“STUDIES ON GRAIN DISCOLORATION OF RICE”

M.Sc.(Ag.) THESIS

by

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DEPARTMENT OF PLANT PATHOLOGY
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“STUDIES ON GRAIN DISCOLORATION OF RICE”

THESIS

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By

CHANDRAMANI RAWTE

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CERTIFICATE – I

This is to certify that the thesis entitled **"STUDIES ON GRAIN DISCOLORATION OF RICE"** submitted in partial fulfilment of the requirements for the degree of **"MASTER OF SCIENCE IN AGRICULTURE"** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **CHANDRAMANI RAWTE** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

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

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CERTIFICATE - II

This is to certify that the thesis entitled **"STUDIES ON GRAIN DISCOLORATION OF RICE"** submitted by **CHANDRAMANI RAWTE** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) in partial fulfilment of the requirements for the degree of "**M.SC. (Ag)"**, in the **Department of Plant Pathology** has been approved by the Student's Advisory Committee after oral examination in collaboration with the external examiner.

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

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LIST OF ABBREVIATIONS

Abbreviations	Description
%	Per cent
µ	Micron
°C	Degree Celsius
/	per
@	At the rate of
@	At the rate of
BOD	Biological oxygen demand
CD	Critical difference
cfu	Colony forming unit
cm	Centimetre
et al.	And others/ co-workers
Fig.	Figure
g	Gram
ha	Hectare
hr^{-1}	Hour
i.e.	That is
kg	Kilogram
l	Litre
m	Metre
Mg	milligram
mm	Millimetre
ppm	parts per million
SEm±	Standard error of mean
sp.	Species
SS	Sum square
SV	Sources of variation
viz.	Namely

CHAPTER - I

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important crop of the world both in terms of area (152 mha) and production (585.6 mt) (Anon, 2004). One out of the three people depends on rice for more than half of their daily diet. About 90 per cent of the world's rice is grown and consumed in Asia and 60 per cent of world population also depend on rice for their half of the calorie intake from this crop (Mahadevappa, 2004).

Rice contributes around 45 per cent of India's cereal production and it is main food source for more than 60 per cent population in the country. India accounts for about 20-25 per cent of the rice in the world trade. Rice is cultivated in about 44.5 m ha area with an annual productivity of 2086 kg/ha (Mishra, 2005).

Chhattisgarh is famous as "Rice Bowl" in India, occupying 3.74 m ha area with productivity of 1730 kg/ha (Urkurkar and Pandey, 2001). However, the productivity of rice in the state is much lower than national productivity level.

Rice crop suffers with many biotic and abiotic stresses that incites diseases. The major diseases of rice are blast, sheath rot, sheath blight, brown spot and bacterial leaf blight that account yield losses by 15-20 per cent.

Sophisticated and integrated approach to crop management i.e. introduction of high yielding varieties, favorable weather condition, change in cropping pattern, plant population with heavy nitrogen, have a great impact on heavy incidence of economically important diseases. Some plant diseases, which were less significant earlier, are now gradually gaining importance and posing serious threat to the crop production. Among them the discoloration of rice grain disease is one, which is also known as “Glume discoloration” and “Dirty panicle” etc.

Discoloration has been prevalent in almost all part of the world where rice is grown. It was earlier considered to be a minor disease is now gaining more importance due to its severity in tropical rice growing areas (Narain, 1992). The disease is distributed throughout Asia, Africa and America. In many regions of India, the early and medium rice cultivars grown particularly in wet seasons are generally exposed to high humidity and warm environmental conditions during flowering and post flowering stages which significantly induced the disease incidence. In Orissa severe rice grain discoloration by large number of fungi has been reported. These fungi individually or in combination were demonstrated to be infectious (Dash and Narain, 1988; Dash, 1986 and Huq, 1985).

Seed discoloration is an early indication of poor seed or grain quality which is generally associated with micro-organisms. Such grains are of poor market value and low consumption quality due to degradation in nutritional value.

Various microorganisms may infect Rice grain before and after harvest causing discoloration. Among these microorganisms involved with discoloration, fungi predominate, however bacterial species have also been reported. The extent of damage varies according to season, locality, seed micro flora, host cultivar, their physiology and genetics.

The seed borne inoculum of *Alternaria alternata* is responsible for ashy grey discoloration and *Helminthosporium oryzae* (*Cochliobolus miyabeanus*) (responsible for black discoloration, dark brown spots and light to dark brown dot like spots) were found in the seed coat and endosperm of discolored seed, where as *Curvularia geniculata* (*Cochiobolus geniculatus*) found responsible for eye shaped spots. Besides, *Fusarium equiseti, Fusarium oxysporum (Gibberella zeae), Fusarium moniliforme (Gibberella fujikuroi)* found responsible for pink discoloration.and *Sarocladium oryzae* responsible for light brown discoloration were found in the seed coat, endosperm and embryo of discolored seed (Sachan and Agrawal, 1995).

Grain discoloration of rice has been found most serious for last few year in our locality looking to its spread and severity this has invited greater interest for detailed studies with the following objectives.

1. To assess percent grain discoloration in important rice varieties.
2. To assess relationship of pests and other rice diseases with grain discoloration of rice.
3. To manage the grain discoloration of rice.

CHAPTER-II

REVIEW OF LITERATURE

Grain discoloration of rice was found to be a serious disease in India and other rice growing countries in the world resulting huge loss in yield and quality of the seed deteriorating the commercial value of the crop. The disease has been observed wide spread with introduction of high yielding varieties and sophisticated management practices.

2.1 Per cent grain discoloration and loss in grain weight of rice varieties

The effect of grain discolouration on seed germination and quality seed losses were recorded. Incidence of discoloration was higher (23%) in PR-106 than in IR-8 (19%). The seed germination reduction was proportional to discoloration severity reported by Sharma *et al*. (1987). The reduction in seed germination in rice cultivar PR-106 and IR-8 were recorded by Sharma *et al*. (1987).

Mishra *et al*. (1991) recorded 1000 grain weight of 66 rice cultivars and found that losses up to 31.2 per cent and 50.2 per cent occurred in seed classified as having less than 50 per cent and more than 50 per cent area of seed discolored, respectively compared with seeds classified as healthy and with no discoloration.

Mishra *et al*. (1991) observed losses in thousand grain weight of 66 rice cultivar and concluded that losses in weight went upto 41.2 and

50.2 per cent, respectively in seed lot having less than 50 per cent discoloured seeds and having more than 50 per cent discoloured seed, respectively.

Bernhardt (1999) also reported rice samples were collected from Arkansas rice cooperative storage facilities in 1996. resulted each samples viz Arkansas (94%), Missouri (4%), Mississippi (1%) and Louisiana (1%) was evaluated amount of percent grain discoloration.

Sinha (1999) reported maximum incidence of seed discolouration in the rice cultivar TN-1 (66%), Manhar (62.8%) and Jaya (58.7%). He also observed that the reduction in grain weight of rice with increase in degree of discoloration. Maximum loss in grain weight was recorded in Basmati (24.8%) followed by Prasad (22.6%) and Bala (21.7%).

Negi *et al*. (2003) reported that incidence of light to dark brown dot like spots was most pronounced in var. Narendra-80 (54.7%), Manhar (46.6%), Saket (45.3%) and Pant Dhan-16 (40.3%). caused by Bipolaris oryzae. While *Curvularia lunata* was recorded in Narendra-80 (44.3%), Indrasan (36.8%), *F. graminearum* was pronounced in Manhar (40.3%), Pant Dhan-16 (39.9%) and Saket-4 (30.8%), *F. moniliforme* pronounced in Narendra 259 (47.4%), Basmati 385 (45.4%). On individual basis variety Basmati-385 showed high incidence of grain discoloration (36.8%) followed by Pant Sugandha Dhan-15 (30.2%), Basmati 386 (29.4%) and Taroaori Basmati (25.8%).

2.2 Mycoflora associated and effect on seed germination

Baldacci *et al*. (1948) in Italy reported 23.4 per cent were identified as *Cochliobolus miyabeanus* (23.4%), *Alternaria* sp (13.4%), *Epicoccum purpurascens* (4.9%), *Penicillum* sp. (4.9%).,*Fusarium* sp. (1.2%), *Cephalosporium* sp (1.2%), and sterile spp (19.7%) from discolored rice grain.

Padmanabhan *et al*. (1949) had studied the grain discoloration in rice caused by several fungi namely *Sarocladium oryzae, Curvularia lunata, Drechslera oryzae, Trichoconis padwickii, Cercospora oyzae, Fusarium moniliforme, Nigrospora oryzae* were isolated from the seeds ,resulting in reducing rate of germination.

According to Johnston (1958) in Malaysia, 9.1 per cent of the seeds examined to be infected with *Drechslera oryzae*, 7.9 per cent *Alternaria padwickii* and 14.6 per cent *Fusarium* spp. Also present were species of *Aspergillus penicillium* and *Curvularia* and reduced seed germination.

Izuka (1958) studied the storage moulds of Burma and Thailand and found that they were mostly species of *Aspergillus*, *Penicillium* and Stregptomyces were isolated from rice seeds germination was adversely affected.

Pandey *et al*. (1982) had studied six fungal species viz: *Aspergillus flavus, A. niger, Alternaria alternata Cladosprium cladosporioides , Epicoccum purpurascens* and *Penicillium granulatum* isolated from seed of *Setaria italica*. Seed were soaked in each of the metabolites for 24 hr. at room temperature, treated seed were

transferred into moist chamber. Results shows that the fungal metabolites reduced the seed germination of *S. italica* by *E. purpurascens* (63.16%) followed by *Aspergillus flavus* (36.84%), *A. niger* (34.74%), *Alternaria alternata* (34.74%), *Cladosprium cladosporioides* (37.19%) and *Penicillium granulatum* (28.42%).

Imolehin (1983) observed *Helminthosporium oryzae*, *Fusarium moniliforme*, *Penicillium* sp., *Curvularia lunata*, *Aspergillus* sp., *Rhizopus arrhizus*, *Geotrichum* sp. and *Alternaria* sp. in the discoloured seed. High negative correlation was obtained between seed infection by all isolated micro organisms and seed germination.

Zakeri *et al*. (1983) reported the presence of *Curvularia geniculata* and *C. lunata* in seed coat, endosperm and embryo of rice seeds and inhibit the seed germination.

Sharma *et al*. (1987) reported that rice discoloration due to fungal species were isolated from discolored seeds namely *Fusarium moniliforme, Alternaria alternata, Curvularia lunata* and *Trichoconis padwicki.* Severity of discoloration was due to *Fusarium moniliforme* and lower percent of germination was occurred.

Jayaweera *et al*. (1988) reported that grain discoloration was inhibitory to the seed germination or the factor inducing grain discoloration had damaged the embryo of seed, resulting in reducing rate of germination.

Ahmed *et al*. (1989) reported that fungi associated with grain discoloration (*Curvularia affinis* and *Helminthosporium oryzae*) resulted

in stunted growth of seedlings and *Fusarium pallidoroseum* caused seed decay, pre and post emergence mortality hampering germination.

According to Agarwal *et al*. (1989), majority of fungi namely, *Alternaria alternata, Curvularia lunata, Fusarium moniliforme, Helminthosporium oryzae, Nigrospora oryzae, Sacrocladium oryzae* and *Trichoconis padwickii* responsible for causing grain discoloration are reported to be seedborne in nature.

Bokhari (1991) recorded that *Curvularia* sp., *Ulocladium* sp., *Alternaria* sp., *Aspergillus* sp*., Fusarium* sp., *Mucor* sp. and *Penicillium* sp. From discoloured rice grain and reported poor seed germination.

Kim (1992) reported that fungi associated with discolored rice grains collected from three areas of Korea were namely *Cladosporium cladosporioides, A. alternata, Pyricularia oryzae, Fusarium sp., F. graminearum* and *Cephalosporium gramineum* the most frequently isolated species from the rice seeds.

Sachan *et al*. (1994) had studied the fungi associated with all the eight types of grain discoloration in rice resulted in loss of viability, germination and seedling vigour. In each case maximum loss in seed viability germination and seed vigour was found in seeds with discoloration on the embryo and endosperm regions compared with lower categories of discoloration.

Deka *et al*. (1995) reported the fungi associated with rice discoloration recorded from freshly harvested grain as well as during storage. *Curvularia lunata* was predominant occurring for *Curvularia* six

months. *Aspergillus niger* was detected up to eight months in storage and may play a major role in seed deterioration, particularly in combination with *C. lunatus*. *Curvularia lunatus* caused the maximum reduction in seed germination.

Misra and Vir (1996) detected fungi causing discoloration of rice seed are *Fusarium equiseti*, *Fusarium solani*, *Fusarium moniliforme* (*Gibberella fujkuroi*), *Pyricuralia oryzae*, *Epicoccum purpurascens* (*E. nigrum*), *Sarocladium oryzae*, *Alternaria alternata*, *Alternaria padwickii*, *Cladosporium cladosporioides* and *Sclerotium oryzae*.

Ali *et al*. (1996) isolated 10 fungal species from seven genera, *Curvularia*, *Drechslera*, *Nigrospora*, *Trichothecium*, *Fusarium*, *Aspergillus* and *Penicillium* from discolored grain of six rice cultivars. The frequency of *Fusarium moniliformae* was highest among the field fungi, while those of *Aspergillus* and *Penicillium* spp. among storage fungi after 8 to 10 months of storage.

Deka *et al*. (1996) had studied the common fungi found associated with rice grains were : *Curvularia lunata, C. palrescens, C. geneiculata, C. eragrostidis, Drechslera oryzae, Fusarium moniliforme, Nigrospora oryzae, Trichoconis padwickii* and *Trichothecium roseum* resulted in loss of germination percentage..

Ali *et al*. (1996) reported that pathogen association with rice cultivar namely *C. lunata* was highest in TN-1 (27.5%), IR-50 (25.0%), IET-6666 (22.5%) and lowest in Mashuri (7.5%) and *F. moniliforme* was highest in Masuri and IET-6666 recorded (25.0%) and lowest with IR-50

(15.0%). Per cent occurrence of *Trichoderma padwickii* ranged from 7.5 to 15.0 association of all fungi was low. However, a *Fusarium* spp. Found constantly associated all the cultivars tested ranged from 22.5 per cent.

Bicca *et al*. (1998) fungi observed in rice seeds namely *Fusarium* sp*., Phoma* sp*., Helminthosporium* sp*., Rhynchosporium* sp*., Alternaria* sp*., Curvularia* sp*., Nigrospora oryzae, Cladosporium* sp*., Aspergillus* sp*., Penicillium* sp*.* and *Epicoccum* sp. However consistent relationship were found between *Fusarium* sp. and *Phoma* sp. in discolored seeds.

Pandey *et al*. (2000) reported mycoflora from seeds of hybrid rice *Alternaria padwickii, Cochliobolus miyabeanus, Drechslera australiensis, Fusarium palidoroseum* and *Magnaporthe grisea* whereas, *C. lunatus, Curvularia ovoides, C. oryzae, Gibberelea fujikuroi, Mangnaporthe salvinii, Nigrospora oryzae* and *Sarocladium oryzae.*

Prakash *et al*. (2001) reported six fungi associated with discolored grain namely *Sarocladium oryzae, Cochliobolus miyabeanus, Gibberella fujikuroi, Curvularia lunata, G. zeae* and *Alternaria* sp. The highest infestation rate in all cultivars was caused by *S. oryzae.*

Gutierrez *et al*. (2002) isolated *Alternaria longissima, Gaeumannomyces graminis var graminis, Microdochium oryzae, Nakataea sigmoidea* and *Pyricularia grisea* from rice seed from the first time in Argentina during seed health testing. The isolated fungi may be seed borne and much associated with grain discoloration.

Negi *et al*. (2003) had studied the effect of grain discoloration, the mycoflora associated with *Bipolaris oryzae, Curvularia lunata, Fusarium graminearum* and *F. moniliforme*. On the seed germination and viability as well as on the seedling vigour of rice cultivars. Whereas, pink to light brown discoloration caused by *F. moniliforme* recorded the highest number of abnormal seedlings.

Reddy *et al*. (2004) reported *Aspergilli* (*Aspergillus flavus, A. ochraceus* and *A. niger*) infections on paddy samples collected from different rice growing areas in India. They included *A. flavus* showing two distinct types, one having olive green and other parrot green colony colours.

