

**“STUDIES ON PREVALENT DISEASES OF OKRA
[*Abelmoschus esculentus* (L.) Moench] WITH SPECIAL
REFERENCE TO POWDERY MILDEW”**

M. Sc. (Ag.) Thesis

by

Ruparani Diwakar

**DEPARTMENT OF PLANT PATHOLOGY
COLLEGE OF AGRICULTURE, RAIPUR
FACULTY AGRICULTURE
INDIRA GANDHI KRISHI VISHWAVIDYALAYA, RAIPUR
(Chhattisgarh)**

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[*Abelmoschus esculentus* (L.) Moench] WITH SPECIAL
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Thesis

Submitted to the

Indira Gandhi Krishi Vishwavidyalaya, Raipur

by

Ruparani Diwakar

**IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF**

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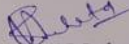
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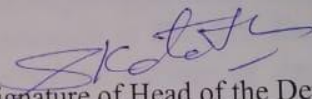
This is to certify that the thesis Viva-voce in respect of **Miss Ruparani Diwakar** student of **M.Sc. (Ag.), Department of Plant Pathology** has been conducted under the chairmanship of Head of the Department along with Advisory Committee on 19/10/2020. The necessary corrections have also been made as per comments/suggestions made by the Advisory Committee and Head of the Department.


Signature of Major Advisor
Mrs. Ashulata Kaushal

Date : 29/10/2020

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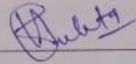
This is to certify that the thesis entitled “**Studies on prevalent diseases of okra [*Abelmoschus esculentus* (L.) Moench] with special reference to powdery mildew**” submitted by **Ruparani Diwakar** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfilment of the requirements for the degree of Master of Science in Agriculture in the Department of Plant Pathology has been approved by the external evaluator and Student’s Advisory Committee after oral examination, under the chairmanship of head of the Department.


Signature of Head of the Department

Dr. A.S. Kotasthane

Date:- 29/10/2020

Major Advisor



Faculty Dean

Approved/Not approved

Director of Instructions

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“Education plays fundamental role in personal and social development, and teacher play a fundamental role in important education,”

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Department of Plant Pathology
College of Agriculture, I.G.K.V.
Raipur (C. G.)

Rupa
Ruparani Diwakar

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LIST OF ABBREVIATIONS

CD	Critical Difference
cm	Centimeter
Fig	Figure
g	Gram
hrs	Hours
<i>i.e.</i>	That is
kg	Kilogram
q	Quintal
ha	Hactere
m	Meter
m ²	Meter square
No	Number
SEm	Standard error of mean
SN	Serial Number
µm	Micrometer
%	Per cent
/	Per
@	At the rate of
RH	Relative Humidity
°C	Degree Celsius
h	hour
<	less than
>	more than
P X P	Plant to plant
R X R	Row to Row
SC	Suspension concentrate
PDI	Per cent Disease Index

THESIS ABSTRACT


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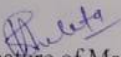
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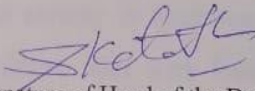
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Signature of student


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Signature of Head of the Department

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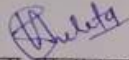
ABSTRACT

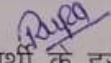
Okra in India is a major vegetable crop grown under tropical and sub-tropical conditions. It belongs to family Malvaceae. The present work on "Studies on prevalent diseases of okra [*Abelmoschus esculentus* (L.) Moench] with special reference to powdery mildew" was carried out at the Horticultural Farm of Indira Gandhi Krishi Vishwavidyalaya Raipur, Chhattisgarh during *kharif* (2019-20). This study involved various objectives including study the occurrence of prevalent diseases of okra, assessment of yield loss of okra, to study the effect of

environmental factors in the development and to identify sources of resistance against powdery mildew of okra. Powdery mildew, *Cercospora* leaf spot, leaf curl and yellow vein mosaic were observed as major prevalent diseases of okra. After the first appearance there was a linear progression observed up to maturity in case of all the diseases observed. The initial disease severity of powdery mildew ranged from 1.11 to 3.31. Maximum disease severity at maturity ranged from 26.99 to 54.1. The disease severity of *Cercospora* leaf spot ranged from 0.16 to 1.30 at the initiation, at maturity it ranged from 7.09 to 11.22. Disease incidence of yellow vein mosaic disease ranged from 0.21 to 0.70 at initiation and at maturity it ranged from 1.66 to 5.49. Disease incidence of leaf curl ranged from 4.87 to 14.66 at maturity. In the assessment of yield loss, the results revealed that fungicidal spray application in protected plots significantly reduced the disease severity and increased yield. The untreated control plots exhibited reduced yield by 51.27% in compare to treated plots. The environmental factors affect the development of the powdery mildew disease. The T (max), T (min) and morning RH showed significant but negative correlation with the severity of the disease, evening RH exhibited non-significant negative correlation with the disease, wind speed showed positive but non-significant correlation, whereas age of the crop was found significant and positively correlated with disease severity in local susceptible check variety studied. Out of 37 genotypes evaluated none were found with completely immune or highly resistant disease reaction, as well as none of the genotype was found with highly susceptible disease reaction. Fourteen genotypes namely 2018/OKYVRES-1, 2018/OKYVRES-2, 2018/OKYVRES-4, 2018/OKYVRES-8, 2017/OKYVRES-1, 2017/OKYVRES-2, 2017/OKYVRES-5, 2017/OKYVRES-9, 2017/OKYVRES-10, 2017/OKHYVRES-2, 2017/OKHYVRES-3, 2017/OKHYVRES-6, 2017/OKHYVRES-9, 2017/OKHYVRES-10 were recorded with moderately resistant reaction and rest twenty three genotypes along with local susceptible check showed moderately susceptible or susceptible reaction against the disease. Apparent rate of infection was higher during 60-75 days after sowing. AUDPC was recorded highest in local susceptible check.

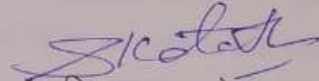
शोध सारांश
शोध सारांश

शोध का नाम	:- "चूर्णिल आसिता के विशेष सन्दर्भ में भिंडी [एबेल्मोस्कस एस्कुलेंटस (एल.) मोएंच] के प्रचलित रोगों पर अध्ययन "
विद्यार्थी का नाम	:- रूपारानी दिवाकर
मुख्य विषय	:- पादप रोग विज्ञान विभाग
मुख्य सलाहकार का नाम एवं पता:-	श्रीमती आशुलता कौशल, वैज्ञानिक पादप रोग विज्ञान विभाग, कृषि महाविद्यालय, इ.गां.कृ.वि.वि. रायपुर (छ.ग.)
सम्मानित किये जाने वाली उपाधि :-	एम.एस.सी. (कृषि), पादप रोग विज्ञान विभाग


मुख्य सलाहकार के हस्ताक्षर


विद्यार्थी के हस्ताक्षर

दिनांक 7/10/2020


विभागाध्यक्ष के हस्ताक्षर

सारांश

भारत में भिण्डी उष्णकटिबंधीय और उपोष्णकटिबंधीय परिस्थितियों में उगाई जाने वाली एक प्रमुख सब्जी है। यह मालवेसी कुल की है। वर्तमान कार्य "चूर्णिल आसिता के विशेष सन्दर्भ में भिंडी [एबेल्मोस्कस एस्कुलेंटस (एल.) मोएंच] के प्रचलित रोगों पर अध्ययन" बागवानी फार्म, इंदिरा गांधी कृषि विश्वविद्यालय रायपुर, छत्तीसगढ़ में खरीफ (2019-20) के दौरान किया गया। इस अध्ययन में विभिन्न उद्देश्यों जिसमें भिण्डी के प्रचलित रोगों की घटना भिण्डी का उपज नुकसान का आकलन, विकास में पर्यावरणीय कारकों का प्रभाव और भिण्डी के चूर्णिल आसिता के खिलाफ प्रतिरोध के स्रोतों की पहचान करना को शामिल किया गया था। भिण्डी में चूर्णिल आसिता, सर्कोस्पोरा पर्ण धब्बा, पर्ण कुंचन और पीत शिरा मोजेक को प्रमुख प्रचलित रोगों के रूप में दर्ज किया गया। परिपक्वता तक एक रैखिक प्रगति, पहली उपस्थिति के बाद देखी गई। चूर्णिल आसिता बीमारी की प्रारंभिक गंभीरता 1.11 से 3.31 तक थी। परिपक्वता पर रोग की अधिकतम गंभीरता 26.99 से 54.1 तक थी। सर्कोस्पोरा पर्ण धब्बा रोग क गंभीरता प्रारंभ में 0.16 से 1.

.11 से 3.31 तक थी। परिपक्वता पर रोग की अधिकतम गंभीरता 26.99 से 54.17 तक थी। सर्कोस्पोरा पर्ण धब्बा रोग क गंभीरता प्रारंभ में 0.16 से 1.30 तथा परिपक्वता पर यह 7.09 से 11.28 तक थी। पीत शिरा मोजेक रोग की घटना प्रारंभ में 0.21 से 0.70 तक तथा परिपक्वता पर यह 1.66 से 5.49 तक थी। परिपक्वता के समय पर्ण कुंचन की बीमारी 4.82 से 14.66 तक थी। उपज नुकसान के आंकलन में परिणामों से पता चला कि संरक्षित प्रक्षेत्र में कवकनाशी छिड़काव करने से रोग की गंभीरता काफी कम हो गई और उपज में वृद्धि हुई। उपचारित प्रक्षेत्रों की तुलना में अनुपचारित नियंत्रण प्रक्षेत्रों में उपज 51.27% की कमी देखी गई। चूर्णिल आसिता रोग के विकास को पर्यावरणीय कारक प्रभावित करते हैं। अधिकतम तापमान न्यूनतम तापमान और प्रातःकालीन आपेक्षिक आद्रता ने रोग की गंभीरता के साथ महत्वपूर्ण लेकिन नकारात्मक सहसंबंध दिखाया सायंकालीन आपेक्षिक आद्रता ने रोग के साथ गैर महत्वपूर्ण नकारात्मक सहसंबंध दिखाया वायु वेग ने सकारात्मक लेकिन गैर महत्वपूर्ण सहसंबंध दिखाया जबकि अध्ययन में पाया गया की स्थानीय अतिसंवेदनशील चेक किस्म में फसल की उम्र को रोग की गंभीरता के साथ महत्वपूर्ण और सकारात्मक रूप से सहसंबंध पाया गया। मूल्यांकन किए गए 37 जीनोटाइप में से कोई भी अतिसंवेदनशील रोग प्रतिक्रिया दर्ज नहीं की गई। 14 जीनोटाइप 2018/OKYVRES-1, 2018/OKYVRES-2, 2018/OKYVRES-4, 2018/OKYVRES-8, 2017/OKYVRES-1, 2017/OKYVRES-2, 2017/OKYVRES-5, 2017/OKYVRES-9, 2017/OKYVRES-10, 2017/OKHYVRES-2, 2017/OKHYVRES-3, 2017/OKHYVRES-6, 2017/OKHYVRES-9, 2017/OKHYVRES-10, मामूली प्रतिरोधी पाए गए। और 23 जीनोटाइप और स्थानीय संवेदनशील चेक को रोग के विरुद्ध मामूली संवेदनशील और संवेदनशील पाया गया। बुवाई के 60–75 दिनों के दौरान संक्रमण की स्पष्ट दर अधिक देखी गई। ए.यू.डी.पी.सी. को स्थानीय संवेदनशील चेक में सबसे अधिक दर्ज किया गया।

CHAPTER I

INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench], also known as Lady's finger or Bhendi in India is a major vegetable crop grown under tropical and sub-tropical conditions. It belongs to Malvaceae family. The crop is often cultivated for its green, non-fibrous, immature fruits (Mastoi and Sahito, 2012). Due to its high multiple qualities like high nutritive and medicinal properties, ease of farming, good portability, export potential and high returns, okra has a well-known position among the fruit vegetables (Benchasri, 2012).

Okra is estimated to be originated someplace around Ethiopia (De Candolle, 1883; Vavilov, 1951), and was used to be cultivated by the former Egyptians by the 12th century B.C. Its cultivation spread throughout North Africa and Middle East. However it originated from Hindustan centre of origin, mainly India, Pakistan and Burma region according to (Zeven and Zhukovsky, 1975). India ranks first in the world with 6,003.00MT (62.28% of the total world production) of ladyfinger/okra. Nigeria ranks second after India with total production of 2060.28MT (21.37% of the total world production). It is also cultivated in Sudan, Mali, Cote d'Ivoire, Niger, Iraq, Pakistan, Ghana, Egypt, Saudi Arabia, Benin, Mexico and Cameroon (FAO, 2017). In India, Gujarat ranks first with the total production of 921.72 tonnes (15.17% of total production) followed by West Bengal with the total production of 914.86 tonnes (15.06% of total production). Chhattisgarh ranks sixth with total production of 323.24 tonnes (5.38% of total production). It is also cultivated in Bihar, Madhya Pradesh, Orissa, Uttar Pradesh, Haryana, Andhra Pradesh and Telangana states (NHB, 2017-18). After onion, okra has the major share in revenue generation through export of fresh vegetables (Kumar and Reddy, 2015).

Okra is mainly cultivated for its edible green seed pod. Plant has heart shaped leaves and large yellow flowers like hibiscus. The pods are usually 3 to 10 inches long, tapering with its ribs down its length. The pods when cut, exude a mucilaginous substance. The whole plant part (fruit, seed, leaves, stem and root) of

okra is useful. The other uses of okra plant include fibre, paper and textile. Fibre content obtained from stem and is used as substitute for jute. The roots and stems of okra are used for juice clarification in sugarcane from which gur (Jaggery) or brown sugar is prepared (Chauhan, 1972).

It requires warm and humid climate for good growth. It is susceptible to low temperature but can be grown successfully under the temperature range between 25-30°C. Rainy season is more favourable for the proper growth of plant. Sandy to clay well manure soil with good drainage is considered fit for okra cultivation. For better yield results soil pH should range from 6.0 to 6.8.

Okra is very excellent source of many nutrient components. It is good source of vitamin A and C also vitamin B complex. It is also rich in calcium, iron, magnesium, phosphorus and potassium.

