of powdery mildew of yield were studied at Raipur during rabi 1994-95 and 1995-96.

Kapoor and Chaudhary (1995) reported that decreasing temperature appeared to stimulate cleistothecial formation by *E. pisi* on peas. Rainfall in July and first fortnight of August also increased the rate of cleistothecial formation.

Thakur and Agrawal (1995) noted rapid development of powdery mildew on mungbean and urdbean when the average maximum temperature range between 27.2 º and 30.3 ºC, relative humidity from 67 to 90% during morning and 12 to 38% at noon and wind velocity from 2.3 to 4.1 km\h. A positive correlation was found between mildew severity and temperature and wind velocity in most of the varieties, however, the correlation with relative humidity was negative and significant except in few varieties. The pooled infection rates (r/unit/d) on resistant *V. radiata and V. mungo* varieties was <0.1 with disease score of 1.5 while in apparently slow mildewing varieties r value were also <0.1 but showed score of 7-9. The effect of disease levels of grain yield of *V. mungo* showed negative significant correlation but in case of *V. radiate* it was negative non significant.

Raghuchandran and Rajgopalan (1995) observed lower incidence of *Erysiphe polygoni* in July sown *vigna mungo* crop then those sown in August-January. High relative humidity, low maximum and minimum temperature and low rainfall favoured severe incidence of powdery mildew.

Banyal and Tyagi (1997) noticed that temperature played a significant role in determining the course of powdery mildew epidemics of pea in and around Palampur. Highly significant and positive correlation between temperature and disease severity were obtained during 1991-92 and 1992-93. The disease developed rapidly when the average of maximum and minimum temperature exceeded. High RH was not a prerequisite for the development of powdery mildew.

Saxena *et al.* (1997) observed 26 ±1º C mean temperature 85.95% relative humidity as amain predisposing factors for powdery mildew development in black gram. The diseases exhibited positive significant correlation with maximum temperatue but a negative significant correlation with morning and evening relative humidity.

Khare *et al.* (1998) reported that the powdery mildew of moong first appeared at 32 days after sowing in both years on susceptible variety PS-16 and it first appeared at flower initiation stage in the remaining varieties used in the study. Similarly, the apparent rate of disease development was also more during 50 % flowering to pod initiation stage. The disease severity is positively correlated with maximum temperature in all the varieties while only in some varieties with minimum temperature, no significant correlation between disease severity and relative humidity was found in all varieties, whereas some varieties showed positive and significant correlation with sunshine.

Sharma (2000) studied the occurrence and control of *Erysiphe pisi* on peas (*Pisum sativum*) in Himachal Pradesh, India, during 1995-96. Overall, disease severity in this region was 53.4% and 46.4% during 1995 and 1996, respectively.

Kumar and Gupta (2006) studied the influence of environmental factors on the development of pea powdery mildew (*Erysiphe pisi*) under laboratory and field conditions. Conidial germination and germ tube length recorded a maximum at 25º C. High relative humidity (100%) favored conidial germination and germ tube

length. Under field conditions, temperature played an important role in the disease development. Highly significant and positive correlations were observed between temperature and disease severity during two crop seasons.

Kachhot *et al*. (2010) observed higher disease index between the periods of January 31-February 27, 2010 with the highest disease (80.5%) during Feb. 14-20. Multiple linear regression analysis revealed that both temperatures and relative humidities influenced 72.73% powdery mildew development on pea and remaining 27.27% were unexplained climatic variations.

2.3 Host Range of *Erysiphe polygoni* DC

Powdery mildew exhibit some degree of host specialization. There are conflicting reports regarding the range of parasitism of *Erysiphe polygoni* DC from black gram.

Yarwood (1957) noted that it has a narrow host range and confined to *Pisum sativum, Pisum arvense* and *Lathyrus* spp. only. Similar findings were also noted by Singh and Singh (1983).

Munshi and Jhooty (1980) found that *Erysiphe polygoni* infect 13 species of plants viz. *Brassica juncea, Medicago dendriculata, Sanchus asper, Trigonella polycerata, Lathyrus odoratus, Chenopodium ambrasioides, Lens esculentus, Oxahs cosniculata, Argemone mexicana* and *Trifolium resupinatum.*

However Bhardwaj and Singh (1984) found the host range of oidium state of *Erysiphe pisi* on some leguminous hosts. They found 19 to 29 hosts to susceptible to powdery mildew which were *Cajanus cajan, Cicer arietinum, Clitoria biflora, Crotolaria juncea, Lathyrus aphaca, Lathyrus odoratus, Lathyrus sativus, Lens esculentus, Macroptilium atropurpuseum, Medicago polymorpha, Pisum arvense, Pisum sativum, Trigonella foenumgraecum, Vicia sativa, Vigna mungo* and *Vigna umbellata.*

Cook and Fox (1992) found that *Erysiphe pisi var. pisi* was not capable for affecting *Luinus polyphyllus, Rhasealus vulgaris* or *Onobrychis* but capable to affect faba been infected *Vicia sativa* and *Lathyrus odoratus*.

Mohan *et al*. (2001) noted that *E. pisi* cause the disease on a wide range of crop legumes including alfaalfa (*M. trucatula*), common bean (*Phaseolos*

vulgaris), faba bean (*Vicia faba*), lentil (*Lens culinaris*), peanut (*Arachis hypogaea*) and red clover (*Trifolium partense*).

2.4 Evaluation of Fungicides, Botanicals and Bio-agent against Powdery Mildew in Field

Mathur *et al.* (1972) obtained effective control of *Erysiphe polygoni* of urid by spraying Elosol followed by Thiovit, however yield was maximum with Thiovit.

Kotasthane and Agrawal (1976) found effective check of mungbean powdery mildew with sprays of Bavistin and Benomyl. Diathane Z-78 was not effective. Bavistin also significantly improved 100 seed weight.

Singh and Naik (1977) found maximum control of *Erysiphe polygoni* causing powdery mildew of *Phaseolus mungo* with calaxin followed by bavistin, benlate and Thiovit.

Vinayak (1977) observed effective control of powdery mildew of green gram by dusting sulphur 25kg/ha thrice. The treatment increase the seed yield by 173%.

Gurha and Gangal (1980) tested 6 fungicides and found best control of powdery mildew of green gram with sulphur (Thiovit) followed by carbendazim (Bavistin). However, carbendazim treatment gave highest yield compared to sulphur.

Moghe *et al.* (1982) tested 8 fungicides against powdery mildew of green gram. Though all fungicides were effective, sulphur dust and Sulpen-80 gave complete elimination of disease and increased the yield by 172.59% and 141.56% respectively.

Agrawal and Philip (1983) achieved most economical control of *Erysiphe polygoni* on *Vigna mungo* with 3 sprays of 0.3% wetsulf at an interval of 12 days. The sprays commenced immediaetly after the appearance of disease. Three sprays increase significantly increased no. of pods per plant and the results were at par with two sprays.

Nawazi and Narayanswamy (1983) obtained best control of *Erysiphe polygoni* infecting *Vigna mungo* and *V. radiata* with bavistin. Other effective fungicide were wettable sulphur, Karathane, Sulphex and benlate.

Singh and Singh (1983) found 3 sprays of ginger extract, garlic oil, Dinocap, wettable sulphur or carbendazim at 20 days of interval are effective to control powdery mildew of pea incited by *Erysiphe polygoni*.

Sivaprakasam (1983) recorded best control of powdery mildew of black gram by benlate and sulphur. Sulphur dust and wettable sulphur increased the yield by 47.3 and 45.9% respectively and resulted in a net profit of Rs. 200 and 187\ha.

Devi and samy (1984) found inhibition of conidial germination of *Erysiphe polygoni* with karathane (Dinocap), bavistin (cabendazim) and Topsin-M (Thiophanate methyl). However, in the field, Dinocap proved superior in reducing powdery mildew incidence in black gram.

Zote *et al.* (1985) tried 9 fungicides to control powdery mildew of mung *(Vigna radiata)* and obtained excellent control of the disease with sprays of Bavistin.

Krishnamohan *et al.* (1986) sprays of calixin (tridemorph) or Bavistin (carbendazim) @ 0.1% has been reported effective to control powdery mildew of black gram.

Tiwari and Kotasthane (1986) reported least incidence of powdery mildew and obtained highest yields of mung bean with two sprays of Bavistin (carbendazim @ 0.05%).

Elazegui and Mew (1987) while working out cost benefit ratio to control powdery mildew of *Vigna radiata* with fungicides, observed that sprays of thiophanate methyl (Topsin) were more economical than benomyl.

Rabindran *et al.* (1988) sprayed different fungicides at various stages of infection to control powdery mildew of black gram and found carbendazim most effective when applied at first appearance of the disease and again 15 days.

Bhatia and Thakur (1989) evaluated systemic and nonsystemic fungicides against powdery mildew of mungbean and recorded maximum disease reduction by spraying bavistin (73.5%) followed by sulfex-80 (66%). Bavistin was effective but not as economical as sulfex-80.

Das and Narain (1990) obtained significant control of *Vigna radiata* by spraying Bavistin (carbendazim), Topsin-M (thiophanate methyl), karathane (dinocap), Derosal (carbendazim) and Sulfex (wettable sulphur). However, single

spray of 0.4% sulfex gave highest cost benefit ratio of 3.3.

Singh *et al.* (1991) used fresh and stored ginger (*Zingiber officinale*) rhizome extract for the control of powdery mildew of pea and found highest dose (2000) ppm of the fresh extract most effective compared to stored extract at 5º C and 15º C for one month. The results were statistically significant.

Abbaiah and Devi (1992) most effectively controlled *Erysiphe polygoni* on black gram by spraying 0.1% carbendazim and obtained maximum net return. However, cost benefit ratio was highest (1:6.7) in thiophanate methyl (Topsin-M) treatment.

Setty *et al.* (1996) assessed effectivity of carbendazim, tridemorph (Calixin), dinocap, sulphur, tridemefon (Bayleton) and mancozeb + dinocap against powdery mildew of black gram and obtained best results with carbendazim.

Srivastava (1996) determined the ability of Bavistin (carbendazim) 0.1%, Topsin-M (thiophanate methyl) 0.1%, Calixin (tridemorph) 0.1%, captaf (captan) 0.2%, Cuman-L (ziram) 0.2%, wettable sulphur 0.3%, Diathane M-45 (mancozeb) 0.2% and Kawach (chlorothalonil) 0.1% to control powdery mildew of black gram. All fungicides significantly control the disease and gave increased yield. Among fungicides Bavistin, Topsin-M, wettable sulphur and Kawach proved superior in reducing disease intensity and increasing yield.

Huq and Nahar (1997) tested 4 fungicides viz., propiconazole (Tilt 25 EC), Tridemorph (Calixin 75 EC), tebuconazole (Folicur 25 EC) and sulfur (Thiovit) against powdery mildew of pea under field conditions and obtained effective control of the disease with 4 sprays of tebuconazole (0.05%), giving benefit cost ratio of 5.69.

Prithviraj *et al.* (1998) evaluated efficacy of ajoene, a constituent of garlic (*Allium sativum*) and Neemazol, a product of neem (*Azadirechta indica*) against powdery mildew of pea in the field individually and also in combinations. Both the products are different concentration (Neemazol 50, 150, 750 ug ml, ajoene 100, 150, 750 ug ml and their combination) reduced disease intensity compared to control.

Sindhan *et al.* (1999) compared efficacy of extract of 10 plant species with Neemadol (Neem product) at 0.25%, 0.50% and 1% and Karathane (dinocap) at

0.1% for the control of powdery mildew of pea. The results showed that most of the plant extracts @30% significantly reduced the disease compared to control. Neemadol an extract of *Azadirechta indica, Allium sepa, A. sativum* and *Zingiber officinale* were highly effective and at par with dinocap in reducing disease intensity. The efficacy of extracts increased with increasing concentration.

Tripathi *et al.* (2003) evaluated efficacy of 0.1% Dinocap, 0.1% Carbendazim, 0.3% Wettable Sulfur, 0.1% Tridemorph, 0.05% Fenarimol, 0.05% Penconazole, 0.2% Chlorothalonil and 0.1% Difenoconazole against powdery mildew (Caused by *Erysiphe polygoni*) in pea (cv. T-163) in Akola, Maharashtra, India, during 2000-01. The fungicides were sprayed during the initial occurrence of the disease and at 10 days thereafter. Tridemorph was the most effective in the reduction of disease incidence (44.23%) and increasing yield (107.93% increase over the control). The effect of the fungicides on fungal spore germination in vitro was evaluated. The greatest inhibition of spore germination was recorded for Tridemorph (72.70%).

Hifsa and Shabeer (2005) evaluated the relative efficacy of different fungicides, i.e. Score (difenoconazole), Kumulux (wettable sulfur) and Topsin M (thiophanate-methyl), and phytobiocides, such as garlic, ginger, turmeric and neem oil, under field conditions with artificial inoculation for the control of powdery mildew (*Erysiphe pisi*) in pea cv. Meteor. Both fungicides and phytobiocides reduced the disease severity. The lowest disease incidence was recorded in plants treated with Score followed by those with turmeric. The mean number of pods per plant (n=15.7), weight of pods per plant (46.7 g) and grain yield (28.4 g) were the highest in treatment with Score followed by that of turmeric indicating that their application resulted in the disease control with a subsequent increase in yield.

Prasad and Dwivedi (2007) evaluated the tilt (Propiconazole) was the most effective treatment, which not only increased seed yield but also reduced disease severity significantly as compared to unsprayed check followed by Karathane (0.1%) and Bavistin (0.1%) during both the crop seasons.

Khan and Iqbal (2008) reported the two fungicides, *i.e* score (difenoconazole) and Bayleton (triadimefon), were found very effective in reducing the disease severity (93%) compared to the other three fungicides. The

effectiveness of Barb (difenoconazole) and Thiomill (thiophanate-methyl) was intermediate, whereas Crest (carbendazim) was the least effective. Thus, powdery mildew can be managed effectively by the use of Score and Bayleton.

Manojkumar *et al.* (2008) reported the fungicides Folicure (tebuconazole), Karathane (dinocap) and Bayleton (triadimefon) was the most effective treatment, against powdery mildew of bell pepper which increased yield and reduced disease severity significantly as compared to unsprayed check followed by Chlorothalonil (44.8%) during both the two seasons.

Surwase *et al*. (2009) reported the fungicides hexaconzole (0.05%) and penconazole (0.05%), botanical NSKE (5%) and bioagents *Trichoderma horzianum* (0.5%) were found highly effective and economical for controlling the disease and giving better seed yield.

Suryawanshi *et al.* (2009) reported the fungicides Karathane (0.1%), Sulfex (0.3%), Carbendazim (0.1%), Topsin-M (0.1%), NSKE (5%) were found highly effective for controlling the powdery mildew of green gram and giving better seed yield.

Jagtap *et al*. (2012) studied application of different bioagents in the integrated disease management trial and found the reduced disease severity ranges from 13.84 to 27.68 per cent. Treatment *Trichoderma hamatum* was most effective followed by *Trichoderma viride* and *Pseudomonas fluorescences*.

2.5 Documentation of Powdery Mildew Fungi

Black gram *(vigna mungo* L.) is one of the important leguminous crop having 21.3% to 26.2% protein, extensively grown in India, for its various uses as vegetable, pulse, feed and fodder. The powdery mildew disease is one of the major factors contributing to low yield of the crop. The pathogen causing powdery mildew have enough potential to attack crop and weed plants.

Very little published work are available on morphological characters and identification of the pathogen in Chhattisgarh. Powdery mildew has long been known as parasitic disease of plants in all part of the world. Linnaeus (1767) established the genus *Erysiphe.*

Singh (1990) described symptoms of the disease that first appeared on the leaves and then on other green parts of the plant. Its attack was characterized by

the formation of white floury patches on both sides of the leaf as well as the tendrils, pods, stem etc. These patches originate as minute discolored specks, from which a powdery mass radiates on all the sides. When the attack had advanced, large areas on the aerial parts of the host may be covered with these white floury patches. The superficial mass consist of mycelium and spores of the fungus.

2.5.1 Morphology of the fungus

The disease is incited by an ascomycetous fungus, *Erysiphe polygoni* DC. It was found on *vigna, Pisum, Medicago, Vicia, Lupinus* and *Lens* spp. (Singh *et al*., 1994).

The fungus is septate, ectophytic, obligate parasite producing whitish mycelium, hypha measures 3.79 um-6.81 um and hyaline conidia. The fungal cell produced an appressorium which gave rise to haustarium, which ultimately penetrates the cell wall. The conidiophore septate, 4 celled arise vertically from the superficial hyphae on the host surface. Conidiophore measures 72.64 um-108.96 (am x 7.9 um-10.21 urn. Foot cell measures 25-55 um. Conidia produced singly or in short chain. The ripe conidia fall off quickly and disseminated by wind. Conidia are ellipsoid or ovate with vacualate cytoplasm and measure 25-30 um x 13-16 um.

Most of the powdery mildew fungi are ectophytic in nature and sub endophytism was reported only in *Leveillula, Phyllaetinia* and *Pleochaeta.*

Fresenius (1852) reported for the first time that conidiophores were the key characters to recognise different species of powdery mildew.

Blumer (1967) recognised five basic conidiophore types based on the work and terminology of Jaczewski (1927) and Brundza (1933)

Oidium-type : Conidiophore base swollen, 8 to 10 A and B units confined to *Erysiphe graminis.*

Euoidium-type : Conidiophore base unswollen with long conidial chain, anamorphs of this type occur in *Erysiphe* Blumer, *Podosphaera* Kunze and *Sphaerotheca* Lev.

Pseudoidium-type : Conidiophores with single conidium at

the top, anamorphs occur in *Linkomyces Golovinomyces*, *Microsphaera* Lev. and *Uncinula* Lev.

Ovulariopsis-type : Conidiophore 50-150 um long consist of cylindrical cells, conidia rhombiodal to club shaped, anamorphs occur *Phyllactinia* Lev.

Oidiopsis-type : The conidial stage of the gen *Leveilula* Arnaud, Conidiophore external as well as on hyphae with host, emerge through stomata simple or sometime branched.

According to Yarwood (1978) size of conidia is a variable character under different climatic and host conditions, thus it should not be used in taxonomy of Erysiphaecae. Blumer (1922) reported that size of conidia is fairly constant for given host in a given environment but it varied greatly with host nutrition (Neger, 1902). ages and vigour of the host leaves (Neger, 1902 and Fishcher, 1957), nutrition of host leaves (Zwirn, 1943) season (Homma, 1937), humidity (Bouwens, 1924) host species (Bouwens, 1924, Homma, 1937).

A chronological review of the major genera of Erysiphaceae by major contributors to their taxonomy was given by Yarwood (1978).

Hirata (1986) reported that powdery mildew fungi includes 19 genera and about 400 species. All genera were divide into two groups:

(A) Those having wide host ranges includes *Erysiphe*, *Leveillula, Sphaerotheca, Podosphaera*, *Microsphaera*, *Uncinula, Phyllactinia* and *Oidium.*

(B) Those having narrow host ranges includes *Setoerysiphe, Cystotheca*, *Sawadae, Kokkalera, Brasiliomyces, Medulsphaera Uncinuliella, Bulboucinula, Furcouncinula, Salmonomyces*, *Typhulochaeta, Queirozia* and *Pleochaeta*.

At present the major parameter of taxonomy are mycelium, conidiophores, conidia, fibrosin bodies, appressoria, conidial germination, cleistothecia and host range etc.

CHAPTER - III

METHODS AND MATERIALS

The experiments were conducted during *Rabi* season, 2015-16 at the Research farm and glass house, Department of Plant Pathology, College of Agriculture, IGKV Raipur. The details of the materials used and the methods or techniques adopted during the course of this investigation are presented in the following sections.

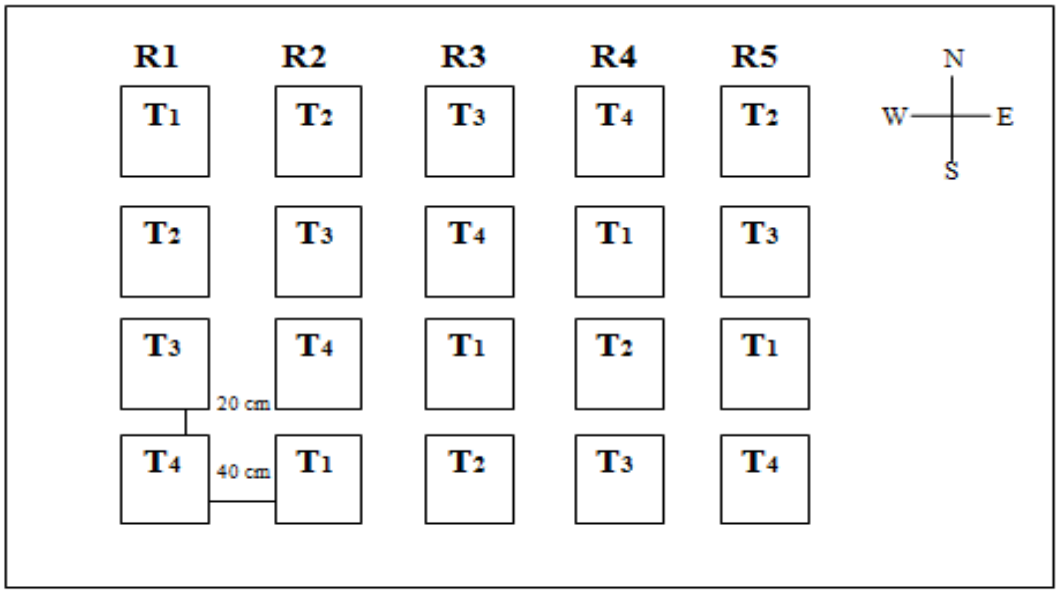
3.1 Effect of Dates of Sowing on Powdery Mildew Severity and Intensity

To know the effect of sowing date and effect of meteorological factors on the coarse of powdery mildew development and its wide spread, the present experiment was conducted in glass house. Black gram was grown in Rabi season. Highly susceptible black gram cultivar was sown in randomized block design on 7, 11 and 29 November and 10 December 2015 by replicating each date of sowing 5 times. Sowing was done in a plot size 1.4×1.4 m. in a polypropylene bags. in each polypropylene bag 25 seeds were sown by dibbling method 20 plants was done in each plot.

Observations of the disease incidence and disease progress/intensity was recorded on tagged plants in each plot for all the dates of sowing by using a disease rating 0-5 scale given by Munj *et al.* (1963) (Table 3.1) and compared to find out the best sowing date.

Table 3.1: Powdery mildew scale

Grade	Percent infection	Reaction	
0	No infection	(HR)	Highly resistant
1	0.1 – 10	(R)	Resistant
2	10.1 – 25	(MR)	Moderately resistant
3	25.1 – 50	(MS)	Moderately susceptible
4	50.1 – 75	(S)	Susceptible
5	75.1 - 100	(HS)	Highly susceptible



Lay out of the experiment on effect of dates of sowing on powdery mildew severity and intensity of black gram.

Details of experiment

Treatments details

T1: 7/11/15
T2: 18/11/15
T3: 29/11/15
T4: 8/12/15

Crop: black gram

Variety: gold star

Design: RBD

Treatments: 4

Replications: 5

Plot size: 1.4 × 1.4 m.

Fertilizer: DAP @ 60 kg/ha

Seed rate: 20 kg/ha

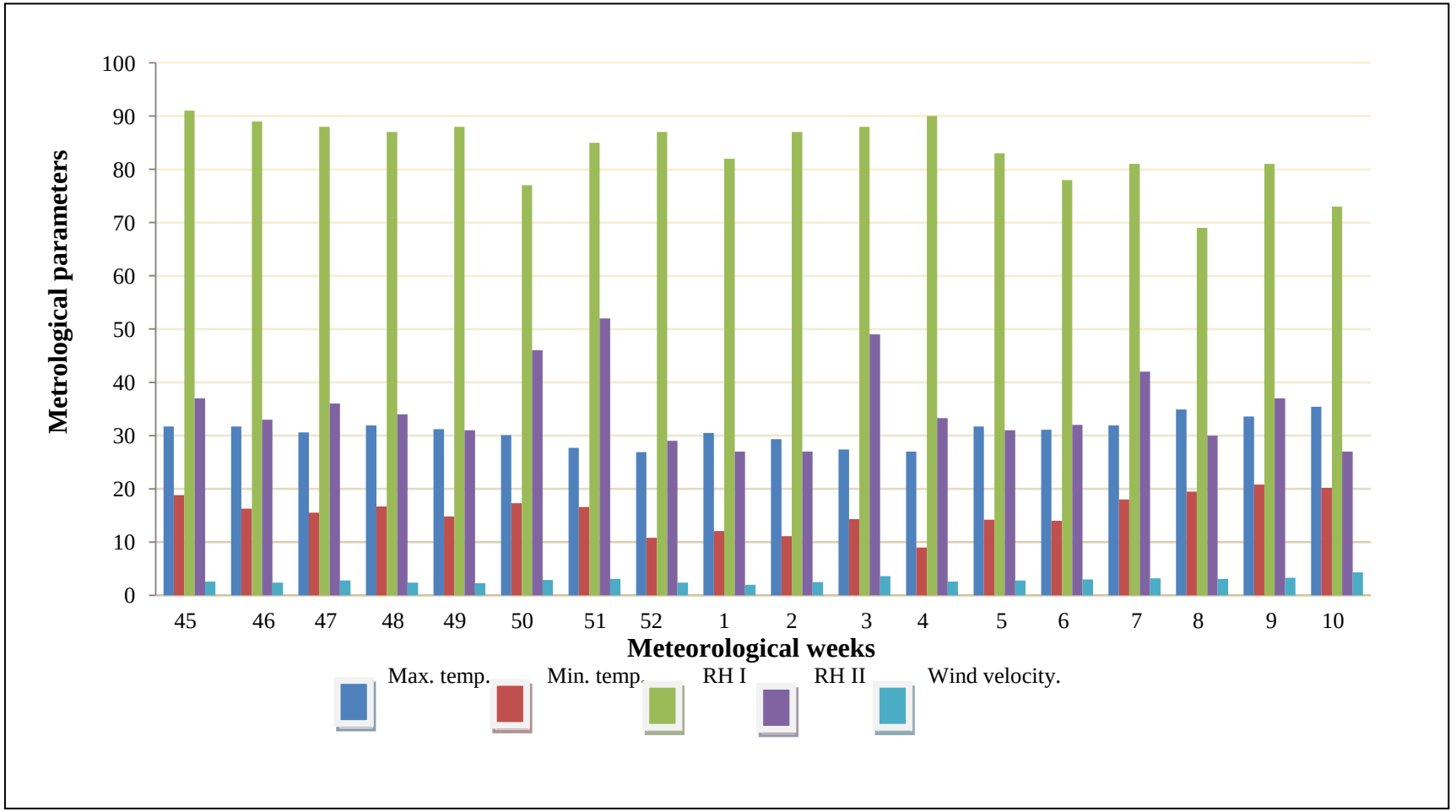


Fig 3.1: Weekly meteorological data during crop growth period (from 5 November, 2015 to 11 March 2016)

3.1.1 Role of environmental factors on development of powdery mildew

Meteorological observations with respect to maximum and minimum temperature, rainfall, relative humidity (RH) and sunshine hours were obtained from Department of Agrometeorology, IGKV, Raipur. Weekly metrological parameters prevailing during the crop period (7th November 2015 to 11th March 2016) are given in Appendix I and illustrated in Fig.3.1. Correlation variables between disease severity (dependent variables) and meteorological parameters (independent variables) were determined by Karl Pearson's formula and correlation coefficient values were tested individually for their significance at 5% probability level using following formula :

$$t = \frac{r(n-2)}{\sqrt{(1-r^2)}}$$

Where, t = test significance; r = correlation coefficient and n = number of observations.

The rate of disease development/ unit / day was estimated according to the method given by Vanderplank (1963). The apparent infection rate (r) for total period was:

$$r = \frac{1}{t2 - t1} \log e \frac{X2[1-X1]}{X1[1-X2]}$$

Where,

r = rate of disease development

t_1 = date of first observation

t_2 = date of second observation

X_1 = disease severity on first observation

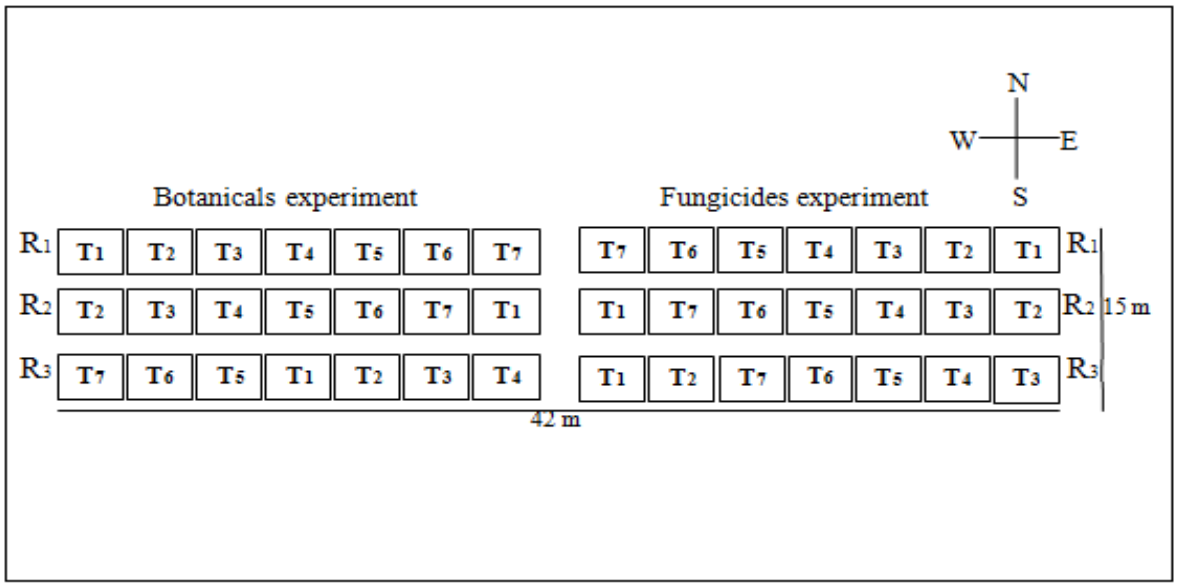
X_2 = disease severity on second observation

3.2 Host range

Twelve host (weed and crop) plants were artificially inoculated with *Erysiphe polygoni* in search of host range. The observations regarding colonization of *Erysiphe polygoni* in different hosts were recorded after 3, 7, 11 and 15 days of inoculation. The hosts receiving fungal colonization were denoted with '+' sign and the hosts showing insensitiveness against *Erysiphe polygoni* were denoted with '-' sign.

3.3 Management of Powdery Mildew of Black Gram

Field experiment performed for testing of both fungicides and botanicals separately in experimental farm of department of plant pathology, IGKV, Raipur during rabi, 2015 with a cultivar of black gram. When total field area was 45×15 m. are divided into two field experiment work conducted in randomized block design (RBD) having 7 treatments with 3 replications plot size were 4×3 m. black gram cultivar gold star was sown on 29 November 2015. Sowing was done by dibbling and maintaining single plant per hill. Recommended cultivation practices were followed timely.



Plant of layout for black gram powdery mildew control

Details of experiment

Crop: black gram **Variety:** gold star **Date of sowing:** 29/11/2015
Seed rate: 20 kg/ha **Fertilizer:** DAP@ 60kg/ha

Fungicides experiment:		**Net plot area**	**Botanicals experiment:**	
Design:	RBD	4m.	**Design:**	RBD
Treatments:	7	3m. $12m^2$	**Treatments:**	7
Replications:	3		**Replications:**	3
Plot size:	4×3 m.		**Plot size:**	4×3m.

Spacing: Row to Row: 30 cm
Plant to Plant: 10 cm

3.3.1 Evaluation of fungicides, botanicals and bio-agent against powdery mildew in the field

Against powdery mildew of the black gram six fungicides were tested and water spray treatment serve as control (Table 3.2). Six fungicides tested were: Sulfex (Elemental sulphur 80%WP), Folicure (Tebuconazole 25.9% EC), Bavistin (Carbendazim 50% WP), Index (Mycobutanil 10% WP), Tide (Propiconazole 25% EC), Roko (Thiophanate methyl 70% WP). Five plant extracts of neem (*Azadirechta indica*), ginger (*Zingiber officinale*), garlic (*Allium sativum*), datura (*Datura stramonium*), karanj (*Pongamia pinnata*) were tested (Table 3.3). Cultural filtrates of *Trichoderma harzianum* and water spray served as control. To prepare neem, datura and karanj extracts 50 gm of fresh leaves were washed with tap water, it chaffed and crushed very well and boiled in 1 liter of water. ginger and garlic extract were prepared by 100 gm of chopped rhizome /bulb were boiled in 1 liter of water and Suspension was filtered through double layer muslin cloth. For culture filtrate *T. harzianum* were grown separately on potato dextrose broth medium in flasks for 15 days. Cultures were filtrated through whatman filter paper no. 1 and the filtrates were used as such separately.

First spray of fungicides, botanicals and one bioagent was taken up of 50 DAS, followed by second spray at 15 days of intervals. Observations of disease severity were recorded 10 days after each spray on randomly selected 5 tagged plants per treatment. The yield data was recorded at crop harvest, percentage disease index and percentage disease control were calculated as follows.

$$\text{Percent disease index (PDI)} = \frac{\text{Total numericals rating}}{\text{Total plants examined} \times \text{Max. grade}} \times 100$$

$$\text{Percent disease control (PDC)} = \frac{\text{PDI in control- PDI in treatment}}{\text{PDI in control}} \times 100$$

Table 3.2: Treatment details of fungicides

Sn.	Common name	Trade name	Concentration
1	Elemental sulphur 80% WP	Sulphex	0.3%
2	Tebuconazole 25.9% EC	Folicure	0.1%
3	Carbendazim 50% WP	Bavistin	0.1%
4	Mycobutanil 10% WP	Index	0.22%
5	Propiconazole 25% EC	Tide	0.05%
6	Thiophanate methyl 70% WP	Roko	0.1%
7	Water spray (control)	-	-

Table 3.3: Treatment details of botanicals

Sn.	Common name	Botanical name	Concentration
1	Garlic	*Alluvium sativum*	10%
2	Ginger	*Zingiber officinale*	10%
3	Neem	*Azadirechta indica*	5%
4	Datura	*Datura stramonium*	5%
5	Karanj	*Pongamia pinnata*	5%
6	*Trichoderma* culture filtrates	*T. harzianum*	5%
7	Water spray (control)	-	-

3.4 Cataloguing of Powdery Mildew Pathogens

The intensive survey had been made around 10 km. periphery of Raipur for collection of the disease plants. These samples brought into the laboratory for disease diagnosis and identification of pathogens. The diseased host symptoms were recorded on basis of visual appearance. The mycelium, conidia and conidiophores of living sample were examined by light microscopy mounted in water. Conidial chains and hyphae were removed from the host surface by pressing german bokia tape on infected portion of host. The conidial chains conidiophores and mycelium etc. were stuck with the bokia tape and this tape were kept on the slide with water drops and examined under microscope. Conidial dimensions were measured by the micrometry. The morphological details of each mildew pathogens

were studied by microphotography as evidence. The coloured photograph of the every powdery mildew host were taken timely with camera sony make.

Severity (intensity) of the disease on different hosts were assessed as per the following scale (0-5 scale), given by (Khan, 1972) as: (-) = No infection i.e., plants without powdery mildew infection; (+) = mild infection (25% infection); (++) = moderate infection, (25-60% infection) and (+++) = heavy infection, (60-100% infection).

Table 3.4: List of host plants under investigation of powdery mildew

SN.	Common name	Botanical name	Family	Date of collection
1	Bawchi	*Psoralea corlifolia*	Fabaceae	15/3/2016
2	Badi doodhi	*Euphorbia hirata* L.	Euphorbiaceae	17/10/15
3	Balsam	*Impatiens balsamina* L.	Balsaminaceae	25/12/15
4	Ber	*Zizyphus jujuba* Lam	Rhamnaceae	9/1/16
5	Bitter gourd	*Momordica charantia* L.	Cucurbitaceae	8/1/16
6	Black gram	*Vigna mungo* L.	Leguminosae	14/9/15
7	Bottle gourd	*Lagenaria vulgaris ser.*	Cucurbitaceae	25/12/15
8	Brinjal	*Solanum melongena* L.	Solanaceae	10/1/16
9	Congress weed	*Parthenium hysterophorus*	Asteraceae	22/1/16
10	Chilly	*Capsicum annum*	Solanaceae	1/2/16
11	Chinese croton	*Excoecaria cochinchinensis*	Euphorbiaceae	21/1/16
12	Chirpoti	*Physalis minima*	Solanaceae	24/12/15
13	Coriander	*Coriandrum sativum* L.	Apiaceae	19/2/16
14	Cow pea	*Vigna unguiculata*	Fabaceae	15/11/15
15	Cucumber	*Cucumis sativus*	Cucurbitaceae	13/10/15
16	Dahlia	*Dahlia variablis*	Asteraceae	20/1/16
17	Fenugreek	*Trigonella foenum*graecum	Leguminosae	5/1/16
18	Green gram	*Vigna radiata* (L) Witezck	Leguminosae	12/9/15
19	Goat weed	*Ageratum conyzoids* L.	Asteraceae	2/12/15
20	Gokhru	*Xanthium strumariiim* L.	Compositae	22/10/15
21	Guar	*Cyamopsis tetragonloba* L.taub	Leguminosae	12/12/15
22	Kundru	*Coccinia indica*	Cucurbitaceae	26/12/15
23	Linseed	*Linum sativum*	Linaceae	18/2/16
24	Marigold	*Calendula officinalis*	Asteraceae	16/3/16
25	Mustard	*Brassica junecea*	Brassicaceae	10/3/16
26	Okra	*Abelmoschus esculentus* L.	Malvaceae	5/10/15
27	Pumpkin	*Cucurbita pepo*	Cucurbitaceae	27/12/15
28	Siriyari	*Heliotropium indicum*	Boraginaceae	27/10/15
29	Sponge gourd	*Luffa cylindrica*	Cucurbitaceae	21/11/15
30	Sunflower	*Helianthus anus*	Asteraceae	20/3/16

CHAPTER – IV
RESULTS AND DISCUSSION

The present chapter deals with the experimental results obtained during the course of investigation on "**Environmental Relationship of Powdery Mildew of Black Gram, Its Management and Documentation of Powdery Mildew Fungi of Chhattisgarh**"

During present investigation, glass house observations were recorded to collect information of the black gram powdery mildew disease epidemiology, host range study of *Erysiphe polygoni*. In the field, fungicides and botanicals for management of powdery mildew and documentation of powdery mildew causing fungi in Chhattisgarh, The results obtained are presented in different sections under various sub-heads.

4.1 Epidemiological Studies on Powdery Mildew of Black Gram

Epidemiology (disease development) of black gram powdery mildew was studied under glass house in *rabi* season, by using susceptible cultivar. Disease severity of different dates of sowing were recorded up to crop harvesting stage (Table 4.1). The data of disease development were correlated with weather factors (Table 4.3) and also calculated apparent infection rate (Table 4.4).

4.1.1 Effect of dates of sowing on powdery mildew severity

During experiments (*Rabi* 2015-2016), it was observed that powdery mildew a prominent disease appeared on the black gram. Further, the severity of powdery mildew and yield of black gram crop was significantly influenced by the different dates of sowing. (Plate 1)

The results presented in the (Table 4.1) indicated that the intensity of powdery mildew and yield of black gram were significantly influenced by different dates of sowing. At 70 DAS the disease intensity showed an increasing trend with the delayed sowing where as the disease was maximum 62.39% on 10 Dec. sown crop followed by 56.15% on 29 Nov. sown crop and 55.02% on 18 Nov. sown crop crop followed by 56.15% on 29 Nov. sown crop and 55.02% on 18 Nov.

sown crop followed by 56.15% on 29 Nov. sown crop and 55.02% on 18 Nov. sown crop. Sown on 29 Nov. it was on par with sowing date 18 Nov. Similarly the minimum disease index (49.23) was obtained in 7 Nov. sown crop. The At 80 DAS the disease intensity showed a increasing trend with the delayed sowing, where the disease intensity was maximum 89.30% on 10 Dec. sown crop followed by 86.59% on 29 Nov. sown crop and 83.73 % on 18 Nov. sown crop. Sown on 29 Nov. it was on par with sowing date 18 Nov. The minimum disease index (71.74%) was obtained in 7 Nov. sown crop (Fig. 4.1).

Table 4.1: Percent disease index of powdery mildew of black gram sown on different sowing dates

Sowing dates	PDI			
	50 DAS	60 DAS	70 DAS	80 DAS
7 Nov. 2015	15.65 (23.30)	35 (36.27)	49.23 (44.56)	71.74 (57.89)
18 Nov. 2015	17.93 (25.05)	26.19 (30.78)	55.02 (47.88)	83.73 (66.21)
29 Nov. 2015	24.39 (29.59)	36.15 (36.96)	56.15 (48.53)	84.39 (66.73)
10 Dec. 2015	27.28 (31.49)	48.36 (44.06)	62.39 (52.17)	89.30 (70.91)
SE (m)±	0.60	1.24	1.74	1.20
CD P= 0.05	1.87	3.89	4.40	3.75

(Figures in parenthesis are arcsine transformed values)

Plate: 1 Glass house view on different dates of sowing of black gram

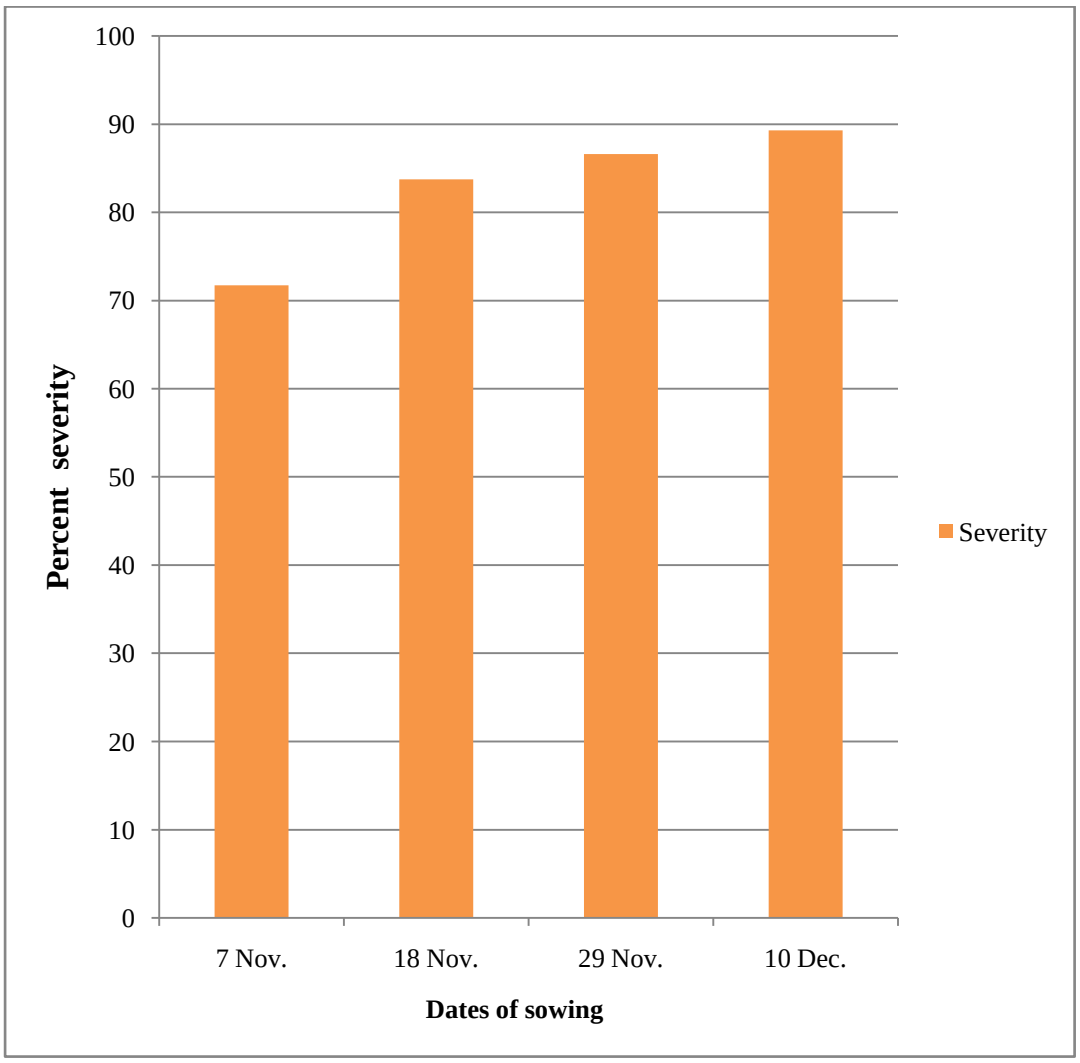


Fig 4.1: Effect of different dates of sowing on powdery mildew severity of black gram (80 DAS)

Adjustment of planting dates is one of the important cultural practices followed to minimize the losses due to the disease. This avoids coincidence with susceptible stage of the crop, thus, resulting in disease escape. Present study revealed that, in the early sown crop of Nov. less incidence of the disease and slower disease progression.

Percent severity of powdery mildew in black gram was significantly influenced by the dates of sowing. It is clear from the results that early sown black gram crop suffered less from the powdery mildew severity than the late sown crop. The second and third date of sowing was found to influence the powdery mildew incidence significantly as compared to other sowings. This might be due to favorable environmental conditions prevailing during the late sowings, which enhance the pathogen to multiply and spread. Similarly, some other workers also reported the influence of the time of sowing on the incidence, development and intensity/ severity of powdery mildew of black gram, green gram, mustard and other crops. .

Mukherjee *et al*. (2013) also found maximum pod production with 26th October sowing which was significantly superior to all other date of sowing followed by 18th November, while, least pod yield was registered with extremely late sown crop (4th December).

Wadje *et al.* (2008) reported that disease intensity was minimum in early sown, moderate in mid-late and maximum in late sown mungbean. Khatri and Gangopadhyay (2008) found that average mildew intensity in pea was significantly lower (24-26% and 29-31%) in early and mid-sown crop whereas, it was significantly higher (33-35%) in late-sown crop. Average seed yield was higher (11.2 to 12q/ha) in crops sown early (Oct 21), while it was low (7.2 to 8.4 q/ha) in late sown crop (Nov.10). Finding of Sanger and Singh (1994) and Thakur *et al*. (2004) are also similar.

Table 4.2: No. of pods per plant in each date of sowing

Sowing dates	No. of pods/ plant
7 Nov. 2015	3 to 4
18 Nov. 2015	2 to 3
29 Nov. 2015	1 to 3
10 Dec. 2015	1 to 2

The disease severity also affected on the number of pods, at the time of harvesting in first sowing date (7th Nov.) showed maximum number of pods (3-4 pods/plant), in second sowing date (18 Nov.), (2-3 pods/ plant) and, third sowing date (29 Nov.), (1-3 pods/plant) and fourth sowing date (10 Dec.), (1-2 pods/ plant). (Table 4.2) clearly indicated that second, third and fourth dates of sowing showed less no. of pods as compared to early first date of sowing.

Kumar *et al.* (2005) found that the late November sown crop escaped the disease to a considerable extent but it also resulted in minimum green pod yield in field pea. While, Nawazi & Narayanaswamy (1983) observed significant reduction in shoot length and plant growth due to powdery mildew in black gram under artificial inoculation conditions. Similar results were also reported by Sharma (2000). The minimum value for all measured parameters was recorded under the last sowing date 9th December. Similar result was reported by Rathi *et al.* (2002) late November sown fenugreek crop shown more than 60 per cent disease intensity which significantly reduced the number of pods per plant and number of seeds per pod.

4.1.2 Interaction study between disease severity and meteorological parameters

In first date of sowing powdery mildew incidence in black gram was observed at 30 DAS in the 49 mw (3-9 Dec.) when maximum temperature was 31.2º c and RH was 88%, second date of sowing disease appeared on 35 DAS, 51 mw (17-23 Dec.) when maximum temperature was 27.7º c and RH was 85% , third date of sowing disease initiated at 36 DAS 1 mw (1-7 Jan.) when maximum temperature was 30.5º c and RH was 82%, in fourth date of sowing disease appeared at 30 DAS, 2 mw (8-14 Jan.) when maximum temperature was 29.3º c

and RH was 87% (Appendix 1).

However in present study, correlation between mildew severity in black gram different dates of sowing and environmental factors has showed different correlated facts. In first date of sowing mildew severity has negative correlation with maximum and minimum temperature, relative humidity (max.) while, relative humidity (min) (Table 4.3). In second, third and fourth date of sowing mildew severity has positive correlation with maximum and minimum temperature, relative humidity (min.) and while, relative humidity (max.) has shown negative correlation with mildew severity.

Table 4.3 Correlation coefficient between powdery mildew and meterological parameters

Dates of sowing	Temperature		Relative humidity	
	Max.	Min.	Max.	Min.
7 Nov. 2015	-0.219	-0.337	-0.099	0.213
18 Nov. 2015	0.403	0.200	-0.661	0.032
29 Nov. 2015	0.626	0.738*	-0.527	0.439
10 Dec. 2015	0.843**	0.874**	-0.748*	0.029

* Significant at 5% ** Significant at 1%

Black gram are grown in *kharif* and as well as in *rabi* season in many parts of India and thereby time required to initiation of disease and severe mildew appear to vary. Hsieh *et al*. (1988) reported, variation in severity of powdery mildew with the season. Soria and Quebral (1973) reported epidemics of powdery mildew in green gram with 25.6ºC, RH 85%, Deshpande and Dhake (1975) due to Erysiphales at 25ºC, Mittal and Sharma (1992) in green gram and black gram kumaon hills of India with maximum temperature 28.5ºC, RH above 70%, Raghuchandran and Rajgopalan (1995) also low minimum and maximum temperature and high RH, Thakur and Agrawal (1995) stated temperature 26 ± 1ºC and RH 85-91% are sutaible for powdery mildew development.

Thus, the results of present study are much in agreement with previous findings. Thakur and Agrawal (1995) reported that a positive correlation occurred between powdery mildew severity and temperature and wind velocity. Highly significant and positive correlation between temperature and disease severity and

non significant correlation between relative humidity and disease severity recorded by Banyal and Tyagi (1998). Khare *et al*. (1998) reported that disease severity was positively correlated with maximum temperature and non significant correlation between disease severity and relative humidity. Kumar and Gupta (2006) also reported that highly significant and positive correlation was observed between temperature and disease severity. Abbaiah (1989) and Saxena and Moly (1993) reported a negative correlation between powdery mildew and relative humidity. Findings of present investigation are in line with the findings of earlier workers.

Table 4.4: Apparent infection rate of powdery mildew development on different dates of sowing

	Apparent infection rate (r)			
Date of sowing	Flowering stage	Pod development stage		Maturity stage
7 Nov. 15	0.001709	0.001637	0.000370	0.000275
18 Nov. 15	0.002346	0.000802	0.000895	0.000278
29 Nov. 15	0.000815	0.000603	0.000454	0.000278
10 Dec. 15	0.001121	0.001475	0.000208	0.000213

The spread of powdery mildew was dependent on the susceptibility of host variety and crop growth stages. In all dates of sowing, maximum disease increment in full flowering to pod development stage, which aggravated up to plant maturity. (Table 4.4). Growth stage of the plant appears to be an important factor for powdery mildew development as observed by Sivaprakasam *et al*. (1981) and Sharma (1992) corroborating with the present findings.

4.2 Host-range and pathogenicity of *Erysiphe polygoni* DC

Black gram *Erysiphe ploygoni* DC dust was inoculated in twelve different hosts to determine host range. The inoculated plants were observed for the development of symptoms on 3, 7, 11 and 15 days after inoculation (Table 4.5).

Table 4.5: Host-range and pathogenicity of *Erysiphe polygoni* DC

SN.	Host Name	Family	Infection after inoculation (Days)			
			3	7	11	15
1	*Parthenium hysterophorus* L.	Compositae	-	-	-	-
2	*Lathyrus sativus L.*	Papilionaceae	+	+	+	+
3	*Pisum sativum*	Fabaceae	-	-	-	+
4	*Vigna radiata* (L.) Wilczek	Leguminosae	-	-	+	+
5	*Glycine max*	Fabaceae	-	-	+	+
6	*Helianthus anus sp*.	Compositae	-	-	-	-
7	*Solanum lycopersicum*	Solanaceae	-	-	-	-
8	*Euphorbia hirta L.*	Euphorbiaceae	-	-	+	+
9	*Linum usitatissimum*	Linaceae	-	-	-	-
10	*Tagetes sp.*	Asteraceae	-	-	-	-
11	*Coriandrum sativum*	Apiaceae	-	-	-	-
12	*Trigonella foenumgraecum*	Leguminosae	-	-	+	+

Lathyrus sativus L. was the first to show the powdery mildew symptoms at 3 days. After 11 days of inoculation the infection was observed in *Vigna radiata* (L.) Wilczek, *Glycine max, Euphorbia hirta L.*and *Trigonella foenumgraecum*. The latent period was longer (15 days) for *Erysiphe polygoni* DC to infect *Pisum sativum.* The plant species namely *Parthenium hysterophorus* L, *Helianthus anus sp*., *Solanum lycopersicum, Linum usitatissimum, Tagetes sp.*and *Coriandrum sativum* showed insensitiveness towards the *Erysiphe polygoni* DC.

In a study of host range of powdery mildew pathogen, 12 hosts including cultivated and wild species were used. Out of these. *Erysiphe polygoni* was found

to infect six host viz., *Lathyrus sativus L., Pisum sativum, Vigna radiata* (L.) Wilczek, *Euphorbia hirta L,*and *T. foenumgraecum.* Yarwood (1957) noticed narrow range of hosts for this pathogen *(P. arvense, Lathyrus* spp. And *P. sativum).* On the other hand Munshi and Jhooty (1980) observed *Erysiphe polygoni* infect 13 species of plants. Bhardwaj and Singh (1984) found that most of the legumes were susceptible to *Erysiphe polygoni.*

4.3 Management of Powdery Mildew of Black Gram

The effect of spraying of fungicides and botanicals on PDI, yield of black gram were studied in gold star variety of black gram. (Tables 4.6 and 4.7) The results are presented under various heads as follows,

4.3.1 Evaluation of fungicides to control powdery mildew in the field

The fungicides used as spray were Elemental sulphur 80% WP (0.3%), Tebuconazole 25.9% EC (0.1%), Carbendazim 50% WP (0.1%), Mycobutanil 10% WP (0.22%), Propiconazole 25% EC (0.05%), Thiophanate methyl 70% WP (0.1%) and water sprayed plot served as control. All the treatments were replicated thrice in a randomized block design. Final observation was taken 15 days after first and second spray. Yield of each fungicide treated plot was also recorded including control.

It is revealed from the data (Table 4.6) that all treatments significantly reduced the powdery mildew severity in black gram (Fig. 4.2) and (Plates 2A and 2B). All the treatments were found effective against the powdery mildew and significantly reduced the disease severity over control. The disease severity recorded 15 days after first and second spray ranged from 31.52 % to 38.87 % and 19.77% to 36.87%, respectively, which were significantly lower than control with disease severity of 50.88% and 68.44% respectively after first and second spray treatments. Among the tested fungicides, Folicur (tebuconazole 25.9% EC) proved most effective giving 71.25% disease control, followed by Tide (propiconazole 25% EC) (PDC, 59.98%), Sulfex (elemental sulphur 80%WP) (PDC, 56.92%), Bavistin (carbendazim 50% WP) (PDC, 55.09%), Roko (thiophanate methyl 70% WP) (PDC, 48.58%) and Index (Mycobutanil 10% WP) (PDC, 44.72%).

Table 4.6: Effect of different fungicides on powdery mildew and yield of black gram

	Treatment	After I spray		After II spray					
		PDI	**PDC**	**PDI**	**PDC**	**Yield g/plot**	**Yield kg/ha**	**%increase in grain yield**	**Test wt. (gram)**
1.	Elemental sulphur 80%WP	35.09 (36.31)	31.06	29.06 (32.57)	56.92	762	635	38.90	39.85
2.	Tebuconazole 25.9% EC	24.19 (33.31)	52.53	19.77 (26.35)	71.25	805	671	50.09	41.04
3.	Carbendazim 50% WP	36.18 (36.97)	28.58	30.64 (33.61)	55.09	735	612	34.12	39.49
4.	Mycobutanil 10% WP	38.87 (38.52)	23.97	36.87 (37.19)	44.72	679	565	23.72	37.96
5.	Propiconazole 25% EC	31.52 (34.15)	37.82	27.06 (31.32)	59.98	763	636	39	40.40
6.	Thiophanate methyl 70%WP	37.51 (37.64)	25.82	36.84 (36.17)	48.58	717	597	30.71	38.39
7.	Control	50.88 (45.50)	-	68.44 (55.89)	-	549	457	-	34.70
	SE(m)±	**2.05**	-	**2.23**	-	**43.40**	**36.21**	-	-
	CD at 5 %	**6.10**	-	**6.95**	-	**135.23**	**112.81**	-	-

(Figures in parenthesis are arcsine transformed values)

PDI – Percent Disease Intensity

PDC – Percent Disease Control

Field view of fungicides trial against powdery mildew disease

Tebuconazole 25.9 EC (0.1%)

Propiconazole 25% EC (0.05%)

Plate 2.A: Effect of fungicides on powdery mildew under field

Elemental sulphur 80%WP (0.3%)

Carbendazim 50% WP (0.1%)

Thiophanate methyl 70% WP (0.1%)

Mycobutanil 10% WP (0.22%)

Plate 2.B: Effect of fungicides on powdery mildew under field

All the treatments were superior over control in respect of grain yield as well as test weight. However, highest grain yield (671 kg/ha), test weight (41.04 g.) and yield increase over control was by (50.09%) were obtained in the treatment Tebuconazole (folicur) this was followed by Propiconazole (tide) (636 kg/ha, 40.40 g. and 39%), Elemental sulphur (sulfex) (635 kg/ha, 39.85 g. and 38.90%), Carbendazim (bavistin) (612 kg/ha, 39.49 g. and 34.12%), Thiophanate methyl (roko) (597 kg/ha, 38.39 g. and 30.71) and Mycobutanil (index) (565 kg/ha, 37.96 g. and 23.72%). The yield obtained in control was 457 kg/ha (Fig. 4.3).

In the field condition, spraying of Tebuconazole was found to be most effective in reducing the powdery mildew incidence which was followed by Propiconazole, Elemental sulphur, Carbendazim, Thiophanate methyl and and Mycobutanil. Several workers also reported the effectiveness of Tebuconazole, Propiconazole, Elemental sulphur and Carbendazim against the powdery mildew pathogen on different crops. Huq and Nahar (1997) tested 4 fungicides viz., Propiconazole, Tridemorph, Tebuconazole and Sulphur against powdery mildew of pea under field conditions and obtained effective control of the disease with Tebuconazole (0.05%), giving benefit cost ratio of 5.69.

Earlier findings of Sharmila *et al*. (2004) on promising efficacy of various triazole fungicides against powdery mildew substantiate the present finding regarding triazole fungicides, *viz*., Tebuconazole. Patel (2007) reported Tebuconazole is best for control of powdery mildew in mustard as compared to Elemental sulphur.

Finding of Singh *et al.* (1983), Naik and Nagaraj (2000) revealed that, Propiconanzole, Carbendazim were effective in reducing powdery mildew.

Among different treatments, application of Tebuconazole showed the highest increase in the yield over control, it was followed by Propiconazole, Sulfex and Carbendazim. Similarly, Srivastava (1996), Setty *et al.* (1996), Huq and Nahar (1997), Prasad and Dwivedi (2007), Manojkumar (2008) and Surwase *et al.* (2009) also reported the increase in the yield by spraying of almost same fungicides. Thus, agreeing with present investigation.

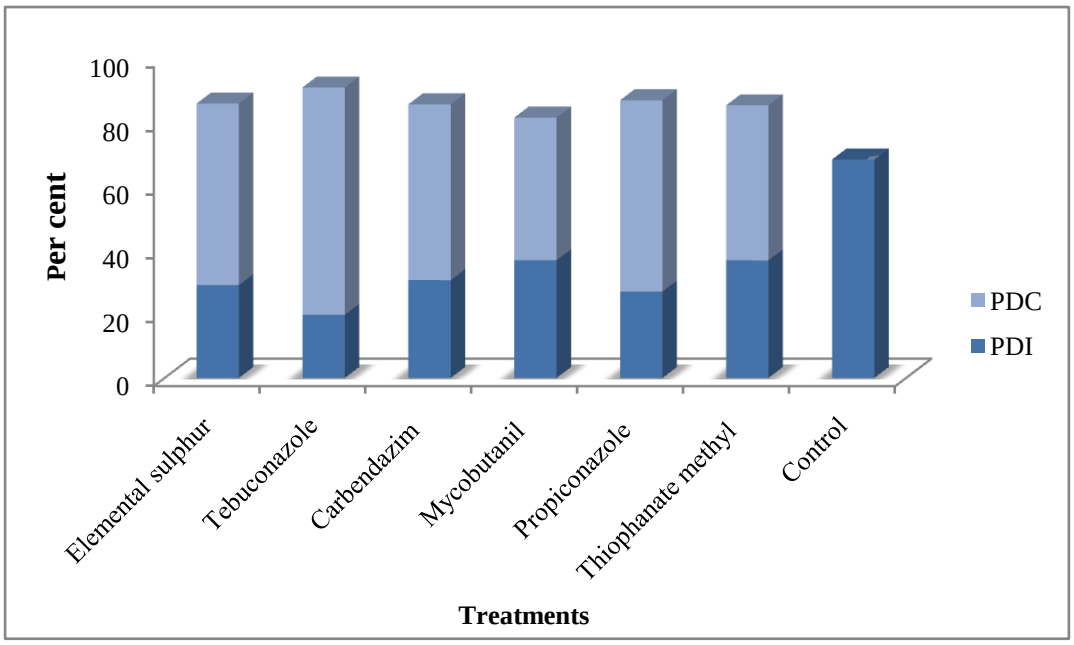


Fig 4.2: Effect of different fungicides on powdery mildew of black gram

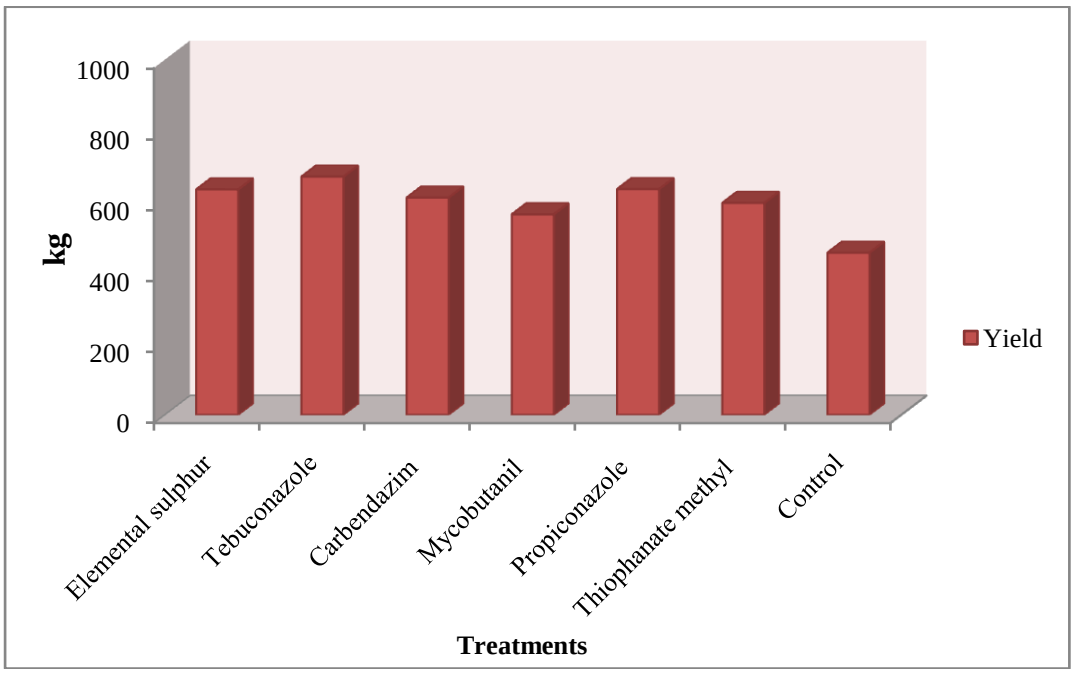


Fig 4.3: Effect of different fungicides on yield of powdery mildew of black gram

4.3.2 Evaluation of botanicals and bio-agent to control powdery mildew in the field

The botanicals used as spray were garlic (10%), ginger (10%), neem (5%), datura (5%), karanj (5%) and one treatment of biocontrol agent cultural filtrates of T*richoderma harzianum* (5%). Water sprayed plot served as control. All the treatments were replicated thrice in a randomized block design. Final observation was taken 15 days after first and second spray. Yield of each treated plot was also recorded including control (Plates 3A and 3B).

It is revealed from the data (Table 4.7) that powdery mildew intensity reduced significantly over control in neem, ginger and garlic botanicals spray treatments. Among the botanicals tested, neem leaf extract was most effective and recorded minimum disease severity (28.04%) which was at par with garlic (29.29%) followed by the botanicals ginger (37.53%), karanj (45.11%), datura (50.63%) and *Trichoderma* (54.40%)). Disease severity of control treatment was 66.84% (Fig. 4.4). Spray of botanicals treatments most effective disease control was given by neem (PDC, 57.82%) which was at par with garlic (PDC, 54.92%) and followed by ginger (PDC, 43.18%), karanj (PDC, 30.60%), datura (PDC, 22.23%) and *Trichoderma* (PDC, 17.53%) (Fig. 4.4). Only the neem, garlic and ginger treatments were superior to control in respect to grain yield and test weight. However, highest grain yield (555 kg/ha), test weight (37.93 g.) and yield increase over control was by (44.12%) were obtained in the treatment neem which was at par with garlic (603 kg/ha, 37.07 g. and 30.56%) and followed by ginger (464 kg/ha, 34.91 g. and 20.44%). Poor yield were obtained in karanj (433 kg/ha, 33.83 g. and 0.12%) The very poor yield were obtained in *Trichoderma* and dhatura (410 kg/ha and 420 kg/ha), test weight (32.67 g. and 33.50 g.) and yield increase overcontrol was (0.06% and 0.08%) respectively. The yield obtained in control was 385 kg/ha. (Fig. 4.5).

