

Management of White Rust of Mustard by Use of Chemicals and Botanicals

THESIS



Submitted to the

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur

In partial fulfilment of the requirement for
the Degree of

MASTER OF SCIENCE

In

**AGRICULTURE
(PLANT PATHOLOGY)**

By

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CERTIFICATE – I

This is to certify that the thesis entitled “Management of white rust of mustard by use of chemicals and botanicals” submitted in partial fulfilment of the requirement for the degree of MASTER OF SCIENCE IN AGRICULTURE (Plant Pathology) of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by Mr. Govind Verma under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instruction.

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 investigation has been acknowledged by him.


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CERTIFICATE – II

This is to certify that the thesis entitled “**Management of white rust of mustard by use of chemicals and botanicals**” submitted by **Mr. Govind Verma** to the J.N. Krishi Vishwa Vidyalaya, Jabalpur in partial fulfilment of the requirements for the degree of **Master of Science in Agriculture** in the Department of **Plant Pathology** has been, after evaluation, approved by the External Examiner and by the Student’s Advisory Committee after an oral examination on the same.

Place : Gwalior

Date : 19/12/2005


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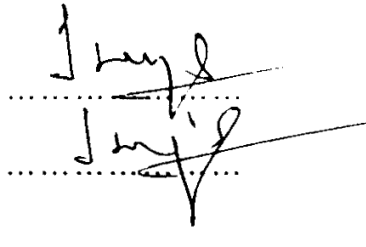
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Place : Gwalior
Date : ..19/12/2005-


(Govind Verma)

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Introduction



CHAPTER – I

INTRODUCTION

Rapeseed and mustard are the major rabi oilseed crops in India. They occupy a prominent place being important next to groundnut. These crops are grown both in subtropical and tropical countries. India occupies the first position with regards to acreage and production of rapeseed and mustard in the world. Rapeseed-mustard group is raised on about 6.7 million hectares with an annual production 5.96 million tonnes in India. In Madhya Pradesh rapeseed, mustard are grown in 536.68 thousand hectares with annual production of 580.38 thousand tonnes* and productivity of 1080 kg per hectare*. The Chambal division alone accounts an area of 292.3 thousand hectares with annual production of 333.9 thousand tonnes and productivity of 1150 kg ha⁻¹ (Anonymous, 2003).

The yield of oil from different forms of rapeseed-mustard is variable 37 - 49 per cent. Their oil is utilized for human consumption for frying purpose and seeds as spices. The oil cake is also used for cattle feed and manure. Oil seed group of crops play a vital role in national economy.

The chemical analysis of mustard seed reveals that it contains protein 22%, fat 40%, nutrient 4%, carbohydrates 24%, fiber 2%, moisture 8% components (Singh, 1958).

Raya (*Brassica juncea* L. Czern and Coss) is recorded as the most important oil seed among the Brassica group because of its high production potential and it is the most remunerative and dominant oilseed crop of the chambal command area as more than 70 per cent production of this crop in Madhya Pradesh, is produced by the Chambal and Gwalior division only.

The pathogen (*A. candida*) produces two types of infection, i.e. general or systemic and local (Butler 1918, Walker 1957). Local infections are manifested by scattered zoosporangial pustules on the under surfaces of leaves, and on stems or pod as blisters containing oospores. The symptoms of general or systemic infection are distortion, hypertrophy, hyperplasia, sterility of inflorescences (stagheads). Yield loss is greater from systemic than local infections (Harper and Pittman, 1974).

* Source : Commissioner of Land Record, Gwalior, 2003-04



PLATE 1- A



PLATE 1- B

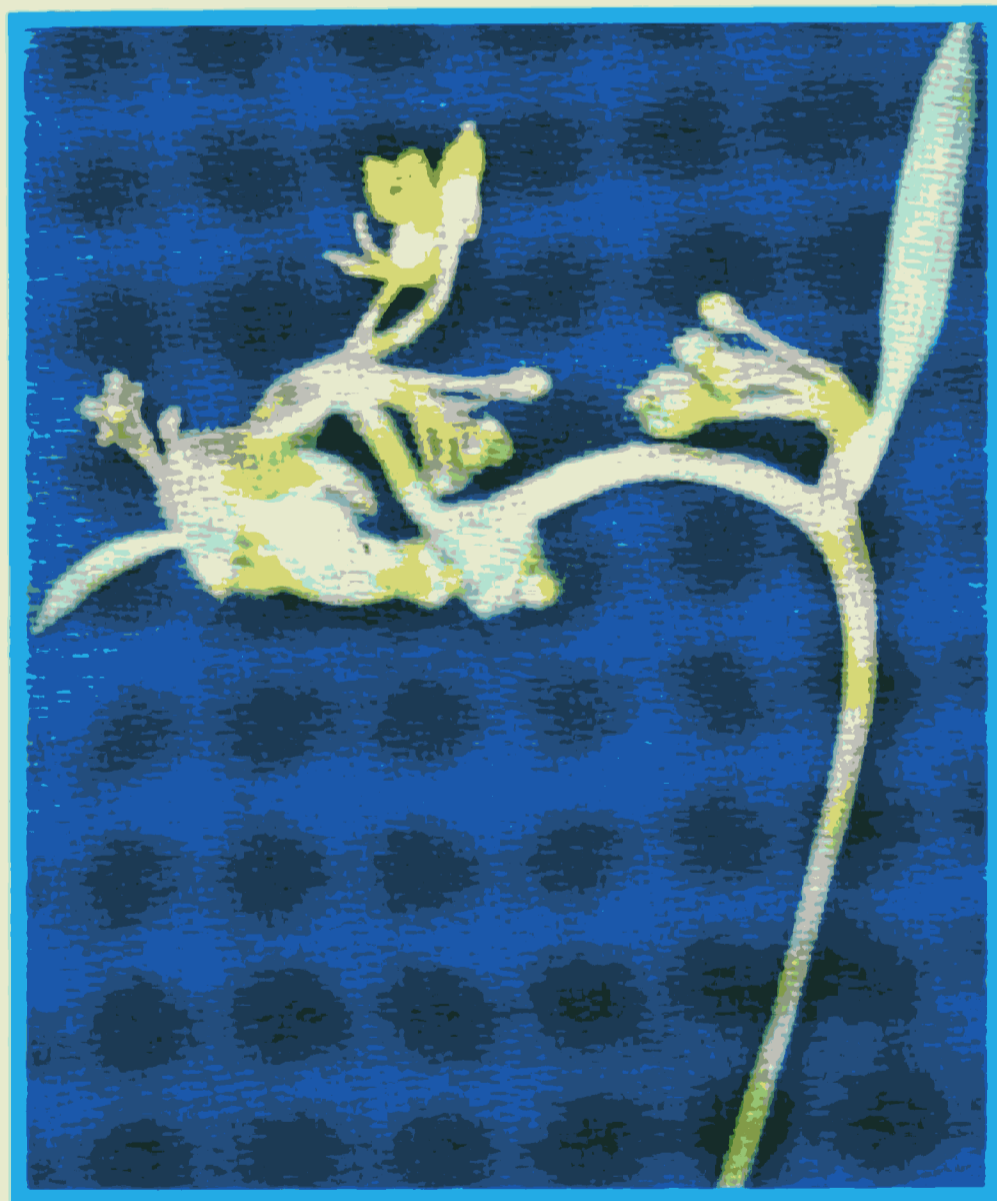


PLATE 1- C

- A - Close up view of leaf infection (lower surface).
- B - Close up view of leaf infection (upper surface).
- C - Close up view of staghead.

Meena *et al.* (2002) reported the fungicides and plant products in managing white rust of mustard caused by *Albugo candida* (Pers. Ex. Lev.) Kuntze. Field and laboratory experiments were conducted on Indian mustard.

Under laboratory conditions, the highest per cent disease control was observed with metalaxyl + mancozeb (100%) and *Azadirachta Indica* (100%). Under field conditions, Metalaxyl + mancozeb had the highest percent disease control (61.74%).

