STUDIES ON POWDERY MILDEW (*Erysiphe polygoni* D C) OF *URDBEAN* [*Vigna mungo* (L.) Hepper] IN RELATION TO WEATHER, HOST PLANT RESISTANCE AND MANAGEMENT

BY

K. TULASI

B.Sc. (Ag.)

THESIS SUBMITTED TO THE
ACHARYA N. G. RANGA AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF

MASTER OF SCIENCE IN AGRICULTURE
(PLANT PATHOLOGY)

CHAIRPERSON: Dr. V. MANOJ KUMAR

DEPARTMENT OF PLANT PATHOLOGY

AGRICULTURAL COLLEGE, BAPATLA
ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY

2016

CERTIFICATE

Ms. K. TULASI has satisfactorily prosecuted the course of research and that thesis entitled **"STUDIES ON POWDERY MILDEW (*Erysiphe polygoni* D C) OF URDBEAN [*Vigna mungo* (L.) Hepper] IN RELATION TO WEATHER, HOST PLANT RESISTANCE AND MANAGEMENT"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by her for a degree of any University.

Date:

(V. MANOJ KUMAR)
Chairperson
Assistant Professor
Department of Plant Pathology
Agricultural College, Bapatla

CERTIFICATE

This is to certify that the thesis entitled **"STUDIES ON POWDERY MILDEW (*Erysiphe polygoni* D C) OF URDBEAN [*Vigna mungo* (L.) Hepper] IN RELATION TO WEATHER, HOST PLANT RESISTANCE AND MANAGEMENT"** submitted in partial fulfilment of the requirements for the degree of '**Master of Science in Agriculture'** of the Acharya N. G. Ranga Agricultural University, Lam, Guntur is a record of the bonafide original research work carried out by **Ms. K. TULASI** under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all assistance received during the course of the investigations have been duly acknowledged by the author of the thesis.

Thesis approved by the student's advisory committee

Chairperson — **Dr. V. MANOJ KUMAR** _____
Assistant Professor
Department of Plant Pathology
Agricultural College, Bapatla

Member — **Dr. V. PRASANNA KUMARI** _____
Assistant Professor
Department of Plant Pathology
Agricultural College, Bapatla

Member — **Dr. Y. ASOKHA RANI** _____
Professor and Head
Department of Crop Physiology
Agricultural College, Bapatla

Date of final viva-voce:

DECLARATION

I, **K. TULASI** hereby declare that the thesis entitled **"STUDIES ON POWDERY MILDEW (*Erysiphe polygoni* D C) OF URDBEAN [*Vigna mungo* (L.) Hepper] IN RELATION TO WEATHER, HOST PLANT RESISTANCE AND MANAGEMENT"** submitted to the **Acharya N.G. Ranga Agricultural University** for the degree of **Master of Science in Agriculture** is the result of original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

Place: Bapatla **(K. TULASI)**

Date: **I. D. No. BAM-14-44**

ACKNOWLEDGEMENT

Accomplishment of this thesis is the result of benevolence of Almighty, blessings of my parents, guidance of my teachers and help of my friends.

I am privileged to express my deep and heartfelt gratitude and veneration to my Major Advisor and Chairman of the Advisory Committee ***Dr. V. Manoj Kumar****, Assistant Professor, Department of Plant Pathology, for his help extended in smooth conduct of the research work, for his intellectual and highly informative advice, curious and guidance and for his munificence showered on me and incessant encouragement and his painstaking efforts in the preparation and presentation of this thesis.*

I sincerely extend my profound gratitude to ***Dr. V. Prasanna Kumari****, Assistant Professor, Department of Plant Pathology, and member of my Advisory Committee for his kind cooperation, whole hearted help and valuable suggestions during my research work.*

I sincerely extend my profound gratitude to ***Dr. Y. Asokha Rani****, Professor & Head, Department Crop Physiology, and member of my Advisory Committee for his kind cooperation, whole hearted help and valuable suggestions during my research work.*

I sincerely extend my profound gratitude to ***Dr. P. Anil Kumar****, Professor & Head, Department of Plant Pathology and for his inspiring guidance, for his kind cooperation, pragmatic suggestions during my research work.*

I sincerely thank ***Dr. M. Adinarayana****, Senior Scientist (Plant Pathology) RARS, Lam, Guntur, for his guidance, encouragement, kind cooperation in smooth conduct of field experiments at RARS, Lam and for his valuable suggestions, during my research work.*

I sincerely extend my profound gratitude to ***Dr. J. Krishna Prasadji****, Principal Scientist (Plant Pathology) Maruteru, APRRI and RARS for his kind cooperation, whole hearted help and valuable suggestions offered during my post graduation study and research work.*

I sincerely thank ***Dr. S.V.S. Gopala Swamy,*** *Scientist, Post Harvest Technology Centre, Agricultural College, Bapatla, for his advice, guidance and encouragement during my research work and for allowing me to use facilities during the research work in their laboratory.*

I express my deep sense of gratitude to ***Mr. A. Salam and Mr. M. Gurivi Reddy*** *Assistant Professor, Department of Plant Pathology for their cooperation and supervision in conduct of my research work.*

I am extremely thankful to Assistant Librarian and Staff for their cooperation during my study.

I find no such measures adequate to quantify all that my parents and family have done for me. I will forever remain indebted to my parents ***Smt Sumithra*** *and* ***Sri Gopala Rao****, the beacon of my life, who had lit up themselves to enlighten every nook and corner and have been supporting pillars for me always. No words can express my immense gratitude to my grandmother,* ***Chittamma****, sister, brother* ***Bala Krishna*** *for being my moral support to build up my academic career.*

I place my sincere thanks to my friends ***Leela, Sabina, Praveen, Prabhakar, Santhi, Sowji, Joo, Poornima, Sudha, Divya, Deekistha, Rekha, Revathi, Nidhi, Vijay Lakshmi, Lakshmi, Bharathi*** *for always being there besides me in difficult times during my course of study and giving constant motivation.*

I would like to acknowledge the constant assistance provided by my seniors, ***Bhavani, Chandrajini, Deepthi, Lalitha, Prathyusha, Janaki, Sowmya, Divya, Darvin*** *junior friends,* ***Gunasri, Bhavani, Jysotha, Amulya, Siva Prasad, Prasanna, Navya*** *for their support and help extended to boost up my morale in carrying out this thesis research work.*

My heartful thanks to all the non-teaching staff of plant pathology, farm workers for their timely help for carrying out my research work. I am very thankful to ***College Librarian*** *and other* ***Library Staff*** *for providing necessary facilities.*

I shall be failing in my study, if don't express my thanks to ***ANGRAU*** *for providing me the financial help in the form of stipend and also encouragement to complete the study successfully.*

Any omission in this brief acknowledge doesn't mean lack of gratitude.

Place:

Date: **(TULASI. K)**

STUDIES ON POWDERY MILDEW(*Erysiphe polygoni* D C) OF *URDBEAN* [*Vigna mungo* (L.) Hepper] IN RELATION TO WEATHER, HOST PLANT RESISTANCE AND MANAGEMENT

K. TULASI

B.Sc. (Ag.)

MASTER OF SCIENCE IN AGRICULTURE

(PLANT PATHOLOGY)

2016

STUDIES ON POWDERY MILDEW (*Erysiphe polygoni* D C) OF *URDBEAN* [*Vigna mungo* (L.) Hepper] IN RELATION TO WEATHER, HOST PLANT RESISTANCE AND MANAGEMENT

BY

K. TULASI

B.Sc. (Ag.)

THESIS SUBMITTED TO THE
ACHARYA N. G. RANGA AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF

MASTER OF SCIENCE IN AGRICULTURE
(PLANT PATHOLOGY)

CHAIRPERSON: Dr. V. MANOJ KUMAR

DEPARTMENT OF PLANT PATHOLOGY

AGRICULTURAL COLLEGE, BAPATLA

ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY

GUNTUR, ANDHRA PRADESH

2016

LIST OF CONTENTS

LIST OF TABLES

4.16	Effect of growth regulator, antitranspirant and fungicides on number of primary branches per plant and number of pods per plant during *rabi* 2015-16 in field	
4.17	Effect of growth regulator, antitranspirant and fungicides on number of seeds per pod and seed yield (q/ha) during *rabi* 2015-16 in field	
4.18	Effect of growth regulator, antitranspirant and fungicides on 100 seed weight (g) during *rabi* 2015-16 in field	
4.19	Economical evaluation of chemicals on powdery mildew infected *urdbean* during *rabi* 2015-16	

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDIX

N

R1R2R3

T_4	IRRIGATION CHANNEL	T_7	IRRIGATION CHANNEL	T_3
T_6		T_5		T_1
T_2		T_3		T_6
T_7		T_1		T_4
T_5		T_6		T_2
T_3		T_4		T_5
T_1		T_2		T_7

T1 : Cycocel@ 30 ppm

T2 : Salicyclic acid @ 50 ppm

T3 : Myclobutanil @ 0.2 % W.P

T4 : Wettable sulphur @ 0.3%W.P

T5 : Neem oil @1000 ppm

T6 : Kaolin (6%)

T7 : Untreated control (Check)

Fig 4.1 Layout of the field experiment on management of powdery mildew in *urdbean*

LIST OF SYMBOLS AND ABBREVIATIONS

@	:	at the rate of
^{0}C	:	Degrees Celsius
%	:	Per cent
AUDPC	:	Area Under Disease Progress Curve
cm	:	Centimetre
DAS	:	Days after sowing
Dia	:	Diameter
DNS	:	Dinitrosalicylic acid
et al.	:	and other co-workers
Fig.	:	Figure
g	:	gram (s)
h	:	hour
ha	:	hectare
Hcl	:	Hydrochloric acid
H_2SO_4	:	Sulphuric acid
i.e.	:	that is
kg	:	kilo gram
L	:	litre
m	:	Metre
mg	:	milli gram (s)
ml	:	milli litre
min	:	minute
mm	:	millimeter
mM	:	millimoles
η	:	Nano
N	:	Normality
Na_2CO_3	:	Sodium Carbonate
NaoH	:	Sodium Hydroxide
nm	:	Nanometre
NS	:	Non significant
OD	:	Optical density
PDI	:	Per cent Disease Index

pH	:	Hydrogen ion concentration
ppm	:	parts per million
q	:	quintals
RBD	:	Randomized Block Design
rpm	:	Revolutions per minute
SEm	:	Standard Error of mean
t	:	Tonnes
µl	:	Microlitre
µm	:	Micrometer
µg	:	Microgram
viz.,	:	Namely
wt	:	weight

ABSTRACT

Author	:	**TULASI. K**
Title of the thesis	:	**STUDIES ON POWDERY MILDEW (*Erysiphe polygoni* D C) OF URDBEAN (*Vigna mungo* (L.) Hepper) IN RELATION TO WEATHER, HOST PLANT RESISTANCE AND MANAGEMENT**
Major Advisor	:	**Dr. V. MANOJ KUMAR**
Degree to which it is submitted	:	**Master of Science**
Faculty	:	**AGRICULTURE**
Department	:	**PLANT PATHOLOGY**
College	:	**Agricultural College, Bapatla**
University	:	**Acharya N. G. Ranga Agricultural University**
Year of submission	:	**2016**

Powdery mildew disease caused by *Erysiphe polygoni* D C is one of the serious constraints that afflict cultivation of blackgram in India and other countries. In view of the significance of the disease, investigation was carried out to study the severity of powdery mildew on *urdbean* (*Vigna mungo* (L.) Hepper) in relation to weather, host plant resistance and management. Observations were made on different aspects like incidence, severity (PDI), morphological characters and biochemical changes and growth and yield parameters.

A roving survey was conducted during *rabi* 2015-16 in Guntur district of Andhra Pradesh. Disease incidence and severity were recorded in the surveyed villages of Tadikonda, Veticherukuru, Pedanandipadu and Kakumanu mandals of Guntur district. Incidence was ranged from of 13.69% (Pedanandipadu mandal) to 87.01% (Tadikonda mandal) and severity were ranged from 11.61% (Kakumanu mandal) to 88.08% (Tadikonda mandal), respectively.

Symptoms first appeared on shaded lower leaves. These white, powdery colonies grew in size and cover both sides of the leaf, petioles and young stems. When disease progressed leaves became smaller and chlorotic with stunting, distortion and premature leaf fall due to infection of *E. polygoni*. The pathogen was observed to produce amphigenous dirty white hyaline mycelium and barrel shaped conidia measuring 1.089 µm × 0.7131 µm at 40X magnification.

Correlation studies with weather parameters and crop age on powdery mildew disease severity revealed that significant positive correlation of disease was recorded with crop age (r=0.984) and maximum temperature (r=0.657). Regression analyses for per cent severity of diseases with weather factors revealed that maximum temperature and wind speed and minimum temperature would influence powdery mildew disease in *urdbean* up to 86.6 per cent.

During *kharif*, out of 47 genotypes evaluated, KUP-1 was immune, two genotypes were highly resistant, and ten were moderately resistant to powdery mildew, whereas, twenty moderately susceptible and ten were susceptible and four highly susceptible. In *rabi*, out of eleven genotypes, two were highly resistant against powdery mildew disease, one moderately resistant, one moderately susceptible, other seven genotypes were highly susceptible.

Among selected blackgram genotypes, significantly highest leaf thickness was observed in highly resistant genotypes KUP-34 (201.4 µm), KUP-40 (191.3 µm). Significantly lowest stomatal frequency was observed in highly resistant genotypes KUP-34 (88.64/mm^2), KUP-40 (99.24/mm^2). Higher trichome density was observed in highly resistant genotypes KUP-34 (62.33), KUP-40 (59.11).

Significantly higher phenol content was observed in highly resistant genotypes KUP-34 (0.912 mg/100 mg) and KUP-40 (0.861 mg/100 mg) and one moderately resistant genotype KUP-12 (0.678 mg/100 mg). Highly susceptible genotype LBG-623 recorded the lowest total phenol content (0.299 mg/100 mg).

Significantly lowest total sugars, reducing sugars and non reducing sugars were recorded in highly resistant genotypes KUP 34 and KUP 40.

In field evaluation of different chemicals, two sprays of Myclobutanil @ 0.2 W.P (31.23%), Wettable sulphur @ 0.3 W.P (32.81%) were found superior as they recorded the lowest per cent disease index. Significant increase in shoot length, number of primary branches per plant, number of pods per plant, 100 seed weight, seed yield was recorded with Myclobutanil spraying at 35 and 45 DAS followed by Wettable sulphur. Highest benefit cost ratio was observed in Wettable sulphur (1.82) followed by Myclobutanil (1.17).

Chapter I

INTRODUCTION

Blackgram [*Vigna mungo* (L.) Hepper] is an important pulse containing 24% protein in its seed and is the richest source of phosphoric acid among pulses, combination with cereal it fulfils the requirement of protein in diets (Duffus and Slaughter, 1980). It is mainly used as dal and in preparation of some special dishes like the sprouted *urdbean* which is very popular in Japan and is highly valued for digestibility and freedom from the flatulence effect**.** Since it serves as a cheaper source of protein (24%) for the poor, it is rightly called the poor man's meat and can also be used as green manure. Blackgram crop is mini-fertiliser factory as it restores soil fertility by fixing atmospheric nitrogen and thus producing nitrogen equivalent of around 22 kg per hectare (Rachie and Roberts, 1974).

Blackgram cultivation is distributed mainly in tropical to sub-tropical countries. The traditional cultivation of blackgram is confined to the South-Asia and adjacent regions. The production of blackgram globally is around 8.5 million tonnes, from the major producing countries such as India, Myanmar and Thailand. In India it is a third important pulse crop cultivated in an area of 2.29 M ha with 1.96 M t production and 500 kg ha^{-1} productivity (Department of Agriculture and Cooperation, Government of India, 2014).

In India, major *urdbean* growing areas are Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Sikkim, Tamil Nadu and Uttar Pradesh and Andhra Pradesh (A.P). In A.P *kharif,* it is grown in 0.25 Lakh ha, producing 0.17 Lakh t with a productivity of 676 kg ha^{-1}, in *rabi,* it occupies 4.29 Lakh ha, producing 3.39 Lakh t with a productivity of 790 kg ha^{-1} (Department of Agriculture and Co-operation, Government of A.P. 2014).The crop is of special significance in A.P as it fits well in rice-pulse cropping system as a relay crop particularly in Krishna - Godavari and North Coastal zones.

Blackgram suffers from biotic stress due to fungal, bacterial and viral diseases resulting in heavy yield losses (Nene, 1972). Powdery mildew reported as a serious problem in all areas of rice based cropping systems of the country (Abbaiah, 1993) causing considerable yield loss every year due to reduction in photosynthetic activity and physiological changes (Legapsi *et al*., 1978).

Although the disease was reported to cause considerable loss, information on its prevalence particularly after the advent of blackgram genotypes, epidemiological factors influencing the disease development and efficacy of growth regulators, antitranspirant and new fungicide molecules in disease management is limited. Hence the present investigation was taken up with the following objectives.

1. To survey for the occurrence of powdery mildew and its severity in Guntur district
2. To study the effect of weather factors on severity of powdery mildew
3. To assess the reaction of *urdbean* genotypes to powdery mildew
4. To evaluate growth regulator, antitranspirant and fungicides against powdery mildew

LITERATURE CITIED

Abbaiah, K. 1993. Development of powdery mildew epidemics in *urdbean* in relation to weather factors. *Indian Journal of Pulse Research.* 6: 186-188.

Agarwal, S.G., Sushma, N and Nema, S. 1989. Resistance in *mungbean* and *urdbean* against powdery mildew. *Indian Journal of Pulses Research.* 2: 76-77.

Agrios, G.N. 2005. Powdery mildews. *Plant Pathology*, 5thed. San Diego USA. Elsevier Academic Press. 346.

Akhtar, J., Lal, H.C., Yogesh Kumar., Singh, P.K., Jyotirmoy Ghosh., Singh, P.K., Zakauallah Khan and Gautam, N.K. 2014. Multiple disease resistance in greengram and blackgram germplasm and management through chemicals under rainfed conditions. *Legume Research*. 37: 101-109.

All India Coordinated Research Project on MULLaRP. 2013. Proceedings and Recommendations Indian Institute of Pulses Research, Kanpur. *www.aicrpmullarp.res.in*.

Allen, P.J. 1959. Physiology and biochemistry of defense. In Horsfall, J.G. & Dimond, A.E . *Plant Pathology*. 435-469.

Andrew, M., Jarosz., Michael, S and Levy, M. 1982. Cuticle thickness in phlox and resistance to powdery mildew unreliable line of defense. *American Journal of Botany*. 69: 824-828.

Anil Kumar, T.B and Rangaswamy, K.T. 1993. Field assessment of partial resistance to powdery mildew in dwarf field pea. *International Journal of Tropical Plant diseases*. 11: 125-126.

Arora,Y.K and Wagle, D.S. 1985. Interrelationship between peroxidase, polyphenol oxidase activities and phenolic content of wheat for resistance to loose smut. *Biochemie und Physiologieder Pflanzen*. 180: 75-80.

Avtar, R., A.S., Rathi, D.S. Jatasra, and U.N. Joshi. 2003. Changes in phenolics and some oxidative enzymes in fenugreek leaves due to powdery mildew infection. *Acta Phytopathologica et Entomologica Hungarica*. 38: 237-244.

Besser, K., Jarosch, B., Langen, G and Kogel, K.H. 2000. Expression analysis of genes induced in barley after chemical activation reveals distinct disease resistance pathways. *Molecular Plant Pathology*. 1: 277-286.

Bharadwaj, S.S and Shyam, K.R. 1993. Effect of fungicide-nutrient applications on powdery mildew disease and pod yield in pea. *Indian Journal of Plant Protection.* 21: 85-86.

Bharat, K.N. 2013. Study on the occurrence of perfect stage of okra powdery mildew in Himachal Pradesh. *International Journal of Farm Sciences.* 3: 52-55

Bhattacharya, A and Shukla, P. 2002. Effect of environment factors on powdery mildew in field pea under irrigated and rainfed conditions. *Indian Journal of Agricultural Research.* 36: 149-155.

Bisht, I.S., Shasshi, B., Kavalkar, T.G., Thomas, T.A and Bhalla, S. 1991. Multiple resistance against and severity of major diseases of greengram in Maharastra. *Legume Research.* 14: 189-190.

Braun, U, Cook, R.T.A, Inman, A.J., Shin, H.D. 2002. The taxonomy of powdery mildew fungi. *The powdery mildews: a comprehensive treatise.* 13-55.

Braun, E. 1987a. A monography of the Erysiphales (powdery mildews). Berlin. J. Cramer, 1–700.

Braun, U. 1987b. A monograph of the Erysiphales (powdery mildews). *Beihefte zur Nova Hedwigia.* 89: 700.

Channaveeresh, T.S., Kulkarni, S and Vijaykumari, A.G. 2014. Evaluation of black gram genotypes for resistance to powdery mildew caused by *Erysiphe polygoni* DC. Karnataka Journal of agricultural sciences. 27: 85-87.

Chattopadhyay, S., Ali, K.A., Gandhi, D., Nirvan, K., Ramesh, K., Aggarwal., Tapas, K., Bandopadhyay., Sarkar, A and Bajpai, A.K. 2011. Association of leaf micro-morphological characters with powdery mildew resistance in field-grown mulberry (*Morus* spp.) germplasm. *AOB Plants.* http://www.ncbi.nlm.nih.gov/pmc/articles.

Commenil, P., Brunet, L and Audran, J.C. 1997. The development of the grape berry cuticle in relation to susceptibility to bunch rot disease. *Journal of Experimental Botany*. 48: 1599-1607.

Dakshayani, R., Mummigatti, U.V., Kulkarni, S and Kumar, R. L. 2005. Screening of green gram genotypes for powdery mildew using biochemical parameters. *Karnataka Journal of Agricultural Sciences.* 18: 500-502.

Das, S.R and Narain, A. 1990. Management of powdery mildew of mungbean with fungicides. *Indian Phytopathology*. 43: 100-101.

Davies, K.M. 2004. Important Rare Plant Pigments. *Plant Pigments and Their Manipulation*. *Annual Plant Reviews.* 14: 214-247.

De Candolle. 1802. History and Taxonomy. *The Powdery Mildew.* Ed. Spencer, D.M., Academic Press, London. 3-15.

Delp, C.J. 1954. Effect of temperature and humidity on grape powdery mildew fungus. *Phytopathology*. 44: 26.

Department of Agriculture and Cooperation, Government of A.P. 2014. Area and production of agricultural crops in Andhra Pradesh. *www.agri.ap.nic.in*.

Department of Agriculture and Cooperation, Government of India. 2014. Area and production of agricultural crops in India. *www.agricoop.nic.in.*

Deshpande, G.D and Dake, G.N. 1978. New records of powdery mildew in Marathwada. *Indian Phytopathlogy*. 31: 256.

Dhanumjayarao, K., Jindal, P.C., Singh, R., Srivastava and Sharma, R.C. 2006. Biochemical variability studies for disease resistance in grape germplasm against powdery mildew with varietal characters. *Indian Journal of Agricultural Research*. 40: 212-214.