Chauhan *et al*. (2005) had studied the rice discolored seeds associated with several pathogenic and saprophytic fungus viz. *Sarocladium* sp., *Penicillium* sp., *Fusarium* sp., *Curvularia* sp., *Phyllostieta* sp., *Pyricularia* sp., *Diplodia* sp., *Aspergillus* sp. and *Alternaria* sp. in recent years.

Samira *et al*. (2005) reported two type of, one is true rice pathogens : *Pyricularia grisea, H. oryzae, H. satium, H. australiensis, H. spiciferum* and *C. lunata*. Second saprophytes that cause rice discoloration like *T. harzianum, A. alternata, N. oryzae, Epicoccum nigrum, F. moniliforme, Cladosporium herbarum* and *Trichothecium roseum*.

2.3 Pathogenicity test

Kodama and Tsuchiya (1981) isolated *Epicoccum purpurascens* from brown blotches on rice and proved their pathogen city by spraying aqueous spore suspension on sheath and ears.

Duraiswamy and Muriappan (1983) proved pathogenicity of three species of fungi on panicles at the various stages of development in the field by spraying a spore suspension (90,000 /ml). Control plants were sprayed with water. All three species of fungi caused discoloration when inoculated at flowering, milking and soft dough stage. *Helminthosporium oryzae* caused maximum discoloration which was inoculated at flowering stage or soft dough stage. Inoculation at dough stage produced no discoloration.

Roy (1983) conducted pathogenicity test using spore and mycelial suspension of three *Curvularia* sp., *Cephalosporium* sp., *Fusarium chlamydosporium* and *Fusarium intertextum*. About 50 per cent of the grains were infected when the glumes were forced open and inocula were placed inside.

Huq (1985) isolated a number of fungi from discoloured rice grain from Bhubaneswar and established pathogenic nature of these fungi by artificially inoculating panicles of healthy Ratna rice variety.

Chien *et al*. (1987) dipped of *Pseudomonas glumae (*108 cfu/ml*)* for 30 min. Resulted germination was affected by 98 per cent of seedlings died, and inoculation at the booting stage by injection with a

similar suspension caused infection and discoloration of all panicles and sheaths.

Jin (1989) reported that isolates of *Curvularia* collected from 15 cities in China and inoculated to rice cultivars in pots showed five typical symptoms rice grains (entirely dark brown, semi dark brown, dark brown lesion, dark brown spots). Husked rice showed light to deep black symptoms and caused discoloration of rice grains.

Dash and Narain (1989) conducted pathogenicity test on five cultivars (Parijat, Pathara, Annapuma, OR-556-8 and OR-163-104) raised in pots. They sprayed fungal spore suspension (500 spores/ ml sterile water) of four selected isolates (*Alternaria altemata*, *Curvularia lunata*, *Fusarium pallidoroseum* and *Sporothrix* sp.) single or with mix in 10 combinations. They observed the disease symptom began to appear on mature grains.

Ahmed *et al*. (1989) proved pathogenicity by inoculating *Curvularia affinis* and *Helminthosporium oryzae* resulted in stunted growth of seedlings and *Fusarium pallidoroseum* caused seed decay and pre and post emergence mortality besides grain discoloration and hampering germination.

Castano *et al*. (1991) isolated 20 seed borne fungi out of which *Helminthosporium oryzae* (*Cochliobolus miyabeanus*) was the predominant species and they conducted pathogenicity test reproduced typical grain discoloration symptoms.

Chai *et al*. (1991) proved pathogenicity of *Alternaria* sp., *Curvularia* sp., *Fusarium* sp. and *Penicillium* sp. by spraying inocula on rice plants at flowering stage and large number of discoloured grains were produced in later stage, although disease symptom and severity differed in species.

Ray (1993) inoculated the cultivars CR-1009, CR-1014 and Ratna with four grain discoloration causing fungi (*Sarocladium oryzae, Drechslera oryzae, Curvularia lunata* and *Trichconis padwickii)* at flowering stage showed maximum discoloured grains than inoculated at heading, booting, milk, dough and mature stage with their individual significances.

Bora and Gogoi (1993) proved pathogenicity by inoculating rice seeds with four isolates (*Fusarium moniliforme*, *Fusarium pallidoroseum*, *Curvularia affinis* and *Helminthosporium oryzae* caused discoloration.

Jin *et al*. (1994) inoculated rice plant with nine *Curvularia* sp. produced 21.7 to 65.4 per cent discoloured rice grains.

Ray (1993) sprayed spore suspension of *Sarocladium oryzae* (3000 spores/ ml), *Curvularia lunata* (700 spores/ml), *Drechslera oryzae* (900 spores/ ml) and *Trichoconis padwickii* (800 spores/ ml) on rice plants at flowering stage in morning hours with the help of an atomizer. However, *Sarocladium oryzae* which is the main causal organism was found to cause grain discoloration in rice plants.

Cottyn *et al*. (1996) inoculated bacterial strains into the flag leaf sheath produced symptom characteristics of infection of *Pseudomonas gumal* (responsible for flumae discoloration).

Sharma *et al*. (1997) reported ten fungi viz., *Alternaria alternata, Aspergillus niger, Curvularia lunata, Fusarium* sp*., Helminthosporium oryzae, Nigrospora oryzae, Pestolotia oryzae, Phyllosticta glumarum, Penicillium* sp*.* and *Sclerotium oryzae* from pigmented rice grain. All fungi, except *A. niger* and *Penicillium* sp. were pathogenic to grain discoloration in four stages like boot stage, heading stage, milk stage and dough stage. However, the heading stage was the most susceptible to grain discoloration.le for flumae discoloration).

Sisterna *et al*. (1998) had studied the pathogenicity of *Curvularia protuberata* and its effect on germination of rice grains (var. Igra 409). These grains showed discoloration and a dark brown mass of conidia and conidiophores covering their surfaces. This is the first report of *C. protuberata* as an associated microorganism of spotting of rice grains.

Negi *et al*. (2003) studied seeds in panicles of rice plants artificially inoculated with spore suspension (9 x 102 spores/ ml) of *Bipolaris oryzae, Curvularia lunata, Fusarium graminearum* and *F. moniliforme*, and observed 30.6% light to dark brown dot like spots due to *Bipolaris oryzae* followed by *Curvularia lunata*, 30.4 per cent, *F. moniliforme* 29.2 per cent and light pink to light brown due to *Furasium graminearum* 24.4 per cent.

Negi *et al*. (2003) inoculated some rice cultivars like: Ajaya, Basmati 385, Narendra 80, Pant Dhan 12 and UPRI 92, 97 with the pathogens namely *Bipolaris oryzae, Curvularia lunata, Fusarium graminearum* and *F. moniliforme* were resulted in light to dark brown spots, dark black and brown and light pink to light brown discoloration on the seeds. All discolorations reduced the viability of rice seeds, with dark brown seeds caused by *F. graminearum* showing the highest reduction in seed viability.

2.3 Weather on incidence of grain discoloration

Martyn (1936) recorded severe infection by *Curvularia lunata* during a wet season in field rice.

Kimura (1937) found that moist weather at the flowering period in rice plant resulted induced discoloration of large number of grains and mycoflora association viz: *Phoma sorghina*, *Cochliobolus miyabeanus*, *Alternaria* sp., *Epicoccum byalopes*, *Gibberella fujikuroi* and other fungi.

Ghosh (1951) found that mould development depended more on the relative humidity of the storage atmosphere than the moisture content of the rice grains, development being fairly rapid on all samples exposed to 65 to 100 per cent RH. He also found that species of *Aspergillus* grow best at 30-35°C, *Penicillium* at 25°C, *Mucor* at 30°C, *Fusarium* at 35°C and *Cladosporium* and *Alternaria* at 22-25°C.

Ebata *et al*. (1989) reported that brown discoloration was caused by wind at flowering and the occurrence of milky white grain was increased by wind 14-21 days after heading.

Jones *et al*. (1990) grown two rice varieties namely IR-7167-33-2-3 and Tainan-5 at low temperature with high RH and intermittent winds, it was observed that both lines showed high level of tolerance against sheath rot and grain discoloration. The panicle tip degeneration was also recorded at low temperature.

Ramalingam *et al* (1991) had studied that rice semidwarf cultivar MDU-4, IR-20 and MDU-2 grown at Tamilnadu. Resulting MDU-4 is has found lower spikelet sterility and grain discoloration than IR-20 and MDU-2 due to low temperature.

Bilgrami and Choudhary (1991) observed the percent incidence of *Aspergillus flavus* in relation to coexisting fungi varied in different season. However, the incidence of *A. flavus* alone on individual maize kernels significantly correlated to the moisture percent of the substrate as well as to the percent RH at 2pm. They have also reported high incidence of *A. flavus* on maize kernel during the monsoon season when the moisture per cent of the seeds as well as RH were quite high. Negative correlation between *A. flavus* and rainfall is obviously due to the effect of rainfall on the airborne inoculums of *A. flavus.*

Sharma *et al*. (1993), 163 samples of rice Cv. PR-106 were collected from during lodging mand flood intensity after 614 mm of rain during the last week of September, 1988 caused widespread losses in the Indian Punjab rice crop. Seeds from completely or partially lodged submerged crop were coated with fungal mycelium and showed reduced vigour and yield when tested in the fields.

According to Hsiech *et al*. (1996) the rice crop in the coastal area of central Taiwan is always low yielding and shows discoloration this could be caused by the salty cold north east monsoon which can affect rice at the flowering stage to induce sterile unfilled grain, and to small mites inducing sheath rot and resulting in unfilled or imperfectly filled brown grain.

Krishnan *et al.* (2005) reported that the effect of environment on seed yield and quality were investigated using 12 rice genotypes grown during 3 year (2002-2003). Results shows that proportion of seed setting, percentage seed germination and grain discoloration were influenced more by environmental effects. Correlation analysis suggested that warm weather condition with high solar radiation and without excessive rainfall during grain filling stage gave the best rice seed yield with high quality and no grain discoloration.

2.5 Effect of Date of sowing on grain discoloration

Suriachandraselvan *et al*. (1989) in the year 1985-86 incidences of brown spot and grain discoloration was lowest with sowing on 10th August, while sheath rot incidence and severity were lowest with sowing on 20th September. In 1986-87, brown spot incidence was lowest with 10th August sowing while that of sheath rot, grain discoloration and sheath rot severity were lowest with sowing on 20th September.

Rao (1990) reported that the yield reduction is mainly due to decreased number of fully filled grain with delayed planting. The

proportion of chaffy, partially filled, poor and average grades increased with delayed planting contributing to higher spikelet number.

Krishnan *et al*. (2005) seed yield and quality were investigated using 12 rice genotypes grown during three years (2002-2003) at four different sowing dates in India. The results show that the potential seed longevity, percentage seed germination and proportion of grain discoloration were occurred and influenced by environmental effects than by genotypic effects.

2.6 Rice disease incidence with grain discoloration

Trimurthy *et al*. (1980) reported that sheath rot caused by *Sarocladium oryzae* is an important disease of rice inflecting economic damage; it also increases the chaffy grain in panicle.

Singh *et al*. (1996) in laboratory tests found *S. oryzae* only on discolored rice seed that was mainly carried externally (78%). Prabhu *et al*. (1996) reported that there was positive correlation between brown leaf spot and grain discoloration severity in early and midseason types.

Dharam *et al*. (2001) reported that stack burn disease (*Alternaria padwickii*) infection in rice causes black discoloration beneath the husk on the tip and beyond, even up to half of the length of the paddy seed, depending on the infection intensity.

Gravois *et al*. (2000) reported that discolored kernels are most often caused by damage from rice stink bugs (*Oebalus pugnax*) and kernel smut disease (*Tilletia barclayana*), but other pathogen and physiological disorders can also contribute to grain discoloration.

Gill *et al*. (1998) in a greenhouse, to study the effect of tungro viruses on sheath rot development of rice Tungro viruses were inoculated during the seedling stage and *Sarocladium oryzae* was inoculated at the early booting stage. RTBV and *S. oryzae* acted synergistically, which resulted in, increased grain discoloration and caused a reduction in panicle emergence.

2.7 Effect of Insect feeding on grain discoloration

Su (1938) reported that injuries from insects in the field or during storage might also increase grain discoloration.

Hyon (1963) reported that injuries from insects in the field or during storage and from wind and rainstorms might also increase grain discoloration.

Muriniate *et al.* (1990) reported in detail about the Brown plant hopper damage on paddy plant. The Brown plant hopper causes weight loss of grains in the paddy crops due the sucking cell sap from plants as a result of it the plant losses its vigor. The cell sap drawn by the hoppers are very essential for plants at grain filling stage. When the hopper suck the cell sap from plants, the quality of sap being minimizes which produces chaffy and partially filled grains. It has been observed that the weight losses due to this insect are 10-15% when the insect population is above ETL.

Cottyn *et al*. (1996) reported that grain discoloration was attributed to fungal disease, insect and abiotic factors.

Samuales *et al.* (1996) studied in detail about the effect of BPH feeding on paddy plant. In this study they have collected and released 30 nymphs on each healthy plants, then these plants were covered with nylon nets. The BPH feeds on the basal portion of the plants during the hot and humid climatic conditions. At maturity the grains were examined for various parameters of grain quality. It was found that weights of these grains were reduced up to 20-25% as compared to normal healthy grains. When these grains were examined under the intensive light sources it was found that the colour of grains turned into light brownish to dull. They have concluded that Brown plant hopper causes indirect effect on rice grain colour and weight. This pest is responsible for causing the grain discoloration which detoriate the rice quality and decreases the market price of produce.

Bernhardt *et al*. (1997) reported that after feeding by rice stink bugs (*Oebalus pugnax*) infection of fungi and bacteria are evaluated and causes of grain discoloration in rice cultivars. Medium rice cultivars namely Lafitte, M202, Koshihikari and Bengal had very high amount of grain discoloration due to rice stink bugs.

Kenneth *et al*. (2000) reported that discolored kernels are most often caused by damage from rice stink bugs [*Oebalus pugnax* (Fabricius)]. Adults and nymphs feeding during the early stages of kernel development prevent kernel development and results in total grain loss.

Rao *et al*. (2000) reported that spikelet sterility or grain discoloration was observed in the 24 villages of west and east Godavari

districts during 1999 wet season affected rice varieties MTU 1001, MTU 2067, MTU 20077, MTU 7029, BPT0-5204, PLA-1100. Symptoms were observed on affected plants due to mite; saprophytic fungus and sheath rot fungus. Visual symptoms such as black lesions in the leaf sheath, discolored grains, complete or partial chaffy grains and various deformities were observed.

Prakash *et al*. (2000) reported that under natural conditions of *Leptocorsia acuta* Thumb. (Earhead bug) infestation in rice field observed six pathogenic fungi namely – *S. oryzae, H. oryzae, A. padwickii, F. moniliforme, F. graminearum* and *C. lunata*. With the discoloration of the bug infested grains. Under artificial inoculation of the three test fungi *S. oryzae, G. zeae and C. lunata.* Thus rice bug *L. acuta* was found to enhance rice grain discoloration of the test fungi.

Rao *et al*. (2003) reported that mites infested grains were discolored in some of the varieties, no fungus was isolated from these grains and this discoloration might be due to chemical reaction of the toxins secreted by these mites. In India, during 1999-2003 varying might population per tiller and grain sterility in rice have been reported to be positively correlated?

2.8 Chemical control of rice grain discoloration.

Schroeder (1964) reported that the use of infrared drying and additional treatment with sodium propionate (5000 ppm) reduced infection grain discoloration due to field fungi.

Sharma *et al*. (1987) reported that different fungicides improved germination of discolored seeds were Baytan (0.25%) was slightly inhibitory to germination of seeds and Thiram (0.3%), Emisan (0.3%) and Derosal (0.2%) proved highly effective in improving the germinability of the seeds. Reported that Thiram, Emisan and Derosal were highly effective in improving the germination of discolored grains.

Ray *et al*. (1988) reported that five chemicals namely Bavistin, Hinosan, Indofil M-45, Tilt and common salt (10%) were sprayed at two stages 1st at boot-leaf and 2nd 20 days after 50% flowering. Mancozeb was also found effective in controlling grain discoloration in Japan and Mancozeb and Bavistin in India.