Table 1.1 Nutritional value of okra per 100 g

Nutrition	Quantity
Energy	138kJ
Carbohydrate	7.46 g
Sugars	1.48 g
Dietary fibre	3.3 g
Fat	0.19 g
Protein	1.9 g
Vitamins	
Vitamin A equiv.	36 µg
Thiamine (B1)	0.2 mg
Riboflavin (B2)	0.06mg
Niacin (B3)	1 mg

Folate (B9)	60 µg
Vitamin C	23 mg
Vitamin E	0.27 mg
Vitamin K	31.3 µg
Minerals	
Calcium	82 mg
Iron	0.62 mg
Magnesium	57 mg
Phosphorous	61 mg
Potassium	299 mg
Zinc	0.58 mg
Other constituents	
Water	89.6 g

Source: USDA database

Okra plant also contains many medicinal properties with it. But before using, it is very necessary to seek advice from a professional. The mucilage can be used as plasma replacement, helpful in washing away toxic substances from the body and have strongly demulcent action (Gemede *et al.*, 2015). In the treatment of syphilis infusion of root is used. In Nepal the juice of root is used in the boils, wound and cuts. It is used in the medication of catarrhal infections, dysuria and gonorrhoea. Other than this fibre present in okra has property of controlling blood sugar level in blood. Okra has nutrient that insure proper functioning of intestine. It is also effective in ulcer and joint healthiness. Due to its alkaline nature, it also gours the mucous membrane in the digestive system. Useful in curing of pulmonary inflammation, bowel irritation and sore throat (Kumar *et al.*, 2013). Its

fruit can be also be used for the control of goitre due to high iodine content in it (Chaudhary, 1979).

A number of diseases (fungal, bacterial and viral) have been reported in India. Diseases are one of the major constraints for low yield of okra (Sastry and Singh, 1974). Fungal diseases namely powdery mildew (*Erysiphe cichoracearum* DC), leaf spot (*Cercospora abelmoschi*), leaf blight (*Rhizoctonia solani*), damping off (*Pythium* spp., *Rhizoctonia* spp. and *Fusarium* spp.) and viral diseases such as yellow vein mosaic, enation leaf curl are commonly observed. Among them powdery mildew is important diseases and of common occurrence which reduces the yield considerably (Khalikar *et al.*, 2011; Dahivelkar *et al.*, 2017)

The causal organism of powdery mildew in okra is *Erysiphe cichoracearum* DC. Which is an obligate parasite. It belongs to; Kingdom – Fungi, Division – Ascomycota, Class – Leotiomycetes, Order – Erysiphales, and Family – Erysiphaceae.

The symptoms of the powdery mildew disease appear as white powder like spots on the surface of the leaf and stem. As the disease progresses, the spots get larger and thicker as a large number of spores form and the mildew spread to the whole length of the plant (Kothari and Shekhawat, 1972; Singh *et al.*, 1988; Vijaya, 2004; Stephen and Chartfield, 2005; Adam, 2012; Bem *et al.*, 2013). Powdery mildew has a pattern in time and space and is influenced by a multiplicity of factor. In which weather play a very important role. Initiation of powdery mildew occurs either through conidia or ascospore under favourable weather conditions.

Powdery mildew caused by *Erysiphe cichoracearum* DC in okra is an economically important disease. It affects most of the commercial varieties of okra. The disease occurs in almost all the season leading to lower yield and resulting in high economic losses (Siddappa *et al.*, 2013). Powdery mildew is a serious disease of okra in India and it affects all stages of growth leading into premature defoliation and about 17–86.6% loss in yield due to the disease (Prabhu *et al.*, 1971; Sridhar and Sinha, 1989), and losses are significant in case of favourable weather conditions if the infection occur at early stage of crop growth (Gupta and Thind, 2006). The accelerated yield potential is often limited by the damage caused by various insects and diseases. Hence the need of the hour is to release

commercially important varieties having the combination of many desirable characteristics including pest and diseases (Nikitha *et al.*, 2016). Morphological characterization is essential and important step for crop improvement programme and it provide scope for improvement of horticultural traits (De Vicente *et al.*, 2005; Oppong-Sekyere *et al.*, 2011; Kumar *et al.*, 2011). Though there are chemicals that can reduce development of disease, they are not economical and may cause environmental pollution. Development of resistant varieties is the most appropriate approach to the disease. The disease initiation and progress are weather dependent and some weather parameters, if not all, can critically influence the epidemic. With this background, the present research work was aimed to evaluate the okra genotypes against powdery mildew pathogen and identify the critical weather parameters associated with the initiation and spread of disease under field conditions.

Looking at the economic importance of the diseases the present pathological studies were undertaken to cover the following aspects:

- 1) To study the occurrence of prevalent diseases of okra during *kharif* cropping period.
- 2) Assessment of yield loss due to powdery mildew of okra.
- 3) To study the effect of environmental factors in the development of powdery mildew.
- 4) To identify sources of resistance against powdery mildew of okra.

CHAPTER II

REVIEW OF LITERATURE

The pertaining literature available on various aspects of disease including occurrence, assessment of yield loss, affect of environmental factors and source of resistance has been included and presented here under:

2.1 Occurrence of prevalent diseases of okra during *kharif* cropping period

Kumar *et al.* (2013) reported damping-off (*Macrophomina phaseolina*, *Pythium aphanidermatum*, and *Rhizoctonia solani*), vascular wilt (*Fusarium oxysporum*), *Cercospora* blight (*Cercospora abelmoschus*, *Cercospora malayensis*) and powdery mildew (*Erysiphe cichoracearum*, *Oidium abelmoschi*), as the most serious fungal diseases of okra in Africa. Okra mosaic virus, transmitted by flea beetles (*Podagrica*), is widespread in Africa but Okra leaf curl virus, transmitted by whitefly (*Bemisia tabaci*) causes major damage. Whitefly is also the vector of *Yellow vein mosaic virus*, a major cause of crop failure in Asia.

Anjorin *et al.* (2013) in his study reported that leaf spot disease of okra had the highest mean incidence of 23.8% and yellow mosaic disease showed the highest severity in okra plant.

Asare-Bediako *et al.* (2014) in his study to find the prevalence and severity of okra mosaic and okra leaf curl disease observed that incidence of OMD and OLCD ranged from 78 to 83% and 63 to 70 % respectively in the Central Region of Ghana, and the corresponding severity indices ranged from 55 to 63% and 41 to 46% respectively.

Rajalakshami *et al.* (2016) reported that in the survey conducted in five different region of Tamilnadu severity of powdery mildew of bhendi ranged from 43.32 to 90.13 per cent.

Nneke (2017) studied the occurrence of *Cercospora* leaf spot disease of okra in Itu Local Government Area of Akwa Ibom State, Nigeria in 2014 and 2015

during month (March-October). For sample five okra farms were selected. Ikot Ntuen in Oku Iboku Clan was observed with highest disease incidence (66.6%) and Ika was observed with lowest disease incidence (16.6%). The pathogen was observed with conidiophores dark in colour, simple, arising in clusters and bearing conidia on new growing tips and were hyaline, filiform and multiseptate. The pathogen was identified as *Cercospora* species on the basis of characteristics observed under the microscope.

Banvasi *et al.* (2020) studied the incidence and severity of foliar diseases of okra during *kharif* and *rabi* season. Per cent disease incidence of *Cercospora* leaf spot, powdery mildew and okra yellow vein mosaic disease was highest (55.60%), (64.60%) and (11.2%) in *kharif* season than in *rabi* season. Whereas the incidence of leaf curl was observed higher in *rabi* season (23%). In context of disease severity average per cent disease severity was observed highest in *kharif* (37.46%) then in *rabi* ((35.90%).

2.2 Assessment of yield loss due to powdery mildew of okra

Bachilal *et al.* (2013) in his field experiment to study the yield loss caused by powdery mildew, reported that comparatively lower disease severity (5.89% - 7.98%) and higher yield (64.59 to 78.30 q/ha) in plots receiving three to six sprays of penaconazole. Disease was reduced up to 81.48, 84.15, 84.85 and 86.34% when sprayed three, four, five and six time respectively. Maximum yield was obtained from plots that received three sprays of penaconazole compared to other treatment and control plot.

Ashtaputre (2014) on his study on assessment of loss due to powdery mildew of chilli during *kharif* reported that three fungicidal sprays of penaconazole are sufficient to lower the disease index. Lower disease index, higher yield and maximum BCR was recorded in plots receiving three sprays of penaconazole. Yield loss of 42.82% was observed due to powdery mildew in unsprayed plots.

Sabeena and Ashtaputre (2019) in the conducted experiment observed that three sprays of Sulphur 80WP at twelve days interval starting from the initiation of the disease was optimum for reducing the disease least per cent disease severity

and increased yield of 9.54q/ha. Yield loss of 50% was observed due to powdery mildew in unsprayed control.

2.3 Effect of environmental factors in the development of powdery mildew

2.3.1 Temperature

Gupta *et al.* (2001) in his study with powdery mildew of cucumber (*Cucumis sativus L.*) caused by (*E. cichoracearum*) observed that mean temperature with disease severity were found to be positively correlated (0.2228) but non-significant.

Agrawal and Rao (2015) in the field experiment with powdery mildew of Indian mustard caused by (*Erysiphe cruciferarum*) observed that severity of the disease was favoured by minimum temperature $> 5^{\circ}\text{C}$ and a maximum temperature of 24–30 $^{\circ}\text{C}$.

Sharma (2016) in his study observed optimum maximum and minimum temperature for maximization of powdery mildew severity on okra leaves as 36.7 and 22.5 $^{\circ}\text{C}$ for *kharif*. Maximum temperature (0.903), (0.890), and mean temperature (0.728), (0.695) were found significant and positively correlated while minimum temperature (0.840), (0.840), was found significant and negatively correlated with the intensity of the powdery mildew in hybrid variety GAO-5, Gitanjali 4 respectively.

Ghulam (2016) in his experiment on the powdery mildew of sunflower caused by (*E. cichoracearum* and *Sphaerotheca fuliginea*) observed that the correlation of minimum temperature with severity of disease was significant. The minimum temperature was also found to effect disease severity positively. The disease severity increased when minimum temperature increased from 22.6 to 29.1 degree.

Nag and Khare (2017) in the epidemiological study of powdery mildew in pea caused by *Erysiphe pisi* DC, observed that increase in PDI was maximum when temperature ranges from 28.5-30.0 $^{\circ}\text{C}$ (maximum) and 13.1-14.2 $^{\circ}\text{C}$ (minimum) temperature. Severity in this varieties was negatively correlated with maximum (-0.17) and minimum (-0.19) temperature.

Mishra and Shirsole (2017) disease severity of powdery mildew in pea plant caused by *Erysiphe pisi* was found to be positively and significantly correlated (0.9643) with the maximum temperature, whereas it was non-significant (0.4378) in case of minimum temperature.

2.3.2 Rainfall

Gupta *et al.* (2001) in his study with powdery mildew of cucumber (*Cucumis sativus L.*) caused by (*E. cichoracearum*) observed that cumulative rainfall with disease severity were found to be positively correlated (0.0753) but non-significant.

Sharma (2016) observed non-significant negative correlation (-0.475), (-0.479) with the powdery mildew intensity of the hybrid okra variety GAO-5, Gitanjali respectively with the rainfall.

Ghulam (2016) observed that the correlation of rainfall with disease severity was non-significant because as there was zero increase in rainfall there was no effect on disease incidence on the sunflower. The relationship was best explained by linear regression model as indicated by higher value ($r = 0.65$) show in rain fall graph.

2.3.3 Relative Humidity

Gupta *et al.* (2001) in his study with powdery mildew of cucumber (*Cucumis sativus L.*) caused by (*E. cichoracearum*) observed that, mean relative humidity showed significant and positive partial correlation (0.6392) with disease severity.

Agrawal and Rao (2015) in the field experiment with powdery mildew of Indian mustard caused by (*Erysiphe cruciferarum*) observed that severity of the disease was favoured by > 2 days of morning (maximum) relative humidity of < 90 %, afternoon (minimum) relative humidity of 24–50 %.

Sharma (2016) observed that morning relative humidity (-0.845), (-0.845), afternoon relative humidity (0.935), (0.922) and mean relative humidity (-0.929), (-

0.905) were showed significant and negatively correlation with the powdery mildew severity of the hybrid okra variety GAO-5, Gitanjali respectively.

Ghulam (2016) in his study observed that relative humidity was significantly correlated with disease severity on all the varieties and relationship was best explained by linear regression model as indicated by 0.70, 0.74, 0.74, 0.73 and 0.72 r values respectively in all the five varieties of sunflower. The disease severity was also increased as the relative humidity increased from 26.1 to 44.3.

Nag and Khare (2017) in the epidemiological study of powdery mildew in pea caused by *Erysiphe pisi* DC, observed that increase in PDI was maximum in 68% average relative humidity. Also the pathogen required high relative humidity during morning ranged from 83% to 93% and relative humidity during evening ranged from 23% (5thSMW 2014) to 47% (2ndSMW 2014). Morning relative humidity was found to be negatively correlated (-0.21) with the disease severity whereas evening relative humidity was found to be positively correlated (0.22).

Mishra and Shirsole (2017) observed that disease severity of powdery mildew in pea plant caused by *Erysiphe pisi* was non-significantly correlated (0.8316) with the relative humidity.

2.3.4 Sunshine Hours

Gupta *et al.* (2001) in his study with powdery mildew of cucumber (*Cucumis sativus* L.) caused by (*E. cichoracearum*) observed that partial correlation between disease severity and sunshine hours was highly significant and negative (-0.7041).

Agrawal and Rao (2015) in the field experiment with powdery mildew of Indian mustard caused by (*Erysiphe cruciferarum*) observed that severity of the disease was favoured by > 5 days of ≥ 9.1 hours of sunshine.

Sharma (2016) observed that sun shine hours of (0.910), (0.902) were positively correlated with the PDI of the hybrid okra variety GAO-5, Gitanjali respectively.

Mishra and Shirsole (2017) observed that disease severity of powdery mildew in pea plant caused by *Erysiphe pisi* was significantly correlated (0.9856) with sunshine hours.

2.3.5 Wind speed

Sharma (2016) observed non-significant negative correlation (-0.339), (-0.325) with the powdery mildew intensity of the hybrid okra variety GAO-5, Gitanjali respectively in the wind speed parameter.

Ghulam (2016) in his study observed that wind speed was significantly correlated with disease severity on all the varieties of sunflower and relationship was best explained by linear regression model as indicated by 0.90, 0.53, 0.56, 0.56 and 0.54 r values respectively show in wind speed graph.

Nag and Khare (2017) in the epidemiological study of powdery mildew in pea caused by *Erysiphe pisi* DC, observed that increase in PDI was maximum in wind velocity 1.6 Km/h. The correlation of powdery mildews severity with the speed of wind was significant and positive (0.67).

2.4 Sources of resistance against powdery mildew of okra

G. P. and Utpal (2013) carried out an experiment in *kharif* season of 2007 at Prabhani (Maharashtra) to find out the source of resistance against powdery mildew of okra. The mean disease incidence of 56.12-62.46% was observed on cultivated varieties of okra. Mean foliage disease severity (PDI) of 5.16-10.20, 12.75-22.85 and 49.80-59.35% was observed in okra varieties at 50, 65 and 80 days after sowing respectively. On the basis of overall mean foliage severity, none of the variety/germplasm was recorded immune and resistant, although 8 varieties (PBN OK-4, PBNOK-5, PBN OK-6, PBN OK-8, PBN OK-9, AOH-23, Surya and NOH 100) were found moderately resistant and 22 were found moderately susceptible against the disease.

Adam (2016) screened 143 accessions of okra germplasm for resistance against powdery mildew in 1999. Thirteen accessions were selected and screened in seasons 2000 and 2001. The results of first season showed that HSD 0039, HSD 0061 and HSD 0089 were slightly infected. The results of 2000 and 2001 seasons

showed that only HSD 0874 was resistant to disease without any single infected plant. In 2007 and 2008 only HSD 0874 was compared with four check varieties. HSD 0874 continue to be completely resistant. The results showed that *Sphaerotheca fuligenia* is the associated causal agent for powdery mildew of okra. HSD 0874 was selected as a source of resistance for powdery mildew caused by *Sphaerotheca fuligenia*.

Sharma and Solanki (2017) in the varietal screening experiment observed that Sonakshi and Taj-042 recorded minimum disease severity that is 13.52 and 13.89%, respectively and showed moderately susceptible reaction against disease. While, the varieties such as R.K.-523 (17.96%), Okra-OH- 102 (21.67%), Siri-19 (25.37%), Arka Anamika (26.11%), Venus (33.70%), GO-2 (34.44%) and Rani (42.59%) exhibited susceptible reaction against powdery mildew of okra, whereas, Gitanjali (54.81%), GAO-5 (57.78%) and Pusa Sawani (60.00%) showed higher disease intensity and categorized as highly susceptible varieties.

Younes (2019) conducted an experiment to test susceptibility of 14 okra genotypes against powdery mildew disease caused by *Erysiphe cichoracearum* and for their yield-components under the agro-climatic conditions of Assiut, Egypt. Data revealed that some varieties ex. Beheira, A-Aiat, Giza (a), Seds, Beni-Suef landraces and Gold Coast cultivar were more tolerant to disease. The other varied in their susceptibility. Genotype Pusa Sawani was found most susceptible in both seasons. Pusa Sawani and Gold Coast cultivar were recorded with higher values for yield and its components in both tested seasons. According to results Beheira, a-aiat, Giza (a), Seds, Beni-Suef landraces, Gold Coast and Pusa Sawani cultivar could be combine as a good genetic resource in okra breeding programs for powdery mildew disease resistance and yield.

Kaur *et al.* (2019) carried out experiment on 30 genotypes of okra for powdery mildew resistance. Based upon the mean performance, genotypes 9801, Kashi Vibhuti, DPO-5, Palam Komal and Punjab Suhawani were found resistant to disease and top yielders. All the genotypes taken for study showed resistance and moderately resistance reaction to disease except Kashi Pragati, Shitla Uphar, Shitla Jyoti, Kashi Satdhari, DPO-6, DPO-8, DPO-9, DPO-13, DPO-19 and Punjab-8.

CHAPTER III

MATERIAL AND METHOD

The present study on “**Studies on prevalent diseases of okra [*Abelmoschus esculentus* (L.) Moench] with special reference to powdery mildew**” was carried out during *kharif* 2019-20. This chapter is about the description of location of the experimental plot, climatic conditions of area where the plot is situated, materials used, treatment, design of the experiment and method of cultivation, data collection and statistical analysis.

3.1 Experimental site

The experiment was carried out at the Horticultural Farm of Indira Gandhi Krishi Vishwavidyalaya Raipur, Chhattisgarh during *kharif* (2019).

3.2 Geographical situation

The location of the experimental site was Raipur which is situated at the central eastern part of Chhattisgarh at longitude 81°36 E, latitude 21°16 N and altitude of 298.56 meters from mean sea level in Chhattisgarh Plain Agro-climatic zone.

3.3 Climatic conditions and soil

Raipur is the capital of Chhattisgarh and comes under dry, sub humid agro climatic region. South-west monsoon is the source of rainfall here. And receives an average of 1200-1400 mm rainfall, of which about 80 per cent rainfall is received during rainy season (June to September) and rest during winter season (October to February). The rainfall pattern has a variation during the season from year to year. The temperature goes as high (maximum) as 48°C in summer and as low (minimum) as 6°C during winter (December-January).

Soil of the experimental field was clay loam locally known as Dorsa (Alfisol). It was slightly acidic with a pH of 6.3. The soil had low nitrogen and medium phosphorus and potassium contents.

3.4 Weather conditions during cropping period

The meteorological data of temperature, rainfall, relative humidity, wind velocity, sunshine hours prevailing during the crop period are presented in table.3.1

Table 3.1 Meteorological data during the crop period (*Kharif* 2019-20)

S. No	Week No.	Date	Temperature (°C)		Rain fall (mm)	Relative Humidity (%)		Wind Velocity (Km/h)	Sun Shine (hours)
			Max. Temp. (°C)	Min. Temp. (°C)		Morning	Evening		
1.	29	July 16-22	35.5	26.4	26.1	84	55	3.2	7.5
2.	30	23-29	32.3	25.5	8.4	88	77	6.3	2.7
3.	31	30-05	28.0	24.4	99.0	90	82	10.9	0.5
4.	32	Aug 06-12	30.2	25.3	185.6	89	83	9.6	2.9
5.	33	13-19	30.8	25.4	49.2	90	74	7.0	3.8
6.	34	20-26	31.7	25.2	27.8	92	75	5.3	3.2
7.	35	27-02	30.9	25.1	53.8	92	73	4.6	1.3
8.	36	Sep 03-09	29.5	24.9	239.0	94	87	5.9	0.5
9.	37	10-16	30.7	25.0	9.2	92	74	7.7	4.3
10.	38	17-23	33.0	25.5	2.4	88	63	3.6	8.2
11.	39	24-30	30.2	24.2	178.1	91	74	4.5	3.8
12.	40	Oct 01-07	32.0	24.3	1.8	90	64	3.8	7.5
13.	41	08-14	31.3	23.6	1.2	91	64	2.4	5.4
14.	42	15-21	30.9	21.8	51.0	92	65	2.6	5.7
15.	43	22-28	28.1	22.2	27.6	92	71	3.7	2.8
16.	44	29-04	31.4	22.2	0.0	92	51	1.2	6.0
17.	45	Nov 05-11	30.6	23.0	81.6	91	65	3.0	5.5
18.	46	12-18	29.6	15.5	0.0	90	38	1.8	8.7
19.	47	19-25	30.2	15.2	0.0	89	38	1.4	8.2

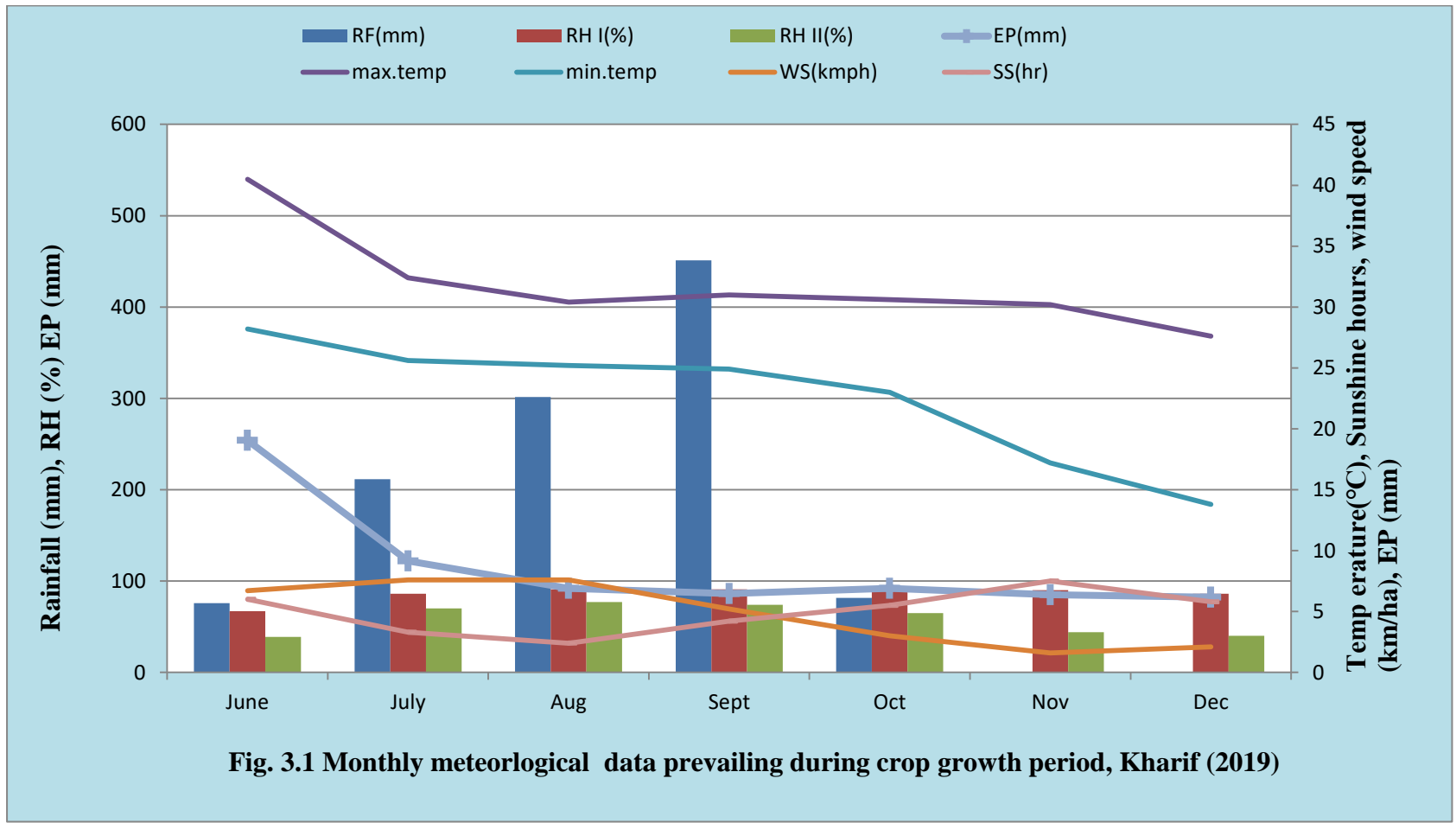
20.	48	26-02	29.7	16.3	0.0	90	43	2.0	6.3
21.	49	Dec 03-09	28.0	13.3	0.0	84	34	2.4	7.6
22.	50	10-16	29.5	15.3	0.0	91	48	1.7	5.2
23.	51	17-23	26.7	14.1	0.8	88	42	1.9	4.9

During the course of research, following objectives were undertaken:-

1. To study the occurrence of prevalent diseases of okra during *kharif* cropping period.
2. Assessment of yield loss due to powdery mildew of okra.
3. To study the effect of environmental factors in the development of powdery mildew.
4. To identify source of resistance against powdery mildew of okra.

3.5 To study the occurrence of prevalent diseases of okra during *kharif* cropping period

The study was undertaken during *kharif* 2019-20 at Horticultural Farm, College of Agriculture, Raipur (Chhattisgarh) to know the occurrence of prevalent diseases of okra during *kharif* cropping period. The per cent disease incidence / per cent disease severity of disease were recorded at fortnightly interval



Powdery mildew

The percentage of disease severity was recorded by employing disease severity scale from 0 to 5 given by (Shivanna, 2003). Where: 0 = No leaf lesions, 1 = 1-10% leaf area affected, 2 = 11-25% leaf area affected, 3 = 26-50% leaf area affected, 4 = 50-75% leaf area affected and 5 = more than 75% area of plant leaf infected.

***Cercospora* leaf spot**

The percentage of disease severity was recorded by employing modified disease severity scale from 0 to 5 given by (Park, 1978). Where 0 = No spot (healthy leaf), 1 = 1-10% leaf area affected; 2 = 10.1-20% leaf area affected; 3 = 20.1-30% leaf area affected; 4 = 30.1-40% leaf area affected and 5 = 40.1 and more leaf area affected.

Enation Leaf curl and yellow vein mosaic

The per cent disease incidence (PDI) was calculated by the following formula:

$$\text{Per cent disease incidence} = \frac{\text{No. of plants infected}}{\text{Total no. of plant}} \times 100$$

3.6 Assessment of yield loss due to powdery mildew of okra

3.6.1 Experiment details

A field experiment was conducted during 2019-20 to assess yield loss due to powdery mildew of okra at Horticultural farm, College of Agriculture, Raipur Chhattisgarh. The plot size was 3 x 2.7 m each with five rows having spacing 30 cm between plants and 60 cm spacing between rows. All agronomic practices were followed as recommended, except fungicidal sprays. Hexaconazole, a broad-spectrum systemic triazole fungicide was used for treating protected plots.

3.6.2 Data recording and analysis

Powdery mildew severity was recorded before first spray using a 0-5 scales given by Shivanna (2003). Subsequent disease scores were taken at 7 days interval. Percent disease index (PDI) was calculated using the formula proposed by (Wheeler, 1969).

$$\text{PDI} = \frac{\text{Sum of all the numerical values}}{\text{Total no. of leaves observed X Maximum grade}} \times 100$$

At proper maturity okra fruits were harvested. At each picking, fruits were harvested plot wise separately and yields were recorded (kg/ha) and expressed in q/ha. Data were compiled and analysed statistically to determine significant differences between protected and unprotected plots. Per cent increase in yield is calculated by following formula.

$$\text{Yield increase (\%)} = \frac{\text{Yield in treatment plot} - \text{Yield in control plot}}{\text{Yield in control}} \times 100$$

3.7 To study the effect of environmental factors in the development of powdery mildew

An experiment was conducted to determine the effect of environmental factors on the development of powdery mildew disease on okra at Horticultural Farm, College of Agriculture, Raipur Chhattisgarh.

3.7.1 Per cent disease index (PDI)

Per cent disease index of powdery mildew were recorded from each plot at weekly interval. Per cent disease index (PDI) was calculated using the formula proposed by (Wheeler, 1969).

$$\text{PDI} = \frac{\text{Sum of all the numerical values}}{\text{Total no. of leaves observed X Maximum grade}} \times 100$$

3.7.2 Meteorological data

Data consisting of mean maximum and minimum temperature (°C), rainfall (mm), relative humidity (%), wind speed (km/hrs) and sunshine hours of *kharif* 2019 were collected from Meteorological department of Indira Gandhi Krishi Vishwavidyalaya Raipur, Chhattisgarh. Average of all above variables were calculated. To determine the influence of various physical factors of environment on the development of disease of okra the data on intensity were correlated with different meteorological parameters on the basis of following formula

$$r = \frac{Cov(X, Y)}{\sigma_x \times \sigma_y} = \frac{\sum_{i=1}^n (X - \bar{X})}{\sqrt{\sum_{i=1}^n (X - \bar{X})^2} * \sqrt{\sum_{i=1}^n (Y - \bar{Y})^2}}$$

Where,

X = Mean of first factor

Y = Mean of second factor

n = Total no. of observations

r = Correlation coefficient

Test of significance of correlation coefficient:

The test of significance of correlation coefficient means to test the hypothesis, whether or not the correlation coefficient is zero in the population that we test.

$H_0: \rho = 0$ vs. $H_1: \rho \neq 0$

Test Statistics $t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$

t-test value n-2 degrees of freedom

3.8 To identify sources of resistance against powdery mildew of okra

Total of 37 genotypes of okra were evaluated against powdery mildew disease under natural conditions at Horticultural Farm, College of Agriculture, Raipur Chhattisgarh to find out resistant genotype.

3.8.1 Experimental details

Field trials were laid out in randomized block design with replicated thrice. Okra genotypes (Group I, Group II, Group III and Group IV) were taken for the study. The seeds of okra genotypes were sown at a spacing of 60 x 30 cm with the plot size 3.0 x 2.7m. The crop was raised as per recommended package of practice. Sowing was done in the last fortnight of July.

Table 3.2 Details of layout

• Farming situation	Medium Black Soil
• Design	R.B.D.
• Replication	03
• Plot size	3.0 x 2.7m
• Plant spacing	30 cm X 60 cm
• Diseases	Powdery Mildew

GROUP-I

	R I	R II	R III
↑	2018/OKYVRES-1	2018/OKYVRES-8	2018/OKYVRES-4
	2018/OKYVRES-2	2018/OKYVRES-6	2018/OKYVRES-3
	2018/OKYVRES-3	2018/OKYVRES-5	2018/OKYVRES-8
	2018/OKYVRES-4	2018/OKYVRES-1	2018/OKYVRES-7
	2018/OKYVRES-5	2018/OKYVRES-2	2018/OKYVRES-1
	2018/OKYVRES-6	2018/OKYVRES-3	2018/OKYVRES-2
	2018/OKYVRES-7	2018/OKYVRES-4	2018/OKYVRES-5
↓	2018/OKYVRES-8	2018/OKYVRES-7	2018/OKYVRES-6

←-----→

Layout Details:

Entries: 8+1

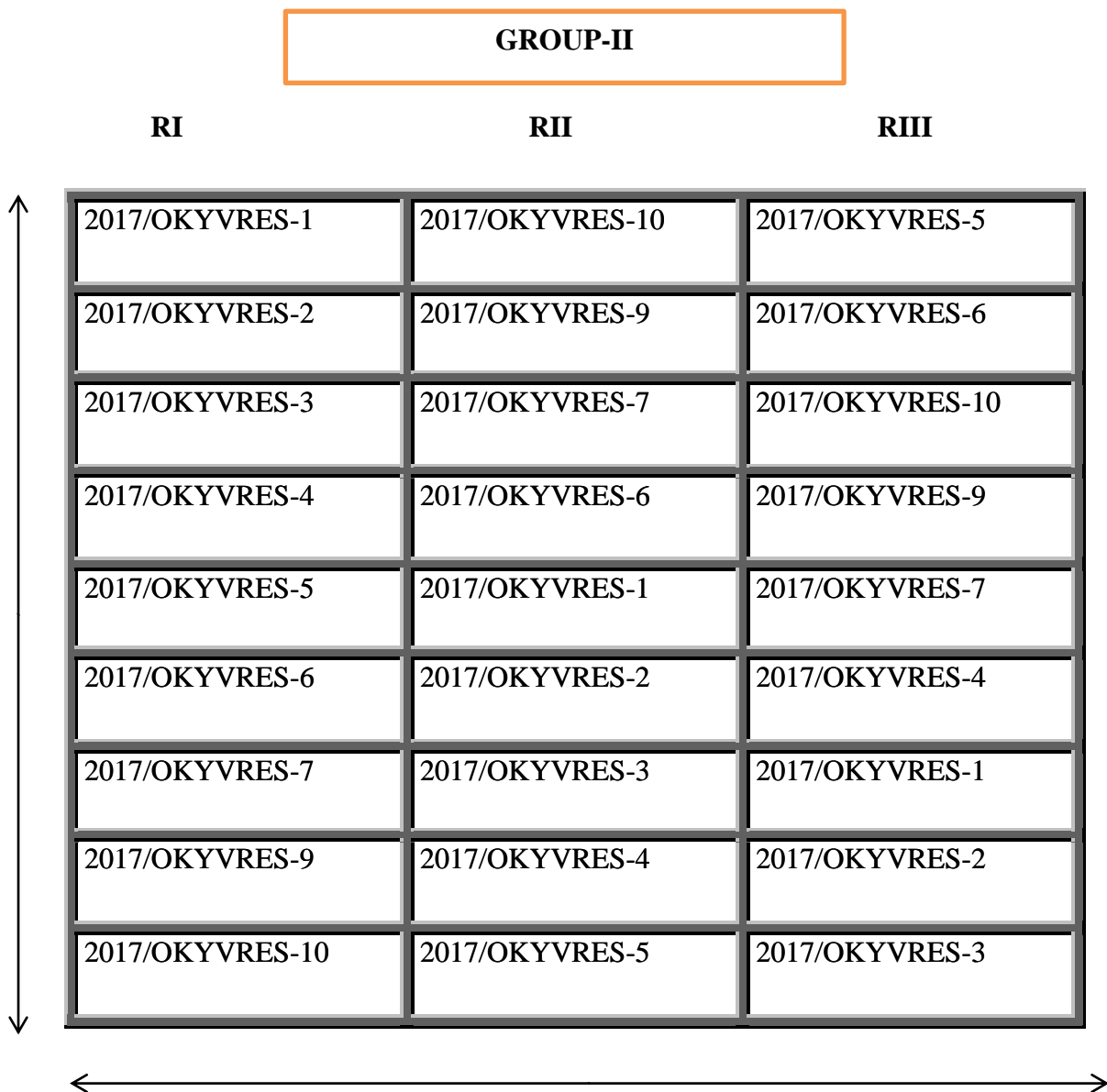
Gross plot size: 8.1m²

Spacing between replication: 1m **Net plot size:** 5.88 m²

Spacing: Row to row (60cm), Plant to plant (30cm)

Design: Randomized Block Design

Fig 3.2: Layout plan of Group-I genotypes



Layout Details:

Entries: 9+1

Gross plot size: 8.1m²

Spacing between replication: 1m

Net plot size: 5.88 m²

Spacing: Row to row (60cm), Plant to plant (30cm)

Design: Randomized Block Design

Fig 3.3: Layout plan of Group-II genotypes

GROUP-IV		
R I	R II	R III
2019/OKYVRES-1	2019/OKYVRES-9	2019/OKYVRES-7
2019/OKYVRES-2	2019/OKYVRES-8	2019/OKYVRES-6
2019/OKYVRES-3	2019/OKYVRES-1	2019/OKYVRES-9
2019/OKYVRES-5	2019/OKYVRES-2	2019/OKYVRES-1
2019/OKYVRES-6	2019/OKYVRES-3	2019/OKYVRES-2
2019/OKYVRES-7	2019/OKYVRES-5	2019/OKYVRES-3
2019/OKYVRES-8	2019/OKYVRES-6	2019/OKYVRES-5
2019/OKYVRES-9	2019/OKYVRES-7	2019/OKYVRES-8
Local susceptible	2019/OKYVRES-13	2019/OKYVRES-13
2019/OKYVRES-11	2019/OKYVRES-12	Local susceptible
2019/OKYVRES-12	2019/OKYVRES-11	2019/OKYVRES-12
2019/OKYVRES-13	Local susceptible	2019/OKYVRES-11

Layout Details

Entries: 11+1

Gross plot size: 8.1m²

Spacing between replication: 1m

Net plot size: 5.88 m²

Spacing: Row to row (60cm), Plant to plant (30cm)

Design: Randomized Block Design

Fig 3.5: Layout plan of Group-IV genotypes

Table 3.3 Details of okra genotypes

S.N.	Genotypes categories	Genotype details	No. of entries	Details of entries
1	Group-I	AVT I	8+1	2018/OKYVRES-1, 2018/OKYVRES-2, 2018/OKYVRES-3, 2018/OKYVRES-4, 2018/OKYVRES-5, 2018/OKYVRES-6, 2018/OKYVRES-8, 2018/OKYVRES-7, local susceptible
2	Group-II	AVT II	9+1	2017/OKYVRES-1, 2017/OKYVRES-2, 2017/OKYVRES-3, 2017/OKYVRES-4, 2017/OKYVRES-5, 2017/OKYVRES-6, 2017/OKYVRES-7, 2017/OKYVRES-9, 2017/OKYVRES-10, local susceptible
3	Group-III	AVT II(HYBRID)	8+1	2017/OKHYVRES-1, 2017/OKHYVRES-2, 2017/OKHYVRES-3, 2017/OKHYVRES-4, 2017/OKHYVRES-8, 2017/OKHYVRES-9, 2017/OKHYVRES-10, 2017/OKHYVRES-6, local susceptible
4	Group-IV	IET	11+1	2019/OKYVRES-1, 2019/OKYVRES-2, 2019/OKYVRES-3, 2019/OKYVRES-5, 2019/OKYVRES-6, 2019/OKYVRES-7,

2019/OKYVRES-8,
2019/OKYVRES-9,
2019/OKYVRES-11,
2019/OKYVRES-12,
2019/OKYVRES-13, local
susceptible

3.8.2 Method of observations

3.8.2.1 Per cent disease index (PDI)

Resistance in powdery mildew was screened under natural infection condition. Five plants from each plot were randomly selected and tagged. Total number of leaves was counted and the leaves were examined individually. Severity of the disease was recorded at an interval of 15 days from the first appearance of the disease. The varieties were graded on the basis of their powdery mildew disease severity (PDI). The details of the key followed for grades and reactions were given by (Shivanna, 2003) and are as follows.

Table 3.4 Disease rating scale for powdery mildew

Grade	PDI	Reaction
0	0	Immune (No disease)
1	1-10%	Highly resistant (HR)
2	11-25%	Moderately resistant (MR)
3	26-50%	Moderately susceptible (MS)
4	51-75%	Susceptible (S)
5	More than 75%	Highly susceptible (HS)

.These rating were used to calculate the Per cent Disease Index (PDI) as follows.
(Wheeler, 1969)

$$\text{PDI} = \frac{\text{Sum of all the numerical values}}{\text{Total no. of leaves observed X Maximum grade}} \times 100$$

3.8.2.2 Area under disease progress curve (AUDPC)

AUDPC was computed for each genotype at 15 days interval using the formula given by (Wilcoxson *et al.*, 1975), who quantified the AUDPC as A-value:

$$\text{AUDPC} = \sum_{i=1}^k \frac{1}{2} (y_i + y_{i-1}) \times d$$

Where, y_i is the disease incidence at i th day of evaluation, k is the number of successive evaluations and d is the interval between i and $i-1$ evaluation of the disease.

3.8.2.3 Apparent rate of infection (r)

The apparent rate of infection (r) is a measure of the speed at which an epidemic develops, the formula for computing apparent rate of disease development was given by (Vanderplank, 1963) and calculated as r - value:

$$r = 2.3/t_2 - t_1 \{ \log x_2/1 - x_2 - \log x_1/1 - x_1 \}$$

Where, r is the apparent infection rate in non-logarithmic phase, x_1 is the disease index at initial week time (t_1), x_2 is the disease index at subsequent week time (t_2). The apparent rate of infection was calculated at 15 days interval for each genotype.

3.8.2.4 Statistical analysis

Table 3.5: The skeleton of the analysis of variance

Source of variation	DF	SS	MSS	F cal	F tab	S.Em \pm	CD 5%
Replication (R)	(R-1)	RSS	RMS	RMS/EMS	-	-	-
Treatment (T)	(T-1)	TrSS	TrMS	TrMS/EMS			
Error	(R-1)(T-1)	ESS	EMS				
Total	RT-1	TSS	-				

The following formulae were used for standard error, critical difference and coefficient of variance estimations.

(a) $S.E.m \pm = \sqrt{EMS/ R}$

(b) $C.D. = \sqrt{2EMS/ R} \times t \text{ (D.F. at 5\%)}$

(c) $C.V. (\%) = \sqrt{EMS/ GM} \times 100$

Where,

R = Number of Replications,

T = Number of Treatments,

C.D. = Critical Difference,

M.S.S= Mean Sum of Square,

S.Em \pm = Standard Error of means.

D.F = Degrees of Freedom

S.S. = Sum of Square

C.V. = Coefficient of Variance

EMS = Error Mean Square

GM = Grand Mean

CHAPTER IV

RESULTS AND DISCUSSION

The data on various aspects of investigation have been presented in this chapter along with appropriate tables and figures. The results have been given under the following headings.

4.1 To study the occurrence of prevalent diseases of okra during *kharif* cropping period

Diseases of okra during the *kharif* cropping season were recorded at various crop growth stages in okra genotypes (Group I, II, III and IV). The data on disease severity of powdery mildew, *Cercospora* leaf spot and disease incidence of yellow vein mosaic, leaf curl of okra was recorded and presented in Table (4.1, 4.2, 4.3 and 4.4).

Table 4.1 Disease occurrence in okra (Genotype group-I)

S.N.	Disease	Disease severity/ Disease incidence (%)						
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS
1.	Powdery mildew*	0	0	0	1.11	12.33	17.05	27.28
2.	<i>Cercospora</i> leaf spot*	0	0	0	0.22	7.22	5.69	10.02
3.	Yellow vein mosaic**	0	0	0.52	0.95	2.45	4.50	4.50
4.	Enation Leaf curl/OELCuV**	0	0	0.20	0.75	1.72	4.82	4.87

*Disease severity %, **Disease incidence %

Table 4.2 Disease occurrence in okra (Genotype group-II)

S.N.	Disease	Disease severity/ Disease incidence (%)						
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS
1.	Powdery mildew*	0	0	0	3.00	11.08	19.99	26.99
2.	<i>Cercospora</i> leaf spot*	0	0	0	0.16	3.78	4.67	11.22
3.	Yellow vein mosaic**	0	0	0.29	1.04	1.44	2.01	2.75
4.	Enation Leaf curl/OELCuV**	0	0	0	1.01	3.81	6.68	8.74

*Disease severity %, **Disease incidence %

Table 4.3 Disease occurrence in okra (Genotype group-III)

S.N.	Disease	Disease severity/ Disease incidence (%)						
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS
1.	Powdery mildew*	0	0	0	2.11	12.10	14.73	24.98
2.	<i>Cercospora</i> leaf spot*	0	0	0	0.63	4.07	4.58	11.28
3.	Yellow vein mosaic**	0	0	0.21	0.22	0.43	1.54	1.66
4.	Enation Leaf curl/OELCuV**	0	0	0	0.45	2.54	3.48	4.42

*Disease severity %, **Disease incidence %

Table 4.4 Disease occurrence in okra (Genotype group-IV)

S.N.	Disease	Disease severity/ Disease incidence (%)						
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS
1.	Powdery mildew*	0	0	0	3.31	9.81	40.08	54.17
2.	<i>Cercospora</i> leaf spot*	0	0	0	1.30	1.93	3.72	7.09
3.	Yellow vein mosaic**	0	0	0.70	3.37	5.35	5.49	5.49
4.	Enation Leaf curl/OELCuV**	0	0	0	6.10	14.73	14.66	14.66

***Disease severity %, **Disease incidence %**

In all groups I, II, III and IV (Table 4.1, 4.2, 4.3, 4.4) of okra genotype I saw a similar pattern in the occurrence of disease. The first appearance of powdery mildew was observed 60 DAS for each group. The initial per cent disease severity was less than 5% and ranged from 1.11 to 3.31%. The per cent disease severity was recorded in increasing trends from the 60 DAS to 105 DAS of the crop period. The maximum disease severity was observed at 105 DAS of the crop which was 54.17% in group IV.

The occurrence of *Cercospora* leaf spot disease was recorded for all groups I, II, III and IV from 15 DAS. The disease not appeared up to 45 DAS of crop period. The first appearance of the disease was observed 60 DAS for each group. It was ranged from 0.16 to 1.30% at the initiation. After that a linear progression was observed up to 105 DAS of crop where it ranged from 7.09 to 11.28%.

First appearance of yellow vein mosaic disease was observed in 45 DAS (ranged from 0.21 to 0.70%) at initiation and at maturity it ranged from 1.66 to 5.49%. The first appearance of enation leaf curl was observed in 60 DAS for all

groups i.e. II, III and IV, whereas in group I the appearance of the disease was observed 45 DAS. At maturity disease incidence of enation leaf curl ranged from 4.87 to 14.66%. Similar studies were also done by (Kumar *et al.*, 2013 and Banvasi *et al.*, 2020) who reported the occurrence of powdery mildew, *Cercospora* leaf spot, yellow vein mosaic and enation leaf curl disease as major diseases of okra during the cropping period in the field conditions.



Powdery mildew



***Cercospora* leaf spot**



Yellow vein mosaic

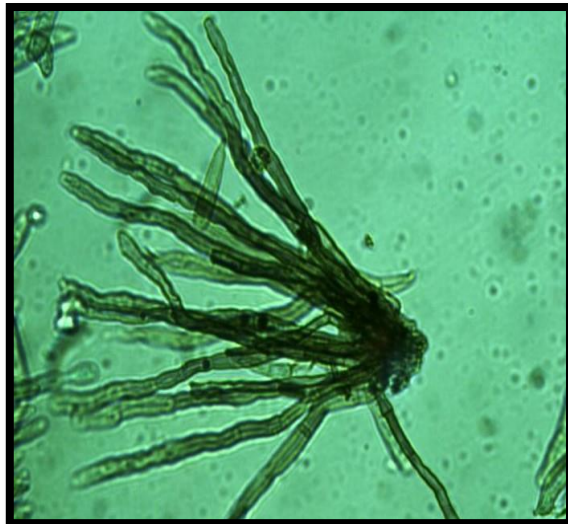


Leaf curl

Plate 4.1 Occurrence of prevalent diseases of okra during *kharif* cropping season 2019



Conidia of *Erysiphe cichoracearum*



Conidiophore of *Cercospora abelmoschi*

Plate 4.2 Microscopic view of the pathogen of powdery mildew and *Cercospora* leaf spot

4.2 Assessment of yield loss due to powdery mildew of okra

A field experiment was conducted at Horticultural Farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur to assess the yield loss due to powdery mildew of okra. In the treated plot sprays of Hexaconazole-5%SC at (0.1%) were applied at fortnight interval during the cropping period. Data pertaining to powdery mildew severity and fruit yield were recorded and presented in table 4.5.

The data revealed that the terminal PDI in treated plot observed to be 11.92% whereas it was 49.96% for untreated control plot. The plots with higher disease severity exhibited lower yield, whereas plots with lower disease severity exhibited higher yield. It is evident from the data that the fungicidal spray application significantly decreased the disease severity and increased fruit yield was obtained. The yield in untreated control plot was observed to be (11.38 q/ha), whereas it was 17.23 q/ha for treated plot. Thus a percentage increase of 51.27% in yield over control was observed, these data corroborates with the earlier findings (Sabeena and Ashtaputre, 2019) who noticed yield loss of 50 % due to powdery mildew in unsprayed control field, (Bachilal *et al.*, 2013) who observed comparatively lower disease index and increased in plots receiving sprays of fungicides, (Dhruj, 2000; Gupta and Shyam, 1998; Khunti *et al.*, 2005) who recorded minimum disease intensity and highest yield in plots receiving treatments of hexaconazole in the field evaluation of fungicide against powdery mildew.

Table 4.5 Assessment of yield loss due to powdery mildew

S. N.	Treatments	Per cent Disease Index (PDI)							Yield q/ha	Per cent yield increase over control
		Days after sowing								
		60	67	74	81	88	95	102		
1	Treated	2.46	4.18	6.22	7.70	9.86	10.53	11.92	17.23	51.27
2	Untreated control	4.50	18.46	25.3	32.64	37.88	46.68	49.96	11.38	-
	SE(m)	0.18	0.35	0.18	0.44	0.60	0.45	0.54	1.20	
	C.D.	0.76	1.42	0.76	1.78	2.44	1.82	2.17	4.84	

Fig. 4.1 Disease progress curve of untreated control plots

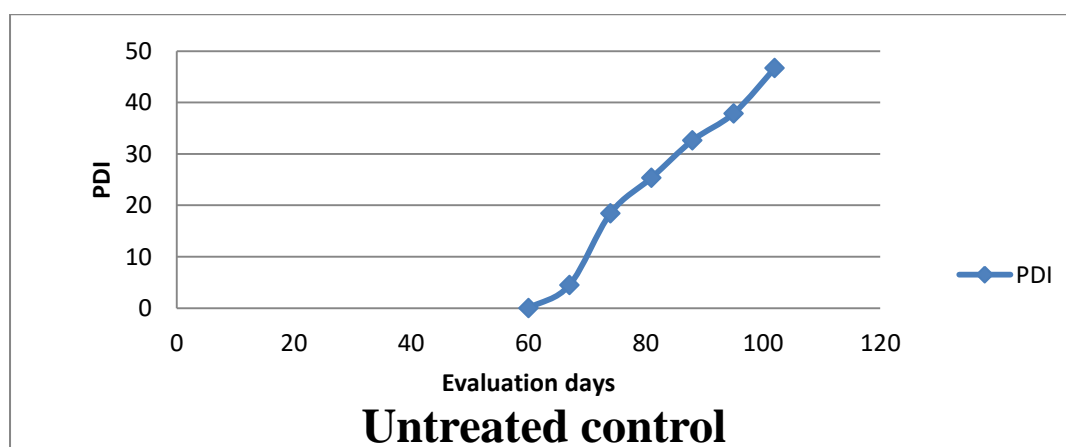




Plate 4.3 Experimental site

4.3 To study the effect of environmental factors in the development of powdery mildew

In order to study the effect of meteorological factors on disease development in local susceptible check variety under field conditions, an experiment was carried out at the Horticultural Farm of Indira Gandhi Krishi Vishwavidyalaya Raipur, Chhattisgarh during *kharif* (2019). The severity of the powdery mildew disease was recorded at seven days interval from the first appearance of the disease.

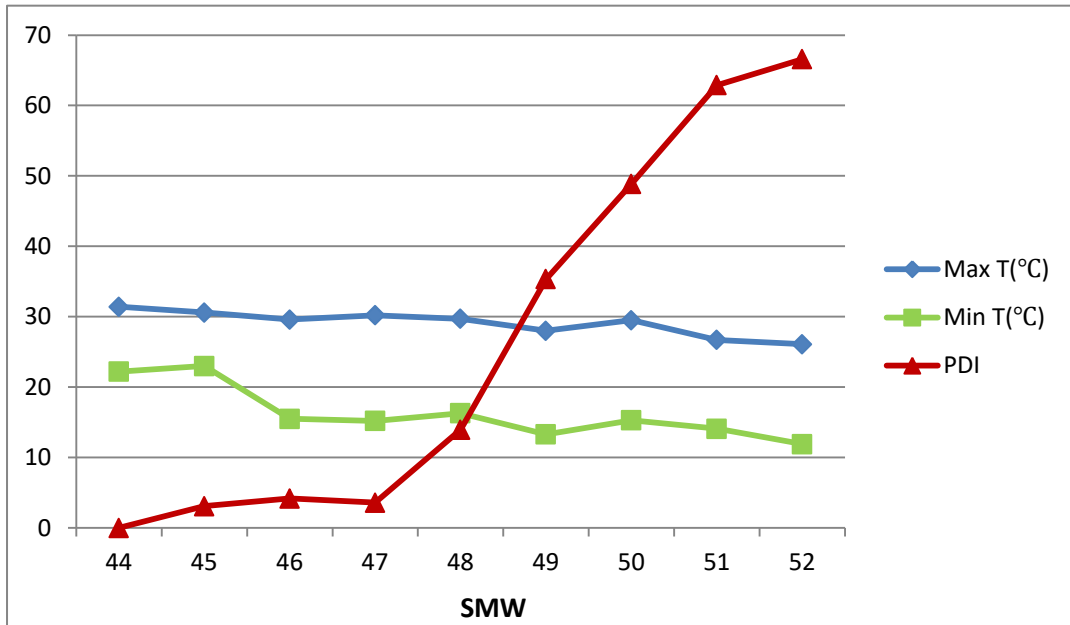
4.3.1 Severity and progress of powdery mildew

The local susceptible check variety was found disease free up to 49 DAS. The initiation of the disease first noticed 56 DAS, where it was found 3.09%. After that linear progress of the disease was observed up to the maturity of the crop. The disease severity was found highest during maturity at 52 SMW where it was found 66.58%.

During the cropping period, maximum temperature ranged from 26.1 to 33°C, minimum temperature ranged from 11.9 to 25.5°C, relative humidity during morning ranged from 81 to 92%, relative humidity during evening ranged from 34 to 74%, wind speed was erratic and ranged from 1.2 to 4.5 km/hr (Table 4.6).

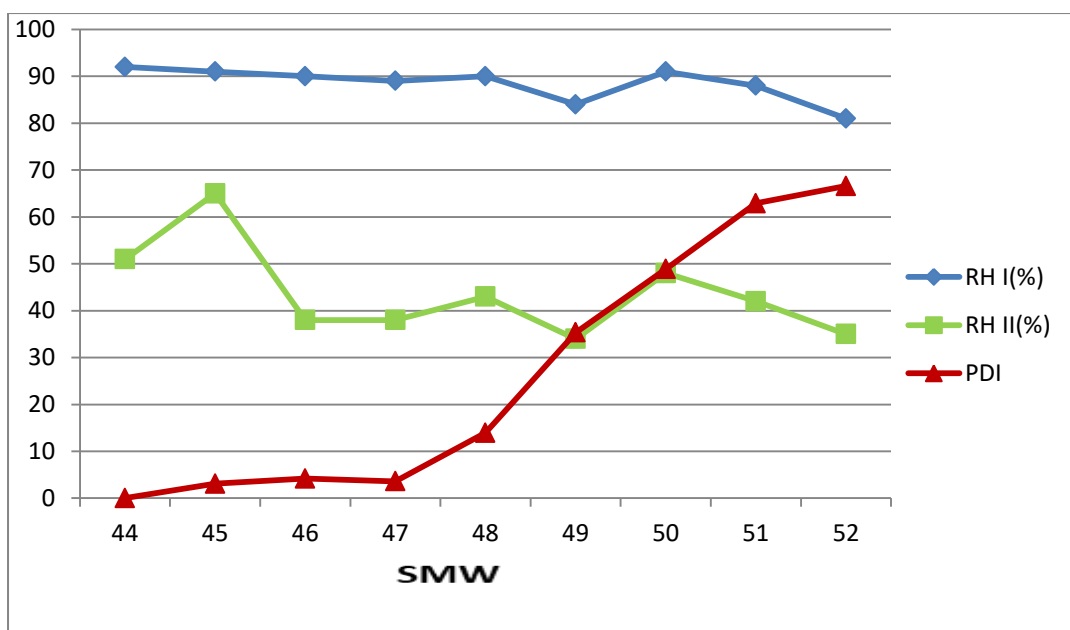
Table 4.6 Meteorological parameters and Powdery mildew severity on local susceptible check variety

SMW	Age of crop	Temperature (°C)		RH (%)		Wind speed (km/hrs)	PDI
		Max	Min	Mor	Eve		Local susceptible check
38	7	33	25.5	88	63	3.6	0
39	14	30.2	24.2	91	74	4.5	0
40	21	32	24.3	90	64	3.8	0
41	28	31.3	23.6	91	64	2.4	0
42	35	30.9	21.8	92	65	2.6	0
43	42	28.1	22.2	92	71	3.7	0
44	49	31.4	22.2	92	51	1.2	0
45	56	30.6	23	91	65	3	3.09
46	63	29.6	15.5	90	38	1.8	4.18
47	70	30.2	15.2	89	38	1.4	3.59
48	77	29.7	16.3	90	43	2	13.95
49	84	28	13.3	84	34	2.4	35.35
50	91	29.5	15.3	91	48	1.7	48.87
51	99	26.7	14.1	88	42	1.9	62.9
52	105	26.1	11.9	81	35	2.5	66.58