Several workers also reported the effectiveness of neem, garlic and ginger against the powdery mildew pathogen on different crops. Botanicals, NSKE, ginger and garlic were reported fungicidal against *Erysiphe polygoni*, causing powdery mildew in pea, mungbean, urdbean and other crops and other species of

Table 4.7: Effect of different botanicals and bio-agent on powdery mildew and yield of black gram

	Treatment	After I spray		After II spray		Yield g/plot	Yield kg/ha	%increase in grain yield	Test wt. (gram)
		PDI	PDC	PDI	PDC				
1.	Ginger	40.07 (39.25)	17.61	37.53 (37.73)	43.18	557	464	20.44	34.91
2.	Garlic	35.14 (36.28)	27.13	29.29 (32.65)	54.92	603	503	30.56	37.03
3.	Neem	35.08 (36.20)	29.40	28.04 (31.88)	57.82	666	555	44.12	37.93
4.	*Trichoderma*	45.58 (42.44)	6.03	54.40 (47.53)	17.53	492	410	0.06	32.67
5.	Datura	46.92 (43.22)	3.69	50.63 (45.36)	22.23	520	420	0.08	33.50
6.	Karanj	45.77 (42.56)	6.22	45.11 (42.17)	30.60	502	433	0.12	33.83
7.	Control	49.25 (44.57)	-	66.51 (54.74)	-	462	385	-	32.22
	SE(m)±	**2.53**	-	**2.52**	-	**34.50**	**28.77**	-	-
	CD at 5 %	**NS**	-	**7.87**	-	**107.48**	**89.65**	-	-

(Figures in parenthesis are arcsine transformed values)

PDI – Percent Disease Intensity

PDC – Percent Disease Control

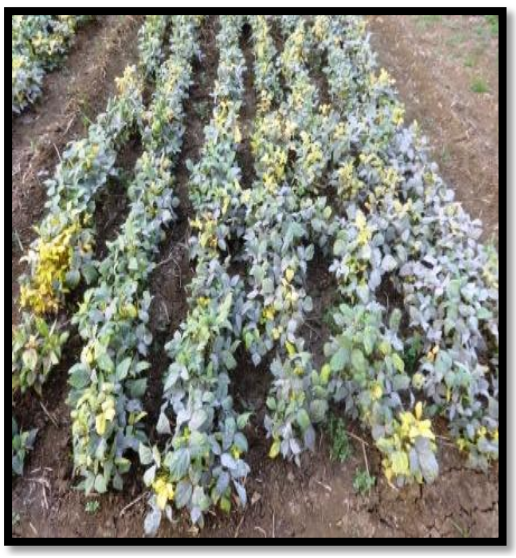
Field view of botanicals trial against powdery mildew disease

Neem (5%) Garlic (10%)

Plate 3.A: Effect of botanicals on powdery mildew under field

Ginger (10%)

Karanj (5%)



Dhatura (10%)

Trichoderma (5%)

Plate 3.B: Effect of botanicals on powdery mildew under field

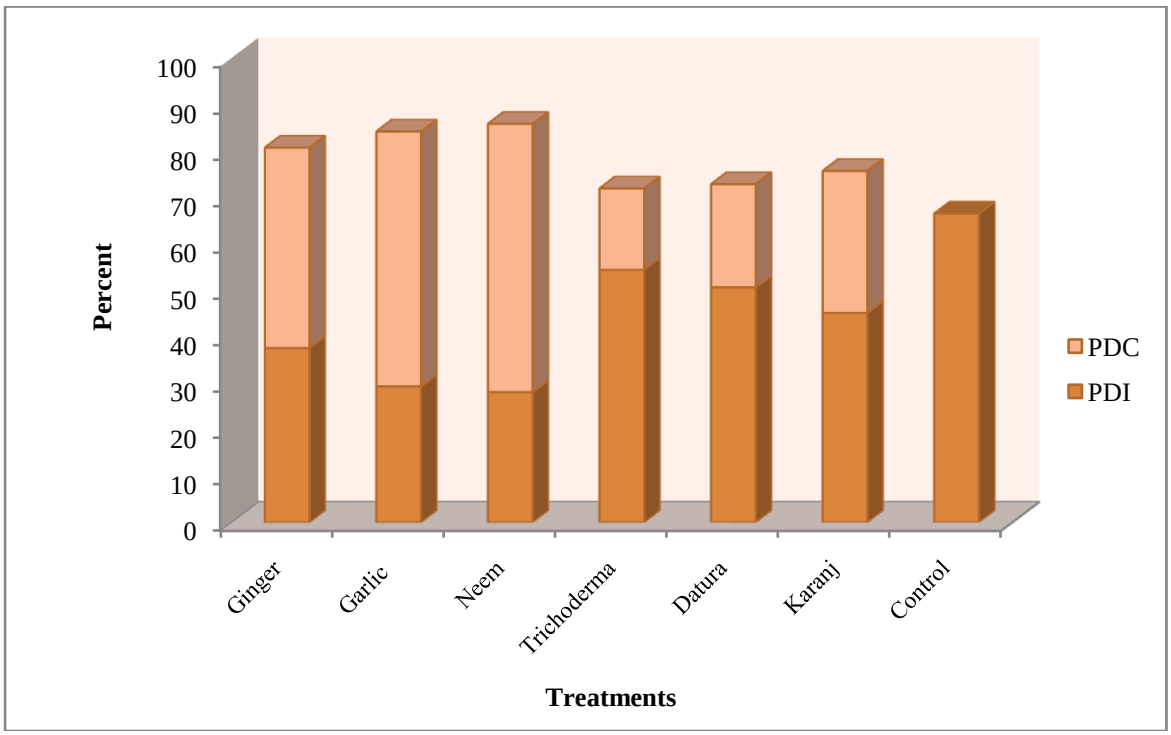


Fig 4.4: Effect of different botanicals and bio-agent on powdery mildew of black gram

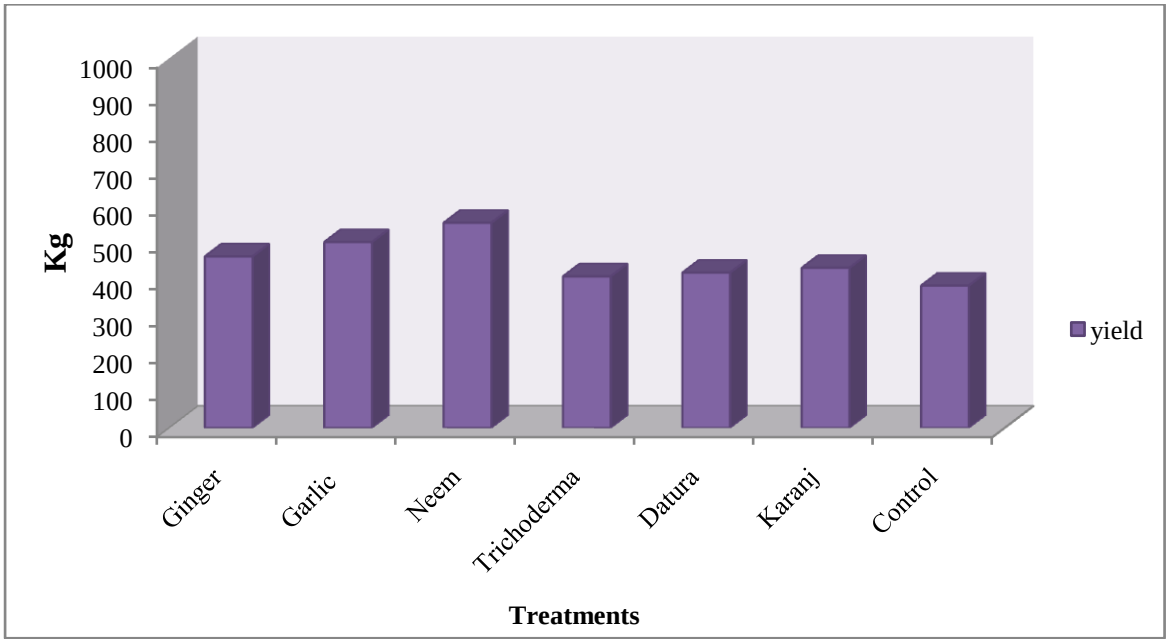


Fig 4.5: Effect of different botanicals and bio-agent on yield of powdery mildew of black gram

Erysiphe causing powdery mildew in agronomical and horticultural crops earlier by (Maurya *et al.* 2004). Singh *et al.* (1991) used ginger rhizome extract against powdery mildew of pea, the results were statistically significant. Prithviraj *et al.* (1998) evaluated efficacy of ajoene, a constituent of garlic and Neemazol, a product of neem against powdery mildew of pea, reduced disease intensity compared to control. Surwase *et al.* (2009) reported NSKE and Ginger was found most effective and recorded minimum mean disease intensity (18.8%) and (10%) respectively and giving better seed yield. Deore and Sawant (2000) found various species of *Trichoderma* quite effective against powdery mildew of guar. So far, investigation on biocontrol potential of the species of *Trichoderma* has been largely concentrated for soil borne diseases.

Among different botanicals treatments, application of neem showed the highest increase in the yield over control, it was followed by garlic and ginger, similar results were obtained by Surwase *et al.* (2009), Hifsa and Shabeer (2005).

4.4 Cataloguing of Powdery Mildew Pathogens

An intensive survey was carried out from Sep. 2015 up to Mar. 2016 Studies carried out in this survey were mainly to record the occurrence of powdery mildew fungi on cultivated as well as wild host.

4.4.1 Monthly distribution of powdery mildew pathogens on their hosts

The data from the Table 4.8 shows that four genera (viz. *Erysiphe* spp., *Sphaerotheca* spp., *Oidium* spp. and *Leveillula* spp.) were recorded in thirty host plants from Sep. 2015 up to Mar. 2016. (Table 4.9 and Table 4.10) The occurrence of genus *Erysiphe* spp. were recorded during the entire investigation period. Whereas the occurrence of the other genus like *Oidium* spp. in December and January, *Sphaerotheca* in October, December and January, *Leveillula* spp. in December, February and March months were also recorded.

Table 4.8: List of 30 host species were infested by powdery mildew pathogen

Sn.	Hosts	Pathogens	Ratings
1	*Vigna radiata* (L.) Wilczek	*Erysiphe polygoni*	+ +
2	*Vigna mungo* (L.) Hepper	*Erysiphe polygoni*	+ +
3	*Abelmoschus esculentus*	*Erysiphe cichoracearum*	+ + +
4	*Cucumis sativus*	*Erysiphe cichoracearum*	+ +
5	*Euphorbia hirata*	*Sphaerotheca euphorbiae*	+
6	*Xanthium strumariiim* L.	*Erysiphe cichoracearum*	+ + +
7	*Heliotropium indicum*	*Oidium heliotropii-indici*	+ + +
8	*Vigna unguiculata* (L.)	*Erysiphe polygoni*	+ +
9	*Luffa cylindrica*	*Erysiphe cichoracearum*	+ +
10	*Ageratum conyzoids* L.	*Sphaerotheca fuliginea*	+ +
11	*Cyamopsis tetragonloba* L.	*Leveillula spp.*	+ +
12	*Physalis minima*	*Sphaerotheca fusca*	+ +
13	*Impatiens balsamina L.*	*Sphaerotheca fuliginea*	+ +
14	*Lagenaria vulgaris ser.*	*Sphaerotheca fuliginea*	+
15	*Coccinia indica*	*Erysiphe cichoracearum*	+ +
16	*Cucurbita pepo*	*Erysiphe cichoracearum*	+ +
17	*Trigonella foenum*graecum	*Erysiphe polygoni*	+
18	*Momordica charantia* L.	*Sphaerotheca fuliginea*	+
19	*Zizyphus jujuba* Lam.	*Oidium zizyphae*	+ +
20	*Solanum melongena*	*Sphaerotheca fuliginea*	+ +
21	*Dahlia variablis*	*Erysiphe cichoracearum*	+ +
22	*Excoecaria cochinchinensis*	*Sphaerotheca sp.*	+
23	*Parthenium hysterophorus*	*Erysiphe cichoracearum*	+
24	*Capsicum annum* L.	*Leveillula taurica*	+ +
25	*Linum sativum*	*Leveillula taurica*	+ + +
26	*Coriandrum sativum* L.	*Erysiphe hereclei*	+ +
27	*Brassica junecea*	*Erysiphe cichoracearum*	+ + +
28	*Psoralea corlifolia*	*Erysiphe sp.*	+ +
29	*Calendula officinalis*	*Leveillula taurica*	+ +
30	*Helianthus anus*	*Erysiphe cichoracearum*	+ +

Erysiphe polygoni, Patel *et* a*l*. 1949. Indian Phytopath., 2: 142-155.

Host: *Vigna radiata* (L.) **Wilczek**

Observed symptoms:

White small diffused spots on the upper surface of leaf were noticed and also seen on pods, twigs and stem. Mycelium on leaves, superficial, form a thick coating on the upper surface (Epiphyllous) and very sparse on the lower surface (Hypophyllous) of the leaves and twigs.

Microscopic observation and measurement:

Hyphae hyaline, smooth, branched, septate varying from 4.36 um-7.89 um, average 6.59 um in width. Conidiophores hyaline euoidium type, cylindrical at base. composed of 3-4 cells, 86.05 um - 121.15 um × 10.40 um-13.20 um, average 96.01 um × 12.16 um, foot cell 27.89-35.57 um in length. Conidia unicellular, hyaline, cylindrical to ovate, 26.43 um-36.71 um × 14.52 um-18.20 um, average 31.50 × 16.65 um, produced in chain. Germ tube terminal and subterminal. (Plate 4)

Habitat:

On living leaves of *Vigna radiata* (L.) Leguminoceae. 12/9/2015, experimental field of Plant breeding and genetics Department, College of Agriculture, Raipur (C.G).

Diagnostic characters:

Conidiophores - Euoidium type

Germ tube- Terminal and subterminal

Erysiphe polygoni, Patel *et* a*l*. 1949. Indian Phytopath., 2: 142-155.

Host: *Vigna mungo* (L.) Heppr

Observed symptoms:

White powdery growth covers completely both the leaf surfaces and irregular spots on twigs. Mycelium on leaves superficial, form thick coating on the upper surface (Epiphyllous) and very sparse in lower surface (Hypophyllous) of the leaves.

Microscopic observation and measurement:

Hyphae hyaline, branched, septate, varying from 5.91 um-7.67 um, average 6.90 um in width. Conidiophores hyaline, cylindrical at the base, composed of 3-4 cells, 75.22 um-100.72 um × 14.42 um-11.12 um, average 90.40 um × 13.18 um, foot cell 24.48-55.81 um in length. Conidia unicellular, hyaline, ovate, 21.71 um-32.14um × 15.50 um-20.15 um, average 30.71 um × 16.46 um, produced singly. Germ tube subterminal and cylindrical. (Plate 5)

Habitat:

On living leaves of *Vigna mungo* (L.) Heppr. 14/9/2015, experimental field of Plant breeding and genetics Department, College of Agriculture, Raipur (C.G).

Diagnostic characters:

Conidiophores - Pseudoidium type

Germ tube - Subterminal, cylindrical.

Symptoms on host

Conidiophore, conidia and conidial germination

Host: *Vigna radiata* (L.) Wilczek

Pathogen: *Erysiphe polygoni*

Plate 4: Powdery mildew Symptoms on *Vigna radiata* (L.) Wilczek and conidiophore, conidia & conidial germination of *Erysiphe polygoni*

Symptoms on host

Conidiophore, conidia and conidial germination

Host: *Vigna mungo* (L.) Heppr

Pathogen: *Erysiphe polygoni*

Plate 5: Powdery mildew Symptoms on *Vigna mungo* (L.) Heppr and conidiophore, conidia & conidial germination of *Erysiphe polygoni*

Erysiphe cichoracearum, Prabhu *et al.* 1971. Indian J. Hort., 28: 310-312.

Host: *Abelmoschus esculentus*

Observed symptoms:

Appearance of dirty white powdery mass on leaves and stem. White powdery mass covered both the leaf surfaces completely. Mycelium on leaves, superficial, form a thick coating on the upper surface (Epiphyllous) and sparse on the lower surface (Hypophyllous) of the leaves.

Microscopic observation and measurement:

Hyphae hyaline, smooth, branched, septate varying from 5.52 um-8.14 um, average 6.83 um in width. Conidiophores hyaline, cylindrical at the base, composed of 3-4 cells, 75.52 um-131.41 um × 10.52 um-14.44 um, average 96.46 um × 12.30 um, foot cell 29.88-52.57 um in length. Conidia were single celled, oval to roundish or barrel-shaped, hyaline, without fibrosin bodies 26.13 um-36.83 um to 11.12 um-19.92 um, average 30.82 × 16.67 um produced in chain. Germ tube subterminal. (Plate 6)

Habitat:

On living leaves of *Abelmoschus esculentus* L. (Malvaceae). 13/10/2015, experimental field of vegetable science Department, College of Agriculture, Raipur (C.G).

Diagnostic characters:

Conidiophores - Euoidium type

Germ tube- Subterminal

Erysiphe cichoracearum, Lazzeri *et al.* 2009. Eur. J. Plant Pathol., 124: 613-619.

Host: *Cucumis sativus*

Observed symptoms:

White, powdery fungal growth develops on both leaf surfaces, petioles, and stems. Mycelium on leaves, superficial, form a thick coating on the upper surface (Epiphyllous) and sparse on the lower surface (Hypophyllous) of the leaves.

Microscopic observation and measurement:

Hyphae hyaline, smooth, branched, septate varying from 5.28um-7.47 um, average 6 um in width. Conidiophores hyaline, cylindrical at the base, composed of 3-4 cells, 82.79 um-131.24 um × 9.27 um - 12.14 um, average 104.74 um × 10.13 um, foot cell 36.16-55.20 um in length. Conidia were single celled, oval to roundish or barrel-shaped, hyaline, with fibrosin bodies 25.07 um-32.25 um to 10.80 um-17.86 um, average 28.64 × 15.53 um produced in chain. Germ tube subterminal. (Plate 7)

Habitat:

On living leaves of *cucumis sativus*.13/10/2015, experimental field of vegetable science Department, College of Agriculture, Raipur (C.G).

Diagnostic characters:

Conidiophores - Euoidium type

Germ tube- Subterminal

Symptoms on host

Conidiophore, conidia and conidial germination

Host: ***Abelmoschus esculentus***

Pathogen: ***Erysiphe cichoracearum***

Plate 6: Powdery mildew Symptoms on *Abelmoschus esculentus* and conidiophore, conidia & conidial germination of *Erysiphe cichoracearum*

Symptoms on host

Conidiophore, conidia and conidial germination

Host: *Cucumis sativus*
Pathogen: *Erysiphe cichoracearum*

Plate 7: Powdery mildew Symptoms on *Cucumis sativus* and conidiophore, conidia & conidial germination of *Erysiphe cichoracearum*

***Sphaerotheca euphorbiae*,** Rao, P.N. 1961. Curr. Sci., 30: 433-435.

Host: *Euphorbia hirata*

Observed symptoms:

The upper leaf surface shows whitish spots to begin with and may be totally covered lower surface and powdery mycelium fully colonized on leaves

Microscopic observation and measurement:

Hyphae were thin-walled, branched and unseptate varying from 5.37 um -6.74 um, average 6.25 um in width. Conidiophores straight or slightly curved, hyaline, cylindrical at the base, composed of 3-4 cells, 84.14 um-145.12 um × 8.37 um-11.47 um, average 108.58 um × 9.84 um, foot cell 32.61-60.19 um in length. Conidia were single celled, oval to round, hyaline 23.63 um-33.15 um to 12.13 um-15.27 um, average 26.45 × 13.58 um produced in singly. Germ tube subterminal and centrally knob like. (Plate 8)

Habitat:

On living leaves of *Euphorbia hirata*.17/10/2015, village mana , Raipur (C.G).

Diagnostic characters:

Conidiophores - Euoidium type

Germ tube - Subterminal and centrally knob like.

Erysiphe cichoracearum, Khan *et al.* 1977. Act Botanica Indica, 5: 139-142.

Host: *Xanthium strumariiim* L.

Observed symptoms:

White diffused spots on the upper surface of the leaf, covers entire leaf lamina with white powdery growth. Mycelium on leaves superficial, form thick coating on the upper surface (Epiphyllous) and very sparse in lower surface (Hypophyllous) of the leaves.

Microscopic observation and measurement:

Hyphae hyaline, smooth, branched, septate, varying from 4.92 um-7.52 um, average 5.94 um in width. Conidiophores hyaline, cylindrical at the base, composed of 3-4 cells, 93.63 um-162.27 um × 8.92 um-13.35 um, average 127.87 um × 10.47 um, foot cell 27.45-51.42 um in length. Conidia unicellular, hyaline, ovate, 22.32 um-33.84 um × 8.06 um-13.87 um, average 28.38 um × 12.83 um, produced in chain. Germ tube subterminal. (Plate 9)

Habitat:

On living leaves of *Xanthium strumarium* L. (Compositae).22.10.2015, village mana , Raipur (C.G.).

Diagnostic characters:

Conidiophores - Euoidium type

Germ tube – Subterminal

Symptoms on host

Conidiophore, conidia and conidial germination

Host: *Euphorbia hirata*
Pathogen: *Sphaerotheca euphorbiae*

Plate 8: Powdery mildew Symptoms on *Euphorbia hirata* and conidiophore, conidia & conidial germination of *Sphaerotheca euphorbia*

Symptoms on host

Conidiophore, conidia and conidial germination

Host: *Xanthium strumariiim* L.
Pathogen: *Erysiphe cichoracearum*

Plate 9: Powdery mildew Symptoms on *Xanthium strumariiim* L. and conidiophore, conidia & conidial germination of *Erysiphe cichoracearum*

Oidium heliotropii-indici, Algodao *et al.* 2010. Australasian Plant Disease Notes, 5: 87–89.

Host: *Heliotropium indicum*

Observed symptoms:

White, powdery growth on both sides of the leaf, initially as small circular to irregular colonies, later usually covering the entire leaf area, giving a silvery aspect to the upper side of the leaves. Mycelium superficial, effuse, form thick coating on the upper surface (Epiphyllous) and very sparse on the lower surface (Hypophyllous) of the leaves.

Microscopic observation and measurement:

Hyphae hyaline, smooth, branched, septate, varying from 5.27um-7.12um, average 6.13 um in width. Conidiophores hyaline, erect, straight to slightly curved, cylindrical, composed of 1-3 cells in chain, 75.38 um-121.34 um × 9.37 um-12.54 um, average 98.13 um × 10.20 um, foot cell 36.17-65.93 um in length. Conidia unicellular, hyaline, ellipsoid-ovoid to doliform with fibrosin bodies distributed, 20.82 um-36.10 um × 9.81 um - 17.79 um, average 24.37 um × 12.95 um, produced in chain. Germ tube subterminal. (Plate 10)

Hyperparasite :

Cicinnobolus cessati (Ampelomyces). some conidiophores are parasiteized by this parasite.

Habitat:

On living leaves of *Heliotropium indicum* , 27.10.2015, krishak nagar, Raipur (C.G.).

Diagnostic characters:

Conidiophores - Oidium type

Germ tube – Subterminal

***Euoidium* spp.,** Roy, A. K. 1973. Indian Phytopath., 26: 578 - 581.

Host: *Vigna unguiculata* (L.) Walp

Observed symptoms:

Forming irregular white patches, sometimes effused to cover the whole leaf surface and stem. Mycelial growth was amphigenous, thick coating on surface of leaves and have epiphytic.