Rodriguez *et al*. (1988) reported that fungicidal spray at 10% panicle emergence with Iprodione at 1 kg/ha, Iprodione + Edifenphos at 0.75 kg/ha + 1 lit/ ha, Iprodione + Zineb at 0.75 kg/ha + 2 kg /ha at Edifenphos at 1 lit/ha reduced infection of grain discoloration in Venezuela

Mishra *et al*. (1990) had studied the fungi causing discoloration of paddy seeds were observed to cause deleterious effect on seed germination under heavy inoculums pressure. The effect was most pronounced with *Pyricularia grisea* and *Fusarium equiseti*. Seed treated with Agrosan GN and Captan was found highly effective in improving seed germination of discolored seeds.

Narain (1992) conducted experiment with 12 fungicides use to improve germinability to seed germination but Thiram, Emisan and

Derosal were highly effective in improving the germinability of discolored seeds.

According to Ray (1993-94) six fungicides namely – Carbendazim, Dcmod, Mancozeb, Copper oxychloride, Di-isopropyl benzyl thio phosphate (IBP) and Edifenphos were sprayed each at 0.05%, 0.1% and 0.2 per cent concentration. However, six fungicides tested, Carbendazim was found to be the most effective in controlling the grain infection at all the concentration even though there were significant variation in the percentage of grain discoloration.

According to Sachan *et al*. (1994) seed treatment with Captan, ceresin, Dithane M-45, thiram, Bavistin, Bavistin + Dithane M-45 (1:1) and Bavistin + Thiram (1:1) considerably reduce the inoculums of seed borne fungi responsible for grain discoloration. However Bavistin + Dithane M-45 and Bavistin + Thiram were significantly superior to other fungicides in increasing the germination and seedling vigor of discolored seeds of rice and reducing the seed borne inoculums.

Vaid *et al*. (1994) conducted experiment in two different trials, Carbendazim at 2 g/kg of seed was best of six seed dressing fungicides for improving germinability of discolored rice seeds and 0.2% carbendazim was also the best of nine sprays for reducing discoloration in harvested grain, caused by a complex of fungi.

Jin *et al*. (1994) reported that discolored rice grain treated with Mancozeb (70%) gave 69.9 per cent control of the disease.

Sistema and Ronco (1994) tested three fungicides at four concentrations against four common fungi. Mancozeb at 500 ppm was the most effective against *Curvulaia lunata*, *Bipolaris oryzae*. Carbendazim and Thiabendazole controlled growth of Fusarium semitectum and Fusarium monilliforme at 50 ppm.

Ali and Deka (1996) reported that Bavistin, as a seed dressing fungicide reduced seed microflora appreciably during storage.

Deka *et al*. (1996) applied Indofil M-45 at the boot leaf stage followed by spray with common salt (10%) 20 days after 50% flowering was found most effective in combination in reducing grain discoloration than fungicide alone at both stage.

According to Ali *et al*. (1996) to control the seed borne field fungi like : *Fusarium* and storage fungi *Aspergillus* and *Penicillin*, seed treatment with bavistin @ 1.0 g/kg seed was found effective maintaining seed germination of more than 70 per cent even after eight months of storage.

Malavolta *et al*. (1997) reported that the effectiveness of spraying with prochloraz (450 g/ha), Tebuconazole (187.5 g/ha), Stannic triphenyl hydroxide (250 g/ha), propiconazle (125 g/ha), Chlorothalonil (1250 g/ha), tricyclazole (187.5 g/ha), Kasugamycihn + Stannic triphenyl acetate (20 + 100 g/ha) in the control of fungi associated with rice grain discoloration was evaluated after harvest. The lowest grain disease severity was found in the treatment with prochloraz in the first year.

Nagala *et al*. (2000) used six fungicides viz Difolatex, ortho difolatan (captafol), Benlate (Benomyl), Dithane M-45 (Mancozeb) and Calixin M (Maneb + Tridemorph) against *Sarocladium* sp. and were found effective at different concentration in prevailing radial growth of *Sarocladium attenuatum*.

Santos *et al*. (2003) reported that the fungicide applications increased grain yield and reduced incidence of grain discoloration and consequent improvement in the quality of the products.

Chauhan *et al*. (2005) reported that the use of three fungicide viz., Mancozeb (0.3%), chlorothalonil (0.25%) and propiconazole (0.25%) were sprayed thrice the first spray was given the panicle initiation emergence and second and third spray were followed at 15 days interval. The spraying with chlorthalonial most effective i.e. it produced 8.8 per cent dicoloured grains, Mancozeb was found next efficacy i.e. 10.3 per cent followed by propiconazole 14.4 per cent discolored grain.

CHAPTER-III

MATERIALS AND METHODS

The present investigation was carried out to diagnose the symptoms of grain discoloration and to study the seed mycoflora associated with different rice varieties. The pathogenic potential of the associated fungi isolated from seed were determined. The effect of discolored rice grain was also assessed on seed germination, seedling vigour, thousand grain weight and morphological characters. The effect of discolored rice grain, role of weather incidence, date of sowing, relation with other paddy diseases and insect feeding. Efficacy of selected fungicides was also studied *in-vivo* condition.

In the present investigation all the materials used and methods followed are given below:

GENERAL MATERIALS USED IN THE STUDIES

All the laboratory studies were done at the Department of Plant Pathology, Indira Gandhi Krishi Vishwavidyalaya, Raipur during course of investigation, glasswares of Borosil make, plastic plates of Torsan make, blotter paper of standard grade and chemicals of standard grade (Merck, Qualigens, S.D. fine etc) were used.

INSTRUMENTS USED IN PRESENT STUDIES

1. Autoclave for sterilization
2. BOD incubator for incubation

3. Compound microscope for microscopic study of mycoflora
4. Hot air oven for dry sterilization
5. Laminar air flow for isolation
6. Stereo binocular microscope for identification of seed borne fungi
7. Electronic weighing balance
8. Hand lance

CLEANING AND STERILIZATION OF MATERIALS

The glassware's were cleaned with detergent powder and finally washed by cleaning solution, rinsed with tap water and or/ distilled water as per requirement of the studies, the dried glassware's sterilized in hot air oven at 180°C for two hours. The forceps, inoculation needle and other metallic instruments were sterilized by dipping them in alchohol and heating over the flame during isolation, multiplication and other studies. Sterilization of media was done by autoclaving at 1.02-kg/ cm2 for 20 minutes. The plastic plates were sterilized with alchohol and air-dried before use.

SEED SAMPLING

The sampling of seeds was done from thoroughly mixed seed lot. The working sample from this lot was obtained by repeated halfing. For seed health evaluation 100 seeds of each variety of rice were used.

COMPOSITION OF THE MEDIA USED

Potato dextrose agar with the following composition were used for detection of mycoflora.

1. Potato (peeled and sliced) - 200 g
2. Dextrose - 20 g

3. Agar	-	20 g
4. Distilled water	-	1000 ml

EXPERIMENTAL SITE

The field experiment was conducted during kharif 2006 at the experimental field of the Department of Plant Pathology, Entomology and Agronomy situated in Research Farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). Besides these field experiments, all the *in-vitro* studies were conducted in the laboratory of Department of Plant Pathology.

3.1 Per cent grain discoloration of important rice varieties

The ten varieties of rice viz., Mahamaya, MTU-1010, Sona masuri, IR 36, Pant-4, IR-64, Indira-9, Kranti, Swarna, HMT were collected from different villages i.e. Somani, Dhamtari, Durg, Aacholi, Tumdibode, Kalkasa and also IGKV Research Farm, Raipur. Each seed samples were mixed thoroughly and from this a working sample of 100 g was made and used for the study of grain discoloration.

The experiments were conducted under Completely Randomized Design (CRD) with four replications *in-vitro*. The seeds were brought into the laboratory and the healthy, discolored and chaffy seeds were separated on visual appearance basis. (The seed lot comprising different symptoms were dark brown discoloration, nectrotic spot and chaffy grains). The per cent grain discoloration were calculated following general arithmetic rule i.e. The Chaffiness Percentage were calculated separately using same formula.

$$\text{Grain discoloration (\%)} = \frac{\text{Number of discolored grains in sample}}{\text{Total grains of sample}} \times 100$$

3.1.1 Loss in grain weight

The seed samples (100g each) of ten rice varieties were collected from field store of the Department of Plant Pathology. These samples brought into the laboratory and healthy and discolored seeds were separated on visual observations. The thousands seed weight of healthy and discolored seeds of each varieties were taken in highly sensitive anamide balance. The difference in seed weight and percent loss in weight were calculated as general formula.

$$\text{Weight losses (\%)} = \frac{\textbf{Wt. Of healthy grains – Wt. Of discolored grains}}{\text{Wt of healthy grains}} \times 100$$

3.2 Mycoflora detection

3.2.1 Varieties used

1. HMT
2. Swarna
3. IR-64
4. IR-36
5. Mahamaya
6. Indira-9
7. Kranti
8. Pant-4
9. MTU 1010
10. Sana Masuri

3.2.2 Standard blotter method (ISTA, 1976)

This method was used to detect the presence of fungi on or in the seeds. By this method fast growing fungi are better detected than the slow growing ones. In each plate, 25 seeds of rice varieties were placed on the moistened blotter paper in such a manner that 16 formed the outer circle, 8 formed inner and one at center. For each variety four

replications were maintained and incubated at 22±2°C for 12 hours light/ dark cycle. The observations were recorded after seven days of incubation. The per cent incidence of each microorganism associated was recorded. Fungi appearing on the seed surface were identified with help of standard manual like Illustrated genera of imperfect fungi (Barnett and Hunter, 1972).

3.3. Pathognicity test

Fungi associated with discolored rice grain were isolated individually on PDA slant and under aseptic condition. They were frequently sub-cultured and their pure culture was maintained for the pathognicity test. The fungi in pure culture with respect to their conidia were critically examined under compound microscope and efforts was made for their identification upto species level referring to relevant literature. The micoflora isolated from the seed were subcultured and tested for their pathognicity if any. At the time of 50% flowering the varieties were spray inoculated with the respective mycoflora isolated separately (Duraiswamy and Mariyappan. 1983).

For pathognicity test variety Kranti was used. The half cooked rice grain were first gently rubbed over the fungal growth (20-25 days) cultured in plates. This has helped the conidia and mycelium in adhering to the grain bits. Such coated rice grain bits were inserted gently into the boot. This procedure was followed in all the artificial inoculation tests, unless otherwise mentioned separately.

At maturity, seeds were collected from every inoculated panicle and grain discoloration was assessed by counting the number of discolored seeds.

3.3.1 Metabolite effect

To study the effect of associated fungal metabolite on germination of rice seeds, 5 mm disc from ten days old culture of *Drecheslera oryzae, Curvularia lunata, Fusarium moniliforme* and *Sarocladium oryzae* were individually multiplied on 50 ml sterilized Rechards broth solution in each 150 ml Erlenmeyer flask. After 15 days of incubation at 25±2°C the liquid of each flask were filtered through Whatman filter no 42. The metabolites were diluted at 50 per cent concentration. Fifty ml of diluted metabolite of each fungus were tested for their effect, individually. The healthy seeds of ten varieties of rice were dipped in above metabolite solution for one hour. Control treatment was maintained in sterilized water. The treated seeds were kept for germination by standard blotter method. The germination for each treatment was recorded after seven days.

3.4. Role of weather on incidence of seed discoloration

The experiment was conducted *in-vivo* on variety Shyamla. Five hills in each replication were tagged. The three replications were maintained. The observations were started from milking stage up to maturity at five days interval. At maturity the tagged hills were harvested carefully and were threshed manually. The healthy and discolored seeds were separated on visual observations.

3.4.1 Meteorological data

The meteorological data (maximum temperature, minimum temperature, relative humidity, rainfall) for the *kharif* season, 2006 were

obtained from the Department of Agricultural Meteorology, IGKV, Raipur. The meteorological factors were correlated with the grain discoloration.

3.5 Date of sowing

The experiment was conducted in the IGKV, Research Farm, Raipur in kharif 2006. The split plot design was followed. The varieties used were HMT, IR-36, Kranti and MTU-1010 for line sowing in three dates viz., 12 June, 24 June and 9 July 2006. Three replications were maintained. The normal agronomical practices were followed. The layout of the experiment is here under:

Plot size : 3.0 x 2.7 = 8.1 m^2

Distance between

Main plot (Date of sowing) : 0.5 m

Sub plot (varieties) : 0.3 m

Replication : 1.0 m

3.6 Relationship of grain discoloration with other paddy diseases

3.6.1 Grain discoloration with sheath rot

Ten varieties viz. Ruchi, RP-2151-21-22, R-320-300, Bamleshwari, Poornima, Kranti, Pant-4, Shaymla, Indira-9 and MTU-101 were used to study relation of seed discoloration with sheath rot disease.

In an experiment half cooked rice grain were first gently rubbed over the fungal growth (20-25 days) cultured in plates. This has helped the spore and mycelium in adhering to the grain bits. Such coated rice

grain bits were inserted gently into the boot (Ritu 2005). At maturity diseased panicles of different rice varieties were collected and threshed. The healthy looking and discolored seeds were separated. The discoloration per cent for each variety was calculated.

3.6.2 Grain discoloration with sheath blight

The varieties viz., PR-106, Kranti, Swarna, Pant-4, Shaymla, IR-64, Indira-9, Poornima, R-320-300, Ruchi were used to study relation of grain discoloration with sheath blight.

In the field experiment, sclerotia from 7 to 9 days old culture were used for inoculation of the plants at maximum tillering stage. The primary tillers of each hill were tagged and inoculated gently by punching and pushing single sclerotium into the sheath just 2½ to 3½ inch above the surface level as per the condition of the sheath. The artificial inoculated panicle selected and tagged. At the time of harvesting tagged hills were collected and brought into laboratory for observation.

The discolored and healthy grains were separated from each panicle. The discoloration percentage for each variety was worked out.

3.6.3 Grain discoloration with False smut

At maturity, ten false smut infected hills were collected from each varieties. The smut bolls per panicle were ranging from three to five. The infected samples were brought into the laboratory and threshed manually. Healthy looking and discolored seeds were separated

carefully on visual appearance basis. The discoloration percentage per hill of each variety was calculated by using general arithmetic rule.

3.6.4 Grain discoloration with Brown spot

At maturity ten brown spot infected hills were collected from each varieties. The infected samples were brought into the laboratory and threshed manually. Healthy and discolored seeds were separated carefully on visual appearance basis. The discoloration percentage per hill of each variety was calculated by using general arithmetic rules.

3.7 Effect of insect feeding on rice grain discoloration

The experiment was conducted in net house of Department of Entomology, College of Agriculture, Raipur. The rice varieties MTU-1010, IR-64, Mahamaya, TN1, Madhuri, Dubraj and Kranti were planted in pot in the net house. Three replications were maintained under completely randomized block design. The proper load of brown plant hopper (BPH) and rice gundhi bug were released 30 nymph on each healthy plant at initiation of milk stage to each rice variety separately for forced feeding. The tillers were harvested very carefully at maturity. Milling was done manually. The discolored and healthy grains were separated. Discoloration percentages for each variety were worked out.

3.8 Chemical control of rice grain discoloration

The field experiments for control of seed discoloration of rice was conducted in Kharif season 2006 in the Research Farm of IGKV, Raipur. The split plot design was adopted with five main treatment and three sub

treatments. Three replication were maintained variety “Mahamaya” was used The details of design is here under:

MAIN TREATMENT – FUNGICIDES

T_1 - Kocide 200 54 F @ 2 g /l.

T_2 - Contaf @ 2 g /l.

T_3 - Carbendazim @ 1 g /l.

T_4 - Macozeb @ 3 g /l.

T_5 - Control (water)

Sub treatments :

A - Spray at tillering stage

AB - Spray at tillering + Milk stage

ABC - Spray at tillering + Milk + Dough stage

3.9 Statistical analysis

Wherever required the experimental data were analyzed using CRD design.

The Skeleton of ANOVA for CRD is given below:

Source of variation	***d.f.***	**S.S.**	**M.S.**	**F ratio**
Treatments	n-1	SS_r	V_r	V_r / V_e
Error	N-n	SS_e	V_e	
Total	N-1			

Where, n = number of treatments

N = Total number of experimental units

CHAPTER-IV

RESULTS AND DISCUSSION

The present chapter deals with the experimental results obtained during the course of investigation on "Study on grain discoloration of rice". The results were statistically analyzed wherever required using the analysis of variance technique and the finding are given below. The results of the research programme have been thoroughly discussed and corroborated in the light of research work done by various workers.

4.1.1GRAIN DISCOLORATION OF RICE VARIETIES

The important rice varieties were screened to workout average per cent grain discoloration. The samples were sorted out in healthy and chaffy seeds. Observations on grain discoloration were recorded.

Data from Table 4.1 reveals that check variety Kranti recorded maximum discolored seeds (32.95%) followed by IR-36 (30.26%), Swarna (29.39%) and Mahamaya (29.46%). The least discoloration was observed (23.10%) in IR-64 variety. None of the variety was observed to exceed grain discoloration as compared to Kranti (check).

Chaffiness is an impregnated part of rice panicle which was assessed from bulk sample tested. Data reveals that chaffiness in all tested varieties varied from 4.75 to 19.82 per cent. The highest chaffiness was (19.32%) in HMT followed by IR-36 (19.64%) and Pant-4 (19.43%). The least chaffiness were recorded in Indira-9 (4.75%). The incidence of rice seed discoloration in TN-1 (6.6%), Manhar (52.8%), Jarga (58.7%), PR-106 (23%), IR-8 (19%), Narendra-80 (54.7%), Saket (45.3%) and Pant Dhan-16 (40%) were reported by Sinha (1999), Sharma *et al*. (1987), Mishra *et al*. (1991) and Negi *et al*. (2003). These finding are very close to our results.

4.1.2 Determination of loss in grain weight of discolored seeds in rice varieties

Seed discoloration badly affects seed development and may cause loss in weight. Data (Table 4.3) shows that seed weight loss varies from 7.63 to 24.90 per cent in the varieties tested. The maximum loss in discolored seed weight (24.90%) was observed in variety Indira-9 followed by Shyamla (19.14%) and IR-64 (15.50%). The loss in seed weight were observed in varieties like MTU-1010 (10.97%), Swarna (10.59%), Pant-4 (9.08%), HMT (8.80%), Mahamaya (7.83%) and (7.63%) Kranti. The least loss in seed weight of discolored seeds was observed in variety Chapti (5.70%).

The present findings corroborates with the findings of Mishra *et al*. (1991) where they observed loss in grain weight upto 31.2 per cent and 50.2 per cent in grains classified as having less than 50% and more than 50% area of seed discoloured, respectively compared with the seeds classified as healthy and with no discoloration. Sinha (1999) reported loss in grain weight by 24.8 per cent in Basmati followed by Prasad (22.6%) and Bala (21.7%) and 58.7-66%), respectively.

4.2.1 MYCOFLORA ASSOCIATED WITH IMPORTANT RICE VARIETIES

Data from the Table 4.4 shows that mycoflora associated with the rice seeds were varied from 25.31 to 38.91 per cent. The varieties Pant-4 and Kranti showed highest per cent association of mycoflora i.e. 38.91 and 31.70 per cent, respectively. The least per cent association of mycoflora was observed in variety Indira-9 (25.31%).

The total mycoflora detected in various varieties of rice seeds were *Alternaria alternata*, *Aspergillus* sp., *Curvularia lunata*, *Drechslera oryzae*, *Fusarium moniliforme*, *Memnoniella* sp., *Nigrospora* sp., *Penicillium* sp., *Periconia* sp., *Rhizophus* sp., *Sarocladium oryzae*, *Stachybotrytis* sp., *Trichoconis padwickii* and *Trichoderma viride*. The mycoflora were associated with all the varieties tested viz., *A. alternata*, *Aspergillus* sp., *C. lunata*, *D. oryzae*, *F. moniliforme* and *Rhizopus* sp.

The mycoflora isolated from discolored rice grains were *Cochliobolus miyabeanus*, *Alternaria* sp, *Epicoccum* sp., *Penicillium* sp., *Fusarium* sp., *Cephalosporium* sp., *Curvularia lunata*, *Drechslera oryzae*, *Trichoconis padwickii*, *Cercospora oryzae*, *Fusarium moniliforme*, *Nigrospora oryzae* and non sporing fungi Baldacci *et al*. (1948), Padmanabhan *et al*. (1949) and Johnston (1958)

4.2.2MYCOFLORA ASSOCIATED WITH DISCOLORED RICE SEEDS

The discolored seeds were separated from bulk samples of rice varieties tested.

The detection of mycoflora was done by standard blotter method are presented in Table 4.5. The fungi *Fusarium moniliforme* and *Rhizopus* sp. were detected from all the varieties tested. The highest (77.31%) association of mycoflora was observed in variety IR-64 followed by IR-36 (70.63%) and Mahamaya (70.63%). The least (51.95%) association of mycoflora was observed in discolored seeds of variety Pant-4.

The highest pathogenic fungi namely *Alternaria alternata*, *Drechslera oryzae*, *Fusarium moniliforme*, *Sarocladium oryzae* and *Trichoconis padwickii* were observed in most of the rice varieties in association with the discoloration. The mycoflora observed were *A. alternata*, *Aspergillus* sp., *Curvularia lunata*, *D. oryzae*, *F. moniliforme*, *Memnoniella* sp., *Nigrospora* sp., *Penicillium* sp., *Periconia* sp.,

Rhizopus sp., *S. oryzae*, *Stachybotrytis* sp., *T. padwickii* and *Trichoderma viride*.

The germination percentage of infected and discolored seeds were very poor ranged from 54.81 to 76.00 per cent in all the varieties tested.

The present investigation are very close to the findings of Zakari *et al*. (1983), Sharma *et al*. (1987), Jayaweera *et al*. (1988), Ahmed *et al*. (1989), Agrawal *et al*. (1989), Bokhari (1991), Kim (1992), Sachan *et al*. (1994), Deka *et al*. (1995), Mishra and Vir (1996), Ali *et al*. (1996), Deka *et al*. (1996), Sharma *et al*. (1997), Bicca *et al*. (1998), Pandey *et al*. (2000), Prakash *et al*. (2001), Gutierrez *et al*. (2002), Negi *et al*. (2003), Reddy *et al*. (2004), Chauhan *et al*.(2005) and Samira *et al*. (2005).

4.2.3MYCOFLORA ASSOCIATED WITH HEALTHY GRAINS OF RICE VARIETIES

The healthy seeds were sorted out from rice varieties tested.

The data on myclflora associated with the rice seeds as detected by standard blotter method are presented in Table 4.6. In all 14 fungi were found associated with 10 varieties of rice seeds. The genus *Aspergillus* and *Rhizopus* were detected for all rice varieties tested. The varieties Indira-9 and Pant-4 were observed to received maximum nine fungi associated with per cent association 23.73 and 21.16, respectively. However, variety Kranti showed highest (30.30%) association of fungi

with seven fungi. The variety IR-36 showed least association of fungi i.e. four with 8.47 per cent.

The total fungi which were isolated from all rice varieties were *Alternaria alternata*, *Aspergillus* sp., *Curvularia lunata*, *Drechslera oryzae*, *Fusarium moniliforme*, *Memnoniella* sp., *Nigrospora* sp., *Penicillium* sp., *Periconia* sp., *Rhizophus* sp., *Sarocladium oryzae*, *Stachybotrytis* sp., *Trichoconis padwickii* and *Trichoderma viride*.

The seed germination per cent at all the varieties tested varied from 82.00 to 96.18 per cent while variety Kranti showed least per cent (78.71) germination with highest per cent (90.30%) mycoflora associated. Deka *et al*. (1995), Bicca *et al*. (1998), Negi *et al*. (2003), Reddy *et al*. (2004) and Chauhan *et al*. (2005) also reported the fungi associated with freshly harvested grains.

4.3.1 Pathogenicity test of the associated mycoflora

The half cooked rice grains impregnated with test fungi were inserted in panicles at boot stage to find out their pathogenic potential.

Data from Table 4.7 shows that the fungi *S. oryzae*, *D. oryzae*, *F. moniliforme* and *C. lunata* showed their pathogenic ability by infecting rice panicles expressed as (+) plus however rice grain without fungi could not initiate infection in rice panicles and expressed as (-) minus. Sharma *et al*. (1997), Haq (1985), Chain *et al*. (1987), Ahmed *et al*. (199), Ray (1993), Bora and Gogoi (1993) and Negi *et al*. (2003) also proved pathogenesity by inoculating rice plants of various stages with

different fungal isolates and proved their pathogenic potential to initiate grain discoloration.

4.3.2 Effect of fungal metabolite of rice seed germination

Data from Table 4.8 reveals that fungal metabolite caused heavy loss in rice seed germination. The metabolite of *Sarocladium oryzae* infected germination loss in the varieties viz. Sona masuri (77.17%), MTU-1010 (74.44%) and Pant-4 (70.11%). The loss in germination varies from 42.70 – 64.21 per cent in rest of the varieties tested. Similarly, the metabolite of *Fusarium moniliforme* showed germination loss in Sona masuri (67.37%), MTU 1010 (67.34%), IR 36 (58.94%) and Pant-4 (57.47%). The other varieties showed their germination loss in between 32.29 to 47.72 per cent.

The metabolite of *Drechslera orzyae* was noticed effective in reducing seed germination of all rice varieties tested. The germination loss above fifty per cent were recorded in varieties Sona masuri (56.52%), MTU-1010 (51.02%) and IR-36 (50.52%). The minimum loss in seed germination was recorded in variety Indira-9 (12.50%) followed by variety Mahamaya (17.02%) and rest of the varieties showed loss in germination in between 21.11 to 40.20 per cent.

The metabolite of *Curvularia lunata* was found less toxic to cause low loss in seed germination. The highest seed germination loss was recorded in variety MTU 1010 (16.32%) followed by Mahamaya (13.82%), Kranti (13.82%), Swarna (13.54%) and Sona masuri

(13.04%). Germination loss in other varieties varied from 8.42 to 10.34 per cent. The present findings corroborates with the observations of Pandey *et al*. (1982) where the metabolite of *Aspergillus flavus*, *A. niger*, *Alternaria alternata*, *Cladosporium cladosporioids*, *Epicoccum purpuranscens* and *Penicillium granulatum* caused reduction in seed germination of *Setaria italica*.

4.4 WEATHER CONDITION AND GRAIN DISCOLORATION

An attempt was made to know any relationship between the weather parameters prevailed during the course of investigation (Kharif 2006). The data (Table 4.9) shows that grain discoloration in variety Shyamla ranged between 2.29-7.77 per cent when minimum and maximum temperature during crop period ranged between 27.8-33.7°C and 18.2- 23.0°C, respectively. The data shows that negative correlation between grain discoloration and temperature, the discoloration per cent decreased when temperature increased. Rainfall and relative humidity does not show any correlation with grain discoloration. The present investigation were very close to the observations of Bilgrami and Choudhary (1991), they observed the incidence of *A. flavus* alone on individual maize kernels significantly correlated to the moisture per cent of the substrate as well as to the per cent relative humidity at 2 pm and also observed the negative correlation between *A. flavus* and rainfall. Krishnan *et al*. (2005) also observed warm weather condition with high solar radiation and without excessive rainfall during grain filling stage gave the best high quality rice seed yield and no seed discoloration.

4.5 DATE OF SOWING

Data from the Table 4.10 reveals that sowing of variety HMT at third date (9th July) was highly effective in reducing incidence of diseases and lowest 21.43% grain discoloration was recorded followed by first (12 June) and second (24 June) dates of sowing of the varieties HMT and IR-36 where incidence of discoloration were 23.81% and 25.08% respectively.

Among the varieties minimum (24.43%) discoloration was recorded in the variety IR-36 followed by HMT (25.93%) and MTU-1010 (27.08%)

According to Rao (1990) delayed planting yielded chaffy and discolored grains as major factor of yield reduction similarly Krishanan *et al*. (2005) reported that proportion of grain discoloration were occurred and influenced by environmental effects than by genotypic effects. The above findings could not support with present observations. This might be due to properly distributed rainfall and less numbers of date of sowings.

4.6 RELATIONSHIP OF GRAIN DISCOLORATION WITH PADDY DISEASES

4.6.1 SHEATH BLIGHT AND GRAIN DISCOLORATION

Data from the Table (4.11) reveals that variety/ line PR 106 received highest (32.71%) grain discoloration followed by varieties Shyamla (29.58%) and Indira-9 (24.04%). The variety Swarna and R-320-300 received discoloration upto 22.48 and 22.22 per cent,

respectively, which were significantly superior over control. The varieties received discoloration less than check variety were IR 64 (13.51%), Poornima (14.75%) and Ruchi (15.44%). The variety Pant-4 showed grain discoloration 19.84 per cent at par with control.

4.6.2 SHEATH ROT AND GRAIN DISCOLORATION

The discolored and healthy seeds were separated from inoculated hills and discoloration per cent were calculated.

Data (Table 4.12) reveals that variety Pant-4 showed highest per cent (91.40%) grain discoloration per hill followed by Poornima (84.98%). The check variety Kranti showed 80.31 per cent discoloration. However, rest of the varieties showed discoloration from 42.40 to 65.44 per cent which were less than check variety Kranti.

4.6.3 FALSE SMUT AND GRAIN DISCOLORATION

Data from the Table 4.13 reveals that variety MTU-1010 showed highest 78.13 per cent grain discoloration per hill followed by Indira-9 (59.08%). The check variety Kranti showed 37.68 per cent discoloration per hill. Most of the varieties showed discoloration from 12.39 to 33.02 per cent which were less than Kranti (check).

4.6.4 BROWN SPOT AND GRAIN DISCOLORATION

Data (Table 4.14) shows that check variety “Kranti” received highest (39.50%) grain discoloration per hill followed by RP 2151-21-22 (35.47%), Indira-9 (32.32%) and IET (31.91%). None of the varieties were recorded grain discoloration more than the check (Kranti). The grain discoloration per cent varied from 23.50 to 39.50 per cent.

THE POSITIVE CORRELATION OF GRAIN DISCOLORATION WITH LEAF SPOT, SHEATH ROT AND KERNEL SMUT WERE OBSERVED BY THRIMURTY *ET AL*. (1980), PRABHU *ET AL*. (1996), SINGH *ET AL*. (1996) AND GRVOIS *ET AL*. (2000) ARE SIMILAR TO OUR FINDINGS. TUNGRO VIRUS INOCULATED WITH *SAROCLADIUM ORYZAE* ACTED SYNERGISTICALLY WHICH RESULTED INCREASED GRAIN DISCOLORATION AND CAUSED REDUCTION IN PANICLE EMERGENCE SUPPORTS OUR FINDINGS. SIMILARLY THE FINDINGS OF DHARAM *ET AL*. (2001) ABOUT GRAIN DISCOLORATION WITH *ALTERNARIA PADWICKII* SUPPORTS OUR FINDINGS.

4.7 EFFECT OF INSECT FEEDING ON RICE GRAIN DISCOLORATION

The Brown plant hopper (BPH) and Gundhi bug were observed to feed on grain at milking stage and caused discoloration. Data from the Table 4.15 shows that variety TN-1 recorded maximum (26.91%) discoloration. The check variety Kranti received 24.51% discoloration followed by Mahamaya (23.90%) and IR-64 (22.34%). Minimum discoloration was observed in variety Dubraj (14.07%).

In rice gundhi bug, data indicates that variety Kranti recorded highest per cent (44.74%) discoloration followed by Madhuri-11 (22.76%), IR-64 (24.27%) and TN-1 (24.25%). The lowest germination (17.50%) was observed in variety MTU 1010. Sucking pests like Brown plant hopper (*Nelaparvata lugens*), rice gundhi bug (*Leptocorsia accta*),

stink bugs (*Oebalus pugnax*) caused chaffiness and grain discoloration reported by Muriniate *et al*. (1990), Bernhardt *et al*. (1992), Samuales (1996), Kenneth *et al*. (2000) and Prakash *et al*. (2000) supports our findings. The findings of Su (1938), Hyon (1963), Cottyn *et al*. (1996) also supports over findings.

4.8Chemical control of grain discoloration of rice

Data from the Table 4.16 revealed that if one spray of Carbendazim at Tillering stage of crop is given the incidence of disease was recorded by 19.49 percent, if two sprays one at Tillering and second at milking stage. The incidence of discoloration was 17.39 per cent. Similarly, three spray were given the incidence of disease was recorded, lowest 16.96 per cent as compare to all the treatments applied. The two sprays of Mancozeb and Cantof given second good effect and minimum disease incidence 23.86 and 26.20 per cent, respectively were observed. Similarly three sprays of Contaf and Mancozeb were recorded effective in reducing disease incidence i.e. 20.65 and 21.21 per cent, respectively. However the Kocide was not effective in any sprays and any stage of the crop.