The present investigation on white rust was proposed with following objectives :

- (1) Survey of white rust disease in Morena, Bhind and Gwalior districts.
- (2) Study of yield losses due to the disease.
- (3) Pot screening of rapeseed-mustard lines against white rust under artificial inoculation condition.
- (4) Field screening of germplasm of mustard against white rust.
- (5) Evaluation of fungicides and botanicals against white rust in mustard.

A decorative border with a dotted line and a floral vine pattern with leaves, framing the central text.

Review

of

Literature

CHAPTER – II

REVIEW OF LITERATURE

A thorough review of literature is of paramount importance to any research. It assists in delineation of the problem area and provides a basis for interpretation of empirical perspective of research. The review of literature helps in providing basic knowledge and understanding the research trends. An attempt has been made to review the literature which is meaningful and has direct relevance to this study.

Survey

Petrie (1985) surveyed the virulent structure of *L. maculans* occurred in 67.9% of 53 fields of *Brassica napus* and *B. campestris* in Saskatchewan in July 1982. An average of 11% of the plants had leaf or stem infection.

Baniquied (1993) observed white rust disease in cool places of Philippines (Trinidad).

Pandya (1996) surveyed 16 villages of Gwalior, Shivpuri, Bhind and Morena in the years 1991-92 and 1992-93 to assess the intensity of white rust in farmer's field. The incidence of white rust was recorded at all the locations. The intensity of white rust leaf infection was in the range of 25.4% to 47.5% during the year 1991-92 and 25.8% to 41.7% during 1992-93, while the incidence of systemic infection during these two years ranged from 0 to 7.5 and 0 to 2.12 per cent, respectively. The magnitude of the disease was higher in the year 1991-92 as compared to that in 1992-93. District wise mean incidence of disease was maximum in Morena district (leaf disease index = 40.08% and stagheads = 2.12%) and minimum in Shivpuri district (leaf disease index = 30.75% and staghead – 0.87%).

Ghasolia *et al.* (2004) reported that out of 640 mustard fields surveyed in 24 districts of Rajasthan, 40-60% incidence was recorded in 31 fields of 10 districts. In 71 fields, disease incidence was 20-39% and in rest of the 538 fields, < 20%. During the survey, Indian mustard crop sown between the last week of October and first week of November showed 2.9% disease incidence, while incidence was significantly higher in crop sown from second to third week of October (28.7%). None of the cultivars were free from

infection. T-59 (Varuna) showed 21.9% disease incidence. A disease incidence of 1.8% was recorded in pearl millet-wheat-fallow-mustard sequence of two years followed by pearl millet-mustard-pulses-mustard. Disease incidence was significantly higher (22.5-24.0%) in fields having 3-4 irrigations at 30 to 35 days interval than that in fields with lesser irrigations. Rot incidence was lowest (0.6%) in unirrigated fields and was statistically at par with one irrigation. Disease incidence was highest in fields with loamy soil (24.0%) and lowest (5.6%) in those with sandy soil.

Vashishtha (2004) reported that maximum white rust intensity of leaf infection in mustard was recorded in Bhind district (33.40%), followed by Morena and Sheopur districts in Chambal division. The staghead incidence was maximum in Sheopur district (6.8%), followed by Bhind and Morena districts.

Losses :

Petrie and Vanterpool (1970) from Canada reported that systemic stem infection of *Albugo candida* causes on an average, reduction 60 per cent in seed yield of individual plants.

Petrie (1973) reported on an average, 6 per cent loss in turnip rape (*B. campestris*) for the year 1970-72 in Saskatchewan (Canada).

Harper and Pittam (1974) reported that systemic infection of white rust (staghead phase) accounts for most of the yield losses. They determined the relationship between the severity of systemic infection of the stem and seed yield of rapeseed in Canada and developed the following equation for assessing yield loss based on experiments conducted under field conditions. Yield loss (%) = 0.952 × per cent stem infected systemically. The loss in yield due to simultaneous occurrence of white rust and downy mildew has been reported to be about 17 to 34 per cent under Indian conditions (Bains and Jhooty, 1979 ; Kolte *et al.*, 1981).

Kolte *et al.* (1981) suggested the following formula for estimating the loss in yield due to white rust or downy mildew alone and due to both.

$$Q = \frac{A - (B \times C)}{A} \times 100$$

Where,

Q = Percentage yield loss.

A = Average actual or expected yield of a healthy plant

B = Average expected yield from the affected raceme, which is equal to actual average yield from the corresponding length of the healthy raceme.

C = Number of affected racemes per plant affected by the disease.

Saharan and Lakra (1988) observed that both phases (leaf and staghead phase) of white rust infection caused losses in total yield of mustard by affecting adversely each component of yield. With the increase in intensities of infection in each phase of the disease. The effect on yield and yield components increased drastically. The maximum effect on yield components was recorded due to 5 LP + 5 SH category of infection, which reduced 70.15 per cent number of branches, 54.50 per cent number of pods per branch, 20.90 per cent pod length, 40.16 per cent number of seeds per pod and 10.38 per cent thousand grain weight which ultimately resulted in 89.84 per cent reduction in total seed yield.

Singh *et al.* (1990) reported that the pathogen *A. candida* caused 31.5 to 37.2 per cent yield loss in the cv. Manipur local and 21.3 per cent loss in Varuna.

Bisht *et al.* (1994) tested 11 genotypes of *B. juncea* and found that yield losses due to shaghead varied from 2.4% to 28.6% depending upon staghead severity.

Kumar *et al.* (2002) reported that white rust (*Albugo candida*) is a major disease of Indian mustard, causing severe losses to seed yield and quality. Sugar and phenol content generally decreased with increasing developmental stage and under late sown conditions. Pathogen infection caused a greater decrease in total sugar and phenol content of susceptible varieties compared to resistant varieties.

Hingole and Mayee (2004) conducted experiments in Maharashtra, India, to estimate yield losses in rapeseed (*Brassica campestris*) and Indian

mustard (*B. juncea*) collectively called rapeseed-mustard, due to infection with white rust (*Albugo candida*) and powdery mildew (*Erysiphe curciferarum*). White rust incidence and severity on foliage was highest in Pusa bold 61.2 and 32.8% respectively and the lowest in Bio-SYR 29.2 and 19.9% respectively. The staghead incidence also was lowest in Bio-SYR and highest in Pusa bold. It indicates that powdery mildew is more serious, causing more losses in yield than white rust.

Screening of cultivars

Parui and Bandyopadhyay (1973) reported that out of 56 lines tested, T4, IB 950, IB 684, IB 949 and IB 595 showed high resistance. T4 is considered to be almost immune to *A. candida*.

Singh *et al.* (1988) investigated that the F₆ progenies of 2 crosses between *B. juncea* and *B. carinata* (15 BH 7A and 15 BH 3A) had resistance to *A. Candida*.

Malik (1989). Screened five varieties each of *Brassica carinata*, *B. juncea* and *B. campestris* (yellow sarson, brown sarson and toria types) against *A. candida* and found that *B. juncea* cultivars are highly susceptible to *A. candida*.

Verma and Bhowmik (1989) observed that none of the Indian cultivars of *B. campestris* and *B. juncea* are resistant to white rust; two lines of *B. napus* BN-Sel and BN-38 Sel showed a resistant and susceptible reaction respectively to the *B. juncea* pathotype of *A. candida* in the form of absence or presence of white rust pustules on their leaves.

Paladhi *et al.* (1993) studied inheritance of field resistance to *Albugo candida* in the F₁ and F₂ generations of 4 inter varietal crosses involving 1 resistant (PI -15) and 4 susceptible *Brassica juncea* genotypes during June-September 1990-91. Resistance was monogenic dominant.

Velazhahan and Thiyagarajan (1994) tested thirty seven genotype of mustard (*Brassica juncea*) for their reaction to white rust under natural field condition. Thirteen genotypes were found resistant, 8 moderately resistant and 16 susceptible or highly susceptible.

Yadav *et al.* (1999) evaluated seventy four Indian mustard (*Brassicca juncea*) lines for resistance to white rust (*Albugo candida*) under irrigated field condition in Bathinda, Punjab. None was completely resistant to the disease. Thirty seven entries were found moderately resistant. The moderately resistant genotype such a PBR 135, PBR 143, PBR 157, PBR 161, PBR 148, PBR 176, PBR 178 and PBR 180, can be used as donor parents in breeding for resistance to these diseases.

Gupta *et al.* (2001) screened forty five Indian mustard for their resistance against Alternaria blight and white rust. None of the tested Indian mustard genotypes were completely free from Alternaria blight at the leaf phase. Only EC-129126, PR 8805 and RC 781 cultivars were found resistant to both Alternaria blight and white rust.

Khunti *et al.* (2001 a) evaluate eight inoculation techniques for the establishment of rust disease (*Albugo candida*) in Indian mustard cv. Varuna. The treatments consisted of (1) seed dressing with zoospores, inoculation of lower (2) and upper (3) leaf surface with zoospore suspension and covering with polyethylene sheets for 48 hours, inoculation of lower (4) and upper (5) leaf surface with zoospore suspension without covering, (6) inoculation of lower leaf surface with ungerminated sporangial suspension, (7) injection of stem with zoospore suspension using syringe, (8) inoculation of stem with zoospore suspension by making minor injuries, and (9) control. The highest per cent disease index was obtained with inoculation of sporangia, germinated at 10°C, on the lower leaf surface and covering with polyethylene sheets for 48 hours.

Gupta *et al.* (2002) reported that genotypes, environment and genotype x environment interactions were significant for the disease at leaf and inflorescence stage under both dates of sowing except at staghead phase under normal sowing conditions. Genotypes EC-129126-1, Shiva, RC 781, ZEM-1 and PR-8805 were resistant to the disease. The lowest disease intensity was observed in the controlled environment. Higher disease intensity was found under artificially inoculated environment.

Pathak and Godika (2002) evaluated 27 genotype of rapeseed mustard (*Brassica campestris*) for multiple disease resistance, five genotypes viz., RN 490, RN 505, PBC 9221, PBN 9501 and PBN 9502 were identified resistant against white rust, powdery mildew, Alternaria blight and stem rot.

Khunti *et al.* (2003) conducted field experiment in Sardar Krushi Nagar, Gujrat, India, under artificial inoculation conditions to evaluate for resistance of 284 Indian mustard genotypes to white rust, caused by *A. cruciferarum* (*Albugo candida*). None of the genotypes was found immune, and only 29 were rated as resistant, 54 as moderately resistant, 128 as moderately susceptible, 44 as susceptible and 29 as highly susceptible.

Effect of fungicides and botanicals against white rust in mustard

Bhargava *et al.* (1997) treated seeds of the susceptible mustard cultivar Varuna with mancozeb or metalaxyl and the plants were sprayed with mancozeb, mancozeb + metalaxyl and chlorothalonil once, twice or thrice after sowing. All the treatments significantly reduced leaf infection. Seed treatment with metalaxyl was more effective than with mancozeb.

Pandya *et al.* (2000) reported that four sprays of ridomil MZ (mancozeb + metalaxyl) at 45, 60, 75 and 90 days after sowing in each of three concentrations, viz., 0.5, 0.3 and 0.2% were found significantly superior to the other tested chemicals for the control of white rust leaf (local) and staghead (systemic) infestation. Although the maximum control of the white rust was obtained in the treatment ridomil 0.5% (PDI = 7.17) but it was not significantly superior to the treatment ridomil 0.3% (PDI = 8.8) and ridomil 0.2% (PDI = 10.5). The maximum PDI was obtained in control (49.6%).

Godika *et al.* (2001) evaluated the efficacy of different fungicides, mancozeb, ridomil mz (mancozeb + metalaxyl), captan, rovril (iprodione), Bayleton (triadimefon), and copper oxychloride, against Alternaria blight (*Alternaria brassicae*) and white rust (*Albugo candida*) of Indian mustard. All fungicides significantly controlled both the diseases, but their efficacy varied. Rovral was the most effective in controlling Alternaria blight, mean disease intensity of leaf and pod was 8.75 and 5.6%, respectively. On the other hand, ridomil mz was the most effective in controlling white rust, mean disease

intensity in leaves and staghead were 8.5 and 0.5%, respectively. Yield was highest with Rovral (2.1 t/ha), followed by mancozeb and ridomil mz, each recording a yield of 1.9 t/ha.

Audichya *et al.* (2001) reported that *B. juncea* cv. Pusa bold inflorescence explants infected with *A. candida* (Causal agent of white rust) were treated with extracts from *B. juncea* healthy leaves (5%). The extract induced auto-immune response in the growing callus against *A. candida*.

Khunti *et al.* (2001 b) reported the efficacy of captafol (0.2%), carbendazim (0.025%), chlorothalonil (0.15%), copper oxychloride (0.2%), dinocap (0.025%), fenarimol (0.02%), mancozeb (0.2%), metalaxyl (0.02%), thophanate-methyl (0.03%), tolclofos-methyl (0.05%), tridemorph (0.04%), wettable sulfur (0.2%) and zineb (0.2%) against white rust (*Albugo candida*) of *B. juncea* cv. Varuna at two locations in Gujarat, India during rabi season of 1989-90 (Sardar Krushinagar) and 1990 (Junagadh). All fungicides significantly reduced the incidence of white rust as compared with the control. The lowest disease index (40.50%) and the highest grain yield (7.20 q/ha) at Sardar Krushinagar were obtained with the application of metalaxyl (0.02%). At Junagadh, the lowest disease index (26.6%) and highest grain yield (7.99 q/ha) were also obtained with this treatment.

Singh *et al.* (2002) reported the efficacy of nine fungicides (Bavistin [carbendazim], Deltan [captan], Dithane M-45 [mancozeb], topsin-M [thiophanate-methyl], foltaf [captafol], captaf [captan], fytolan [copper oxychloride], foltaf + fytolan, and captaf + fytolan against white rust [*Albugo candida*] of *Brassica juncea* (cv. Pusa Raya - 45). At their scheduled dosages by spraying them twice at 15 days interval, starting from the appearance of white spots. Bavistin was the most effective followed by Dithane M-45 in controlling the disease and in effecting maximum protection of seed yield.

Meena and Jain (2002) reported that under laboratory conditions, the highest percent disease controls were observed with metalaxyl + mancozeb (100%) and *Azadirachta indica* (100%). Under field conditions, metalaxyl + mancozeb had the highest per cent disease control (61.74%).

Meena *et al.* (2003) reported the efficacy of plant extracts (garlic and *Acacia nilotica*) and different isolates of *Trichoderma viride* in controlling white rust of Indian mustard caused by *Albugo candida* in a field experiment conducted in Rajasthan, India during the rabi seasons of 2000-03. In a separate experiment, the efficacy of different metalaxyl formulations, along with the plant extracts and isolates of *T. viride* in controlling white rust, blight caused by *Alternaria brassicae* and powdery mildew were determined. Application of garlic extract was at par with the application of mancozeb in reducing white rust incidence and number of stagheads per plot and in increasing the seed yield. Application of Apron [metalaxyl] 35 ES at 6 ml/kg + Ridomil Gold [metalaxyl] at 0.25 g/litre resulted in the lowest incidence of white rust, *Alternaria brassicae* and powdery mildew, and highest seed yield and 1000-seed weight.

Yadav (2003) conducted a field experiment on Indian mustard cv. Varuna to determine the efficacy of non-systemic and systemic fungicides including mancozeb against *Alternaria* leaf and pod blight (*Alternaria brassicae*, *Alternaria brassicicola* and *Alternaria raphani*) and white rust (*Albugo candida*). The treatments comprised : ridomil mz (metaxyl + mancozeb) ; indofil M-45 (mancozeb); one spray ridomil MZ + 2 sprays indofil M-45; 2 sprays ridomil Mz , 3 sprays indofil M-45; 3 sprays antracol (propineb), 3 sprays kavach (chlorothalonil), 3 sprays antracol (Propineb), 2 sprays kavach (chlorothalonil), and control (water spray). Pooled data showed that all the fungicidal treatments were significantly superior to the control in reducing leaf or pod infection and in increasing grain yield. Two sprays of ridomil mz at 60 and 80 days after sowing reduced the disease indices of white rust and *Alternaria* blight on the leaves from 62.7 to 17.1% and from 57.3 to 41.8%, respectively, and increased the yield from 1052 (control) to 1842 kg/ha. The highest grain yield (1900 kg/ha) was recorded from antracol treatments.

Meena *et al.* (2004) reported that a minimum leaf wetness period of 6 h was essential for disease initiation. Sucrose solution (0.2%) supported increased zoosporangial germination. Early-and normal-sown crops escaped the disease whereas, late sown crops suffered more under field conditions.

Under detached leaf culture technique, the disease appeared 7-9 days after incubation. The upper surface of young leaves of the host was more prone to infection. Disease intensity in crops sown during the first fortnight of October was less as compared to those sown in mid-November. Leaves treated with metalaxyl + mancozeb did not show any disease development while *Azadiractha indica* leaf extract effectively controlled the disease.

A decorative border with a dashed line and a floral vine pattern with leaves, framing the central text.

Material

and

Methods

CHAPTER - III

MATERIAL AND METHODS

The present section deals with the material and methodology used in the study. The present investigations were carried out during the year 2004-05 at the Zonal Agricultural Research Station, Morena and Plant Pathology Section of Agricultural College, Gwalior (M.P.). The observations of disease for survey were recorded on farmers' fields.

1. Survey of white rust

The survey was made in fifty one randomized selected villages of Morena, Bhind and Gwalior districts in the year 2004-05 for the assessment of white rust intensity of rapeseed-mustard. These districts had rapeseed and mustard as the main oil seed crop. The survey of the disease was conducted using simple random sampling scheme. Block wise list of villages surveyed for white rust is given in Table 3.1.

Table 3.1 : Blockwise list of villages surveyed for white rust (*Albugo candida*).

S. No.	District	Block	Village		
1.	Morena	Morena	Jagtapur	Bicholi	Mungawali
		Joura	Dhamkhan	Mai	Mudawali
		Kalarus	Suzarma	Chodera	Deephara
		Sabalgarh	Kutghan	Tongadeopur	Mangrole
		Porsa	Kaunthar	Bhajpura	Khajurpura
		Ambah	Senthra	Thara	Balkapura
2.	Bhind	Bhind	Bindunpura	Madiayan	Adadpura
		Mehgaon	Kanathar	Baghora	Cheerol
		Gohad	Khaneta	Chimka	Adori
		Lahar	Asvar	Hetampura	Lotanpur
		Ater	Kheri	Hulapura	Pattapura
		Roan	Gorai	Chachai	Birkhadi
3.	Gwalior	Gwalior	Jalalpur	Mau	Jawayar
		Ghatigaon	Dursedi	Maharanpura	Rehat
		Bhitarwar	Eraya	Jujharpur	Nikodi
		Dabra	Bilaua	Rafadpur	Tekanpur
		Morar	Khureri	Badagaon	Sirol



PLATE 2 - A



PLATE 2 - B

A& B - View of survey field.

For the survey three villages from each block of the districts were selected on random basis and from each village three fields were randomly selected. From each selected field 25 plants were randomly selected and observations on leaf were recorded by adapting the following 0-5 scale.

0	-	No symptoms
1	-	1 –10% leaf area infected
2	-	11 – 25% leaf area infected
3	-	26 – 50% leaf area infected
4	-	51 – 75% leaf area infected
5	-	75% and above leaf are infected

The data on the disease incidence was recorded and the per cent staghead (systemic infection) was calculated on the basis of the following formulae :

$$\text{Staghead (\%)} = \frac{\text{Number of twigs infected}}{\text{Total number of twigs}} \times 100$$

2. Assessment of yield losses

Systemic infection of white rust causes considerable losses in the yield of mustard. Hence, in the present study a field experiment was carried out to find out the quantitative losses in the yield due to unit increase in the yield due to unit increase in the staghead per cent. The details of the experiment area as follows :

Design	:	Randomized block design
Replication	:	4
Treatment	:	7 (three fungicides + three botanicals + one untreated check)
Plot size	:	4.8 m × 5m
Plant distance	:	30 cm × 10 cm (population was uniformly maintained by thinning)
		R. R. = 30 cm., P.P. = 10 cm
Variety	:	Varuna
Date of sowing	:	11.12.04
Fertilizer	:	80 kg N, 40 kg P ₂ O ₅ and 20 kg K ₂ O/ha



PLATE 3 - A



PLATE 3 - B

VIEW OF EXPERIMENTAL FIELD

Table 3.2 : Meteorological data* during the crop season.

Month	Date	Temperature °C		Rainfall (mm)	Relative humidity (%)	
		Max.	Mini.		Morning	Evening
Oct. 2004	30 – 6	33.5	22.4	00.00	82.0	55.7
	7 – 13	31.4	19.5	34.00	91.4	71.0
	14 – 20	29.7	15.2	29.50	92.0	62.4
	21 – 27	31.1	15.2	00.00	86.2	64.5
November	28 – 3	29.2	13.2	00.00	81.1	62.5
	4 – 10	28.5	9.5	00.00	80.4	54.0
	11 – 17	29.4	11.0	00.00	83.2	56.1
	18 – 24	30.5	10.0	00.00	78.0	42.7
December	25 – 1	30.00	8.2	00.00	75.5	52.0
	2 – 8	26.7	7.7	00.00	85.5	57.7
	9 – 15	23.5	7.7	00.00	87.5	53.3
	16 – 22	25.0	8.1	00.00	86.7	53.8
	23 – 31	20.3	5.2	00.00	73.8	64.2
Jan. 2005	1 – 7	22.1	4.8	00.00	87.6	59.8
	8 – 14	21.5	3.5	00.00	86.2	51.2
	15 – 21	20.7	5.0	00.00	87.2	55.0
	22 – 28	19.0	3.5	1.5	90.0	59.0
February	29 – 4	20.5	3.7	8.0	86.7	61.0
	5 – 11	26.8	7.0	1.5	73.7	62.1
	12 – 18	26.5	9.8	00.00	83.7	64.2
	19 – 25	23.2	6.5	00.00	76.0	63.3
March	26 – 4	29.2	11.2	0.50	76.8	46.2
	5 – 11	29.5	14.5	01.50	80.1	69.1
	12 – 18	30.7	14.7	00.00	79.8	38.5
	19 – 25	34.5	17.4	00.00	61.5	41.8
	26 – 1	33.7	16.4	00.00	46.8	36.7
April	2 – 8	33.8	17.5	00.00	56.0	37.0

* Source : Meteorological records of ZARS Wazara (Year 2004-05)

Treatment details :

In the present study a field experiment was carried out with seven treatments viz. T₁, T₂,.....,T₇ to find out the quantitative losses in the yield due to unit increase in the staghead per cent.

Where ,

T₁ - First spray of ridomil mz 72 wp 0.25% just after appearance of white rust followed by two sprays of mancozeb 0.2% at 15 days interval.

T₂ – First spray of ridomil mz 72 wp 0.25% followed by two sprays of carbendazim 0.05% + mancozeb 0.2%.

T₃ – First spray of carbendazim 0.05% + mancozeb 0.2% followed by two sprays of mancozeb.

T₄ – Three sprays of neem leaf extract, @ 10% concentration.

T₅ – Three sprays of eucalyptus leaf, extract @ 10% concentration.

T₆ – Three sprays of garlic, extract @ 1% concentration

T₇ – Check (no spray).

Ridomil mz 72 wp (80 gm/ metalaxyl + 640 gm mancozeb per kg formulation)

Staghead per cent was calculated by the following formula :

$$\text{Staghead (\%)} = \frac{\text{Number of malformed twigs}}{\text{Total number of twigs}} \times 100$$

Varying category of staghead incidence along with corresponding yield was recorded for each treatment and thereafter the value of correlation coefficient between these two was worked out. Further, regression equation was developed to predict qualitative yield losses.

3. Evaluation of fungicides and botanicals against white rust in mustard

A trial was conducted with fungicides and botanicals to find out the effective and suitable treatment for the control of disease. The details of the experiment are given below :

Design	:	Randomized block design
Replication	:	4

Treatment	:	7 (three fungicides + three botanicals + one untreated check)
Plot size	:	4.8 m × 5m
Plant distance	:	30 cm × 10 cm (population was uniformly maintained by thinning)
		R. R. = 30 cm., P.P. = 10 cm
Variety	:	Varuna
Date of sowing	:	11.12.04
Fertilizer	:	80 kg N, 40 kg P ₂ O ₅ and 20 kg K ₂ O/ha

Treatment details :

There were seven treatments viz. T₁, T₂,T₇ to find out the effective and suitable treatment for the control of disease in the experiment conducted.

Where ,

T₁ - First spray of ridomil mz 72 wp 0.25% just after appearance of white rust followed by two sprays of mancozeb 0.2% at 15 days interval.

T₂ – First spray of ridomil mz 72 wp 0.25% followed by two sprays of carbendazim 0.05% + mancozeb 0.2%.

T₃ – First spray of carbendazim 0.05% + mancozeb 0.2% followed by two sprays of mancozeb.

T₄ – Three sprays of neem leaf extract @ 10% concentration.

T₅ – Three sprays of eucalyptus leaf extract @ 10% concentration

T₆ – Three sprays of garlic extract @ 1% concentration

T₇ – Check (no spray).

Twenty five plants from each net plot were randomly selected and tagged and observations on leaf infection were recorded on the tagged plants by adopting 0-5 scale. Staghead per cent was recorded on the basis of per cent malformed twigs in the net plot. Yield of each net plot was also recorded separately.

Preparation of botanical extract :

Fresh plant extracts were prepared by grinding the required quantity of leaves (100 g). Before grinding equal quantity of water was added in the respective plant parts (1 : 1 weight / volume basis). The crude extract of leaves was sieved through muslin cloth. These filtered extracts were added @ 10 per cent.

The sprays were applied on 02.02.05 , 16.02.05 and 04.3.05. To see the effects of various spray applications against white rust on leaf, observations were recorded on 15.02.05 (65-70, DAS), 02.3.05 (80-85, DAS) and 17.3.05 (95-100 DAS). In addition, to see the effect on systemic infection, observations were recorded on 02.3.05 (80-85, DAS), 17.3.05 (95-100, DAS) and 27.3.05 (100-110, DAS).

4. Screening of rapeseed mustard lines against white rust under natural and artificial condition

Use of resistant cultivars is the for the control of white rust. In orders to find out the variety resistant against *A. candida* the screening of varieties was done under natural and artificially inoculated condition. The same lot of cultivars was tested in both the conditions.

4.1 Screening under artificial inoculations :

Screening under artificial inoculation was done in plastic pots. Seed of 36 Brassica cultivars were planted in a mixture containing 2/3 sterilized soil and 1/3 farm yard manure in plastic pots in two replications. After emergence, seedlings were thinned to 2-3 plants per pot.

For the preparation of inoculum, sporangia from pustules on fresh leaves infected with *A. candida* were suspended in distilled water in petriplates. Plates were incubated at 10-18°C room temperature during the months of December and January. After 2 hrs microscopic examination was made to make sure that sporangia had germinated and enough zoospores were present in the suspension. This suspension was immediately sprayed over ten days old seedlings with the help of a bottle sprayer. Inoculated



PLATE 4 - A



PLATE 4 - B

- A - Screening of rapeseed-mustard lines (natural condition).
B - Screening of rapeseed-mustard lines (artificial condition).

plants were incubated for three days in the partially water filled tub, covered by plastic sheet to provide maximum humidity for infection. Three days after inoculation the pots were placed outside the tub and were watered regularly. pustules on the inoculated plants appeared 9-14 days after inoculation. Observations were taken by using 0-5 scale.

4.2 Field screening :

Thirty five cultivars were screened in the field by adopting a field screening technique, suggested by Kolte (1986). Test rows were planted singly. After every five test rows, a row of susceptible check (Varuna) was planted.

Other details of the experiment are as follows :

Design	:	Randomized block design
Replication	:	2
Plot size	:	3 m length single row
Plant distance	:	30 cm × 10 cm (population was uniformly maintained by thinning) R. R. = 30 cm.. P.P. = 10 cm
Date of sowing	:	08.12.04
Fertilizer	:	80 kg N, 40 kg P ₂ O ₅ and 20 kg K ₂ O/ha

Leaf infection was recorded as per 0-5 scale and converted into percent disease index. while systemic infection was recorded as per cent twigs malformed.



Results

CHAPTER – IV

RESULTS

1. Survey of white rust

It is apparent from the data in Table 4.1 and Fig. 4.1 that white rust is a very dangerous disease of mustard in the districts of Morena, Bhind and Gwalior.

It was observed in varying proportion in all the surveyed blocks. The intensity of white rust leaf infection was in the range of 24.94 per cent (Sabalgarh block of Morena district) to 37.88 percent (Morena block of Morena district), whereas, the incidence of systemic infection (malformation or staghead percent) was in the range of 3.7 per cent (Gohad block of Bhind district) to 7.4 per cent (Dabra block of Gwalior district). It is evident from the data presented in Table 4.2 that the average intensity of leaf infection was 30.09 per cent while the mean staghead was 5.22 per cent.

The data presented in Table 4.2 and Fig. 4.2. reveal that maximum disease intensity (32.82%) of leaf infection was observed in Bhind district, followed by Morena district (30.63%) and Gwalior district (26.84%). Whereas, the maximum incidence of systemic infection (5.74%) was surveyed in Gwalior district, followed by Bhind district (5.05%) and Morena district (4.86%).

Besides the disease incidence the following observations were also recorded from the surveyed fields.

1. Early sowing i.e., sowing of mustard in the first fortnight of October was commonly adopted by the majority of mustard growers.
2. In most of the surveyed field, farmers sowed their local varieties, while in the rest of the fields Varuna, Pusa bold, Kranti and Rohini were sown.
3. Application of nitrogenous fertilizer was higher in Bhind followed by Morena and Gwalior districts.
4. None of the selected farmers applied potash fertilizer in their fields.
5. Awareness regarding the application of fungicides among the farmers was commonly observed.

6. It is observed that timely sown crop was free from staghead, but in late sown crop, the staghead was seen upto 10 per cent in Morena district generally.
7. In timely sown crop, white rust infection was seen in leaf only.
8. Most of the farmers were not of with balance dose of fertilizers.

Table 4.1 : Block-wise mean incidence of white rust in mustard.

Blocks	Leaf infection (per cent disease index) Mean	Systemic infection (per cent staghead) Mean
District : Morena		
Morena	37.85	5.2
Joura	35.25	4.9
Sabalgarh	22.41	3.9
Kailaras	30.45	5.4
Ambah	27.25	4.5
Porsa	30.62	5.3
District : Bhind		
Bhind	30.21	7.2
Mehgaon	34.93	4.9
Gohad	27.41	3.7
Lahar	35.62	4.8
Atter	37.35	5.4
Roan	31.43	4.3
Gwalior		
District : Gwalior		
Gwalior	26.21	5.3
Dabra	28.34	7.4
Morar	23.56	4.2
Bhitarwar	30.65	6.1
Ghatigaon	25.42	5.7

Table 4.2 : District-wise mean incidence of white rust in mustard.

District	Leaf infection (per cent disease index) Mean	Systemic infection (percent staghead) Mean
Morena	30.63	4.86
Bhind	32.82	5.05
Gwalior	26.84	5.74
Mean	30.09	5.22

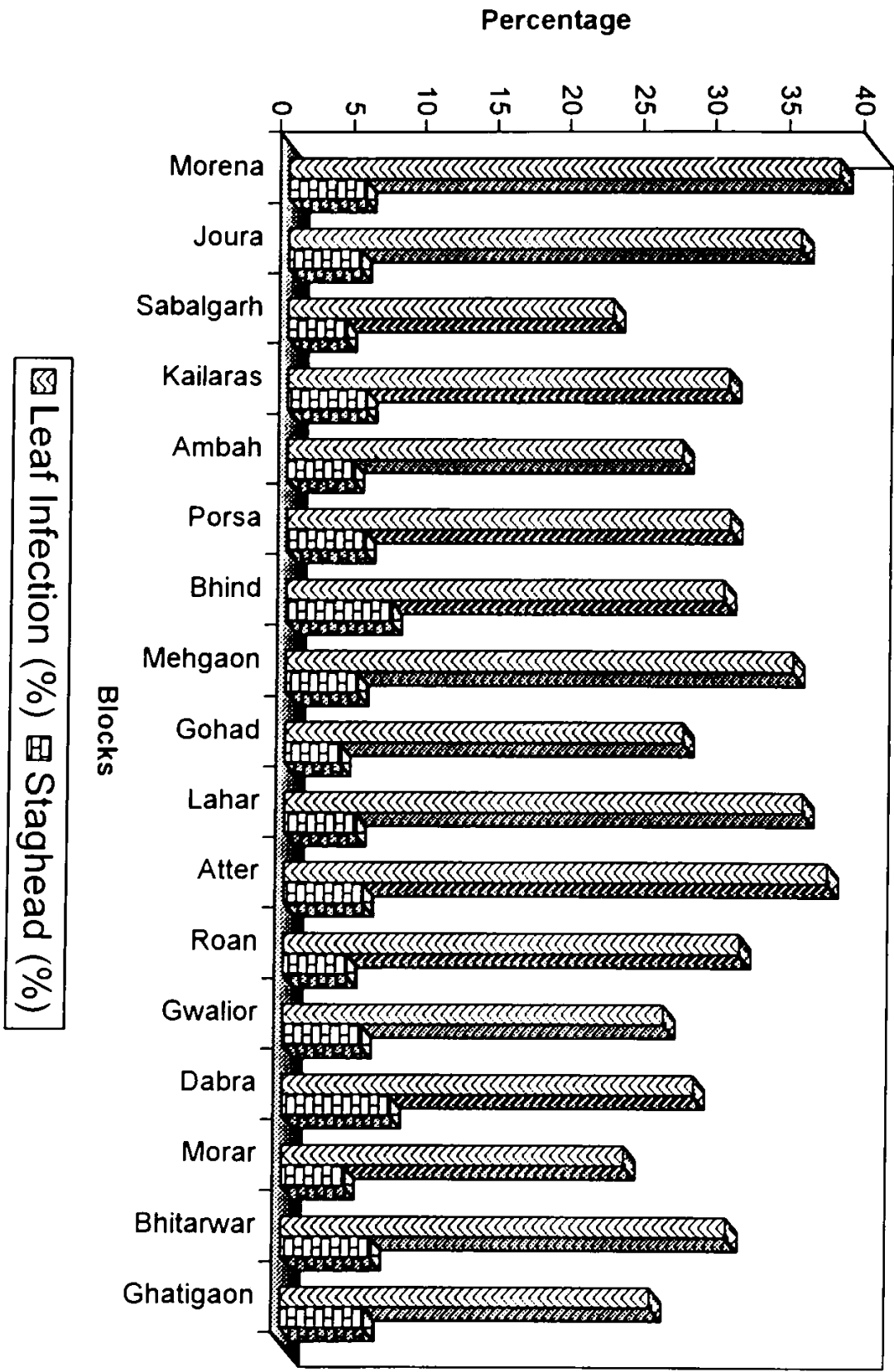
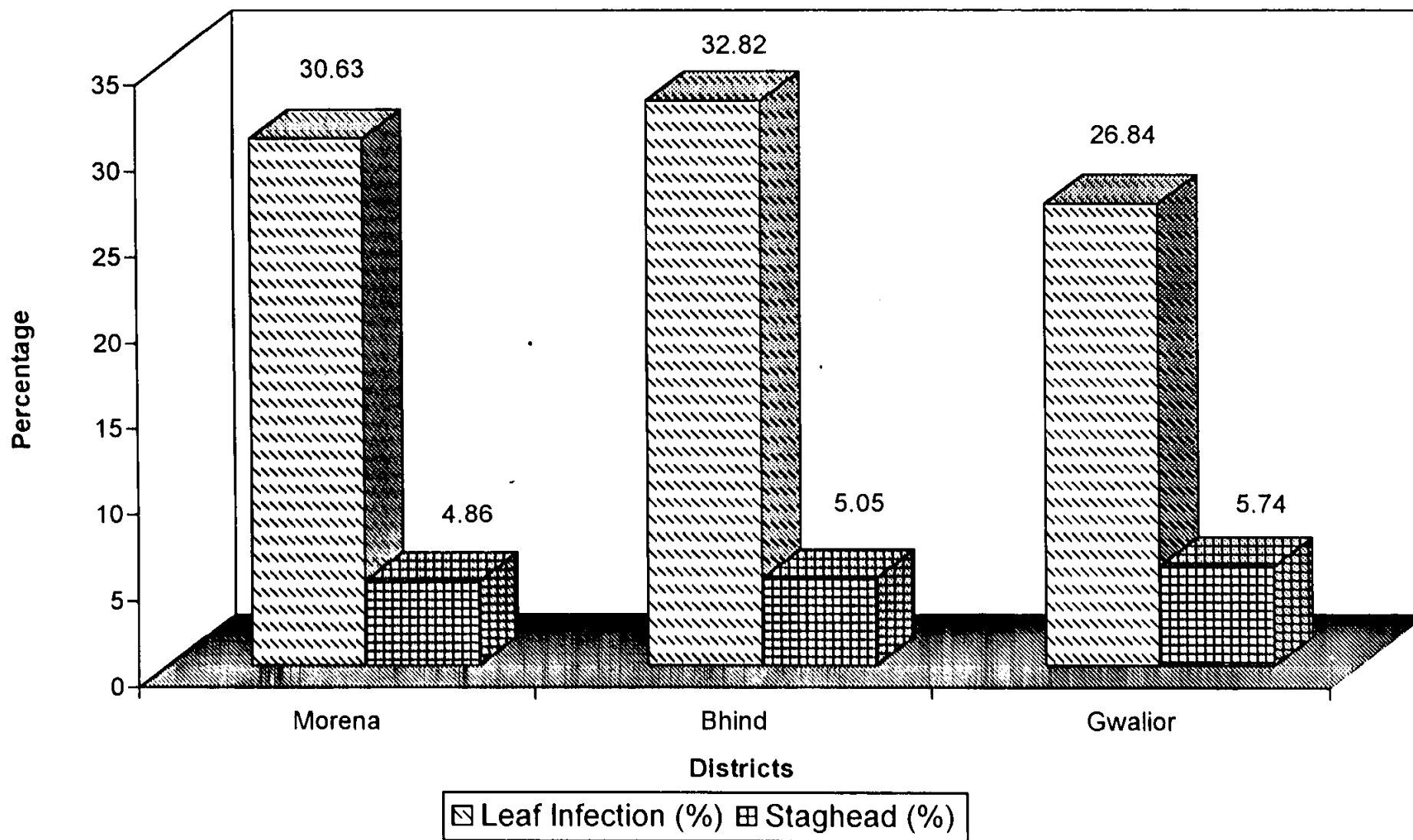


Fig. 4.1 : Block-wise mean incidence of white rust in mustard.

Fig. 4.2 : District-wise mean incidence of white rust in mustard.



2. Loss assessment of yield due to disease

White rust systemic infection (staghead phase) is the most destructive phase of the disease and responsible for heavy yield losses. Hence, a field experiment was conducted to obtain different category of staghead per cent with different spray schedules. In addition to varying incidence of staghead, the corresponding yield was also recorded. The relationship between staghead incidence and corresponding yield was worked out and the data are presented in Table 4.3. A regression equation was also fitted for the prediction of quantitative yield losses due to unit increase in the incidence of staghead. The regression line has been shown in Fig. 4.3 :

A highly significant and negative correlation (-0.9462) was observed between staghead per cent (X) and grain yield (Y). This negative value of correlation indicates that grain yield decreases with corresponding increase in the incidence of stagheads. The fitted regression equation $Y = 1999.26 - 35.26 X$ indicates a decreases of 35.26 kg/ha yield of mustard due to unit increase the incidence of stagehead.

Table 4.3 : Correlation between systemic infection (staghead formation) and yield of mustard var. Varuna.

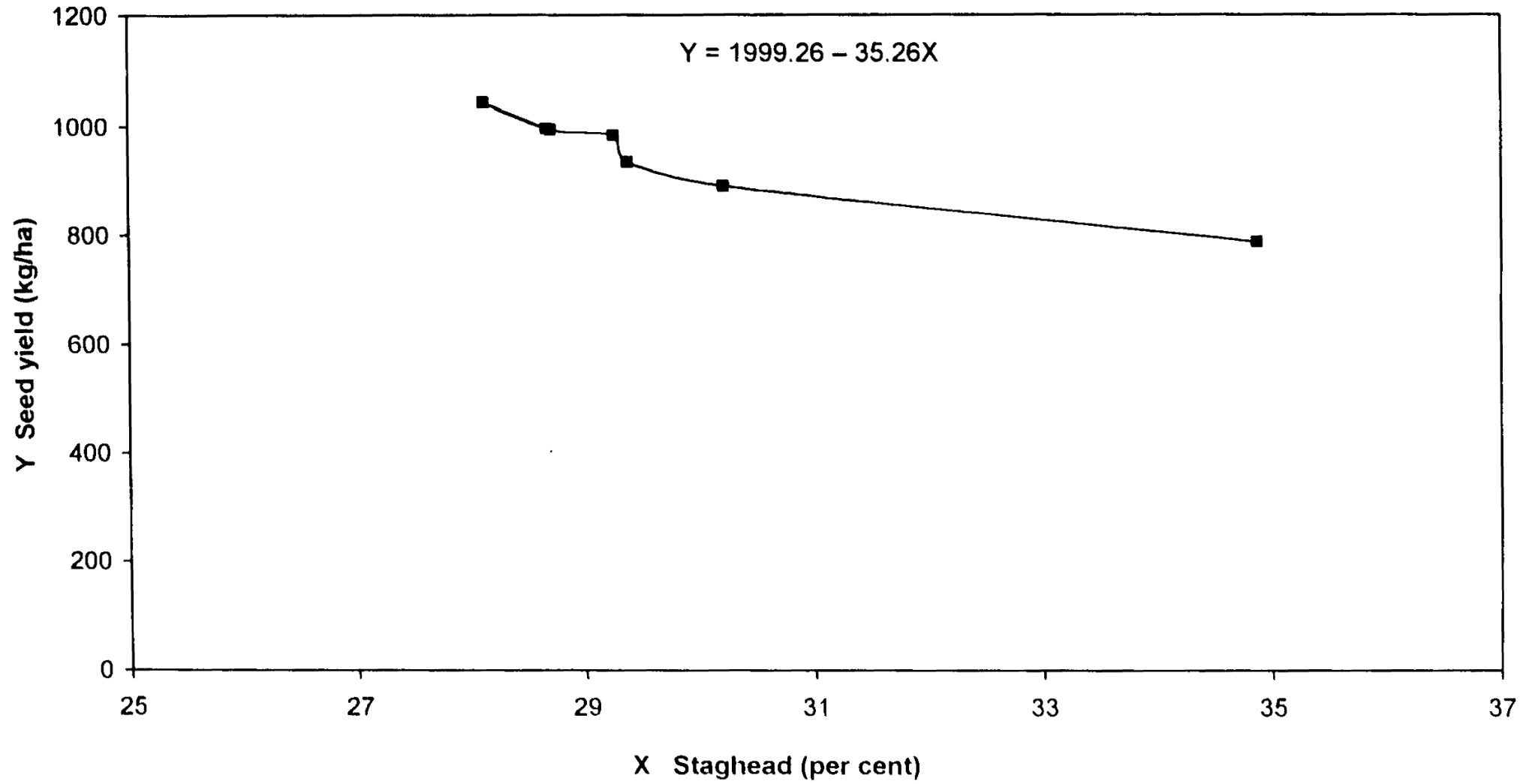
S. No.	Treatments	Staghead (%)	Yield (kg/ha)
1.	T ₁	28.66	995
2.	T ₂	28.11	1042
3.	T ₃	28.70	993
4.	T ₄	29.25	982
5.	T ₅	29.37	933
6.	T ₆	30.21	890
7.	T ₇	34.87	786
Correlation co-efficient (r) :		-0.9462**	
Regression equation of Y on X :		$Y = 1999.26 - 35.26X$	

** Significant at 1%

T₁ - First spray of ridomil mz 72 wp 0.25% just after appearance of white rust followed by two sprays of mancozeb 0.2% at 15 days interval.

T₂ - First spray of ridomil mz 72 wp 0.25% followed by two sprays of carbendazim 0.05% + mancozeb 0.2%.

Fig. 4.3 : Relationship between staghead formation and seed yield of mustard.



- T₃ – First spray of carbendazim 0.05% + mancozeb 0.2% followed by two sprays of mancozeb.
- T₄ – Three sprays of neem leaf extract, @ 10% concentration.
- T₅ – Three sprays of eucalyptus leaf, extract @ 10% concentration.
- T₆ – Three sprays of garlic, extract @ 1% concentration
- T₇ – Check (no spray).

3. Pot screening with artificial inoculation condition

The pot experiment was conducted on 08th Dec., 04. The data exhibited in Table 4.4 reveal that only seven cultivars viz. PBC-2002-2(B), TMB-2005, TMB – 2006, RTM-2002, NPC-14, ONK-1 and JTC-55 were free from leaf infection at both the stage of 75 DAS and 100 DAS. The other cultivars like NDT-03-1, JM 2, JM-WR-946-3-13, ORT (M)-5-2 and JM-1 also performed well under artificial inoculation showing only 0.40, 0.40, 0.80, 2.40 and 2.80 per cent infection respectively at the stage of 75 DAS and 3.20, 5.20, 3.20, 6.40 and 10.80 per cent respectively at the stage of 100 DAS. Sixteen cultivars namely, PBC-2002 – 2(B), TMB-2005, TMB-2006, RTM-2002, NPC-14, ONK-1, JTC-55, NDT-03-1, JM-WR-946-3-13, JM-2, ORT (M)-5-2, JM-1, BAUSM-92-1-1, HYDR-47, RH –204 and LET-17 were significantly superior over susceptible check (Varuna) in respect of leaf infection.

4. Field screening of germplasm of mustard against white rust

The experiment was conducted as ZARS Morena (M.P.) on 17.11.04 for screening of 35 Brassica cultivars against white rust. The severity of white rust on leaves was seen at 75 days after sowing (DAS) and 100 DAS. The data are summarized in Table 4.5

4.1 Severity of white rust on leaves at 75 DAS :

It is evident from Table 4.5 that nine cultivars viz., PBC-2002-2 (B), TMB-2005, TMB-2006, ORT (M)-5-2, RTM-2002, NPC-14, ONK-1, JTC-55 and JM-2 were free from leaf infection under natural condition, while maximum intensity (42.40%) was recorded in LET-17. Fourteen cultivars viz. NDT-03-1, BIO-322-93, PBC-2002-2 (B), TMB-2005, PBR-253, JM-WR-946-3-13, TMB-2006, PBR-253, ORT (M)-5-2, RTM-2002, NPC-14, ONK-1, JTC-55 and JM-2 were significantly superior over susceptible check (Varuna) in respect of leaf infection.

Table 4.4 : Evaluation of *Brassica material* against white rust under artificial inoculation condition.

S. No.	Cultivars	Average disease Sev. on leaf 75 DAS	Average disease Sev. on leaf 100 DAS
1.	NDT-03-1	0.40 (2.57)	3.20 (10.31)
2.	BIO-Q-442-99	8.40 (10.61)	22.80 (27.78)
3.	BIO-322-93	14.40 (16.80)	31.20 (33.95)
4.	PBC-2002-2(B)	0.00 (0.00)	0.00 (0.00)
5.	HUJM-201	17.40 (20.42)	30.00 (32.90)
6.	TMB-2005	0.00 (0.00)	0.00 (0.00)
7.	PBR-253	7.60 (15.96)	18.40 (25.38)
8.	JM-WR-946-3-13	0.80 (3.64)	3.20 (7.33)
9.	TMB-2006	0.00 (0.00)	0.00 (0.00)
10.	RGN-94	12.40 (20.56)	32.00 (34.45)
11.	ORT(M)-5-2	2.40 (6.33)	6.40 (10.48)
12.	RAU RDL-02-01	14.80 (22.61)	24.80 (29.80)
13.	RTM – 2002	0.00 (0.00)	0.00 (0.00)
14.	BAUS M-92-1-1	9.20 (17.56)	12.40 (19.34)
15.	HYPR-47	8.40 (15.98)	17.20 (23.68)
16.	RM-101	11.20 (19.51)	25.60 (30.22)
17.	RGN-101	9.60 (17.99)	22.40 (28.23)
18.	NPC-14	0.00 (0.00)	0.00 (0.00)
19.	NPJ-93	7.20 (15.48)	24.00 (29.08)

20.	CS-611-1-3-5	15.60 (22.97)	28.00 (31.89)
21.	CS-101-4-P ₂	13.20 (21.29)	24.40 (29.51)
22.	SKM-109	14.00 (21.93)	19.20 (25.95)
23.	SKM-139	11.60 (19.85)	22.80 (28.51)
24.	SKM-125	12.40 (20.60)	31.20 (33.90)
25.	SKM-9928	12.00 (20.27)	22.00 (27.97)
26.	RH-204	6.00 (13.99)	15.20 (22.69)
27.	RH-0007	9.20 (17.66)	29.60 (32.66)
28.	BPR-558	13.20 (21.29)	37.20 (37.58)
29.	LET-17	7.60 (15.55)	16.00 (23.03)
30.	ONK-1	0.00 (0.00)	0.00 (0.00)
31.	NRCR-837	17.60 (24.80)	30.80 (34.94)
32.	NRCDR-2	8.00 (16.41)	17.20 (24.47)
33.	JTC-55	0.00 (0.00)	0.00 (0.00)
34.	JM-1	2.80 (6.85)	10.80 (19.04)
35.	JM-2	0.40 (2.57)	5.20 (13.10)
36.	Varuna	6.40 (14.55)	45.60 (42.45)
	SEm (±)	2.68	6.51
	CD (at 5%)	7.70	18.70

Note : Data are the mean of two replications. Data in parentheses are angular transformed values on which statistical analysis is based.

Table 4.5 : Field screening of Brassica material against white rust.

S. No.	Cultivars	Average disease Sev. on leaf (%) 75 DAS	Average disease Sev. on leaf (%) 100 DAS	Average disease Sev. on staghead (%)
1.	NDT-03-1	2.40 (6.33)	2.80 (6.85)	0.00 (0.00)
2.	BIO-Q-442-99	37.60 (37.79)	46.80 (43.16)	0.00 (0.00)
3.	BIO-322-93	2.00 (5.77)	3.20 (7.33)	14.29 (16.17)
4.	PBC-2002-2(B)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
5.	HUJM-201	31.60 (34.20)	41.20 (39.93)	10.00 (13.28)
6.	TMB-2005	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
7.	PBR-253	11.60 (19.69)	24.40 (29.59)	0.00 (0.00)
8.	JM-WR-946-3-13	12.00 (20.27)	16.00 (23.58)	0.00 (0.00)
9.	TMB-2006	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
10.	RGN-94	28.00 (31.95)	34.80 (35.77)	0.00 (0.00)
11.	ORT(M)-5-2	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
12.	RAU RDL-02-01	32.40 (34.68)	45.60 (42.47)	0.00 (0.00)
13.	RTM – 2002	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
14.	BAUS M-92-1-1	25.60 (30.17)	42.40 (40.63)	7.14 (11.11)
15.	HYPR-47	34.60 (32.95)	36.00 (36.80)	8.30 (12.20)
16.	RM-101	38.00 (37.97)	46.00 (42.71)	26.36 (30.83)
17.	RGN-101	32.80 (34.93)	43.60 (41.33)	19.41 (26.04)
18.	NPC-14	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)

19.	NPJ-93	28.40 (32.26)	39.60 (38.97)	8.30 (12.02)
20.	CS-611-1-3-5	33.60 (35.21)	41.60 (40.16)	23.81 (28.73)
21.	CS-101-4-P ₂	39.20 (38.76)	44.40 (41.79)	58.33 (49.88)
22.	SKM-109	32.40 (34.70)	42.80 (40.86)	32.14 (33.57)
23.	SKM-139	36.00 (36.86)	41.60 (40.15)	10.00 (13.28)
24.	SKM-125	37.20 (37.55)	34.00 (35.61)	25.56 (29.35)
25.	SKM-9928	34.40 (35.91)	36.40 (37.10)	0.00 (0.00)
26.	RH-204	26.80 (31.17)	35.20 (36.35)	0.00 (0.00)
27.	RH-0007	26.80 (31.15)	30.80 (33.71)	25.00 (22.50)
28.	BPR-558	38.80 (38.53)	48.80 (44.31)	57.13 (49.19)
29.	LET-17	42.40 (40.61)	39.20 (38.66)	20.19 (26.56)
30.	ONK-1	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
31.	NRCR-837	34.80 (35.82)	48.40 (44.09)	10.00 (13.28)
32.	NRCDR-2	40.40 (39.45)	46.80 (43.17)	0.00 (0.00)
33.	JTC-55	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
34.	JM-2	0.00 (0.00)	6.00 (14.17)	0.00 (0.00)
35.	Varuna	33.70 (35.28)	48.88 (43.86)	33.89 (35.53)
	SEm (\pm)	1.88	2.66	2.16
	CD (at 5%)	5.41	7.64	6.22

Note : Data are the mean of two replications. Data in parentheses are angular transformed values on which statistical analysis is based

4.2 Severity of white rust on leaves at 100 DAS :

The data in Table 4.5 Indicate that eight cultivars viz. PBC-2002-2(B), TMB-2005, TMB-2006, ORT (M)-5-2, RTM-2002, NPC-14, ONK-1, and JTC-55 were free from leaf infection under natural condition, while maximum intensity (48.80%) was recorded in BPR-558. Fifteen entries viz. NDT-03-1, BIO-322-93, PBC-2002-2 (B) , TMB-2005, PBR-253, JM-WR- 946-3-13, TMB-2006, RGN-94, ORT (M)-5-2, RTM-2002, NPC-14, SKM-139, RH-007, ONK-1, JTC- 55, and JM-2 were significantly superior over susceptible check (Varuna) in respect of leaf infection.

4.3 Severity of systemic infection :

The data in Table 4.5 exhibit that eighteen entries viz. NDT-031, BIO-Q-442-99, PBC-2002-2(B), TMB-2005, PBR-253, JM-WR-946-3-13, TMB-2006, RGN-94, ORT (M)-5-2, RAURDL-02-01, RTM-2002, NPC-14, SKM-9928, RH-204, ONK-1, NRCOR-2, JTC-55 and JM-2 were free from systemic infection, maximum percentage of staghead (58.33%) was seen in CS-101-4-P₂ followed by BPR-558 (57.13%). All the entries except RM-101, CS-101-4-P₂, SKM-109, SKM-125 and BPR-558, were observed significantly superior over check (Varuna).

5. Evaluation of fungicides and botanicals against white rust in mustard

5.1 Effect of white rust on leaf :

After first spray application, observations were recorded at (65-70) DAS. It is depicted in the Table 4.6 that at (65-70) DAS, the minimum intensity of white rust on leaf (17.4%) was recorded in treatment T₂ (first spray of ridomil mz 72 wp 0.25% followed by two sprays of carbendazim 0.05% + mancozeb 0.2%), but it was at par with the other treatments except treatment T₇ (no spray).

After second spray application, observations were recorded at (80-85) DAS, the minimum intensity of white rust on leaf (23.4%) was noticed in treatment T₂, followed by T₁ and T₃. Among the botanicals, treatment T₄ (three sprays of neem leaf extract) was superior. