EPIDEMIOLOGY AND MANAGEMENT OF COWPEA RUST CAUSED BY *Uromyces phaseoli* var. *vignae* (Barcl.) Arth.

RAMANAGOUD B. HONNUR

DEPARTMENT OF PLANT PATHOLOGY
COLLEGE OF AGRICULTURE, DHARWAD
UNIVERSITY OF AGRICULTURAL SCIENCES,
DHARWAD – 580 005

JUNE, 2015

EPIDEMIOLOGY AND MANAGEMENT OF COWPEA RUST CAUSED BY *Uromyces phaseoli* var. *vignae* (Barcl.) Arth.

Thesis submitted to the
University of Agricultural Sciences, Dharwad
in partial fulfillment of the requirements for the
Degree of

Master of Science (Agriculture)

in

Plant Pathology

By
RAMANAGOUD B. HONNUR

DEPARTMENT OF PLANT PATHOLOGY
COLLEGE OF AGRICULTURE, DHARWAD
UNIVERSITY OF AGRICULTURAL SCIENCES,
DHARWAD – 580 005

JUNE, 2015

DEPARTMENT OF PLANT PATHOLOGY
COLLEGE OF AGRICULTURE, DHARWAD
UNIVERSITY OF AGRICULTURAL SCIENCES, DHARWAD

CERTIFICATE

This is to certify that the thesis entitled "EPIDEMIOLOGY AND MANAGEMENT OF COWPEA RUST CAUSED BY Uromyces phaseoli var. vignae (Barcl.) Arth." submitted by Mr. RAMANAGOUD B. HONNUR for the degree of MASTER OF SCIENCE (Agriculture) in PLANT PATHOLOGY to the University of Agricultural Sciences, Dharwad is a record of research work done by him during the period of his study in this University under my guidance and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

DHARWAD
JUNE, 2015

(K. B. YADAHALLI)
CHAIRMAN

Approved by:

Chairman: ______________________
(K. B. YADAHALLI)

Members: 1. ______________________
(SHAMARAO JAHAGIRDAR)

2. ______________________
(S. K. DESHPANDE)

3. ______________________
(P. S. PATTAR)

Acknowledgement

With regardful memories……….

At the outset I submit that it is by the blessings of the almighty and prayers of my family. I don't think one can effectively put one's heartfelt emotions into words. It becomes all the more difficult for a person like me who is not endowed with this art. Whatever, I write here can only be a deceptive reflection of the tumult of feelings that is in my heart at this moment.

At last the movement has come to look into the deeper layers of heart, which is filled with the feelings of togetherness, loveliness, consolation and satisfaction, a sign of relief and a sense of fulfilment. Some are momentary and some are permanent, but both involve a number of near and dear persons to whom I acknowledge my warm regards and take this opportunity to express my feeling during the course of my study and research.

I am extremely rejoiced to express my deep sense of gratitude and reverence of feel towards the esteemed chairman of my Advisory Committee, Dr. K. B. YADAHALLI, Professor of Plant Pathology, College of Agriculture, Hanumanamatti, University of Agricultural Sciences, Dharwad, for his untiring and peerless guidance, thought provoking suggestions, consummate, critical evaluation and sustained encouragement throughout the period of my study. I am in wonder of his inexhaustible energy, patience, interest and involvement, which helped me a lot in improving and finalization of this manuscript. I sincerely and proudly confess that it has been a great privilege for me to have been one of his students.

It is with immense pleasure that I imprint my profound sense of gratitude and indebtedness to Dr. SHAMARAO JAHAGIRDAR, Professor of Plant Pathology, AICRP on Soybean, University of Agricultural Sciences, Dharwad and member of my advisory committee for his keen interest, persistent encouragement and valuable suggestions throughout my stay in the department, during study and research.

Mere words cannot express my profound indebtedness and heartfelt deep sense of gratitude to Dr. S. K. DESHPANDE, Professor and Head, Department of Genetics and Plant Breeding and Dr. P. S. PATTAR, Associate Professor, Department of Agronomy, Krishi Vigyan Kendra, Bagalkot, University of Agricultural Sciences, Dharwad, who served as members of my advisory committee and also for their constructive suggestions, timely help, inspiring encouragement, critical comments and valuable suggestions, that helped to plug the gaping holes and improve overall quality of the thesis.

It is rather difficult to express in words my sincere and heartfelt gratitude to Dr. A. S. Byadgi, Professor and Head, Dr. V. B. Nargund, Professor, Department of Plant Pathology, College of Agriculture, University of Agricultural Sciences, Dharwad, for his encouragement, scholarly advice and kind help at every stage of the investigation. I am very happy to remember

him forever for his dedication as a motivating teacher to the young minds. His contribution in the completion of the thesis was indispensable.

On a personal note, I extend my deep sense of righteous gratitude, indebtedness, heartfelt respect to all the staff of Department of Plant Pathology. Dr. V. I. Benagi, Dr. S. Lingarju, Dr. Yashoda R. Hegde, Dr. M.S. Patil, Dr. M. R. Ravi Kumar, Dr. M.S.L. Rao, Dr. Virupaksha Prabhu H., for their kind cooperation extended to me during the course of my study and research.

To express my sincere gratitude to my beloved parents, mother Smt. Mallamma and father Shri. Balanagouda, who, in spite of their limited education, sacrificed everything to give me the most and best education possible. I also thank my Sweet Sister Basamma and Brother Basanagouda, who also sacrificed some of their interests for my benefit. in the form of words is rather restrictive both in expression and quantum yet at this juncture, it is my esteemed duty to reserve my higher regards to threw with whose boundless love, needy inspirations like showers to a drying crop for their unshakeable confidence in me.

I also thank to my seniors Anand, Chidu, Madhu, Ananth, Druva, Ravi, Huligappa, Anil, Pradeep, , Sharada, Sangeetha, Kavyashree, Rathna, Sukrutha, Preethi, Sowmya, Anusha, Veena, Roopa, and my classmates Manjunath Managoli, Sunil Sirasangi, Kumar Lambani, Ganesh Kambar, Nanjundaswami, Gulappa, Naganagouda, Chandrasekhar, Shivaraj, Kotramma, Basamma, Rani, Ratna, without them I will not had much of ease in completing my M. Sc. programme.

I owe my special thanks to the library and hostel staff for their hospitality during my stay in Dharwad. Last but not the least I thank all those who helped me directly or indirectly during period of my stay in this UAS campus.

Finally, I extended my thanks to Mr. Arjun and Mr. Kalmesh (Arjun Computers, Dharwad) for having spared their deep experience, patience and skill by way of neat presentation of this thesis. Finally I share my sincere thanks and inspirations to all those seen and unseen hand and minds.

……….any omission in this short manuscript doesn’t mean lack of gratitude.

DHARWAD

JUNE, 2015 **(RAMANAGOUD B. HONNUR)**

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDIX

1. INTRODUCTION

Pulses provide the vital protein in the diet of majority of Indians. In addition, they provide nutritious fodder to the cattle. These crops play an important role in Indian Agriculture and are the best known as "poor man's meat", which constitute the major source of dietary protein. Pulses contain 20 to 30 per cent protein, which was 2.5 to 3.0 times more than the value normally found in cereals. Besides their high nutritional value, they have a unique characteristic of maintaining and restoring soil fertility through biological nitrogen fixation which plays a vital role in sustainable agriculture (Asthana, 1998).

Among the pulses, cowpea (*Vigna unguiculata* L.) (2n=22) commonly called as Lobia, is one of the most ancient human food sources and short duration multipurpose pulse crop grown extensively in tropical and subtropical countries. It belongs to family Fabaceae. The name cowpea originated from the fact that the plant was an important source of hay for cows in the south-eastern United States and in other parts of the world. It is native to India, as wild cowpeas only exist in Africa and Madagascar (Steele, 1976). It was introduced to the Indian sub-continent from Africa approximately 2000 to 3500 years ago.

Cowpea forms an important component of farming system, being cultivated for seeds (shelled green or dried), pods or leaves that are consumed as green vegetable or for pasture, hay, silage and green manure. It fits well in a variety of cropping systems and is grown as a cover crop, mixed crop, catch crop or green manure crop in different parts of India like Punjab, Delhi and Haryana.

It is also called as vegetable meat due to high amount of protein in grain with better biological value on dry weight basis. On dry weight basis, cowpea grain contains 23.4 per cent protein, 1.8 per cent fat and 60.3 per cent carbohydrates and it is rich source of calcium and iron (Gupt, 1978). It is usually the first crop to be harvested before the cereals crops are ready and therefore is referred to as "hungry-season crop". Apart from this the cowpea as an excellent forage crop and with heavey vegetative growth cover ground checking soil erosion. As a leguminous crop, it fixes about 70 -240 kg per hectare of nitrogen per year and is a valuable component of farming systems in many areas because of its ability to restore soil fertility for succeeding cereals crops grown in rotation with it. In the world cowpea is grown in 10.73 m.ha with the production of 5.7 m.t and productivity of 505.5 kg/ha. In India, cowpea was grown in area of about 3.9 m. ha with the production of 2.2 m. t.and productivity of 625 kg per ha. In Karnataka, cowpea was grown in area of about 0.78 m. ha with the production of 0.22 m.t and productivity of 302 kg per ha (Anon., 2013). Cowpea varieties such as C-152 and TVX-1839-9E are mainly grown for seed purpose while S-488, Pusa-Barsathi for vegetable purpose.

In spite of tremendous improvement in development of new varieties it has not been possible to achieve green revolution in pulses unlike in cereals because of its confinement to poor and marginal soils and due to its relatively high susceptibility to diseases and insect pests. The overall grain yields of cowpea in the present traditional systems are low Sing *et al.* (1997) due to complex of biotic and abiotic factors. The a biotic factors that cause yield reduction include poor soil fertility, drought, temperature extremes, excessive moisture, late maturity, acidity and stress due to intercropping with cereals. The cowpea is affected by number of fungal, bacterial and nematode diseases. Among the fungal diseases rust, root rot, anthracnose, powdery mildew, leaf spots and bacterial disease like bacterial blight and cowpea mosaic virus are economically important. Among these diseases rust caused by *Uromyces phaseoli* var. *vignae* (Barcl.) Arth is the most economically important disease.

Rust is one of the economically important and a serious disease which affects cowpea production in most parts of Karnataka. When the disease advances, there will be premature defoliation leading to reduced seed size resulting in severe yield loss. Reduction in photosynthetic activity and increase in respiration activity after infection, leads to potential decrease in yield depending on the stage and time at which the disease appears.

Generally disease appears severely on July sown crop during southwest monsoon period resulting in appreciable crop losses (Chandrasekhar *et al.,* 1989). The disease was first reported by Barclay in 1891 from Shimla. Himachal Pradesh.

Further, it was reported by Butler and McRae in the year of 1909 from Tamil Nadu and Maharashtra. This disease was reported from Dharwad and Mysore by Rangaswami *et al.* (1970).

The rust pustules appear on any part of the plant above ground. The infection appears on lower surface of the leaves in the form of small raised sori. Infection is evident first as minute almost white, slightly raised pustules which later became distinct, redish brown circular sori that are typical of rusts pustule. These sori are initially covered with epidermis which ruptures and release spore dust. Under favourable weather conditions numerous sori appear subsequently in rings around the first sorus. Similar sori also are encountered on the upper surfaces of the leaves on the same foci of infection. Both teliospores and uredospore are observed in the same sori.

Looking into the economic importance of this disease, the research programme has been planned to survey for rust disease to assess the combined severity to know the susceptible stage, characteristic symptoms and to identify the hot spots in major cowpea growing areas. Identification of most susceptible stage for the infection to decide the critical stage at which the management options can be recommended since there is limited information on susceptible stage and new molecules of fungicides and resistant sources. The present study assumed prime importance to answer these questions with following objectives.

1. Survey for recording the severity of cowpea rust in northern Karnataka.
2. To identify the susceptible stage of infection.
3. *In vitro*, glasshouse and field evaluation of fungicide molecules against rust.
4. To screen the available genotypes for rust disease both in field and glasshouse.

2. REVIEW OF LITERATURE

Rust of cowpea caused by *Uromyces phaseoli* var *vignae* (Barcl.) Arth. is one of the most wide spread disease, which also affects a number of leguminaceae members of economic importance such as bean, pea, Bengal gram, green gram and many weeds cultivated throughout the world. However, very less information is available on rust of cowpea. Hence, in the present study in addition to rust, literature on rust of other crops and preferably members of leguminaceae has been also reviewed.

2.1 Survey for recording the severity of cowpea rust in northern Karnataka.

Barclay (1891) reported cowpea rust caused by (*Uromyces phaseoli* var *vignae* (Barcl.) from north Indian state Simla, Himachal Pradesh where cowpea rust was severe in nature.

Rangswami *et al.* (1970) reported cowpea rust caused by (*Uromyces phaseoli* var *vignae* (Barcl.) from Dharwad and Mysore areas of Karnataka, the severity was more in Dharwad followed by Mysore.

Jones (1983) reported that chickpea rust (*U. ciceris-arietini*) is widespread in the Mediterranean region, South-East Europe, South Asia, East Africa and Mexico. It was usually of little importance as it appeared late in the season when the crop was at maturity. However, severe infection can cause significant losses.

Emechebe and Soyinka (1985) reported that cowpea rust caused by *Uromyces phaseoli* var *vignae* (Barcl.) Arth. As the major cowpea disease in the rainforest and southern Guinea savanna zones of West Africa and in medium- elevation areas of East Africa.

Mariga *et al.* (1985) reported that cowpea rust caused by *Uromyces phaseoli* var *vignae* (Barcl.) Arth, occasionally caused epidemics of economics importance in Zimbabwe.

Gjaerum *et al.* (1986) reported Lupine rust caused by *Uromyces lupinicolus* was one of the locally important disease in Europe, yield losses occur when plants are infected early in the growing stage of the crop.

Hiremath *et al.* (1987) surveyed Soundatti, Nargund and Navalgund taluks of Dharwad districts, where the chickpea was raised under irrigated condition. The survey indicated that chickpea rust severity was as high as 90 to 100 per cent.

Stoffella *et al.* (1990) reported that cowpea rust disease caused by *Uromyces phaseoli* var *vignae* (Barcl.) also called as that brown rust was one of the most severe fungal disease of cowpea at fort pierce, Florida, USA.

Delacueva *et al.* (1994) surveyed and reported that, the soybean rust was known in the Philippines. Since 1914, but has become economically important only in the last 20 years reducing the yield up to 20-40 per cent annually.

Habtu *et al* (1996) surveyed three different locations in Ethiopia like Rift Valley, Sidamo and Keffa. In area of Sidamo reported as high bean rust (*Uromyces appendiculutus* (Pers.) Ung) intensity, with low plant density were compared to other areas like Rift Valley and Keffa.In area Rift Valley low rust intensity was closely associated with year (1990) and high rust intensity with year (1993).

Jellis *et al.* (1998) they reported that faba bean rust (caused by *Uromyces viciae-fabae*) is present almost everywhere that faba beans are grown. It is a major disease in the Middle East, North Africa, Europe and China, where moderate to substantial yield losses can occur.

Pande *et al.* (2009) they surveyed on bean rust it caused by *Uromyces viciae-fabae* in the region of Mediterranean countries and also they reported that loss of crop due to this rust upto 50%.

Nargund *et al.* (2011) surveyed and reported that during 2009-10 *rabi* season chickpea suffered heavily due to rust caused by *U. ciceris arietini*. This disease was noticed in 2006-07 on Bhima genotype in a sporadic manner in Dharwad location. During 2009-10 the severity of the disease was 100 per cent where all the genotypes grown at Main Agricultural Research Station (MARS), Dharwad encompassing germplasm lines, ICRISAT collections, segregating populations and F_1 of several crosses showed highly susceptible reaction to rust.

Shifa *et al.* (2011) conducted survey in Hararghe highlands of Ethiopia during the 2009 cropping season to determine the incidence and severity of faba bean rust (*Uromyces viciae-fabae*) in major faba bean growing districts of Hararghe highlands and its association with environmental factors and cultural practices. A total of 90 faba bean fields were surveyed in six districts of Ethiopia. The mean incidence of the disease varied from 44.6% in Bedeno, in Deder 40%, Metta 40% to 98% in Tullo, while severity of the disease varied from 12.7% in Kurfachale to 65% in Gorogutu districts.

2.2.1 Symptomatology

Singh (1973) reported that symptoms appeared with the development of aecia. The yellow aecia appear first on the lower surface of the leaves, stem and petiole of pea rust. The formation of aecial stage was preceded by a slight yellowing which gradually turns brown. The pustules were powdery light brown in appeared all the four stages developed on every green part of the host including the pods.

Kale (1992) reported that cowpea rust disease symptoms were appeared on any part of the plant above ground. The infection was noticed on the upper surface of the leaves in the form of raised sori. Infection was evident first as minute almost white, slightly raised pustules which later become distinct, reddish brown circular sori that were typical of rust.

2.2 Identification of the susceptible stage of infection.

Chaturvedi *et al.* (1980) identified flowering and pod maturity stages as important periods in the reducing the yield of cowpea due to rust caused by *Uromyces phaseoli* var *vignae* (Barcl.) Arth.

Hagedorn and Inglis (1986) reported that bean crop was flowering and pre flowering highly susceptible stage to rust caused by *Uromyces phaseoli* var *typica* disease.

Chandrashekar *et al.* (1988) reported that severity of cowpea rust (caused by *Uromyces phaseoli* var *vignae* (Barcl.) Arth) at flowering stage and pod formation stage compare to different stages of the crop, resulted in reduction of yield by 50 percent.

Ten days old plants were highly susceptible to rust disease of cowpea. The least infection was observed on the crop after 60 and 70 days after sowing (DAS).Further, 80 days crop failed to get the infection as reported by Kale (1992).

Bhardwaj and Sharma (1996) reported that rust incidence was severe in later sown crop as compared to the early sown, they tested genotype, Arkel and VL-7 were the short duration varieties and recorded the per cent disease index of rust (*Uromyces viciae-fabae*) was lowest in 15 October sowing followed by 30 September. VL-7 and Arkel were observed to have lowest disease index of rust.

Mittal (1997) reported that effect of sowing dates on rust disease incidence and crop yield in Lentil cultivar VL-Massor-1 sown on four dates (9, 19 and 29 October and 9 November) during five *rabi* seasons. He observed that rust incidence was more 10 days old plant as compare with later sown crop.

Venkata Rao (1997) observed that 40 and 50 days old greengram plants were highly susceptible to powdery mildew caused by *E. polygoni*. Shivanna (2003) noticed that 50 days old okra plants were highly susceptible to powdery mildew caused by *E. Cichoracearum.*

Madhusudhan (2002) reported that, early growth stage was found susceptible to the anthracnose disease development in soybean. Maximum disease severity of 39.25 PDI was recorded on 40 days old seedlings.

Kushwaha *et al.* (2006) reported pea rust (caused by *Uromyces fabae*) was more severe at the time of pod formation stage compared to different stages of the crop.

Pande *et al.* (2009) reported that lentil rust was (caused by *Uromyces vicia- fabae* (Pers.) de Bary.) the disease occurs during the flowering or early pod stage of crop. as aecia, this developed into secondary aecia or uredia. The resulting aeciospores and uredospores lead to a further disease spread in the crop season.

Kavyashree (2014) reported that greengram powdery mildew disease under artificial inoculation appeared on 20 days old plants. However, the maximum per cent disease index was observed at 40 days old plants (100 PDI) followed by 30 days old plants (94.30 PDI).

Kavyashree (2014) reported that glasshouse study revealed that the maximum severity of *Cercospora* leaf spot in green gram on was recorded 50 days old plants (43.00 PDI) and initiation of the disease was seen on 30 days old plants and no any infection at 10 and 20 days old crop.