Similar findings were also observed by Ray *et al*. (1988), Ray (1993-94), Sachan *et al*. (1994), Vaid *et al*. (1994), Sistema and Ronco (1994). They suggested that carbendazim was found to be the most effective in controlling the grain infection at all the concentrations even through there were significant variation in the percentage of the grain discoloration.

CHAPTER-V

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FUTURE RESEARCH WORK

The present investigation entitled “Studies on grain discoloration of rice” was carried out in the Department of Plant Pathology, I.G.K.V., Raipur. The investigation mainly consisted of three parts i.e. (a) to assess per cent grain discoloration in important rice varieties, (b) to assess relationship of pests and other rice diseases with grain discoloration of rice, (c) to manage the grain discoloration of rice.

The results obtained in the present investigations were summarized as below:

The grain discoloration were observed in all the varieties tested in the range of (23.10 - 32.95%). The variety Kranti was recorded as highly prone to discoloration having (32.95%) discoloration. The grain discoloration badly affected seed development and caused loss in seed weight by 24.90 per cent in the variety Indira-9. The total mycoflora detected from discolored seeds are *Alternaria alternata*, *Aspergillus* sp., *Curvularia lunata*, *Drecheslera oryzae*, *Fusarium moniliforme*, *Memnoniella* sp., *Nigrospora* sp., *Penicillium* sp., *Periconia* sp., *Rhizophus* sp., *Sarocladium oryzae*, *Stachybotrytis* sp., *Trichoconis padwickii* and *Trichoderma viride*.

The frequency of mycoflora varies with the varieties of rice. The mycoflora like *F. monilifora*, *Alternaria alternata*, *Drechslera oryzae* and *Sarocladium oryzae* were recorded as highly virulent to cause loss in seed germination.

In pathogenicity test the pathogens like *A. altrnata*, *D. oryzae*, *S. oryzae* and *C. lunata* proved their pathogenic ability.

In fungal metabolite test the metabolite of *S. oryzae* was recorded most effective and caused seed mortality as compare to other fungal metabolite. The negative correlation between grain discoloration and temperature were observed. The dates of sowing could not show any variation, however varietal variation responded positively. The positive correlation of grain discoloration with brown spot, sheath blight, sheath rot, false smut and bacterial leaf blight were recorded. Similar, positive correlation of grain discoloration with sucking pests like rice gundhi bug and Brown plant hopper have been recorded. In management of grain discoloration the fungicide carbendazim was found highly effective as compare to other fungicides tested.

Conclusion

Grain discoloration has been prevalent in almost all part of the world and is an early indication of poor seed or grain quality, which is associated with micro-organisms. Such grains have poor market value and low consumption quality due to degradation in nutritional value.

In present investigation, the important varieties collected for different localities showed various degree of grain discoloration ranging from 23.10 to 32.95. The mycoflora detected from infected and discolored grains were fourteen, out of which *D. oryzae, S. oryzae, F. monoliforme* and *C. lunata* were highly pathogenic. Metabolitiess of *S. oryzae* were observed highly toxic to check seed germination. The role of temperature were negatively correlated and dates of sowing could not exhibit and effect on discolorations. The rice diseases like brown spot, sheath blight, sheath rot, False smut bacterial leaf blight and sucking pests like Brown plant hopper and rice gundhi bug exhibited positive correlation with grain discoloration.

The Carbendazim was found highly effect to control rice grain discoloration.

Suggestions for future research work

Looking to the immense important of rice and in the light of findings of present investigation the following suggestions can be made for further development in the knowledge of seed health.

1. More eco-friendly approaches like bio-control, bio-pesticides, compatible fungicides with the nature, which can minimize the severity need thorough investigations.
2. The biochemical changes in seeds due to presence of mycoflora in storage needs to be investigated thoroughly.
3. Relationship with other paddy diseases and insects needs detail studies.

4. The timely application of suitable practices to control grain discoloration needs to be worked out thoroughly.

“STUDIES ON GRAIN DISCOLORATION OF RICE”

By

Chandramani Rawte

ABSTRACT

Discoloration in rice is minor disease now a days gaining importance due to its severity in tropical rice growing areas. Grain discoloration is an early indication of poor quality seeds associated with microorganisms. The present study entitled “Studies on grain discoloration of rice” was conducted in the Department of Plant Pathology, College of Agriculture, IGKV, Raipur, (C.G.).

In the present investigation ten important rice varieties were used to detect percent grain discoloration. The variety Kranti received maximum (32.95%) grain discoloration and maximum loss in grain weight was recorded in variety Indira-9 (24.90%). The fourteen mycoflora were isolated from discolored as well as healthy rice grains but their intensities were very high in discolored grains. The pathogens like : *Curvularia lunata*, *Drecheslera oryzae*, *Fusarium moniliforme* and *Sarocladium oryzae* showed their pathogenic ability and metabolites of these pathogens were also affected seed germination.

In weather factors and their impact on grain discoloration showed negative correlation with temperature observed. Date of sowing did not exhibit any variation. The maximum (29.84%) discoloration was recorded in the variety Kranti out of three varieties tested. The positive correlation of grain discoloration with brown spot, sheath blight, sheath rot, false smut and bacterial leaf blight were recorded. Similar, positive correlation of grain discoloration with sucking pests like rice gundhi bug and Brown plant hopper have been recorded.

The disease development studies under in vitro condition clearly revealed the Carbendazim was found significantly superior in reducing grain discoloration and the lowest discoloration (21.69%) was recorded.

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REFERENCES

Agarwal, P.C.; Mortensen, C.N. and Mathur, S.B. 1989. Seedborne diseases and seed health testing of rice. CAB, International Mycological Institute, Kew, Surey, U.K. 106pp.

Ahmed, Q. and Prasad, R.K. 1985. Fungi from rice seeds. II. Effect of seed infection by *Trichoniella padwickii*, *Oryza*, **22(3-4)** : 234-236.

Ahmed, S.I.; Sidiqui, N.U. and Khan, M.Q. 1989. *Pakistan J. Botany*, **21** : 309-312.

Ali, M.S. and Deka, B. 1996. Role of fungi causing grain discoloration of rice and management under storage. *Indian J. Mycol. Pl. Pathol*.,**26(1)**: 79-85.

Arunyanart, P., Surin, A. and Disthapom, S. 1981. Seed discoloration disease and its chemical control. *International Rice Research Newsletter,* **6(3)** : 14-15.

Baldacci, E. and Picco, D. 1948. Observation on rice disease during the eyars. Of crop. Risicolt **36 :** 73.77, 113 – 117.

Barnett, H.L. and Hunter, B. 1972. Illustrated genera of imperfect fungi Ed. IV. Pub. Macmillan publishing company New York. 129-197.

Bernhardt, J.L. 1999. Screening rice lines for susceptibility to discolored kernels : Results of a statewise rice survey for discolored kernels. Research Series Arkansas Agricultural Experiment Station. **468** : 119-126.

Bernhardt, J.L.; Moldenhauer, K.A.K. and Gravois, K.A. 1997. Screening rice lines for susceptibility to discolored kernels. Research Series Arkansas Agricultural Experiment Station**. 456** : 67-74.

Bicca, F.M.; Baudet, L. and Zimmer, G.T. 1998. Separation of discolored seeds from rice seed lots using the gravity table and influence of seed health. *Revista Brasileira de Sementes*, **20(1**) : 106-111.

Bilgram : , K.S., and Choudhary, A.K; 1991. Effect of Climatological factors on the incidence of *Aspergillus flavus* in relation to Co-existing mycoflora on maize kernels. *Indian Phytopathol.* **44** : 527 – 529.

Bokhari, H.A. 1991. Seed born fungi of rice (*Oryza sativa* L.) from Saudi Arabia. *Zeitschrift fur pflanzenkrankheiten und pflanzenschutz*, **98(3)** : 287-292.

Bora, L.C. and Gogoi, R. 1993. Estimation of seed quality deterioration of deep water rice by seed borne microflora in Assam. *Indian J. of Myco. Pl. Pathol.*. **23(2**) : 214-216.

Castano, Z.j.; Klap, K. and Zaini, Z. 1991. Etiology of grain discoloration in upland rice in West Sumatra. *International Rice Research Newsletter*, **16**(**1**) : 21-22.

Chai, R.Y.; Jin, M.Z. and Zhang, Q.S. 991. The inhabiting fungi of discolored paddy rice grains and their pathogenicities. *Acta Agriculturae Zhejiangensis*, **3**(**2**) : 61-64.

Chauhan, H.L.; Patel, K.G. and Patel, R.V. 2005. Efficacy of fungicides against grain discoloration of rice. Advances in Fungal Diversity and Host Pathogen Interactions. 18-20.

Chien, C.C. and Chang, Y.C. 1987. The susceptibility of rice plant at different growth stages and of 21 commercial rice varieties to *Pseudomonas glumae*. *Journal of Agricultural Research of China*. **36(3**) : 302-310.

Cottyn, B.; Cerez, M.T.; Outryve, M.F.; Barroga, J.; Swings, J. and Mew, T.w. 1996. Bacterial disease of rice. Pathogenic bacteria associated with sheath rot complex and grain discoloration of rice. *Plant disease;* **8(4)** : 429-437.

Dash, A.N. 1986. Further studies on paddy seed discoloration and its nature with relation to associated fungi. M.Sc(Ag) Thesis. Orissa University of Agriculture and Technology, Bhubaneswar, 78pp.

Dash, A.N. and Narain, A. 1988. Detection of grain discoloration fungal organisms of rice and production of disease free seeds. Indian *J. of Myco. Pl. Pathol,* **18(1**) : 24-30.

Deka, B. and Ali, M.S. 1995. Rice grain fungi : Occurrence and role over storage seed. *Plant health,* **1** : 26-28.

Deka, B., Ali, M.S. and Chandra, K.C. 1996. Management of grain discoloration of rice. *Indian J. Mycol. Pl. Pathol*, **26(1**) : 105-106.

Dharam, S.and Maheshwari, V.K.2001.The influence of stack burn disease of Paddy on seed health stotus. *Seed Research*. **29 (2)**: 205 – 209.

Duraiswamy, V.S. and Mariappan, V. 1983. Rice grain discoloration. *International Rice Research Newsletter,* **8(3)** : 9-10.

Ebata, M. and Ishikawa, M. 1989. Effects of wind and rain on the fertilization, kernel development and kernel characters of rice plants. *Japanese Journal of Crop Science,* **58(4**) : 555-561.

Ghosh, J.J. 1951. The effect of environmental factors on fungal deterioration of stored rice grains. *Science and Culture*, **17** : 42-43.

Gill, M.A. and Bonman, J.M. 1998. Predisposition and synergistic effect of rice Aungro viruses to *Sarocladium oryzae* causing sheath rot of rice. *Pakistan J. Phytopahtology*, **10(2**) : 122-126.

Gomez, K.A. and Gomez, A.A. 1983. Statistical procedures for Agricultural Research, A Wiley- Interscience Publication, New York . pp.704.

Gravois, B.K.A. and Bernhardt, J.L. 2000. Heritability and genotype x Environment interactions for discolored rice kernels. *Crop Science*, **40(2)** : 314-318.

Gutierrez, S.A; Mazzanti-de-Cantanon, M.A; and Cundom, M.A. 2002 Fungi isolated from rice seed in Argentina *Phyto pathologica.* **37(2)** ; 156 – 163.

Hsieh, C.F.; Liu C. and Hsu, K. 1996. The effect of different air pollutants on the growth of crops in the coastal area of central Taiwan. Chinese *Journal of Agrometeorology*, **3(3) :**159-168.

Huq, A. 1985. Detection of few rice grain discolorating fungi and their pathogenic potential. M.Sc.(Ag.) Thesis submitted to O.U.A.T, Bhuaneswar, 72pp.

Hyon, J.S. 1963. Developmnt of storage fungi in polished rice infested with rice weevil, *Sitophilus oryzae.* L. *Seo University Journa*. B. **13 (8)** 77-86.

Iizuka, H. 1958. Studies of the micro organisms found in Thai rice and Burma rice. Part II. On the microflora of Burma rice. Ibid. **4** : 108-119.

Imolehin, E.D. 1983. Rice seed borne fungi and their effect on seed germination. *Plant Disease*, **67(12)** : 1334-1336.

Jayaweera, K.P.; Wijesundera, R.L.C. and Medish, S.A. 1988. Seed borne fungi of *Oryza sativa*. *Indian Phytopathology*, **41(3)**: 355-358.

Jha, D.K. and Prasad, R.K. 1984, 85. Seed borne fungi of rice in Chhota Nagpur plateau – Bihar. *Indian Journal of Mycology and Plant Pathology*,. **14(3)** : 277-278.

Jin, M.Z.; Chai, R.Y. Zhang, Q.S. and Lin, W.C. 1994. Preliminary study of symptoms and pathogen of coloured rice grain. *Plant Protection*, **20(2)** : 7-8.

Jin, M.Z. 1989. Preliminary study of discolored rice grains caused by *Curvularia*. *Acta Phytopathologica sinica*, **19(1) :** 21-26.

Jonhston, A. 1958. Fungicidal treatment of paddy seed. *Malaysian Agricultural Journal*, **41** : 282-289.

Jones, M.P: Wank;, S.B.C; Roy, A.C; Ayuk- Takem,J.A; 1990. Promising Cold. Tolerant and high-yielding rice lines for Ndop Plain, Northwest Cameroon. *International Rice Research Newsletter.* **15** : 3,17.

Kenneth, A. G. and John L.B. 2000. Heritability and genotype x environmental interactions for discolored rice kernels. *Crop Science,* **40** : 314-318.

Kim, C.H. 1992. Fungi associated with discolored rice grains. Research report on the rural development administration. *Crop Protection*, **34(1)** : 6-11.

Kimura, K. 1937. On the relation of fungi to discolored rice seeds. *Forch. Reflator. Kyoto.* **3**: 209-233.

Kodama, F. and Tsuchiya, S. 1981. Brown blotch on glume of rice plants caused by *Epicoccum purpurascens*. Annual Report of the Society of Plant Protection of North Japan, **32** : 107-109.

Krishnan, P. and Rao, A.V.S. 2005. Effect of genotype and environment on seed yield and quality of rice. *Journal of Agriculture Science*, **143(4)** : 283-292.

Mahadevappa, M. 2004. Rice production in India- Relevance of hybrid and transgenic technologies. *Indian J. Genet*, **64** : 1-4.

Malavolta, V.M.A. and Bedendo, I.P. 1999. Losses due to rice grain discoloration caused by *Bipolaris oryzae*. *Microdochium oryaze*, *Phoma sorghina* in several infection times. *Summa Phytopathologica* 25(4) : 324-330.

Malavolta, V.M.A. and Takuda, H.M. 1997. Chemical control of fungi causing rice grain discoloration. *Summa Phytopathologica*, **23(1**) : 25-28.

Martyn, E.B. 1936. Report on the botanical and mycological division for the year, 1935. Divisional reports of the Department of Agriculture, British Guiana, 1935, 89-92.

Mishra, B. 2005. 'More crop per drop'. The Hindu Survey of Indian Agriculture. **23(2**) : 41-44.

Mishra, A.K. and Vir, D. 1990. Efficacy of fungicides – XLVI : Effect of fungicidal seed treatment against heavy inoculum pressure of certain fungi causing discoloration of paddy seeds. *Indian Phytopath*ology, **43(2)** : 175-178.

Misra, A.K. and Vir, D. 1991. Assessment of losses due to discoloration of paddy seeds. Loss in seed weight in different rice cultivars due to seed

discoloration. *International Journal of Tropical Plant Diseases*, **9(2**) : 245-249.

Muriniate, S.L. and Lusianao, P. 1990. Effect of brown plant hopper infestation on rice grain quality and weight. *An American Newsletter,* 36-38pp.

Nagala, G.N. and Adeniji, M.O. 2000. Measurement of fungitoxicity using the filter paper disk method. *Tropenlandwirt,* **101(1**) : 55-72.

Narain, A. 1992. Recent advance of few minor disease of rice posing threats. *Indian Journal of Mycology and Plant Pathology*, **22(1**) : 1-26.