Dinesh, B.M. 2009. Studies on powdery mildew of sunflower caused by *Erysiphe cichoracearum* DC. Msc. *Thesis* University of Agricultural Sciences, Dharwad, India.

Dinesh, M.B., Kulkarni, S., Harlapur, I.S., Benagi, I.V and Mallapur, P.C. 2010. Prevalence of powdery mildew in sunflower growing areas in northern Karnataka. *Karnataka Journal of Agricultural Sciences.* 23: 521-523.

Donald, M.F. 2008. Foliar disease of watermelon. Louisiana Plant Pathology and Disease Identification and Management series. *Publication.* 3046.2.

Doran, W.L. 1922. Laboratory studies of the toxicity of some sulphur fungicides. *New Hampshire state agricultural experiment station technology, Bull.*19.

*Duffus, C.M and Slaughter, 1980. Seed and their uses. *Wiley and sons Chichester*. New York. USA. 60-64.

Fondevilla, S and Rubiales, D. 2011. Powdery mildew control in pea. *Agronomy for Sustainable Development.* 32: 401-409.

Friend, J. 1979. Phenolic substances and plant diseases. *In : Biochemistry of plant phenolics* (Swin. T., Harbone, B.J. and Sumere, F.V (Eds). 557-588.

Gabler, F.M, Smilanick, J.L., Mansour, M., Ramming, D.W and Mackey, B.E. 2003 Correlations of morphological, anatomical and chemical features of grape berries with resistance to *Botrytis cinerea*. *Phytopathology*. 93: 1263-1273.

Gadre, U.A., Joshi, M.S and Mandokhot, A.M. 2002. Effect of weather factors on the incidence of alternaria leaf blight, white rust and powdery mildew of mustard. *Annuals of Plant Protection Sciences.*10: 337-339.

Garg, I.D and Mandahar, C.L. 1975. Physiology of powdery mildew infected leaves of *Abelmoschus esculentus*. III. Carbohydrates. *Indian Phytopathology*. 26: 173-177.

Gawande, V.L., Patil, J.V., Naik, R.M and Kale, A.A. 2002. Plant biochemical defense against powdery mildew (*Erysiphe polygoni* D C) disease in *mungbean* (*Vigna radiata* (L.) Wilczek). *Journal of Plant Biology*. 29: 337-341.

Georgiev, K and Galina, K and Naydenova. 2013. Physiological function of non-glandular trichomes in red clover (*Trifolium pretense*). *Journal of Agricultural Sciences.* 58: 217-222.

Glenn, D.M., Puterka, G.J., Drake, S.R., Unruh, T.R., Knight, A.L., Baherle, P., Prado, E and Baugher, T. 2001. Particle film application influences apple leaf physiology, fruit yield and fruit quality. *Journal of American Society of Horticultural Sciences.* 126: 175-181.

Gogoi, R., Singh, D.V and Srivastava, D.K. 2001. Phenols as a biochemical basis of resistance in wheat against Karnal bunt. *Plant Pathology*. 50: 470-476.

Gomez, K.A and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research* (2^{nd} ed), John Wiley and Sons Ltd., Singapore. 683.

Grewal, J.S. 1988. Disease of pulse crops-An overview. *Indian Phytopathology*. 41: 1-14.

Guleria, P.B., Bajaj, K.L., Guleria, S and Paul, B. 1997. *Plant Disease Research*. 12: 185-188.

Gupta, M and Sharma, S.K. 2009. Epidemiology and management of powdery mildew of apple in nurseries. *Biological Forum*. 20: 12 -17.

Gupta, K., Saharan, G.S and Singh, D.2002. Assessment of white rust severity on Brassica juncea under genotype environmental conditions. *Journal of Mycology of Plant Pathology*.32: 106-109.

Hammett, K.R.W and Manners, J.G. 1974. Conidium liberation in *Erysiphe graminis*. III. Wind tunnel studies. *Transaction British Mycological Society*. 2: 267-282.

Hans, J and Boeswinkel. 1980. The morphology of imperfect stages of powdery mildew. *Botanical Review*. 46: 167-224.

Harika, K. 1996. Host range and geographical distrubution of powdery mildews. *Agricultural Niigata University*. 472.

Hartman, G.L., Wang, T.C and Kim, D. 1993. Field evaluation of *mungbean* resistance to cercospora leaf spot and powdery mildew. *International Journal of Pest Management*. 39: 418-421.

Hattappa, S., Chattopadhyay, S and Dutta, S.K. 2003. Some Biochemical Changes in the Leaves of Mulberry (*Morus alba* L.). Infected by Powdery Mildew (*Phyllactinia corylea* (Peis, Karst). *Environment and Ecology*. 21: 47-49.

Heintz, C and Blaich, R. 1990. Ultrastructural and histochemical studies on interactions between *Vitis vinifera* L. and *Uncinula necator* (Schw.) *Burr*. *New Phytologist*. 115: 107-117.

Helal, R.M., Zaki, M.S and Fadl, F.A. 1978. Physiological studies on the nature of resistance to powdery mildew in cucumber. *Research Bulletin*. *Ain –Shams. University*, Cairo.12.

Hill, N.S. 2004. *Phlox paniculata* 'Blue Boy' and *Rudbeckia hirta* 'Indian Summer': Cultural guidelines for greenhouse growth and powdery mildew control. Msc. Horticulture. *Virginia Polytechnic Institute and State University*. 69-74.

Hodge, J.E and Hofreiter, B.T. 1962. In: *Methods in Carbohydrate Chemistry*. (eds.) Whistler, R.L. and Be Miller, J.N., Academic Press, New York. 420.

Horsefall, J.G and Diamond, A.E. 1960. *Plant pathology- An advanced treatise*. 123

Howard, R.J., Garland, J.A and Seaman, W.L. 1994. Diseases and pests of vegetable crops in Canada: an illustrated compendium. *The Canadian Phytopathological Society*, Ottawa, Canada. 554.

Illahi, I., Mittal, V., Ramegowda., Dhar, A.G.K and Khan, M.A. 2011. Occurrence of major foliar diseases of mulberry under temperate climatic conditions of Kashmir, India. *International Journal of Science and Nature*. 2: 51-54.

Jayasekhar, M and Ebeneza, E.G. 2016. Management of powdery mildew of black gram (*Vigna mungo*) caused by *Erysiphe polygoni*. *Agricultural Science Digest.* 36: 72-74.

Kadry, M.M., Montaser, F.A.M and Mohamed, M.M. 2011. Use of abiotic and biotic inducers for controlling fungal diseases and improving growth of alfalfa. *World Journal of Agricultural Sciences.* 7: 566-576.

Kalia, P and Sharma, S.K. 1988. Biochemical genetics of powdery mildew resistance in pea. *Theoretical and Applied Genetics.* 76: 795-799.

Kamalesh, M., Shekhawat, K.S., Bhatia, L.K and Mathur, K. 1991. Performance of pea varieties against powdery mildew. *Indian Phytopathlogy*. 44: 137

Kannaiyan, J., Greenberg, D.C., Haciwa, H.C and Mbewe, M.N. 1987. Screening cow pea for resistance to major diseases in Zambia. *Tropical Grian Legume Bulletin*. 34: 23-26.

Kanzaria, K.K., Dhruj, I.U and Sahu, D.D. 2013. Influence of weather parameters on powdery mildew disease of mustard under North Saurashtra Agroclimatic Zone. *Journal of Agrometerology*.15: 86-88.

Karkanis, A., Bilalis, D., Efthimiadou, A and Katsenios, A. 2012. Effects of field bindweed (*Convolvulus arvensis* L.) and powdery mildew [*Leveillula taurica* (Lev.) Arn.] on pepper growth and yield. *Horticultural science.* 39: 135-138.

Kaushal, R.P and Singh, B.M. 1989. Genetics of resistance in blackgram to powdery mildew caused by *Erysiphe polygoni. Indian Journal of Agriculltural Sciences.* 59: 684-685.

Keinath, A.P and Du Bose, B. 2004. Evaluation of fungicides for prevention and management of powdery mildew on watermelon. *Crop Protection*. 23: 35-42.

Khunti, J.P., Bhoranyia, M.F and Vora, V.D. 2002. Management of powdery mildew and cercospora leaf spot of *mungbean* by some systemic fungicides. *Indian Journal of Mycology of Plant Pathology*. 32: 35-36.

Kimani, N.C and Onguso, J and Njau, P. 2015. Screening of Kenyan bread varieties for resistance to the emerging strains of stem rust fungi. *World Journal of Agricultural Research.* 3: 5-10.

*Kiss, L and Szentivanyi, O. 2001. Infection of bean with cucumber powdery mildew, *Podosphaera fusca*. *New Disease Reporter*. 50: 411.

Konczak, I and Zhang, W. 2004. Anthocyanins-more than nature's colour. *Journal of Biomedicine and Biotechnology*. 4: 239-240.

Kortekamp, A and Zyprian, E. 1999. Leaf hairs has basic protective barrier against downy mildew of grape. *Journal of Phytopathology*.147: 453-459.

Kshirsagar, B.N., Chavan, G.L., Sawargaon., Karand, S and Ambhore, S. 2008. Effect of cycocel on growth parameters of green gram (*Vigna radiata*). *International Journal of Agricultural Sciences.* 4: 346-347.

Kumar, A., Biradar, S.A., Rajanna, B and Govindappa, M.R. 2014. Survey and survillence of powdery mildew in linseed growing areas of northern Karnataka. *Journal of Mycopathology Research.* 52: 59-63.

Kumar, M.V. 1999. Studies on powdery mildew (*Erysiphe polygoni* DC) on blackgram - rice fallows of Guntur district. Msc. *Thesis* Acharya.N.G. Ranga Agricultural University, Bapatla, India.

Kumar, N., Sharma, S., Kumar and Natal, R. 2007. Evalution of field genotypes against powdery mildew under natural epiphytotic conditions. *Journal of Plant Improvement.* 9: 17-18.

Kumar, P.Y., Kulkarni, S.A., Noorulla, H., Sunkad, G., Mallesh and Konda, C.R. 2013. Distribution of powdery mildew of greengram in major growing areas of northern Karnataka, India. *International Journal of Current Research.* 9: 2388-2390.

Kunkliker, S and Padaganar, G.M. 1991. Effect of date of sowing on incidence of greengram powdery mildew. *Karnataka Journal of Agricultural Sciences.* 4: 165-167.

Kuo, Y.H, Ikegami, F., Lambein, F. 1998. Neuroactive and other free amino acids in seed and young plants of *Panax ginseng*. *Phytochemistry*. 62: 1087-1091.

Lakshmipathi, B.H., Viswanth, S., Kumar, A.T.B and Satyan, B.A. 1993. Reaction of greengram genotypes to powdery mildew. *Current Research University of Agricultural Sciences,* Bangalore. 22: 101-102.

Lalancette, N., Peter, D.B., Shearer, W and Tietjen, W.T. 2005. Evaluation of hydrophobic and hydrophilic kaolin particle films for peach crop, arthropod and disease management. *Pest Management Science*. 61: 25-39.

Lattanzio, V., Veronica., Lattanzio, M.T and Cardinali, A. 2006. Role of phenolics in the resistance mechanisms of plants against fungal pathogens and insects. Phytochemistry. *Advances in Research*. 2: 23-67.

Legapsi, B.M., Capiton, E.M and Hubbell, J.N. 1978. AVRDC. Phillipines, programme studies. *First International Symposium on Mungbean.* 220-223.

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

*Lima, P., Lopes, C.A and CafeFilho, A.C. 2010. Stomatal patterns of capsicum genotypes resistant or susceptible to *Oidlopsis haplophylli*. *Summa Phytopathologia*. 36: 25-29.

Mach, E and Portele, K. 1884. *Weinlaube, Berlin.*11: 113.

Malhotra, S.K and Singh, A. 2000. Diversity for resistance to powdery mildew in peas. *Legume Research.* 23: 69-70.

Malick, C.P and Singh, M.B. 1980. Quantification of total phenol content. *Plant Enzymology and Histo Enzymology*. Kalyani publishers, New Delhi. 286.

Manners, J.G and Hossain, S.M.M. 1963. Effects of temperature and humidity on conidia germination in *Erysiphe cichoracearum*. *Transactions of the British Mycological Society*. 46: 225-234.

Martin, C and Glover, B.J. 2007. Functional aspects of cell patterning in aerial epidermis. *Current Opinion in Plant Biology.* 10: 70–78

Mc Grath, M.T and Thomas, C.E. 1996. *Powdery mildew.* 28-30.

Miller, G.L. 1959. Use of dinitrosalicylic acid reagent for determination of reducing sugar. *Analytical Chemistry*. 31: 426-428.

Mir, A.R., Wani, H.A., Bhat, Y.M., Nisa, U.T and Ahamd, S. 2011. Incidence and intensity of powdery mildew fungi on the plants of Papilionaceae. *New York Science Journal* 4: 251-253.

Mittal, R.K and Sharma, A.K. 1991. Powdery mildew of blackgram and greengram in the Kumaon hills. *Indian Journal of Mycology and Plant Pathology*. 22: 202-203.

Moharam, A.H.M and Ali, O.A.H. 2014. Preventative and curative effects of several plant derived agents against powdery mildew disease of okra. *Notulae Scientia Biologicae*. 4: 76-82.

Muhammad, A.A and Ali, K.A. 2014. Powdery mildew induced physiological and biochemical changes in pea. *Pakisthan Journal of Agricultural Sciences*. 51: 893-899.

Munjal, R.L., Chenulu,V.V and Hora, I.S. 1963. Assessment of losses due to powdery mildew (*Erysiphe polygoni*) on pea. *Indian Phytopathololgy*. 16: 260-267.

Nair, S.K., Nanda, H.C., Khare, N., Motiramani, N.K., Chandrakar, D.K and Kotasthane, A.S. 2015. Resistance in *mungbean* genotypes against powdery mildew disease. *Journal of Food Legumes.* 28: 78-81.

Nene, Y.L and Thapliyal, P.N. 1993. Fungicides in plant disease control. 3rd ed. 345-346.

Nene, Y.L. 1972. A survey of the viral diseases of pulse crops in Uttar Pradesh. *First Annual Report. FG-IN-358,* Uttar Pradesh Agricultural University. 1-25.

Nidhi, P., Singh, M.N., Misra, M.K., Singh, D.K., Pal Yash., Dhurai, S.Y and Rishi, P. 2015. *Indian Journal of Plant Genetic Resources.* 28: 303-306.

Niks, R.E and Rubiales, D. 2002. Potentially durable resistance mechanisms in plants to specialized fungal pathogens. *Euphytica*.124: 216-216.

Nofal, M.A and Wafaa, H. 2006. Integrated management of powdery mildew mango in Egypt. *Crop Protection*. 25: 480-486.

Nour, M.A. Studies on *Leveillula taurica* (Lev.) Arn. and other powdery mildews. *Transactions of the British Mycological Society.* 41: 17-38.

Parashar, R.D and Sindhan, G.S. 1986. Biochemical changes in varieties resistant and susceptible to powdery mildew disease. *Progressive Horticulture*. 18: 135-137.

Parthasarathy, S and Jaiganesh, V. 2015. Plant activator and silcon nutrient mediated resistance against powdery mildew of blackgram. *Agricultural Sciences.* 4: 2277-8160.

Patil, B.G and Moghe, P.G. 1993. Reaction of mung, urd, and kulthi varieties to powdery mildew. *Journal of Maharastra Agricultural University*. 18: 467-468.

Patil, N.K., Adiver, S.S., Hiremath, P.C., Anil Kumar., T.B and Hedge, R.K. 1989. Field reaction of green gram varieties to powdery mildew. *Current Research University of Agricultural Sciences.* Bangalore. 18: 83.

Pawar, K.B., Perane, P.P and Deshmukh, R.B. 1995. Screening of *mungbean* and *urdbean* entries against powdery mildew. *Journal of Maharastra Agricultural University.* 20: 323-324.

Pérez., H.N., Pérez-Harguindeguy, A.Y.S., Díaz, A.E., Garnier, B.S., Lavorel, C.H., Poorter, D.P., Jaureguiberry, A.M.S., Bret-Harte, E.W.K., Cornwell, F.J.M., Craine, G.D.E., Gurvich, A.C., Urcelay, A.E.J., Veneklaas, H.P.B., Reich, I.L., Poorter, J.I.J., Wright, K.P., Ray, L.L., Enrico, A.J.G and Pausas, M.A.C. 2013. New handbook for standardised measurement of plant functional traits worldwide F. 2013. *Journal of Botany*. 61: 167-234.

Poonam, C., Rastogi, K.N and Rashmi, G. 2013. Performance of field pea genotypes against powdery mildew (*Erysiphe polygoni*). *Progressive Research.* 8: 280-282.

Prakash, O.M and Raoof, M.A. 1994. Studies on powdery mildew (*Odium mangiferae*) diseases of mango, distrubution perputation, losses and chemical control. *Biotechsage memoris*. 20: 31-45.

Prashanthi, L., Reddy, B.V.B., Rani, R., Rajeswari, T., Sivaprasad, Y and Reddy, K.R. 2010. Screening blackgram genotypes under artificially inoculated conditions and based on molecular markers for powdery mildew resistance. *Legume Research*. 33: 17-22.

*Rachie, K.O and Roberts, L.M. 1974. Grain legumes of low land tropics. *Advances in Agronomy*. 26: 1-132.

Raguchander, T., Amutha, G., Arjunan, G and Samiyappan. 2001. Assessment of slow mildew resistance in *urdbean*. *Indian Phytopathlogy*. 54: 444-448.

Raguchander, T and Rajappan, K. 1995. Relationship between powdery mildew and meterological factors in *urdbean*. *Plant Disease Research.* 10: 5-9.

Raju, S.G and Anil Kumar, T.B. 1990. Sources of partial resistance to powdery mildew in cowpea. *Archiv Fur Phytopathlogie UndPflanzens Chutz.* 27: 153-156.

Raju, S.G and Kumar, A.T.B. 1991. Evaluation of cowpea genotypes for partial resistance to powdery mildew. *Euphytica.* 50: 191-195.

Ramakrishnan, C.K.D and Savithramma, D.L. 2014. Screening of *mungbean* germplasm for powdery mildew disease resistance. *International Journal of Agronomy and Agricultural Research.* 4: 16-21.

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

Rathore, B.S and Rathore, R.S. 1995. Studies on varietal resistance and chemical control of powdery mildew of fenugreek. *Indian Journal of Mycology and Plant Pathology*. 25: 260-262.

Raut, B.T., Aurangabadkar, J.H., Wangikar, P.D and Khune, N.N. 1986. Chemical control of powdery mildew on greengram and blackgram. *Punjabrao Krishi Vidyapeeth Research Journal.* 10: 134-137.

Rehman, A., Mehboob, S., Sohali, M., Gondal, S.A., Idrees. M and Ali. 2014. Estimation of genetic diversity of pea germplasm against powdery mildew disease and its chemosynthetic management. *Pakistan Journal of Plant Pathology*. 26: 309-313.

Rettinassababady, C., Ramadoss, N and Thirumeni, S. 2000. Effect of plant extract in the control of powdery mildew of blackgram (*Erysiphe polygoni* DC). *Agricultural Science Digest.* 20: 193-194.

Rheb, A., Nadia, M.E.A., Shenoudy and Anwar, H.M. 2014. Effect of powdery mildew on mango chlorophyll content and disease control. *Egyptian Journal of Agricultural Research.* 92: 451-462.

Richard, N.B and Roger, M.W. 1994. Secondary metabolites in plant defence mechanisms. *Phytopathology*. 127: 617-633.

Saini, R.S., Arora, Y.K, Chawla, H.K.L and Wagle, D.S. 1988. Total phenols and sugar content in wheat cultivars resistant and susceptible to *Ustilago nuda* (Jens) *Rostrup. Biochemie und Physiologie der Pflanzen.* 183: 89-93.

Saxena, D.R and Saxena, M. 1991. Epidemiology of powdery mildew of *mungbean* [*Vigna radiata* (L.) Wilczek]. *Indian Journal of Pulses Research.* 4: 65-67.

Schnathrost, W.C. 1960. Effects of temperature and moisture stress on lettuce powdery mildew of the fungus. *Phytopathology.*50: 380.

Senugupta, P.K. 1974. Disease of major pulse crops in India. *Pest articles and news summaries.* 20: 409-415.

Shaik, M. 1985. Race non-specific resistance in bean cultivars to races of *Uromyces appendiculatus* var. *appendiculatus* and its correlation with leaf epidermal characters. *Phytopathology.*75: 478–481.

Sharma, H., Kalaria, B.D., Ghoghari, D.P and Khandelwal, V. 2012. *Indian Journal of Mycology and Plant Pathology*. 42: 494-496.

Sharma. 1991. A techinique for creation of artificial epiphytotics of powdery mildew and evaluation of resistance in pea against this disease under hill conditions. *Vegetable.* 18 : 77-81.

Sharmila, S.A., Kachapur, R.M and Patil, S.M. 2006. A survey on the incidence of powdery mildew of chilli. *Karnataka Journal Agricultural Sciences.*19: 168-169.

Singh, B.B and Sarkar, S.K. 1976. Effect of growth of growth retardants on growth, flowering, productivity and chemical composition of soybean. *Harayana Journal of Horticulture.* 5: 195-202.

Singh, G and Kaur, M. 1980. Effect of growth of growth regulators on podding and yield of *mungbean*. *Plant Physiology*. 24: 366-370.

Singh, H.B and Singh, V.P. 1983. Effect of some new sulphur compounds, plant extracts and vegetable oils on conidia of *Erysiphe polygoni* DC. *Agricultural Research Rural Development.* 6: 5-10.

Sirdhan, G.S and Parashar, R.D. 1984. A comparative study of pea varieties resistant and susceptible to powdery mildew disease. *Progressive Horticulture.* 16: 137-139.

Solanki, V.A., Patel, B.K and Shekh, A.M. 1999. Meterological variables in relation to an epiphytotic of powdery mildew disease of mustard. *Indian Phytopathology*. 52: 138-141.

Soria, J.A and Quebral, F.C. 1973. Occurrence and development of powdery mildew resistance on mung. *Phillippine Agriculturist*. 57: 158-177.

Sreeramulu, B and Kondaiah, A. 2014. A survey on fungal diseased crops in Cuddapah district of Andhra Pradesh. *Indian Journal of Fundamental and Applied Life Sciences.* 4: 244-251.

Taggar, G.K and Gill, R.S. 2012. Preference of Whitefly, *Bemisia tabaci*, towards blackgram genotypes: Role of morphological leaf characteristics. *Phytoparasitica.* 40: 461-474.

Tantanapornkul, N., Wongkaew, S and Laosuwan, P. 2005. Effects of powdery mildew on yield, yield components and seed quality of *mungbean*. *Suranaree Journal of Science and Technology*.13: 159-162.

*Thakur, M.P and Agarwal, K.C. 1995. Epidemiological studies on powdery mildew of *mungbean* and *urdbean*. *International Journal of Pest Management*. 41: 146-153.

Thakur, P.C and Verma, T.S. 1998. Sources of resistance in pea against powdery mildew. *Indian Journal of Mycology and Plant pathology*. 23: 81-84.

Tirupathiswamy, N., Rosaiah, K.B and Srinivasa, R.K. 2014. Screening blackgram genotypes against powdery mildew. *Annals of Plant Sciences.* 3: 594-599.

Upadhyay, A.L and Singh, V.K. 1994. Performance of pea varieties against powdery mildew and rust. *Indian Journal Pulse Research.* 7: 92-93.

Varadarajan, F and Wilson, K.J. 1973. A technique to spore germination studies on plant leaves. *Current Science*. 42: 70.

Veena., Yashoda, R., Hegde., Divyajyoti, U and Priya, H.R. 2014. Survey and integrated management of fungal foliar diseases of greengram. *Research in Environment and Life Sciences.* 7: 165- 168.

Venu, C., Cheralu, C., Skiander, A., Sadanandam, A., Ali, S and Reddy, S.M. 1997. Screening for resistance of powdery mildew disease of *mungbean*. (*Vigna radiata* L. Wilczek). *Microbial Biotechnology*. 178-179.

Wallace, E., Blodgett, F.M and Helser, L.R. 1911. Studies of the fungicidal value of lime sulphur preparations. *Cornell University Agricultural Experiment Station, Bull*. 290.

Warkentin, D.T., Rashid, Y.K and Xue, G.E. 1996. Fungicidal control of powdery mildew in field pea. *Canadian Journal of Plant Sciences.* 76: 933-935.

Wheeler, B.E.J. 1969. *An Introduction to Plant Diseases.* John Wiley, London. 301.

Wrolstad, R.E. 2004. Interaction of natural colours with other ingredients. Anthocyanins pigments-Biodiversity and coloring properties. *Journal of Food Science*. 69: 419-421.

Yadav, D.L., Jaisani, P and Pandey, R.N. 2014. Identification of sources of resistance in *mungbean* genotypes and influence of fungicidal application to powdery mildew epidemics. *International Journal of Current Microbiology Applied Sciences.* 3: 513-519.

Yarwood, C.E. 1957. Powdery mildews. *Botanical Review.* 23: 235-301.

Ziv, O and Frederiksen, R.A. 1983. Control of foliar diseases with epidermal coating materials. *Plant Diseases*. 67: 212-214.

Ziv, O and Frederiksen, R.A. 1987. The effect of film-forming antitranspirants on leaf rust and powdery mildew incidence on wheat. *Plant Pathology*. 36: 242-245.

* **Original not seen**

Note: The literature is cited as per the "Thesis Guide Lines" prescribed by Acharya N.G. Ranga Agricultural University, Lam, Guntur.

Chapter III

MATERIAL AND METHODS

The present investigation was carried out during *kharif* and *rabi* 2015-16. Laboratory and field studies were conducted at the Regional Agricultural Research Station, Lam, Guntur District, Agricultural College Farm and Department of Plant Pathology, Agricultural College, Bapatla, Guntur District. Geographically the Agricultural College Farm, Bapatla is situated at an altitude of 5 m above the mean sea level and at 80^0 30′ E Longitude and 15^0 54′ N Latitude and seven km away from the coast of Bay of Bengal. The meteorological data recorded during the experimental period September 2015– March 2016 is presented in the Appendix I.

3.1 DISEASE SURVEY

3.1.1 Survey for the Incidence and severity of Powdery mildew disease of *Urdbean*

Survey was conducted during 2015-16 *rabi* season in major *urdbean* growing mandals of Guntur district, Andhra Pradesh. Four mandals were chosen based on statistics of preceeding year where the crop concentration was more. Based on the information, in each mandal two villages and in each village, two fields were surveyed at random. In each field 20 plants were selected at five locations, four corners of the field and one at the centre to record the incidence and severity of powdery mildew, were fixed.

Per cent disease incidence for powdery mildew disease was calculated by using the following formula:

$$\text{Per cent disease incidence (PDI)} = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100$$

The incidence and severity of powdery mildew were recorded mandal-wise. Powdery mildew severity was assessed by disease rating (AICRP, MULLaRP, 2013) (Table 3.1).

Table 3.1 Modified MULLaRP scale (0-5)

Grade	Description	Reaction
0	Plants free from infection on leaves, stems free from the disease	Free (F)
1	Plants showing traces to 10% infection on leaves, stems free from the disease	Highly Resistant (HR)
2	Slight infection with thin coating of powdery growth on leaves covering 10.1-25% leaf area, slight infection on stem and the pods usually free	Moderately Resistant (MR)
3	Dense powdery coating on leaves covering 25.1-50 % leaf area, moderate infection on pods	Moderately Susceptible (MS)
4	Dense powdery coating covering 50.1 -75% leaf area, stems heavily and pods moderately infected. Infected portion turns grayish.	Susceptible (S)
5	Severe infection with dense powdery growth covering 75% area of the whole plant including pods, stems etc. resulting in premature defoliation and drying.	Highly Susceptible (HS)

The per cent disease index (PDI) was computed from the above scale by using the following formula (Wheeler, 1969).

$$PDI = \frac{\text{Sum of all the numerical ratings}}{\text{Number of observations} \times \text{maximum disease grade}} \times 100$$

3.2 INFLUENCE OF WEATHER CONDITIONS ON SEVERITY OF POWDERY MILDEW IN *URDBEAN*

A trial was conducted to determine the influence of weather conditions on the severity of powdery mildew disease in blackgram. Highly susceptible blackgram cultivar PU 31 was planted in a bulk plot of 10 x 10 m^2 during *rabi* 2015-16 at Agricultural College Farm, Bapatla, Andhra Pradesh.

The severity of powdery mildew disease was recorded at every five days interval from 35 DAS to one week prior to harvesting. Meteorological data such as rainfall, maximum temperature, minimum temperature, relative humidity at morning

and evening hours and wind velocity was collected from the Meteorological Station located at Agricultural college farm, Bapatla. Correlation and regression analyses were conducted to determine the influence of weather conditions on the severity of powdery mildew disease in blackgram (Plate 3.1).

3.3. EVALUATION OF URDBEAN GENOTYPES AGAINST POWDERY MILDEW

The experiment was laid out in randomised block design (RBD) with two replications to evaluate 47 entries each during *kharif* and 11entries *rabi* 2015-16. Each genotype was sown in two rows of five m length with a susceptible check variety of LBG 623 (standard check) sown as infector row. The reaction of the entries to powdery mildew was assessed by recording the severity at weekly interval from 35 DAS to one week prior to harvesting, using disease rating scale developed by (AICRP, MULLaRP, 2013) (Fig 3.1, Plate 3.2, 3.3). AUPDC values for representative genotypes per each category will be calculated by (Kimani *et al.*, 2015)

$$\mathbf{AUDPC} = \sum_{i=1}^{k} \frac{1}{2}(S_i + S_{i-1}) \times d$$

Where,

S_i = Disease incidence at ith day or evaluation

k =Number of successive evaluation of the disease

d = Interval between i and i-1evaluation of disease

3.3.1 MORPHOLOGICAL CHARACTERS OF SELECTED BLACKGRAM GENOTYPES

3.3.1.2 Estimation of Leaf Thickness (mm)

A total of 16 genotypes representing all catagories of reaction were selected from the genotypes evaluated during *kharif* 2015-16, and were sown in three replications of 5 m each at Agricultural college, Bapatla, Department of plant pathology during *rabi* 2015-16. Three plants were selected at random from each genotype at 45 DAS. Three

leaves from each plant were selected randomly from each plant to measure leaf thickness by using Venier callipers (Perez *et al.*, 2013). Same genotypes and similar sampling method was used for estimation of stomatal frequency, trichome density, and biochemical analysis.

3.3.1.2 Estimation of Stomatal Frequency (number of stomata/mm^2)

Healthy trifoliate leaf from of 45 days old were collected and were smeared with synthetic gum. The gum was allowed to dry, flakes were peeled and were mounted on microscope glass slide. Number of stomata per mm^2 was counted using ocular micrometer with 40 X objective lens (Varadarajan and Wilson, 1973)

3.3.1.3 Estimation of Trichome Density (5 mm dia leaf disc)

. Circular leaf discs of 5 mm dia were made with punching machine soaked in saffron dye for 5-10 min and were used to enumerate number of hairs using stereo zoom microscope as outlined by Tagger and Gill (2012).

3.3.2 Biochemical Analysis

3.3.2.1 Glassware

The glassware used in the present study was of Corning or Borosil make. Petri plates, conical flasks, test tubes, pipettes, measuring cylinders, beakers were used in the present study. Axygen make micropipettes and microtips were used.

3.3.2.2 Cleaning of Glassware

Glassware was washed first with detergent powder and then washed under tap water. Later they were kept overnight in cleaning solution prepared by mixing 75 g of potassium dichromate, 500 ml of concentrated sulphuric acid and 1000 ml of distilled water and rinsed with tap water followed by distilled water.

3.3.2.3 Chemicals

Analytical or reagent grade chemicals were used in the present study.

3.3.2.4 Estimation of Total phenols: Total phenols were estimated by Folin-Ciocalteau Reagent method (Malick and Singh, 1980).

Reagents

1. 80% ethanol
2. Folin-Ciocalteau Reagent
3. 20% Na_2CO_3
4. Standard:

Stock Solution : 100 mg of Catechol was dissolved in 100 ml water

Working standard : 10 ml of stock diluted to 100 ml with water

Procedure for estimation

1. 0.5 g of sample was ground with a pestle and mortar in 5 ml of 80% ethanol.
2. The homogenate was centrifuged at 10,000 rpm for 20 min. The supernatant was saved.
3. The residue was re-extracted with 2.5 ml of 80% ethanol, centrifuged and the supernatants were pooled.
4. The supernatants were evaporated to dry.
5. The residue was dissolved in a 5 ml of distilled water.
6. Different aliquots (0.2 to 2 ml) were pipetted into tubes.
7. The volume in each tube was made up to 3 ml with water.
8. 0.5 ml of Folin-Ciocalteau reagent was added to each tube.
9. After three min, 2 ml of 20% Na_2CO_3 was added.
10. The contents were mixed thoroughly, the tubes were placed in boiling water for exactly one min, cooled and absorbance at 650 nm was measured against a reagent blank.
11. A standard curve was prepared using different concentrations of catechol.
12. Amount of total sugars present in the sample tube were calculated from the graph.

$$\text{Total phenols (µg)} = \frac{\text{Total volume of aliquot x Phenol value from graph}}{\text{Used aliquot}}$$

3.3.2.5 Estimation of total sugars: Total sugars were estimated following Anthrone method (Hodge and Hofreiter, 1962).

Reagents

1. 2.5 N-HCl
2. Anthrone Reagent: 200 mg of anthrone is dissolved in 100 ml of ice-cold 95% H_2SO_4.
3. Standard Glucose:

   Stock Solution : 100 mg of glucose was dissolved in 100 ml water

   Working standard : 10 ml of stock diluted to 100 ml with water and few drops of toluene was added and stored at 4 ^{0}C

Procedure for estimation

1. 100 of the sample was weighed into a boiling tube.
2. Sample was hydrolyzed by keeping in a boiling water bath for 3 h with 5 ml of 2.5 N HCl and was cooled to room temperature.
3. It was neutralised with solid sodium carbonate until the effervescence ceased.
4. The volume was made up to 100 ml and centrifuged.
5. The supernatant was collected and 0.5 ml of aliquot was taken for analysis.
6. Standards were prepared by taking 0, 0.2, 0.4, 0.6, 0.8 and 1 ml of the working standard and ‘0’ served as blank.
7. The volume was made up to 1 ml in each test tube by adding distilled water.
8. 1ml of anthrone reagent was added to each test tube and heated for 8 min in a boiling water bath.

9. It was cooled rapidly and the intensity of green to dark green colour was measured in spectrophotometer at 630 nm.

10. A standard graph was prepared by plotting concentration of the standard on the X-axis versus absorbance on the Y-axis.

11. Amount of total sugars present in the sample tube were calculated from the graph.

$$\text{Amount of total sugars present in 100 mg of the sample} = \frac{\text{mg of glucose}}{\text{Volume of test sample}}$$

3.3.2.6 Estimation of reducing sugars: Reducing sugars estimation was carried out by Dinitrosalicylic acid method (Miller, 1959).

Reagents

1. Dinitrosalicylic acid reagent (DNS reagent): 1 g dinitrosalicylic acid, 200 mg crystalline phenol and 50 mg of sodium sulphite were dissolved in 100 ml of 1% NaOH.

2. 40% of Rochelle salt solution (Potassium sodium tartrate)

3. Standard Glucose Solution:

Stock Solution : 100 mg of glucose was diluted in 100 ml water

Working standard : 10 ml of stock diluted to 100 ml with water

Procedure for estimation

1. Sugars were extracted with hot 80% ethanol from 100 mg of weighed sample.
2. Supernatant was collected and evaporated by keeping it on a water bath at 80 ^{0}C.
3. 10 ml of distilled water was added and 0.5 ml of aliquots was pipetted into separate test tubes.
4. Standards were prepared by taking 0, 0.2, 0.4, 0.6, 0.8 and 1 ml of the working standard and ‘0’ served as blank.

5. The volume was made up to 3 ml in each test tube by adding distilled water.
6. 3 ml of DNS reagent was added and heated for 5 min in a boiling water bath.
7. 1 ml of 40% Rochelle salt solution was added and intensity of dark red colour was measured at 510 nm.
8. Amount of total sugars present in the sample tube were calculated from the graph.

$$\text{Amount of reducing sugars} = \frac{\text{Sugar value from graph} \times \text{Total volume} \times 100}{\text{Aliquot of sample used} \times \text{wt. of the sample}}$$

3.3.2.7 Estimation of non-reducing sugars: The amount of non-reducing sugar was calculated by deducting the reducing sugar content from that of the total soluble sugars.

3.4. TO EVALUATE GROWTH REGULATOR, ANTITRANSPIRANT AND FUNGICIDES AGAINST POWDERY MILDEW

Field experiment was conducted during *rabi* 2015-16 at the Agricultural College Farm, Bapatla, Guntur, Andhra Pradesh.

3.4.1 Design and Layout

The experiment was laid out in RBD with thee replications. The plan of layout of the experiment was shown in (Fig 4.1 and Plate 3.4)

3.4.2 Date of Sowing

Rabi: 13-10-2015

3.4.3 Spacing and Plot Size

Plot size: 5 × 4m

Spacing: 30 × 10 cm

3.4.4 Variety: PU 31

3.4.5 Land Preparation

The land was prepared by thorough ploughing and harrowing the soil to a fine tilth.

3.4.6 Fertilizer Application

Nitrogen @ 20 kg and Phosphorus @ 50 kg/ha were applied as basal dose before sowing.

3.4.7 Treatment Details

T1 : Cycocel @ 50 ppm

T2 : Salicyclic acid @ 30 ppm

T3 : Myclobutanil @ 0.2 % W.P

T4 : Wettable sulphur @ 0.3%W.P

T5 : Neem oil @1000 ppm

T6 : Kaolin (6%)

T7 : Untreated control (Check)

*****The dosage of cycocel, salicyclic acid were standardized by running pliot project experiments to avoid phytotoxicity.

3.4.8 After Care

Weeding and intercultivation activities were carried out regularly and irrigation was given at 15 and 45 DAS.

3.4.9 Harvesting

The crop was harvested at physiological maturity in all plots by pulling out the plants along with roots. The plants were dried in the sun and later threshed for separation of seeds from the pods. Seeds from each micro plot were weighed after drying.

3.4.10 Collection of Experimental Data

3.4.10.1 Disease incidence and Severity

Powdery mildew disease severity was recorded in each treatment plot at 35, 45, 55 DAS and PDI was calculated.

3.4.10.2 Growth and yield parameters

Observations on growth and yield contributing parameters like number of primary branches, pods/plant and number of seeds/pod and 100 seed weight were made on five randomly selected plants from each treatment plot at harvesting stage.

3.4.10.3 Number of primary branches/plant

The number of primary branches per plant was counted for five selected plants and the mean value was calculated.

3.4.10.4 Pods/plant

The number of pods per plant was counted for the five selected plants and the mean value was calculated.

3.4.10.5 Seeds/pod

The number of seeds per pod was counted for the five pods from selected five plants and the mean value calculated.

3.4.10.6 100 seed weight

A lot of seeds were drawn at random from each treatment replication wise. 100 seeds were counted from each sample, weighed separately and expressed in grams.

3.4.11 Economics

3.4.11.1 Cost of cultivation

The cost of the required operations per hectare included the cost of seed, chemicals and labour charges as per the existing market prices.

3.4.11.2 Gross returns

The gross returns were calculated by considering the prices of blackgram seed prevailing in the local market.

3.4.11.3 Net returns

The net returns Rs ha^{-1} was calculated by deducting the cost of cultivation from the gross returns on ha^{-1} basis.

Net returns = Gross income ha^{-1} - Cost of cultivation ha^{-1}

3.4.11.4 Benefit cost ratio

Benefit cost ratio was worked out by dividing gross returns and cost of cultivation

3.6 STATISTICAL ANALYSIS

The data obtained from all the experiments were statistically analyzed following the standard procedures (Gomez and Gomez, 1984).

Chapter IV

RESULTS AND DISCUSSION

Results of the studies are presented and discussed in this chapter.

4.1. SURVEY FOR THE INCIDENCE AND SEVERITY OF POWDERY MILDEW DISEASE OF *URDBEAN*

In Guntur district, a total of 16 fields of eight villages *viz.,* Kantheru, Ponnekalu, Kothapalem, Manchala, Vargani, Nagalupadu, Bhallupadu and Appapuram, belonging to four mandals *viz.*, Tadikonda, Veticherukuru, Pedanandipadu and Kakumanu were surveyed in which PU 31, LBG 752, LBG 623 are being cultivated. Age of the crop varied in different fields due to variation in dates of sowing. The crops were approximately 40- 60 DAS (Table 4.1). Since the age of the crop is one of the important factor for occurrence and development of powdery mildew. The results of the survey are presented based on age of the crop as follows.

In 40 days old crop the mean powdery mildew disease incidence was maximum in Kothapalem village (57.76%) of Veticherukuru mandal followed by Kantheru village (46.44%) of Tadikonda mandal and minimum in Bhallupadu village (3.43%) of Kakumanu mandal followed by Vargani village (3.67%) of Pedanandipadu mandal and severity was maximum in Kothapalem (51.32%) followed by Ponnekalu village (37.16%) of Tadikonda mandal and minimum in Bhallupadu (2.35%) followed by Vargani (5.73%) (Table 4.1, Fig.4.2 and Fig.4.3).

In 60 days old crop the mean powdery mildew disease incidence was maximum in Kantheru (87.01%) followed by Kothapalem (83.10%) and minimum in Vargani (21.91%) followed by Bhallupadu (39.94%) and mean per cent disease index (severity) was maximum in Kantheru (88.08%) followed by Kothapalem (83.73%) and minimum in Vargani (19.16%) followed by Bhallupadu (33.56%). (Table 4.1, Fig.4.2 and Fig.4.3). The mean disease incidence was in the range of 3.43% (Bhallupadu village at 40 DAS) to 87.01% (Kantheru village at 60 DAS) and severity was in the range of 2.35% (Bhallupadu village at 40 DAS) to 88.08% (Kantheru village at 60 DAS). Highest mean incidence and mean severity was recorded in Tadikonda mandal (81.83 % and 80.76% respectively) and lowest (42.18% and 37.16%) in Pedanandipadu mandal. The variation in disease at various locations maybe mainly due to cultivated variety, crop age and climatic factors and cultural practices.

Among the weeds spieces associated with *urdbean* fields *viz., Euphorbia geniculate, Convolvulus arvensis, Sida cordifolia, Abutilon indicum, Acalypha indica, Achyranthes aspera, Andrographis paniculata, Crotalaria verrucosa, Celosia argentina, Digera arvensis, Cleome viscosa, Xanthium strumarium* and *Mimosa pudica etc. Euphorbia geniculate* was found infected with powdery mildew disease in all the four mandals.

Findings of Dinesh *et al*. (2010) reported that powdery mildew disease varied in different locations depending on the crop age. Nour (1958) reported that *Euphorbia* spieces were alternate host for powdery mildew infection. Similarly, field bindweed (*Convolvulus arvensis)* is highly susceptible to powdery mildew infection as reported by Karkanis *et al.* (2012).

4.2 SYMPTOMATOLOGY AND MORPHOLOGY OF PATHOGEN

The infected leaf surface, petioles, stem and pods appeared as small, round, whitish, powder-like spots (Plate 3.5). Symptoms first appeared on crown leaves on shaded lower leaves and on leaf under surfaces. These white powdery colonies grew in size and cover both sides of the leaf, petioles and young stems. When disease progressed lower leaves showed and chlorosis, distortion and premature leaf fall due to infection of *E. Polygoni.* Severe infection of inflorescence was found to affect pod setting where as severe infection at later stages showed shrivelled and dried appearance to immature pods. The morphology of *E. polygoni* noted that the fungus produced amphigenous dirty white hyaline mycelium and barrel shaped conidia measuring 1.089 µm × 0.7131 µm at 40 × magnification (Plate 3.6).

4.3. EFFECT OF WEATHER FACTORS AND AGE OF THE CROP ON POWDERY MILDEW SEVERITY

Correlation study was undertaken at Agricultural College, Bapatla to study the relationship between severity of powdery mildew disease with weather parameters and crop age. The mean data on the weather parameters *viz.* maximum temperature (max), minimum temperature (min) (^{0}C), morning relative humidity (RH) (%), evening relative humidity (RH) (%), wind speed (kmph) and rainfall (mm) was recorded from 20 DAS at five days interval upto 65 DAS (Appendix-I) on PU 31 during *rabi* 2015-2016.

The maximum temperature varied from 26.90 ^{0}C to 33.80 ^{0}C, minimum temperature varied from 15.30 ^{0}C to 26.00 ^{0}C. Relative humidity during morning and evening ranged from 87 to 93 per cent and 63 to 89 per cent, respectively (Appendix 1). The disease severity ranged from 0 per cent to 90.85 per cent. (Table 4.2, Fig.4.4)

The severity had a high significant positive correlation with crop age (r = 0.984). and maximum temperature (r = 0.657). Non-significant correlation was observed between severity and rest of the independent variables (Table 4.3).These observations are in agreement with the findings of Thakur and Agarwal (1995); Solanki *et al*., 1999; Yarwood (1957); Bhattacharya and Shukla, 2002; Gupta *et al*., 2002; Gupta and Sharma, 2009 and Kanzaria *et al.,* 2013. The maximum temperature during the period of occurrence of powdery mildew up to last observation on severity was in the range of 30.90^{0}C -33.80^{0}C (Appendix-I) and is well within the favourable range of 28 ^{0}C- 36 ^{0}C for powdery mildew (Delp, 1954; Schnathorst, 1960; Manners *et al*., 1963). Hence, the maximum temperature showed a strong positive influence on powdery mildew severity.

Regression analysis with performed by powdery mildew severity as dependent variable and maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, rainfall, wind speed and crop age as independent variables to find out the best fit multiple regression equation by using the coefficients of determination (R^2).

Stepwise multiple regression analysis was performed using the following equation:

$$y = bo + b_1x_1 + b_2x_2 + b_3x_3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots + b_nx_n$$

where y = per cent disease index, b_o = intercept, b_1, b_2…….b_n = regression coefficient, and x_1, x_2, ……..x_n = independent variables. The results were presented in the Table 4.4

Multiple regression analysis yielded seven distinct equations with R^2 values ranging from 0.991 to 0.412 ($P \leq 0.05$). However, the best fit equation was obtained in maximum temperature, wind speed, RH (8.30 am), minimum temperature as independent variables (equation 4).

Y = -279.80 +10.017 (max temp)*+-35.57(wind speed)*+1.070 (RH morning) +5.5803(min temp)*

N = 10 R^2 = 0.86 F value = 9.29 Standard error = 15.98

* Significant at 5% level

The best fit equation showed 86.6 per cent role of tested independent variables on powdery mildew severity (Table 4.4). Results were in accordance with the reports of earlier workers (Solanki *et al*. 1999; Bhattacharya and Shukla, 2002; Gadre *et al*. 2002; Gupta and Sharma, 2009; Kanzaria *et al*. 2013). Similarly, maximum and minimum temperature were favourable for disease development as reported by earlier findings (Yarwood *et al.* 1957). Wind speed effected an instantaneous dispersal of conidia of *Erysiphe polygoni* which was reported by Hammett & Manners, 1974.

4.4 SCREENING OF BLACKGRAM GENOTYPES AGAINST POWDERY MILDEW

Forty seven blackgram genotypes including check LBG-623 were screened against powdery mildew disease under field conditions during *kharif*, 2015 and eleven genotypes including check LBG-623 during *rabi*, 2015-16. The results indicated that powdery mildew disease severity varied among the genotypes.

4.4.1 Reaction of Blackgram Genotypes against Powdery Mildew

Among the 46 genotypes evaluated with LBG- 623 as check during *kharif*, 2015. One genotype KUP-1 free from disease (0%), two genotypes KUP-40 (9.03%) and KUP-34 (9.73%) were highly resistant (HR), ten genotypes *viz.*, KUP-23 (14.44%), KUP-43 (17.84%), KUP-3 (21.10%), KUP-6 (21.59%), KUP-31 (23.06%), KUP-12 (23.34%), KUP-14 (23.44%), KUP-11 (23.63%), KUP-24 (24.44%) and KUP-36 (24.93%) were moderately resistant (MR). Twenty genotypes *viz.*, KUP-46 (26.90), KUP-16 (32.705), KUP-21 (33.55%), KUP-32 (36.88%), KUP-15 (37.40%), KUP-22 (49.20%), KUP-5 (41.18%), KUP-33 (41.80%), KUP-7 (43.56%), KUP-13 (44.03%), KUP-4 (36.99%), KUP-19 (40.91%), KUP-20 (46.39%), KUP-29 (48.15%), KUP-38 (47.78%), KUP-45 (35.31%), KUP-18 (40.85%), KUP-30 (39.42%), KUP-27 (43.08%), KUP-35 (49.49%) were moderately susceptible (MS), ten genotypes *viz.*, KUP-9 (60.36%), KUP-41(68.12%), KUP-2 (68.26%), KUP-25 (50.75%), KUP-44 (52.46%), KUP-17 (61.90%), KUP-8 (63.97%), KUP-28 (53.13%), KUP-37 (53.81%), KUP-39 (58.00%) and four genotypes *viz.*, KUP-10 (70.23%), KUP-26 (70.36%), KUP-42 (71.55%) and LBG-623 (85.05%) were highly susceptible. (Table 4.5, 4.6).

Powdery mildew severity during *rabi* varied from 8.94 % (RUP-9) to 96.52% (LBG-623). Out of 11 genotypes, none was immune to powdery mildew, two genotypes RUP-9 (8.94 %) and RUP-6 (9.77%) were highly resistant, one RUP-7 (12.78%) was moderately resistant, RUP-4 (45.28%) was moderately susceptible, RUP-1 (60.40%) and RUP-2 (64.98%) were rated as susceptible. The genotypes *viz.*, RUP-5 (71.95%), RUP-3 (75.79%), RUP-8 (78.89%), RUP-10 (82.01%) and LBG-623 (96.52%) were highly susceptible (Table 4.7, 4.8).

Agarwal *et al*. (1989) have reported that out of 85 *Vigna mungo* varieties, LBG17 was found resistant. Kaushal and Singh (1989) reported that out of 48 blackgram genotypes only P115 was found to be resistant. Raguchander *et al*. (2001) reported PDU and IC12/2 exhibited partial resistance and had lowest per cent mildew severity. Prashanthi *et al*. (2010) evaluated fifteen blackgram genotypes during *kharif* 2007 and found LBG-623 and LBG-648 as resistant sources against powdery mildew disease. Akthar *et al*. (2014) screened during *kharif* 2008 and 2009 out of 14 genotypes of blackgram, only three genotypes *viz.*, BS 2-3, IPU 02-43 and B 3-8-8 showed resistant or highly resistant response against powdery mildew. Tirupathiswamy *et al*. (2014) reported that out of three blackgram cultivars, LBG 17 resistant against powdery mildew. Channaveeresh *et al*. (2014) revealed that, out of 126 genotypes screened, three genotypes viz., LBG-17, LBG-685 and LBG-685×VT (F2-F3) were found to be resistant to powdery mildew. Ramakrishnan and Savithramma (2014) during *kharif* 2010 screened 374 entries of greengram, were six genotypes found to be highly resistant.

During *kharif* 2015, KUP-40 showed lowest Area Under Disease Progress Curve value (114.275), KUP-14 showed 467.565, KUP-30 showed 683.41, KUP-17 showed 1016.155 and LBG-623 showed highest 1556.345 AUPDC value. (Table.4.9 and Fig 4.5)

During *rabi* 2015-16, RUP-9 showed lowest AUPDC value (132.45), RUP-7 showed 168.175, RUP-4 showed 525.525, RUP-1 showed 876.715 and LBG-623 showed highest AUPDC value (1268.015). (Table.4.10 and Fig 4.6).

4.4.2 Morphological and Vegatative Characters in Selected Blackgram Genotypes

4.4.2.1 Leaf thickness (µm)

Significantly highest leaf thickness was observed in highly resistant genotypes KUP-34 (201.4 µm), KUP-40 (191.3 µm) and four moderately resistant genotypes KUP-12 (176.2 µm), KUP-6 (173.6 µm), KUP-11 (171.7 µm), KUP-31 (167.3 µm) which were on a par. Two susceptible genotypes KUP-39 (134.8 µm), KUP-25 (135.7 µm) and four moderately susceptible genotypes viz., KUP-27 (138.1 µm), KUP-30 (139.9 µm), KUP-4 (143.1 µm) and KUP-5 (141.8 µm) showed significantly less leaf thickness compared to highly resistant category and were on par. Highly susceptible genotype LBG-623 (107.3 µm) which showed lowest leaf thickness which was on par with one susceptible genotype KUP-37 (118.6 µm). (Table 4.13, Fig 4.7).

High degree of resistance and moderate resistance to powdery mildew in the blackgram genotypes can be attributed to higher leaf thickness. Cuticle thickness in phlox found to be more in resistant genotype Texas 4n than susceptible genotype Oklahoma as reported by Andrew *et al.* (1982). Leaf and cuticular or epidermal thickness have also been associated with powdery mildew resistance (Commenil *et al*., 1997).

4.4.2.2 Stomatal frequency (per mm^2)

Significantly lowest stomatal frequency was observed in highly resistant genotypes KUP-34 (88.64/mm^2), KUP-40 (99.24/mm^2) and were on a par with moderately resistant genotypes KUP-12 (104.55/mm^2), KUP-6 (107.58/mm^2), KUP-11 (106.82/mm^2), KUP-31 (109.09/mm^2) and one moderately susceptible KUP-15 (111.36/mm^2). Three moderately susceptible genotypes KUP-5 (124.24/mm^2), KUP-30 (125.00/mm^2), KUP-27 (126.52/mm^2) and one susceptible genotype KUP-25 (128.79/mm^2) were on a par in their stomatal frequency . Highly susceptible genotype LBG-623 (193.94/mm^2) and one susceptible genotype KUP-37 (184.85/mm^2) were found to have highest stomatal frequency and were on a par. (Table 4.13, Fig. 4.8 and Plate 3.7).

Stomatal frequency was observed to be an important character in determining the resistance in the studied genotypes. Stomata play an important role for powdery mildew infection of comptiable host (Braun *et al.,* 2002). Dhanumjayrao *et al.* (2006) observed high variation in stomatal density in grape genotypes against powdery mildew.

4.4.2.3 Trichome density (5mm diameter disc)

Significantly higher trichome density was observed in highly resistant genotypes KUP-34 (62.33), KUP-40 (59.11) and were on a par with each other. Four moderately resistant genotypes *viz.,* KUP-12 (42.56), KUP-6 (41.11), KUP-11 (36.00), KUP-31 (38.78) and two moderately susceptible genotypes KUP-4 (36.56), KUP-15 (39.44) showed on a par trichome density with that of resistant genotypes. Rest of the moderately susceptible genotypes KUP-18 (34.22), KUP-5 (34.23), KUP-30 (33.89) and KUP-27 (33.33) showed significantly low trichome density and were on a par. The highly susceptible genotype LBG-623 (19.33) was found to possess significantly lowest trichome density and was on par with one susceptible genotype KUP-37 (25.00) (Table 4.13, Fig. 4.9 and Plate 3.8).

In highly resistant and moderately resistant genotypes, the trichome density was found to be significantly highest which implies that trichome density can a morphological character contributing for the resistance of blackgram genotypes to powdery mildew.

Trichomes play an important role by inhibiting penetration of the pathogen into the host plant by keeping the pathogen away from the infection courts (Horsfall and Diamond, 1960). Similarly, Martin and Glover (2007) found that trichomes can act as physical barriers to infection. High frequency of trichomes can also prevent mycelial penetration and infection of other biotrophic fungi (Shalik, 1985). From the work of Kortekamp and Zyprian (1999), it appears that increased number of hydrophobic pubescences may repel water from leaf surfaces thus preventing successful penetration. Alternatively, a high trichome number may simply reduce the frequency of germ tube contact points that can lead penetration (Niks and Rubiales, 2002). The results strongly suggested that morphological characters showed resistance to powdery mildew has existed among genotypes.

4.4.2.4 Growth type

The growth type was recorded as indeterminate in two genotypes (KUP-12, KUP-30) and rest of the genotypes *viz.*, KUP-34, KUP-40, KUP-6, KUP-11, KUP-31, KUP-15, KUP-18, KUP-4, KUP-5, KUP-27, KUP-25, KUP-37, KUP-39 and LBG-623 were determinate which showed non-significant as per chi-square test (Table 4.11, 4.12).

4.4.2.5 Petiole colouration

The genotypes KUP- 12, KUP-6 and KUP-11 showed dark green pigmentation .the genotypes KUP-31 KUP-15 KUP-18 and KUP-30 showed green colour pigmentation KUP-4 and KUP-27 exhibited pigmentation of greenish with purple splashes. The genotypes with pigmentation of petiole showed high degree of resistance to powdery mildew (KUP-34 and KUP-40). The reaction of genotypes with petiole pigmentation of Dark green, Green and greenish with purple splashes were either moderately resistant or moderately susceptible. Light green petioled types were susceptible to highly susceptible to powdery mildew (Table 4.11).

4.4.2.6 Pigmentation of stem

The genotypes having purple pigmentation of stem highly resistance genotypes. to moderately resistant reaction. Whereas genotypes dark green to green colour stem showed moderately susceptible or highly susceptible reaction (Table 4.11).

Davies (2004) emphasized the production of anthocyanins or tannins, quinones and phytomelanins and their involvement in plant defence. Konczak and Zhang (2004) and Wrolstad (2004) reported that certain anthocyanins have demonstrable antiviral, antibacterial and fungicidal activities. Purple pigmentation observed in certain genotypes in present study substantiates earlier reports as they have recorded low powdery mildew incidence than green pigmentation.

4.4.2.7 Days to flowering

Days to flowering among tested genotypes varied between 31-37 and it`s relation to genotype reaction seems to be erratic (Table 4.11).

4.4.3 Studies on Biochemical Variability in Selected Blackgram Genotypes

4.4.3.1 Total Phenols content (mg/100 mg)

Significantly difference in phenol content was observed in between two highly resistant genotypes KUP-34 (0.912 mg/100 mg) and KUP-40 (0.861 mg/100 mg) followed by a moderately resistant genotype KUP-12 (0.678 mg/100 mg). Two moderately resistant genotypes KUP-6 (0.617 mg/100 mg), KUP-11(0.581 mg/100 mg) were on par in their phenol content followed by KUP-31 (0.487 mg/100 mg) and KUP-15 (0.475 mg/100 mg) in its total phenol content. Moderately resistant and moderately susceptible were on a par. KUP-18 (0.448 mg/100 mg) showed on a par phenol content with KUP-31 and KUP-15. KUP-4 (0.44 mg/100 mg) moderately susceptible genotype was on par with its phenol content with that of KUP-18 (0.448 mg/100 mg), KUP-5 (0.381), KUP-30 (0.365 mg/100 mg), KUP-27 (0.358 mg/100 mg) showed on a par total phenol content. Susceptible and highly susceptible genotypes showed lowest phenol content and there are on a par. Overall differential phenol contents was observed among highly resistant and moderately resistant genotypes and moderately susceptible and susceptible genotypes (Table 4.14 and Fig 4.10).

Total phenol content has a role to play in resistance mechanism. Concentration of phenolic compounds was usually higher in resistant genotypes than in susceptible genotypes of different crop plants (Arora and wagle, 1985, Saini *et al*., 1988). Parashar and Sindhan (1986) noted higher content of total phenols in stem and leaf of powdery mildew resistant varieties of pea than susceptible. Kalia and Sharma (1988) found higher levels of phenolics and phenol oxidising enzymes in resistant cultivars of pea (P 185 and P 6583) than susceptible, the correlation between the biochemical parameters and disease index were also high. Hattappa *et al.* (2003) noticed that the biochemical changes in mulberry (*Morus alba*) leaves infected with *Phyllactinia corylea* causing powdery mildew the total chlorophyll, reducing sugar and protein content of mulberry leaves decreased with increased infection by the fungus. Helal *et al.* (1978) reported that the resistance to *E. cichoracearum* in the cucumber variety Poinsettia was due to a high concentration of phenols which hindered infection and a low concentration of sugars prevented establishment of the pathogen in the host tissues.

4.4.3.2 Total soluble sugars

4.4.3.2.1 Total Sugars content (mg/100 mg)

Significantly lowest sugar content was observed in highly resistant genotypes KUP-34 (4.48 mg/100 mg) KUP-40 (4.62 mg/100 mg) and were on a par in their total sugar content with moderately resistant genotypes *viz.*, KUP-12 (4.63 mg/100 mg), KUP-6 (4.65 mg/100 mg), KUP-11 (4.66 mg/100 mg) and KUP-31 (4.74 mg/100 mg). Moderately susceptible genotypes *viz.*, KUP-15 (5.97 mg/100 mg), KUP-18 (5.90 mg/100 mg), KUP-30 (5.96 mg/100 mg), KUP-27 (5.97 mg/100 mg) were on par with susceptible genotypes KUP-25 (6.93 mg/100 mg), KUP-39 (7.01 mg/100 mg), KUP 37 (6.91 mg/100 mg) in their total sugars. Two moderately susceptible genotypes KUP-4 (5.83 mg/100 mg) and KUP-5 (5.84 mg/100 mg) recorded significantly higher sugar content than aforementioned genotypes and insignificant quantity of total sugars between them. Highest total sugar content was observed in highly susceptible genotype LBG-623 (7.39 mg/100 mg) (Table 4.14, Fig.4.11).

Resistance of genotypes was inverse to the total sugar content.

4.4.3.2.2 Reducing sugars content (mg/100 mg)

Highly resistant genotypes KUP-34 (2.39 mg/100 mg) and KUP-40 (2.36 mg/100 mg) did not significantly differ in their reducing sugar content and were on par with moderately resistant genotypes, KUP -12 (2.70 mg/100 mg), KUP -6 (2.67 mg/100 mg), KUP -11 (2.67 mg/100 mg) and KUP-31 (2.82 mg/100 mg) in their reducing sugar contents. Moderately susceptible genotypes *viz.*, KUP-15 (2.89 mg/100 mg) and KUP -18 (2.71 mg/100 mg) observed to have reducing sugar content on par with highly resistant and moderately resistant genotypes. Moderately susceptible genotype KUP-4 (3.01 mg/100 mg) was on a par with moderately resistant genotypes KUP -12 (2.70 mg/100 mg), KUP-6 (2.67 mg/100 mg), KUP-11 (2.67 mg/100 mg), KUP-31(2.82mg/100 mg), KUP-15(2.89 mg/100 mg) and KUP -18 (2.71mg/100 mg). Moderately susceptible genotypes KUP-5 (2.82 mg/100 mg), KUP-30 (2.89 mg/100 mg), KUP-27 (2.96 mg/100 mg) and susceptible genotypes KUP-25 (3.87 mg/100 mg), KUP-39 (4.00 mg/100 mg), KUP-37 (4.05 mg/100 mg) and one highly susceptible genotype LBG-623 (4.10 mg/100 mg) were on par in their reducing sugars content. Highly resistant genotypes showed lowest reducing sugar contents (Table 4.14 and Fig.4.12)

4.4.3.2.3 Non-reducing sugars (mg/100 mg)

Highly resistant genotypes KUP-34 (1.96 mg/100 mg), KUP-40 (2.26 mg/100 mg) observed to have lowest non-reducing sugars, they did not differ significantly in their non-reducing sugar content and were on par with moderately resistant genotypes *viz.*, KUP-12 (1.94 mg/100 mg), KUP-6 (1.64 mg/100 mg), KUP-11 (2.00mg/100 mg) and KUP-31 (1.92 mg/100 mg) in non-reducing sugar content. Moderately susceptible genotypes KUP-15 (3.08 mg/100 mg), KUP-18 (3.19 mg/100 mg), KUP-4 (3.16 mg/100 mg), KUP-5 (3.02 mg/100 mg), KUP-30 (3.07 mg/100 mg), KUP-27 (3.02 mg/100 mg) were on par with susceptible genotypes KUP-25 (3.05 mg/100 mg), KUP-39 (2.91 mg/100 mg), KUP-37 (2.86 mg/100 mg) and also on par with highly susceptible genotypes LBG-623 (3.39 mg/100 mg) for the non-reducing sugar content (Table 4.14 and Fig. 4.13).

Non reducing sugar content in the genotypes showed an inverse relation with resistance to powdery mildew.

Muhammad and Ali (2014) found that incidence of powdery mildew in pea induces changes in reducing sugars, non-reducing sugars, total sugars powdery mildew resistant and susceptible peas genotypes. Dakshayani *et al.* (2005) reported that the susceptible genotypes Chinamung, Pusa Baisakhi and TM-98-50 recorded higher levels of sugars compared to the TARM-18. Parashar and Sindhan (1986) reported that powdery mildew resistant pea varieties (P185 and P388) had higher contents of total phenols in stem and leaf and low concentration of total sugars and reducing sugars, than susceptible varieties. Gawande *et al.* (2002) carried out a biochemical study on reducing, non-reducing and total sugars and found that resistant genotypes had lower total sugars content before and after infection.

Garg and Mandahar (1975) observed that okra leaves infected with powdery mildew *(E. cichoracearum)* had higher reducing sugars content than healthy leaves. Guleria *et al.* (1997) reported the post-infection of powdery mildew decrease the reducing sugar content in the leaves of both resistant (DPP68 and JP71) and susceptible cultivars (Bonneville and Lincoln) in pea.

4.5 TO EVALUATE GROWTH REGULATOR, ANTI-TRANSPARENT AND FUNGICIDES AGAINST POWDERY MILDEW

In a field experiment powdery mildew severity was erratic and non-significant at 35 DAS. Before second spray at 45 DAS the Cycocel @ 50 ppm showed significant reduction in powdery mildew severity (19.45%) compared to other treatments and was on a par with Salicyclic acid @ 30 ppm (20.87%) and T_5-Neem oil @ 1000 ppm (23.18%). However the treatments *viz.*, T_4-Wettable sulphur @ 0.3 W.P (25.77%), and T_3-Myclobutanil @ 0.2 W.P (26.29%), T_6-Kaolin @ (6 %) (25.53%), showed significantly lesser than the severity than in untreated check (33.96%) and were on a par (Table 4.15 and Fig.4.14).

At 55 DAS the lowest severity was recorded in T_3-Myclobutanil @ 0.2 W.P (31.23%) which was on par with T_4-Wettable sulphur @ 0.3 W.P (32.81%) and T_2-Salicyclic acid @ 30 ppm (32.82%). Whereas, treatments T_1- Cycocel @ 50 ppm (35.53%), T_6-Kaolin @ (6 %) (35.03%), T_5-Neem oil @ 1000 ppm (39.80%) were on par at each other. Highest severity was observed in untreated check (57.64%) (Table 4.15 and Fig.4.14).

Mycobutanil showed lowest disease severity as the fungicide interfere with the biosynthesis of fungal sterols inhibit ergosterol biosynthesis. Ergosterol is essential to structure of cell wall and it`s absence causes irreparable damage to the cell wall leading fungal death and also interfere in conidia and haustoria formation. The change in sterol content and saturation of polar fatty acids at alteration in membrane fluidity and behaviour of membrane bound enzymes (Nene and Thapliyal, 1993). Mach and Portele (1884) suggested that sulphur was oxidized to sulphur dioxide and latter compound was toxicant. Wallace *et al.* (1911) also showed that the fungicidal effect of sulphur was due to sulphur dioxide produced by the oxidiation of sulphur in moist air. Doran (1922), however, investigated the role of oxygen in the fungitoxicity of sulphur and showed that the presence of oxygen increased the fungitoxicity of sulphur. Although, cost-benefit ratio was high in Wettable sulphur (1.82) compared to Myclobutanil (1.17), but at 55 DAS after second spray which Myclobutanil showed to be best among the treatments for management of powdery mildew.

4.6 EFFECT OF DIFFERENT CHEMICALS ON VEGETATIVE CHARACTERS *URDBEAN* POWDERY MILDEW

4.6.1 Number of Primary Branches per plant

The treatments had a significant effect on the number of primary branches/plant with the maximum (12.66) in Myclobutanil and minimum (9.43) in unsprayed check. The treatments, Wettable sulphur, Salicyclic acid, Cycocel were on par with Neem oil. Kaolin was on par with unsprayed check. All treatments except Kaolin were showed significantly more number of primary branches per plant than check. Myclobutanil treatment increased the primary branches number by 25.51% than unsprayed check (Table 4.16 and Fig 4.15a).

4.6.2 Number of Pods per plant

The highest number of pods per plant was observed in plants which received Myclobutanil treatment (13.01) which was 27.20 % more than in unsprayed check (9.47) and was significantly higher than that recorded in other treatments. Wettable sulphur, Neem oil, Salicylic acid were on par with each other. Cycocel and Kaolin were on a par with unsprayed check (Table 4.16 and Fig 4.15b).