2.3 *In vitro,* glasshouse and field evaluation of fungicide molecules against the rust

A. Glasshouse

Jacks (1954) under glass house condition reported that when broad bean plants were sprayed with a fungicidal suspension and inoculated 24 hours later with a spore suspension of *Uromyces fabae*, it was observed that in unsprayed plants, the mean number of rust lesions were 295.8 per leaf against none in plants sprayed with 0.45 per cent dithane Z-78 (65% zineb), 0.5 per cent ferbam spray (70% ferbam) and 0.5 per cent manzate (70% maneb). On the other hand the plants sprayed with 0.4 per cent thiospray (70% zineb) gave 0.3 or less number of lesions per leaf.

b. Field condition

Zaumeyer (1946) reported excellent control of broad bean rust through the use of 20-25 lb sulphur dust per acre. Filed dusted twice with sulphur showed an average yield of 1600 to 1800 lb seed per acre as against 800 to 1000 lb in untreated fields.

Herrera and Plata (1964) reported that cupravit was effective in inhibition of germination of uredospore of bean rust caused by *U.phaseoli* var *typica.* under *in vitro* condition.

Hedge (1974) conducted an experiment on pea crop, sprayed twice with benlate (0.05%), calixin (0.1%), plantvax (0.1%), combinations of benlate + plantvax and calixin + plantvax. The results indicated that calixin and combination of calixin + plantvax effectively controlled pea rust.

Sokhi and Sohi (1976) reported the effectiveness of fungicides like captafol, mancozeb, benomyl and mancozeb - dinocap mixture on cowpea rust caused by *Uromyces phaseoli* var *vignae* (Barcl.) Arth. And increase seed yield.

Yoshii (1977) reported the effect of fungicides *viz.*, sicarol, plantvax, daconil and brestan at 0.1 per cent in glasshouse condition against bean rust *Uromyces appendiculatus* and found that daconil and brestan at helped in completely control of infection.When they were applied ten days after inoculation in the presence of small pustules, infection was not controlled, but disease development was limited.

Singh and Musymi (1979) reported that the management of rust of cowpea caused by *Uromyces phaseoli* var *vignae* (Barcl.) Arth. By a new systemic fungicide bayleton with three sprays at 21 days interval at the rate of 500g/ha.

Rolim *et al.* (1981) reported that field evaluation oxycarboxin at 2 lit / ha under natural condition on bean rust *Uromyces phaseoli* var. *typica* was found effective followed by triforine at 1.5 lit / ha.

Singh *et al.* (1981) proved that dithane M-45 (0.2%), bayleton (0.025%) and calixin (0.1%) were superior as compared to other fungicides in reducing the rust disease of bean caused by *Uromyces viciaae fabea* Schrot and increased yield.

Kale (1992) opined that management of cowpea rust caused by *Uromyces phaseoli* var *vignae* (Barcl.) by spray with diclobutrazole against rust in field condition.

Kale (1992) reported that *in vitro* evaluation of diclobutrazole and mancozeb at higher concentration (0.25% and 0.3% respectively) completely inhibited the uredospore germination of cowpea rust followed by tridemorph, triadimefon and cyproconazole where as propiconazole and hexaconazole were least effective in inhibiting the uredospore germination.

Upadhyay and Gupta (1994) reported effect of bayleton, calixin, calixin-M, dithane m-45, karathane and sulfex and chemicals were tested against rust (*Uromyces viciae-fabae*) on pea variety, T- 163 and PV-3 susceptible to rust. triadimefon, maneb + tridemorph and tridemorph were found to have effective against rust disease under field conditions.

Diaz Franco and Perez Garcia (1995) reported the effect of propiconazole, triademefon and triforine to control rust of chickpea (*Uromyces ciceris-arietini*). Observations revealed that propiconazole decreased the infection.

Fuzi (1995) reported that result of field with control fungicides to compare their efficacy with that of systemic sterol biosynthesis inhibiting fungicides against rust (*Uromyces pisi*) and powdery mildew (*Erysiphe pisi*) of peas.

Khaled *et al.* (1995) reported chemical control of pea rust (*Uromyces viciae-fabae*) in field during 1989-90 and 1990-91.They tested fungicides benomyl, carboxin, metalaxyl, oxycarboxin, thiram, triadimefon and triforine alone or with macozeb gave good protection against rust.

Pandey *et al.* (1995) observed the control of Lentil rust with fungicides, that the best control was recorded by tridemorph followed by metiram and benomyl.

Ayub *et al.* (1996) evaluated six fungicides propineb, tridemorph, tebuconazole, Oxycarboxin, Carbendazim and propiconazole, were assessed for their ability to control *Uromyces viciae-fabae* (Pers.) de Bary The caused to lentil rust.

Gonzaliz and Garcia (1996) reported that fungicides like mancozeb at (0.2%) and chlorothaonil (0.2%) found effective in the management of bean rust caused by *Uromyces phaseoli*.

Istran (1996) reported that evaluavation of contact fungicides against *Uromyces viciae-fabae* on pea and *Erysiphe pisi.* All the treatments reduced infection the best results were recorded with treatment Opus (epoxyconazole).

Kale and Anahosur (1996) observed that fungicides like triadimefon and mancozeb were equally effective in managing the cowpea rust disease caused by *Uromyces phaseoli* var *vignae* (Barcl.) Arth.

Huq and Nahar (1997) reported that tested four fungicides, propiconazole tridemorph, tebuconzole and Sulfur under field conditions for their ability to management of pea rust (*Uromyces viciae-fabae*)). Four sprays with tebuconazole (0.05%) were highly effective in management of the disease.

Singh and Singh (1997) studied the efficacy of eight fungicides thiophanate-methyl, tridemorph, benomyl, carbendazim, mancozeb, zineb, metalaxyl and fletriafol for the control of pea rust caused by *Uromyces viciae-fabae*. The highly susceptible pea cultivar Rachna was sown and first sprayed as fungicides was applied just after the appeared of symptoms, followed by two more sprayed at ten days interval. All the fungicide treatments significantly reduced the disease severity and increased the grain yield of pea. PP-450 was the most effective fungicide gave 74.7% disease control. From the pooled data of two seasons, it was concluded that three sprayed at 10 days interval of PP-450 at 0.1%, ridomil at 0.2% or calixin at 0.06% may be recommended for the management of pea rust.

Desai (1998) reported that chemical management of fig rust with spray of mancozeb at (0.2%) in all three seasons.

Gupta and Shyam (1998) reported that use of six new fungicides *viz*., triadimefon, hexaconazole, difenconazole, flusilazole, fenarimol and penconazole along with mancozeb and chlorothalonil for the management of pea rust caused by *Uromyces phaseoli* and powdery mildew of pea caused by *Erysiphe polygoni*. They reported that hexaconazole (0.10%) and difenconazole (0.015%) were found highly effective in reducing the severity of rust and increase in the green pod yield.

Sharma (1998) reported that mancozeb was effective fungicide for management of rust of french bean caused by *Uromyces appendiculatus.* The extent of avoidable losses due to this disease was 60.8 per cent during the epidemic year.

Sumartini (1998) studied on rust of french bean (*Phaseolus vulgaris*) caused by *Uromyces phaseoli* (*Uromyces appendiculatus*), observed that triadimefon (bayleton) fungicides was effective. The proper time of triadimefon application (based on rust disease intensity) increased its effectiveness and efficiency, triadimefon sprayed three to five times on one-third of the lower-canopy when the disease intensity was five per cent and then at ten days interval afterwards decreased rust intensity by 22 per cent or 55 per cent in the dry or wet seasons, respectively. This fungicide treatment reduced the fresh pod and grain yield losses by 32 per cent and 62 per cent respectively.

Srivastava (1999) reported that field evaluation seven fungicides carbendazim, thiophanate-methyle, captan, wettable sulfur, ziram, mancozeb and chlorothalonill, against bean rust caused by *Uromyces appendiculatus.*The maximum disease management and highest increase in yield were achieved by thiophanate-methyl followed by carbendazim and wettable sulphur.

Basandrai *et al.* (2000) reported that lentil rust caused by *Uromyces vicia- fabae* (Pers.) de Bary. was managed by seed treatment with a suitable fungicide such as diclobutrazole and also preventive fungicide sprayed of mancozeb at early disease development stage have been recommended.

Gupta and Shyam (2000) reported that pea plants treated with seven fungicides *viz.,* fenarimal, defenoconzole, triadimefon, cyperconazole, flusilazole, henconazole and hexaconazole and two non-systemic mancozeb and chlorothalonil, fungicides after being inoculated with *Uromyces viciae fabae* aeciospores for 72 hr. Cyperconazole, flusilezole, penconazole and hexaconazole completely inhibited rust incidence and rust severity on leaves. mancozeb and chlorothalonil resulted in a rust severity of 22.91 and 38.75 per cent, respectively.

Mahanta *et al.* (2000) reported that french bean seed treatments with carbendazim and thiram at 0.2 and 0.3 per cent respectively and foliar spray with 0.1 per cent carbendazime 0.1 per cent, propiconazole 0.1 per cent, thiophanate-methyl 0.25 per cent, mancozeb, 0.5 per cent and water, were under taken in an experiment in Orissa. Seed treatment with carbendazim or thiram was effective in *Uromyces phaseoli* (*U. apbendiculatus*) and increased crop yield over the control. Among the foliar spray mancozeb were the most effective in reducing the intensity of disease and increasing yield. Seed treatment with thiram and subsequent spraying with mancozeb was the best combination treatment for manageing the rust disease.

Singh and Tripathi (2004) reported that field evaluation of ten fungicides. bitertanol, triadimefon, propiconazole, captafol, tebuconazole, mancozeb, probineb, carbendazim, tridemorph and wettable sulfur against rust of pea. They found that 2 to 3 sprayed of bitertanol, 0.1% at 15 days interval was most effective in reducing the disease severity and resulted in appreciable increase in grain yield.

Rahman *et al.* (2005) reported that influence of time of mancozeb sprays on rust of pea (*Pisum sativum* L.) indicated by *Uromyces viciae-fabae* (pers.) Schroet. revealed that four sprayed (0.2%) at ten days intervals commencing with iniciation of the disease were most effective in reducing rust severity from 69.7% to 10.2% and increasing seed yield from 1108.3 kg to 1824.9 kg per ha.

Ahmed *et al.* (2006) tested efficacy of six fungicides against the controlling of lentil is caused by *Uromyces vicia- fabae* among the six fungicides, propiconazole @ 0.05% was the most effective fungicide against rust disease.

Alam *et al.* (2007) tested efficacy of eight new fungicides against powdery mildew and rust disease of garden pea and they reported that all fungicides resulted significantly better performance over control. Considering per cent disease index (PDI), Pod yield and yield contributing characters. sedozole 5 EC performed better than other fungicides. The highest PDI of both diseases was observed in control treatment, where as the lowest PDI and per cent disease reduction over control was recorded in sedozole 5 EC (propiconazole) may be used for manageing powdery mildew and rust disease and increasing pod yield of garden pea.

Emeran *et al.* (2011) reported effectiveness of eleven foliar fungicides on faba bean rust *(Uromyces viciae-fabae* (Pers. Schröt.) All the fungicides tested provided very effective preventive manageing of rust disease, triazoles (difenoconazol, epoxiconazol, tebuconazole) and their mixtures with benzimidazoles (carbendazim-flutriafol and carbendazim- flusilazole) provided the most effective control.

2.4 Screening the available genotypes for rust disease both field and glasshouse.

Mehta and Mundkur (1946) tested different chickpea cultivars at Karnal (Haryana) for resistance to chickpea rust. Some cultivars showed seedling resistance, which was lost at a later stage. Cultivar IP8a, susceptible in the seedling stage was only mildly attacked later.

Mathura (1954) reported that, the varieties such as*,* Prabhat samagar, 25491-9-1, 488-9-1, RCH-7, CL-1, CL-2, CL-843, Puas barsati, CS -5 and EC 257 -1 found to be resistance against cowpea rust.

Sokhi and Sohi (1976) reported that the possibility of getting healthy crop during rainy season by growing varieties like Cream-40, Iron (immune) and Pusa Barsati moderately resistant to cowpea rust.

Chandrashekar *et al.* (1988) reported that RC -19 and GUJ -2 as highly resistant V-118, V-16, V -70 as (moderately resistant) and C-152 as highly susceptible variety against the cowpea rust.

Anilkumar *et al.* (1989) reported that twenty one promising genotypes of cowpea screened against the cowpea rust caused by *Uromyces phaseoli* var *vignae* (Barcl.) Arth and identified V-105, V-154, V-282 and V-385 to be resistant against rust disease.

Kale (1992) reported that out of twenty four genotypes, the genotype *viz*, Chiroli, CO-4, DFC-1, I-26 and NPRC-2 showed immune reaction against rust disease of cowpea and other 14 genotypes, *viz.,* Iron grey,C-190, CG-5, COVU-623,GC,-827, HG -22, HG-171, I C-38956, P-969, P-1355, V-37, V-28, 82-1-3 and 930-1 were found to be resistant.

Uma and Salimath (2003) screened the cowpea varieties against the rust disease caused by *Uromyces phaseoli* var *vignae* (Barcl.) Arth. Some of varieties of cowpea, such as C-11, C-70 and KM-1 were highly resistant to rust disease.

Madrid *et al.* (2008) stated that a gene that manageing resistance to chickpea rust (*Uromyces ciceris-arietini*) has been identified in a Recombinant Inbred Line (RIL) population derived from an interspecific cross between *Cicer arietinum* (ILC72) x *Cicer reticulatum* (Cr5-10), susceptible and resistant to rust respectively.

Fernandez *et al.* (2011) reported that of fourtythree germplasm of *Vicia faba* screened against the two diseases like chocolate-spot and rust of *Vicia faba*, identified as eleven germplasm that showed better resistanat to both diseases in both field and controlled condition as compared with a susceptible check.

Wahome *et al.* (2011) identified snap bean lines with MDR to angular leaf spot, anthracnose at two locations in Kenya. Among the advanced varieties two bush variety KSB10 W and KSB 10 BR and one climbing variety (HAV130) had consistent multiple disease resistance to angular leaf spot, anthracnose and rust at both the locations.

Deshpande *et al.* (2012) identified some of the potential and novel cowpea genotypes for multiple disease resistance *viz.,* IC 257410, IC257410 and IC214753 (for resistance against rust and leaf spot) IC201095, IC257406, IC257435 (for resistance against leaf spot and CMV) IC202795 (immune to rust and leaf spot), IC202743, IC202786 (immune to rust and CMV) and a novel land race bellary local (immune to rust, leaf spot and CMV).

Gupta *et al.* (2012) reported that among twentyfive chickpea genotypes only three genotypes *viz.*, ICC 3137, ICCV 9675 and ICCL 87316 were found to be moderately resistant against rust. ICCV 9675 and ICCL 87316 were found to be superior for number of pods per plant and seed yield per plant respectively. The studies revealed ICC 3137, ICCV 9675 and ICCL 87316 as diverse genotypes were moderately resistant to rust. These can be utilized as promising genotypes for future breeding and hybridization program with susceptible lines which were otherwise superior for other traits.

Josefina *et al.* (2012) reported that 140 varieties of chickpea (*Cicer arietinum* L.) and 109 of varieties related wild species (*Cicer spp.*) were screened to hickpea rust (*Uromyces ciceris-arietini* (Grognot) Jacz. & Boyd). Varying levels good partial resistance were identified based on a reduced disease severity.The higher levels of resistance were observed in wild *Cicer* species.

Patil (2013) reported that all the presently grown cultivars were highly susceptible to the disease. No source of resistance to rust have been identified and so far only measures relating to sowing dates and chemical control have been proposed. One of the reasons for absence of variability may be its monophyletic descendence from *Cicer reticulatum*. Only a certain degree of slow-rusting has been reported and it tends to be more frequent in wild *Cicer* relatives. Chickpea germplasm line RIL58-ILC72/Cr5 was reported as moderately resistant to rust disease.

Divya *et al.* (2014) reported that totally eleven genotypes were screened against french bean rust under artificial epiphytotic condition among these genotypes Two resistant parents Arka Anoop and IC-525236, three susceptible parents IIHRPB-1, IIHRPB-2 and IIHRPB-7 and six crosses IIHRPB-1 x Arka Anoop, IIHRPB-2 x Arka Anoop, IIHRPB-7 x Arka Anoop, IIHRPB-1 x IC-525236, IIHRPB-2 x IC-525236 and IIHRPB-7 x IC-525236.

Sharma (2014) reported that chickpea varieties such as NRC 34, NEC 249, JM 583, JM 2649, HPC 63, HPC 136 and HP 147 have been found resistance to rust in Lahul valley (Himachal Pradesh) under field conditions.

3. MATERIAL AND METHODS

The present laboratory investigations were carried out at the Department of Plant Pathology, College of Agriculture, University of Agricultural Sciences, Dharwad and the field experiments during *Rabi* 2014-2015 were carried out at, College of Agriculture, Hanumanamatti, University of Agricultural Sciences, and Dharwad. The materials used and the methodology adopted in different experiments are detailed in this chapter.

3.1 General laboratory procedures

3.1.1 Glassware and cleaning

In all the laboratory experimental studies, Borosil glass wares were used. The glasswere, were kept in the cleaning solution containing 60 g potassium dichromate ($K_2Cr_2O_7$) and 60 ml of concentrated sulphuric acid (H_2SO_4) in one litre of water for a day. Then, they were cleaned by washing with detergent followed by rinsing several times in tap water and finally in distilled water.

3.1.2 Sterilization

All glassware, solid and liquid media were sterilized by autoclaving at 1.1 kg per cm^2 (121˚C) for 20 minutes. The plant tissues were surface sterilized in 1:1000 sodium hypochloride solution followed by three changes in sterile water. All cultural studies were conducted in aseptic condition under laminar flow. The tips of inoculation needle, forceps and were sterilized under flame.

3.2 Survey to assess the severity of cowpea rust disease in northern Karnataka

A roving survey was conducted during *kharif, rabi* and summer seasons of 2014-2015 in major cowpea growing areas of northern Karnataka *viz.,* Dharwad, Bagalkot, Haveri and Belgaum districts. In each district five villages were surveyed and in each village one to three fields were surveyed for recording the severity of cowpea rust. Severity was recorded by following 0-9 Scale (Mayee and Datar, 1986). Similarly to monitor the disease severity in the fixed plot survey was taken up at MARS, Dharwad during *kharif, rabi* and summer 2014.

3.2.1 Methodology

During the survey each field 15 plants were selected at random for recording the severity of cowpea rust. Based on this data disease severity was worked out and expressed Per cent Disease Index (PDI) as per by Wheeler (1969).

3.2.2 Disease scoring scale description

Grade	Description
0	No symptoms on leaf
1	Small, round, powdery, brown uredosori covering one per cent or less of the leaf area
3	Typical uredosori, covering 1 to 10 per cent of the leaf area
5	Typical uredosori, covering 11 to 25 per cent of the leaf area
7	Typical uredosori, covering 26 to 50 per cent of the leaf area
9	Uredosori cover 51 per cent or more of the leaf area. Withering of the leaves.

(Kale, 1992)

$$\text{PDI} = \frac{\text{Sum of individual disease ratings}}{\text{No. of leaves assessed} \times \text{Maximum disease grade on rating scale}} \times 100$$

Observations recorded

1. Disease severity on leaves stems and pod

2. Stage of the crop

3. Irrigated or rainfed

4. Cropping system

The infected samples were collected from the farmers field during the survey time and the spores were dislodged from the leaves using a camel foot brush and collected both in small test tube both spores and leaves sample were stored at – 70^0 C deep freezer and further were used for various *in vitro* and pot culture experiment in glass house.

3.2.3 Pathogencity studies

Diseased leaf samples were collected from the variety C -152 from the Main Agriculture research station (MARS), Dharwad during *kharif* 2014 and were brought to the laboratory in polythene bags. The uredospores spore suspension was prepared with distilled water with a concentration of more than 100 uredospores per microscopic field observation. These prepared spore suspension was used for artificial inoculation to cowpea seedling raised in pots in glasshouse.

The cowpea seedlings were raised in pots in the glass house and 25 days old seedlings were inoculated with uredospores spore suspension by spraying the foliage and also followed by the leaf stapling method and cotton swabbing method, these seedlings were incubated by covering polythene bag in glasshouse to maintain high relative humidity (90%) and 20^0 C lower temperature for expression of symptoms. The inoculated seedlings were monitored for expression of symptoms. Prior to their artificial inoculation the cowpea seedling were sprayed with water and covered with polythene bags for 24 hours, which helped creation of high relative humidity.

3.2.4 Morphology of the pathogen

Infected leaf samples were collected from the rust affected cowpea field on C- 152 from the College of Agriculture, farm, Dharwad during *kharif* 2014 and were brought to the laboratory in polythene bag. The hand section of rust pustules from leaves were taken, mounted in lactophenol on a clean washed glass slide. A cover slip was placed over the suspension and studied the uredospores with regard to their morphology. Length and breadth of uredospores was recorded. The colour, shape, echinulation were recorded for the spores. All the measurements were made under high power with a Olympus Images, work carried out at AICRP on soybean MARS Dharwad.

3.3 Identification of susceptible stage for the infection of rust of cowpea.

Staggered sowing in pots at an interval of ten days was done in a glasshouse so as to get 10, 20, 30, 40, 50, 60, 70 and 80 days old plants for simultaneous inoculations. The inoculation was done simultaneously for all the stages. Three pots for each plant age group were maintained. The spraying with a uredospores suspension with concentration rich in suspension at least more than 1000 uredospores per microscopic field .The inoculated plants were covered with polythene bag for 48 hrs to create high humidity. The observations on disease severity were recorded on the 10th day after inoculation using 0 to 9 scale and per cent disease index was calculated.

3.3.1 Different date of sowings under glass house condition to identify the most susceptible stage of infection

Different date of sowing

24 -7- 2014	4 -8 – 2014	14 - 8 – 2014	24 - 8 - 2014
4 - 9 – 2014	14 - 9 – 2014	24 - 9 – 2014	4- 10 – 2014

3.4 *In vitro*, glasshouse and field evaluation of fungicide molecules against the rust.

3.4.1 *In vitro* evaluation of fungicides

Various fungicides were evaluated under *in vitro* condition by spore germination technique. The required concentrations were prepared by dissolving known quantity of fungicides in sterile distilled water separately under aseptic conditions. The uredospores spores suspension was prepared separately in sterile distilled water. A drop of a spore suspension was mixed with one drop of fungicide solution in a cavity slide to achieve the required concentration. In each treatment, three replications were maintained. Slides were then incubated at a room temperature (25±1°C) for 24 hours. The observation on the spore germination was recorded at different intervals *viz.,* 0 hours, 12 hours, 24 hours, 48 hours, and 72 hours after incubation under microscope at 400 x magnifications. A control with only sterile water was maintained. per cent uredospores germination was calculated by the following formula given by Vincent (1947).

$$I = \frac{C - T}{C} \times 100$$

I = Per cent inhibition

C = Number of spores germinated in control

T = Number of spores germinated in treatment

The bioassay of four non systemic fungicides (at the concentration of 0.1%, 0.2% and 0.25%), four systemic fungicides (at the concentration of 0.05%, 0.1% and 0.15%) and four combi products (0.1%, 0.2% and 0.25%) were taken under *in vitro* conditions.

List of chemicals used for the *in vitro* studies

Non systemic fungicides	Trade name	Conc (%)		
Mancozeb 75 WP	Dithane M-45	0.1	0.2	0.25
Chlorothalonil 70 WP	Kavach	0.1	0.2	0.25
Copper oxychloride 50 WP	Blitex	0.1	0.2	0.25
Zineb 68 WP	Dithane Z-78	0.1	0.2	0.25
Systemic fungicides Conc (%)				
Propiconazole 25 EC	Tilt	0.05	0.1	0.15
Hexaconazole 5 EC	Contf	0.05	0.1	0.15
Tebuconazole 250 EW	Raxil	0.05	0.1	0.15
Difenconazole 25 EC	Score	0.05	0.1	0.15
Combi products Conc (%)				
Carbendazim 12% + Mancozeb 68% WS	Saaf	0.1	0.2	0.25
Trifloxystrobin 25% + Tebuconazole 50% W/W	Native	0.1	0.2	0.25
Hexaconazole 4 + Zineb 68	Avtar	0.1	0.2	0.25
Hexaconazole 5% + Captan 70% WP	Taqat	0.1	0.2	0.25

3.4.2 Evaluation of fungicide molecules against the rust under glasshouse condition and field condition

Glasshouse experiment was conducted during *karif* 2014, at the Department of Plant Pathology, College of Agriculture, University of Agricultural Sciences, Dharwad in order to find out suitable fungicides and its concentration in managing the disease with a susceptible variety C-152 was used with the details of the experiment were presented below.

Details of the glasshouse experiment

- Location: Dept. of Plant Pathology ,Colloge of Agriculture,Dharwad
- Variety : C-152
- Three pots for each treatment
- Number of treatments : 12
- Number of replications : 03

Treatment details

T_1	Spray with Mancozeb 75% WP @ 0.25 at 50% flowering
T_2	Spray with Chlorothalonil 75% WP @ 0.25% at 50% flowering
T_3	Spray with Copper oxychloride 50 WP @ 0.25% at 50% flowering.
T_4	Spray with Zineb 75% WP @ 0.25% at 50% flowering.
T_5	Spray with Propiconazole 25% EC @ 0.1% at 50% flowering.
T_6	Spray with Hexaconazole @ 0.1% at 50% flowering.
T_7	Spray with Tebuconazole 25% EC @ 0.15% at 50% flowering
T_8	Spray with Difenconazole 25% EC @ 0.15% at 50% flowering
T_9	Spray with Mancozeb 63% + Carbendazim 12% WP @ 0.25% at 50% flowering.
T_{10}	Spray with Zineb 68% + Hexaconazole 4% @ 0.1% at 50% flowering.
T_{11}	Spray with Trifloxystrobin 5% + Tebuconazole 50%W/W @ 0.1% at 50% flowering.
T_{12}	Spray with Captan 70% + Hexaconazole 5% @ 0.1% at 50% flowering
T_{13}	Control

The observations of disease severity were recorded by useing 0-9 scale and Per cent disease index was worked out as par Wheeler (1969). A field experiment was conducted during *Rabi* 2014, at College of Agriculture Hanumanamatti, in order to find out suitable fungicides and its concentration in managing the disease. The details of the experiment are presented below.

Soil characteristics

The soil of experimental site was red sandy soil in nature. The physical and chemical properties were congenial for the growth of crop.

Details of field experiment

Location : College of Agriculture, Hanamanamatti

Design : Randomized Block Design

Variety : C- 152

Plot size : 1.8 x 4 sq.mts

Number of treatments : 12

Number of replication : 03

Treatment details

T_1	Spray with Mancozeb 75% WP at 0.25 at 50% flowering
T_2	Spray with Chlorothalonil 75% WP @ 0.25% at 50% flowering
T_3	Spray with Copper oxychloride 50 WP @ 0.25% at 50% flowering.
T_4	Spray with Zineb 75% WP @ 0.25% at 50% flowering.
T_5	Spray with Propiconazole 25% EC @ 0.1% at 50% flowering.
T_6	Spray with Hexaconazole @ 0.1% at 50% flowering.
T_7	Spray with Tebuconazole 25% EC @ 0.15% at 50% flowering
T_8	Spray with Difenconazole 25% EC @ 0.15% at 50% flowering

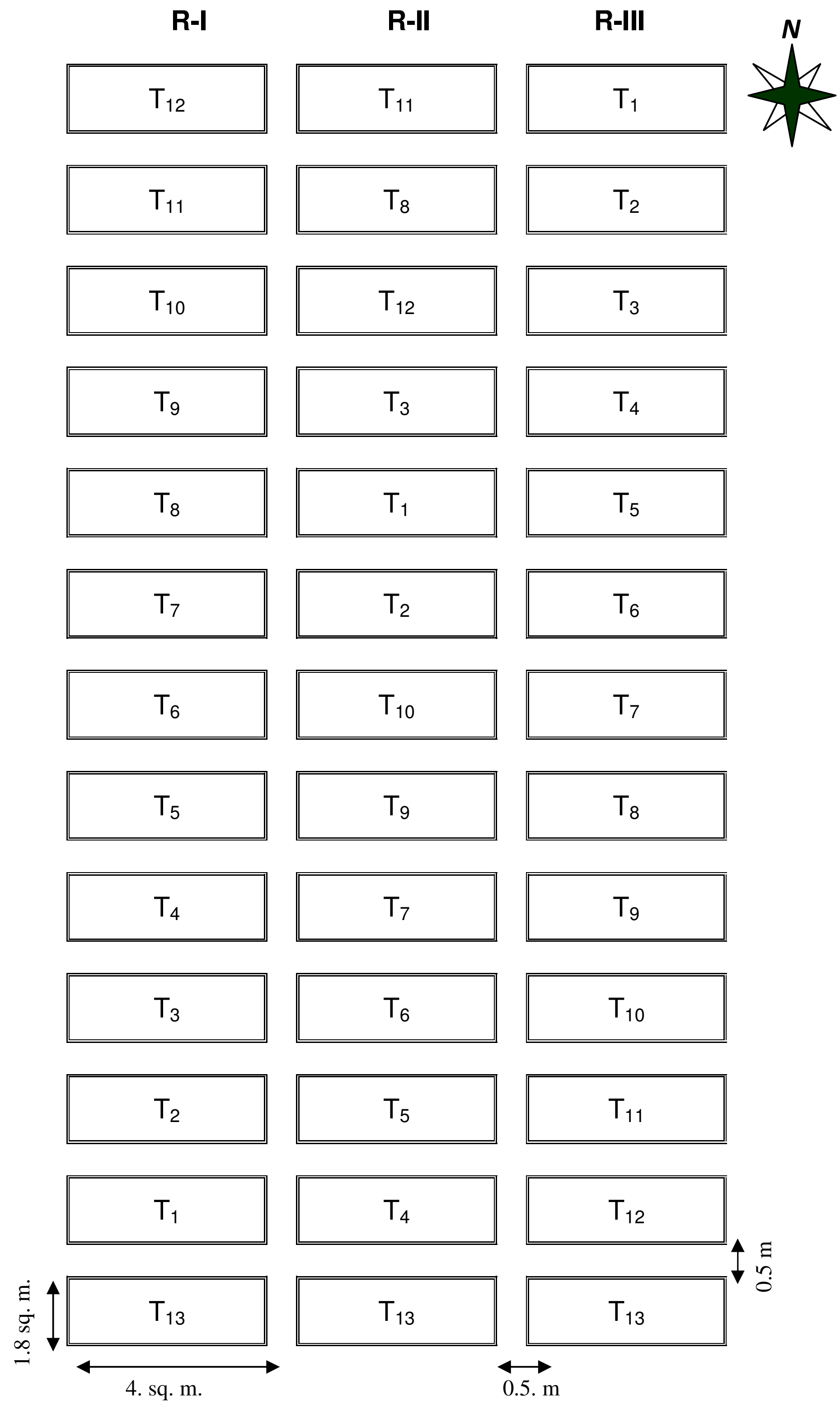


Fig. 1: Plan of layout

T_9	Spray with Mancozeb 63% + Carbendazim 12% WP @ 0.25% at 50% flowering.
T_{10}	Spray with Zineb 68% + Hexaconazole 4% @ 0.1% at 50% flowering.
T_{11}	Spray with Trifloxystrobin 5% + Tebuconazole 50%W/W @ 0.1% at 50% flowering.
T_{12}	Spray with Captan 70% + Hexaconazole 5% @ 0.1% at 50% flowering
T_{13}	Control

Observations recorded

1. Disease severity at periodical intervals (0-9) scale and worked out PDI as par wheeler (1969)
2. Yield parameters.
3. Economic analysis.

3.5 To screen the available genotypes for rust disease both in field and glasshouse

3.5.1 Screening of promising entries under artificial inoculation in glasshouse against rust disease of cowpea

Eighteen promising cowpea varieties obtained from the Department of Genetics and Plant Breeding, College of Agriculture, University of Agricultural Sciences, Dharwad, were screened against rust disease *(Uromyces phaseoli* var.*vignae (*Barcl.) Arth) of cowpea under glasshouse conditions. Three seeds of each cultivar were sown per pot and two such pots were maintained for each genotype. Later, two seedlings per pot were maintained for screening purpose. The uredospores suspension of rust pathogen was prepared and seedlings were inoculated with the spore suspension 30-35 days after sowing by spraying method. The inoculated plants were kept for incubation, each pots (seedlings) was covered with a polythene bags for 10 days, it helped to create higher relative humidity and low temperature for expression of symptoms. The observation on severity of rust was recorded on tenth day after inoculation by useing 0 to 9 scales given by Mayee and Datar (1986).

3.5.2 Field screening of available genotypes for rust disease

Eighteen promising cowpea genotypes with good agronomic practices were screened against rust disease to identify rust resistance sources under field condition at the Main Agricultural Research Station (MARS), University of Agricultural Sciences, and Dharwad. The genotypes were obtained from the Dept of Genetics and Plant Breeding, Agriculture College Dharwad. The observations were recorded by using 0-9 scale (Mayee and Datar, 1986) by selecting five plants in each genotype. Based on their reactions the genotypes categorised as immune, resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible entries.

Thirty one promising materials of cowpea were screened against rust disease to identify rust resistance sources under natural epiphytotic field condition at The Main Agricultural Research Station (MARS), University of Agricultural Sciences Dharwad during *kharif,* 2014. The genotypes were obtained from Dept of Genetics and Plant Breeding Agriculture College Dharwad the observations were recorded by using 0-9 scale (Mayee and Datar, 1986) by selecting five plants in each genotype. Based on their reactions the genotypes categorised as immune, resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible entries.

Details of field experiment

Location	: MARS Dharwad
Date of sowing	: 25.7.2014
Design	: Augmented
Plot size	: 6 x3 mts
Spaceing	: 45x10 cm
Date of observation	: 10.9.2014

3.6 Statistical analysis

The statistical analysis was done as per the procedure given by Panse and Sukhatme (1985).

4. EXPERIMENTAL RESULTS

The results of the experiment conducted in the Department of Plant Pathology, UAS, Dharwad and field experiments at MARS Dharwad and College of Agriculture Hanumanamatti, University of Agricultural Sciences, and Dharwad, during 2014-15 were presented here under.

4.1 Survey for recording the severity of cowpea rust in northern Karnataka

Survey for cowpea rust disease was carried out in four districts of northern Karnataka during *kharif, rabi* and summer 2014-15 to find out the severity of the disease, as explained in the “Material and Methods” and the village wise disease severity has also been presented in Table 1 to 5.

4.1.1 Severity of cowpea rust during *kharif,* 2014

The results on severity of rust in northern Karnataka are presented in Table 1a, 1b and 1c, Plate 1, 2, and 3. The maximum mean severity of cowpea rust was observed in Dharwad district (35.29 PDI) followed by Belagavi district (34.06 PDI) and Haveri district (31.38 PDI). The minimum severity was noticed in Bagalkot district (29.98 PDI).

In Dharwad district maximum disease severity of cowpea rust was recorded at MARS, Dharwad (43.55 PDI) at pod development stage followed by Yattitanagudda village (40.88 PDI) at pod development stage. However, least disease severity was observed in selavadi village of Navalgund taluk (30.30 PDI) at flowering stage of the crop. Among these four taluks surveyed the highest average severity of cowpea rust was observed in Dharwad taluk (36.93 PDI) followed by Hubballi taluk (35.62 PDI) and Kundagol taluk (34.91 PDI). The least average severity was observed in Navalgund taluk (33.71 PDI).

In Belagavi district, the maximum severity of cowpea rust was recorded in Inchal village (41.00 PDI) of Bailhongal taluk, at pod development stage followed by Belavadi village (39.78 PDI) of Bailhongal taluk at flowering stage. The minimum severity

Table 1a: Survey to assess the severity of cowpea rust disease in northern Karnataka during *kharif* 2014

District	Taluk	Village	Stage of the crop	Type of cultivation	PDI
Bagalkot	Bagalkot	Bevinamatti	Flowering	Rainfed	31.96
		Honnakatti	Pod development	Rainfed	33.37
		Sorkoppa	Pod development	Rainfed	31.59
				Taluk mean	**32.38**
	Badami	Guledagudda	Flowering	Rainfed	33.46
		Kerur	Pod development	Irrigated	30.92
		Kulgeri	Flowering	Rainfed	29.77
				Taluk mean	**31.38**
	Bilagi	Badagandi	Pod development	Rainfed	27.28
		Girisagara	Flowering	Rainfed	29.97
		Teggi	Flowering	Rainfed	26.98
				Taluk mean	**34.91**
	Hungund	Amingad	Pod development	Rainfed	31.68
		Kodihal	Flowering	Rainfed	23.35
		Ilkal	Flowering	Rainfed	33.28
				Taluk mean	**29.43**
	Mudhol	Dadanatti	Pod development	Rainfed	30.44
		Killa Hoskote	Flowering	Rainfed	27.33
		Shirur	Flowering	Rainfed	28.22
				Taluk mean	**28.66**
				District mean	**29.98**
Belagavi	Bailhongal	Belavadi	Flowering	Irrigated	39.78
		Budarkatti	Pod development	Irrigated	33.67
		Honaga	flowering	Rainfed	36.22
		Inchal	Pod development	Rainfed	41.00
		Kakati	Pod development	Irrigated	34.67
				Taluk mean	**36.35**

Contd……

District	Taluk	Village	Stage of the crop	Type of cultivation	PDI
Belagavi	Gokak	Boregal	Pod development	Irrigated	25.67
		Goturu	Flowering	Rainfed	36.00
		Kavali katti	Flowering	Rainfed	25.32
		Khanapura	Pod development	Irrigated	28.67
		Musaguppi	Flowering	Rainfed	28.78
				Taluk Mean	**31.78**
				District Mean	**34.06**
Dharwad	Dharwad	Amminabhavi	Flowering	Rainfed	32.44
		Hebballi	Flowering	Rainfed	33.33
		Kannvihonnapur	Pod development	Rainfed	37.77
		MARS, Dharwad	Pod development	Rainfed	43.55
		Mugali	Pod development	Rainfed	40.11
		Narendra	Pod development	Rainfed	30.33
		Yattinagudda	Pod development	Rainfed	40.88
				Taluk mean	**36.93**
	Hubballi	Amargola	Pod development	Rainfed	32.44
		Gabbur	Pod development	Rainfed	34.33
		Bomma samudra	Maturity	Rainfed	36.66
		Belagali	Pod development	Rainfed	38.60
		Siraguppi	Pod development	Rainfed	36.11
				Taluk mean	**35.62**
	Kundagol	Gudenakatti	Flowering	Rainfed	32.55
		Ramanakoppa	Flowering	Rainfed	35.64
		Samsi	Flowering	Rainfed	36.55
				Taluk mean	**34.91**
	Navalgund	Annigeri	Pod development	Irrigated	32.11
		Basapur	Pod development	Rainfed	36.22
		Majjigudda	Pod development	Rainfed	34.22
		Sasvihalli	Flowering	Rainfed	35.71
		Selavadi	Flowering	Irrigated	30.30
				Taluk mean	**33.71**
				District mean	**35.29**

Contd…

District	Taluk	Village	Stage of the crop	Type of cultivation	PDI
Haveri	Hanagal	Akkialur	Flowering	Rainfed	33.67
		Masanagatti	Pod development	Rainfed	39.11
		Tilavalli	Pod development	Rainfed	35.00
				Taluk mean	**35.92**
	Haveri	Guttal	Flowering	Rainfed	31.00
		Haveri	Flowering	Rainfed	28.55
		Negalur	Flowering	Rainfed	25.22
				Taluk mean	**28.25**
	Ranebennur	Asundi	Flowering	Rainfed	37.22
		Chalageri	Maturity	Rainfed	31.13
		Itagi	Pod development	Rainfed	27.61
				Taluk mean	**31.98**
	Shiggaum	Bankapur	Flowering	Rainfed	34.67
		Hulagur	Flowering	Rainfed	25.94
		Kengapur	Flowering	Rainfed	24.75
				Taluk mean	**28.45**
				District mean	**31.38**

Table 1b: Taluk wise mean severity of rust disease of cowpea during *kharif* 2014

District	Taluk	Range	PDI
Bagalkot	Bagalkot	Max	33.37
		Min	31.59
		Average	**34..22**
	Badami	Max	33.46
		Min	29.77
		Average	**31.61**
	Bilagi	Max	29.97
		Min	25.98
		Average	**27.97**
	Hungund	Max	33.28
		Min	23.35
		Average	**28.31**
	Mudhol	Max	30.44
		Min	27.33
		Average	**28.88**
Belagavi	Bailhongal	Max	41.00
		Min	33.67
		Average	**37.33**
	Gokak	Max	36.00
		Min	25.67
		Average	**30.66**
Dharwad	Dharwad	Max	43.55
		Min	30.30
		Average	**36.92**
	Hubballi	Max	38.60
		Min	32.44
		Average	**35.52**
	Kundagol	Max	37.55
		Min	32.55
		Average	**35.05**
	Navalgund	Max	36.71
		Min	30.30
		Average	**33.26**
Haveri	Hanagal	Max	39.11
		Min	33.67
		Average	**36.39**
	Haveri	Max.	31.00
		Min.	25.55
		Average	**28.27**
	Ranebennur	Max	37.22
		Min	27.61
		Average	**32.42**
	Shiggava	Max	34.67
		Min	24.75
		Average	**29.71**

Table 1c: Cowpea rust severity as influenced by cropping situation, stage of the crop and location during 2014

		Kharif			
		Cropping situation		**Stage of the crop**	
		Rainfed	**Irrigated**	**Flowering**	**Pod development**
Mean PDI		39.45	32.66	30.51	25.11
Districts		Bagalkot	Belagavi	Dharwad	Haveri
Mean PDI		29.98	34.06	35.35	31.38
Range	**Min.**	23.35	25.32	30.33	24.75
	Max.	33.46	41.00	43.55	39.11

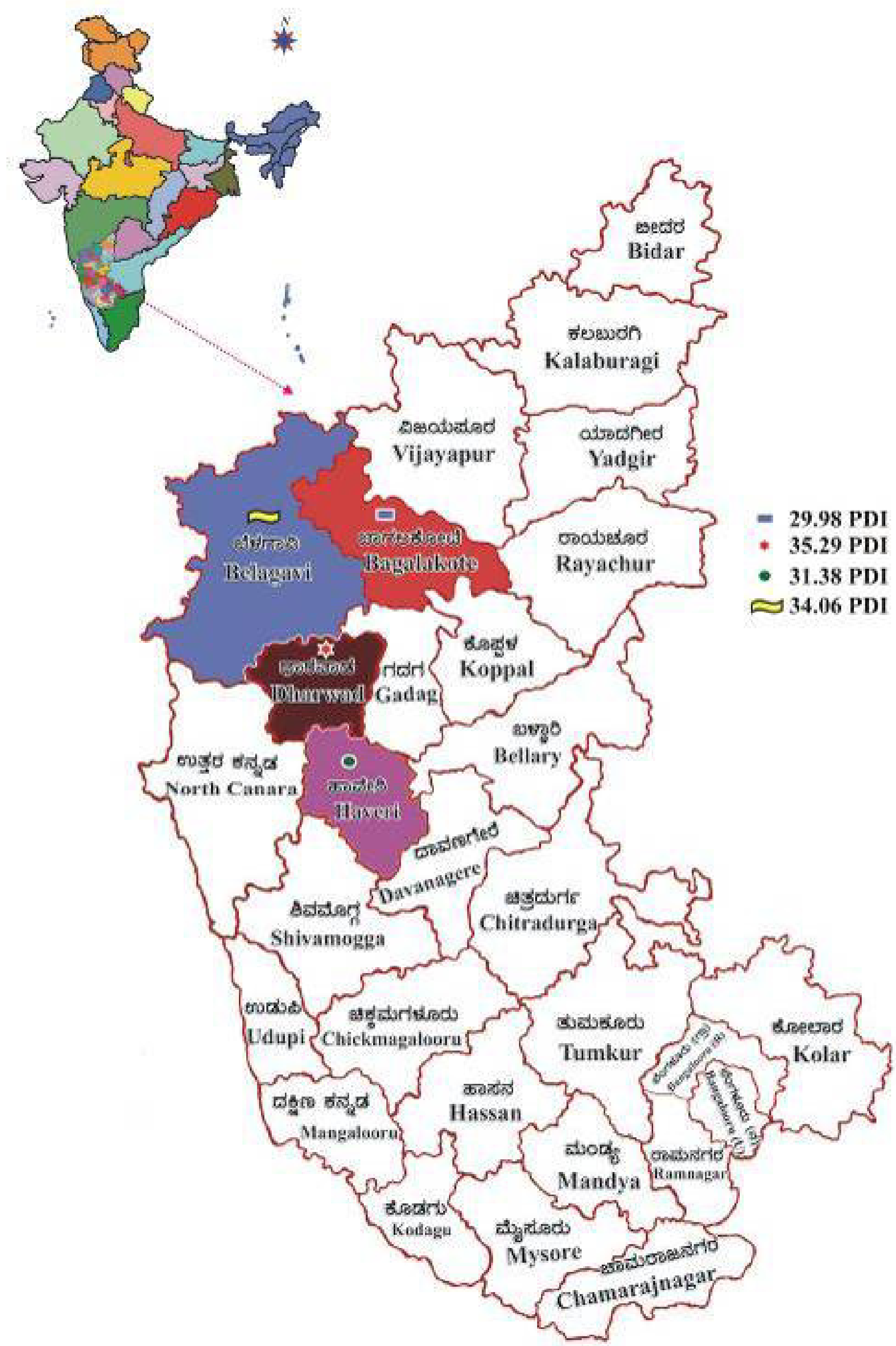


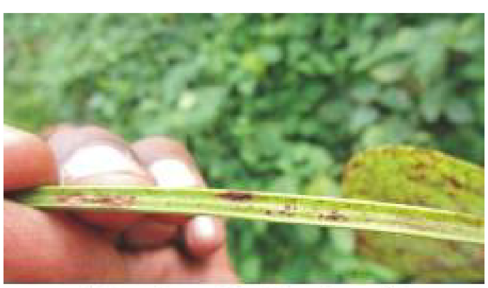
Fig. 2: Severity of cowpea rust in major growing areas of northern Karnataka

Plate 1: Disease rating scale for rust.

a) Pustules on lower surface of the leaf

b) Pustules on upper surface of the leaf

c) Pustules completely covered on surface of the leaf



d) Pustules produced on the petiole

Plate 2: Symptoms of cowpea rust.

was observed in Kavalikatti village (25.32 PDI)) of Gokak taluk at pod development stage, followed by Boregal (25.67 PDI) of Gokak taluk at pod development stage. Among the two talukas surveyed the highest average disease severity (36.35 PDI) was observed in Bailhongal taluk. The least disease severity was observed in Gokak taluk (31.78 PDI).

In Bagalkot district, the maximum disease severity of cowpea rust was recorded in Guledagudda (33.46 PDI) of Badami taluk at flowering stage followed by Honnakatti (33.37 PDI) of Bagalkot taluk at pod development stage. The minimum severity was observed in Kodihal village (23.35 PDI) of Hunagund taluk at flowering stage. Among the five taluks surveyed the highest average disease severity was observed in Bagalkot taluk (32.38 PDI) followed by Badami taluk (31.38 PDI). The least disease severity was observed in Bilagi taluk (28. 28 PDI).

In Haveri district, the maximum severity of cowpea rust was recorded in Masanagatti village (39.11 PDI) of Hanagal taluk at pod development stage followed by Asundi village (37.22 PDI) of Ranebennur taluk at flowering stage. The minimum severity was observed in Kengapur village (24.75 PDI) of Shiggaon taluk at flowering stage. Among the four taluks surveyed the highest average severity of cowpea rust was observed in Hanagal taluk (35.92 PDI). The least disease severity was observed in Haveri taluk (28.25 PDI).

4.1.2 *Rabi* season

The result on severity of rust in northern Karnataka presented in Table 2. The maximum mean severity of cowpea rust was observed in Dharwad district (17.09 PDI) followed by Belagavi district (12.92 PDI) and Haveri district (12.76 PDI). The minimum severity was noticed in Bagalkot district (2.99 PDI).

In Dharwad district the maximum disease severity of cowpea rust was recorded at MARS, Dharwad (27.44 PDI) at pod development stage followed by Somaopur village (20.00 PDI) at flowering stage. However, least disease severity was observed in Bhadrapuru village of Navalgund taluk (11.00 PDI) at pod development of the crop. Among these three taluks surveyed, the highest average severity of cowpea rust was

Table 2: Survey to assess the severity of cowpea rust disease in northern Karnataka during *rabi* 2014-15

District	Taluk	Village	Stage of the crop	Type of cultivation	PDI
Bagalkot	Bagalkot	Kankanakoppa	Pod development	Irrigated	11.11
		Neerlkeri	Pod development	Irrigated	15.56
		Sulikeri	Pod development	Rainfed	-
				Taluk mean	**13.33**
	Badami	Belure	Pod development	Rainfed	0.00
		Chimalagi	Flowering	Irrigated	0.00
		Katapur	Pod development	Rainfed	0.00
				Taluk mean	**0.00**
	Hungunda	Bhimanagada	Flowering	Irrigated	0.00
		Gudur	Pod development	Irrigated	0.00
		Sulibavi	Flowering	Irrigated	0.00
				Taluk mean	**0.00**
				District mean	**0.00**
Belagavi	Bailhongal	Badal anakalagi	Flowering	Irrigated	15.56
		Belavadi	Flowering	Rainfed	13.00
		Budarkatti	Pod development	Irrigated	11.11
				Taluk mean	**13.22**
	Belagavi	Kakati	Pod development	Irrigated	14.75
		Sutagatti	Flowering	Irrigated	13.33
		Vantamuri	Flowering	Rainfed	10.00
				Taluk mean	**12.69**
				District mean	**12.95**
Dharwad	Dharwad	Hebblli	Flowering	Rainfed	13.33
		MARS Dharwad	Pod development	Rainfed	27.44
		Narendra	Pod development	Rainfed	15.56
		Somapur	Flowering	Rainfed	20.00
				Taluk mean	**19.08**
	Hubballi	Amargola	Pod development	Rainfed	20.00
		Belagali	Flowering	Irrigated	13.30
		Sirguppi	Pod development	Rainfed	22.25
		Varur	Flowering	Rainfed	**0.00**
				Taluk mean	**11.22**
	Navalagunda	Bhadrapur	Pod development	Rainfed	11.00
		Hallikeri	Pod development	Rainfed	15.56
		Nalavadi	Flowering	Rainfed	14.44
				Taluk mean	**13.70**
				District mean	**17.09**
Haveri	Haveri	Devihosure	Pod development	Irrigated	0.00
		Haveri	Flowering	Irrigated	0.00
		Karajagi	Pod development	Irrigated	0.00
		Neralagi	Flowering	Irrigated	0.00
				Taluk mean	**0.00**
	Ranebennur	Asundi	Flowering	Irrigated	31.11
		Hanumanamatti	Flowering	Rainfed	10.00
		Itagi	Pod development	Irrigated	20.00
		Kakola	Pod development	Irrigated	15.56
				Taluk mean	**25.52**
				District mean	**12.95**

observed in Dharwad taluk (19.08 PDI) followed by Hubballi taluk (18.51 PDI) the least average severity was observed in Navalgund taluk (13.70 PDI) of the areas recorded least severity of rust disease.

In Bagalkot district cowpea rust was recorded in Neerlkeri village (15.56 PDI) at Pod development stage, where as in most of the areas there was no incidence of rust disease.

In Haveri district, the maximum severity of cowpea rust was recorded in Asundi village (31.11 PDI) of Ranebennur taluk at pod development stage followed by Itagi village (20.00 PDI) of Ranebennur taluk at pod development stage. The minimum severity was observed in Hanumanamatti village (10.00 PDI) of Ranebennur taluk at flowering stage.

In Belagavi district, the maximum severity of cowpea rust was recorded in Badal Anakalagi village (15.56 PDI) of Bailhongal taluk at flowering stage followed by Kakati village (14.75 PDI) of Belagavi taluk at pod development stage. The minimum severity was observed in Vantamuri village (10.00 PDI)) of Belagavi taluk at flowering stage. Among the two talukas surveyed the highest average disease severity (13.22 PDI) was observed in Bailhongal taluk. The least disease severity was observed in Belagavi taluk (12.69 PDI).

4.1.3 Summer season

The result on severity of rust in northern Karnataka presented in Table 3. In Dharwad district, Botanical garden of MARS Dharwad incidence of rust severity was (17.55 PDI) in Dharwad taluk (6.91 PDI) and there was no disease in other areas of district. In Haveri district rust incidence was in Ranebennur taluk.

In Bagalkot district there was no cowpea rust disease, and also there was no severity of cowpea rust disease in other two districts. This rust disease was only severity in the *kharif* season and followed by in *rabi* only few per cent of disease was present in this season and in summer there was no incidence of rust.The result on fixed plot survey conducted and presented in Table 4 and 5.

Table 3: Survey to assess the severity of cowpea rust disease in northern Karnataka during summer 2014-15

District	Taluk	Village	Stage of the crop	Type of cultivation	PDI
Bagalkot	Bagalkot	Honnakatti	Pod development	Rainfed	0.00
		Neelgund	Pod development	Rainfed	0.00
		Sulla	Pod development	Irrigated	0.00
				Taluk mean	**0.00**
	Badami	Holehalure	Pod development	Rainfed	0.00
		Hosur	Pod development	Rainfed	0.00-
		Kerur	Flowering	Irrigated	0.00
				Taluk mean	**0.00**
	Hunagund	Basavanal	Pod development	Rainfed	0.00
		Ilakal	Flowering	Irrigated	0.00
		Kamatagi	Flowering	Irrigated	0.00
				Taluk mean	**0.00**
				District mean	**0.00**
Belagavi	Bailhongal	Belavadi	Flowering	Rainfed	0.00
		Inchal	Pod development	Irrigated	0.00
		Nesargi	Flowering	Irrigated	0.00
				Taluk mean	0.00
	Gokaka	Lolasur	Flowering	Irrigated	0.00
		Musaguppi	Flowering	Rainfed	0.00
		Tigadi	Pod development	Irrigated	0.00
Dharwad	Dharwad	Amminabavi	Pod development	Rainfed	000.
		IGFRI Block	Flowering	Rainfed	0.00
		MARS Dharwad	Flowering	Rain fed	17.55
		Narendra	Pod development	Rainfed	10.12
				Taluk mean	**13.83**
	Hubballi	Bhadrapur	Flowering	Rainfed	0.00
		Hubballli	Pod development	Irrigated	0.00
		Sirguppi	Pod development	Rainfed	0.00
	Navalagund	Alagavadi	Pod development	Rainfed	0.00
		Annigeri	Flowering	Rainfed	0.00
		Amaragol	Pod development	Rainfed	0.00
				Taluk mean	**0.00**
				District mean	**0.00**
Haveri	Haveri	Devihosure	Pod development	Irrigated	0.00
		Nelogall	Flowering	Rainfed	0.00
		Devagiri	Pod development	Irrigated	0.00
		Haveri	Flowering	Rainfed	0.00
	Ranebennur	Asundi	Pod development	Irrigated	22.55
		Halageri	Flowering	Irrigated	0.00
		Hanumanamatti	Flowering	Rainfed	0.00
		Kakola	Pod development	Rainfed	0.00
				Taluk mean	0.00
				District mean	11.27

In fixed plot surveyed, the maximum severity of cowpea rust was recorded in *kharif* season (39.30 PDI) at pod development stage followed by the *rabi* (21.76 PDI) at flowering stage. The disease severity in the summer season was (17.55 PDI) at flowering stage.

4.1.4 Symptoms of cowpea rust

The infection was noticed on the lower surface of the leaves in the form of raised sori. Infection was evident first as minute almost white, slightly raised pustules which later become distinct, reddish brown circular sorry that were typical of true rust. These sori were initially covered with epidermis which ruptures in spore releasing spore dust. Under favourable weather conditions numerous sori appeared. Similarly sori also covered on the upper surface of the leaves on same point of infection. The symptoms were more conspicuous on the leaves even though disease spread to petioles (Plate 3).

4.1.5 Morphological characters of the pathogen

The morphological characters of the pathogen causing rust of cowpea collected from affected plant from MARS Dharwad with respect to their uredospores were studied as described in Materials and Methods. The hand sections taken from cowpea rust pustule on slide were observed for the morphological characters of the pathogen. Pustules were brown in colour. They were globoid or ellipsoid, echinulate and single celled, sessile. Uredospores measured 22 to 34 µm in length and 18 to 24 µm in breadth. The spore wall was golden brown in colour (Plate 4).

4.1.6 Proving pathogencity of rust disease

The artificial inoculation of cowpea plants was carried out as explained as explained in “Materials and Methods”. To establish the pathogencity of the pathogen and also study the symptom of cowpea rust.

When the cowpea leaves were inoculated with the uredospores of *Uromyces phaseoli* var.*vignae (*Barcl.) Arth. The characteristics, slightly raised pustules appeared which are later turned to reddish brown. Small, circular raised pustules on lower surface of leaves were observed seven days after inoculation. After ten days of inoculation appeared characteristics numerous pustules was observed subsequently in

Table 4: Fixed plot survey to assess the severity of cowpea rust disease in MARS Dharwad during 2014-15 on cultivar C-152

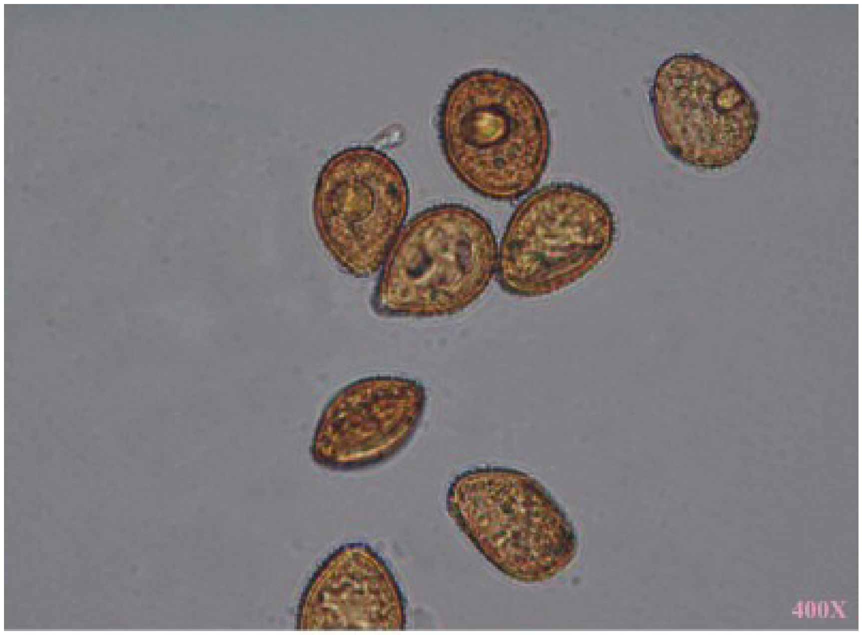
	Season	**Per cent disease index (PDI)**	
		Rainfed (PDI mean)	**Irrigated (PDI mean)**
MARS, Dharwad	*Kharif*	39.30	No crop
	Rabi	21.76	No crop
	Summer	No crop	17.55

a) *Kharif* season

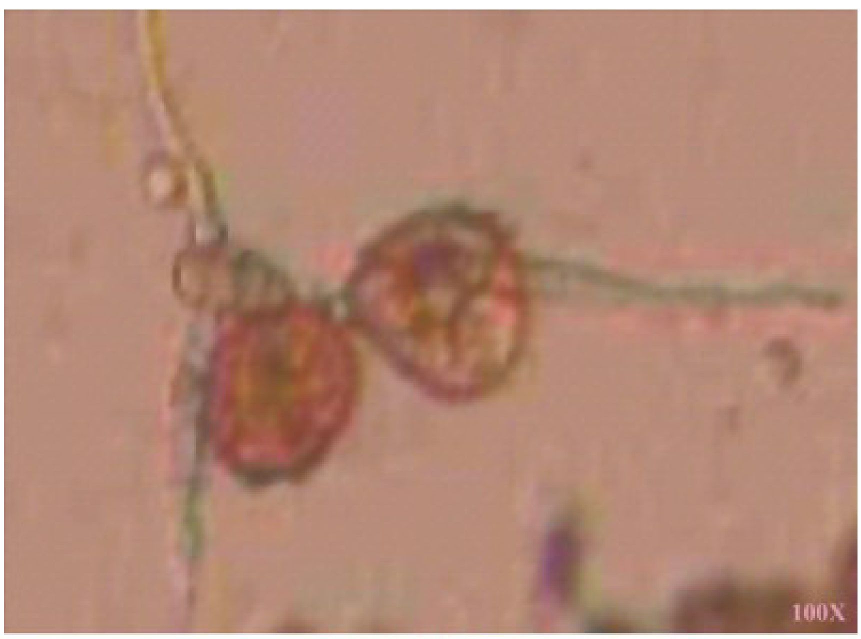
b) *Rabi* season

c) Summer season

Plate 3: Severity of cowpea rust during survey 2014-15.



a) Uredospores



b) Germinated uredopores

Plate 4: Morphology of uredospore of *Uromyces phaseoli* var. *vignae.*

ring form around first pustule and similar reddish brown pustules were also encountered on upper surface of leaves on the same foci of infection. The pustules are different in shape and also size measuring 1 to 2.0 mm in diameter. Many pustules were observed in each leaves. When too many of these pustules developed on the leaf gave, rusty appearance to leaf. After twenty days pustules are often surrounded by striking, yellow hallow later these leaves dried resulted in defoliate. Later the hand sections of these rusty leaves were observed under microscope. It was observed as uredospores of *Uromyce phaseoli* var.*vignae* (Barcl.) Arth.

4.2 To identify the susceptible stage of infection

The experiment was carried on susceptible variety C-152 under artificial inoculation to find out the most vulnerable crop stage against rust disease infection as explained in "Material and Methods" and data is presented in Table 5 and Plate 5.

The identification of susceptible stage revealed that the crop was more vulnerable for the infection between 30-50 old plant.The observation after 10days ofter inoculation revealed that maximum disease severity was recorded (30.09 PDI) in case of seedlings inoculated on 10 days old seedlings followed by (26.21), (24.88) and (25.93) PDI in case of 20, 30,and 40 day old seedlings and there was no disease on seedling inoculated at 70 and 80 dys old seedlings.After 20 days after inoculation(DAI) the maximum disease severity (67.26 PDI) was recorded in seedling inoculated at 10 days after sowing, followed by (61.48) and (47.22 PDI) in case of 20 and 30 days after sowing. The disease severity showed a decreasing trend as the age of the seedlings advanced.There was no infection after 20 days after inaulation in case of 70 and 80 days old seedlings inoculated. Howere severity was minimum at (26.93 PDI) on 60 days old seedling inoculated with the pathogen.

4.3 *In vitro,* glasshouse and field evaluation of fungicide molecules against the rust

4.3.1a *In vitro* evaluation of fungicide molecules against rust pathogen of cowpea

The results *in vitro* evaluation of fungicides molecules are presented in Table 6, 7, 8 and Plate 6.

Table 5: Identification of susceptible stage of infection for cowpea rust disease under glass house condition during 2014

Age of the seedlings (Days)	PDI	
	10 DAI	**20 DAI**
10	30.09 (33.25)*	67.26 (55.08)
20	26.21 (30.78)	61.48 (51.62)
30	24.88 (29.90)	47.22 (43.39)
40	25.93 (30.58)	40.36 (39.42)
50	22.38 (28.23)	35.37 (36.48)
60	18.04 (25.12)	26.93 (31.25)
70	0.00 (0.08)	0.00 (0.08)
80	0.00 (0.08)	0.00 (0.08)
S.Em.±	0.39	0.47
CD @ 1%	1.17	1.76

* Arcsine values

DAI: Days after inoculation

PDI: Per cent Disease index

a) General view

b) Creating relative humidity

c) Infection at 10 days old plant

d) Infection at 20 days old plant

e) No infection at 80 days old plant

Plate 5: Identification of susceptible stage of rust.

Among the non systemic fungicides tested at three different concentrations (0.1%, 0.2% and 0.25%), the maximum per cent inhibition of uredospores germination was recorded in treatment involving zineb 68 WP at 0.25% (100%) followed by chlorothalonil 70 WP at 0.25% (98.33%), mancozeb 75 WP at 0.25% (98.33%) the minimum per cent inhibition of uredospores germination was recorded in treatment involving copper oxychloride 50 WP at (0.25%) per cent (92.83%). Irrespective of concentrations of fungicides tested, the treatments involving zineb 68 WP recorded maximum inhibition of uredospores germination (92.99%) followed by chlorothalonil 70 WP (92.02%) which were on par with each other and least inhibition was recorded in copper oxychloride 50 WP (86.59%).

Among the systemic fungicides tested against *Uromyce phaseoli* var. *vignae* (Barcl.) Arth at three different concentrations (0.05%, 0.1% and 0.15%), the maximum per cent inhibition of uredospores germination was recorded in treatments containing hexaconazole 5% EC and propiconazole 25% EC at (0.1%) 100% uredospore inhibition followed by tebuconazole 25% EC at (0.1%) (96.67%).The least per cent inhibition of uredospores germination was observed in difenconazole 25% EC at 0.05% and 0.1% per cent (86.88%). Irrespective of concentrations of fungicides tested, the treatments involving propiconazole 25% EC recorded maximum inhibition of uredospores germination (98.86%) followed by hexaconazole 5% EC (98.56%) and least inhibition was recorded in difenconazole 25% EC 10% EC (90.65%).

Among the combi fungicides tested at three different concentrations (0.1%, 0.2% and 0.25%), the per cent inhibition of uredospores germination was recorded in both hexaconazole 5% + captan 70 % WP at 0.1% per cent (100%) and trifloxystrobin 25% + tebuconazole 50% W/W at 0.1% (100%) which are statically on par each other. The least per cent inhibition of uredospore germination was recorded in treatment with carbendazim 12% + mancozeb 68% WS at 0.1 per cent (90.52%). Irrespective of concentrations of fungicides tested, the treatments involving trifloxystrobin 25% + tebuconazole 50% W/W at 0.1% (100%) was recorded maximum inhibition of uredospore germination (99.33%) which was followed by hexaconazole 5% + captan 70% WP at 0.1% per cent (100%) and least inhibition was recorded in carbendazim 12% + mancozeb 68% WS (96.84%).

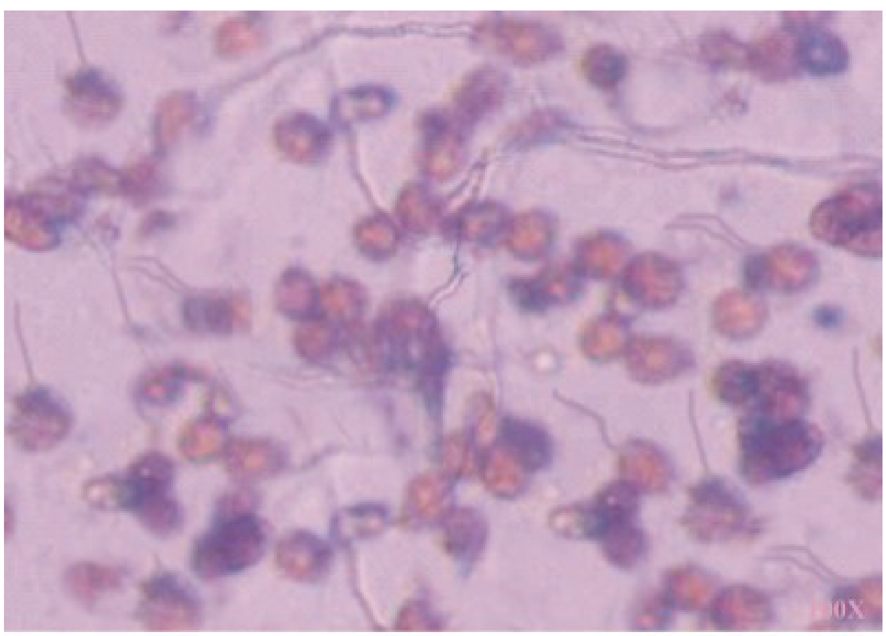
Table 6: *In vitro* evaluation of non systemic fungicides against *Uromyces phaseoli* var. *vignae*

Fungicides	Per cent spore germination inhibition			Mean
	Concentration (%)			
	0.1%	**0.2%**	**0.25%**	
Chlorothalonil 70 WP	84.67 (66.92)*	91.41 (72.93)	98.33 (82.54)	92.02 (73.56)
Copper oxychloride 50 WP	80.95 (64.10)	86.58 (68.48)	92.83 (74.44)	86.59 (68.49)
Mancozeb 75 WP	85.33 (67.45)	90.95 (72.46)	98.33 (82.72)	91.53 (73.05)
Zineb 68 WP	89.67 (71.22)	90.96 (72.42)	100.00 (89.96)	92.99 (74.62)

	Fungicides(F)	Concentration (%)	F x C
S.Em±	0.75	0.37	1.00
CD at 1%	1.87	0.92	2.50

* Arcsine values

a) Ungerminated uredospores



b) Germinated uredospores

Plate 6: ***In vitro* evaluation of fungicides against *Uromyces phaseoli* var. *vignae.***

Table 7: *In vitro* evaluation of systemic fungicides against *Uromyces phaseoli* var *vignae*

Fungicides	Per cent spore germination inhibition			Mean
	Concentration (%)			
	0.05%	**0.1%**	**0.15%**	
Difenconazole 25% EC	86.88 (68.74)*	91.74 (73.27)	93.33 (75.00)	90.65 (72.17)
Hexaconazole 5% EC	96.59 (79.33)	100.00 (89.96)	100.00 (89.96)	98.56 (83.07)
Propiconazole 25 EC	95.62 (77.32)	100.00 (89.96)	100.00 (89.96)	98.86 (83.84)
Tebuconazole 25% EC	86.00 (68.00)	91.78 (73.31)	96.67 (79.45)	91.77 (73.30)

	Fungicides(F)	Concentration (%)	F x C
S.Em±	0.68	0.57	0.38
CD at 1%	2.04	1.42	1.52

* Arcsine values

Table 8: *In vitro* evaluation of combi products against *Uromyces phaseoli* var *vignae*

Fungicides	Per cent spore germination inhibition			Mean
	Concentration (%)			
	0.1%	**0.2%**	**0.25%**	
Carbendazim 12% + Mancozeb 68% WS	90.52 (72.21)*	100.00 (89.96)	100.00 (89.96)	96.84 (79.73)
Hexaconazole 5% + Captan 70 % WP	97.00 (79.99)	100 (89.96)	100 (89.96)	99.00 (84.23)
Trifloxystrobin 25% + Tebuconazole 50% W/G	98.00 (81.84)	100 (89.96)	100 (89.96)	99.33 (85.27)
Zineb 68% + Hexaconazole 4%	96.00 (78.49)	100.00 (89.96)	100.00 (89.96)	98.66 (83.32)

	Fungicides (F)	Concentration (C)	F x C
S.Em±	0.56	0.48	0.61
CD at 1%	1.40	1.21	1.73

* Arcsine values

4.3.1b Evaluation of fungicides against cowpea rust disease under glasshouse condition

The results on evaluation of fungicides which were found effective under glasshouse are presented in Table 9 and Plate 7.

The data revealed that the minimum diaese severity (19.55 PDI) was recorded in propiconazole 25% EC, followed by hexaconazole 5% EC (21.18 PDI) the treatments trifloxystrobin 5%+tebuconazole 50% W/W WP, chlorothalonil 75% WP , mancozeb 75% WP were found stetastically on par with each other.The maximum disease severity was recorded in untreated control (39.22 PDI).

4.3.2 Management of cowpea rust in field condition

A field experiment was conducted as explained in Material and Methods. The result in severity of the disease and growth and yield parameters is presented in Table 9 and Plate 8.

4.3.3 Disease severity

Among the 12 different treatments evaluvated for the management, growth and minimum disease severity was recorded in propiconazole 25% EC (22.07 PDI) followed by hexaconzole 5% EC (22.83 PDI) and treatments trifloxystrobin 5%+ tebuconazole 50% W/W WP, chlorothalonil 75% WP and mancozeb 75% WP were statistically on par with each other.The maximum disease severity was recorded in (57.77 PDI) was recorded in untreated control.

4.3.1 Pods per plant

The maximum number of pods per plant was recorded in propiconazole 25% EC (17.45) and followed by hexaconazole (16.07), trifloxystrobin 5%+tebuconazole 50% W/W ((16.55) and minimum number of pods per plant was recorded in untreated control (12.44).

Table 9: Evaluation of fungicides against cowpea rust under glasshouse and field condition during 2014

Fungicides	Con (%)	PDI Under glasshouse 10 days after 2^{nd} spray	PDI Under field condition 10 days after 2^{nd} spray
Captan 70% + Hexaconazole 5%	0.25	26.22 (31.44)*	28.88 (32.43)
Chlorothalonil 75% WP	0.25	22.55 (28.34)	27.55 (31.64)
Copper oxychloride 50 WP	0.25	29.93 (33.15)	28.99 (32.56)
Difenconazole 25% EC	0.1	27.07 (31.34)	27.55 (31.65)
Hexaconazole 5% EC	0.1	21.18 (27.83)	22.83 (28.53)
Mancozeb 63% + Carbendazim 12% WP	0.25	26.19 (30.77)	28.07 (31.80)
Mancozeb 75% WP	0.25	23.85 (29.22)	26.55 (28.03)
Propiconazole 25% EC	0.1	19.55 (26.23)	22.07 (28.00)
Tebuconazole 25% EC	0.1	24.85 (29.89)	28.47 (32.23)
Trifloxystrobin 5%+Tebuconazole 50% W/W WP	0.1	25.86 (30.48)	24.47 (29.63)
Zineb 68% + Hexaconazole 4%	0.1	25.18 (30.11)	25.88 (30.55)
Zineb 75% WP	0.25	21.81 (29.44)	26.22 (30.79)
Control	-	39.22 (38.76)	57.77 (49.45)
SEm±		0.41	1.14
CD at 1%		1.62	2.85

* Arcsine values

a) General view of experimental setup

b) Creating relative humidity

c) Propiconazole @ 0.1%

d) Hexazonazole @ 0.1%

e) Untreated (control)

Plate 7: Evaluation of fungicides against cowpea rust under glasshouse condition.

a) Experimental field view

b) Propiconazole @ 0.1%

c) Hexaconazole @ 0.1%

d) Trifloxystrobin 5%+Tebuconazole 50% W/W WP @ 0.1%

e) Untreated

Plate 8: Evaluation of fungicides against cowpea rust under field condition.

4.3.2 Test seed weight (g)

Maximum seed weight was recorded in propiconazole 25% EC (9.77 g) followed by hexaconzole 5% EC (9.00 g) followed by trifloxystrobin 5%+tebuconazole 50% W/ (9.76 g) and least seed weight was recorded in copper oxychloride 50 WP (6.75 g)

4.3.3 Seed yield q/ha

The maximum yield (10.5 q/ha) was recorded in plots sprayed with propiconazole and followed hexaconzole 5% EC (10 q/ha) and trifloxystrobin 5%+tebuconazole 50% W/W (10.00 q/ha), and minimum yield was recorded in plots sprayed with copper oxychloride 50 WP (7.5 q/ha)

4. 3.4 Economic analysis

Economic analysis of this study were presented in Table 10, the result from showed.That application of propiconazole @ 0.1% recorded the maximum net income with B: C ratio of 2.24 with net income Rs. 25408 followed by hexaconazole with B: C ratio (2.16) with net income 23956 and trifloxystrobin 5%+tebuconazole 50% W/W with B: C ratio (2.18) with net income Rs. 24877 and minimum net income was recorded in Copper oxychloride @ 0.25% net income with B: C ratio (1.47).

4.4 Screening of cowpea genotypes.

4.4.1 Screening of promising entries for cowpea rust under artificial inoculation in glasshouse

Totally eighteen genotypes were screened against cowpea rust under glasshouse condition at the Department of Plant Pathology, College of Agriculture, University of Agricultural Sciences, Dharwad, Karnataka by creating artificial disease pressure and reactionsand results were presented in Table 11 and Plate 9.

Out of eighteen genotypes screened, none of them were found to be immune. Four genotypes of cowpea *viz.*, DCS1-18, CPD -84, CP -108, and CP - 43 were found to be highly resistant with disease grade1. Nine genotypes of cowpea *viz.,* DCS47-1, DCS 1-20, C-151 x (CP-14), KBC-1-M, TPTC-1, CP-24, CP-25, CP-33, CP-24 were found

Table 10: Economic analysis of management of cowpea rust

Treatments	PDI	No of pods per plant	Test weight (g)	Yield (q/ha)	B:C ratio
Captan 70% + Hexaconazole 5% WP	28.88 (32.43)*	13.111	8.00	8.00	1.45
Chlorothalonil 75% WP	24.47 (29.63)	12.73	7.00	8.70	1.56
Copper oxychloride 50 WP	28.99 (32.56)	10.29	6.75	7.50	1.47
Difenconazole 25% EC	27.55 (31.65)	14.54	7.56	8.50	1.61
Hexaconazole 5% EC	22.83 (28.53)	16.07	9.00	10.00	2.16
Mancozeb 63% + Carbendazim 12% WP	28.07 (31.80)	16.55	8.85	8.50	1.55
Mancozeb 75% WP	26.22 (30.79)*	13.24	7.66	8.00	1.50
Propiconazole 25% EC	22.07 (28.00)	17.45	9.77	10.50	2.24
Tebuconazole 25% EC	28.47 (32.23)	11.12	6.75	8.00	1.57
Trifloxystrobin 5%+Tebuconazole 50% W/W WP	24.47 (29.63)	15.62	9.97	10.00	2.18
Zineb 68% + Hexaconazole 4% WP	25.88 (30.55)	16.55	7.58	8.75	1.69
Zineb 70% WP	26.55 (28.03)	14.45	7.80	8.75	1.70
Control	57.77 (49.45)	12.44	7.55	7.50	1.47
S.Em ±	1.14	1.38	0.27	0.55	-
CD at 5%	2.85	4.04	0.71	1.24	-

*Arcsine value

Table 11: Screening of promising entries for cowpea rust disease under artificial inoculation in glasshouse during 2014

Grade	Disease reaction	Description	Promising genotypes	Total entries (18)
0	Immune	No symptoms on leaf	-	0
1	Resistant	Small, round, powdery, brown uredosori covering one per cent or less of the leaf area	DCS1-18, CPD-84 (CP-12), CP-108, CP -43(TPTC-29), C-151 x (CP-14),	5
3	Moderately resistant	Typical uredosori, covering 1 to 10 per cent of the leaf area	DCS47-1, DCS1-20, KBC-1-M, CP-25 (Phule CP05040), CP-33 (PTB 13-1), CP-24 (PCP306-1), CP-23(RC-101), TPTC -1(CP -15)	8
5	Moderately susceptible	Typical uredosori, covering 11 to 25 per cent of the leaf area	CP-28 PGCP-6,(C) Goa local , DC -15,	3
7	Susceptible	Typical uredosori, covering 26 to 50 per cent of the leaf area	CP -14 (PGCP -2)	1
9	Highly susceptible	Uredosori cover 51 per cent or more of the leaf area. Withering of the leaves.	C-152	1

a) General view of experimental setup

b) Creating relative humidity

c) Resistant genotype, CPD-84

d) Moderately resistant genotype, DCS-47-1

e) Susceptible genotype, C-152

Plate 9: Screening of cowpea genotypes under glasshouse condition.

to be moderately resistant with disease grade 3. Three genotype of cowpea DC-15, Goa local CP-28 were found to be moderately susceptible with disease grade 5. Genotype of PGCP-2 (CP-14), were found to susceptible with disease grade 7.the maximum disease severity was recorded in C-152 with disease grade 9.

4.4.2 Field screening of available cowpea genotypes for rust disease

The results on field screening were presented in Table, 12 and 13 and Plate 10. Totally 49 promoising cowpea genotypes were screened for rust reaction under natural epiphytotic field condition in research block of the Dept of Genetics and Plant Breeding, the Main Agricultural Research Station, Dharwad. The disease severity was recorded using 0-9 scale as described in Material and Methods.

The results from the data revealed that out of eighteen genotypes screened, none of them were found to be immune However, five genotypes *viz.,* CPD 84, CP-43, C-151- (CP-14), CP-23, CP-33 were found to be highly resistant with grade 1.

Eight genotypes, DCS 47-1, DCS -5-1 -18, DCS -5-3-20, KBC-1-7, TPTC-1 (CP-15), CP - 108, C-152 x GM6 (F-5), CP -25, were found to be moderately resistant with disease grade 3. Three genotype CP - 28, DC-15 and Goa local were found to be moderately susceptible with disease grade 5. Genotype PGCP -2 (CP-14) was found to be Susceptible with disease grade 7. The highly susceptible C-152 check recoded disease grading 9.

In other set, five cowpea genotypes *viz.,* CP-20, CP-19, CP-11, CP-36, CP-41, were found to be immune with disease grade 0. Twelve genotypes of cowpea CP-24, CP-21, CP-17, CP-16, CP-15, CP-25, CP-26, CP-27, CP-32, CP-35, CP-40, CP-41, were found to be resistant with a disease grade 1.

Nine genotypes of cowpea *viz.* CP-18, CP-14, CP-13, CP-12, CP-28, CP-29, CP-30, CP-33 and CP-39 were found to be moderately resistant with a disease grade 3.Two genotype *viz.,* CP-23, CP-38, were found to be moderately susceptible with a disease grade 5. Two genotypes CP-31, CP-22 were found to be susceptible with a disease grade 7. Two genotypes of CP-34, CP-37, were found to be highly susceptible as recorded a disease grade 9. And susceptible check C- 152 recorded as disease grade 9 indicating highly susceptible reaction.

Table 12: Field screening of promising trial material for rust disease of cowpea

Grade	Disease reaction	Description	Promising genotypes	Total entries (31)
0	Immune	No symptoms on leaf	CP-20,CP-19, CP-11, CP-36, CP-41,	5
1	Resistant	Small, round, powdery, brown uredosori covering one per cent or less of the leaf area	CP-24, CP-17, CP-16, CP-15, CP-25, CP-26, CP-27, CP-32, CP-35, CP-40, CP-41,	11
3	Moderately resistant	Typical uredosori, covering 1 to 10 per cent of the leaf area	CP-18, CP-14, CP-13, CP-12, CP-28, CP-29, CP-30, CP-33, CP-39,	9
5	Moderately susceptible	Typical uredosori, covering 11 to 25 per cent of the leaf area	CP-23, CP-38,	2
7	Susceptible	Typical uredosori, covering 26 to 50 per cent of the leaf area	CP-31, CP-22	2
9	Highly susceptible	Uredosori cover 51 per cent or more of the leaf area. Withering of the leaves.	CP-34, CP-37,	2

Table 13: **Field screening of promising yield trial material against cowpea rust disease**

Grade	Disease reaction	Description	Promising genotypes	Total entries (18)
0	Immune	No symptoms on leaf	Nill	0
1	Resistant	Small, round, powdery, brown uredosori covering one per cent or less of the leaf area	CPD – 84 (CP-12), C -151x CP-14, CP -43(TPTC-29) , CP- 108, DCS -5-1-18	5
3	Moderately resistant	Typical uredosori, covering 1 to 10 per cent of the leaf area	DCS47-1, , DCS -5-3-20, KBC -1-7, TPTC-1(CP-15), C-151 x GM6 (F-5), CP -25, CP -25 (Phule CP05040), CP -23,	8
5	Moderately susceptible	Typical uredosori, covering 11 to 25 per cent of the leaf area	CP -28, DC -15, Goa local,	3
7	Susceptible	Typical uredosori, covering 26 to 50 per cent of the leaf area	PGC P-2(CP-14)	1
9	Highly susceptible	Uredosori cover 51 per cent or more of the leaf area. Withering of the leaves.	C -152	1

a) General view of field screening

b) CPD-84 (Resistant)

c) C-152 (CP-14) (Resistant)

d) DCS-47-1 (Moderately resistant)

e) C-152 (Highly susceptible)

Plate 10: Screening of cowpea genotypes under field condition.

5. DISCUSSION

Cowpea (*Vigna unguiculata* L.) (2n=22) one of the most ancient human food sources and short duration multipurpose pulse crop grown extensively in tropical and subtropical countries. It belongs to family Fabaceae. The name cowpea originated from the fact that the plant was an important source of hay for cows in the south-eastern United States and in other parts of the world. It is popular because of its nutritional quality and its suitability for multiple cropping systems. Being a pulse crop it helps greatly in improving the fertility of the land by way of addition of nitrogen to the soil during its growth period and it makes soil richer. Native to Africa, as wild cowpeas only exist in African and Madagascar (Steele, 1976).

Cowpea suffers from many destructive diseases caused by facultative and obligate pathogens. Rust of cowpea caused by *Uromyces phaseoli* var.*vignae* (Barcl.) Arth. an obligate pathogen is an important disease, as it affects the economic yield. This disease is severe in all cowpea growing states of India and also after countries of the world wherever the cowpea is cultivated. It's one of most wide spread disease, which affects many crops like pea, bengalgram and greengram and many weeds generally throughout the world. In India, it is one of the most serious diseases in south India and infect crop almost throughout the year around Bangalore (Sokhi and Sohi, 1976).

In recent years disease is appearing in severe form in Karnataka. Inspite of this not much detail work with regard to different aspects has been carried out although attempts have been made to find out, severity of cowpea rust disease in the northern districts of Karnataka.

The present investigation was carried out to find the severity of cowpea rust disease in northern parts of Karnataka. Attempts have been made to work out the most susceptible stage of infection for rust disease.Evaluation of available promsing genotypes for rust. The present studies also involved the evaluation of fungicides the results obtained are discussed here under.

5.1 Survey for recording the severity of cowpea rust in northern Karnataka during *karif*, *rabi* and summer season of 2014-2015

An extensive survey was carried out to assess the severity of cowpea rust disease in four districts of northern Karnataka *viz*., Dharwad, Belagavi, Bagalkote and Haveri districts during *kharif rabi and* summer season of 2014-15.

5.1.1 *Kharif* season

Survey gives information about existences of variability among the pathogen in particular agroclimatic zones and the intensity with which it affects the yield and quality. It is necessary to conduct a systematic survey of disease to understand its appearance, prevalence, distribution and extent of its spread to identify endemic areas or hot spots (Fig. 3). The data on survey revealed that the disease severity varied from locality to locality. The severity of cowpea rust varied from (23.35 to 43.55 PDI), Maximum mean severity of cowpea rust was observed in Dharwad district (35.29 PDI) followed by Belagavi district (34.04 PDI) and Haveri district (31.38 PDI). The minimum severity was noticed in Bagalkote district (29.98 PDI)

In general the highest PDI of 43.55 was noticed at MARS, Dharwad followed by Yattinagudda village (40.88 PDI) of Dharwad district and the least PDI of cowpea rust was observed in Kodihal village of Hunagund taluk (23.35 PDI). Among all the districts surveyed Dharwad district recorded highest disease severity, which may be due to favourable environmental conditions *viz.,* optimum temperature, relative humidity that must have favoured the build up of inoculum subseqsuently showing increase in disease severity. The least severity was recorded in Bagalkot district. This may be due to unfavourable environmental conditions such an dry weater condition during susceptible stage of infection that might have reduced the build up of inoculum.Similar observation were made in the survey for cowpea rust disease by (Bracly, 1891) and Emechebe and Soyinka (1985), in chickpea rust Nargund *et al.* (2011) reported that during 2009-10 *rabi* season chickpea suffered heavily due to rust caused by *U. ciceris arietini*. This disease was noticed in 2006-07 on Bhima genotype in a sporadic manner in Dharwad location.

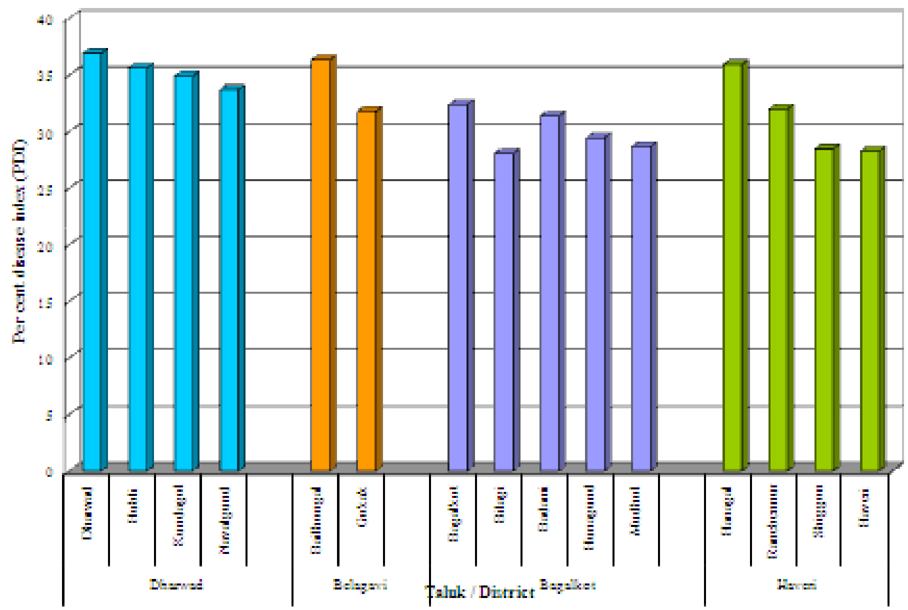


Fig. 3: Survey for recording the severity of cowpea rust in northern Karnataka.

During 2009-10 the severity of the disease was 100 per cent where all the genotypes grown at Main Agricultural Research Station (MARS), Dharwad encompassing germplasm lines, ICRISAT collections, segregating populations and F_1 of several crosses showed highly susceptible reaction to rust.

5.1.2 *Rabi* season

In Dharwad district highest disease severity (17.09 PDI) was recorded in the MARS Dharwad, followed by the Belagavi district (PDI 12.95).

5.1.3 Summer season

In Dharwad district, at MARS Dharwad rust severity (15.15 PDI) was noticed that while in other districts like Haveri, at Ranebennur least rust incidence was noticed. In Bagalkote and Belagavi districts rust was not noticed.

5.1.4 Symptomatology of cowpea rust

The symptoms were characterised by the production of minute almost white, slightly raised pustules which later become distinct, reddish brown circular sori that were typical of rust. These sori were initially covered with epidermise which ruptured in releasing spore dust. Under favourable weather conditions numerous sori appeared. However, Kale (1992) described appearance of rust symptoms initially on upper surface of the leaves followed by lower surface. The present findings to the initial rust symptoms appeared on upper surface later spread to lower surface.

5.1.4 Morphological characters of the pathogen

The uredospore were brownish in colour, globoid or round, ellipsoid, echinulated in shape and single celled.Uredospores measured to 22 to 34 µm in length and 18 to 24 µm in breadth. The spore wall was golden brown in colour. The uredospores were brownish in colour, globoid or round, ellipsoid, echinulated in shape and single celled.The spore wall was golden brown in colour. Similarl observations were made by Kale 1992.

5.1.5 Pathogenicity studies

Cowpea leaves were inoculated with the spores of *Uromyce phaseoli* var.*vignae* the characteristics, slightly raised pustules appeared which are later turned to reddish brown small, circular raised pustules on lower surface of leaves were observed seven days after inoculation. After ten days of inoculation appeared of characteristics numerous pustules appeared subsequently in ring form around first pustule and similar reddish brown pustules were also encountered on upper surface of leaves on the same foci of infection. The pustule different in shape and also size measuring 1 to 2.0 mm in diameter, many pustules were observed in each leaves. When too many of these rust pustules developed on the leaf gave rusty appearance to leaf. After 20 days pustules were surrounded by striking, yellow haloes later these leaves dried and they drop off from plant. Similarl observations were also made by Kale (1992)

5.2 Identification of susceptible stage of infection

Identification of most susceptible stage of infection would help in development of integrated management statergies and application of effective chemicals at most vulanerable stage of infection in this contest the present study identified. The observation after 10days ofter inoculation revealed that maximum disease severity was recorded (30.09 PDI) in case of seedlings inoculated on 10 days old seedlings followed by (26.21), (24.88) and (25.93) PDI in case of 20, 30,and 40 day old seedlings and there was no disease on seedling inoculated at 70 and 80 dys old seedlings.After 20 days after inoculation(DAI) the maximum disease severity (67.26 PDI) was recorded in seedling inoculated at 10 days after sowing, followed by (61.48) and (47.22 PDI) in case of 20 and 30 days after sowing. The disease severity showed a decreasing trend as the age of the seedlings advanced.There was no infection after 20 days after inaulation in case of 70 and 80 days old seedlings inoculated (Fig. 4). However severity was minimum at (26.93 PDI) on 60 days old seedling inoculated with the pathogen. The observations are in confirmation with Chandrashekar *et al.,* (1988) who reported that severity of cowpea rust (caused by *Uromyces phaseoli* var *vignae* (Barcl.) Arth) at flowering stage and pod formation stage compared were to different stages of the crop

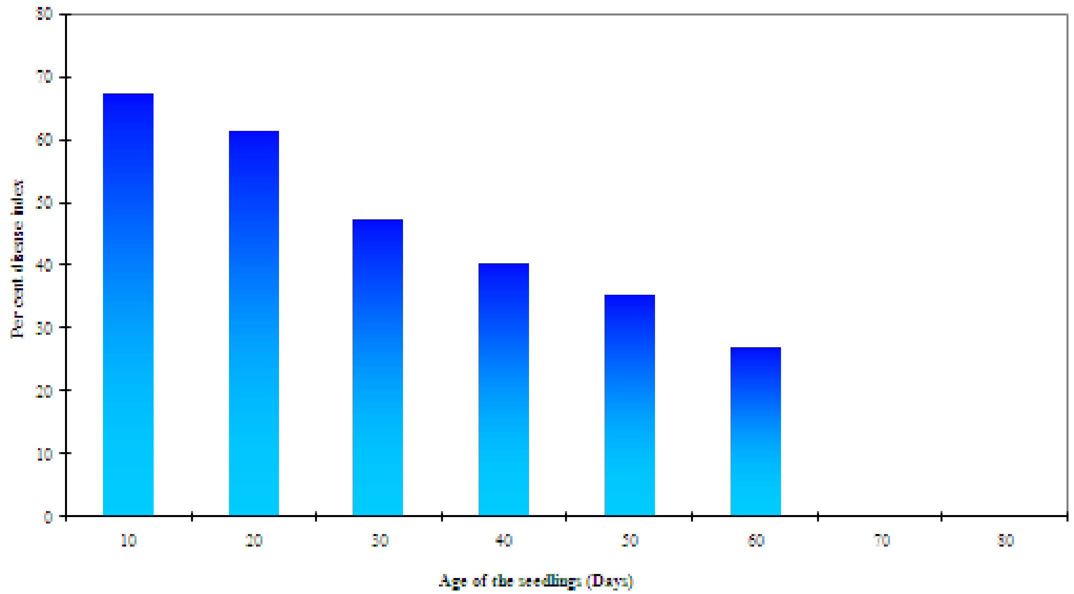


Fig. 4: Identification of susceptible stage of infection for cowpea rust disease under glass house condition.

resulted in reduction of yield by 50 per cent. Ten days old plants were highly susceptible to rust disease of cowpea. The least infection was observed on the crop after 60 and 70 days after sowing (DAS).Further, 80 days crop failed to get the infection as reported by Kale (1992).

The survey conducted in the farmers field revealed that flowering and pod development stage more prone for the cowpea rust. The super imposing of results of survey with a glasshouse analysis on the susceptible stage of the infection revealed that crop is vulnerable to infection due to rust after flowering and more severe at time of pod development stage.The information will help in understanding the more susceptible of *Uromyces phaseoli* var *vignae* (Barcl.) Arth on the cowpea and suitably develop the management strategies looking dynamism in disease severity and stage of the crop.

5.3 *In vitro,* glasshouse and field evaluation of fungicide molecules against the rust

It is possible that the cultural practices may provide the desired level of disease control but additional precaution any measures in the form of chemical protection is essentioal in case of outbreak of the disease or resistant genotypes become susceptible. Use of chemicals has become more popular in recent times because of their quick results especially in absence of resistant varieties. *In vitro* fungicidal evaluation helped to know their efficacy in laboratory conditions eliminating the non effective ones. Therefore, twelve fungicides were evaluated on the bases of inhibition of uredospore germination (Fig. 5 to 7).

In this study, four systemic, four non-systemic and four combi - fungicides were evaluated at three concentrations in the laboratory for their efficacy against cowpea rust pathogen. The fungicides evaluated against cowpea rust revealed that propiconazole 25 EC @ 0.1 and 0.15 per cent, showed 100% inhibition of uredospores, zineb 68% + hexaconazole 4% @ 0.2% and 0.25% concentrations showed 100% inhibition of uredospores and zineb 68 WP @ and 0.25% showed inhibition of 100% inhibition of uredospores over control. These results are in agreement with Kale (1992) in the chemical management of cowpea rust the present result brought out a new important an effectives of triazoles fungicides against rust of cowpea in Karnataka.

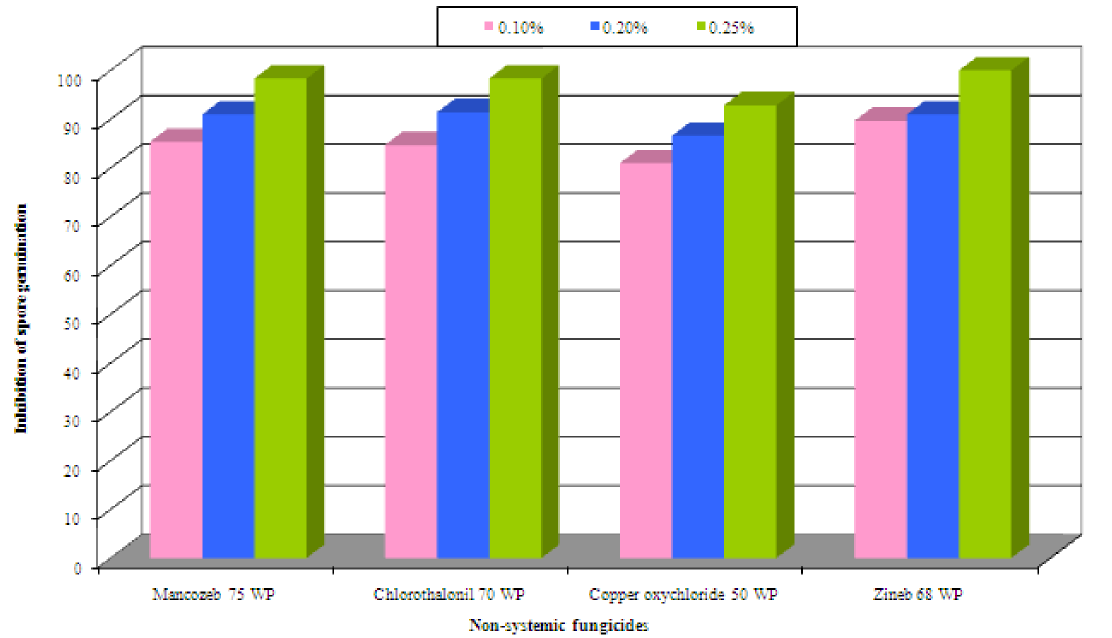


Fig. 5: ***In vitro*** **evaluation of non systemic fungicides against** ***Uromyces phaseoli*** **var** ***vignae.***

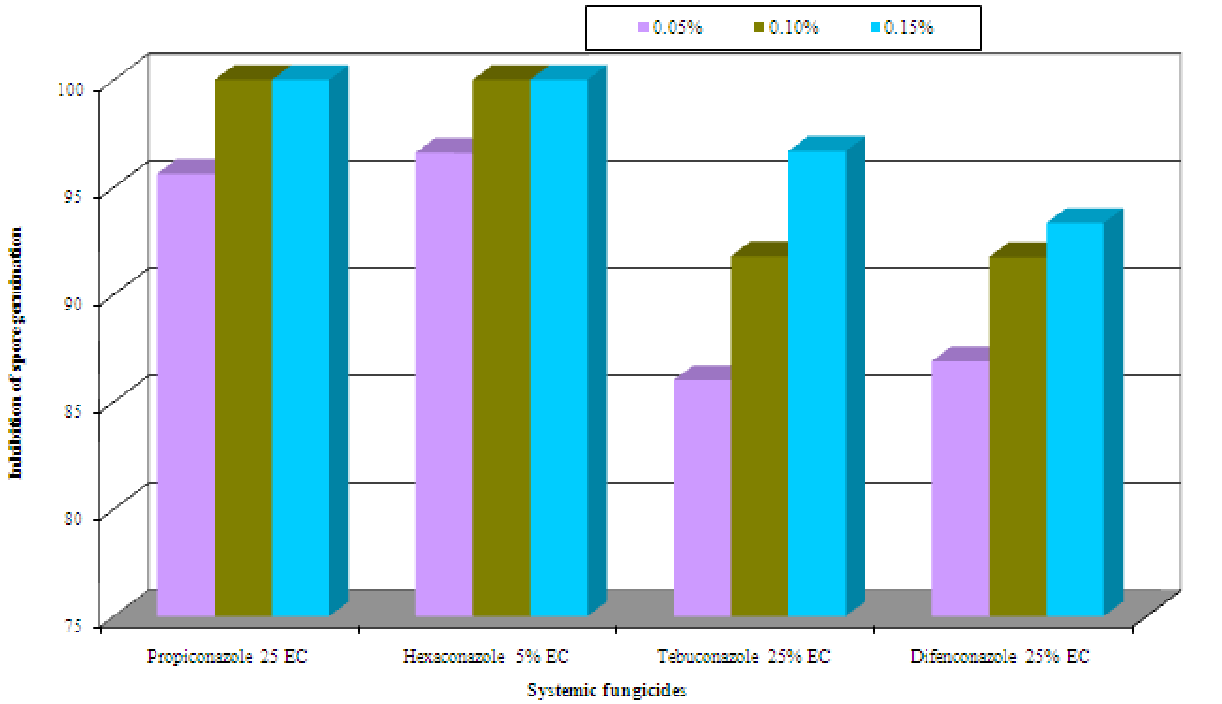


Fig. 6: *In vitro* **evaluation of systemic fungicides against** ***Uromyces phaseoli*** **var.** ***vignae*****.**

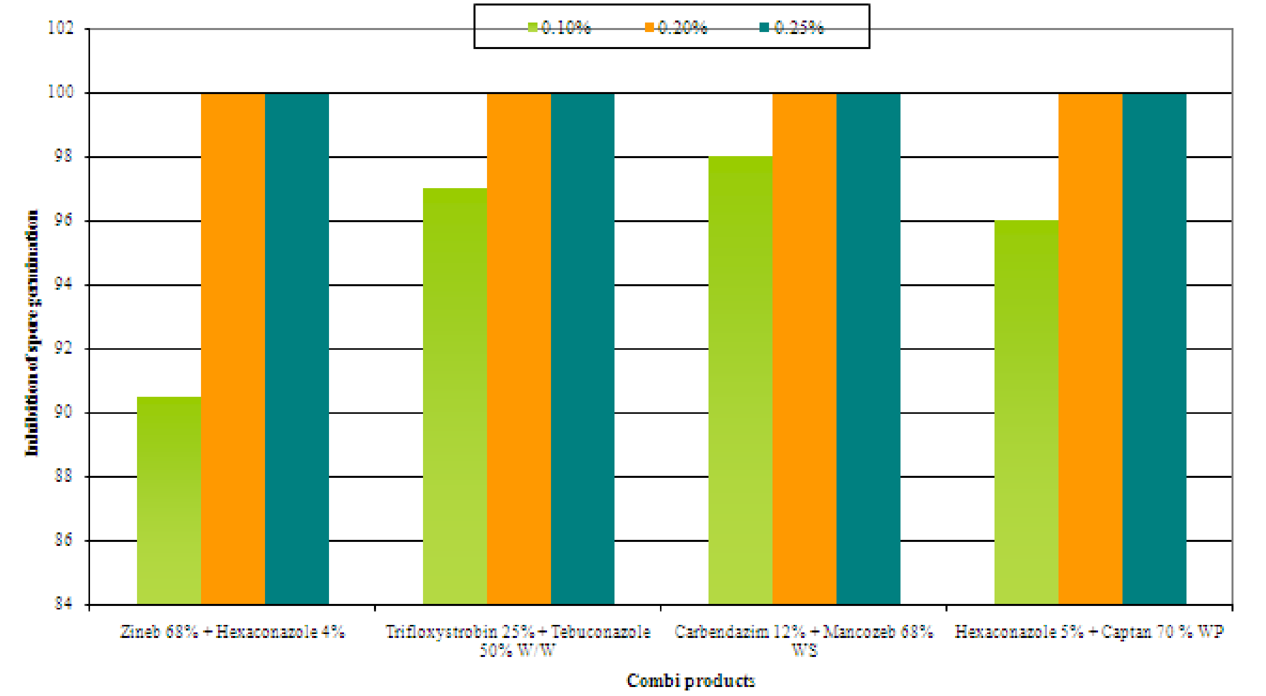


Fig. 7: ***In vitro*** **evaluation of combi products against** ***Uromyces phaseoli*** **var.** ***vignae*****.**

The present study revealed that systemic fungicides such as hexaconazole 5% EC, propiconazole 25% EC at (0.1% and 0.15% concentrations) and zineb 68% + hexaconazole 4% (at 0.2% and 0.25% concentrations) were very effective against rust pathogen tested.similar results are aggreement with Gupta and Shyam (2000) reported that pea plants were treated with seven fungicides *viz.,* fenarimal, defenoconzole, triadimefon, cyperconazole, flusilazole, henconazole and hexaconazole and two non-systemic mancozeb and chlorothalonil, fungicides after being inoculated with *Uromyces viciae fabae* aeciospores for 72 hr. Cyperconazole, flusilezole, penconazole and hexaconazole completely inhibited rust incidence and rust severity on leaves. Mancozeb and chlorothalonil resulted in a rust severity of 22.91 and 38.75 per cent, respectively

5.3.1 Evaluation of fungicides against cowpea rust disease under glasshouse condition

The result on glasshouse evaluation of fungicides revealed that the minimum disease severity was (19.55 PDI) was recorded in propiconazole 25% EC, followed by hexaconazole 5% EC (21.18 PDI) the treatments trifloxystrobin 5%+tebuconazole 50% W/W WP, chlorothalonil 75% WP, mancozeb 75% WP were found stetastically on par with each other.The maximum disease severity was recorded in untreated control (39.22 PDI).Treatments were found significantally superior over rest of other chemicals. Similar trend was observed in 10 DAS spray. These results are in conformity with earlier reports by Jacks (1954) under glass house condition reported that when broad bean plants were sprayed with a fungicidal suspension and inoculated 24 hours later with a spore suspension of *Uromyces fabae*, it was observed that in unsprayed plants, the mean number of rust lesions were 295.8 per leaf against none in plants sprayed with 0.45 per cent dithane Z-78 (65% zineb), 0.5 per cent ferbam spray (70% ferbam) and 0.5 per cent manzate (70% maneb). On the other hand the plants sprayed with 0.4 per cent thiospray (70% zineb) gave 0.3 or less number of lesions per leaf.

5.3.2 Management of rust disease of cowpea in field condition

All the chemicals have reduced the rust incidence significantly compared to untreated control (PDI 43.37). Among various chemical tested propiconazole 25% EC was very effective and reduced the disease with maximum yield (10.50 q/ha) followed by hexaconzole 5% EC the reduced the disease with increased yield (10.q/ha).

These results are in agreement with Alam *et al.* (2007) in the chemical management of garden pea rust.They were yield and yield parameters such as number of pods, test weight were highest in treatments involving spray with propiconazole 25% EC (9.77 g) followed by hexaconazole 5% EC (9.00g) even though the yield and gross returns were highest in treatments containing propiconazole 25% EC and highest benefit cost ratio of (B:C ratio 2.24).followed by trifloxystrobin 5%+ tebuconazole 50% W/W WP (B:C ratio 2.18) hexaconazole 5% EC (B:C ratio 2.16) and least was recorded in untreated control.

The present findings identified certain fungicides molecules belonging to spray of triazoles and strobulins which can be developing the spray schedule against rust of cowpea in northern Karnataka. Similar results are confirmed with Kavayshree (2014) worked on greengram foliar diseases and also Ahmed *et al.* (2006) tested efficacy of six fungicides against the controlling of lentil is caused by *Uromyces vicia fabae* among the six fungicides, propiconazole @ 0.05% was the most effective fungicide against rust disease.

5.4 Screening of cowpea genotypes

5.4.1 Screening of promising entries for cowpea rust under artificial inoculation in glass house

The management of the disease through host plant resistance has been the best choice in all the crops. Utilization of resistant cultivars in farming systems is the most simple, effective and economical method in the management of disease. Besides this, these resistant cultivars conserve natural resources and reduce the cost, time and energy compared to the other methods of disease management.

Out of eighteen genotypes screened, none of them were found to be immune to rust disease. Four genotypes of cowpea *viz.*, DCS1- 18, CPD - 84, CP - 108, CP- 43, were found to be resistant and nine genotypes of cowpea *viz.,* DCS1- 47, DCS1- 20, C- 152 x (CP -14), KBC -1- M, TPTC- 1, CP- 24, CP - 25, CP- 33, CP- 24 were found to be moderately resistant. Three genotypes of cowpea DC- 15, Goa local, CP - 28 was found to moderately susceptible. genotype of cowpea C -152 was found to be highly susceptible. Similar results were also reported by Anilkumar *et al.* (1989) and Kale (1992).and

5.4.2 Field screening of cowpea genotypes for rust disease

Totally 18 cowpea genotypes and 31 initial varietal trail materials were screened for rust disease under natural epiphytatic field condition. The results from the table revealed that, out of eighteen genotypes screened, none of them were found to be immune and, however, five genotypes *viz.,* CPD -84, CP -12, C -152- (CP-14), CP -23, CP -33 were found to be resistant.

Eight genotypes namely DCS1 - 47, DCS - 5 - 118, DCS - 5 - 3 - 20, KBC- 17, TPTC 1 (CP- 15), CP -108, C- 152 x GM6 (F -5), CP- 25 were found to be moderately resistant. Three genotypes showed were found to be moderately susceptible CP -28, DC-15, Goa local, one genotype PGCP-2 (CP-14) was found to be Susceptible. Genotype C-152 was found to be highly susceptible. Similar results were also reported in cowpea by Anilkumar *et al.* (1989) reported that V 105, V 154, V 276, V 282 and V 385 were resistant against rust disease of cowpea. And also to worked out to AUDPC values for these varieties the highest

Out of thirty-one promising entries of cowpea, five cowpea genotypes *viz.,* CP -20, CP -19, CP -11, CP -36, CP -41, were found to be Immune. Twelve genotypes showed that, resistant CP - 24, CP -21, CP -17, CP -16, CP -15, CP -25, CP -26, CP -27, CP -32, CP -35, CP -40, CP -41. and nine genotypes *viz.* CP -18, CP -14, CP -13, CP -12, CP -28, CP -29, CP -30, CP -33, CP -39, were found to be moderately resistant, two genotype *viz.,* CP -23, CP -38, were found to be moderately susceptible, two genotypes of cowpea CP -31, CP -22 were found to be susceptible. Two genotypes of cowpea CP -34, CP -37, were found to be highly susceptible.

These findings are agreement with Aiyer (1950) American variety called Iron cowpea is resistant to rust of cowpea, Chandrasekhar *et al.* (1989) reported that RC-19 and Guj-2 were highly resistant, V-118, V-16,and V-70 were moderately resistant and C-152 highly susceptible to cowpea rust. Deshpande *et al.* (2012) identified some of the potential and novel cowpea genotypes for Multiple disease resistance *viz.,* IC 257410, IC257410 and IC214753 (for resistance against rust and leaf spot); IC201095, IC257406, IC257435 (for resistance against leaf spot and CMV); IC202795 (immune to rust and leaf spot), IC202743, IC202786 (immune to rust and CMV) and a novel land race bellary local (immune to rust, leaf spot and CMV).

6. SUMMARY AND CONCLUSIONS

The results obtained on different aspects of rust disease of cowpea were conducted at Department of Plant Pathology, UAS, Dharwad during 2014-2015 the results obtained are summerised in this chapter.

The survey in four districts of northern Karnataka revealed that the disease severity varied from locality to locality. The severity of rust disease varied from 23.35 to 43.55 PDI, Maximum mean severity of rust was observed in Dharwad district (35.29 PDI) followed by Belagavi district (34.04 PDI) and Haveri district (31.38 PDI). The minimum severity was noticed in Bagalkot district (29.98 PDI).

In general the highest PDI of 43.55 was noticed at MARS, Dharwad followed by Inchal village (41.00 PDI) of Bailhongal taluk and the least PDI of cowpea rust was observed in Kodihal village of Hunagund taluk (23.35 PDI). Similarly surveyed in all three seasons, in *kharif* season the maximum disease severity was recorded, followed by *rabi* season and least disease incidence in the season of summer.

The results of glasshouse study revealed that the maximum disease severity of rust was recorded on 10 days old plants (67.26 PDI) followed by 20 days old plants (61.48 PDI) and 30 days old plants (47.22 PDI) and there was minimum infection at 60 days old plant (26.93 PDI) and there was no infection on70 and 80 days old plants.

In vitro evaluation of systemic, non-systemic and combi - fungicides at three concentrations against rust pathogen revealed that all the fungicides evaluated were significantly superior over the control. The treatment with and propiconazole 25% EC at (0.10 and 0.15 per cent) 100 per cent uredospores germination inhibhition (100%) and, chlorothalonil 70 WP at (0.25%) per cent (100 per cent uredospores germination inhibhition) and trifloxystrobin 25% + tebuconazole 50% W/W at 0.2% per cent (100% uredospores germination inhibhition)

The results of glass house experiment revealed that, all the fungicides were found to be effective in reducing the severity of cowpea rust disease and compared to untreated check propiconazole 25% EC at (0.1%) and hexaconzole 5% EC at (0.1%) were found to be effective to minimise the disease severity.

In the field evaluation of common spray for the management of rust disease revealed that propiconazole 25% EC at (0.1%) and hexaconzole 5% EC at (0.1%) were found to be effective to minimise the disease severity and recorded highest yield and yield parameters. Maximum seed yield (10.50 q/ha) and yield parameters such as number of pods and test weight were recorded in treatments involving spray with propiconazole 25% EC at (0.1%) followed by hexaconazole 5% EC at ((0.1%).

Eighteen genotypes were screened against cowpea rust diseases under glasshouse condition and the results revealed that none of the genotype found to be immune to rust disease. Four genotypes of cowpea *viz.*, DCS1-18, CPD-84, CP-108, CP -43, were found to be resistant to rust disease. One genotype of cowpea C-152 was found to be highly susceptible.

Eighteen genotypes field screened the results, out of eighteen genotypes screened, none of them were found to be immune and, however, five genotypes *viz.,* CPD 84, CP -12, C -152- (CP -14), CP -23, CP -33, were found to be resistant. Nine genotypes of cowpea *viz.*, DCS 1 -20, KBC -1- M, TPTC -1, CP -24, CP -25, CP -33, and CP 24 were found to be moderately resistant. Eight genotypes namely DCS47-1, DCS -5- 1-18, DCS -5- 3- 20, KBC -1-7, TPTC -1 (CP -15), CP - 108, C -151 x GM6 (F-5), CP -25 were found to be moderately resistant. Three genotype shows were found to be moderately susceptible, DC -15, CP-28 and Goa local. One more genotype C-152 was found to be highly susceptible.

Field screened of thirty-one promosing entries , five cowpea genotypes *viz.,* CP-20, CP-19, CP-11, CP-36, CP-41, were found to be Immune. Twelve genotypes of cowpea CP-24, CP-21, CP-17, CP-16, CP-15, CP-25, CP-26, CP-27, CP-32, CP-35, CP-40, CP-41, were found to be Resistant. Nine genotypes of cowpea *viz.* CP -18, CP -14, CP -13, CP -12, CP -28, CP -29, CP - 30, CP -33, CP -39, were found to be moderately resistant.Two genotypes of cowpea CP -34, CP -37, were found to be highly susceptible.

Conclusions

1) MARS, Dharwad and Yattinagudda (Dharwad taluk) were identified as hot spots for cowpea rust.

2) Ten days, Twenty and Thirty day's old plants were identified as most susceptible stages for infection of cowpea rust diseases.

3) *In vitro* evaluation fungicides revealed that propiconazole 25% EC at (0.1%) and hexaconzole 5% EC at (0.1%) were found to be effective to minimise the disease severity and recorded highest yield and yield parameters.

4) CPD – 84 (CP-12), C -151x CP-14, CP -43(TPTC-29), CP- 108, DCS -5-1-18 were identified as resistant lines and moderately resistant lines DCS47-1, DCS -5-3-20, KBC -1-7, TPTC-1(CP-15), C-151 x GM6 (F-5), CP -25, CP -25 (Phule CP05040), CP -23,against cowpea rust both *in vitro* and *in vivo.*

5) Chemical spray of propiconazole 25% EC at (0.1%) and hexaconzole 5% EC at 0.1% followed by the zineb 75% WP at 0.25% and trifloxystrobin 5% + tebuconazole 50% W/W at 0.1% and zineb 68% + hexaconazole 4%at 0.1% was identified as best chemical to management the rust disease.

Future line of work

1. To study the variability of pathogen associated with cowpea rust.

2. To study the mechanism of resistance in resistant lines.

REFERENCES

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

*Aiyer, A. K., 1950, Field crops of India .third edition, the Bengalore printing and publishing Co. Ltd Bengalore: 146-151.

Alam, M. M., Sadat, M. A., Hoque, M. Z. and Rashid, M. H., 2007, Management of powdery mildew and rust diseases of garden pea using fungicides *International. J. Sustain, Crop Prod.,* 2 (3): 56-60.

*Anilkumar, B. T., Chandrashekar, M. and Veerappa, K. B., 1989, Assessment of cowpea genotypes for multiple disease resistance (Abs). *Indian Phytopathol*., 42 : 334

Anonymous, 2013, *FAO, http//www.fao.stat.fao.org.*

*Asthana, A. N., 1998, Pulse crops research in India. *Indian J. Agric. Sci.,* 68 : 448-452.

*Ayub, A., Rahaman, M. Z., Ali, S. and Khatun, A., 1996, Fungicidal spray to control leaf rust of lentil. *Bangladesh J. Plant Paaiyer thol.,* 12 (2): 61-62

Barclay, A. 1891, Additional Urediniae from the neighbourhood of Simla. *J. Aseatic Soc. Bengal,.* 60: 211- 230.

Basandrai, D., Basandrai, A. K., Thakur, H. L. and Thakur, S. K. 2000, Inheritance of field resistance against lentil rust (*Uromyces viciae fabae*) in lentil (*Lens culinaris* L.). International Food Legumes Researc Conference –IV, IARI, New Delhi India October, 18-22, p.336.

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

Chandrashekar, M., Anilkumar, T. B. and Saifulla, M., 1988, Effect of different dates of sowing cowpea on the severity of leaf rust caused *Uromyces phaseoli var. vignae. Tron. Agric.,* 66: 149-152

Chaturvedi, G. S., Agarval, P. K. and Sinha, S. K., 1980, Growth and yield of determinate and indeterminate cowpeas in dryland agriculture. *J. Agric. Sci. Camb*., 94:137-144.

Delacueva, F. M., Laurena, A. C. and Natural, M. P., 1994, Occurrence of soybean rust caused by *Phakopsora pachyrhizi* Syd. In the Philippines and its wild legumes hosts. *Ann. Phytopathol. Soci. Japan*, 60: 109-112.

Desai, S. A., 1998, Chemical control of fig rust. *Karnataka J. Agric. Sci*., 11: 827-828.

Deshpande, S. K., Patil, B. R., Salimath, P. M., Nidagundi, J. M. and Karthigeyan, S., 2012, Evaluation of native and collected Germplasm for earliness Seed traits and resistance to rust, CMV and leaf spot in Cowpea [*Vigna unguiculata* (L.) Walp]. *Electron. J. Pl. Breed*., 1(4): 384-392

Diaz Franco, A. and Perez Garcia, P., 1995, Chemical control of rust and Rabia of chickpea and its influence on yield. *Revista mexicana de Fitopatholo*., 13 (2): 123-125.

Divya, B., Aghora, T. S., Rekha, A., Sudeep, P. and Radha, B. N., 2014, Physiological Basis of Rust Resistance in French bean (*Phaseolus Vulgaris*). *Intl. J. Horti*., 4 (11): 53-57.

Emechebe, A. M. and S. A. Shoyinka., 1985, Fungal and bacteria diseases of cowpea in Africa. Cowpea research, production and utilization, edited by S.R. Singh and K.O. Rachie, John Wiley and Sons, Chichester, UK, pp. 173–192.

Emeran, A. A., Sillero J. C., Fernández, M. A Rubiales, D. 2011, Chemical control of faba bean rust *(Uromyces viciae-fabae). Crop Prot.,* 30: 907-912.

Fernandez, A. M. V., Sillero, J. C., Emeranc, A. A., Floresd, F. and Rubialesa, D., 2011, Multiple-disease resistance in *Vicia faba* : Multi-environment field testing for identification of combined resistance to rust and chocolate spot. *Field. Crops. Res.,* 124: 59–65.

Fuzi, I. 1995, Fungicides against disease of pea, *Pisum sativum* L., in Hungary. *Pesticides Sci*., 45 (3): 292–95.

Gjaerum, H. B., Tjamos, E. C., Viranyi, F., Smith, J. Dunez, D. H., Phillips, R. A., Lelliot and Archer, S. A., 1986, Basidiomycetes II : Uredinales. In: I. M. (Eds.), *European Handbook of Plant Diseases,* pp. 473–503.

Gonzaliz, M. and Garcia, E., 1996, Evaluation of fungicides for the control of bean rust *(Uromyces appendiculatus). Agronomica Masoamericana*., 7 (1): 86-89.

Gupt, V, P., 1978, Investigations on bacterial blight of cowpea coused by *Xanthomonas vignicola* (Burk.) Dye with special reference to seed transmission and control, *M. Sc., Thesis*, Uni.Udaipur, Udaipur.

Gupta, D., Sharma, H. C., Pathania, P., Pande, S., Clements, S. L. and Bala, I., 2012, Evaluation of cultivated chickpea (*Cicer arietinum* L.) for agro-morphological traits and resistance to rust in Northwestern Indian Himalaya. *Indian Phytopathol.,* 65 (3):149-209.

Gupta, S. K. and Shyam, K. R. 1998, Control of powdery mildew and rust of pea by fungicide. *Indian Phytopathol.,* 51 (2):184- 86.

Gupta, S. K. and Shyam, K. R., 2000, Post infection activity of ergosterol biosynthesis inhibiting fungicides against pea rust. *J. Mycol. Pl. Pathol.,* 30 (3): 414-15.

Habtu, A., Sachet, I. and Zadoks, J. C., 1996, A survey of cropping practices and foliar Diseases of common beans in Ethiopia. *Crop Prot.,* 15: 79-186.

Hagedorn, D. J. and Inglis, D. A. 1986, *Handbook of Bean Disease,* Friday foundation New Richmond Madison Wiscosion Publishing, pp. 10 -12.

Hedge, R. K., 1974, Chemical control of powdery mildew and rust in peas. *Pesticides*., 8 (10): 21-22.

Herrera, H. A. and Plata, O. J., 1964, Comparison of four fungicides in the control of bean rust *U. appendiculatus*. *Acta. Agron., Palmira*, 13: 109-129.

Hiremath, P. C., Reddy, B. M. R., Deshpande, V. P. and Hegde, R. K., 1987, Occurrence of rust epidemic on Bengal gram in Karnataka., *Curr. Res.* Univ. Agril. Sci., Bangalore, Karnataka (India), 16 (12): 171-172.

Huq, H. I. and Nahar, M. S., 1997, Efficacy and economics of different fungicides in controlling rust and powdery mildew of garden pea., *Bangladesh J. Sic. Indust. Res*. 32 (4): 533-536.

Istran, F., 1996, Control fungicides against fungal diseases of peas. *Novenyvedelem,* 32 (3): 144 - 146.

Jacks, H., 1954, Screening test with fungicides for control of broad bean rust. *Rev. Appl. Mycol.,* 36: 274-279.

Jellis, G. J., Bond, D. A. and Boulton, R. E., 1998, Diseases of faba bean. In: D. J. Allen and J. M. Lenn´e (Eds.), *The Pathology of Food and Pasture Legumes,* CAB International, Wallingford, UK, pp. 371–422.

Jones, D. R., 1983, Chickpea rust A disease new to Australia., Queensland Dep of Primary Industry Farm Note AGDEX 168 : 637

Josefina, C. S., Alı, I. M. and Rubiales, D., 2012, Identification and characterization of resistance to rust (*Uromyces ciceris-arietini* (Grognot) Jacz. & Boyd) in a germplasm collection of Cicer spp. *Euphytica,* 188: 229–238.

Kale, J. K., 1992, Studies on some aspects of the rust of cowpea (*vignae ungiculata* (L) (WALP) Caused by *Uromyces phaseoli* var. *vignae* (Barcl.) Arth. *M. Sc. (Agri.) Thesis*, Uni. Agric. Sci. Dharwad, Karnataka (India).

Kale, J. K. and Anahousur, K. H., 1996, Chemical controls of cowpea rust. *Karnataka J. Agric. Sci.*, 9 (1): 179-81.

Kavyashree, M. C., 2014, Studies on fungal foliar diseases of green gram (*Vigna radiat* L.) Wilczek *M. Sc. (Agri.) Thesis,* Univ. Agri. Sci., Dharwad, Karnataka (India).

Khaled, A. A., Moity, E. S. and Omar, S., 1995, Chemical control of some faba bean diseases with fungicides. *Egyptian J. Agri. Res.,* 73 (1) : 45-56.

Kushwaha, C., Ramesh, C. and Srivastava, C. P., 2006, Role of aeciopores in outbreaks of pea (*Pisum sativum*) rust *(Uromyces fabae). European J. Plant. Pathol.,* 115 (3): 323-30.

Madhusudhan, B. S., 2002*, Studies* on soybean anthracnose caused by *Colletotrichum truncatum* (Schw). Andrus and Moore. *M. Sc. (Agri.) Thesis*, Univ. Agric. Sci., Bangalore, Karnataka (India).

Madrid, E., Rubiales, D., Moral, A., Moreno, M. T., Millan, T., Gil, J. and Rubio, J., 2008, Mechanism and molecular markers associated with rust resistance in a chickpea interspecific cross (*Cicer arietinum* x *Cicer reticulatum*). *Eur. J. Pl. Pathol*., 121: 43–53.

Mahanta, I. C., Dhal, A., Mohanty, A. K. and Mohapatra, S. S., 2000, Integrated management of diseases of kidney bean or rajmash (*Phaseolus vulgaris* L.) in North central plateau zone of Orissa. *Orissa J. Horti.,* 28 (2): 25-28.

Mariga, I. K., Giga. and Maramba, P., 1985, Cowpea production constraints and research in Zimbabwe. *Tropic.Grain. legume* Bulletin 30: 9-14

Mathur, R. S., 1954, Diseases of pulse crops in Uttar Pradesh. *Agr. Ani. Husb. Uttar Pradesh.,* 5 (1) : 24-28.

Mayee, C. D. and Datar, V. V., 1986, Phytopatholometry, *Technical Bulletin-1 (Special Bulletin-3)* Marathwada Agricultural University, Parbhani.

Mehta, P. R. and Mundkar, B. B., 1946, Some observation on rust of gram (*Ciceri arietinum*). *Indian J. Agric. Sci.,* 16 (2): 186-192.

Mittal, R. K. 1997, Effect of sowing dates and diseased development in lentil as sole and mixed crop with wheat. *J. Mycol. Pl. Pathol.,* 27 (2): 203-09.

Nargund, V. B., Benagi, V. I., Salimath, P. M., Rao, M. S. L., Nagaraju. P. and Basavarajappa, M. P., 2011, Effect of climate change in relation to severity of chickpea rust in northern Karnataka. *Nation. Symp. on Integrated Disease Management Strategies in Relation to Climate Change in South India*. October 14-15, 2011, Dharwad, Karnataka (India).

Pande, P., Sharma, M., Kumari, S., Gaur, P. M., Chen, W., Kaur, L., MacLeod, W., A. Basandrai, D., Basandrai, A., Bakr, J., S. Sandhu, H. S., Tripathi and Gowda, C. L. L., 2009, Integrated foliar diseases management of legumes, *Intl. Conf. on Grain Legumes : Quality Improvement, Value Addition and Trade*.

Pandey, S. K., Srivastava, R. K. and Shahi, H. N. 1995. Fungicidal evaluation against rust of lentil. *Ann. Pl. Prot. Sci.,* 3 (2): 164.

Panse, V. G. and Sukhatme, P. V., 1985, *Statistical Methods for Agricultural Workers,* ICAR Publications, New Delhi (India), p. 359.

Patil, B. S., 2013, Rust disease of chickpea. *Agropedia*.

Rahman, M. A. Yasmin, L. Bariand, M. A. and Hossain, A. E., 2005, *Shabgi fosoler rog-balai O Pratikar,* Plant Pathology Division, Horticulture Research Centre, Bangladesh Agriculture Research Institute. Gazipur, pp. 20-23.

Rangawami, G., Seshadri, V. S. and Lucy Channamma, K. A., 1970, Fungi of south India. Univ. Agric. Sci., Bangalore, Karnataka (India)., 193.

Rolim, P. R. R., Neto, B. P., Roston, A. J. and Oliveira, D. A., 1981, Chemical conrol of bean (*Phaseolus vulgaris* L.) Diseases. I. Rust (*Uromyces phaseoli* pers. Wint var *typica* Arth.). *Biologico*., 47: 201-205.

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

Sharma, A. K., 1998, Epidemiology and management of rust disease of French bean. *Vegetable. Sci*., 25 (1): 85-88.

Sharma, P. D., 2014, *Plant Pathology,* Rajsons Printers, New Delhi, p. 315.

Shifa, H., Hussien, T. and. Sakhuja, P. K., 2011 Association of Faba Bean Rust (*Uromyces viciae-fabae*) with Environmental Factors and Cultural Practices in the Hararghe Highlands, Eastern Ethiopia. *East Afri. J. Sci*., 85: 8-15

Shivanna, E., 2003, Epidemiology and management of okra powdery mildew caused by *Erysiphe cichoraceaumr* DC. *M. Sc. (Agri.) Thesis,* Univ. Agri. Sci., Dharwad, Karnataka (India).

Sing, B. B., Chambliss, O. I. and Sharma, B., 1997, Recent Advances in Cowpea Breeding. *Adv. in Cowpea Res.,* Co Publications of IITA and JIRCAS. IITA Ibadan, Nigeria, pp. 30-49.

Singh, D. and Tripathi, H. S., 2004, Epidemiology and management of field pea rust. *J. Mycol. Pl. Pathol.,* 34 (2): 675-79.

Singh, D., Tripathi, H. S., Singh, A. K. and Gupta, A. K., 2012, Effect of sowing dates and weather parameters on severity of rust of field pea*. J. Pl. Dis. Sci.,* 7 (2): 147-149.

Singh, J. P. and Musymi, A. B. K., 1979, Control of pea rust and powdery by a new systemic fungicide bayleton. *Pesticides,* 33: 51-53.

Singh, R. R. and Singh, M., 1997, Chemical control of pea rust*, Ann. Pl. Prot. Sci.* 5 (1) : 118-19.

Singh, R.S., 1973, *Plant Diseases,* Oxford and IBH, New Delhi (India), p. 512.

Singh, S. J., Sokhi, S. S. and Grewal, R. K., 1981, Relative efficacy of fungi toxicants against pea rust, *Indian Phytopathol.,* 34 (3): 272-75.

Singh, V. K., Sangar, R. B. S. and Singh, R. N., 1996, Effect of varieties and sowing dates on disease incidence and productivity of field pea (*Pisum sativum*). *Indian J. Agron.,* 41 (3) : 451-53.

Sokhi, S. S. and Sohi, H. S., 1976, Epidemiological studies on rust of cowpea (Abs.) on the severity of leaf rust caused by *Uromyces phaseoli* var. *vignae., Tron. Agric.* 66: 149-152.

Srivastava, L. S., 1999, Efficacy of fungitoxicants in managing rice bean rust in Sikkim. *J. Hill Res.,* 12 (1): 86-87.

*Steele, W. M., 1976, Cowpea *vigna unguiculata* (Leguminousae-papillionatae). In: Simmonds N. W. (Ed.) *Evolution of Crop Plants*, *Longman*, London, pp. 183-185.

*Stoffella, P. J., Bullock, R. C. and Sonoda, R. M., 1990, Influence of pesticide spray schedules on growth and yields of cowpeas. *Proc. of Inter-American Soc. Trop. Hortic.,* 34: 83–87.

Sumartini, 1998, Rust disease in french bean and its control. *J. Peneletian and Pengembangan Pertanian*, 17 (4) : 149.

Uma, M. S. and Salimath, 2003, Inheritance of rust resistance in cowpea (*Vigna unguiculata* (L) Walp.)., *Indian J. Genet.,* 63: 167-168.

Upadhyay, A. L. and Gupta, R. P., 1994, Fungicidal evaluation against powdery mildew and rust of pea (*Pisum sativum* L.). *Ann. Agric. Res.,* 15 (1): 114-16.

Venkta Rao, M, 1997, Studies on powdery mildew of green gram (*Vigna radiat* L) caused by *Erysiphe polygoni* DC. *M. Sc. (Agri.) Thesis,* Univ. Agri. Sci., Dharwad, Karnataka (India).

Vincent, J. M., 1947, Distortion of fungal hyphae in presence of certain inhibitors. *Nature,* 159: 239-241.

Wahome, S., Wkimani, P., Mmuthomi, J. W., Narla, R. D. and Uruchara, R. B., 2011, Multiple Disease Resistance in snap bean genotypes in Kenya., *African Crop Sci. J.* 19 (4), pp. 289 -302.

Wheeler, B. E. J., 1969, *An Introduction to Plant Disease,* John Wiley Sons Ltd., London, p.301.

*Yoshii, K., 1977, Therapeutic effect of fungicides to control bean rust. *Fitopatolo,* 12 : 99-100.

*Zaumeyer, W. J and Goldsworty, M. C., 1946, control of bean rust by fungicidal dusting and spraying (abs.). *Phytopathology,* 35: 489.

** - Originals not seen*

Appendix I: List of decoded promising entries against the cowpea rust

Sl. No.	Entries	Code
1	RC -101(C)	CP 14
2	GC-3(C)	CP 28
3	GC-901(AVT-2)	CP 11
4	KBC-4(AVT-2)	CP 12
5	PCP-0306-1(AVT-2)	CP 40
6	Phule CP-05040(AVT-2-N)	CP 41
7	TPTC-29(AVT-1)	CP 13
8	GC-13-1(GC1002) AVT-1-N)	CP 15
9	TC-142	CP 16
10	KBC-6	CP 17
11	CPD -172	CP 18
12	GC-1106	CP 19
13	PGCP-24	CP 20
14	HG-14	CP 21
15	PGCP-24	CP 22
16	GC-1105	CP 23
17	PGCP-11	CP 24
18	KBC-9	CP 25
19	PGCP-27	CP 26
20	TC-141	CP 27
21	GC-1110	CP 29
22	CPB-165	CP 30
23	KBC-7	CP 31
24	Goa cowpea-3	CP-32
25	KBC-8	CP 33
26	PGCP-12	CP 34
27	KBC-5	CP 35
28	PTB-1	CP 36
29	PANT LABIA-3	CP 37
30	DC-16	CP 38
31	PGCP-28	CP 39

EPIDEMIOLOGY AND MANAGEMENT OF COWPEA RUST CAUSED BY *Uromyces phaseoli* var. *vignae* (Barcl.) Arth.

RAMANAGOUD HONNUR **2015** **Dr. K .B. YADAHALLI**
MAJOR ADVISOR

ABSTRACT

The overall yield of cowpea in the present systems is low due to complex of biotic and abiotic factors. Among the biotic factors rust disease plays an important role in yield reduction. The disease survey conducted during *kharif*, *rabi* and summer of 2014-15, revealed, the highest disease severity was recorded at MARS Dharwad (43.55 PDI), in Dharwad district and least disease severity was recorded at Kodihal (23.35 PDI) at Hungund taluk of Bagalkot district. Cowpea rust was more severity in rainfed condition and flowering stage of the crop. 30 days old seedlings are highly susceptible. Uredospores were globoid, echinulate, single celled. Uredospores measured 22 to 34 µm in length and 18 to 24 µm in breadth. Under *in vitro* condition, the fungicides such propiconazole 25% EC followed by hexaconazole 5% EC the fungicides significantly inhibited uredospore germination and least inhibited uredospore germination was recorded in copper oxychloride 50 WP. Under glasshouse condition the least per cent (19.55PDI) disease severity was recorded in propiconazole 25% EC at 0.1 per cent while under field conditions, least disease severity (22.07 PDI) disease was recorded in propiconazole 25% EC at 0.1 per cent. The maximum disease severity (57.77 PDI) was recorded in untreated condition. The economics of disease management revealed maximum net income of Rs.25408 in propiconazole 25% EC with B: C ratio of 2.24 followed by trifloxystrobin 25%+tebuconazole 50% (net income Rs.24877 with B: C ratio 2.18) hexaconazole 5% (net income Rs. 23956 B: C ratio of 2.16). Among the 49 genotypes screened, DCS-5 -1-18, CPD-84 (CP-12), CP-108, CP -43(TPTC-29), C-151 x (CP-14) were identified as source of resistance against the cowpea rust both glasshouse and field condition.