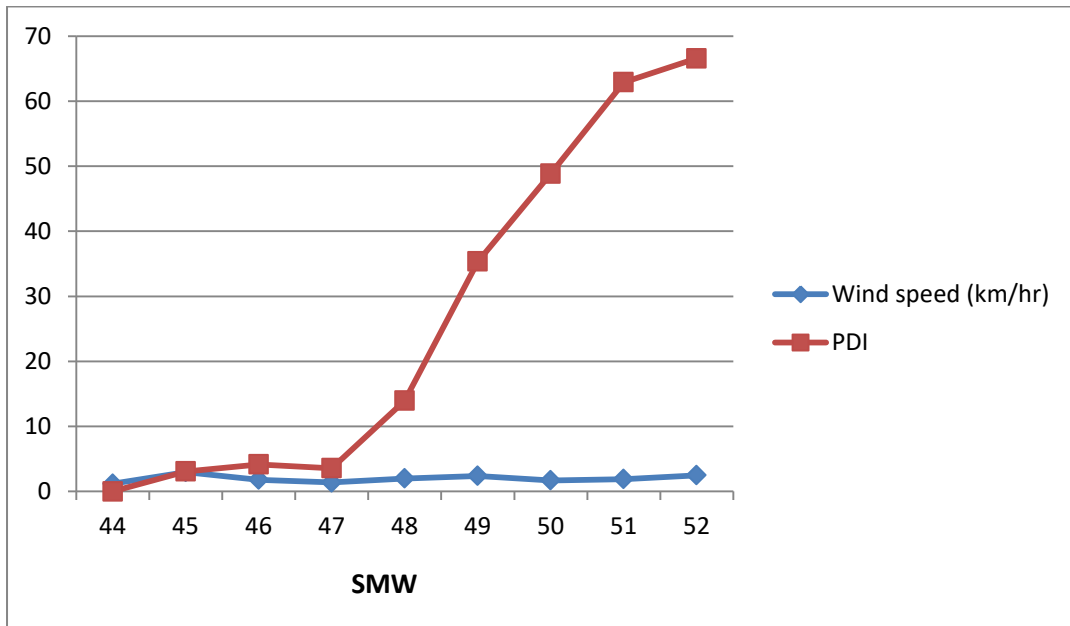
SMW-Standard Meteorological weak

Fig 4.2 Relation of disease severity with maximum and minimum temperature



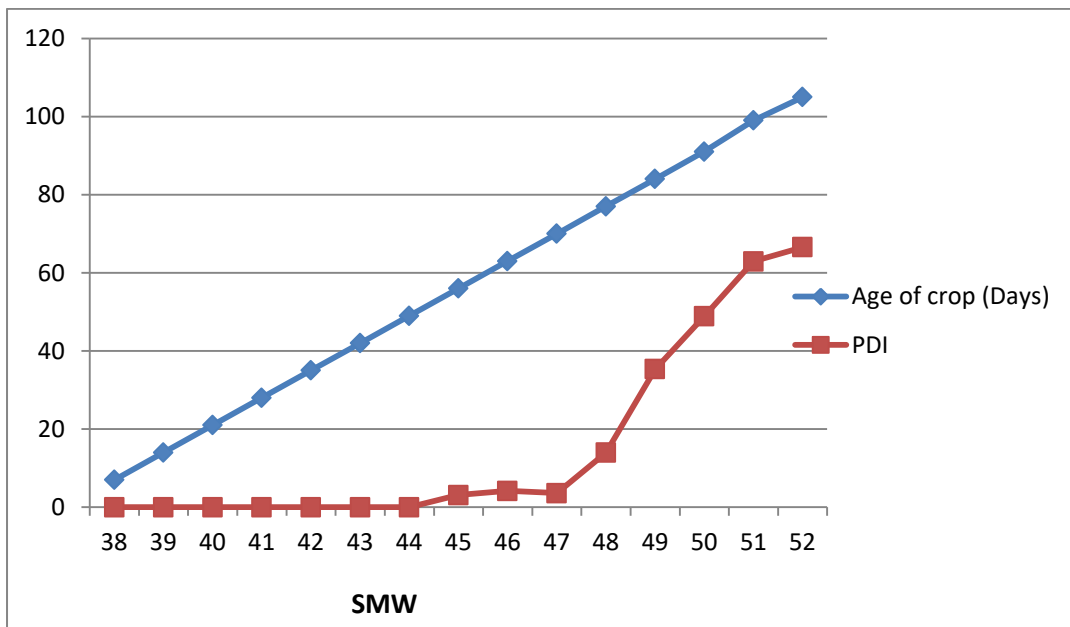
SMW-Standard Meteorological Weak

Fig 4.3 Relation of disease severity with morning (RH I) and evening (RH II) relative humidity



SMW-Standard Meteorological Week

Fig 4.4 Relation of disease severity with wind speed



SMW-Standard Meteorological Week

Fig 4.5 Relation of disease severity with age of the crop

Data (Table 4.6) depict that at 29.6 to 31.4°C temperature from 44 to 47 SMW favours for inoculum build up and thereafter as temperature declines favours disease progress in exponential fashion, this shows temperature range from 26.1 to 29.7°C were highly congenial for exponential disease progress (PDI). Disease progress (PDI) and relative humidity were negatively correlated with each other because conidia of *Erysiphe* contains more than 90% water which does not require much humidity in the environment. Wind speed showed positive relation with the disease progress (PDI) which is necessary for inoculum build up in the field. Age of crop also showed positive relation with the disease progression.

4.3.2 Correlation

Table 4.7 Simple correlation between disease severity and meteorological factors

S.N.	Weather parameters	Correlation coefficient (r)
1	Maximum temperature (°C)	-0.8952*
2	Minimum temperature (°C)	-0.6940*
3	Relative humidity I %	-0.6517*
4	Relative humidity II %	-0.3876
5	Wind Speed (km/hrs)	0.2375
6	Age	0.8346*

*significant at 5% (Table value is 0.514)

In local susceptible check variety, it was observed from the correlation analysis that maximum temperature ($r = -0.8952$), minimum temperature ($r = -0.6940$) and relative humidity I ($r = -0.6517$) exhibited significant negative correlation with the disease severity, whereas rainfall, relative humidity II observed to be negatively but non-significantly correlated with disease. Wind speed exhibited non-significant positive correlation with the disease. The age of the crop exhibited significant and positive correlation ($r = 0.8346$) with the disease severity (Table 4.7).

The result showed consistent effect of minimum temperature, minimum relative humidity, wind speed and age of the crop on both the varieties. These results to a greater extent corroborate the findings of various workers (Morrison,

1964) who reported positive correlation of sunshine hour with the disease severity and the highest per cent of conidial germination at 18-24°C, (Yarwood, 1957) also reported higher incidence of disease was reported at 18-28°C and low relative humidity (<80%), (Al-Radded, 1993) who reported negative correlation of the temperature with the severity of the disease, (Thakur and Agrawal, 1995; Gupta *et al.*, 2001) reported negative correlation of relative humidity with disease severity in some varieties. (Ruppel and Tomasovic, 1977) reported that disease severity increased with the age of the plant.

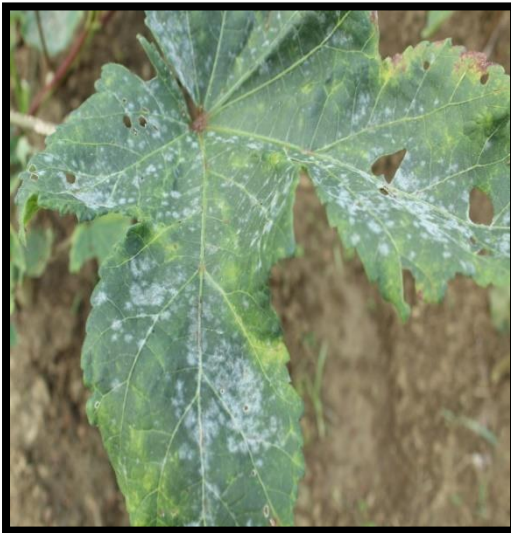
4.4 To identify sources of resistance against powdery mildew of okra

4.4.1 Per cent disease index (PDI)

A sum of eight genotypes in group I, 9 genotypes in group II, 8 genotypes in group III and 11 genotypes in group IV with a susceptible check variety were evaluated against powdery mildew disease of okra during *kharif* 2019. The per cent disease index was calculated and results are presented in table.4.8, 4.9, 4.10 and 4.11.

In okra genotypes (group I) (table 4.8) substantial variability was found in per cent disease index (PDI) of all group I genotypes evaluated under the study. During the course of study PDI varied from 0.05 to 3.08, 4.61 to 27.19, 9.08 to 48.86, 21.05 to 66.58 per cent at 60, 75, 90, 105 DAS respectively. All the genotypes were free from disease up to 45 days after sowing. Highest per cent disease index was observed at 105 DAS in all the genotypes.

During study lowest PDI was recorded in 2018/OKYVRES-2 (21.05%) followed by 2018/OKYVRES-4 (21.10%) and highest in local susceptible variety (66.58%) followed by 2018/OKYVRES-5 (38.40%) at 105 DAS.



Initial symptoms of powdery mildew on okra leaves



Heavily infected leaves of okra with powdery mildew



Powdery mildew infected field of okra

Plate 4.4 Symptoms of powdery mildew in the experimental field



Group-I genotypes



Group-II genotypes



Group-III genotypes



Group-IV genotypes

Plate 4.5 Experimental site to identify source of resistance against powdery mildew in okra

Table 4.8 Evaluation of okra genotypes (group I) against powdery mildew during *kharif* 2019-20

S. N.	Genotypes	Per cent Disease Index (PDI)							Disease reaction
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS	
1	2018/OKYVRES-1	0.00	0.00	0.00	0.38	7.35	19.21	23.20	MR
2	2018/OKYVRES-2	0.00	0.00	0.00	2.12	8.48	18.02	21.05	MR
3	2018/OKYVRES-3	0.00	0.00	0.00	1.42	10.72	24.30	34.16	MS
4	2018/OKYVRES-4	0.00	0.00	0.00	0.05	4.61	11.75	21.10	MR
5	2018/OKYVRES-5	0.00	0.00	0.00	1.46	13.29	23.88	38.40	MS
6	2018/OKYVRES-6	0.00	0.00	0.00	0.55	7.91	18.15	28.2	MS
7	2018/OKYVRES-7	0.00	0.00	0.00	0.91	27.19	9.08	27.44	MS
8	2018/OKYVRES-8	0.00	0.00	0.00	1.98	19.10	12.04	24.68	MR
9	Local susceptible	0.00	0.00	0.00	3.08	13.95	48.86	66.58	S
SEm±		-	-	-	0.20	0.88	1.81	2.07	
CD (P=0.05)		-	-	-	0.62	2.64	5.49	6.26	

In okra genotypes (group II) (table 4.9) PDI varied from 1.51 to 4.63, 6.56 to 13.90, 14.68 to 48.80, 22.76 to 66.58 per cent at 60, 75, 90, 105 DAS respectively. All the genotypes were free from disease up to 45 days after sowing. During study lowest PDI was recorded in 2017/OKYVRES-1 (22.76%) followed by 2017/OKYVRES-2 (23.45%) and highest in local susceptible variety (66.58%) followed by 2017/OKYVRES-4 (34.32%) at 105 DAS.

Table 4.9 Evaluation of okra genotypes (group II) against powdery mildew during *kharif* 2019-20

S. N.	Genotypes	Per cent Disease Index (PDI)							Disease reaction
		15	30	45	60	75	90	105	
		DAS	DAS	DAS	DAS	DAS	DAS	DAS	
1	2017/OKYVRE S-1	0.00	0.00	0.00	2.97	12.98	18.76	22.76	MR
2	2017/OKYVRE S-2	0.00	0.00	0.00	3.24	11.8	17.45	23.45	MR
3	2017/OKYVRE S-3	0.00	0.00	0.00	2.41	12.99	24.37	30.73	MS
4	2017/OKYVRE S-4	0.00	0.00	0.00	1.51	13.28	25.32	34.32	MS
5	2017/OKYVRE S-5	0.00	0.00	0.00	2.42	9.96	14.68	24.68	MR
6	2017/OKYVRE S-6	0.00	0.00	0.00	2.61	6.56	20.46	29.46	MS
7	2017/OKYVRE S-7	0.00	0.00	0.00	4.63	10.05	17.13	25.13	MS
8	2017/OKYVRE S-9	0.0	0.00	0.00	3.65	12.8	24.3	23.94	MR
9	2017/OKYVRE S-10	0.0	0.00	0.00	3.57	9.36	17.4	28.43	MR
10	Local susceptible	0.0	0.00	0.00	3.08	13.9	48.8	66.58	S
	SEm±	-	-	-	0.33	0.92	1.78	2.32	
	CD (P=0.05)	-	-	-	0.99	2.75	5.35	6.93	

In okra genotypes group III significant variability was found PDI of all genotypes (group III) (table 4.10) evaluated under the study. During the course of study PDI varied from 0.69 to 4.41, 6.19 to 18.77, 6.20 to 48.86, 16.20 to 66.58 per cent at 60, 75, 90, 105 DAS respectively. All the genotypes were free from disease up to 45 days after sowing.

During study lowest PDI was recorded in 2017/OKHYVRES-6 (16.20%) followed by 2017/OKHYVRES-9 (21.22%) and highest in local susceptible variety (66.58%) followed by 2017/OKHYVRES-8 (35.40%) at 105 DAS.

Table 4.10 Evaluation of okra genotypes group III against powdery mildew during *kharif* 2019-20

S. N.	Genotypes	Per cent Disease Index (PDI)							Disease reaction
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS	
1	2017/OKHYVRE S-1	0.00	0.00	0.00	4.41	18.77	15.18	25.18	MS
2	2017/OKHYVRE S-2	0.00	0.00	0.00	1.94	8.69	13.48	23.48	MR
3	2017/OKHYVRE S-3	0.00	0.00	0.00	2.16	11.00	13.97	23.97	MR
4	2017/OKHYVRE S-4	0.00	0.00	0.00	2.59	21	20.69	30.69	MS
5	2017/OKHYVRE S-6	0.00	0.00	0.00	2.65	12.02	6.20	16.20	MR
6	2017/OKHYVRE S-8	0.00	0.00	0.00	0.82	10.98	24.07	35.40	MS
7	2017/OKHYVRE	0.00	0.00	0.00	0.69	6.19	10.89	21.22	MR

S-9									
8	2017/OKHYVRE S-10	0.00	0.00	0.00	1.60	8.1	13.33	23.66	MR
9	Local susceptible	0.00	0.00	0.00	3.08	13.95	48.86	66.58	S
SEm±		-	-	-	0.22	1.12	1.36	2.60	
CD (P=0.05)		-	-	-	0.69	3.40	4.14	7.88	

Substantial variability was found PDI of all okra genotypes (group IV) (table 4.11) under the study. During the course of study PDI varied from 1.46 to 6.31, 6.01 to 15.55, 29.61 to 48.87, 46.11 to 66.58 per cent at 60, 75, 90, 105 DAS respectively. All the genotypes were free from disease up to 45 days after sowing.

During study lowest PDI was recorded in 2019/OKYVRES-5 (46.11%) followed by 2019/OKYVRES-11 (46.99%) and highest in local susceptible variety (66.58%) followed by 2019/OKYVRES-8 (59.29%) at 105 DAS.

Table 4.11 Evaluation okra genotypes (group IV) against powdery mildew during *kharif* 2019-20

S.no.	Genotypes	Per cent Disease Index (PDI)							Disease reactio n
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS	
1	2019/OKYVRES-1	0.00	0.00	0.00	4.07	15.55	37.74	58.19	S
2	2019/OKYVRES-2	0.00	0.00	0.00	2.97	6.01	29.61	51.39	S
3	2019/OKYVRES-3	0.00	0.00	0.00	3.27	11.26	38.54	51.57	S
4	2019/OKYVRES-5	0.00	0.00	0.00	3.19	10.22	46.27	46.11	MS
5	2019/OKYVRES-6	0.00	0.00	0.00	3.83	8.42	44.04	54.64	S
6	2019/OKYVRES-7	0.00	0.00	0.00	3.07	11.67	32.82	53.01	S

7	2019/OKYVRES-8	0.00	0.00	0.00	6.31	8.17	37.63	52.84	S
8	2019/OKYVRES-9	0.00	0.00	0.00	2.26	6.74	37.64	59.29	S
9	2019/OKYVRES-11	0.00	0.00	0.00	1.84	6.57	42.46	46.99	MS
10	2019/OKYVRES-12	0.00	0.00	0.00	1.46	6.57	47.01	51.14	S
11	2019/OKYVRES-13	0.00	0.00	0.00	3.21	12.60	38.32	57.95	S
12	Local susceptible	0.00	0.00	0.00	4.18	13.95	48.87	66.58	S
<hr/>									
	SEm±	-	-	-	0.31	0.31	1.14	4.01	
	CD (P=0.05)	-	-	-	0.63	0.64	2.37	8.32	
<hr/>									

4.4.1 Reaction and level of resistance of okra genotypes (group I, II, III and IV) against powdery mildew

From the data it is evident that out of 37 genotypes evaluated under different categories 14 genotypes exhibited moderately resistant reaction against powdery mildew disease, 13 genotypes exhibited moderately susceptible reaction against the disease and 10 genotypes exhibited susceptible reaction against the powdery mildew disease. None of the genotype evaluated were observed with completely immune or highly resistant reaction against the disease. As well as none of the genotype were observed with highly susceptible disease reaction (table 4.12).

Table 4.12 Classification of genotypes on the basis of their reaction against powdery mildew disease

Grade	PDI	Reaction	No.	Name of genotypes
0	0	Immune (no disease)	-	
1	1-10%	Highly resistant (HR)	-	
2	11-25%	Moderately Resistant (MR)	4+5+5	<p>Group I-</p> <p>2018/OKYVRES-1, 2018/OKYVRES-2, 2018/OKYVRES-4, 2018/OKYVRES-8,</p> <p>Group II-</p> <p>2017/OKYVRES-1, 2017/OKYVRES-2, 2017/OKYVRES-5, 2017/OKYVRES-9, 2017/OKYVRES-10</p> <p>Group III-</p> <p>2017/OKHYVRES-2, 2017/OKHYVRES-3, 2017/OKHYVRES-6, 2017/OKHYVRES-9, 2017/OKHYVRES-10</p>

3	26-50%	Moderately susceptible (MS)	4+4+3+2	Group I- 2018/OKYVRES-3, 2018/OKYVRES-5, 2018/OKYVRES-6, 2018/OKYVRES-7, Group II- 2017/OKYVRES-3, 2017/OKYVRES-4, 2017/OKYVRES-6, 2017/OKYVRES-7 Group III- 2017/OKHYVRES-1, 2017/OKHYVRES-4, 2017/OKHYVRES-8 Group IV- 2019/OKYVRES-5, 2019/OKYVRES-11
4	51-75%	Susceptible (S)	11	Group IV- 2019/OKYVRES-1, 2019/OKYVRES-2, 2019/OKYVRES-3, 2019/OKYVRES-6, 2019/OKYVRES-7, 2019/OKYVRES-8, 2019/OKYVRES-9, 2019/OKYVRES-12, 2019/OKYVRES-13, Local susceptible
5	More than 75%	Highly susceptible (HS)	-	-

*LSI = 3.16

4.4.2 Area under disease progress curve AUDPC (A-value) and apparent rate of infection (r-value) of powdery mildew and yield (q/ha) in different okra genotypes

Apparent rate of infection (r) and area under disease progress curve AUDPC (A-value) for powdery mildew severity on different okra genotypes was also calculated. The apparent rate of disease development (r) is a measure of the speed at which an epidemic develops. It is used to assess the highest and least infection periods with respect to each crop cultivars in relation to age (Vanderplank, 1963). The AUDPC is a variable which estimates the amount of disease across the season. The rate of disease increase in fields and the cumulative amount of disease over a season (expressed as AUDPC) provide useful measures of disease progress. The curve of the amount of disease against time is called DPC/Disease progress curve. Which is typically sigmoid in shape with slow increase in the beginning followed by a logistic increase and a leveling at the maximum level of disease (fig 4.6).

Table 4.13 Apparent rate of infection (r-value) of powdery mildew in different okra genotypes

S.no.	Genotypes	Rate of infection 'r'			Average 'r'
		60-75 DAS	75-90 DAS	90-105 DAS	
1	2018/OKYVRES-1	0.084	0.010	0.001	0.032
2	2018/OKYVRES-2	0.026	0.008	0.001	0.012
3	2018/OKYVRES-3	0.040	0.007	0.002	0.016
4	2018/OKYVRES-4	0.184	0.013	0.005	0.067
5	2018/OKYVRES-5	0.041	0.005	0.003	0.016
6	2018/OKYVRES-6	0.069	0.009	0.003	0.027

7	2018/OKYVRES-7	0.062	-0.010	0.010	0.021
8	2018/OKYVRES-8	0.036	-0.004	0.006	0.013
9	2017/OKYVRES-1	0.023	0.003	0.001	0.009
10	2017/OKYVRES-2	0.020	0.004	0.002	0.009
11	2017/OKYVRES-3	0.027	0.005	0.001	0.011
12	2017/OKYVRES-4	0.040	0.005	0.002	0.016
13	2017/OKYVRES-5	0.024	0.004	0.004	0.011
14	2017/OKYVRES-6	0.017	0.012	0.002	0.011
15	2017/OKYVRES-7	0.011	0.005	0.003	0.006
16	2017/OKYVRES-9	0.018	0.005	0.000	0.008
17	2017/OKYVRES-10	0.015	0.006	0.003	0.008
18	2017/OKHYVRES-1	0.018	-0.002	0.004	0.007
19	2017/OKHYVRES-2	0.028	0.005	0.005	0.013
20	2017/OKHYVRES-3	0.028	0.002	0.004	0.012
21	2017/OKHYVRES-4	0.030	0.000	0.003	0.011
22	2017/OKHYVRES-6	0.024	-0.008	0.011	0.009
23	2017/OKHYVRES-8	0.057	0.007	0.002	0.022
24	2017/OKHYVRES-9	0.056	0.007	0.006	0.023
25	2017/OKHYVRES-10	0.033	0.006	0.005	0.014
26	2019/OKYVRES-1	0.018	0.006	0.002	0.009
27	2019/OKYVRES-2	0.013	0.016	0.003	0.011
28	2019/OKYVRES-3	0.019	0.009	0.001	0.010
29	2019/OKYVRES-5	0.018	0.011	0.000	0.010

30	2019/OKYVRES-6	0.012	0.013	0.001	0.009
31	2019/OKYVRES-7	0.021	0.008	0.002	0.010
32	2019/OKYVRES-8	0.004	0.013	0.001	0.006
33	2019/OKYVRES-9	0.021	0.016	0.002	0.013
34	2019/OKYVRES-11	0.026	0.016	0.000	0.014
35	2019/OKYVRES-12	0.032	0.017	0.000	0.017
36	2019/OKYVRES-13	0.021	0.008	0.002	0.010
37	Local susceptible	0.016	0.008	0.001	0.009

Apparent rate of infection (r) in all the genotypes showed similar trend in the speed of progress of disease, it was higher during (60-75) days after sowing followed by (75-90) days after sowing and lowest speed of progress was observed during (90-105) days after sowing. Average value of ' r ' ranged from 0.006 to 0.067 (table 4.13), indicating thereby the susceptibility of plants was more during 60-75 days after sowing. Our results matched with the earlier findings as the higher disease progress during 66-87 days of crop age *i.e.* at fruiting stage (Sharma, 2016). The growth stage of the plant appears to be an important factor for powdery mildew development as observed by (Sivaprakasam *et al.*, 1981), (Sharma, 1992) and (Mishra and Shirsole, 2017). This information is important in deciding the time of application of fungicides for the efficient management of the pathogen.

Table 4.14 Area under disease progress curve AUDPC (A-value) for genotype group I, II and IV

S.N.	Genotypes	AUDPC	Yield(q/ha)
1	2018/OKYVRES-1	578.13	47.78
2	2018/OKYVRES-2	587.23	25.84
3	2018/OKYVRES-3	803.00	41.44

4	2018/OKYVRES-4	404.65	19.73
5	2018/OKYVRES-5	867.7	41.87
6	2018/OKYVRES-6	610.75	40.62
7	2018/OKYVRES-7	763.5	14.71
8	2018/OKYVRES-8	682.15	22.74
9	2017/OKYVRES-1	691.50	21.19
10	2017/OKYVRES-2	663.35	17.24
11	2017/OKYVRES-3	827.23	23.35
12	2017/OKYVRES-4	859.15	26.46
13	2017/OKYVRES-5	591.10	12.33
14	2017/OKYVRES-6	665.65	23.54
15	2017/OKYVRES-7	665.78	27.57
16	2017/OKYVRES-9	790.08	40.10
17	2017/OKYVRES-10	668.85	38.02
18	2019/OKYVRES-1	1,296.85	23.15
19	2019/OKYVRES-2	964.25	20.93
20	2019/OKYVRES-3	1,182.78	18.99
21	2019/OKYVRES-5	1,241.10	12.88
22	2019/OKYVRES-6	1,254.08	26.91
23	2019/OKYVRES-7	1,110.90	12.65
24	2019/OKYVRES-8	1,178.00	20.62
25	2019/OKYVRES-9	1,144.18	9.59
26	2019/OKYVRES-11	1,487.90	18.58

27	2019/OKYVRES-12	1,209.18	20.21
28	2019/OKYVRES-13	1,246.58	15.70
29	Local susceptible	1,506.75	27.12

The value of 'A' ranged from 404.65 to 1506.75 for the evaluated genotypes of group I, II and IV. Eighteen genotypes *viz.* 2018/OKYVRES-1, 2018/OKYVRES-2, 2018/OKYVRES-3, 2018/OKYVRES-4, 2018/OKYVRES-5, 2018/OKYVRES-6, 2018/OKYVRES-7, 2018/OKYVRES-8, 2017/OKYVRES-1, 2017/OKYVRES-2, 2017/OKYVRES-3, 2017/OKYVRES-4, 2017/OKYVRES-5, 2017/OKYVRES-6, 2017/OKYVRES-7, 2017/OKYVRES-9, 2017/OKYVRES-10 and 2019/OKYVRES-2 exhibited 'A' value less than 1000, whereas ten genotypes including local susceptible check exhibited 'A' value more than 1000 *viz.* 2019/OKYVRES-1, 2019/OKYVRES-3, 2019/OKYVRES-5, 2019/OKYVRES-6, 2019/OKYVRES-7, 2019/OKYVRES-8, 2019/OKYVRES-9, 2019/OKYVRES-11, 2019/OKYVRES-12, 2019/OKYVRES-13, Local susceptible (table 4.16). Maximum value for 'A' was observed for local susceptible variety (1,506.75) followed by 2019/OKYVRES-11 (1,487.90), whereas minimum A-value of (404.65) was observed in genotype 2018/OKYVRES-4 followed by 2018/OKYVRES-1 (578.13) (Table 4.14).

Yield ranged from 9.59q/ha to 47.78q/ha for all the evaluated genotypes of group I, II and IV. Yield ranged from 12.33q/ha to 47.78q/ha in the okra genotypes showing 'A' value less than 1000, whereas it ranged from 9.59 to 27.12q/ha in okra genotypes showing 'A' value more than 1000 (Table 4.16). Highest yield of 47.78q/ha was observed in genotype 2018/OKYVRES-1 followed by 2018/OKYVRES-5 (41.87q/ha), whereas minimum yield was observed in genotype 2019/OKYVRES-9 (9.59q/ha) followed by 2019/OKYVRES-7 (12.65q/ha) (Table 4.14).

Table 4.15 Area under disease progress curve AUDPC (A-value) for genotype group III

S.N.	Genotypes	AUDPC	Yield(q/ha)
1	2017/OKHYVRES-1	764.50	35.45
2	2017/OKHYVRES-2	537.98	58.54
3	2017/OKHYVRES-3	586.82	21.52
4	2017/OKHYVRES-4	894.52	54.88
5	2017/OKHYVRES-6	434.68	10.04

6	2017/OKHYVRES-8	803.63	32.76
7	2017/OKHYVRES-9	425.85	43.35
8	2017/OKHYVRES-10	513.68	16.83
9	Local susceptible	1,506.75	27.12

The value of 'A' ranged from 425.85 to 1506.75 for the evaluated genotypes of group III. All the genotypes 2017/OKHYVRES-1, 2017/OKHYVRES-2, 2017/OKHYVRES-3, 2017/OKHYVRES-4, 2017/OKHYVRES-6, 2017/OKHYVRES-8, 2017/OKHYVRES-9, 2017/OKHYVRES-10 showed 'A' value less than 1000 except for local susceptible which exhibited 'A' value more than 1000 (Table 4.16). Maximum value for AUDPC was observed for local susceptible variety (1,506.75) followed by 2017/OKHYVRES-4 (894.52), whereas minimum A-value of (425.85) was observed in genotype 2017/OKHYVRES-9 followed by 2017/OKHYVRES-6 (434.68) (Table 4.15).

Yield ranged from 10.04q/ha to 58.54q/ha for all the evaluated genotypes of group III. Highest yield of 58.54q/ha was observed in genotype 2017/OKHYVRES-2 followed by 2017/OKHYVRES-4 (54.88Q/ha), whereas minimum yield was observed in 2017/OKHYVRES-6 (10.04q/ha) (Table 4.15).

Table 4.16 Summary table, AUDPC and yield of okra genotypes I, II, III and IV

S.N.	AUDPC ('A' value)	No. of genotypes	Genotypes
1.	Okra genotypes group I, II and IV A-value <1000	18	2018/OKYVRES-1, 2018/OKYVRES-2, 2018/OKYVRES-3, 2018/OKYVRES-4, 2018/OKYVRES-5, 2018/OKYVRES-6, 2018/OKYVRES-7, 2018/OKYVRES-8, 2017/OKYVRES-1, 2017/OKYVRES-2, 2017/OKYVRES-3, 2017/OKYVRES-4, 2017/OKYVRES-5, 2017/OKYVRES-6, 2017/OKYVRES-7, 2017/OKYVRES-9, 2017/OKYVRES-10, 2019/OKYVRES-2

2.	Okra genotypes group I, II and IV A-value >1000	11 (including local susceptible check)	2019/OKYVRES-1, 2019/OKYVRES-3, 2019/OKYVRES-5, 2019/OKYVRES-6, 2019/OKYVRES-7, 2019/OKYVRES-8, 2019/OKYVRES-9, 2019/OKYVRES- 11, 2019/OKYVRES-12, 2019/OKYVRES-13, Local susceptible
3.	Okra genotypes group III (Hybrid) A-value <1000	08	2017/OKHYVRES-1, 2017/OKHYVRES-2, 2017/OKHYVRES-3, 2017/OKHYVRES-4, 2017/OKHYVRES-6, 2017/OKHYVRES-8, 2017/OKHYVRES-9, 2017/OKHYVRES-10

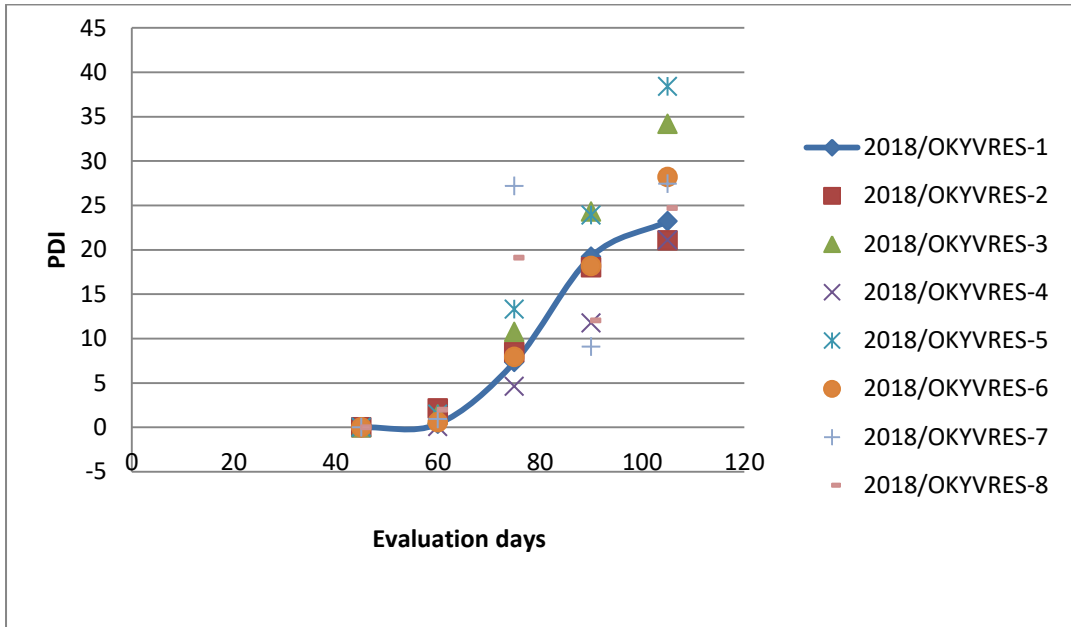


Fig 4.6 Disease progress curve for different okra genotypes in group I

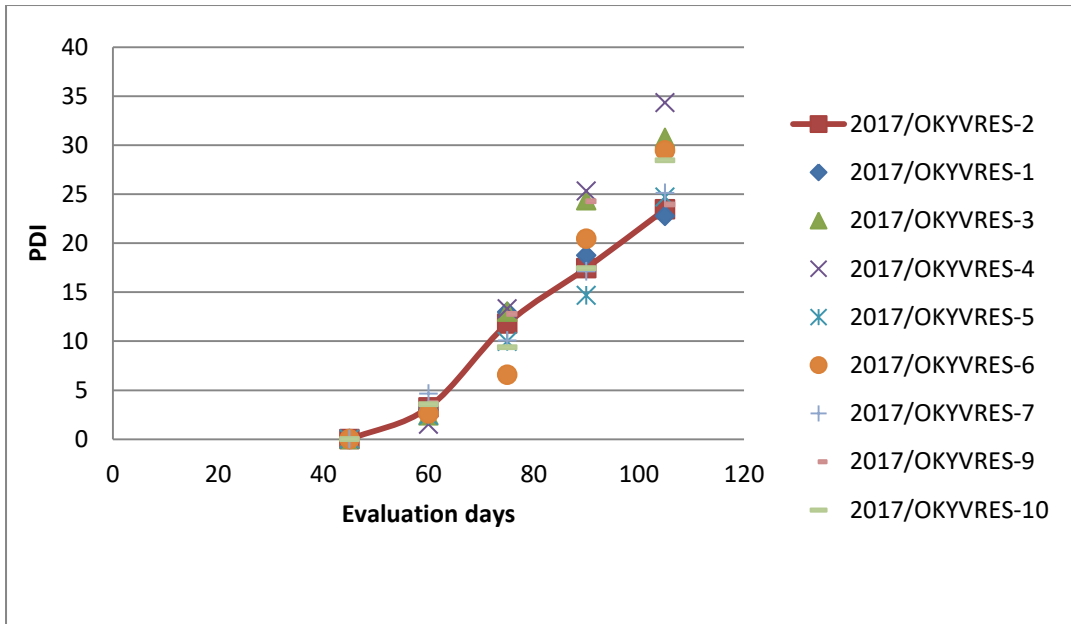


Fig 4.7 Disease progress curve for different okra genotypes in group II

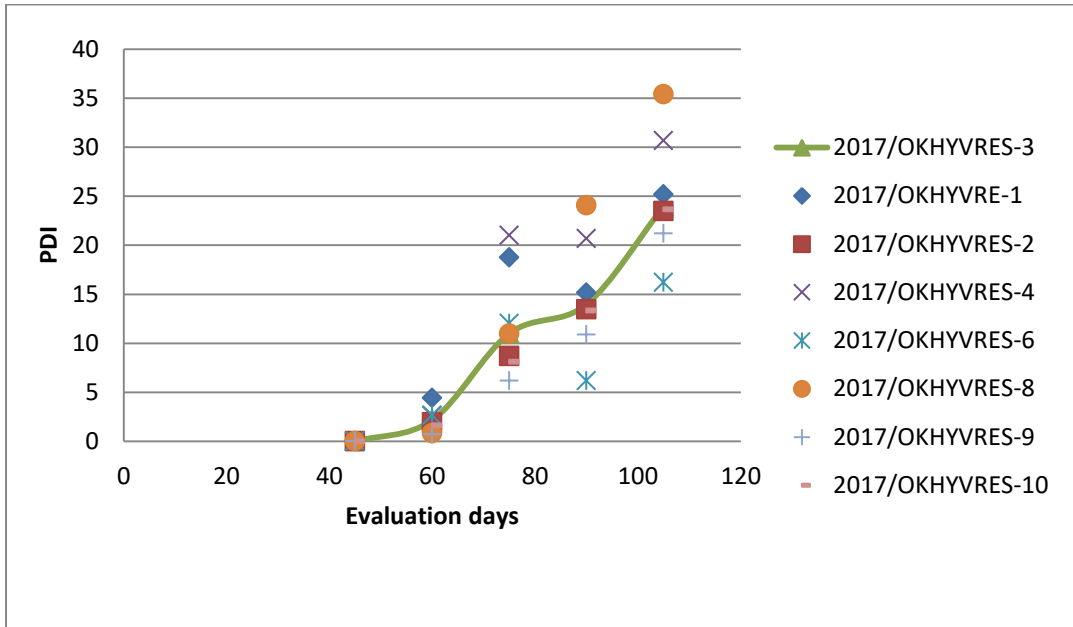


Fig 4.8 Disease progress curve for different okra genotypes in group III

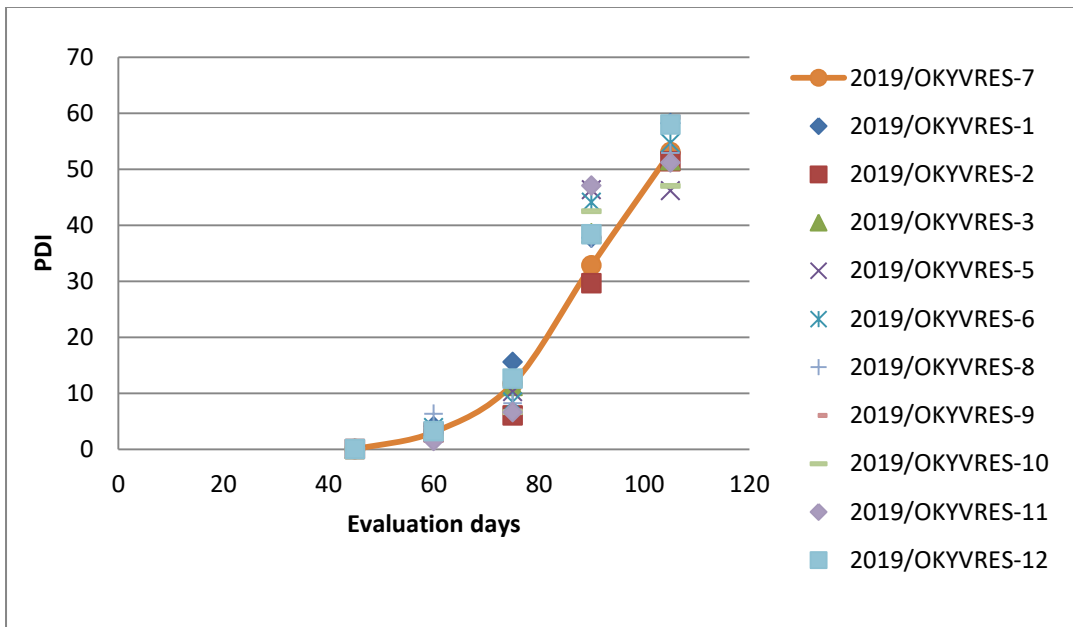


Fig 4.9 Disease progress curve for different okra genotypes in group IV

CHAPTER V

SUMMARY AND CONCLUSIONS

Okra in India is a major vegetable crop grown under tropical and sub-tropical conditions. It belongs to family Malvaceae. The present study on “Studies on prevalent diseases of okra [*Abelmoschus esculentus* (L.) Moench] with special reference to powdery mildew” was carried out at the Horticultural Farm of Indira Gandhi Krishi Vishwavidyalaya Raipur, Chhattisgarh during *kharif* (2019-20). This study involved various objectives including study the occurrence of prevalent diseases of okra during *kharif* cropping period, assessment of yield loss due to powdery mildew of okra, to study the effect of environmental factors in the development of powdery mildew, to identify sources of resistance against powdery mildew of okra.

The occurrence of powdery mildew, *Cercospora* leaf spot, leaf curl and yellow vein mosaic was observed as major prevalent diseases of okra. The observation regarding per cent disease index of fungal diseases and per cent disease incidence regarding viral diseases were recorded at fortnight interval for each disease. A similar pattern was observed in the appearance of the all the diseases. Appearance of powdery mildew and *Cercospora* leaf spot was seen 60 DAS for all the genotypes, whereas for leaf curl and yellow vein mosaic it was seen 45 DAS for all the group of genotypes except for group I, II and III where the appearance of leaf curl was observed 45 DAS.

In the assessment of yield loss due to powdery mildew data pertaining severity of the disease and fruit yield were recorded both treated and untreated control plots. All agronomic practices were followed as recommended, except fungicidal sprays. Hexaconazole-5%SC, a broad spectrum fungicide was used for treating protected plots. Disease severity was recorded before first spray using a 0-5 scale. Subsequent disease scores were taken at 7 days interval. At proper maturity okra fruits were harvested. At each picking, fruits were harvested plot wise separately and yields were recorded (kg/ha) and expressed in q/ha. Data were

compiled and analysed statistically to determine significant differences between protected and unprotected plots. The data revealed that the terminal PDI in treated plot observed to be 11.91% whereas it was 49.96% for untreated control plot. The yield in untreated control plot was observed to be (11.38 q/ha), whereas it was 17.23 q/ha for treated plot. A percentage increase of 51.27% over control was observed in protected plots.

In the study pertaining the effect of environmental factors in the development of powdery mildew, per cent disease index of local susceptible check variety were recorded from each plot at weekly interval. To determine the influence of various physical factors of environment on the development of disease of okra the data on intensity were correlated with different meteorological parameters. The initiation of the disease first noticed 56 DAS in both the genotypes after that linear progress of the disease was observed up to the maturity of the crop. It was observed from the correlation analysis that maximum temperature (-0.8952), minimum temperature (-0.6940) and relative humidity I (-0.6517) exhibited significant negative correlation with the disease severity, whereas relative humidity II observed to be negatively but non-significantly correlated with disease. Wind speed exhibited non-significant positive correlation with the disease. The age of the crop exhibited significant and positive correlation (0.8346) with the disease severity.

In the identification of source of resistance against powdery mildew a sum of 37 genotypes along with a local susceptible check were evaluated under field conditions. The data pertaining per cent disease index (PDI), area under disease progress curve (AUDPC) and apparent rate of infection was recorded and calculated for each genotype at 15 days interval. Among them 14 genotypes exhibited moderately resistant reaction against powdery mildew disease, 13 genotypes exhibited moderately susceptible reaction against the disease and 10 genotypes exhibited susceptible reaction against the powdery mildew disease. None of the genotype evaluated were observed with completely immune or highly resistant reaction against the disease. As well as none of the genotype were observed with highly susceptible disease reaction. Higher value of A observed

during 60-75 days after sowing. At the same time maximum A-value of (1506.75) was observed on the local susceptible variety followed by (1296.83) on 2019/OKYVRES-1 genotype, whereas minimum A-value of (404.40) was observed in genotype 2018/OKYVRES-4.

CONCLUSION

From the above investigation it was concluded that crop of okra may get infected from a number of fungal and viral diseases and there was a similar pattern in the occurrence of both fungal and viral disease. After the first appearance there was a linear progression observed up to maturity. Highest severity was observed in case of powdery mildew disease which ranged from 26.99 to 54.17 per cent.

Data pertaining assessment of yield loss due to powdery mildew of okra revealed that fungicidal spray application with Hexaconazole-5%SC in protected plots significantly increased the fruit yield in comparison control and a percentage increase of 51.27% in yield over control was observed.

The environmental factors affect the development of the powdery mildew disease. The T (max), T (min) and morning RH showed significant but negative correlation with the severity of the disease, evening RH exhibited non-significant negative correlation with the disease, wind speed showed positive but non-significant correlation, whereas age of the crop was found significant and positively correlated with disease severity in local susceptible check variety studied.

Among the 37 genotypes evaluated none were found with completely immune or highly resistant, as well as none of the genotype were found with highly susceptible disease reaction. 14 genotypes namely 2018/OKYVRES-1, 2018/OKYVRES-2, 2018/OKYVRES-4, 2018/OKYVRES-8, 2017/OKYVRES-1, 2017/OKYVRES-2, 2017/OKYVRES-5, 2017/OKYVRES-9, 2017/OKYVRES-10, 2017/OKHYVRES-2, 2017/OKHYVRES-3, 2017/OKHYVRES-6, 2017/OKHYVRES-9, 2017/OKHYVRES-10 were recorded with moderately resistant reaction and rest 23 genotypes along with local susceptible check showed moderately susceptible or susceptible reaction against the disease. Higher apparent

rate of infection was observed during 60-75 days after sowing. Maximum A-value of (1506.75) was observed on the local susceptible variety.

Suggestions for future work

1. The present work could be tested in other seasons.
2. Studies on pathogenic variability could be done by using different molecular tools.
3. Studies on management of disease could be work out by adopting different integrated management practices.
4. Studies on date of showing could be done to escape from disease.
5. Studies on survival structure could be done for the better understanding of life cycle of *Erysiphe cichoracearum*.

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
RESUME

Name : Ruparani Diwakar
Date of Birth : 12-09-1994
Present address : New Girls hostel, IGKV, Jora, Raipur, C.G.
Phones : 8963936651
E-mail : ruparandidiwakar94@gmail.com
Permanent address : Marine Drive, Pratappur Naka, Ambikapur
District- Surguja (C.G.)
Pin: 497001

Academic Qualification:

Degree	Year	University/ Institute
High School	2010	CBSE
Higher Secondary	2012	CBSE
B.Sc. (Ag.)	2018	Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.)
M.Sc. (Ag.)	2020	Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.)

Professional experience: Yes (RAWE)
Membership of Professional Societies: No
Awards/ Recognitions: No
Publications (If any)
Acceptance for publication: Yes


Signature