Microscopic observation and measurement:

Hyphae hyaline, smooth, branched, septate, varying from 5.58 um-7.28 um, average 6.61 um in width. Conidiophores hyaline, simple, straight and cylindrical at the base, composed of single hyphal cell, 71.94 um-147.15 um × 8.74 um-12.44 um, average 107.57 um × 10.18 um, foot cell 27.17-45.32 um in length. Conidia unicellular, hyaline, ovate, 23.41 um-31.32 um × 11.67 um-16.58 um, average 26.61 um × 14 um, produced in chain. Germ tube subterminal. (Plate 11)

Habitat:

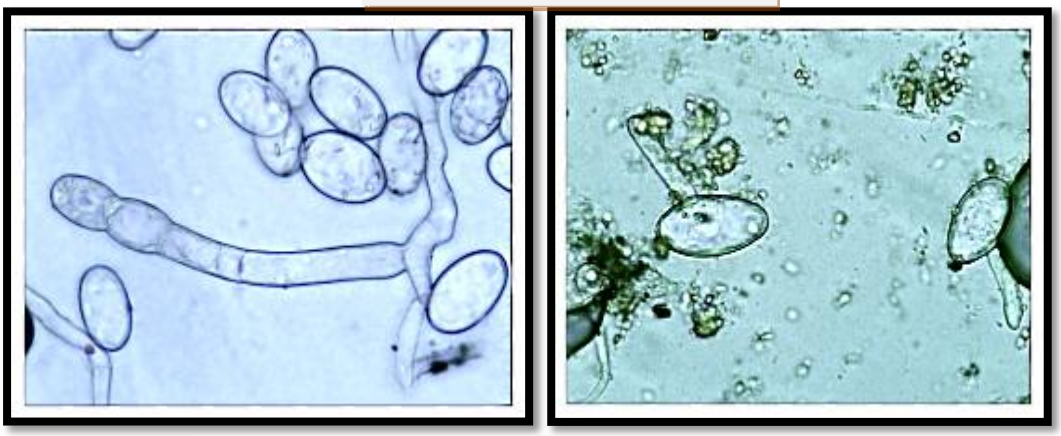
On living leaves of *Vigna unguiculata* (L.) Walp (Leguminosae). 15.11.2015, Vegetable Farm of Breeding Department, Raipur (C.G.).

Diagnostic characters:

Conidiophores - Euoidium type

Germ tube - Subterminal

Symptoms on host

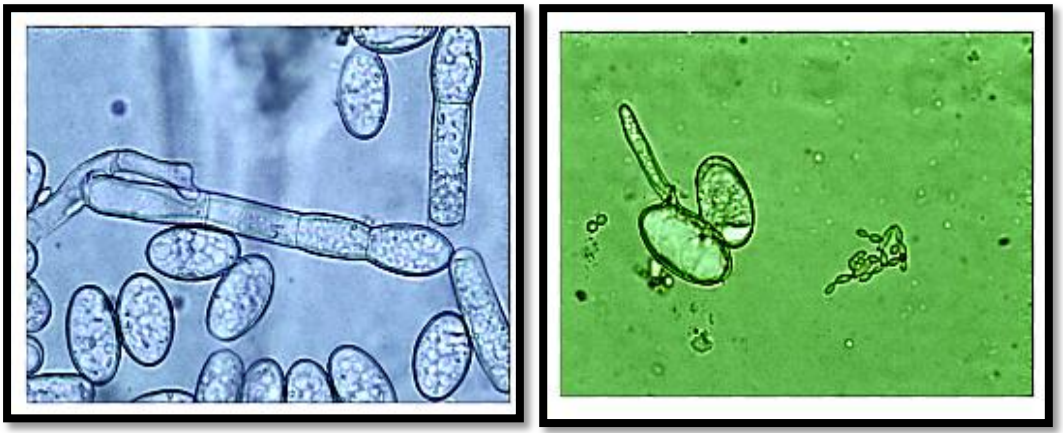


Conidiophore, conidia and conidial germination

Host: *Heliotropium indicum*
Pathogen: *Oidium heliotropii-indici*

Plate 10: Powdery mildew Symptoms on *Heliotropium indicum* and conidiophore, conidia & conidial germination of *Oidium heliotropii-indici*

Symptoms on host



Conidiophore, conidia and conidial germination

Host: *Vigna unguiculata* (L.) Walp
Pathogen: *Erysiphe polygoni*

Plate 11: Powdery mildew Symptoms on *Vigna unguiculata* (L.) Walp and conidiophore, conidia & conidial germination of *Erysiphe polygoni*

Erysiphe cichoracearum, Khan *et al.* 1977. Act Botanica Indica, 5: 139-142.

Host: *Luffa cylindrica*

Observed symptoms:

Powdery mildew was found as small, white patches of while powdery growth on leaves. These enlarges rapidly cover the entire surface, Mycelium on leaves superficial, form thick coating on the upper surface (Epiphyllous) and very sparse on lower surface (Hypophyllous) of the leaves.

Microscopic observation and measurement:

Hyphae hyaline, septate, varying from 5.27 um-7.71 um, average 6.52 um in width. Conidiophores hyaline, straight, erect and cylindrical at the base, composed of 4 to 5 cell, 78.87 um-161.31 um × 7.47 um - 10.42 um, average 120.57 um × 8.86 um, foot cell 28.74-41.58 um in length. Conidia hyaline, ovate, cylindrical 21.30 um - 38.89 um × 9.81 um-15.72 um, average 28.69 um × 12.69 um, formed in chain. Germ tube subterminal and cylindrical. (Plate 12)

Habitat:

On living leaves of *Luffa cylindrica* 21.11.2015, e×periment field of Vegetable science, Raipur (C.G.).

Diagnostic characters:

Conidiophores - Euoidium type

Germ tube - Subterminal, cylindrical

Sphaerotheca fuliginea, Mukhtar *et al.* 2013. Pakistan Journal of Weed Science Research 19(4): 475-479.

Host: *Ageratum conyzoids* L.

Observed symptoms:

White powdery masses cover on the both leaf surface and circular colonies of mycelium formed, mycelium have ectophytic.

Microscopic observation and measurement:

Hyphae hyaline, septate, varying from 5.13 um-7.10 um, average 6.17 um in width. Conidiophores hyaline, straight and cylindrical at the base, composed of 3 to 4 cell, 82.93 um-154.90 um × 7.74 um-11.6 um, average 136.75 um × 9.57 um, foot cell 45.90-63.80 um in length. Conidia hyaline, ovate, rounded with fibrosin bodies 24.12 um-34.11 um × 11.64 um-15.12 um, average 27.59 um × 13.51 um, formed in chain. Germ tube subterminal. (Plate 13)

Hyperparasite :

Cicinnobolus cessati (Ampelomyces). some conidiophores are parasiteized by this parasite.

Habitat:

On living leaves of *Ageratum conyzoids* L.,2.12.2015, experiment field of Vegetable science, Raipur (C.G.).

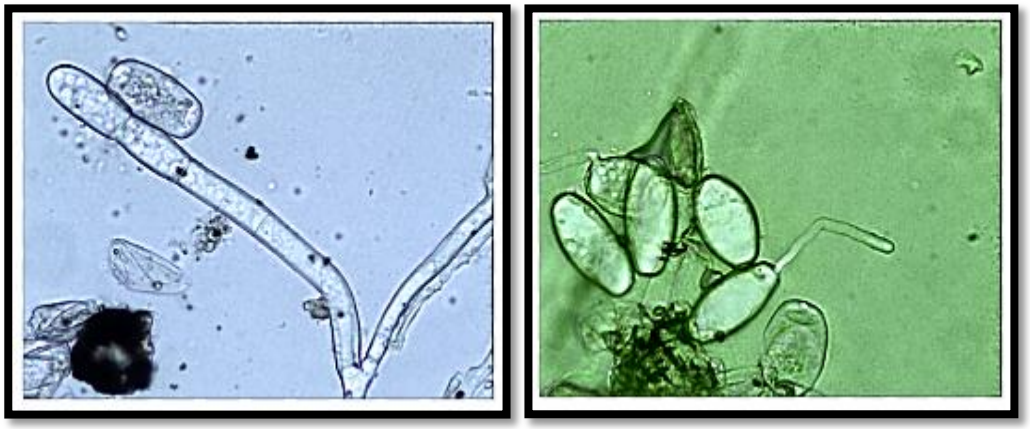
Diagnostic characters:

Conidiophores - Euoidium type

Germ tube - Subterminal

Fibrosin bodies - Rod like.

Symptoms on host

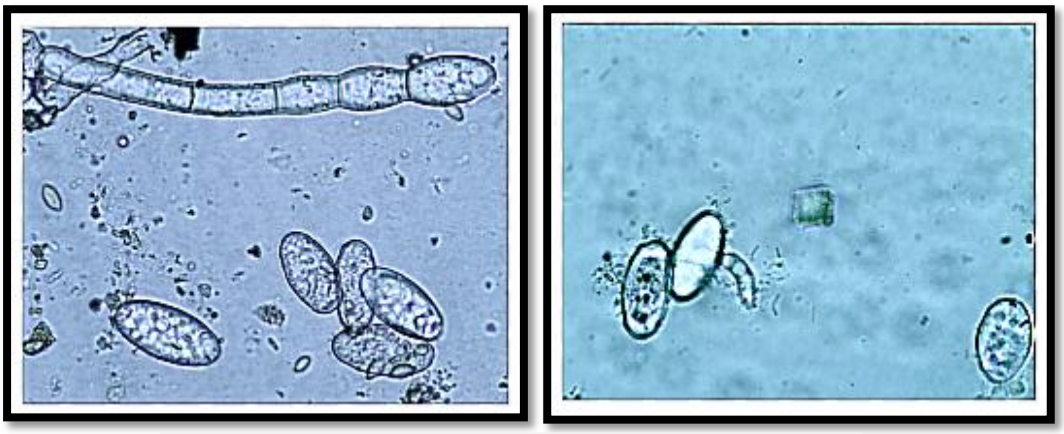


Conidiophore, conidia and conidial germination

Host: *Luffa cylindrica*
Pathogen: *Erysiphe cichoracearum*

Plate 12: Powdery mildew Symptoms on *Luffa cylindrica* and conidiophore, conidia & conidial germination of *Erysiphe cichoracearum*

Symptoms on host



Conidiophore, conidia and conidial germination

Host: *Ageratum conyzoids* L.
Pathogen: *Sphaerotheca fuliginea*

Plate 13: Powdery mildew Symptoms on *Ageratum conyzoids* L. and conidiophore, conidia & conidial germination of *Sphaerotheca fuliginea*

Leveillula spp., Bagyanarayana *et al*. 1988. Kavak, 16(1-2): 45-49.

Host: *Cyamopsis tetragonloba* L.taub

Observed symptoms:

Whitish mycelial colonies growth showed on the leaves and stem. Some leaves become yellow and necrotic patches can formed. Mycelium semi endophytic on leaves superficial, form thick coating on the upper surface (Epiphyllous) and very sparse in lower surface (Hypophyllous) of the leaves.

Microscopic observation and measurement:

Hyphae hyaline, septate, varying from 5.51 um-7.10 um, average 6.18 um in width. Conidiophores cylindrical at the base, composed of 2-3 cells, 53.84um - 101.39 um × 7.54 um-9.56 um, average 72.60um × 8.65um, foot cell 46.16-54.80 um in length. Conidia unicellular hyaline, globular or round-shaped, 29.28 um-44.34 um × 15.60 um-17.24 um, average 35.72 um × 16.53 um, produced singly at the time in a chain of two conidia. Germ tube subterminal. (Plate 14)

Habitat:

On living leaves of *Cyamopsis tetragonloba* L.taub. 12.12.2015, village, piroda, Raipur (C.G.).

Diagnostic characters:

Conidiophores – Oidiopsis type

Germ tube – Subterminal.

Sphaerotheca fusca, Pawar *et al.* 2011. Recent research in science and technology. 3(5): 94-95.

Host: *Physalis minima*

Observed symptoms:

White superficial colonies with covering almost entire leaf were produced mycelium amphigenously on leaf. Mycelium on leaves superficial, form thick coating on the upper surface (Epiphyllous) and very sparse on lower surface (Hypophyllous) of the leaves

Microscopic observation and measurement:

Hyphae hyaline, septate, varying from 5.28 um-7.12 um, average 6.17 um in width. Conidiophores hyaline, straight and cylindrical at the base, composed of 3 to 4 cell, 87.74 um-144.51 um × 9.27 um-12.87 um, average 108 um × 10.47 um, foot cell 36.41-52.83 um in length. Conidia hyaline, ovate, rounded with fibrosin bodies 23.37 um-30.24 um × 11.30 um - 16.12 um, average 27.02 um × 14.49 um, formed in chain. Germ tube subterminal. (Plate 15)

Hyperparasite :

Cicinnobolus cessati (Ampelomyces). some conidiophores are parasiteized by this parasite.

Habitat:

On living leaves of *Physalis minima* 24.12.2015, experiment field of Vegetable science, Raipur (C.G.).

Diagnostic characters:

Conidiophores - Euoidium type

Germ tube - Subterminal

Fibrosin bodies - Rod like

Symptoms on host

Conidiophore, conidia and conidial germination

Host: *Cyamopsis tetragonloba* L.taub
Pathogen: *Leveillula spp.*

Plate 14: Powdery mildew Symptoms on *Cyamopsis tetragonloba* L.taub and conidiophore, conidia and conidial germination of *Leveillula* spp.

Symptoms on host

Conidiophore, conidia and conidial germination

Host: *Physalis minima*
Pathogen: *Sphaerotheca fusca*

Plate 15: Powdery mildew Symptoms on *Physalis minima* and conidiophore, conidia & conidial germination of *Sphaerotheca fusca*

Sphaerotheca fuliginea, Akram *et al.* 1995. Plant Dis., 79: 754.

Host: *Impatiens balsamina L.*

Observed symptoms:

Powdery White appearance observed on both leaves and stem. Mycelium ectophytic, more abundant on the upper leaf surface (Epiphyllous) and very sparse on the lower surface (Hypophyllous) of the leaves.

Microscopic observation and measurement

Hyphae hyaline, smooth, branched, septate, varying from 3.78 um-5.99 um, average 4.94 um in width. Conidiophores hyaline, unbranched, cylindrical at the base composed of 3-6 cells in chain, 71.26 um-152.59 um × 9.34 um-13.37 um, average 99.98 um × 10.36 um, foot cell 59-65 um in length. Conidia unicellular, hyaline, ellipsoid-ovoid, smooth with fibrosin bodies distributed, 21.74 um-35.31 um × 11.89 um-15.55 um, average 28.24 um × 23.76 um, produced in chain. Germ tube terminal. (Plate 16)

Hyperparasite :

Cicinnobolus cessati (Ampelomyces). some conidiophores are parasiteized by this parasite.

Habitat:

On living leaves of *Impatiens balsamina L,* 25.12.2015, krishak nagar, Raipur (C.G.).

Diagnostic characters:

Conidiophores - Euoidium type

Germ tube – Subterminal

Fibrosin bodies - Rod like

Sphaerotheca fuliginea, Siradhana and Chaudhari. 1972. Indian. J. Mycol. Pl. Path.,2: 76-79.

Host: *Lagenaria vulgaris ser.*

Observed symptoms:

powdery mildew appears in the form of small, circular scattered patches. The colour of the colony white to grayish brown mycelium on leaves when upper surface is completely covered with fungal growth (Epiphyllous) infection also spreads on the lower surface (Hypophyllous) of the leaves.

Microscopic observation and measurement:

Hyphae hyaline, septate, varying from 4.92 um-7 um, average 6.12 um in width. Conidiophores hyaline ,erect, straight cylindrical at the base, composed of 1-3 cells in chain, 84.10 um-150.22 um × 9.51 um-13.81um, average 120.61 um × 10.55 um, foot cell 28-65.11 um in length. Conidia unicellular, hyaline, ovaid, distributed, 24.45 um-33.19 um × 11.30 um-16.59 um, average 27.83 um × 14.48 um, produced in chain. Germ tube subterminal and cylindrical. (Plate 17)

Habitat:

On living leaves of *Lagenaria vulgaris ser.* 25.12.2015, experiment field of Vegetable science, Raipur (C.G.).

Diagnostic characters:

Conidiophores - Euoidium type

Germ tube – Subterminal and cylindrical

Symptoms on host

Conidiophore, conidia and conidial germination

Host: *Impatiens balsamina L.*
Pathogen: *Sphaerotheca fuliginea*

Plate 16: Powdery mildew Symptoms on *Impatiens balsamina L.* and conidiophore, conidia & conidial germination of *Sphaerotheca fuliginea*

Symptoms on host

Conidiophore, conidia and conidial germination

Host: ***Lagenaria vulgaris ser.***
Pathogen: ***Sphaerotheca fuliginea***

Plate 17: Powdery mildew Symptoms on *Lagenaria vulgaris ser.* and conidiophore, conidia & conidial germination of *Sphaerotheca fuliginea*

Erysiphe cichoracearum, Khan *et al.* 1970. Indian Phytopath., 23: 497-502.

Host: *Coccinia indica*

Observed symptoms:

white superficial spots and powdery growth showed on leaves, stem, fruit and flower or on whole plant. Mycelium ectophytic on leaves superficial, form thick coating on the upper surface (Epiphyllous) and very sparse in lower surface (Hypophyllous) of the leaves.

Microscopic observation and measurement:

Hyphae branched, hyaline, septate measuring from 5.62 um-7.43 um, average 6.26 um in width. Conidiophores hyaline, straight, septate and cylindrical at the base, composed of 4 to 5 cell, 89.15 um-143.63 um × 9.48 um-13.28 um, average 118.53 um × 11.19 um, foot cell 35.94-57.74 um in length. Conidia unicellular, hyaline, ovate, barrel shaped, 24.75 um-36.70 um × 11.25 um-15.46 um, average 31.13 um × 13.53 um, formed in chain. Germ tube subterminal. (Plate 18)

Hyperparasite :

Cicinnobolus cessati (Ampelomyces). some conidiophores are parasiteized by this parasite.

Habitat:

On living leaves of *coccinia indica* ,26.12.2015, village, jora, Raipur (C.G.).

Diagnostic characters:

Conidiophores - Euoidium type

Germ tube – Subterminal

Erysiphe cichoracearum, Kabitarani *et al.* 1991. Indian phytopath., 44: 137 -139.

Host: *Cucurbita pepo*

Observed symptoms:

White to dirty-grey irregular patches on leaves tendrils and stem. The Lower surface of the leaf was more severally affected than the upper surface. Mycelium on leaves, superficial, form thick coating on the upper surface (Epiphyllous) and very sparse on the lower surface (Hypophyllous) of the leaves.

Microscopic observation and measurement:

Hyphae hyaline, smooth, branched, septate, varying from 4.5 um-5.24 um, average 4.85 um in width. Conidiophores hyaline, cylindrical at the base, composed of 4-6 cells in chain, 94.32 um-148.44 um × 9.51 um-13.81um, average 122.69 um × 11.72 um, foot cell 41-59.65 um in length. Conidia unicellular, hyaline, ovate, distributed, 22.26 um-35.53 um × 10.59 um-15.81 um, average 28.88 um × 13.25 um, produced in chain. Germ tube subterminal, cylindrical. (Plate 19)

Habitat:

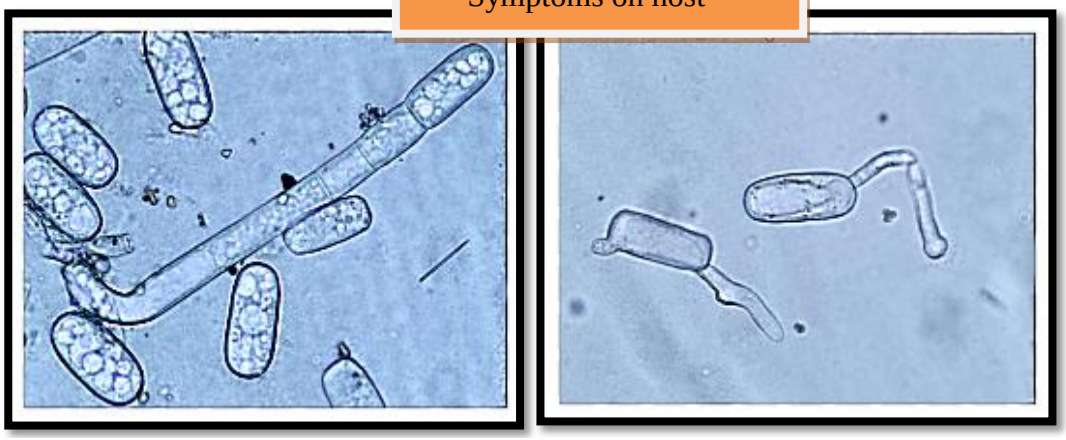
On living leaves of *Cucurbita pepo* 27.12.2015, experiment field of Vegetable science, Raipur (C.G.).

Diagnostic characters:

Conidiophores - Euoidium type

Germ tube – Subterminal

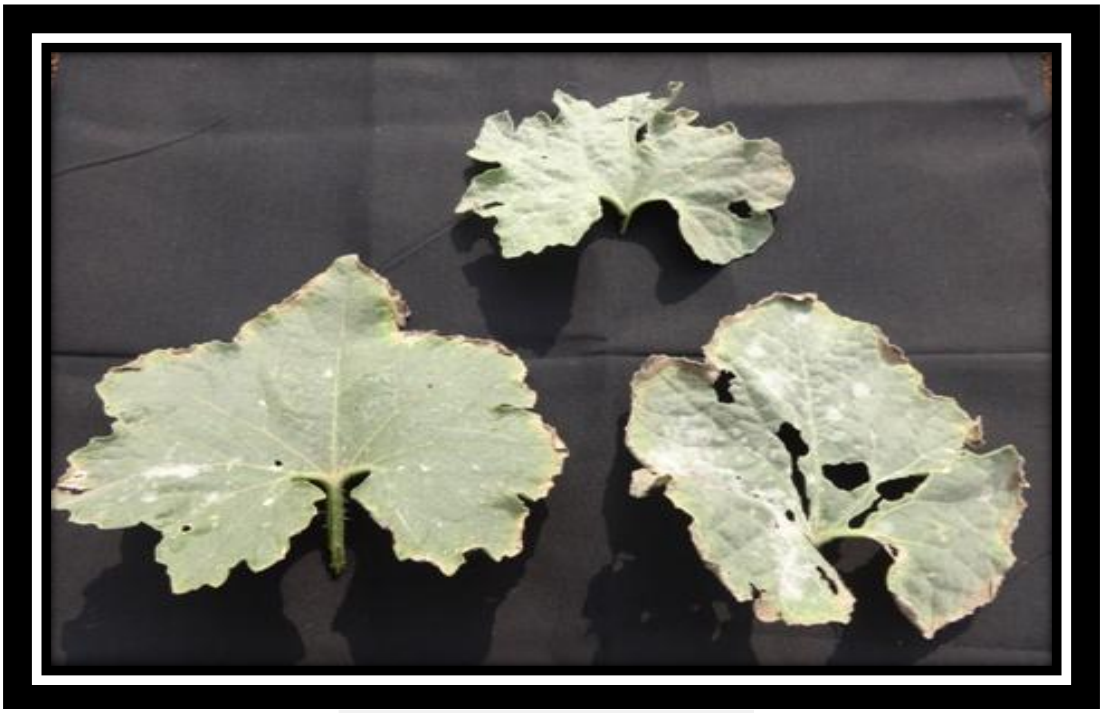
Symptoms on host



Conidiophore, conidia and conidial germination

Host: ***Coccinia indica***
Pathogen: ***Erysiphe cichoracearum***

Plate 18: Powdery mildew Symptoms on *Coccinia indica* and conidiophore, conidia & conidial germination of *Erysiphe cichoracearum*



Symptoms on host

Conidiophore, conidia and conidial germination

Host: ***Cucurbita pepo***
Pathogen: ***Erysiphe cichoracearum***

Plate 19: Powdery mildew Symptoms on *Cucurbita pepo* and conidiophore, conidia & conidial germination of *Erysiphe cichoracearum*

Erysiphe polygoni, Salmon. 1900. Mem. Torr. Bot. Club, 9: 1-292.