Negi, H. and Das, B. 2003. Germinability, viability and seedling vigour of discoloured rice seeds. *Plant Disease Research*. Ludhiana **18(2**) : 165-167.

Negi, H. and Das, B. 2003. Screening of rice varieties against seed discoloration. *Indian Phytopath,* **56(4)** : 460-461.

Padmanabha, S.Y. 1949. Occurrence of fungi inside rice kernels. *Curr. Sci*, **18** : 442-443.

Pandey, K.N; Pandey, B.C; Sah, M; and Gupta,R.C ; 1982 Effect of fungal metabolities on germinatin and sprouting of seeds of *Setaria italica* grown on Almora hills. *Indian phytopathol.* **35** ; 136 – 138.

Pandey, V., Agarwal, V.K. and Pandey, M.P. 2000. Location and seed transmission of fungi in discoloured seeds of hybrid rice. *Indian Phytopathology,* **53(1)** : 45-49.

Prabhu, A.S.; Soave, J; Zimmermann, F.J.P.; Filippi, M.C.; Souza, N.R.G.; Curvo, R.C.V.; Lopes, A.M.; Sobral, C.A.M.; Ferreira, R.P.; Kobayashi, T. and Galvao, E.U.P. 1996. Genetic variability for disease resistance in Brazilian upland rice native germplasm. *Pesquisa Agropecuaria Brasileira,* **31(6)** : 413-424.

Prakash, A. and Rao, J. 2000. Interaction of earhead bugs, *Leptocorisa acuta* Thumb and certain pathogenic fungi to deterioration in rice grain quality. *Entomon*, **25(1)** : 55-60.

Prakash, A. and Rao, J. 2001. Interaction of pentatomid bugs and certain pathogenic fungi to deteriorate paddy grain quality. *Indian Phytopathology*, **54(2)** : 258-260.

Ramaling, A; Maheswaran, M; Subramanian, M; Rathinam, AAD; subramanan, S; soundrapandian, G.1991.MDU-4, a high yielding; cold tolerant rice for Tamilnadu. *International Rice Research newsletter*., **16** : 5 , 16.

Ranganathai, K.G. 1985. Incidence of grain discoloration of paddy in Karnataka, *Madras Agricultural Journal*, **72(8)** : 468-469.

Rao, J. and Prakash, A. 2003. Panicle mites causing sterility in farmer's paddy fields in India. *Journal of Applied Zoological Research,***14(2)** : 212-217.

Rao, P.H. and Reddy, S.M. 1988. Influence of humidity on seed mycoflora and deterioration of sorghum seed during storage. *Indian J. Mycol. Pl. Pathol*, **17(1**) :6-10.

Rao, P.S. 1990. Influence of date of planting on high density grain in rice. *Oryza,* **27** :101-103.

Ray, P. 1988. Chemical management of Grain discoloration. Ph.D. thesis, Utkal University, Bhubaneswar,54pp.

Ray, P. 1993. Fungicidal control of rice grain discoloration. *Oryza,* **30** : 367-369.

Reddy, C.S.; Reddy, K.R.N.; Kumar, R.N.; Laha, G.S. and Muralidharan, K. 2004. Exploration of alfatoxin contamination and its management in rice. *J. Mycol. Pl. Pathol*, **34(3**) : 816-820.

Ritu , Kumari. 2005 Plant resistance and new molecules for the manajemnt of sheath blight and sheath rot of rice. M. Sc. (Ag). Thesis. Submited to IGKV Raipur (C.G.) pp : 34

Rodriguez, H.A., Nass, H. and Aleman, L. 1988. Incidence and control of rice grain discoloration. *Phytopathologia Venezolana*, **1 (1**) : 5-7, 12.

Sachan, I.P. and Agarwal, V.K. 1994. Efficacy of seed treatment of discolored seeds of rice on seed borne inoculum, germination and seedling vigour. *Seed Research,* **22(1)** : 45-49.

Sachan, I.P. and Agrawal, V.K. 1995. Seed discoloration of rice, location of inoculum and influence on nutritional value. *Indian Phytopathology*, **48(1)** : 14-20.

Sachan, J.P. and Agarwal, V.K. 1994. Effect of seed discoloration of rice on germination and seedling vigour. *Seed Research,* **22(1)** : 39-44.

Samira, Serghat, Karima Mradmi, Tauhami, A.O. and Alah, D. 2005. Rice leaf pathogenic fungi on wheat, oat, *Echinochloa phyllapogon* and *Phragmites australis*. *Phytopathologia Mediterranea,* **44(1)** : 44-49.

Samuales, Y.J. and Hashimoto I.V. 1996. Effect of brown plant hopper in rice crop. Tech Information article USA. *An American Newsletter*, 32-38.

Santos, A.B. and Prabhu, A.S. 2003. Effect of harvesting system and fungicide application on the performance of irrigated ratoon rice. *Revista rasileira d Engenharia Agricola e Ambiental*, **7(3)**:572-576.

Sharma, A. and Chaudhury, K.C.B. 1986. Seed microflora of paddy from Manipur State. *Seed Research,* **13(2)** : 131-134.

Sharma, H.L., Randhawa, H.S., Kapur, A. and Singh, Satnam. 1987. Seed discoloration in rice. *Oryza*, **24(1)** : 37-41.

Sharma, O.P and Vaid, A. 1993. Mycoflora of discolored rice grain and its pathopgenic potential in Himachal Pradesh. *Himalayan microbial diversity* I ; 273 – 281.

Sharma, O.P. and Valid, A. 1997. Mycoflora of discolored rice grains and its pathogenic potential in Himachal Pradesh. Himalyan Microbial Diversity, Part I ; 273-281.

Singh, D., Mahehswar, V.K. 2001. The influence of stack burn disease of paddy on seed health status. *Seed Research*, **29(2)** : 205-206.

Singh, K.D., Bhattacharya, H.C. and Pathak, A.K. 1996. Nature of perpetuation of sheath rot (*Sarocladium oryzae*) in rice seeds and its control. J. *Agric. Sci. Soc. North East India*, **9** : 76-78.

Sinha, A.P. 1999. Occurrence of seed discoloration of rice in Midwestern plain zone of Uttar Pradesh. *Agricultural Science Digest,* **19(3)** : 191-192.

Sistema, M. and Ronco, L. 1994. Efficacy of three fungicides for controlling growth of five seed borne fungi associated with rice grain spotting. *International Rice Research Notes*, **19(2)** : 25-26.

Sisterna, M.N. and Bello, G.M.D. 1998. *Curvularia protuberata*, a new seed borne pathogen of rice. *Acta Phytopathologica et Entomologica Hungarica*, **33(1/2)** : 111-114.

Soave, J.; Pizzinatto, M.A.; Usberti F.J.A.; Azzini, L.E.; Camargo, O.B. D; Villela, O. and Gallo, P.B. 1985. Response of low land rice varieties to grain spotting fungi. *Bragantia*, **44(1)** : 331-346.

Su, M.T. 1938. Report of the Mycologist, Burma, Mandalay for the year ending 31st March, 1938. 10 pp.

Sugha, S.K. and Singh, B.M. 189. Effect of glume blight of rice on grain yield and quality. *Indian Phytopathology,* **42(1)** : 163-164.

Suriachandraselvan, M. and Ranganatha, T.B. 1989. Effect of planting season on the incidence of rice diseases. *Madras Agricultural Journal*, **76(5)** : 297-300.

Thrimurty, V.S.; Veda, O.P.; Satpute, R.G. and Kashyap, R. 1980. Sheath rot incidence and chaffy grain percentage of some popular rice. *Int. Rice Res. Notes*, **5(5**) : 7.

Urkurkar, J.S. and Pandey, R.L. (2001).Asinchit awastha mein dhan adharit dwifasli kheti. Chhattisgarh Kee Krishi Samridhi. 42-51.

Vaid, A.; Sharma, O.P. and Kaushik, R.P. 1994. Effect of grain discoloration disease on some important quality parameters of rice. *Plant Disease Research,* **9(2)** : 190-192.

Vaid, A.; Sharma, O.P. and Sugha, S.K. 1994. Comparative efficacy of fungicides against discoloration of rice. *Plant Disease Research*, **9(2)** : 150-152.

Zakeri, Z. and Zad, J. 1983. Contribution knowledge of rice mycoflora of three rice cultivar in Iran. *Iranian J. Pl. Path*, **19** : 1-2.

Zeigler, R.S. and Alvarez, E. 1989. Pseudomonas species causing rice sheath rot and grain discoloration. *International Rice Research Newsletter*, **14:** 1, 26.

Zulkifli, E.; Klap, J. and Castano, J. 1991. Effect of grain discoloration in upland rice on some yield components. *International Rice Research Newsletter*, **16(4)** : 20.

Appendix I Weekly meteorological data during the crop period

WEEK No	Date		Temperature (°C) Maximum	Minimum	RAINFALL (mm)	Relative humidity (%) I	II	Evaporation (mm)	Sunshine (hours)
27	July, 2006	02-08	30.6	25.2	55.4	85	69	4.4	2.3
28		09-15	32.5	26.0	18.1	82	62	5.8	2.3
29		16-22	28.0	23.8	159.2	93	84	2.4	0.3
30		23-29	29.7	24.1	129.1	94	77	2.8	3.1
31		30-05	28.9	24.2	45.3	92	79	3.3	1.3
32	August, 2006	06-12	29.5	24.2	7.0	89	75	4.9	6.3
33		13-19	29.1	24.2	266.8	93	80	3.5	2.3
34		20-26	29.2	24.6	30.8	93	81	2.6	1.9
35		27-02	28.4	23.7	60.1	92	75	2.4	1.8
36	September, 2006	03-09	31.3	25.1	114.4	94	71	3.9	7.0
37		10-16	32.0	24.6	72.2	94	77	3.0	4.9
38		17-23	30.9	24.4	11.6	90	70	3.8	6.7
39		24-30	31.5	23.1	34.0	90	64	4.1	7.7
40	October, 2006	01-07	31.8	23.7	5.9	94	63	3.5	7.7
41		08-14	33.7	23.0	0.0	91	43	3.9	8.6
42		15-21	33.3	20.8	0.0	93	46	4.1	9.0
43		22-28	31.3	18.8	0.0	90	47	4.0	9.3
44		29-04	27.8	20.8	1.6	93	65	2.3	2.8
45	November, 2006	05-11	29.6	18.3	0.0	92	43	3.1	5.6
46		12-18	29.4	14.6	0.0	91	35	3.4	9.0
47		19-25	31.0	15.2	0.0	89	31	3.3	8.4
48		26-02	30.7	18.0	0.0	87	41	3.5	7.2
49	December, 2006	03-09	30.8	15.0	0.0	88	32	3.4	8.3
50		10-16	29.4	12.2	0.0	88	29	3.3	8.5
51		17-23	26.9	10.6	0.0	90	35	3.1	8.1
52		24-31	28.1	11.9	0.0	88	36	2.7	8.1
01	January, 2007	01-07	26.7	9.6	0.0	88	30	3.1	8.5
02		08-14	28.8	10.6	0.0	89	32	3.0	8.3
03		15-21	28.4	11.5	0.0	83	30	3.4	7.5
04		22-28	29.8	10.4	0.0	83	22	3.8	9.0
05		29-04	31.6	15.6	0.0	80	32	3.9	7.1
06	February, 2007	05-11	31.3	16.4	0.0	85	37	4.6	7.6
07		12-18	37.6	15.0	22.4	87	43	4.0	8.2
08		19-25	30.4	13.0	0.0	81	21	4.9	10.2
09		26-04	32.0	16.6	0.0	78	27	5.9	9.6
10	March, 2007	05-11	31.9	17.0	0.0	74	30	5.3	8.2
11		12-18	32.6	17.8	2.5	80	30	5.6	8.0
12		19-25	37.3	21.2	0.0	67	22	7.1	9.1
13		26-01	35.7	18.7	0.0	58	14	8.0	9.9

Table 4.1 : Per cent grain discoloration of important paddy varieties

S. No.	Varieties	Grain discoloration (%)	Chaffiness (%)
1.	IR-36	30.26	19.64
2.	Pant-4	29.67	19.43
3.	Mahamaya	29.46	9.27
4.	Swarna	29.39	15.91
5.	HMT	28.30	19.82
6.	MTU-1010	27.37	17.05
7.	Indira-9	25.43	4.75
8.	Sona Masuri	23.81	15.06
9.	IR-64	23.10	11.68
10.	Kranti	32.95	6.09
	SEm±	1.58	1.68
	CD (5%)	4.56	4.85

Table 4.2 : Loss in grain weight due to grain discoloration

S. No.	Varieties	Healthy grain	Discolored grain	Weight difference	Weight loss (%)
1.	MTU-1010	26.23	23.35	2.88	10.97
2.	Pant-4	31.71	28.83	2.88	9.08
3.	Indira-9	25.13	18.85	6.28	24.90
4.	IR-64	27.03	22.84	4.19	15.50
5.	Shaymla	28.36	22.93	5.43	19.14
6.	HMT	18.40	16.78	1.62	8.80
7.	Swarna	29.08	26.00	3.08	10.59
8.	Kranti	13.63	12.59	1.04	7.63
9.	Mahamaya	32.16	29.64	2.52	7.83
10.	Chapti	29.47	27.79	1.68	5.70

Table 4.6 : Pathogenicity test

S. No.	Pathogen	Infection in panicle
1.	*Sarocladium oryzae*	+
2.	*Drechslera oryzae*	+
3.	*Fusarium moniliforme*	+
4.	*Curvularia lunata*	+
5.	Control (without pathogen)	-

Table 4.7 : Effect of fungal metabolite on rice germination

S. No.	Variety	Germination (%) of untreated seeds	Reduction in germination (%) of treated seeds			
			S. oryzae	*F. moniliforme*	*D. oryzae*	*C. lunata*
1.	Sona masuri	92	77.17	67.39	56.52	13.04
2.	MTU 1010	98	74.44	67.34	51.02	16.32
3.	IR-36	95	64.21	58.94	50.52	8.42
4.	IR-64	97	60.82	47.72	40.20	9.27
5.	Swarna	96	42.70	32.29	27.08	13.54
6.	Kranti	94	48.93	38.29	23.40	13.82
7.	Indira-9	88	60.22	35.22	12.50	9.09
8.	HMT	90	53.33	41.11	21.11	5.55
9.	Mahamaya	94	56.38	42.55	17.02	13.82
10.	Pant-4	87	70.11	57.47	21.83	10.34

Table 4.9 : Effect of date of sowing on grain discoloration.

Variety / Dates	Kranti	MTU-1010	HMT	IR - 36
12.06.06	28.56	23.28	23.81	25.53
24.06.06	29.90	28.06	26.55	25.08
09.07.06	31.06	29.92	21.43	26.20
$\overline{X}$	29.84	27.08	25.93	24.93
	SEm±	CD (5%)		
Dates	0.485	1.530		
Varieties	1.388	4.391		

Table 4.10 : Relationship of grain discoloration with sheath blight

S. No.	Varieties	Grain discoloration (%)
1.	PR-106	32.71
2.	Shaymla	29.58
3.	Indira-9	25.04
4.	Swarna	22.48
5.	R-320-300	22.22
6.	Pant-4	19.84
7.	Ruchi	15.44
8.	Poornima	14.75
9.	IR-64	13.51
10.	Kranti	19.63
	SEm±	0.79
	CD (5%)	2.35

Table 4.11 : Relationship of grain discoloration with sheath rot

S. No.	Varieties	Grain discoloration (%)
1.	Pant-4	91.40
2.	Poornima	84.98
3.	Indira-9	65.44
4.	Ruchi	56.44
5.	MTU-1010	55.57
6.	RP-2151-21-22	44.15
7.	Bamleshwari	43.90
8.	R-320-300	43.46
9.	Shaymla	42.40
10.	Kranti	80.31
	SEm±	0.80
	CD (5%)	2.30

Table 4.12 : Relationship of grain discoloration with False smut

S. No.	Varieties	Grain discoloration (%)
1.	MTU-1010	78.13
2.	Indira-9	59.08
3.	Poornima	33.02
4.	Shyamla	32.34
5.	HMT	30.53
6.	R-435-108	26.23
7.	TN-1	25.43
8.	R-320-300	24.27
9.	RP-2151-21-22	12.39
10.	IR-64	37.68
	SEm±	0.66
	CD (5%)	1.95

Table 4.13 : Relationship of grain discoloration with brown spot

S. No.	Varieties	Grain discoloration (%)
1.	RP-2151-21-22	35.47
2.	Indira-9	32.32
3.	IET-8585	31.91
4.	Shaymla	28.28
5.	R-320-300	27.19
6.	Ruchi	26.93
7.	R-1142-603-1-1	24.20
8.	Poornima	22.50
9.	R-435-108	23.50
10.	Kranti	39.50
	SEm±	0.71
	CD (5%)	2.11

Table 4.14 : Effect of insect feeding on rice grain discoloration

S. No.	Varieties	Grain discoloration (%)	
		BPH	Gundhi bug
1	TN1	26.91	24.25
2	Mahamaya	23.93	24.27
3	IR-64	22.34	24.27
4	Madhuri-11	18.67	22.76
5	MTU-1010	15.66	17.50
6	Dubraj	14.07	21.00
7	Kranti (check)	24.51	44.74
	SEm±	0.48	0.38
	CD (5%)	1.43	1.12

Table 4.15 : Chemical control of grain discoloration of rice

Spray / Fungicides	Tillering	Tillering + Milking	Tillering + Milking +Dough	$\overline{X}$
Kocide	28.95	26.45	26.62	27.34
Contaf	27.84	26.20	20.65	24.89
Carbendazim	19.49	17.39	16.96	17.94
Mancozeb	27.01	23.86	21.21	24.02
Control (water)	35.24	24.45	23.03	27.57
	SEm±	CD (5%)		
Fungicides	1.216	2.720		
Stages	3.890	8.020		

Table 4.3 : Mycoflora associated with important rice varieties

Variety	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Pant-4	2.66	7.33	1.33	1.20	13.06	-	1.33	1.33	1.66	3.36	2.33	-	1.66	1.66	38.91
MTU-1010	1.20	6.10	1.80	1.30	4.33	1.33	-	1.33	2.66	6.10	1.66	-	-	1.66	29.47
Sona Masuri	1.33	4.33	1.33	1.66	5.33	1.01	1.33	1.66	1.01	3.33	2.66	1.66	1.06	1.33	29.03
HMT	4.00	-	2.01	3.50	6.10	1.33	-	1.33	-	7.66	-	1.33	1.20	-	28.46
Swarna	2.00	5.66	2.66	2.66	5.10	-	-	1.01	1.33	3.00	1.33	2.33	1.33	-	28.41
IR-64	1.20	3.33	1.33	1.20	5.33	-	-	2.66	3.66	7.33	-	2.33	-	-	28.37
Mahamaya	2.33	4.08	1.66	2.33	5.33	2.66	-	-	-	5.80	2.66	-	1.33	-	28.18
IR-36	1.20	2.01	2.66	1.66	5.33	1.33	1.66	2.33	-	6.66	-	1.66	-	1.33	27.83
Indira-9	1.66	4.66	2.66	3.06	2.01	-	1.66	2.66	-	1.22	2.66	-	1.40	1.66	25.31
Kranti	1.33	8.66	4.01	3.66	2.04	-	-	2.01	1.66	4.01	2.66	-	1.66	-	31.70
SEm±															2.77
CD (5%)															8.16

1. *Alternaria alternata*
2. *Aspergillus* sp.
6. *Memnoniella* sp.
7. *Nigrospora* sp.
11. *Sarocladium oryzae*
12. *Stachybotrytis* sp.

3. *Curvularia lunata*
4. *Drecheslera oryzae*
5. *Fusarium moniliforme*
8. *Penicillium* sp.
9. *Periconia* sp.
10. *Rhizophus* sp.
13. *Trichoconis padwickii*
14. *Trichoderma viride*

Table 4.4: Mycoflora associated in discoloured seeds

Variety	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total	Germination (%)
Mahamaya	8.00	-	10.66	10.66	18.66	-	-	-	-	18.66	2.66	-	1.33	-	70.63	76.00
IR-64	8.00	13.33	1.33	2.66	16.00	-	-	2.66	4.00	9.33	-	20.00	-	-	77.31	71.81
IR-36	9.33	4.00	2.66	5.33	16.00	9.33	2.66	-	-	18.66	-	1.33	-	1.33	70.63	68.66
MTU-1010	4.00	9.33	8.00	8.00	6.66	1.33	1.33	5.33	2.66	8.00	-	-	-	-	54.64	68.32
Indira-9	4.00	10.66	-	4.00	12.00	-	2.66	2.66	-	9.33	-	-	2.66	6.66	54.63	66.14
Sona masuri	-	9.33	8.00	6.66	9.33	1.33	-	1.33	4.00	4.00	2.66	6.66	6.66	-	59.96	65.68
Swarna	4.00	2.66	-	6.66	12.00	2.66	-	-	1.33	4.00	1.33	20.00	1.33	-	55.97	62.71
HMT	4.00	5.33	14.66	2.66	8.00	1.33	-	-	-	10.66	-	9.33	2.66	-	58.63	60.39
Pant-4	6.66	9.33	-	-	13.33	-	-	2.66	2.66	5.33	-	2.66	6.66	2.66	51.95	54.81
Kranti	-	12.00	8.00	6.66	16.00	-	-	4.00	2.66	1.33	4.00	-	5.33	-	59.98	62.00

1. *Alternaria alternata*
2. *Aspergillus* sp.
3. *Curvularia lunata*
4. *Drecheslera oryzae*
5. *Fusarium moniliforme*
6. *Memnoniella* sp.
7. *Nigrospora* sp.
8. *Penicillium* sp.
9. *Periconia* sp.
10. *Rhizophus* sp.
11. *Sarocladium oryzae*
12. *Stachybotrytis* sp.
13. *Trichoconis padwickii*
14. *Trichoderma viride*

Table 4.5 : Mycoflora associated in healthy seeds

Variety	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total	Germination (%)
Sona Masuri	1.33	2.66	-	-	1.50	2.66	1.33	-	-	2.33	-	-	-	1.33	13.14	96.18
Mahamaya	1.33	8.00	-	1.33	1.33	2.66	-	-	-	5.33	-	-	-	-	19.98	96.00
IR-64	-	3.00	-	1.33	1.33	-	-	-	1.33	5.00	-	1.33	-	-	13.32	95.31
IR-36	2.66	2.16	-	-	-	-	-	1.33	-	2.32	-	-	-	-	8.47	92.81
Swarna	-	8.00	1.66	-	2.66	-	-	1.36	-	1.50	-	5.33	-	-	20.51	89.99
MTU-1010	2.01	3.32	-	-	3.66	-	-	3.50	-	4.20	2.66	-	-	2.66	22.01	88.88
HMT	-	3.66	2.33	1.33	-	-	-	1.33	-	2.33	-	-	1.33	-	12.31	86.16
Indira-9	1.33	5.10	2.66	1.33	2.66	-	-	-	-	2.66	2.66	-	1.33	4.00	23.73	84.76
Pant-4	1.33	3.01	2.33	2.66	4.33	-	1.33	1.33	-	1.33	3.51	-	-	-	21.16	82.00
Kranti	2.33	6.66	-	-	6.66	-	-	4.00	-	6.66	2.66	-	1.33	-	30.30	78.71

1. *Alternaria alternata*
2. *Aspergillus* sp.
3. *Curvularia lunata*
4. *Drecheslera oryzae*
5. *Fusarium moniliforme*
6. *Memnoniella* sp.
7. *Nigrospora* sp.
8. *Penicillium* sp.
9. *Periconia* sp.
10. *Rhizophus* sp.
11. *Sarocladium oryzae*
12. *Stachybotrytis* sp.
13. *Trichoconis padwickii*
14. *Trichoderma viride*

Table 4.8 : Correlation between weather parameters and grain discoloration

S. No.	Observation date	Grain discoloration (%)	Weather parameter data				
			Temperature (°C)		Rainfall (mm)	Relative humidity (%)	
			Maximum	Minimum		I	II
1.	10.10.06	2.29	33.70	23.00	0	91	43
2.	16.10.06	3.78	33.30	20.80	0	93	46
3.	22.10.06	5.90	31.30	18.80	0	90	47
4.	28.10.06	7.77	27.80	20.80	1.6	93	65
Correlation regression value			-0.9566	-0.6269	0.787	0.2216	0.873

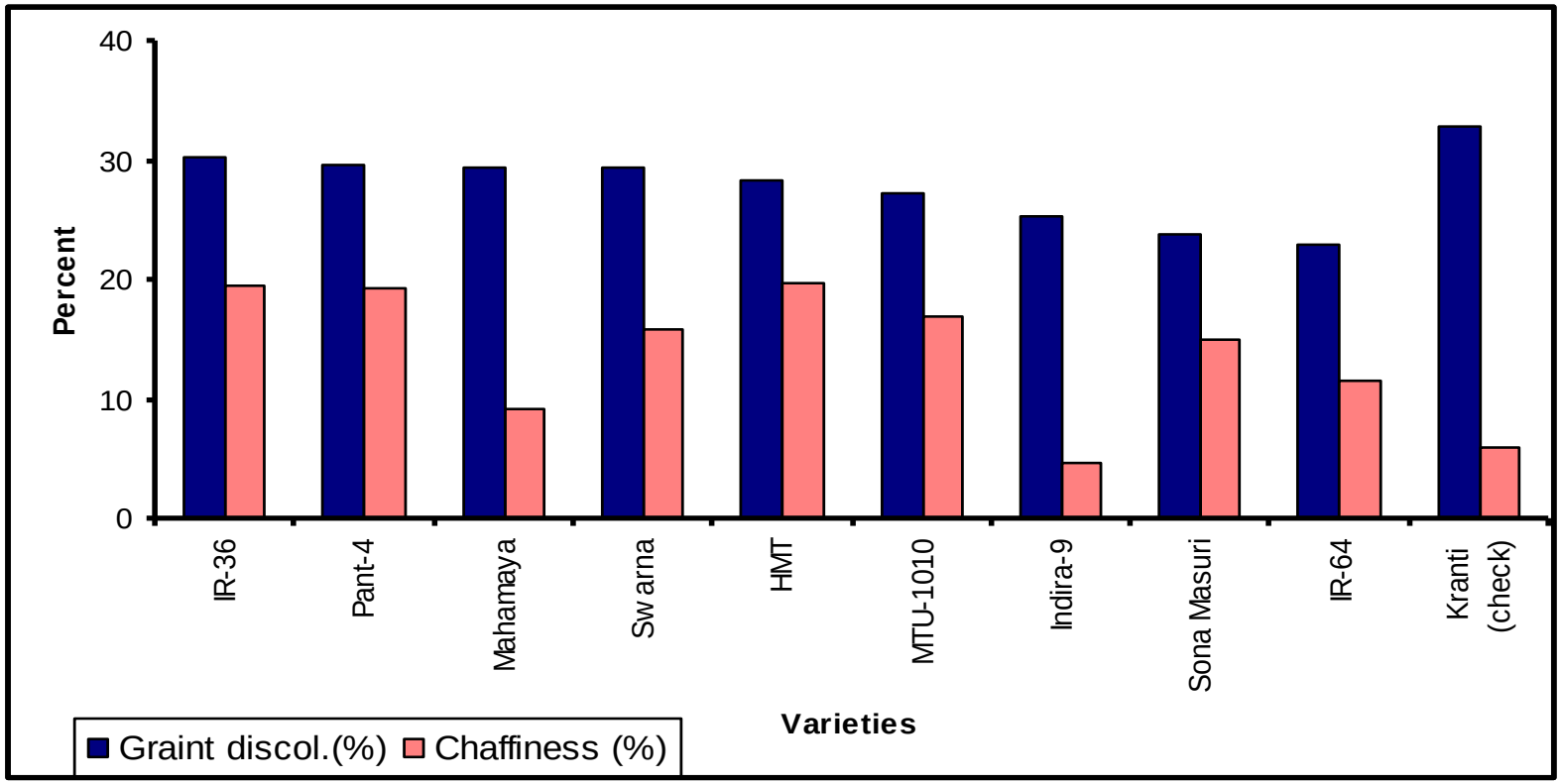


Fig.4.1 : Per cent grain discoloration of important paddy varieties

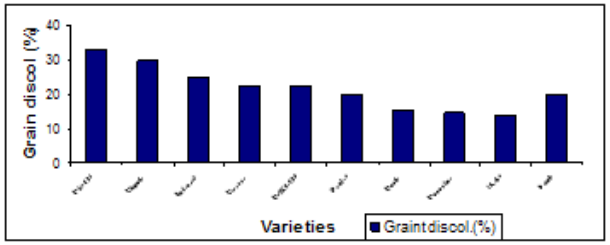


Fig.4.6 : Relationship of grain discoloration with sheath blight

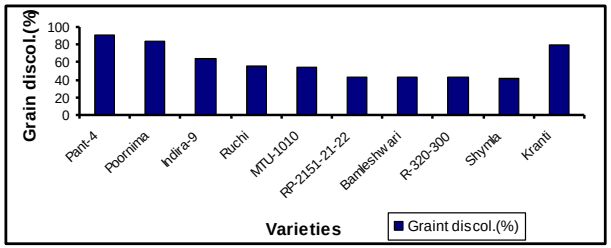


Fig.4.7 : Relationship of grain discoloration with sheath rot

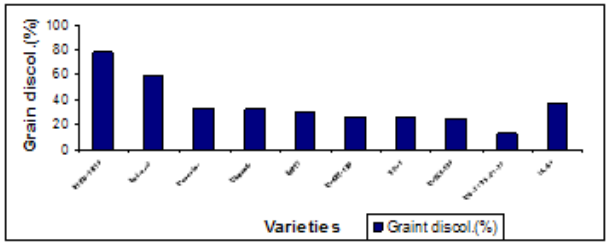


Fig.4.8 : Relationship of grain discoloration with false smut

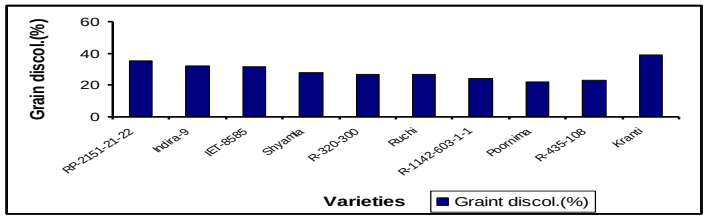


Fig.4.9 : Relationship of grain discoloration with Brown spot

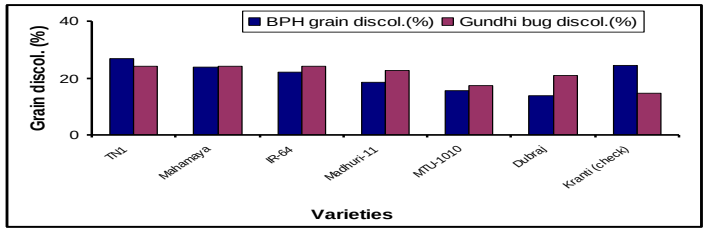


Fig.4.10 : Effect of insect feeding on rice grain discoloration

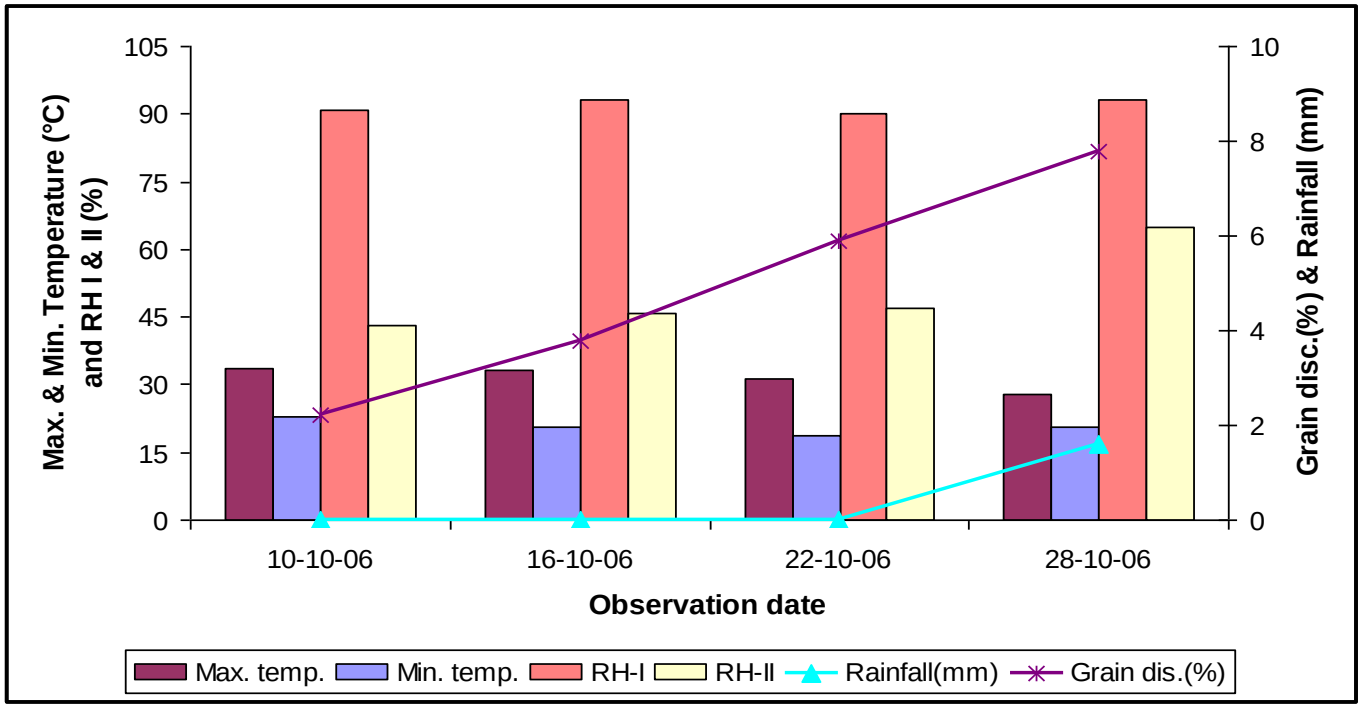


Fig4.5. : Correlation between weather parameters and grain discoloration

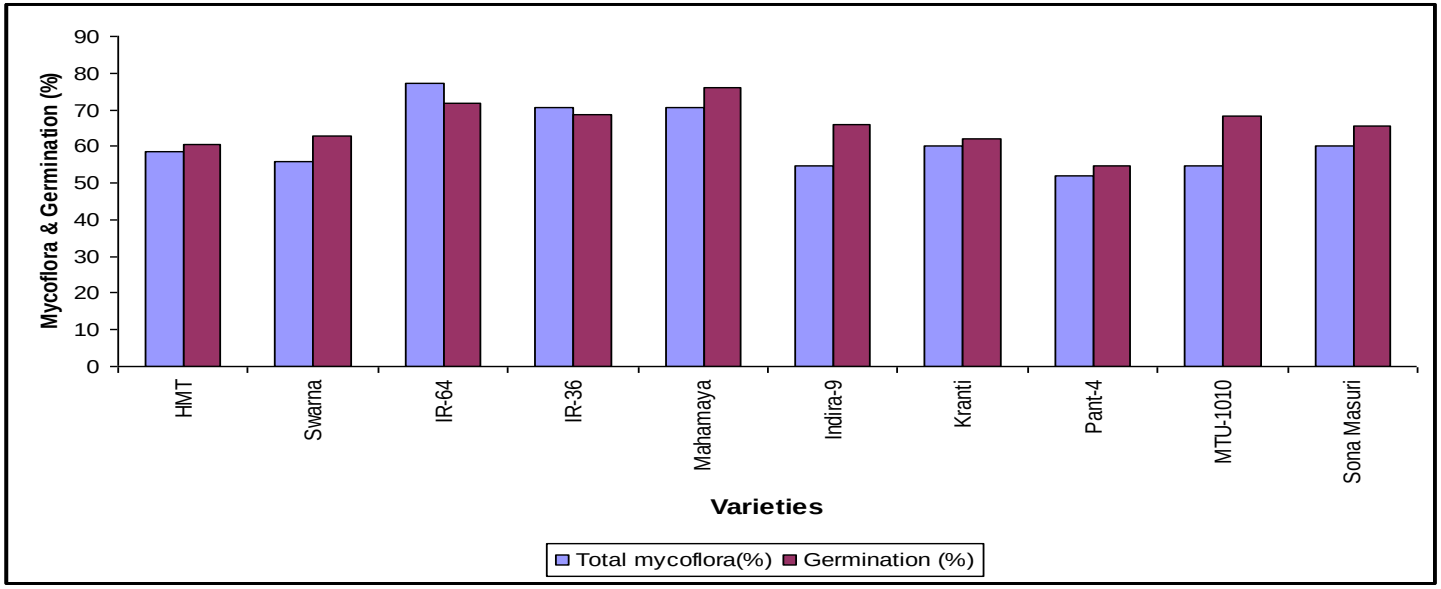
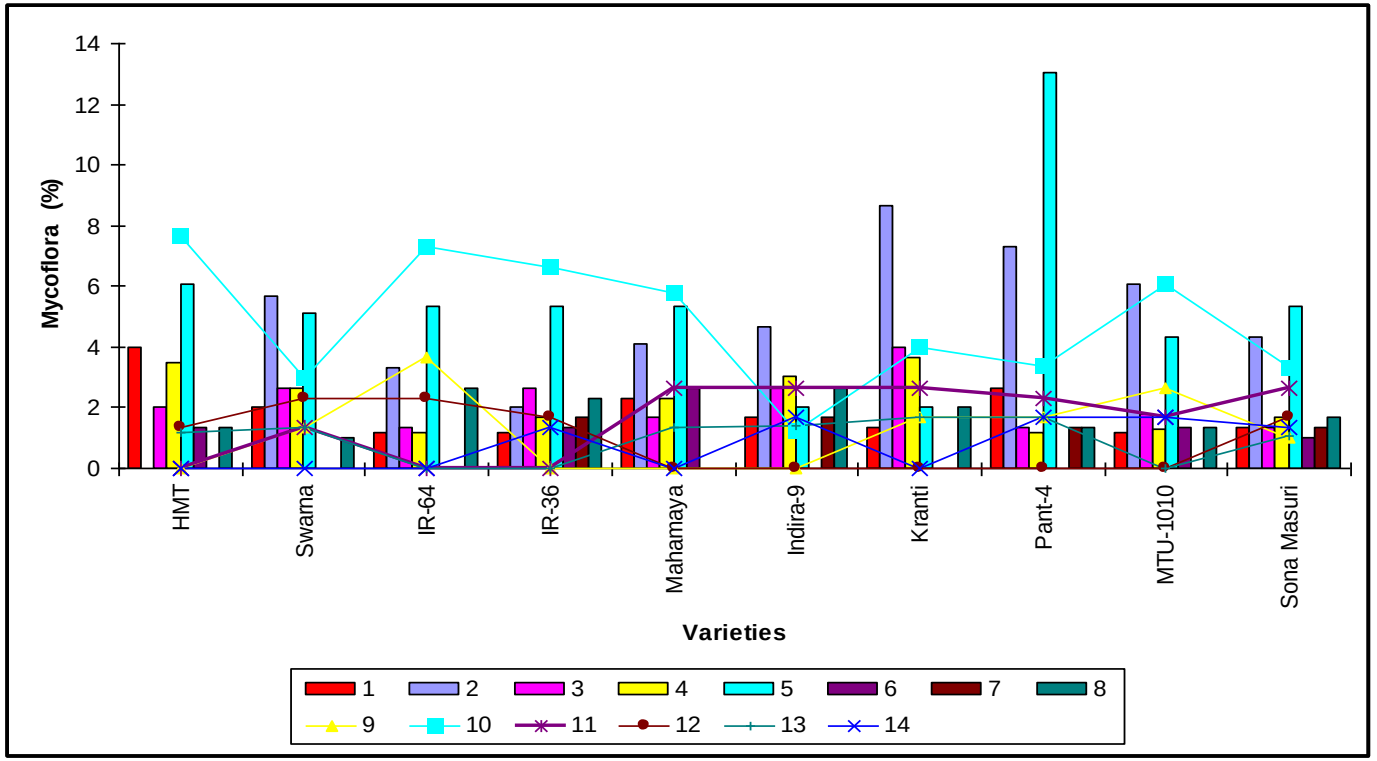


Fig.4.3 : Mycflora associated in discoloured grain



1. Alternaria alternata 2.Aspergillus sp. 3.Curvularia lunata 4.Drecheslera oryzae 5.Fusarium moniliforme 6.Memnoniella sp. 7.Nigrospora sp. 8.Penicillium sp. 9.Periconia sp. 10.Rhizophus sp. 11.Sarocladium oryzae 12.Stachybotrytis sp. 13.Trichoconis padwickii 14. Trichodermaviride

Fig.4.2 : Mycoflora associated with important rice vareiteis

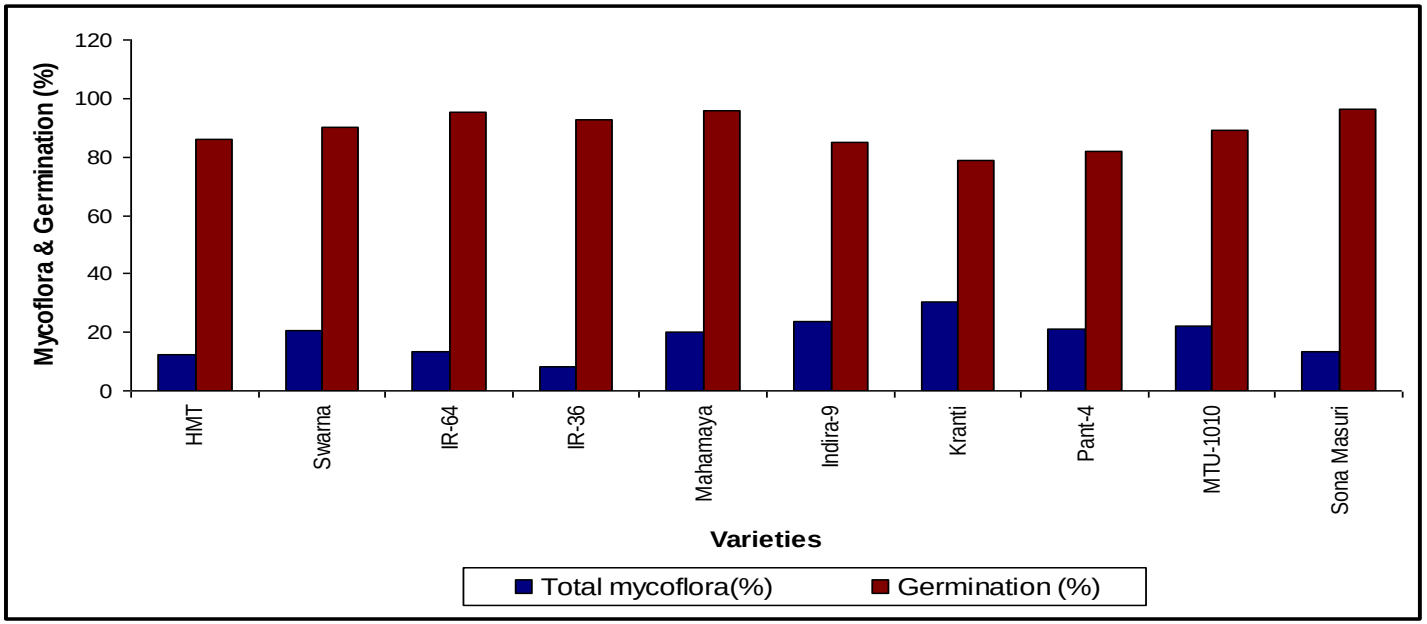


Fig.4.4 : Mycflora associated in healthy looking seeds

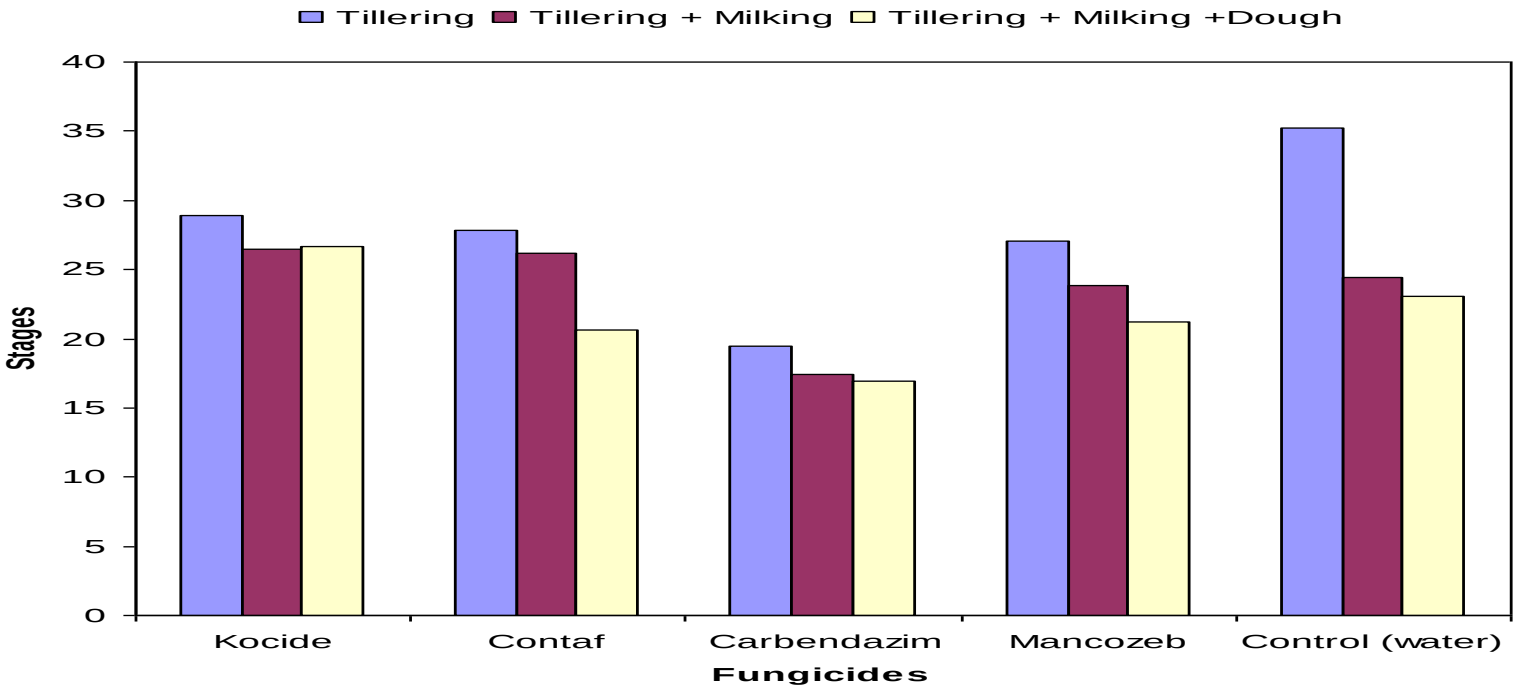


Fig 4.15 : Chemical control of grain discoloration of rice

HEALTHY SEED

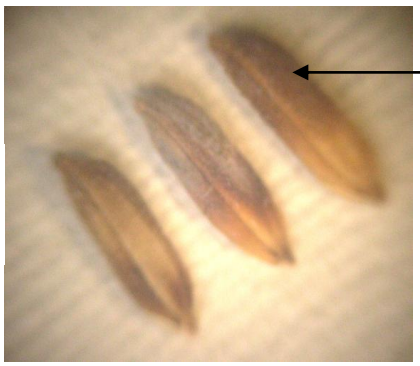
DISCOLORED

Plate 4.1: Healthy looking and discolored grains

DISCOLORED SEEDS HEALTHY SEEDS

Fusarium

Moniliforme



Curvularia

w of

Plate 4.3: Germination percent of healthy and discolored seeds

Plate4.4: Component plating of discolored seeds Shows Pathogens / microorganism associated with husk only.

Plate 4.5: Effect of fungal metabolite on seed germination

Healthy seed **Discolored seed**

Plate 4.1: Healthy looking and discolored grains

Plate 4.2 : Close up view of discolored grains

Plate 4.3: Germination percent of healthy looking and discolored seeds

Plate4.4: Component plating of discolored seeds

Plate 4.5: Effect of fungal metabolite on seed germination