4.6.3 Seed yield (Q/ha)

The seed number per pod varied from 4.42 (unsprayed check) to 5.59 (Myclobutanil). Unsprayed check (4.42 q/ha) showed significantly superior over all treatments. Wettable sulphur (5.31 q/ha) seeds per pod followed by Salicyclic acid (5.20 q/ha), Kaolin (5.36 q/ha) and Cycocel (5.23 q/ha), all of them being on a par with Neem oil (5.02 q/ha). Myclobutanil recorded as highest seed yield (5.59 q/ha). Increase in seed number over control in Myclobutanil treatment was 20.93% followed by Kaolin (17.53%) were higher than the unsprayed check (Table 4.17 and Fig 4.16a).

4.6.4 No of seeds per pod

The highest yield was obtained with Myclobutanil (8.96) which was 31.80% more than unsprayed check (6.11) but was on a par with the yield in Salicyclic acid (8.73), Wettable sulphur (8.64) and Neem oil (8.63). Kaolin showed significant (7.40). Cycocel (6.57) was on a par with untreated check (6.11) (Table 4.17 and Fig 4.16b).

Yield reduction in infected plants than the corresponding healthy plants was highest in unsprayed check and lowest in Myclobutanil which suggests that the treatments were effective not only in significantly decreasing powdery mildew severity but also in growth promotion and thereby yield enhancement.

4.6.5 100 Seed weight (g)

Highest seed weight was obtained in Myclobutanil (4.62 g) followed by Salicyclic acid (4.40 g) and were on a par for their 100 seed weight. While other treatments, Wettable sulphur (3.63 g) and Cycocel (3.62 g) were on apar. Neem oil (3.34 g) and Kaolin (3.50 g) on a par with each other, respectively (Table 4.18 and Fig 4.17).

The Myclobutanil and other treatments particularly Salicyclic acid could substantially reduce disease severity and consequently increased growth and yield of blackgram. The increase in growth and yield might be due to their beneficial effects on plant metabolism coupled with their effect on disease reduction.

4.6.6 B:C ratio

Benefit cost ratio (B:C) of the treatments was calculated by using the average yields of *urdbean* crop during *rabi*, 2015-16 and presented in the Table 4.19. The highest B:C of 1.82 was obtained for Wettable sulphur @ 0.3 % W.P spraying at 35 and 45 DAS followed by 1.29 (Salicyclic acid @ 30 ppm), 1.17 (Myclobutanil @ 0.2 % W.P), 1.09 (Neem oil @ 1000 ppm), 0.87 (Cycocel @ 50 ppm), 0.71 (Kaolin 6%) and 0.30 (Unsprayed check) (Table 4.19).

Chapter II

REVIEW OF LITERATURE

The review of literature on "Studies on powdery mildew of *urdbean* in relation to weather, host plant resistance and management" and also the literature relevant to the present investigation is presented in this chapter.

2.1. HISTORY AND DISTRIBUTION OF THE DISEASE

Powdery mildew has long been known as important disease of plants in all parts of world. Linnaeus (1767) established a genus *Erysiphe*. De Condolle (1802) described many species of the genus. Powdery mildew caused by *Erysiphe polygoni* D C a wide spread plant diseases that are conspicuous by their superficial white mycelia and powder-like conidia (Yarwood, 1957; Kiss and Szentivanyi, 2001). They are mostly host-specific, ranging from a single species to a family of plants, and are obligate parasites that cannot survive without their host plant. It was reported from Bangladesh, Brazil, Colombia, Conga, Costa rica, Egypt, Ethiopia, Guatemala, India, Israel, Jamaica, Kenya, Lebanon, Malawi, Mauritius, Mexico, Mozambique, Myanmar, Nepal, New south wales, Pakistan, Peru, Queensland, New Caledonia, South Africa, Sri Lanka, Tanazania, USA, Venuzuela, Zaire, Zambia, Zambabwe (Harika, 1996). In India, the disease is present in almost all states of the country (Prakash and Raoof, 1994).

2.2. IMPORTANCE OF THE DISEASE

Several reports have been published on yield loss due to powdery mildew in pulses. Powdery mildew can decrease plant canopy, reduce yields through decreased fruit size and number of fruits per plant, and reduce fruit quality, flavour and storage life (Donald, 2008; Keinath and Du Bose, 2004; McGrath and Thomas, 1996).

Rathi *et al.* (2002) found that more than 60 per cent powdery mildew disease intensity significantly reduced the number of pods per plant, number of seeds per pod and test weight in blackgram. Grewal (1988) reported reduction in the yield of green gram and black gram in many states of India due to powdery mildew. The existence of negative correlation between grain yield and powdery mildew resistance in pea (Munjal *et al.*,1963).

Tantanapornkul *et al.* (2005) found that powdery mildew reduced yield, seed weight per plant, seeds per plant, pods per plant and seed size on *mungbean* genotypes and it was also found that the disease caused the reduction of seed germination, seedling vigor and weight of bean sprout and became severe in dry season (Fondevilla and Rubiales, 2011).

2.3 SYMPTOMS AND MORPHOLOGY OF THE PATHOGEN

Yarwood (1957) reported stunting, distortion and premature leaf fall due to the infection of *E. polygoni* causing powdery mildew disease in pulses. Senugupta (1974) observed smaller and chlorotic leaves of pea due to infection of powdery mildew, severe infection gave shrivelled and dried appearance to immature pods.

Symptoms appear first on crown leaves, on shaded lower leaves and on leaf under surfaces. These white, powdery colonies grow in size and cover both sides of the leaf, petioles and young stems (Howard *et al.,* 1994).The disease is noted with appearance of small, round, whitish, powder-like spots on leaf surfaces, petioles and stems (McGrath and Thomas, 1996).

Hans and Boeswinkel (1980) measured conidial size of *E. polygoni* infecting green gram as 38.4×14×3µm and that of black gram 37×19µm. Conidia were single celled, oval to roundish or barrel-shaped, hyaline, without fibrosin bodies and 25-40 x 15-25 µm in diameter. Conidia formed singly at the apex of conidiophores, hyaline, morphologically distinguished primary conidia roughly lanceolate, usually apically pointed, 30-80 x 9-28 mm and secondary conidia roughly ellipsoid to cylindrical, sometimes somewhat irregular, rounded or truncate at the apex, not pointed, approximately the same size like the primary conidia (Braun, 1987a). Raut *et al.* (1986) recorded powdery mildew of *E. polygoni* on stem and leaves of green gram and blackgram at flowering. Severe infection of inflorescence was found to affect pod setting, adversely Bharat (2013).

2.4 SURVEY

Survey conducted in *rabi* 1997-98 in rice fallows revealed that the powdery mildew of black gram was prevalent in all major black gram growing areas in Guntur district of Andhra Pradesh (Kumar *et al*., 1999).

Sharmila *et al.* (2006) survey in four districts of Kashmir valley revealed that incidence and severity of the powdery mildew disease on some plants of family Papilionaceae such as *Phaseolus aconitifolis, P. aureus, P. vulgaris, Pisum sativum* and *Robina pseudoaccacia* showed moderate to mild infection in different localities of Kupwara and Baramulla whereas *P. aconitifolis, P. aurens, P. vulgaris* and *P. sativum* showed mild infection in different localities of district Kupwara, Baramulla, Srinagar and Anantnag.

Dinesh *et al.* (2010) surveyed on sunflower powdery mildew during 2008-09 revealed that, the disease was noticed in varying intensities in seven districts. Maximum PDI was noticed in Hanumanala village (98.00%) of Gangavati taluka followed by Budugumpa village (84.00%) of Koppal taluka.

Mir *et al.* (2011) carried out survey on chilli powdery mildew in three districts, Dharwad district had maximum severity of powdery mildew (80.69%), followed by Haveri district (43.98%) and least severity in Belgaum district (20%).

Illahi *et al.* (2011) Survey revealed that the powdery mildew on apple was prevalent throughout the Kashmir valley. Its incidence started during August with disease incidence (DI) and percent disease index (PDI) of 3.47 and 1.04, respectively, reached peak in the month of October with DI and PDI of 5.71 and 2.15, respectively. The powdery mildew incidence was least (5.4%) on Chinese white at Baramulla and was maximum (41.57%) on Goshoerami at Pampore. Irrespective of the mulberry varieties the incidence ranged from 18.47 per cent (Baramulla) to 29.35 per cent (Pampore). Irrespective of locations, it ranged from 9.71 (KNG) to 35.39 per cent (Tr-10).

Kumar *et al.* (2013) surveyed in *kharif* 2012 and revealed the prevalence of powdery mildew on green gram in all green gram growing parts of Northern Karnataka. Survey carried out on severity of sunflower powdery mildew in different districts of northern Karnataka during 2008-09 showed that maximum mean per cent disease severity (PDI) was observed in Koppal district (74.11%) followed by Haveri district (66.61%). Whereas, minimum PDI was noticed in Bagalkot district (30.94%) followed by Belgaum district (34.11%) (Dinesh *et al.*, 2010).

Rehab *et al.* (2014) survey on mango powdery mildew disease during seasons 2011 and 2012 in Sharkeya, Behera, Ismailia and Giza as well as Noubareya district has revealed highest disease severity was observed in Ismailia being (46.6%) and the lowest in Giza (23.6%).

Roving survey was conducted in *kharif* 2011 on green gram in four districts of Karnataka. The maximum disease severity of powdery mildew (75.32%) was noticed in Dharwad district where as minimum disease severity in Belgum, Baglkot and Gulbarga districts (Veena *et al.*, 2014).

Sreeramulu and Kondaiah, 2014 surveyed on fungal diseased crops in Cuddapah district of Andhra Pradesh in varied regions of 51 mandals among them Koduru showed highest disease severity.

Kumar *et al.* (2014) Surveys in northern Karnataka districts during *rabi* of 2009-2012 revealed that during *rabi* of 2009-10 mean disease incidence was maximum in Raichur district (57.5%) followed by Bidar (56%) and Gulbarga (52%). During *rabi* of 2010-11 mean disease incidence was maximum in Raichur district (46.25%) followed by Bidar (42%) and during *rabi* 2011-2012 mean disease incidence was maximum in Raichur district (93.5%) followed by Bidar (25%) and Bijapur (16.33%).

2.5 EFFECT OF WEATHER FACTORS ON POWDERY MILDEW SEVERITY

Deshpande and Dake (1978) noticed the epidemics of Eysiphales at 25^0C temperature. Soria and Quebral (1973) noted highest incidence of *E. polygoni* on pea in Janurary when monthly mean temperature, RH, wind velocity, and total rainfall were 25.6^0C, 85%, 1.8 kmph and 1.61 inches respectively.

Kunkalikar and Padagnur (1991) reported that the occurrence of powdery mildew on *mungbean* minimum mean temperature of 20 ^{0}C and RH of 82.5 to 83.5% were essential.

Saxena and Saxena (1991) studied powdery mildew of *mungbean* caused by *E. polygoni* and found positive correlation of disease intensity with maximum temperature but the correlation with relative humidity and rainfall were negative.

Mittal and Sharma (1992) studied the development and spread of powdery mildew of green gram and black gram in the Kumaon hills of India and observed the disease appearance at 90 days after sowing when the crops were in post flowering and pod formation stages. During this period average maximum and minimum temperature (28.8 ^{0}C &17.2 ^{0}C), RH above 75% and weekly rainfall 5.8 spread over 1-2 days.

Raguchander and Rajappan (1995) observed lower incidence of *E. polygoni* in July sown *Vigna mungo* crop than those sown in August-January, high RH, low maximum and minimum temperature and low rainfall favoured severe incidence of powdery mildew.

Thakur and Agarwal (1995) reported severe appearance of powdery mildew in 33 varieties of greengram and 18 vareities of blackgram during winter seasons with most rapid development when temperature varied from 27.2 to 30.30^{o}C, relative humidity from 67 to 90 per cent during morning and 12 to 38% at noon and wind velocity from 2.3 to 4.1 km hr^{-1}. A positive correlation was observed between powdery mildew severity with temperature and wind velocity, but the correlation with relative humidity was non-significant, except in a few varieties.

Bhattacharya and Shukla (2002) found that maximum temperature, sunshine duration has positive effect on powdery mildew severity whereas relative humidity was negative under both irrigated and rainfed conditions.

2.6. REACTION OF HOST GENOTYPES TO POWDERY MILDEW INFECTION (Host Plant Resistance)

Among various strategies to manage the diseases, cultivation of resistant varieties is an eco-friendly, practically feasible and economically viable method. In recent past many resistant varieties have been developed against the powdery mildew by various workers.

Agarwal *et al*. (1989) reported that out of 170 *Vigna radiata* and 85 *Vigna mungo* varieties screened for resistance to *E. polygoni* ML 223 and ML395 were found to be most resistant to *mungbean* and LBG17 was found to be the most resistant blackgram variety. Kaushal and Singh (1989) reported that out of 48 blackgram accessions evaluated at the seedling stage for resistance to 636 various isolates of pathogen only P115 was found to be resistant to *E. polygoni*.

According to Patil *et al*. (1989) Out of 40 cultivars of greengram evaluated under field conditions with natural infection of *E. polygoni* only one (B.G.G.-1) was moderately resistant, two moderately susceptible and remaining highly susceptible.

Prashanthi *et al*. (2010) evaluated fifteen blackgram genotypes and found LBG-623 and LBG-648 as resistant sources against powdery mildew disease.

Sixty five genotypes were screened against the powdery mildew of *mungbean* during *kharif* 2011-2012 at Anand, among them one genotype LGG-460 was found resistant, while PDM-288, IPM-02-1, GM-9926, TMV-37, SAPTARI LOCAL, GM - 02-21, GM - 03-06, GM - 03-08, GM - 03-15 and GM - 03-16 moderately resistant, however rests of the genotypes moderately susceptible to susceptible (Yadav *et al*., 2014).

Field screening was conducted during *kharif,* 2008 and 2009 revealed that out of 31 genotypes of greengram, only genotype ML1299 and out of 14 genotypes of blackgram, only 3 genotypes *viz.,* BS2-3, IPU02-43 and B3-88 showed resistant or highly resistant response of multiple diseases including cercospora leaf spot, web blight and powdery mildew (Akthar *et al.,* 2014).

Seventy diverse genotypes of mungbean were evaluated against powdery mildew in field under natural epiphytotic conditions during *rabi* 2009-10 and *kharif* 2010 seasons. During *rabi* season two genotypes *i.e*. Pragya and TARM-1 were found to be highly resistant against powdery mildew disease, eight genotypes were resistant, twelve genotypes were moderately resistant, twenty genotypes were moderately susceptible, twenty genotypes were susceptible and eight genotypes were highly susceptible with Location severity index (LSI) of 3.03.(Nair *et al*., 2015).

Nidhi *et al* (2015) screened 51 mungbean genotypes. Out of which, TM 96-2 were found to be highly resistance, nine are resistant , five as moderate resistance, 16 as susceptible and 20 highly susceptible for powdery mildew reaction.

Tirupathiswamy *et al.* (2014) reported that out of three blackgram cultivars evaluated nethiminimu, chikkuduminimu were susceptible and LBG 17 was resistant against powdery mildew.

Ramakrishnan and Savithramma (2014) screened 374 entries of greengram under natural environmental conditions against powdery mildew disease and categorized six entries as highly resistant, 68 resistant, 47 moderately resistant, 50 moderately susceptible, 99 susceptible and 104 highly susceptible

Upadhyay and Singh (1994) reported that, out of 50 genotypes of pea tested in field, none was found completely free from *E. polygoni* but T 10, BHU 456, HFP 4, P185, NDP 1, and P 6583 were classified as resistant HUP 2, JP 4, PRS8 and HFP 12 as moderately resistant and 21 as tolerant.

According to Sharma (1991) out of 200 pea varieties scored for resistance against *E. polygoni* only 14 entries showed strong resistance under both natural and artificial conditions, while 13 found to be moderately resistant. Kumar and Rangaswamy (1993) studies on pea powdery mildew revealed the area under disease progress curve values by gompit and logit growth rates for 22 varieties, the genotypes KPMR 155, KFPD 7, KFPD 8, KMPR 157, showed low AUPD values and therefore, low incidence of powdery mildew.

Bisht *et al.* (1991) evaluated field reactions of 2287 germplasm collections of *Vigna radiata* for natural infections of *Cercospora* spp., *E. polygoni* and *Xanthomonas compestris*. pv. *Phaesoli*, 31 lines showed multiple disease resistance.

Hartman *et al.* (1993) reported that out of accessories of global green gram collection screened for the resistance to *C. canescens* and *E. polygoni*, few lines were highly resistant to powdery mildew over years, but others were moderately resistant or susceptible in other years. According to Lakshmipathi *et al.* (1993), out of 45 *Vigna radiata* genotypes tested in field and in glass house, for their reaction to powdery mildew, the disease severity on one genotype ML3 was moderate, 30 genotypes were susceptible and 14 were highly susceptible.

Patil and Moghe (1993) screened ten varieties of green gram and blackgram varieties for resistance to *E. polygoni* and found four varieties of green gram and four varieties of blackgram highly resistant. Pawar *et al.* (1995) reported that out of 50 greengram cultivars screened against powdery mildew only TARM 18 was found to be completely resistant but none of the cultivars showed resistant, but some cultivars were found to be less susceptible than other disease.

According Venu *et al.* (1997) among 72 *mungbean* germplasm lines screened for powdery mildew resistance under field condition, JRUM1, WGG 46, WGG 47, WGG 48, WGG 62, TARM 1, TARM 2 and TARM 22 showed complete resistance. According to Thakur and Verma (1998) among 70 cultivars of pea screened, HFP-6 was highly resistant to *E. polygoni* and is the only one suitable for use in breeding programme under conditions in hilly areas of Himachal Pradesh.

Malhotra and Singh (2000) evaluated 51 pea genotypes for resistance against powdery mildew under both natural and artificial epiphytotic conditions and observed that VG-1 as highly resistant, nine genotypes, *viz.*, HPPC 16, HPCC 77, HPCC 95, Rachana, Pant P-9, PH-1, JP 514-A, VG-9 and Sugar Giant, as resistant.

Ninety genotypes of field pea were tested against powdery mildew under natural epiphytotic conditions. The genotypes *viz.*, FP-208, HFP0-212, FP-216, HFP-221, FP-415, FP-405, FP-420, Jayanthi and Ultra showed minimum disease index, hence it can be used as resistant donor in future breeding programs (Kumar *et al.*, 2007)**.** 32 genotypes of field pea were evaluated for resistant to powdery mildew. JP885, Shubhra, Rachna, Pant P 31, HFP0 129 and Ambika was found high yielder and resistant to powdery mildew were RPF4, Pant p 31 and HFP0219 (Poonam *et al*., 2013).

Rehman *et al.* (2014) screened ten advanced lines of peas among them 018337, 019309, 026721, 018398 and 018395 were found moderately resistant against powdery mildew of pea and 026700, 026703 and 026719 gave a moderately susceptible ones and PFP-400 were found to be susceptible. Cutivar meteor found to be highly susceptible to powdery mildew.

Kannaiyan *et al.* (1987) reported that out of 140 cowpea lines screened to *E. polygoni* only five were found to be moderately resistant. Kuo *et al.* (1988) found that Taichung 12 bred from Taichung 11× manoa sugar has good resistance to *E. polygoni* infecting pea. Kamalesh *et al.* (1991) research findings revealed that out of 85 pea cultivars tested for resistance to *E. polygoni*, 11 were resistant, 18 were moderately resistant and 56 were susceptible or highly susceptible.

Raju and Kumar (1990) reported that out of 22 cowpea lines tested under greenhouse condition for resistance to powdery mildew, APC lines 68, 585, 809 and 708 exhibited partial resistance while APC 703 highly resistance. Findings of Raju and Kumar (1991) revealed that out of 20 germplasm lines of cowpea, evaluated for their resistance to *E. polygoni* under greenhouse condition APC lines no 59, 282,489, 610 and 1244 exhibited partial resistance whereas, APC No. 43 was susceptible.

2.7. MORPHOLOGICAL CHARACTERS FOR DISEASE RESISTANCE

Among morphological characters, aspects of stomata, cuticle and trichome morphology can influence disease resistance **(**Niks and Rubiales, 2002).

2.7.1 Leaf Thickness

Leaf and cuticular or epidermal thicknesses had been associated with powdery mildew resistance (Commenil *et al.,* 1997). Which showed a positive correlation of cuticle thickness of various grape cultivars resistance to powdery mildew (Heintz and Blaich, 1990). Gabler *et al.* (2003) revealed that the mechanical obstacles of epidermal thickness deposition could readily be bypassed during haustorial penetration when the surface porosity of the leaves is high.

2.7.2 Stomatal Frequency and Trichome Density

Braun (1987b) revealed that some lines in the mildew-susceptible germplasm of mulberry of which RFS-135, Mother graft, Shrim-5 and Mizuzawa) have a smaller stomatal density, the number of stomata per unit area of leaf surface and stomatal index were positively correlated with powdery mildew resistance.

Eighty per cent of the resistant germplasm were characterized by high trichome densities and a high stomatal density and stomatal index. There are some significant genotypic effects of stomatal frequency on penetration by powdery mildew pathogens (Lima *et al.*, 2010).

Chattopadhyay *et al.* (2011) Evaluated 30 lines of mulberry with contrasting susceptibilities to powdery mildew (15 resistant and 15 susceptible), susceptible genotypes showed significant more stomatal index, stomatal area and less trichome density. Whereas, resistant group was distinguished by 17.4 % lower stomatal density, 12.5% smaller stomatal index per unit leaf area, 20.0 % greater trichome density and 18.0% higher stomatal area compared with the susceptible group. Trichome density was negatively correlated with disease severity index and with the accumulative area under disease progression curves (AUPDC).

Georgiev *et al.* (2013) found positive relation between the degree of pubescence and resistance to powdery mildew under natural conditions.

2.8. BIOCHEMICAL CHARACTERS FOR DISEASE RESISTANCE

Involvement of phenolic compounds in many aspects of plant parasite relationship other than plant protection has been reported by Friend in 1979. The role of phenolics in the resistance mechanisms in plants has been reviewed by several workers (Allen, 1959; Richard and Roger 1994; Lattanzio, 2006; Agrios, 2005; Gogoi, 2001). Concentration of phenolic compounds was usually higher in resistant genotypes than in susceptible genotypes of different crop plants (Arora and Wagle, 1985 and Saini *et al*., 1988).

Garg and Mandahar (1975) observed that okra leaves infected with powdery mildew *(E. cichoracearum)* had higher reducing sugars content than healthy leaves. Helal *et al.* (1978) reported that the resistance to *E. cichoracearum* in the cucumber variety Poinsettia was due to a high concentration of phenols which hindered infection and a low concentration of sugars prevented establishment of the pathogen in the host tissues.

Guleria *et al.* (1997) reported the post-infection decrease the reducing sugar content in the leaves of both resistant (DPP68 and JP71) and susceptible cultivars (Bonneville and Lincoln) of pea against powdery mildew.

Sridhan and Parashar (1984) found higher content of total phenols, O-dihydric phenols, P, K, Zn, and Cu but lower of N, Mn, and Fe in the foliage of resistant and moderately resistant varieties of pea compared to susceptible. Parashar and Sindhan (1986) noted higher content of total phenols and Orthodihydro-phenols and lower of total sugars and reducing sugars in stem and leaf of powdery mildew of resistant varieties of pea than susceptible.

Kalia and Sharma (1988) found higher levels of phenolics and phenol oxidising enzymes in resistant cultivars of pea (P 185 and P 6583) than susceptible cultivars, the correlation between the biochemical parameters and disease index were also high.

Gawande *et al.* (2002) carried out biochemical study on reducing, non-reducing and total sugars and total phenols before and after powdery mildew infection in seven *mungbean* genotypes found that resistant genotypes had higher total phenols before and after infection. The total phenols were positively correlated with resistance. Whereas, sugars were negatively associated with disease resistance.

Avtar *et al.* (2003) observed higher levels of total phenols in resistant genotypes (NLM and HM 350) than susceptible (T8 and HM 65) fenugreek genotypes before and after the appearance of powdery mildew (*E. polygoni*) in artificially inoculated and natural environments.

Dakshayani *et al.* (2005) reported that the susceptible genotypes Chinamung, Pusa Baisakhi and TM-98-50 recorded higher levels of sugars compared to the TARM-18.

Muhammad and Ali (2014) found that incidence of powdery mildew in pea induces changes in reducing sugars, non-reducing sugars, total sugars powdery mildew resistant and susceptibility of peas genotypes.

2.9 MANAGEMENT OF DISEASE

2.9.1 Systemic Acquired Resistance (SAR) and Powdery Mildew disease Management

Systemic acquired resistance (SAR) is a mechanism of induced defence that confers long lasting protection against a broad spectrum of microorganisms. SAR requires the signal molecule salicylic acid (SA) and is associated with accumulation of pathogenesis-related proteins, which are thought to contribute to resistance. It is well established that resistance to pathogens and the production of some PR proteins in plants can be induced by SA or acetylsalicylic acid, even in the absence of pathogenic organisms.

Application of salicylic acid on *mungbean* was found to increase pod number and grain yield (Singh and Kaur, 1980).

Besser *et al.* (2000**)** stated that salicyclic acid and it is synthetic mimics 2,6-dichloroisonictonic acid (DCINA) and benzothiadiazole (BTH) protect barley against powdery mildew.

Kardy *et al.* (2011) reported that $KHPO_4$ and Salicyclic acid proved to be best inducer treatments, in increasing yield components over control on alfalfa plants against fungal diseases.

Salicyclic acid and acetyl salicyclic acid at 50ppm was most effective in reducing the powdery mildew incidence (6.10% & 7.55%) and recorded maximum blackgram pod yield and minimum disease as compared to test fungicide and untreated control (Parthasarathy and Jaiganesh, 2015).

2.9.2. Effect of Growth Regulator and Anti-Transparent on Powdery Mildew Disease Management

Glenn *et al.* (2001) conducted an experiment during 1997 to 1999 found that the kaolin-based particle film reduced the incidence and severity of apple (*Malus domestica* Borkh.) diseases. Antitransparent flims reduced the incidence of powdery mildew on wheat and barley (Ziv and Frederiksen, 1983, 1986).

Application of cycocel @ 500ppm resulted in reduction of plant height, increased dry matter production, leaf area index, net assimilation rate and number of flowers per plant in soybean (Singh and Sarkar, 1976).

Hill (2004) conducted an experiment to find the effects of plant growth regulator on powdery mildew severity on *Phlox paniculata* 'Blue Boy' and *Rudbeckia hirta* 'Indian Summer' during Spring 2004, in which the Cycocel (chlormequat) 4000 $mg \cdot L^{-1}$ showed significantly lower powdery mildew severity.

Lalancette *et al.* (2005) found that application of kaolin significantly delayed fruit maturation, increased fruit size, increased fruit number and yield on young trees.

Nofal *et al.* (2006) reported that Alphonso and Seddek varieties naturally infected by powdery mildew, kaolin applied at 15 days intervals effectively controlled *Odium mangiferae* on blossom clusters and fruit set. Kshirsagar *et al.* (2008) found that the effect of growth regulator *i.e.* cycocel @ 25, 50, 75, 100, 125, 150, 175 ppm and observed that there was increase in number of nodules and number of lateral branches in greengram plant.

2.9.3 Effect of Fungicides and Powdery Mildew Disease Management

Das and Naraian (1990) found that spraying with Bavistin, Topsin M, Karathane, derosal and Wettable sulphur significantly controlled the powdery mildew of greengram. A single spray of 0.4 per Sulphex gave highest cost benefit ratio of 3.3.

Rathore and Rathore (1995) conducted a field trial to control powdery mildew (*E. polygoni*) of fenugreek using fungicides and host resistance. Triadimefon (0.1%) and Sulphur dust (25 kg/ha) were most effective against the disease and recorded significantly increased yields over the control plots.

Singh and Singh (1983) observed reduction in powdery mildew in pea when sprayed with neem oil at 2 per cent concentration. Rettinasasababady *et al.,* (2000) stated that neem oil is used to control the powdery mildew disease with 74.50 per cent**.** Moharam and Ali (2014) showed that neem oil was most effective against powdery mildew disease in okra with decrease in the disease severity up to 29.92% resulting in improved plant growth and yield.

The efficacy of Sulphur (Kumulus S) and Mycobutanil (nova 40W) fungicides for control of powdery mildew in field pea two locations in Manitoba in 1994 and 1995. Both fungicides were effective in reducing disease severity and increasing seed yield and seed weight of the susceptible cultivar Radley (Warkentin *et al*., 1996).

Bhardwaj and Shayam (1993) found that Wettable sulphur as Sulphex and Carbendazim as Bavistin in combination with NPK fertilizers resulted maximum pod yield. Sulphur was superior to carbendazim in controlling of *E. polygoni* in pea spray when at seven days interval resulted better control than at 15 days intervals.

Khunti *et al*. (2002) reported that fungicides Hexaconzole and Tridemorph were most effective in reducing powdery mildew of *mungbean*. Sulphur, Propioconzole and Carbendizam were found to be moderately effective management of powdery mildew and cercospora leaf spot of *mungbean* by some systemic fungicides.

A field experiment was conducted (2007-2010) to investigate the efficacy of six fungicides, Tridemefon, Fenarimirol, Flusilazole, Penconzole, Wettable sulphur and Dinocap and control against powdery mildew. Among them, Flusilazole was found most effective in reducing the disease (6.26%) and followed by Wettable sulphur (14.20%) (Sharma *et al.,* 2012).

Dinesh *et al.* (2009) noted that Azadiractin was found to be the best botanical which recorded least disease incidence of 25.78 per cent which was on par with NSKE (27.56%) followed by lantana leaf extract (35.11%) followed by turmeric leaf extract (37.78%).

Jayasekhar and Ebenezar (2016) revealed that maximum reduction of disease incidence was recorded in Wettable sulphur 0.25% (15.80%) followed by Carbendazim 0.1% (58.91%) and castor oil 1% with *Ampelomyces quisqualis* (48.53%) on blackgram.

Chapter V

SUMMARY AND CONCULSIONS

Powdery mildew disease causing considerable loss annually and is major menace to *urdbean*. Considering the importance of *urdbean* crop and negative impact of powdery mildew disease the present investigation "Studies on powdery mildew disease of *urdbean* (*Vigna mungo* (L.) Hepper)" was envisaged to evolve a holistic, eco-friendly and cost effective control measures during 2015-16 in the Agricultural College, Bapatla, Guntur district, Andhra Pradesh.

A roving survey was undertaken on the incidence and severity of powdery mildew disease during *rabi* 2015-16 in Guntur district of Andhra Pradesh. Disease incidence and severity of powdery mildew were surveyed in villages of Tadikonda, Veticherukuru, Pedanandipadu and Kakumanu mandals of Guntur district. Incidence was ranged from of 13.69% (Pedanandipadu mandal) to 87.01 % (Tadikonda mandal) incidence & severity were ranged from 11.61(Kakumanu mandal) to 88.08% (Tadikonda mandal), respectively.

Correlation studies with weather parameters and crop age on powdery mildew disease severity revealed that positive correlation of disease was recorded with crop age and maximum temperature. Multiple regression analysis yielded seven distinct equations with R^2 values ranging from 0.991 to 0.412 ($P \leq 0.05$). However, the best fit equation was obtained in maximum temperature, wind speed, RH (8.30 am), Minimum temperature as independent variables showed 86.6 per cent role of tested independent variables on powdery mildew severity.

During *kharif*, forty seven genotypes including check screened against powdery mildew diseases under field conditions with LBG 623 as susceptible check showed varied per cent severity. Out of 47 genotypes, KUP-1 was immune, two genotypes KUP-30 and KUP-40 were highly resistant, and ten were moderately resistant respectively to powdery mildew, whereas, the rest of the genotypes were moderately susceptible to highly susceptible. In *rabi*, out of eleven genotypes, RUP-6 and RUP-9 were highy resistant against to powdery mildew disease, RUP-7 moderately resistant, RUP-4 moderately susceptible, other seven genotypes were highly susceptible.

Among selected blackgram genotypes, significantly highest leaf thickness was observed in highly resistant genotypes KUP-34 (201.4 µm), KUP-40 (191.3 µm). Highly susceptible genotype LBG-623 (107.3 µm) which showed lowest leaf thickness which was on par with one susceptible genotype KUP-37 (118.6 µm). Significantly lowest stomatal frequency was observed in highly resistant genotypes KUP-34 (88.64/mm^2), KUP-40 (99.24/mm^2). Highly susceptible genotype LBG-623 (193.94/mm^2) and one susceptible genotype KUP-37 (184.85/mm^2) were found to have highest stomatal frequency. Significantly higher trichome density was observed in highly resistant genotypes KUP-34 (62.33), KUP-40 (59.11) and were on a par with each other. The highly susceptible genotype LBG-623 (19.33) was found to possess significantly lowest trichome density.

Significantly higher phenol content was observed in highly resistant genotypes KUP-34 (0.912 mg/100 mg) and KUP-40 (0.861 mg/100 mg) and one moderately resistant genotype KUP-12 (0.678 mg/100 mg). Highly susceptible genotype LBG-623 recorded the lowest total phenol content (0.299 mg/100 mg).

Significantly lowest sugar content was observed in highly resistant genotypes KUP-34 (4.48 mg/100 mg) KUP-40 (4.62 mg/100 mg) and were on a par. Highest total sugar content was observed in highly susceptible genotype LBG-623 (7.39 mg/100 mg). Highly resistant genotypes KUP-34 (2.39 mg/100 mg) and KUP-40 (2.36 mg/100 mg) showed lowest reducing sugars and there on a par. Highly resistant genotypes KUP-34 (1.96 mg/100 mg), KUP-40 (2.26 mg/100 mg) showed observed to have lowest non reducing sugars, they did not differ significantly in their non-reducing sugar content.

In field evaluation of different chemicals, two sprays of Myclobutanil @ 0.2 W.P, Wettable sulphur @ 0.3 W.P at 35 and 45 DAS found superior as they recorded the lowest severity at 55 DAS with 31.23% and 32.81% respectively. did not Significant increase in shoot length, number of primary branches per plant, number of pods per plant, 100 seed weight, seed yield was recorded with Myclobutanil spraying at 35 and 45 DAS followed by wettable sulphur. Highest cost benefit ratio was observed in Wettable sulphur (1.82) followed by Myclobutanil (1.17).

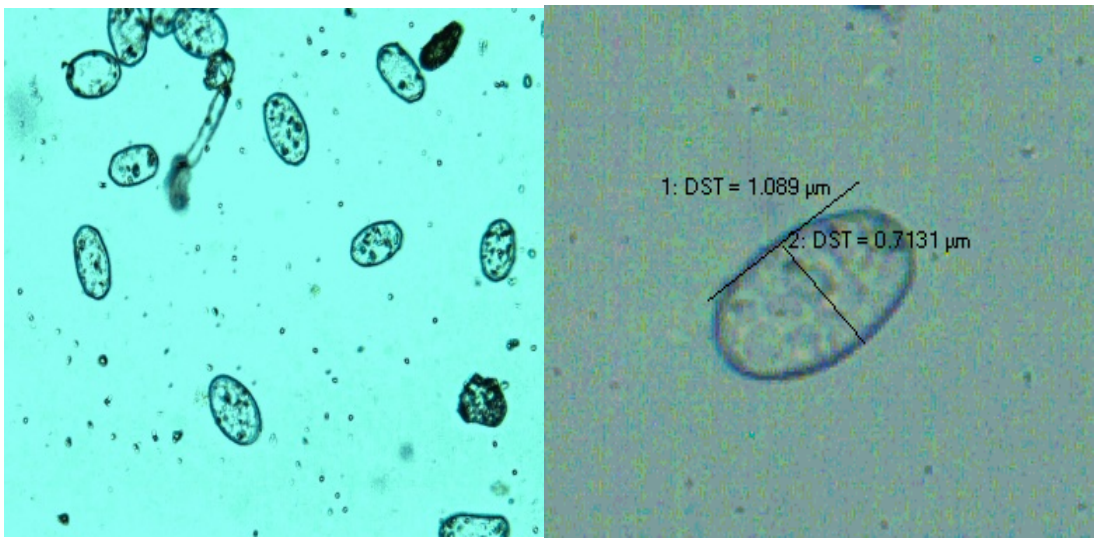


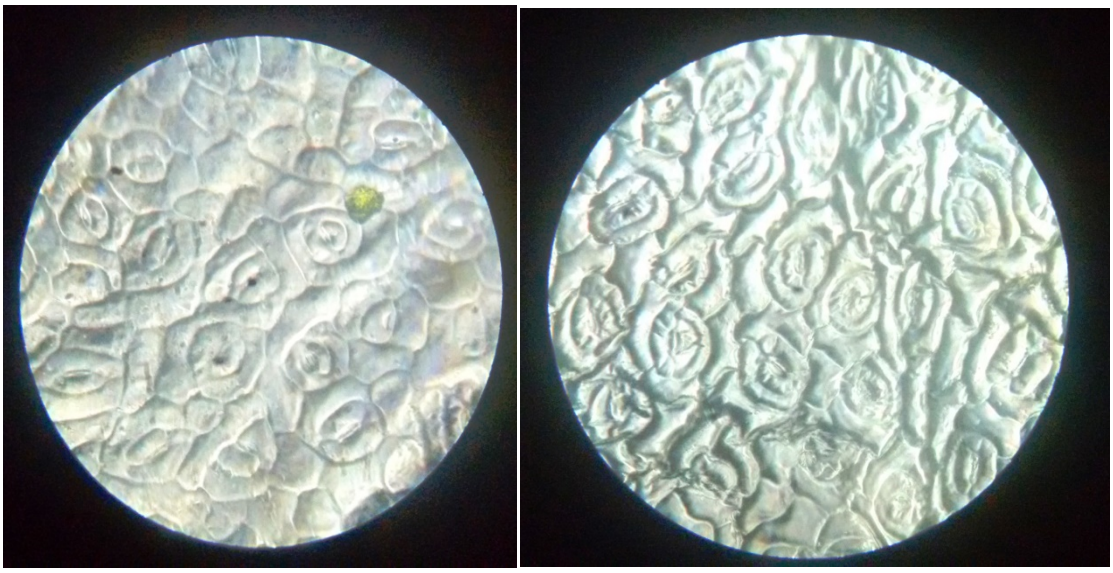
Plate 3.6 Morphology of fungus powdery mildew caused by *Erysiphe polygoni* (10X & 40X)

Plate 3.5 Symptoms of powdery mildew disease under field conditions

Plate3.4 View of field experiment on management of powdery mildew disease during *rabi*2015- 16 in *urdbean*

Plate 3.2 View of field experiment on screening of powdery mildew disease in *urdbean* during *kharif* 2015

Plate 3.3 View of field experiment on screening of powdery mildew disease in *urdbean* during *rabi* 2015-16



KUP-34 LBG-623

Plate 3.7 Variation in stomatal frequency in powdery mildew disease resistant (KUP-34) and susceptible (LBG-623) black gram genotypes (40X)

KUP-34 LBG-623

Plate 3.8 Variation in trichome density in powdery mildew disease resistant (KUP-34) and susceptible (LBG-623) black gram genotypes (40X)

Plate 3.1 View of field experiment on study of *urdbean* powdery mildew disease in relation to weather parameters during *rabi* 2015-2016

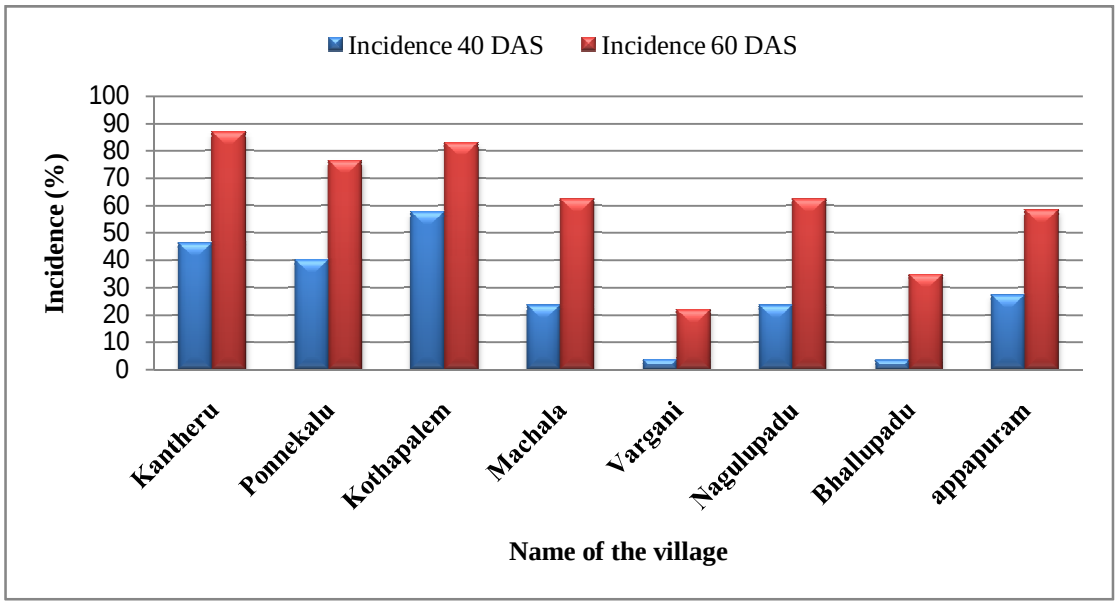


Fig. 4.2 Powdery mildew incidence at 40 and 60 DAS in *urdbean* in Guntur district during *rabi* 2015-16

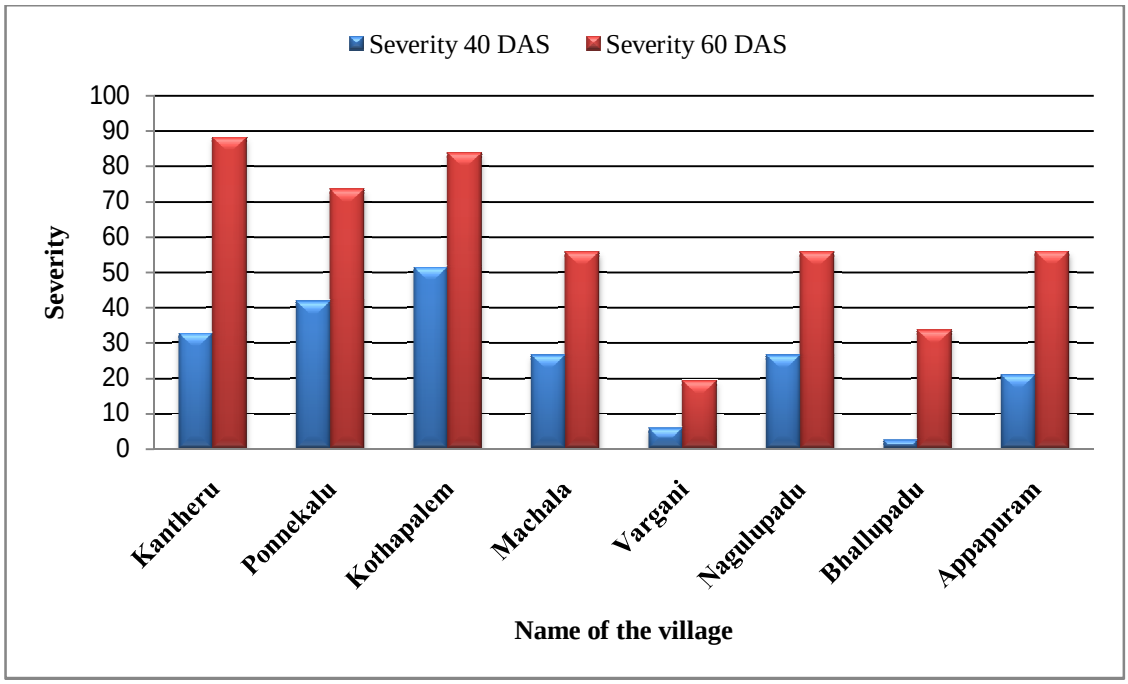


Fig.4.3 Powdery mildew severity at 40 and 60 DAS in *urdbean* in Guntur district during *rabi* 2015-16

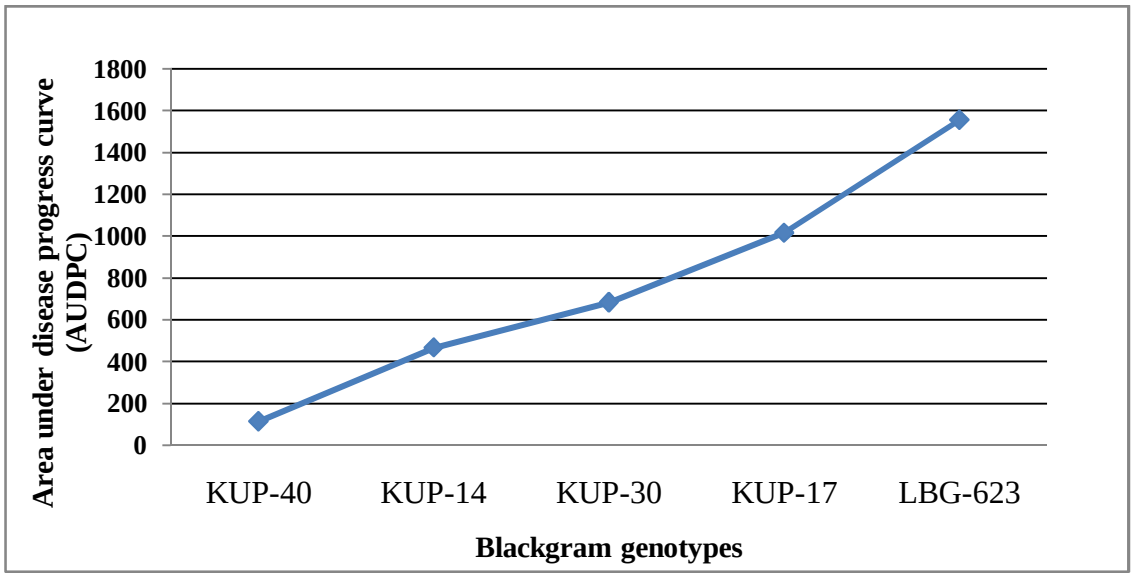


Table 4.9 Area under disease progress curve of *urdbean* selected genotypes during *kharif*, 2015

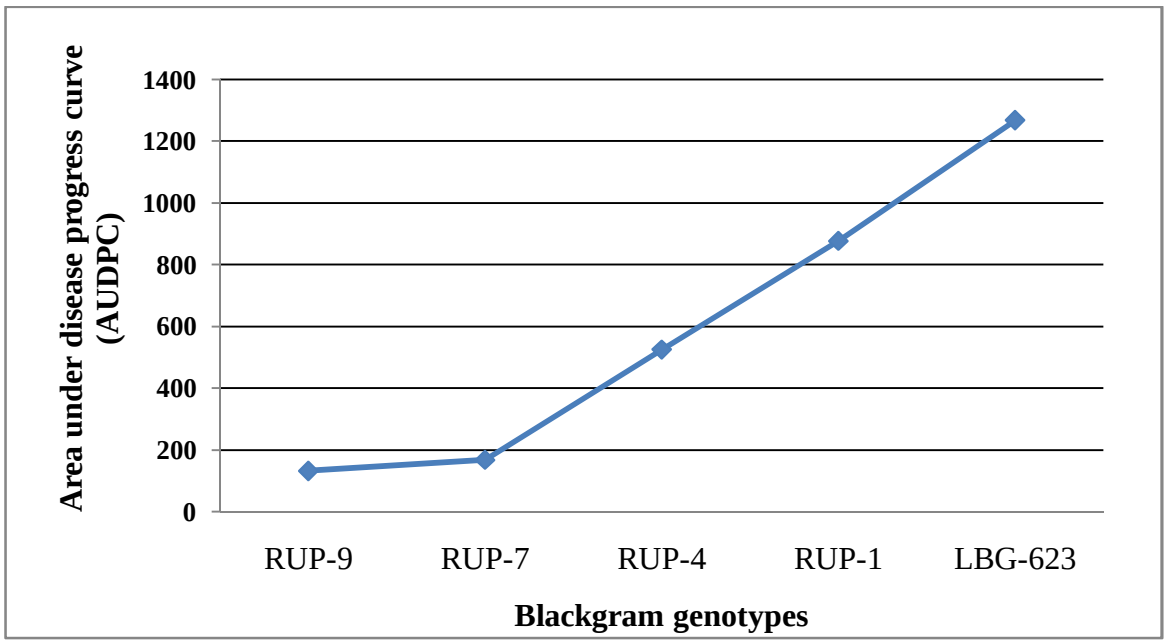


Table 4.10 Area under disease progress curve of *urdbean* selected genotypes during *rabi*, 2015

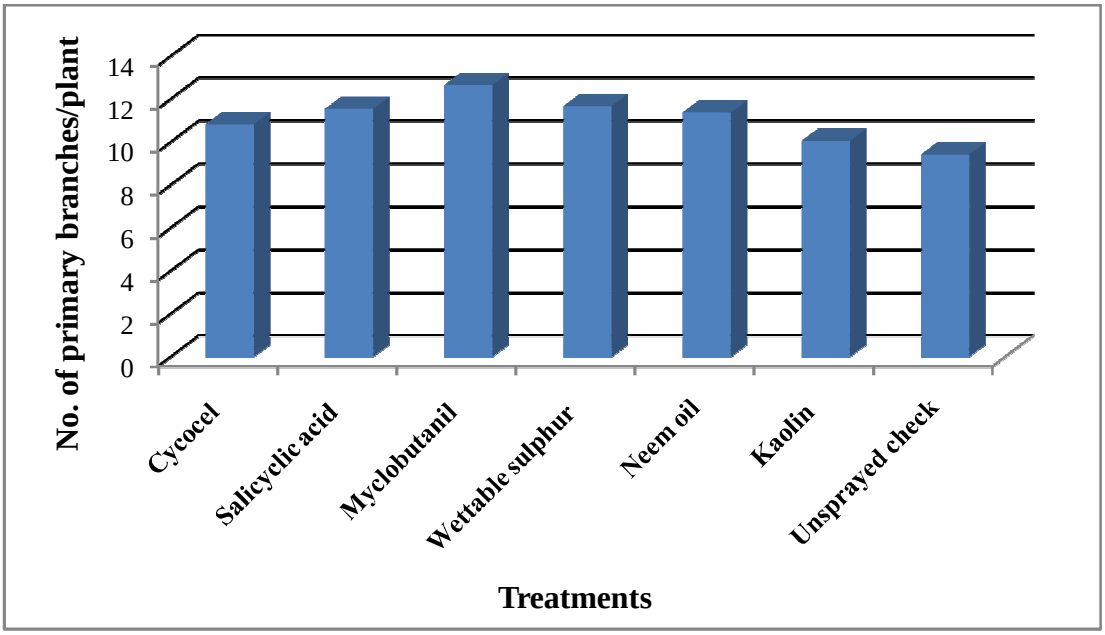


Fig 4.15a Effect of regulator, anti-transpirant and fungicides on no. of branches during *rabi* 2015-16 in field

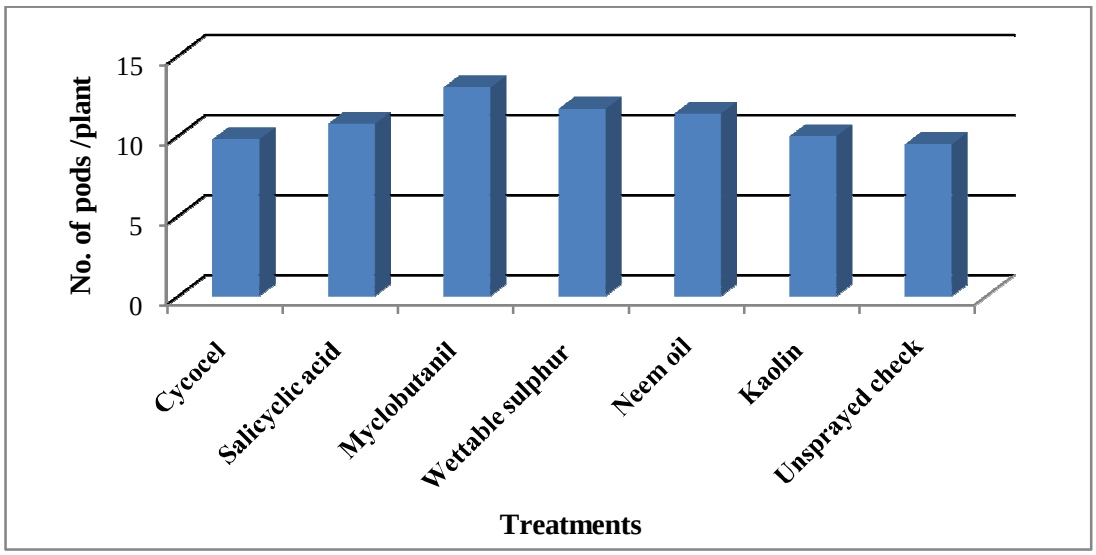


Fig 4.15b Effect of regulator, anti-transpirant and fungicides on no. of pods per plant during *rabi* 2015-16 in field

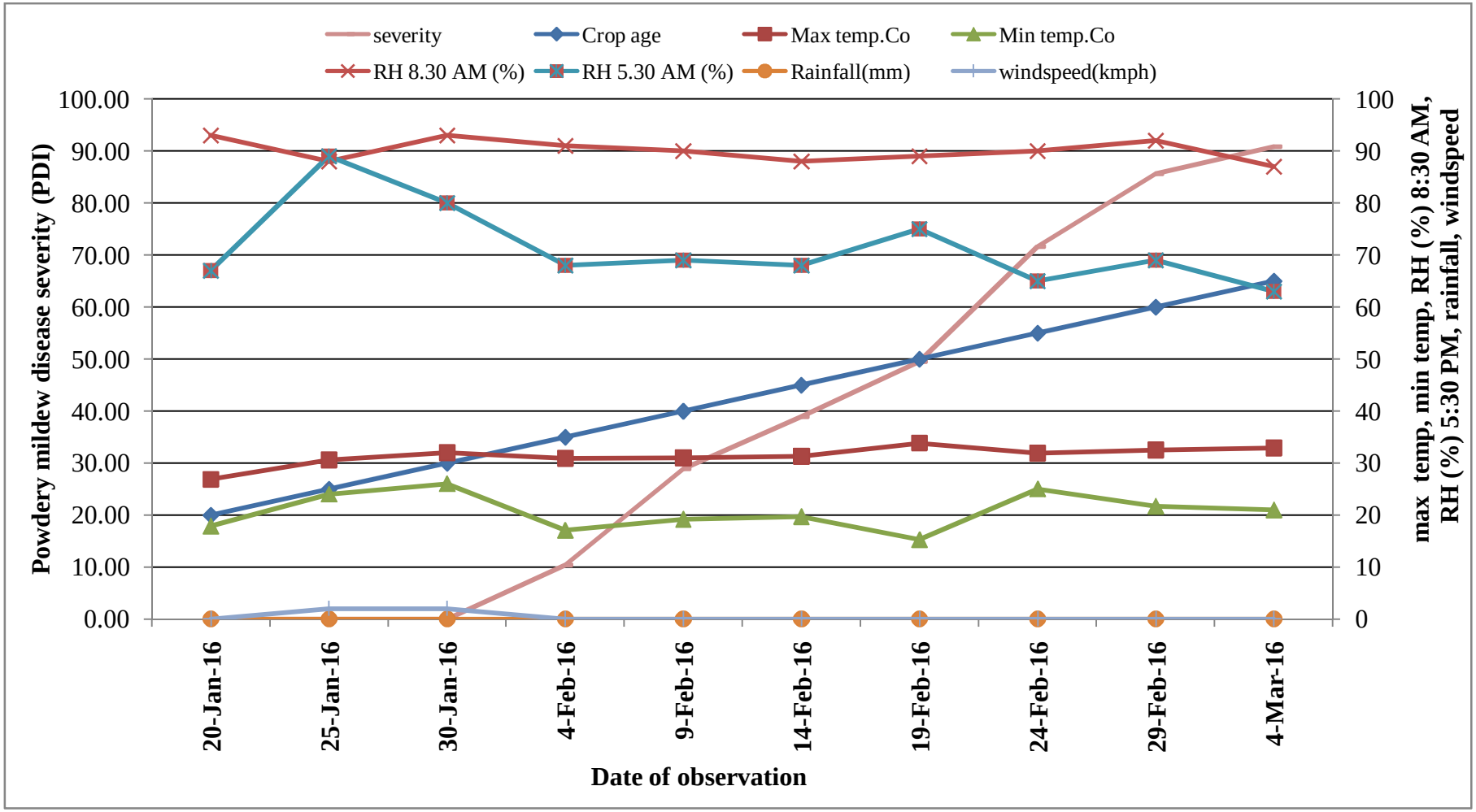


Fig. 4.4 Powdery mildew severity in relation to weather parameters and crop age factors during *rabi* 2015-16

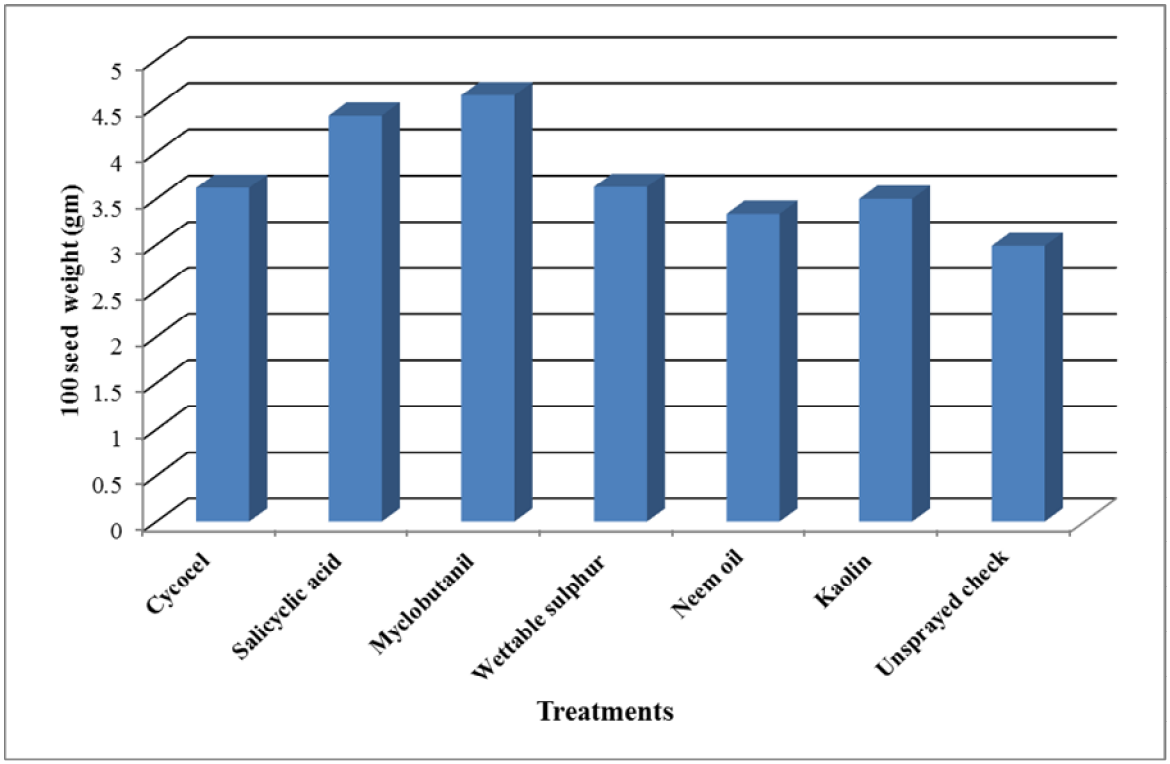


Fig. 4.17 Effect of treatments on 100 seed weight (g) during *rabi*, 2015-16

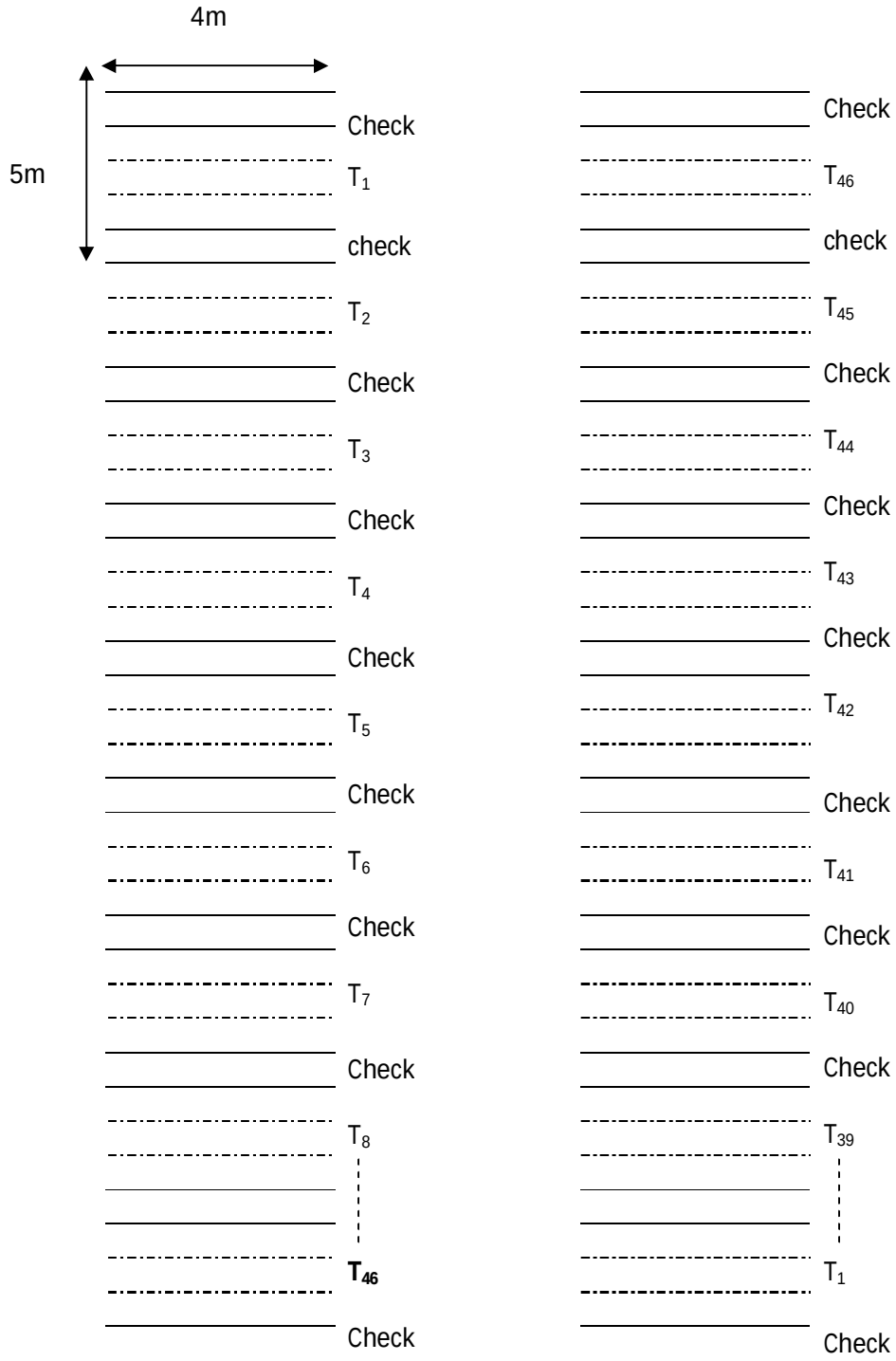
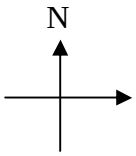


Figure 3.1 Representative layout for screening blackgram genotypes under field condition during *kharif*, 2015



R1 R2 R3

T_4	IRRIGATION CHANNEL	T_7	IRRIGATION CHANNEL	T_3
T_6		T_5		T_1
T_2		T_3		T_6
T_7		T_1		T_4
T_5		T_6		T_2
T_3		T_4		T_5
T_1		T_2		T_7

T1 : Cycocel@ 30 ppm

T2 : Salicyclic acid @ 50 ppm

T3 : Myclobutanil @ 0.2 % W.P

T4 : Wettable sulphur @ 0.3%W.P

T5 : Neem oil @1000 ppm

T6 : Kaolin (6%)

T7 : Untreated control (Check)

Fig. 4.1 Lay out of the field experiment on management of powdery mildew in *urdbean*

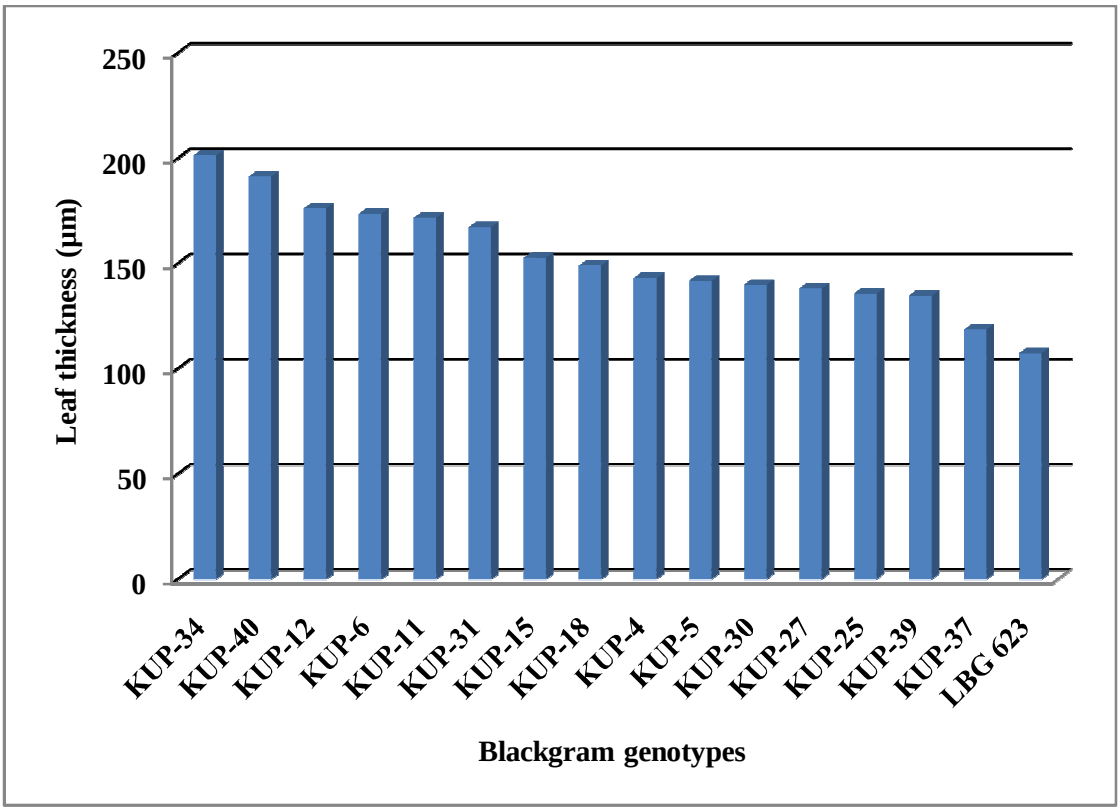


Fig. 4.7 Variation of leaf thickness (µm) in selected blackgram genotypes

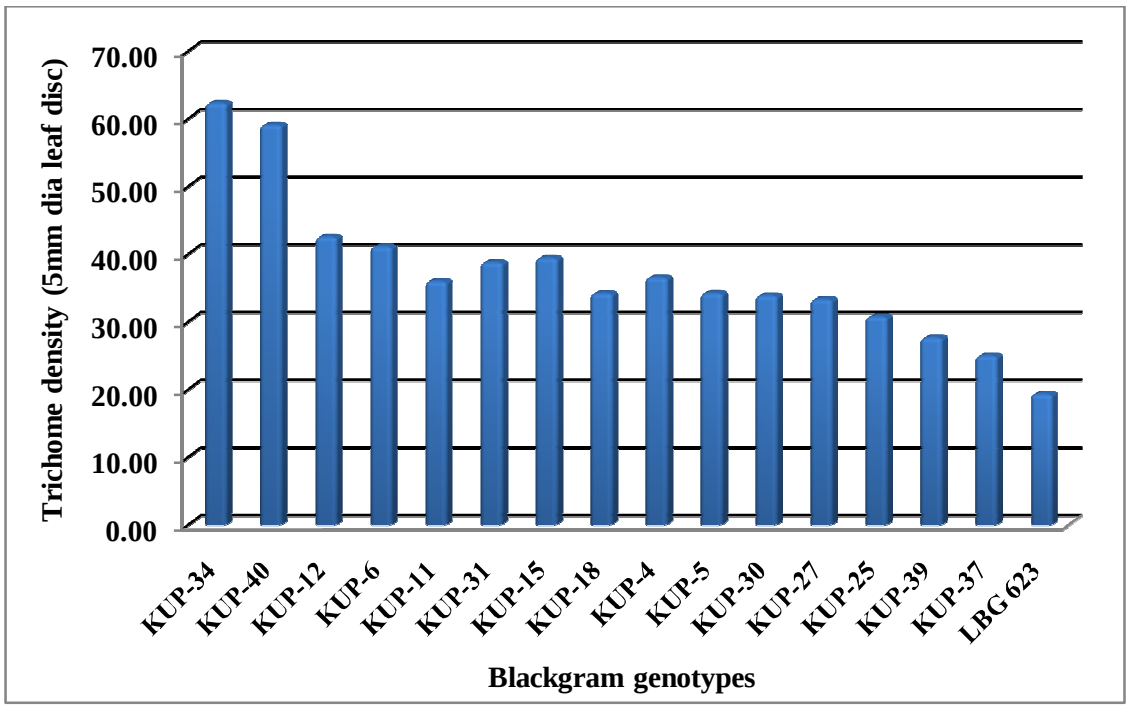


Fig. 4.9 Variation of trichome density (5mm dia leaf disc) in selected blackgram genotypes

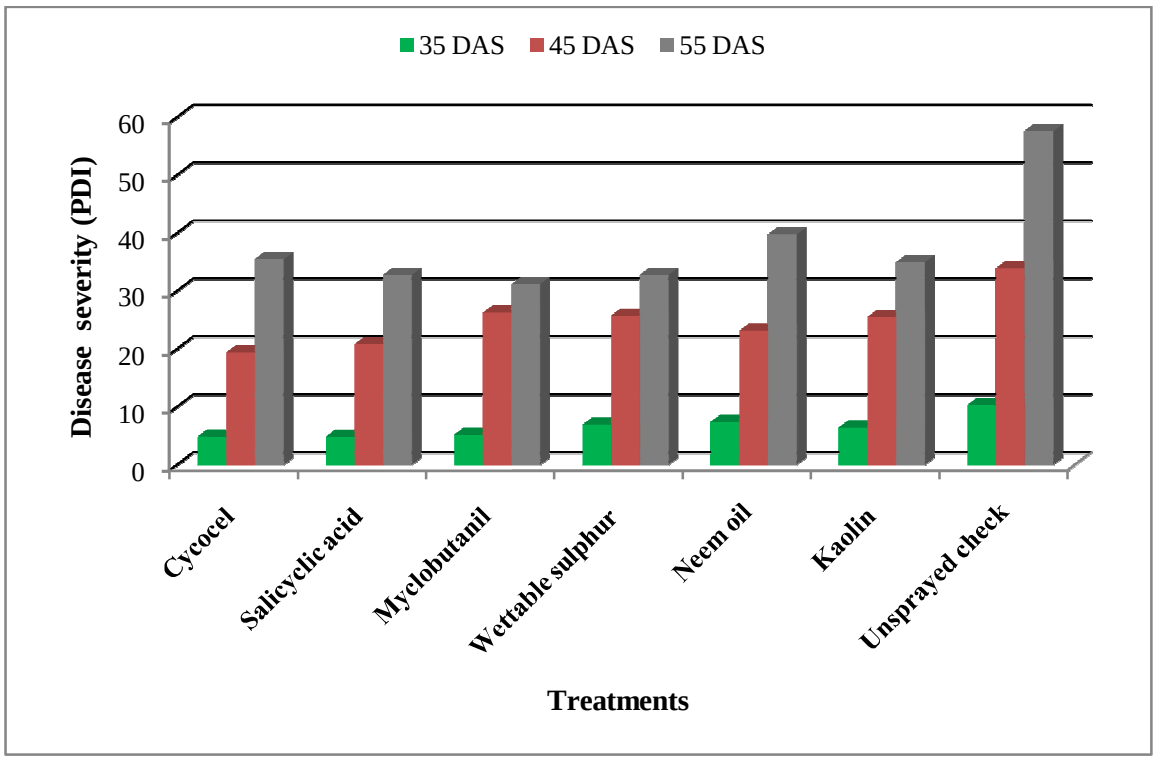


Fig. 4.13 Effect of growth regulator, anti-transparent and fungicides on *urdbean* against powdery mildew during *rabi* 2015-16

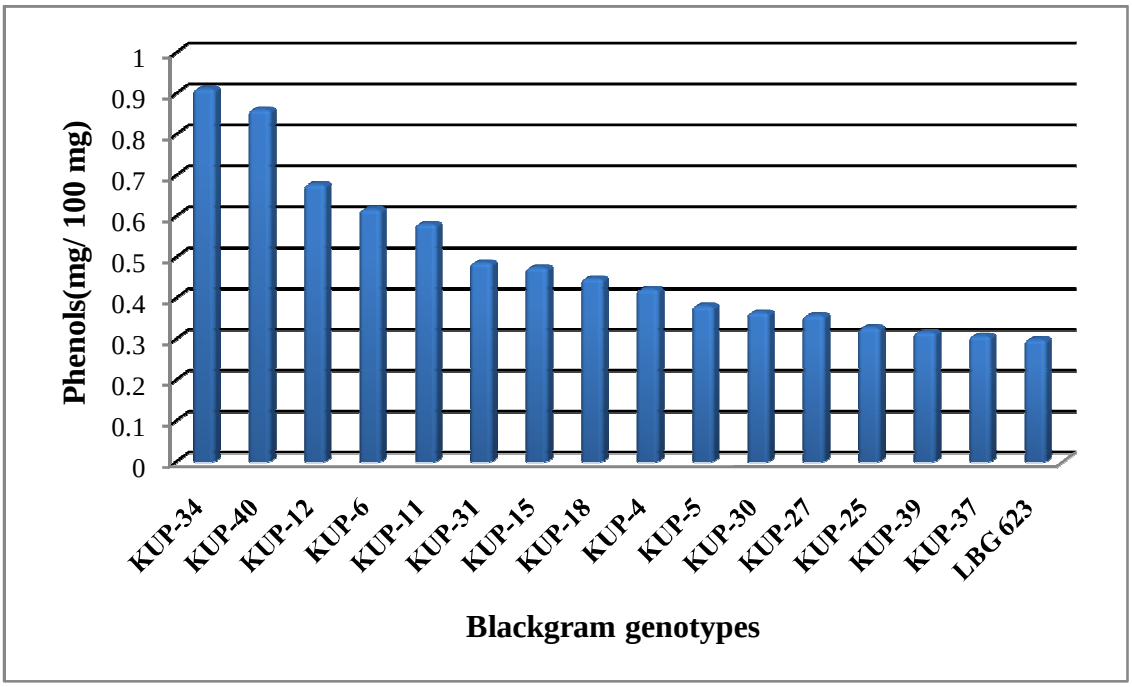


Fig. 4.10 Variation in total phenols (mg/100 mg) on selected blackgram genotypes

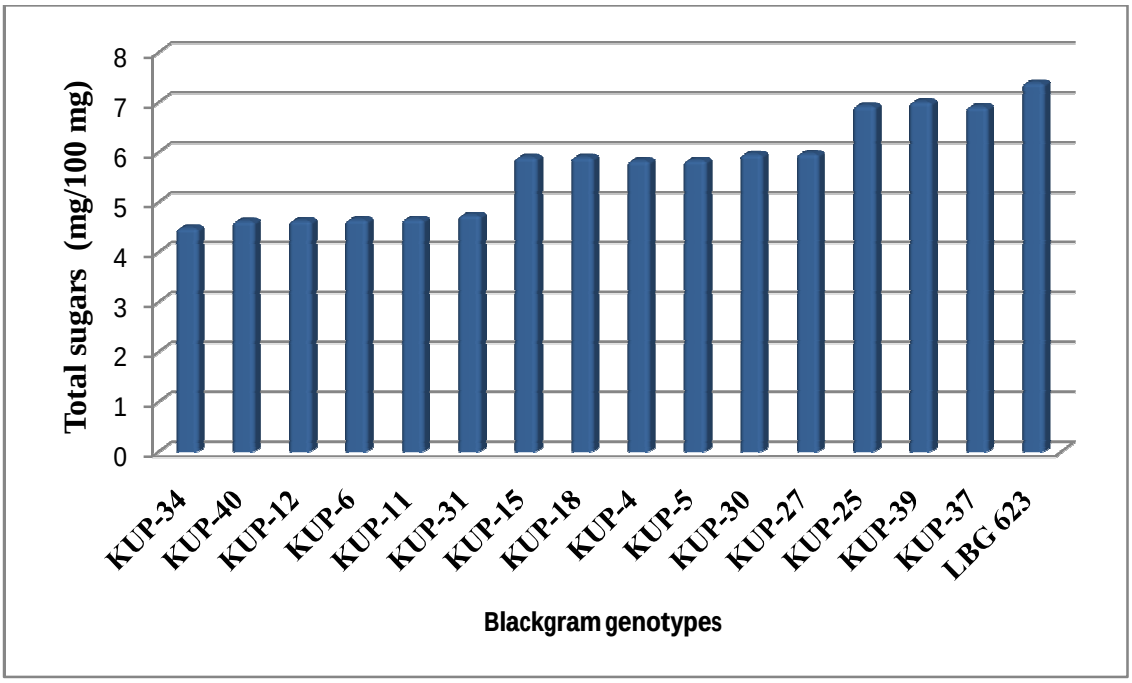


Fig.4.11 Variation in total sugars (mg/100 mg) on selected blackgram genotypes

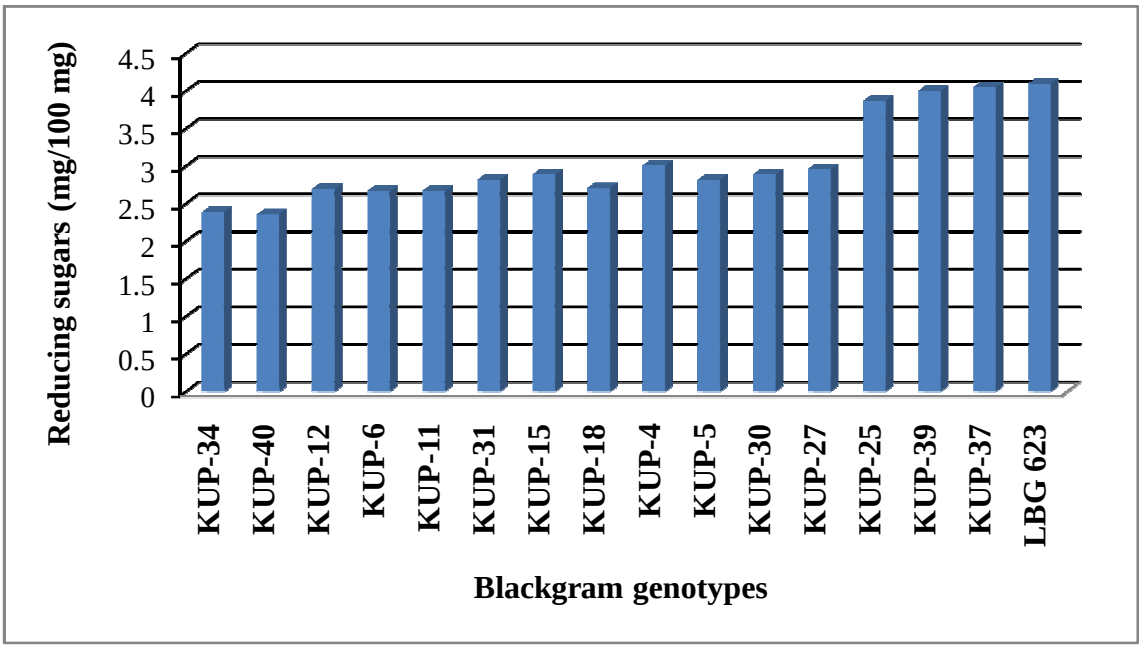


Fig.4.12 Variation of reducing sugars (mg/100 mg) in selected blackgram genotypes

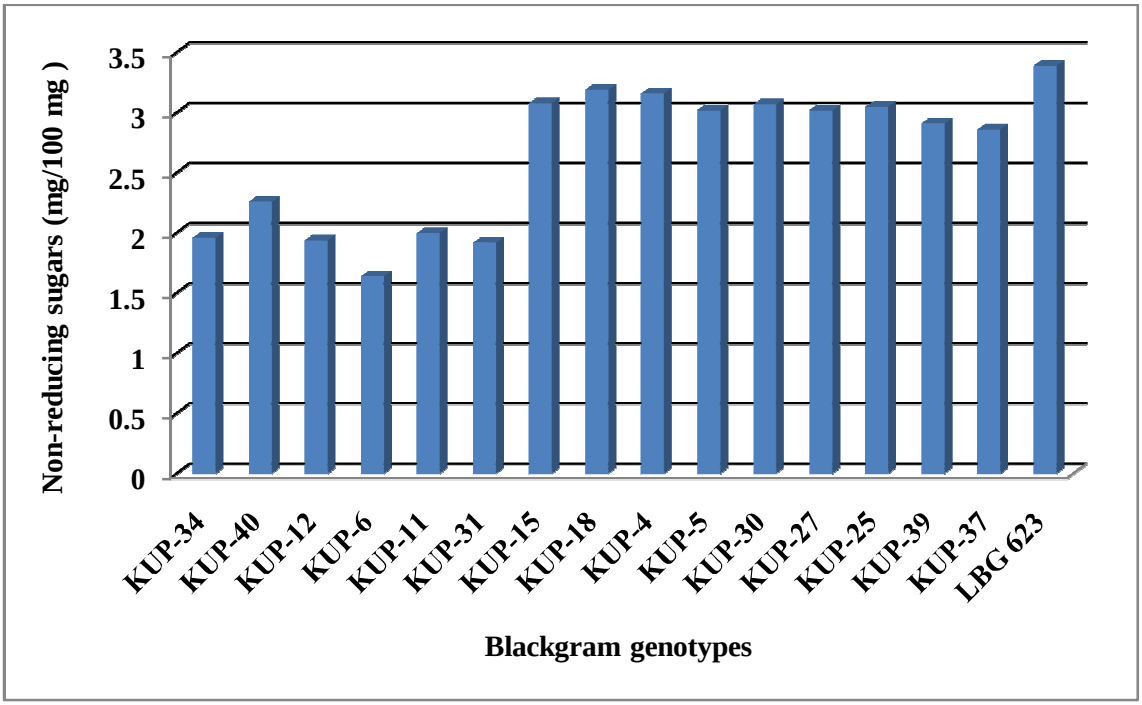


Fig.4.13 Variation of non-reducing sugars (mg/100 mg) in selected blackgram genotypes

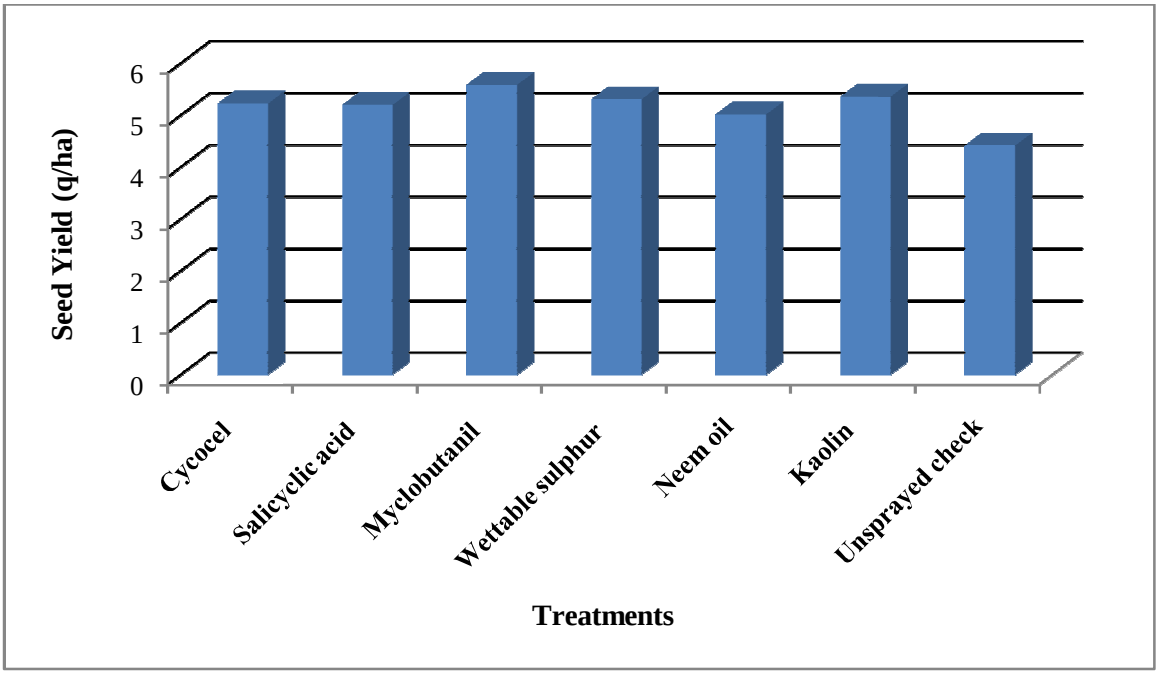


Fig. 4.16a Effect of growth regulator, anti-transpirant and fungicides on seed yield (q/ha) during *rabi* 2015-16

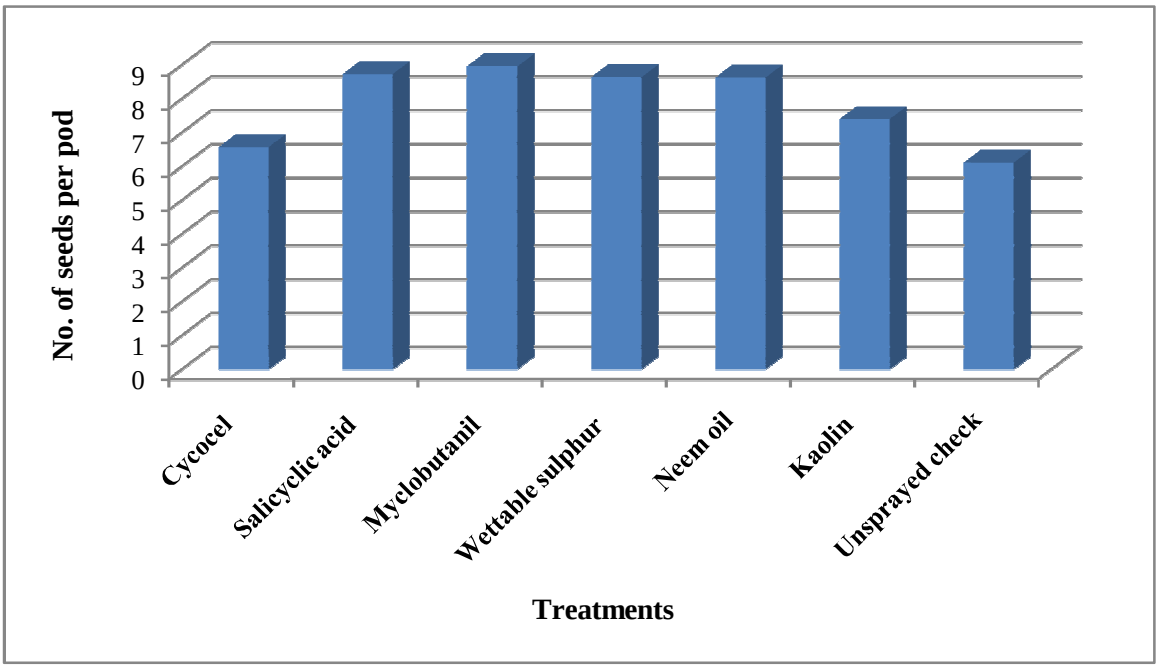


Fig. 4.16b Effect of growth regulator, anti-transpirant and fungicides on no. of seeds per pod during *rabi* 2015-16

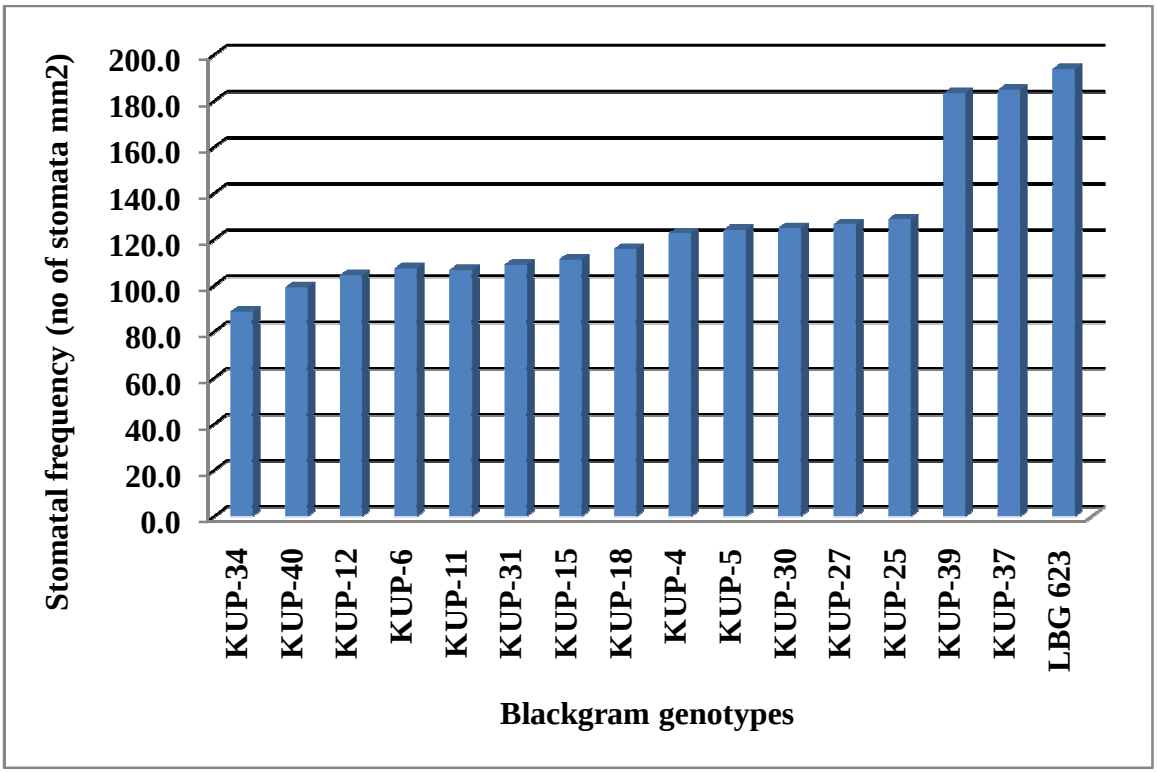


Fig. 4.8 Variation in stomatal frequency (no of stomata mm^2) in selected blackgram genotypes