Host: *Trigonella foenum*graecum

Observed symptoms:

White to grey powdery masses or distinct circular to ellipsoidal patches could be seen on both upper and lower surface of the leaves. Mycelium on leaves, superficial form thick coating on the uppersurface (Epiphyllous) and very sparse on the lower surface (Hypophyllous) of the leaves.

Microscopic observation and measurement:

Hyphae hyaline, smooth, branched, septate, varying from 4.27 um-7.2 um, average 6 um in width. Conidiophores hyaline, simple, erect and cylindrical at the base, composed of 2-3 cells, 75.50 um-126.89 um × 5.78 um-9 um, average 81.34 um × 7.85 um, foot cell 27.63- 40 um in length. Conidia unicellular, hyaline, ellipsoidal and cylindrical to ovate, 24.98 um-38.07 um × 11.80 um-16.24 um, average 33.96 um × 13.54 um, produced singly. Germ tube subterminal and cylindrical. (Plate 20)

Habitat:

On living leaves of *Trigonella foenum*graecum ,5.1.2016, experiment field of Vegetable science, Raipur (C.G.).

Diagnostic characters:

Conidiophores - pseudoidium type

Germ tube – Subterminal, cylinrical

Sphaerotheca fuliginea, Khan *et al.* 1955. Indian Phytopath., 23: 497-502.

Host: *Momordica charantia* L.

Observed symptoms:

White powdery circular patches and spots appeared on the leaves. Mycelium on leaves, superficial form thick coating on the upper surface (Epiphyllous) and very sparse on the lower surface (Hypophyllous) of the leaves.

Microscopic observation and measurement:

Hyphae hyaline, smooth, branched, septate, varying from 6.20 um-7.32 um, average 7.52 um in width. Conidiophores hyaline, straight, erect and cylindrical at the base, composed of 3-4 cells, 94.45 um-155.89 um × 8.94 um-12.81 um, average 125.27 um × 10.68 um, foot cell 33.10-57.52 um in length. Conidia unicellular, hyaline, doliform, ellipsoidal and cylindrical to ovate, fibrosin bodies rod-like, distributed, 24.32 um-36.44 um × 11.86 um-17.30 um, average 30.58 um × 14.78 um, produced singly. Germ tube subterminal and cylindrical. (Plate 21)

Habitat:

On living leaves of *Momordica charantia* L., 8.1.2016, Village, Labhandi, on farm side, Raipur (C.G.).

Diagnostic characters:

Conidiophores - Euoidium type

Germ tube – subterminal, cylindrical

Fibrosin bodies – Rod like.

Symptoms on host

Conidiophore, conidia and conidial germination

Host: *Trigonella foenum*graecum
Pathogen: *Erysiphe polygoni*

Plate 20: Powdery mildew Symptoms on *Trigonella foenum*graecum and conidiophore, conidia & conidial germination of *Erysiphe polygoni*

Symptoms on host

Conidiophore, conidia and conidial germination

Host: *Momordica charantia* L.
Pathogen: *Sphaerotheca fuliginea*

Plate 21: Powdery mildew Symptoms on *Momordica charantia* L. and conidiophore, conidia & conidial germination of *Sphaerotheca fuliginea*

Oidium zizyphae, Bagyanarayana *et al.* 1988. Kavak. 16(1-2): 45-49.

Host: *Zizyphus jujuba* Lam.

Observed symptoms:

Whitish powdery mass irregularly covered on the leaves and twigs. Upper surface of leaves are less affected as compared to lower surface of leaves. Mycelium on leaves, superficial, form thick coating on the upper surface (Epiphyllous) and very sparse on the lower surface (Hypophyllous) of the leaves and twigs.

Microscopic observation and measurement:

Hyphae hyaline, septate, smooth, branched, varying from 3.91 um-7.51 um, average 5.51 um in width. Conidiophores hyaline, cylindrical at the base, composed of 3 cells, 65.88 um-157.44 um × 5.43 um-9.31 um, average 118.89 um × 7.19 um, foot cell 26.44-5.35 um in length. Conidia unicellular, hyaline, ovate, 22.51 um-39.59 um × 13.53 um-17.96 um, average 30.49 um × 16.98 um, produced singly. Germ tube subterminal and cylindrical. (Plate 22)

Habitat:

On living leaves of. *Zizyphus jujuba* Lam., 9.1.2016, at mana camp near police acadamy, Raipur (C.G.).

Diagnostic characters:

Conidiophores - Oidiopsis type

Germ tube – Subterminal, cylindrical

Sphaerotheca fuliginea, Akram *et al*. 1995. Plant Dis., 79: 754.

Host: *Solanum melongena* L.

Observed symptoms:

Whitish colonies formed on the surface of all leaves, petioles, stems and sepals. The infected leaves became slightly distorted or discolored, yellowish in the early stages. Mycelium on leaves, superficial, form thick coating on the upper surface (Epiphyllous) and very sparse on the lower surface (Hypophyllous) of the leaves and twigs.

Microscopic observation and measurement:

Hyphae hyaline, septate, smooth, branched, varying from 6 um-7.17 um, average 6.33 um in width. Conidiophores hyaline, straight, erect, cylindrical at the base, composed of 4-5 cells, 87.95 um-169.81 um × 8.94 um- 10.86 um, average 126.35 um × 9.77 um, foot cell 37.95-54.11 um in length. Conidia unicellular, hyaline, ovate, cylindrical, with fibrosin bodies 28.72 um-43.74 um × 12.63 um-18.36 um, average 32.74 um × 15.13 um, produced singly. Germ tube subterminal. (Plate 23)

Habitat:

On living leaves of. *Solanum melongena* L.,10.1.2016, Village, piroda, on farm site, Raipur (C.G.).

Diagnostic characters:

Conidiophores - Euoidium type

Germ tube – Subterminal

Fibrosin bodies – Rod like.

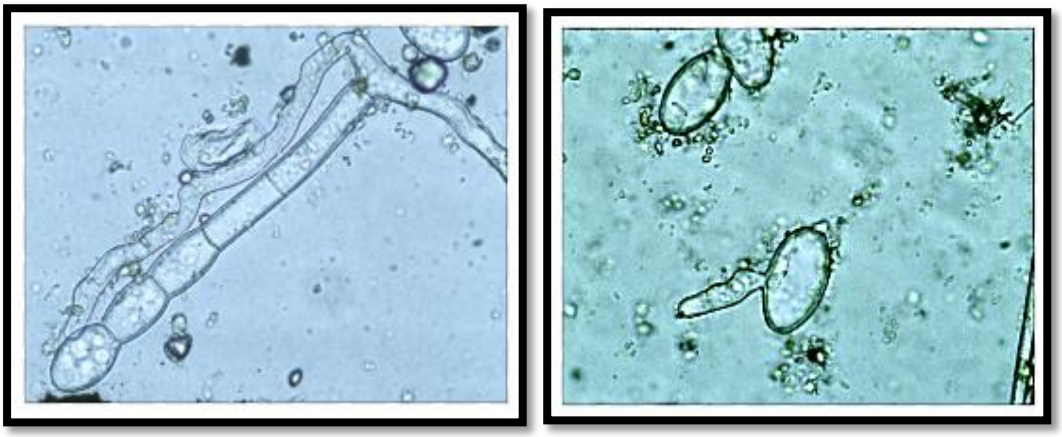
Symptoms on host

Conidiophore, conidia and conidial germination

Pathogen: *Oidium zizyphae*

Plate 22: Powdery mildew Symptoms on *Zizyphus jujuba* Lam. and conidiophore, conidia & conidial germination of *Oidium zizyphae*

Symptoms on host



Conidiophore, conidia and conidial germination

Host: *Solanum melongena* L.
Pathogen: *Sphaerotheca fuliginea*

Plate 23: Powdery mildew Symptoms on *Solanum melongena* L. and conidiophore, conidia & conidial germination of *Sphaerotheca fuliginea*

Erysiphe cichoracearum, Hussain, S.I. and Akram, Md. 1997. Indian Phytopath., 50(2): 250-255.

Host: *Dahlia variablis*

Observed symptoms:

White grayish circular to irregular patches consisting on stem, bud and leaves. Mycelium ectophytic, hyaline, smooth, branched, septate forming thin coat on upper surface (Epiphyllous) and very sparse in lower surface (Hypophyllous) of the leaves

Microscopic observation and measurement:

Hyphae hyaline, septate, sub straight, varying from 5.43 um-7.21 um average, 5.69 um in width, Conidiophores hyaline, erect, cylindrical at the base, composed of 4-5 cells, 73.12 um-184.68 um × 8.52 um-10.35 um average 124.98 um × 9.21 um, foot cell 48.29-77.48 um in length. Conidia unicellular, hyaline, cylindrical to ovate, doliformed, measured, 23.51 um-38.98 um × 11.84 um-17.80 um average 33 um × 15.28 um produced in chain. Germ tube subterminal and cylindrical. (Plate 24)

Habitat:

On living leaves of. *Dahlia variablis*, 20.1.2016, near V.C. Building, IGKV., Raipur, (C.G.).

Diagnostic characters:

Conidiophores - Euoidium type

Germ tube – Subterminal, cylindrical

***Sphaerotheca* sp**., Siradhana and Chaudhari. 1972. Indian.]. Mycol. Pl. Path., 2: 76-79.

Host: *Excoecaria cochinchinensis*

Observed symptoms:

White circular patches on the upper surface and expanded on lower surface of leaf, petiols and stem. Top leaves are most affected, infected part of leaves turn into brown in colour. Mycelium ectophytic, hyaline, smooth, branched, septate forming thin coat on upper surface (Epiphyllous) and very sparse in lower surface (Hypophyllous) of the leaves.

Microscopic observation and measurement:

Hyphae hyaline, septate, varying from 5.68 um-7 um average, 6.06 um in width, Conidiophores hyaline, erect, straight, cylindrical at the base, composed of 5-6 cells, 58.98 um-144.28 um × 8.48 um-11.79 um average 90.27 um × 9.68 um, foot cell 28.30-48.81 um in length. Conidia unicellular, hyaline, ellipsoidal, ovate, with fibrosin bodies 24.08 um-35.14 um × 11.36 um-17.83 um average 33.83 um × 15.14 um produced in chain. Germ tube subterminal. (Plate 25)

Habitat:

On living leaves of. *Excoecaria cochinchinensis*, 21.1.2016, IGKV, Raipur (C.G.).

Diagnostic characters:

Conidiophores - Euoidium type

Germ tube – Subterminal

Fibrosin bodies – Rod like

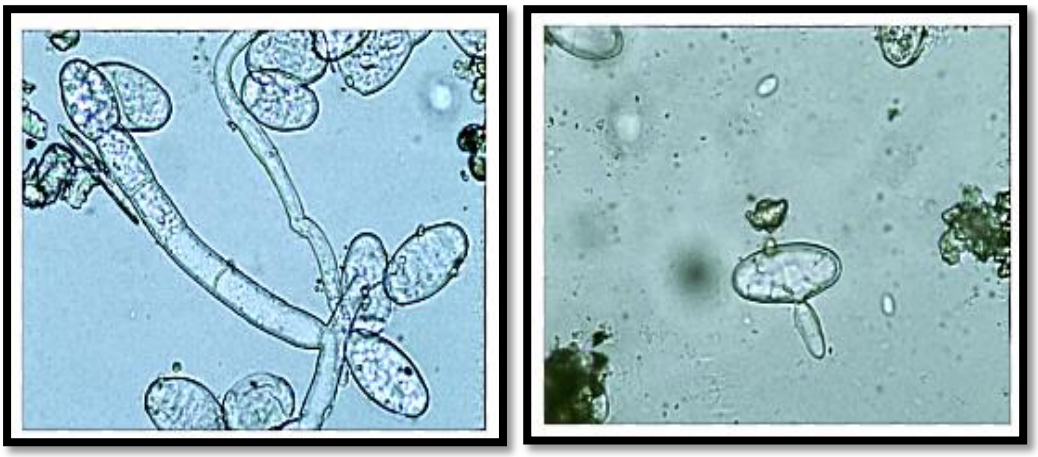
Symptoms on host

Conidiophore, conidia and conidial germination

Host: *Dahlia variablis*
Pathogen: *Erysiphe cichoracearum*

Plate 24: Powdery mildew Symptoms on *Dahlia variablis* and conidiophore, conidia & conidial germination of *Erysiphe cichoracearum*

Symptoms on host



Conidiophore, conidia and conidial germination

Host: *Excoecaria cochinchinensis*
Pathogen: *Sphaerotheca fuliginea*

Plate 25: Powdery mildew Symptoms on *Excoecaria cochinchinensis* and conidiophore, conidia & conidial germination of *Sphaerotheca* spp.

Erysiphe cichoracearum, Patel, R. and Sharma, N. D. 1966. Advance in Plant Sciences, 4: 1-22.

Host: *Parthenium hysterophorus*

Observed symptoms:

White round, superficial spots on upper surface of leaves, covered the entire upper surface of leaves. Mycelium on leaves, superficial, form thick coating on the upper surface (Epiphyllous) and very sparse on the lower surface (Hypophyllous) of the leaves.

Microscopic observation and measurement:

Hyphae hyaline, septate, varying from 5.60 um-7.19 um, average 6.27 um in width. Conidiophores hyaline, cylindrical at the base, composed of 4-5 cells, 79.20 um-159.70 um × 8.93 um- 11.60 um, average 115.85 um × 10.35 um, foot cell 34.57-60.69 um in length. Conidia unicellular, hyaline, ovate, cylindrical, ellipsoidal, thin walled, smooth, 23.17 um-39.23 um × 10.92 um-16.97 um, average 28.86 um × 13.96 um, produced singly. Germ tube subterminal. (Plate 26)

Habitat:

On living leaves of *Parthenium hysterophorus*, 22.1.2016, New Raipur, on road site, Raipur (C.G.).

Diagnostic characters:

Conidiophores - Euoidium type

Germ tube – Subterminal, cylindrical

Leveillula taurica, Bagyanarayana *et al.* 1988. Kavak, 16(1-2): 45-49.

Host: *Capsicum annum*

Observed symptoms:

White powdery coating appeared on the leaves and stem, lower surface of leaves more severe than upper surface of leaves. Mycelium endophytic, thick coating on lower surface (Hypophyllous) and very sparse on the upper surface (Epiphyllous) of the leaves.

Microscopic observation and measurement:

Hyphae hyaline, septate, varying from 3.72 um-6.89 um average 4.77 um in width. Conidiophores hyaline, septate, cylindrical at the base, composed of 3-4 cells, 107.36 um-176.52 um × 4.24 um-7.48 um, average 152.16 um × 6.29 um, foot cell 22.17-59.01 um in length. Conidia unicellular hyaline, dimorphic, lanceolate, 42.81 um-63.15 um × 12.08 um-17.07 um, average 51.55 um × 14.07 um, produced singly at the time in a chain of two conidia. Germ tube subterminal and cylindrical. (Plate 27)

Habitat:

On living leaves of. *Capsicum annum*, 1.2.2016, near, experiment field of Vegetable science, IGKV, Raipur (C.G.).

Diagnostic characters:

Conidiophores - oidiopsis type

Germ tube – Subterminal, cylindrical.

Symptoms on host

Conidiophore, conidia and conidial germination

Host: *Parthenium hysterophorus*
Pathogen: *Erysiphe cichoracearum*

Plate 26: Powdery mildew Symptoms on *Parthenium hysterophorus* and conidiophore, conidia & conidial germination of *Erysiphe cichoracearum*

Symptoms on host

Conidiophore, conidia and conidial germination

Host: ***Capsicum annum***
Pathogen: ***Leveillula taurica***

Plate 27: Powdery mildew Symptoms on *Capsicum annum* and conidiophore, conidia & conidial germination of *Leveillula taurica Leveillula taurica,*

Bagyanarayana *et al.* 1988. Kavak, 16(1-2): 45-49.

Host: *Linum sativum*

Observed symptoms:

Small, circular, irregular and dirty white patches appeared on the leaves, stems, flowers and capsules. Mycelium ectophytic, superficial, form thick coating on the upper surface (Epiphyllous) and very sparse on the lower surface (Hypophyllous) of the leaves.

Microscopic observation and measurement:

Hyphae hyaline, septate, varying from 4.48 um-7.21 um average 6.04 um in width. Conidiophores hyaline, septate, cylindrical at the base, composed of 5-6 cells, 100.97 um-198.21 um × 7.56 um-10.07 um, average 147.71 um × 8.84 um, foot cell 51.42-68.19 um in length. Conidia unicellular hyaline, ovoid, cylindrical, 25.44 um- 46.77 um × 8.83 um-11.89 um, average 31.54 um × 10.71 um, produced singly. Germ tube subterminal and cylindrical. (Plate 28)

Habitat:

On living leaves of *Linum sativum*, 18.2.2016, near, Experiment field of Plant Breeding and Genetics Department, IGKV, Raipur (C.G.).

Diagnostic characters:

Conidiophores - Oidium type

Germ tube – Subterminal, cylindrical.

Erysiphe hereclei, Khan *et al*. 1977. Acta. Botanical Indica, 5: 139-142.

Host: *Coriandrum sativum* L.

Observed symptoms:

White powdery growth observed on the leaves, petioles flowers stalks and bracts. Mycelium superficial, amphigenous form thick coating on leaves and all aerial parts.

Microscopic observation and measurement:

Hyphae hyaline, smooth, septate, branched, varying from 3.76 um-5.21 um, average 4.60 um. Conidiophores hyaline, cylindrical at the base, composed of 2-3 cells, 73.82 um-158.02 um × 5.73 um-8.77 um, average 115.54 um × 6.70 um, foot cell 30.78-38.44 um in length. Conidia unicellular, hyaline, cylindrical, 22.43 um-42.47 um × 9.60 um-14.56 um, average 32.04 um × 11.32 um, produced singly. Germ tube subterminal and cylindrical. (Plate 29)

Habitat:

On living leaves of, *Coriandrum sativum* L.,19.2.2016, near, Experiment Field of Vegetable Science Department, IGKV, Raipur (C.G.).

Diagnostic characters:

Conidiophores - Pseudoidium type

Germ tube – Subterminal, cylindrical.

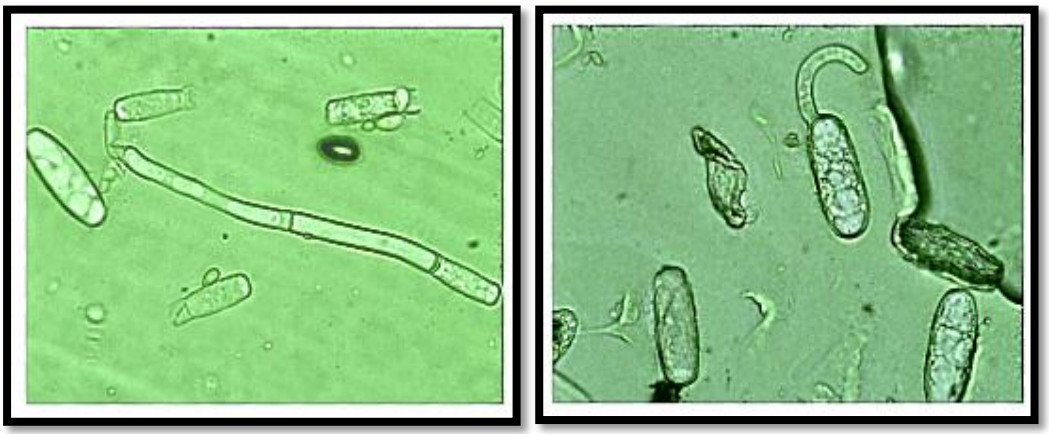
Symptoms on host

Conidiophore, conidia and conidial germination

Host: ***Linum sativum***
Pathogen: ***Leveillula taurica***

Plate 28: Powdery mildew Symptoms on *Linum sativum* and conidiophore, conidia & conidial germination of *Leveillula taurica*

Symptoms on host



Conidiophore, conidia and conidial germination

Host: *Coriandrum sativum* L.
Pathogen: *Erysiphe hereclei*

Plate 29: Powdery mildew Symptoms on *Coriandrum sativum* L. and conidiophore, conidia & conidial germination of *Erysiphe hereclei*

Erysiphe cichoracearum, Sharma. 1979. Indian J. Mycol. P. Pathol., 9: 29-32.

Host: *Brassica junecea*

Observed symptoms:

Dirty, white floury patches on the leaves, stem, beans and whole plant parts, the whole leaf may be covered with powdery mass. Mycelium amphigenous, form thick coating on the upper surface (Epiphyllous) and very sparse on the lower surface (Hypophyllous) of the leaves.

Microscopic observation and measurement:

Hyphae hyaline, smooth, septate, branched, varying from 4 um-6.12 um, average 5.16 um. Conidiophores hyaline, straight, cylindrical at the base, composed of 2-3 cells, 64.42 um-117.14 um × 7.51 um-10.72 um, average 83.15 um × 8.23 um, foot cell 40.41-60.31 um in length. Conidia unicellular, hyaline, cylindrical, 27.86 um-39.84 um × 11.72 um-14.24 um, average 34.71 um × 13.14 um, produced singly. Germ tube subterminal. (Plate 30)

Habitat:

On living leaves of, *Brassica junecea* L.,10.3.2016, Experiment Plant Breeding and Genetics Department , IGKV, Raipur (C.G.).

Diagnostic characters:

Conidiophores - Pseudoidium type

Germ tube – Subterminal

***Erysiphe* sp.,** Salmon. 1900. Mem. Torr. Bot. Club. 9: 1-292.

Host: *Psoralea corlifolia*

Observed symptoms:

White powdery mass covered on whole leaves and stem, upper surface of leaf more infected than lower surface. Mycelium, ectophytic thick coating on upper surface (Hypophyllous) and very sparse on the lower surface (Epiphyllous) of the leaves.

Microscopic observation and measurement:

Hyphae hyaline, septate, varying from 3.18 um-6.84 um, average 5.26 um. Conidiophores hyaline, cylindrical at the base, composed of 2-3 cells, 50.84 um - 102.90 um × 6.84 um-8.72 um, average 81.22 um × 7.52 um, foot cell 37.97 - 66.32 um in length. Conidia unicellular, hyaline, cylindrical, 24.56 um-40.27 um × 11.52 um-14.75 um, average 32.41 um × 13.30 um, produced singly. Germ tube subterminal and cylindrical. (Plate 31)

Habitat:

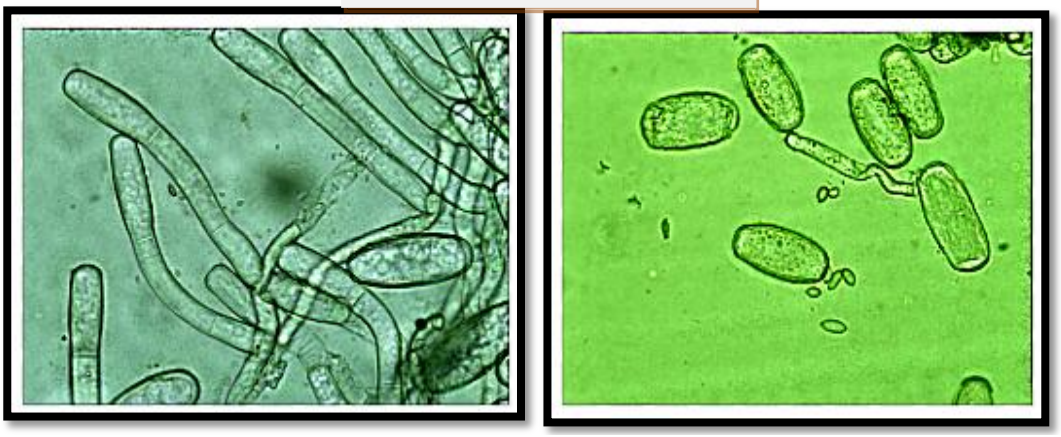
On living leaves of, *Psoralea corlifolia*, 15.3.2016, in Medicinel plants field , IGKV, Raipur (C.G.).

Diagnostic characters:

Conidiophores – Euoidium type.

Germ tube – Subterminal, cylindrical.

Symptoms on host



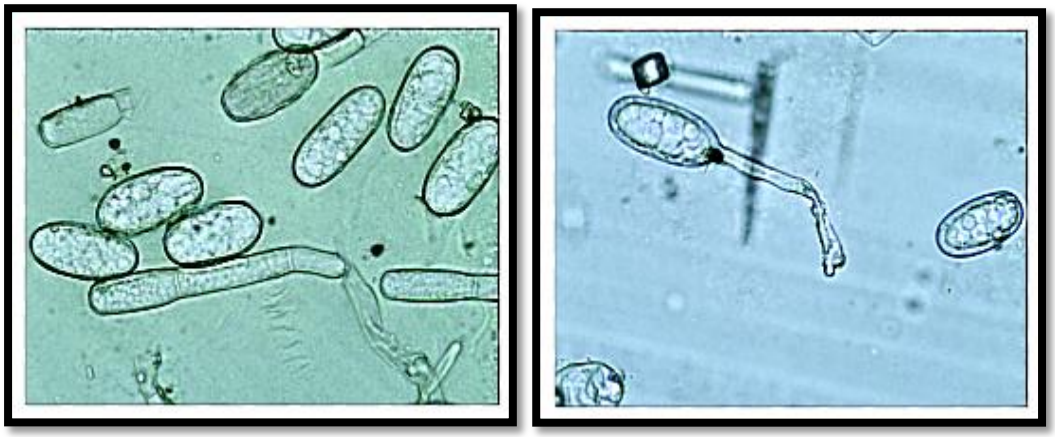
Conidiophore, conidia and conidial germination

Host: *Brassica junecea*

Pathogen: *Erysiphe cichoracearum*

Plate 30: Powdery mildew Symptoms on *Brassica junecea* and conidiophore, conidia & conidial germination of *Erysiphe cichoracearum*

Symptoms on host



Conidiophore, conidia and conidial germination

Host: *Psoralea corylifolia*
Pathogen: *Erysiphe* sp.

Plate 31: Powdery mildew Symptoms on *Psoralea corylifolia* and conidiophore, conidia & conidial germination of *Erysiphe spp.*

Leveillula taurica, Bagyanarayana *et al.* 1988. Kavak. 16(1-2): 45-49.

Host: *Calendula officinalis*

Observed symptoms:

Frosty white, powdery spots developed on leaves, colonies become so e×tensive, entire plant appeared white. Mycelium, endophytic thick coating on lower surface (Hypophyllous) and very sparse on the upper surface (Epiphyllous) of the leaves.

Microscopic observation and measurement:

Hyphae hyaline, septate, varying from 4.84 um-5.99 um, average 4.99 um. Conidiophores hyaline, cylindrical at the base, composed of 2-3 cells, 89.31 um - 189.98 um × 4.90 um - 6.25 um, average 152.71 um × 5.54 um, foot cell 20-29.87 um in length. Conidia unicellular hyaline, rhomboid, lanceolate, 41.43 um-57.31 um × 13.69 um-17.89 um, average 49.10 um × 15.30 um, produced singly. Germ tube subterminal and cylindrical. (Plate 32)

Habitat:

On living leaves of, *Calendula officinalis*, 16.3.2016, near, V.C. building, University, IGKV, Raipur (C.G.).

Diagnostic characters:

Conidiophores – Oidiopsis type

Germ tube – Subterminal, cylindrical.

***Erysiphe cichoracearum*,** Saliman *et al*. 1982. Plant Disease, 66: 572-573.

Host: *Helianthus anus*

Observed symptoms:

White circular powdery spots appeared on lower leaves. Above ground level plant part also affected, lower leaves more infected than upper leaves. Mycelium superficial, ectophytic form thick coating on the upper surface (Epiphyllous) and very sparse on the lower surface (Hypophyllous) of the leaves.

Microscopic observation and measurement:

Hyphae hyaline, smooth, septate, branched, varying from 4.69 um-7 um, average 6.20 um. Conidiophores hyaline, cylindrical at the base, composed of 3-4 cells, 114.05 um-197.60 um × 9.28 um - 11.06 um, average 147.71 um × 10.02 um, foot cell 53.28-61.17 um in length. Conidia unicellular, hyaline, cylindrical, ovoid, 23.26 um-33.83 um × 13.28 um-18.63 um, average 30.36 um × 15.62 um, produced singly. Germ tube subterminal and cylindrical. (Plate 33)

Habitat:

On living leaves of, *Helianthus anus*, 20.3.2016, Experiment Plant Breeding and Genetics Department , IGKV, Raipur (C.G.).

Diagnostic characters:

Conidiophores - Pseudoidium type

Germ tube – Subterminal, cylindrical.

Symptoms on host

Conidiophore, conidia and conidial germination

Host: ***Calendula officinalis***
Pathogen: ***Leveillula taurica***

Plate 32: Powdery mildew Symptoms on *Calendula officinalis* and conidiophore, conidia & conidial germination of *Leveillula taurica*

Symptoms on host

Conidiophore, conidia and conidial germination

Host: *Helianthus anus*
Pathogen: *Erysiphe cichoracearum*

Plate 33: Powdery mildew Symptoms on *Helianthus anus* and conidiophore, conidia & conidial germination of *Erysiphe cichoracearum*

Table 4.9: Classification of 30 host plants species under study on the basis of conidiophore characters

Conidiophore characters	Host name
Euoidium	*Abelmoscus esculentus* (L) *Ageratum conyzoids* L. *Coccinia indica* *Cucumis sativus* *Cucurbita pepo* *Dahlia variablis.* *Euphorbia hirata* *Excoecaria cochinchinensis* *Helianthus anus* *Impatiens balsamina L.* *Legenaria vulgaris ser.* *Luffa cylindrica* *Momordica charantia* L. *Parthenium hysterophorus* *Psoralea corlifolia* *Physalis minima* L. *Solanum melongena* *Vigna unguiculata* (L) Walp *Vigna radiata* (L) Wilezck *Vigna mungo* (L) Hep per *Xanthium strumarium* L.
Oidiopsis	*Calendula officinalis* *Capsicum annum* L. *Cyamopsis tetragonloba* L. *Zizyphus jujuba* Lam
Oidium	*Heliotropium indicum* *Linum sativum*
Pseudoidium	*Brassica junecea* *Coriandrum sativum* L. *Trigonella foenumgraecum*

The powdery mildew fungi are ectophytic in nature and sub endophytism were reported in *Leveillula, Phallaetenia* and *Pleochaeta.* All powdery mildew genera were devided into two groups:

A) Those having wide host range includes *Erysiphe, Leveillula, Sphaerotheca, Podosphaera, Macrosphaera, Uncinula, Phyllactinia* and *Oidium.*

(B) Those having narrow host ranges includes *Setoerysiphe, Cystotheca, Sawadae, Kokkalera Brasilwmyces, Medulsphaera, Uncinuliella, Bulboucinula, Fercouncinula, Salmonomyces, Typhalochaeta, Queirozia* and *Pleochaeta.*

Hirata (1986) reported 19 genera and 400 species of powdery mildew fungi. All the powdery mildew fungi of the present collection belong to the large host range, group A.

The powdery mildew fungi were identified on the basis of Conidiphores characters and their type (Blumer, 1967, Jaczewski, 1927 and Brundza, 1933). Blumer (1967) reported five basic types of conidiophore i.e. *oidium* type, *Euoidium* type, *Pseudoidium* type, *Ovulariopsis* type and *Oidiopsis* type but four types of conidiophores were found under study and are presented in Table 4.8 Some other characters were also considered like presence or absence of fibrosin bodies, conidia produced singly or in chains, conidial shape i.e. cylindric, ellipsoid, rhomboid etc. germ tube produced centrally, subterminal, knob like lobed.

In the present investigations four genera namely *Erysiphe, Oidium, Spharaerotheca* and *Leveillula* and nine species were recorded from thirty hosts. All the fungi except few were reported by several workers and all were of the similar view as discussed above. The data in support as reported by other workers are detailed in Table 4.10.

The genus *Erysiphe* spp. on *Psoralea corlifolia* (Bawchi) and *Sphaerotheca* spp. on. *Excoecaria cochinchinensis* (Chinese croton) hosts were observed for the first time.

Table 4.10: Key character of powdery mildew pathogen on conidiophores basis

S.N.	Host name	Conidiophores character	Pathogen	References
1	*Abelmoscus esculentus* (L)	Euoidium	*Erysiphe cichoracearum*	Prabhu *et al.*1971
2	*Ageratum conyzoids* L.	Euoidium	*Sphaerotheca fuliginea*	Mukhtar *et al.* 2013
3	*Brassica junecea*	Pseudoidium	*Erysiphe cichoracearum*	Sharma 1979
4	*Calendula officinalis*	Oidiopsis	*Leveillula taurica*	Bagyanarayana *et al.* 1988
5	*Capsicum annum* L	Oidiopsis	*Leveillula taurica*	Bagyanarayana *et al.* 1988
6	*Coccinia indica*	Euoidium	*Erysiphe cichoracearum*	Khan *et al.* 1970
7	*Coriandrum sativum* L.	Pseudoidium	*Erysiphe hereclei*	Khan *et al.* 1976
8	*Cucumis sativus*	Euoidium	*Erysiphe cichoracearum*	Lazzeri *et al.* 2009
9	*Cucurbita pepo*	Euoidium	*Sphaerotheca fuliginea*	Hussain, S.I. and Akram, Md. 1997
10	*Cyamopsis tetragonloba* L.	Oidiopsis	*Leveillula* spp.	Bagyanarayana *et al*. 1988
11	*Dahlia variablis*.	Euoidium	*Erysiphe cichoracearum*	Husan, S.I. and Akram, Md. 1997
12	*Euphorbia hirata*	Euoidium	*Sphaerotheca euphorbiae*	Rao, P.N. 1961
13	*Excoecaria cochinchinensis*	Euoidium	*Sphaerotheca* spp.	Somani *et al*. 1976
14	*Helianthus anus*	Euoidium	*Erysiphe cichoracearum*	Saliman *et al*. 1982
15	*Heliotropium indicum*	Oidium	*Oidium heliotropii-indici*	Algodao *et al.* 2010
16	*Impatiens balsamina L.*	Euoidium	*Sphaerotheca fuliginea*	Akram *et al.* 1995
17	*Legenaria vulgaris ser.*	Euoidium	*Sphaerotheca fuliginea*	Siradhana and Chaudhari.1972
18	*Linum sativum*	Oidium	*Erysiphe cichoracearum*	Bagyanarayana *et al.* 1988
19	*Luffa cylindrica*	Euoidium	*Erysiphe cichoracearum*	Khan *et al.* 1977
20	*Momordica charantia* L.	Euoidium	*Sphaerotheca fuliginea*	Khan *et al.* 1955
21	*Parthenium hysterophorus*	Euoidium	*Erysiphe cichoracearum*	Patel, R. and Sharma, N. D. 1966
22	*Psoralea corlifolia*	Euoidium	*Erysiphe* spp.	Salmon. 1900
23	*Physalis minima* L.	Euoidium	*Sphaerotheca fusca*	Pawar *et al.* 2011
24	*Solanum melongena*	Euoidium	*Sphaerotheca fuliginea*	Akram *et al.* 1995
25	*Trigonella foenumgraecum*	Pseudoidium	*Erysiphe polygoni*	Salmon. 1900
26	*Vigna radiata* (L) Wilezck	Euoidium	*Erysiphe polygoni*	Patel *et* a*l*. 1949
27	*Vigna mungo* (L) Hep per	Euoidium	*Erysiphe polygoni*	Patel *et* a*l*. 1949
28	*Vigna unguiculata* (L) Walp	Euoidium	*Erysiphe polygoni*	Roy, A. K. 1973
29	*Xanthium strumarium* L	Euoidium	*Erysiphe cichoracearum*	Khan *et al.* 1977
30	*Zizyphus jujuba* Lam	Oidiopsis	*Oidium zizyphae*	Bagyanarayana *et al.* 1988

CHAPTER – VI

SUMMARY AND CONCLUSIONS

The present investigation **"Environmental Relationship of Powdery Mildew of Black Gram, Its Management and Documentation of Powdery Mildew Fungi of Chhattisgarh"** was carried out at Department of Plant Pathology, College of Agriculture Raipur (IGKV) during *Rabi* 2015-16.

The investigation mainly consists of four objectives:

1) Epidemiological studies of black gram powdery mildew.
2) Host range study of *Erysiphe polygoni* DC.
3) Studies of management of powdery mildew of black gram.
4) Documentation of powdery mildew pathogens of Raipur.

The summary and conclusion of findings of the present investigations are given below:

The effect of dates of sowing on powdery mildew of black gram, among four dates of sowing, the disease severity was found more in late sown crop (10^{th} Dec.) PDI was (89.30%), (29^{th} Nov.) PDI was (86.59%) and (18^{th} Nov.) PDI was (83.73%) in comparison to early sown crop (7^{th} Nov.) PDI was (71.74%). Three to four no. of pods per plant were recorded in 7^{th} Nov. sowing date.

In case of epidemiological studies, incidence of powdery mildew in first, second, third and fourth date of sowing 30, 35, 36 and 30 DAS respectively. Whereas, maximum temperature was more than 25° c and RH was more than 80%. In first date of sowing mildew severity showed negative correlation with all the environmental parameters, except RH (min.) that had shown positive correlation with mildew severity. In second, third and fourth dates of sowing mildew severity showed positive correlation with all the environmental parameters, except RH (max.), that had shown negative correlation with mildew severity. Whereas, in third date of sowing was significantly and positively correlated with maximum temperature. Fourth date of sowing was significantly and positively correlated with temperature (min.), temperature (max.) and RH (max.). In all dates of sowing Flowering stage to pod development stage showed maximum apparent infection rate.

All the 12 hosts inoculated with *Erysiphe polygoni* DC show disease after 3 days of inoculation in *Lathyrus sativus L.* later, after 7 days of inoculation failed to show disease. After 11 and 15 days of inoculation showed the symptoms of powdery mildew *Vigna radiata* (L.) Wilczek, *Glycine max, Euphorbia hirta L., Trigonella foenumgraecum* and *Pisum sativum*.

The investigation demonstrates that according to disease situation, the activity of different fungicides can be utilized in proper management of powdery mildew of black gram under field condition. Moreover, Maximum yield was obtain in Tebuconazole treatment at 0.1 per cent (671 kg/ha.) followed by Propiconazole, Elemental sulphur, Carbendazim and Low per cent reduction of disease and yield was noticed in Thiophanate methyl and Mycobutanil, whereas control showed only 457 kg/ha. Studies on the effect of different botanicals and one bioagent revealed that neem and garlic effectively reduce the disease and increased yield over control. Neem showed maximum yield (555 kg/ha.) followed by garlic and ginger. The low yield obtained in karanj, datura and *Trichoderma*, whereas control showed 385 kg/ha.

Powdery mildew fungi from 30 host species (distributed in 14 families of Angiosperms) were collected mainly from 10 km around the periphery of Raipur. out of which 9 host plants were vegetables, 7 were weeds, 4 were ornamentals, 3 were pulses, 3 were oilseeds, 2 were spices, 1 were fruit and 1 were medicinal plant. Powdery mildew collections have been classified according to conidiophore type only, without assigning them to any known species in absence of abundant collection, accurate description of anamorph-teleomorph state was not possible, hence, left for future taxonomic assessment.

CONCLUSIONS

- 7^{th} November was the suitable time of sowing for black gram as compared to late November sowing and early December sowing of black gram.
- In epidemiological studies, weather parameters played vital role in disease development. Maximum temperature and sunshine hours influence disease development significantly. Any drastic change in weather condition would adversely affect the development of powdery mildew pathogen.

- Most of the weeds and legumes could act as alternate host for black gram powdery mildew. Thus, avoid weeds and other legumes around the black gram.
- On the basis of experimental findings, spraying of Tebuconazole was most effective for disease management, Tebuconazole followed by Propiconazole significantly increased the yield.
- In the botanicals neem and garlic were suitable for controlling powdery mildew of black gram in field. It was show better yield also.
- The genus *Erysiphe* sp. on Bawchi *(Psoralea corlifolia)* and *Sphaerotheca* sp. on Chinese croton (*Excoecaria cochinchinensis*) hosts, were observed for the first time in India.

SUGGESTIONS FOR FUTURE RESEARCH WORK

1) More number of dates should be tried to determine the optimum date of sowing to escape the crop against powdery mildew.
2) Raw epidemiological study can be further increase for predication.
3) Host range of *Erysiphe polygoni* DC should be studied by cross inoculation method.
4) To study the effect of different botanicals and bio-agent on disease incidence and yield.
5) More bio-product and organic product to be assessed for management of powdery mildew diseases, suitable for organic farming and eco-friendly as well.
6) Third taxonomic account of anamorph state of powdery mildew fungi should be studied at Raipur.

REFERENCES

Abbaiah, K. 1993. Development of powdery mildew epidemics in urdbean in relation to weather factor. Indian J. Pulses Res., 6: 186-188.

Abbaiah, K. and Devi, T.D. 1992. Evaluation of fungicides against powdery mildew and cercospora leaf spot of black gram. Indian Journal plant protection, 20(2): 133-137.

Agrawal, K.C. and Philip, R. 1983. Economic control of powdery mildew of urid, (*Phaseolous mungo*) by wetsulf. Indian Phytopathol., 36(2): 359-361.

Ahmed, A.U., Bakr, M.A., Chowdhury, J.A. and Sarkar, M.A. 2006. Efficacy of six fungicides in controlling rust (*Uromyces fabae*) disease of lentil (*Lens culinaris*). Bangladesh J. Plant Pathol., 22(1-2): 39-40.

Akram, MD. and Husain, I. 1995. *Impatiens balsamina*: a natural host of *Sphaerotheca fuliginea*. Plant Dis., 79:754.

Algodao, E. and Oswaldo, R. 2010. First report of *Oidium heliotropii-indici* on *Heliotropium indicum* from Brazil. Australasian Plant Disease Notes, 5: 87–89.

Anonymous. 2012. Www. nhb.gov.in, 2012.

Anonymous. 2014. Report of Agriculture Department, Chhattisgarh Government, Krishi Diary, Directorate of Extension Services, IGKV, Raipur. :5.

Anonymous. 2015. Www.agmarknet.nic.in, 2015.

Anonymous. 2015. Www.agricoop.nic.in, 2015

Anonymous. 2015. Www.doa.gov.lk, 2015.

Bagyanarayana, G., Sudhakara Rao, A. and Ramachar, P. 1988. Powdery mildew *(Erysiphales)* from Hyderabad, Andhra Pradesh. Kavak, 16(1-2): 45-49.

Banyal, D.K. and Tyagi, P.D. 1997. Role of climatic factors in the development of powdery mildew of pea. Indian J.Mycol. Pl. Pathol., 27(1): 64-66.

Bhardwaj, C.L. and Singh, B.M. 1984. Host range of oidium state of *Erysiphe pisi* from peas on some leguminous hosts in Kangra Valley of Himachal Pradesh. Indian Phytopath., 37: 732-733.

Bhardwaj, M.L. and Sharma, I.M. 1996. Performance of early pea genotypes under different sowing times in the hills of Himachal Pradesh. Journal of Hill Research, 9(1): 62-64.

Bhatiya, J.N. and Thakur, D.P. 1989. Field evaluation of systemic and non systemic fungicides against powdery mildew of different economic crops. Indian Phytopath., 42: 571-573.

Blumer, S. 1922. Das problem des' bridging species beiden parasitichen pilze. mitt. Naturf. Ges. Bern., : 1200-1500.

Blumer, S. 1967. Echte mehltaupilze (Erysiphaceae), Ein Bestimmungsbuch fur die in Eurapa Vorkommenden Arten. Gustav Fischer, Jena, :436. Bot. I. nd., 5: 87-88.

Bouwens, H. 1924. Untersuchungeen ubes Erysipheen. Meded Phytopathol. Lab. Willie Commelin schotten. Baarn., 8: 3-28.

Braun, U. 1987. A monograph of the Erysiphales (powdery mildews). Beih. NovHedwigia, 89: 1-700.

Brundza, K. 1933. Beitrage fur kenntnie des Erysiphaceaen Litauens. Jhrb. Landwirtech. Akad. Litauen, 33: 107-197.

Butler, E. J. 1918. Fungi and diseases in plants. Thacker Spink and Co. Calcutta, : 547.

Cook, R.T.A. and Fox, R.T.V. 1992. *Erysiphe pisi* Var pisi on faba beans and other legumes in Britain. Plant Pathology, 41(4): 506-512.

Das, S.R. and Narain, A. 1990. Management of powdery mildew of mungbean with fungicides. Indian Phytopath., 43(1): 100-101.

De Candolle, A.P. 1805. Flore Francaise, 2: 272-275.

De Candolle, A.P. 1815. Flore Francaise, 5: 104-109.

Deore, P. B. and Sawant, D. M., 2000, Management of guar powdery mildew by *Trichoderma sp.* culture filtrates. J. Maharashtra Agric. Uni., 25: 253-254.

Deshpandey, G. D. and Dake, G.N. 1978. New records of powdery mildew in marathwada Indian Phytopathol., 31: 256.

Devi, T.P. and Samy, P.N. 1984. Fungicidal control of the powdery mildew of black gram madras. Agric. J., 71(5): 315-317.

Elazegui, F.A. and Mew, T.W. 1987. Efficiency of some chemical control of two leaf disease of moongbean grown after rice. Journal of plant protection in the tropics, 4(2): 85-94.

Fischer, R. 1957. Sydowis, 1: 203-209.

Fresenius, G. 1852. Beitrage Zurmykologie. Heft, 2: 39-80.

Gurha, S.N. and Gangal, L.K. 1980. Control of powdery mildew of green gram (*Vigna radiate* L.) wilchzek. Madras Agril. J., 67(10): 666-668.

Hirata, K. 1966. Host range and geographical distribution of the powdery mildews. *Nigata Univ.* Nigata, Japan.

Hirata, K. 1971. Host range and geographical distribution of Erysiphaceae as view from the families of Angiosperms and comparison with Meliolineae *Sydowia,* 25(1-6): 100-118.

Hirata, K. 1986. Host range and geographical distribution on powdery mildew fungi. *Japan Scientific societies Press,* : 741.

Hisfa, K. and Shabeer, A. 2005. Relative efficacy of phytobiocides and fungicides in controlling powdery mildew in pea. Shrhad. J. of Agri., 21(1): 101-102.

Homma, Y. 1937. Erysiphaceae of Japan. J. Fac. Agric. Hokkaido Univ., 38: 183-461.

Hsieh, L.C., Chang Y.C. and Chien, C.C. 1988. Studies on the ecology of the powdery mildew of beans. Journal of Agricultural Research of China, 37(1): 76-85.

Huq, H.I. and Nahar, M.S. 1997 a. Efficacy and economics of different fungicides in controlling rust and powdery mildew of garden pea. Bangladesh journal of scientific and industrial research, 32(4): 533-536.

Hussain, S.I. and Akram, Md. 1997 b. Distribution pattern and identity of composites in the distribution of Agra division. Indian Phytopath., 50(2): 250-255.

Jaczewski, A.A. 1927. Pocket key for the documentation of fungi. Part-II. Powdery mildews. State Institute of Experimental Agriculture, Leningrad, : 626.

Jagtap, G.P. and Khalikar, P.V. 2012. Integrated management of pea powdery mildew caused by *Erysiphe Polygoni* DC. Scientific J. of Agri., 1(1): 33-38.

Kabitarani, A. and Bhagirath, T. 1991. Powdery mildew of cucurbits in Manipur. Indian phytopath., 44: 137-139.

Kachhot, P. Shah, R. Mali, B.L. and Jain, H.K. 2011. Mildew of pea (*Pisum savitum* L.) caused by *Erysiphe pisi* DC. J.of Pl. Dis. Sci., 6(1): 39-43.

Kapoor, A.S. and Chaudhary, H.K. 1995. Mode of perpetuation of *Erysiphe pisi* in dry temperate zone of Himachal Pradesh. Indian Phytopathology, 48(1): 77-78.

Khan, M.M. and Khan, A.M. 1970. Studies on cucurbit powdery mildew-1. Perthecial production in cucurbit powdery mildew in northern India. Indian Phytopath., 23: 497-502.

Khan, M.W. and Sharma, G.K. 1955. Taxonomic evaluation of anamorph character in identification of powdery mildew fungi on cucurbits. Indian phytopath., 48: 314-324.

Khan, W., Akram, M., Khan, M. A. and Khan A. M. 1977. Occurrence of powdery mildews at Aligarh and adjoining areas. Acta Botanical Indica, 5: 139-142.

Khan, Y.M. and Iqbal, M.A.M. 2008. Evaluation of various fungicides against powdery mildew disease on peas. Pakistan J.of Phytopath., 20(2): 270-271.

Khare, N., Lakpale, N. and Agrawal, K.C. 1998. Epidemiology of powdery mildew of mungbean in Chhattisgarh region of Madhya Pradesh. J. Mycol. PL Pathol., 28(1): 5-10.

Khatri, N.K. and Gangopadhyay, S. 2008. Effect of date of sowing on powdery mildew and white rust of mustard in arid region of Bikaner. J. Mycol. Pl. Path., 38(3): 681-682.

Kotasthane, S. R. and Agrawal, S.C. 1978. Control of foliar disease of mungbean by fungicides. Pesticides, 10(8): 35-36.

Krishnamoahan, G., Gangadharan, K. and Shanmugasundaram, P. 1986. Efficacy of certain fungicides against powdery mildew disease of black gram (*Vigna mungo* L. Hepper) powdery mildew (*Erysiphe polygoni* DC) madras. Agric. J., 73(3): 173-175.

Kumar, A. and Gupta, S.K. 2006. Influence of abiotic environmental factors on pea powdery mildew. Indian J. Mycol. Pl. Pathol., 36(2): 182-184.

Kumar, V. and Gupta, P. 2008. Efficacy of fly ash based rhizobium on growth and incidence of powdery mildew in pea. Ann. Pl. Protec. Sci., 16: 248-249.

Kunkalikar, S. and Padagnur, G.M. 1989. Studies on powdery mildew of green gram Vigna radiata (L.) Wilczek caused by *Erysiphe polygoni* DC. Karnataka Journal of Agriculture Sciences, 2(1): 96.

Kunkalikar, S. and Padagnur, G.M. 1991. Effect of date of sowing on incidence of green gram powdery mildew. Karnataka Journal of Agriculture Sciences, 4 (3-4): 165-167.

Lazzeri, L. D., Rongai, D. and Cerato, C. 2009. A natural fungicide for the control of *Erysiphe betae* and *Erysiphe cichoraceanim.* Eur. J. Plant Pathol., 124: 613-619.

Leveille, J.H. 1851. Organisation of disposition methodique desespeces qui composent de genre Erysiphe Ann. Sci. Nat., 15: 105-179.

Linnaeus, C. 1753. Species Plantarum, 2: 11-86.

Linnaeus, C. 1767. History and taxonomy. In: The Powdery Mildew. *Ed. Spencer, D. M., Academic Press,* London, :16-25.

Manojkumar, A., Ganeshan, G., Reddy, K.N. and Ramchandra, Y.L. 2008. Integrated disease management for control of powdery mildew in bell pepper. The asian and austrilian J. of pl.sci. and biotechno., 2(2): 107-112.

Mathur, R.L., Daftari L.N. and Jhamariya, S.L. 1972. Effectiveness and economics of fungicidal control of powdery mildew of udid. Rajsthan J.Agriculturel Sciences, 2(1): 21-23.

Maurya, S., Singh, D.P., Srivastava, J.S. and Singh, U.P. 2004. Effect of some plant extracts on pea powdery mildew (*Erysiphe pisi*). Ann. Pl. Protec. Sci., 12(2): 296-300.

Mcgrath, M. T. 2001. Fungicide resistance in cucurbit powdery mildew experiences and challenges. Plant Dis., 85: 236-245.

Mittal, R.K. and Sharma, A.K. 1992. Powdery mildew of black gram and green gram in kumaon hills. Indian Journal of Mycology and Plant Pathology, 22 (2): 202-203.

Moghe, S.V. and Uttikar, P.G. 1981. Effects of sowing dates on the incidence of powdery mildew on Green gram (*Vigna radiata).* Indian J.mycol., Plant Pathol., 11(1): 91-99.

Moghe, S.V., Uttikar, P.G. and More, B.B. 1982. Fungicidal control of powdery mildew *(Erysiphe polygoni* DC*)* of Green gram (*Vigna radiata)* Wilczek. Pesticides, 16(8): 10-11.

Mohan, S.K., Bijman, V.P. and Miller, D.R. 2001. Powdery mildew caused by *Erysiphe pisi* on alfalfa in Idaho and Oregon. Plant Dis., 85: 678.

Mukherjee, D., Sharma, B.R. and Mani, J.K. 2013 a. Influence of different sowing dates and cultivars on growth, yield and disease incidence in garden pea (*Pisum sativum*) under mid hill situation. Indian J. Agric. Sci., 83: 918-923.

Mukhtar, I., Khokhar, I. and Sobia, M. 2013 b. New record of *Podosphaera xanthii* on *Ageratum conyzoides* L. in Pakistan. Pakistan Journal of Weed Science Research, 19(4): 475-479.

Munjal, R.L., Chenulu, V.V. and Hora, T.S. 1963. Assessment of losses due to powdery mildew. *(Erysiphe polygoni* DC) on pea. *Indian Phytopath.*, 16(1) : 268-270.

Munshi, G.D. and Jhooty, J.S. 1980. Host range and pathogenicity of *Erysiphe polygoni* DC. Indian J. Mycol. PI Path. 10(2): 28.

Naik, K.S. and Nagaraj, A. 2000. Chemical control of powdery mildew of okra. Indian Journal of Plant Protection, 28: 41-42.

Nawazi, R.M.S. and Narayanswamy, D.P. 1983. Chemical control of powdery mildew disease of black gram and green gram. Pesticides, 17(12): 23-24.

Nayak, B.C. and Patra, A.K. 2000. Response of green gram (Vigna radiata) cultivars to dates of sowing during winter. *Indian Journal of Agricultural Sciences*.**70** (5): 320-322.

Neger, F.W. 1902. Seitrage Zur Biologic der Eyrsipheen I. *Flora.*, 90: 221-272.

Patel S. J. 2007. Influence of Foliar Sprays of Fungicides, Phytoextracts and Bioagent on Powdery Mildew and Yield of Mustard. Karnataka J. Agric. Sci., 21(3): 462-463.

Patel, M.K., Ramat, M.M. and Bhide, V.P. 1949. Fungi of Bombay, Supplement- I. Indian Phytopath., 2: 142-155.

Patel, R. and Sharma, N. D. 1966. Advance in Plant Sciences, 4: 1-22.

Paul, Y.S. and Kaushal, R.P. 1985. Effect of relative humidity on germination of powdery mildew conidia. Indian Phytopathol., 38(4): 757-758.

Pawar, V. P. and Patil, V. A. 2011. Occurrence of powdery mildew on some wild plants from Khandesh region of Maharashtra State. Recent Res. in Sci. and Techn., 3(5): 94-95.

Prabhu, A.S., Pathak, K.D. and Singh, R.P. 1971. Powdery mildew of 'Bhindi' *(Abelmoschus esculentus* L. Moench) in Delhi State. Indian J. Hort., 28: 310-312.

Prasad, P. and Dwivedi, S.N. 2007. Fungicidal management of field pea (*Pisum sativum* L.) powdery mildew caused by *Erysiphe polygoni* Dc. Progressive Research. 2(1): 116-118.

Prithiviraj, B., Singh, U.P. and Singh, K.P. 1998. Field evaluation of ajoene, a constitude of garlic (*Alluim sativum*) and neemazol product of neem *(Azadirechta indica*) for the control of powdery mildew (*Erysiphe pisi*) of pea (pisum sativum). Zeitschrift Fur Pflanzenkrankheitea und Pflanzenschutz , 105(3): 274-278.

Rabindran, R. Pillayarsamy, K. jeyarajan, R. and Narayansamy, P. 1988. Need based application of fungicide for control of powdery mildew (*Erysiphe polygoni* DC of black gram.) madras. Agric. J., 75(9-10): 358-361.

Raghuchandan, T. and Rajgoplan, K. 1995. Relationship between pwdery mildew and meteorological factors in urdbean. Plant Disease Research, 10(1): 5-9.

Rahman, M.A., L. Yasmin, M.A. Bariand and A. E. Hossain. 2005. Shabgi Fosoler Rog-balai O Protikar. Plant pathology Division. Horticulture Research Centre. Bangladesh Agriculture Research Institute. Gazipur, : 20-23.

Rakhonde, P. N., Anvikar, D.G., Mane, S. S. And Harne, A. D. 2013. Implications of different sowing dates on incidence of powdery mildew (*Erysiphe polygoni* DC) and yield of green gram. J.Pl.Dis.Sci., 8(2): 252-253.

Rao, P.N. 1961. *Sphaerotheca* on two members of Euphorbiaceae from Hydrabad (India). Curr. Sci., 30: 433-435.

Rathi, A.S., Gupta, P.P. and Jhorar, B.S. 2002. Yield losses due to powdery mildew disease in fenugreek (*Trigonella foenumgraecum* L.). Journal of Spices and Aromatic Crops, 11(2): 143-145.

Roy, A.K. 1973. Occurrence and control of powdery mildew on a few plants in Assam. Indian Phytopath., 26 : 578-581.

Saliman, M., Yang, S.M., and Wilson, L. 1982. Reaction of *Helianthus* species to *Erysiphe cichoracearum*. Plant Disease, 66: 572-573.

Salmon 1900. A monograph of the Erysiphaceae. Mem Torr. Bot. Club, 9: 1-292.

Sanger, R.B.S. and Singh, V.K. 1994. Effect of sowing date and pea varieties on the severity of rust, powdery mildew and yield. Indian J. Pulses Res., 7 (1): 88-89.

Saxena, M., Saxena, D.R. and Saxena, R.R. 1997. Effect of interrelationship of weather parameters on powdery mildew of epidemics in *Vigna mungo* L. *crop research*, 14(3): 501-505.

Setty, T.A.S., Parmeswar, P.S. and Krishnappa, M.R. 1996. Control of powdery mildew of black gram with fungicides. Current research, 25(1): 14-15.

Sharma, A.K. 1979. Powdery mildew disease of some crucifers from Jammu and Kashmir State. Indian J. Mycol. PL. Pathol., 9: 29-32.

Sharma, A.K. 1992. Effect of planting dates and weather on powdery midew of pea. Indian J. Mycol. PL. Pathol., 72(12): 974.

Sharma, K.D. 2000. Management of pea powdery mildew in trans-Himalayan region. Indian Journal of Agricultural Sciences, 70(1): 50-52.

Sharmila, A. S., Kachapur, M. R. and Patil, M. S., 2004, Field evaluation of fungicides against powdery mildew of chilli. J. Mycol. Pl. Pathol., 34: 98-99.

Shukla, P. and Amin, K.S. 1991. Integrated disease management of powdery mildew of field peas (*Pisum sativum* L.) caused by *Erysiphe polygoni*. Legumes research, 14(2): 59-63.

Sindhan, G.S., Hooda, I. and Parashar, R.D. 1999. Evaluation of plant extracts for the control of powdery mildew of pea. J. mycol. Plant pathol., 29(2): 257-258.

Singh *et al.* 1994. The powdery mildew of pea. Indian Institute of Pulses Research. : 1-6.

Singh, R.S. 1990. Powdery mildew of pea. Plant disease sixth edition, Oxford and IBH Publication, New Delhi, : 227-230.

Singh, S.D. and Naik, S.M.P. 1977. Field control of powdery mildew of urd by fungicides . Indian J. Mycol. Pl. Path., 6(1): 99.

Singh, U.P. and Sing, H.B. 1983. Comparative Efficacy of Some commercial fungicides plant extracts and the oil for control of powdery mildew (*Erysiphe polygoni* DC) of pea (*Pisum sativum* L.). Australasian Plant Pathology, 12(2): 22-24.

Singh, U.P., Mishra, G.D., Singh, K.P. and Shrivastava, B.P. 1995. Effect of sowing dates on the incidence and severity of powdery mildew of pea (*Pisum sativum* L.). New Agricultural., 6(1): 1-6.

Singh, U.P., Shrivastava, B.P., Singh, R.P. and Mishra, G.D. 1991. control of powdery mildew of pea by ginger extract. Indian phytopath., 44: 65-69.

Siradhana, B.S. and Chaudhari, S.L. 1972. Occurrence of *Erysiphe cichoracearum* and *Sphaerotheca fulginea* at Udaipur, Rajasthan, India. Indian J. My col. PI. Path., 2: 76-79.

Sivaprakasam, K. 1983. Efficacy of some chemicals in the control of black gram (vigna mungo L. Hepper) powdery mildew (*Erysiphe polygoni* DC) madras. Agric. J., 70(2): 95-96.

Sivaprakasam, K., Marimuthu, T., Radhakrishnan, T. and Vairavan, K. 1981. Influence of date of sowing spacing on the incidence of powdery mildew of green gram and black gram. Madaras Agricultural Journal, 68: 65-67.

Somani, R.B., Sapkal, K.N., Wangikar, P.D. and Kodmilwar, R.V. 1976. A new host of *Sphaerotheca fuliginea*. Indian Phytopath., 29: 216.

Soria, J.A. and Quebral, F.C. 1973. Occurrence and development of powdery mildew on mung Philippine Agriculturist., 57: 153-177.

Srivastava, L.S. 1996. relative efficacy of fungitoxicants against powdery mildew of black gram in Sikkim. Journal of hill research, 9(2): 296-298.

Surwase, A.G., Badgire, D.R.and Suryawanshi, A.P. 2009 a. Management of pea powdery mildew by fungicides, botanicals and bio-agents. Annuals of Pl. Prot. Sci., 17(2): 384-3.

Suryawanshi, A.P., Wadje, A.G., Gawade, D.B., Kadam, T.S. and Pawar, A.K. 2009 b. Field evaluation of fungicides and botanicals Against powdery mildew of mungbean. Agric. Sci. Digest, 29(3): 209-211.

Thakur, M. P. 1992. Severity of powdery mildw of mugbean as influenced by crop age and intercropping with tillage. Indian. J. Mycol. Pl. Path., 23(3): 233-240.

Thakur, M.P. and Agrawal, K.C. 1995. Epidemiological studies on powdery mildew of mungbean and urdbean. Int. J. Pest Management, 41: 146-153.

Thakur, M.P., Sone, S.K., Khare, N. and Agrawal, K.C. 2004. Effect of sowing dates and varieties on severity and development of powdery mildew of mungbean. J.Mycol. Pl. Path., 34 (1): 83-85.

Tiwary, A.and Kotasthane S. R. 1986: chemical control of fungal foliar disease of mungbean. Pesticides, 20(12): 47-48.

Tripathi, D.V., Chavhan, P.N., Raut, B.T., Ingle, Y.V. and Pardey, V.P. 2003. Efficacy of fungicides, botanicals and varietals resistance against powdery mildew of pea (*Pisum sativum* L.) PKV-Research-Journal, 25(2): 102-105.

Vander Plank, J.E. 1963. Plant disease, Epidemics and control. Academic Press, New York, p: 349.

Vinayak, M.S. 1977. Field evaluation of fungicides and cultural methods to control powdery mildew (*Erysiphe polygoni* DC) of green gram, M.SC. Thesis, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India.

Wadje, A.G., Suryawanshi, A.P., Gawade, D.B., Kadam, T.S. and Pawar, A.K. 2008. Influence of sowing dates and varieties on incidence of powdery mildew of mungbean. J.Pl. Dis. Sci., 3(1): 34-36.

Yarwood, C.E. 1973. Pyrenomycetes : Erysiphales. In : The Fung Vol. IV A edited by G.C. Ainsworth, F.K. Sparrow and A.S. Sussman. Academic Press, New York, San Fransisco and London, 621: 71-86.

Yarwood, C.E. 1936. The diurnal cycle of the powdery mildew, *Erysiphe polygoni.*

Yarwood, C.E. 1957 a. Defoliation by a rain favoured, a dew favoured, a shade favoured disease. *Phytopath.*, 41: 194-195.

Yarwood, C.E. 1957 b. Powdery mildew. Botanical Review, 23: 235-293.

Yarwood, C.E. 1978. History and taxonomy of powdery mildew in "The powdery mildews" by D.M. Spencer, acad. Press, London, New York and San Francisco, 565: 1-37.

Yarwood, C.E., Cohen, M. and Santili, V. 1954. Temperature relations of powdery mildew. *Hilgardia*, 22: 603-608.

Yen, J.M. and Wang, C.C. 1973. Etude Dur les Champignons parasites du Sud-Fst asiatique VII. Quelques especes d'oidium de forsecahiers du pacifique, 11: 75-116.

Zote, K.K., Khalikar, P.V. and Dandnaik, B.P. 1985. Efficacy of fungicides against powdery mildew of mung. Pesticides, 19(8): 42-43.

Zwirn, H.E. 1943. Studies on *Leveillula taurica.* Palest. J. Bat., 3: 52-53.

APPENDIX – A

Weekly meteorological data during crop growth period (from 5 November, 2015 to 11 March, 2016)

Month/year	WK No.	Date	Max. Temp. (^{0}C)	Min. Temp. (^{0}C)	Rainfall (mm)	Rainy Days	Relative humidity %		Vapour Pressure (mm of Hg)		Wind Velocity (Kmph)	Evapo-ration (mm)	Sunshine (hours)
							I	II	I	II			
November, December, 2015	**45**	Nov 05-11	31.7	18.8	0.0	0	91	37	15.8	12.4	2.6	3.5	7.8
	46	12-18	31.7	16.3	0.0	0	89	33	13.3	11.0	2.4	3.3	7.5
	47	19-25	30.6	15.5	0.0	0	88	36	12.6	11.3	2.8	3.3	8.3
	48	26-02	31.9	16.7	0.0	0	87	34	13.4	11.6	2.4	3.3	7.5
		Average	**31.47**	**16.82**	**0.0**	**0**	**88.75**	**35**	**13.78**	**11.57**	**2.55**	**3.35**	**7.77**
December, 2015	**49**	Dec 03-09	31.2	14.8	0.0	0	88	31	12	10	2.3	3.0	8.0
	50	10-16	30.1	17.3	4.4	1	77	46	12.2	13.6	2.9	2.7	4.4
	51	17-23	27.7	16.6	9.4	1	85	52	13.1	13.3	3.1	2.3	2.0
	52	24-31	26.9	10.8	0.0	0	87	29	9.1	7.4	2.4	2.6	6.2
		Average	**28.97**	**14.87**	**3.45**	**0.5**	**84.25**	**39.5**	**11.6**	**11.07**	**2.67**	**2.65**	**5.15**
January, February, 2016	**1**	Jan 01-07	30.5	12.1	0.0	0	82	27	9.2	8.2	2.0	2.9	7.9
	2	08-14	29.3	11.1	29.3	0	87	27	9.4	7.9	2.5	3.1	7.5
	3	15-21	27.4	14.3	2.0	1	88	49	11.3	12.1	3.6	2.4	3.8
	4	22-28	27.0	9.0	0.0	0	90	33.3	8.3	8.9	2.6	3.0	8.7
	5	29-04	31.7	14.2	0.0	0	83	31	10.3	10.5	2.8	3.7	9
		Average	**29.18**	**12.14**	**6.26**	**0.2**	**86**	**33.46**	**9.7**	**9.52**	**2.7**	**3.02**	**7.38**
February, March, 2016	**6**	Feb 05-11	31.1	14.0	0.0	0	78	32	10.2	10.6	3.0	4.2	8.9
	7	12-18	31.9	18.9	0.3	1	81	42	13.4	15.1	3.2	3.4	4.5
	8	19-25	34.9	19.3	0.0	0.0	69	30	12.8	11.7	3.1	4.6	6.9
	9	26-04	33.6	20.8	0.0	0.0	81	37	15.8	13.4	3.3	4.1	3.8
	10	05-11	35.4	20.2	0.6	1	73	27	13.7	11.1	4.3	5.5	7.4
		Average	**33.38**	**18.64**	**0.18**	**0.4**	**76.4**	**33.6**	**13.18**	**12.38**	**3.38**	**4.36**	**6.3**

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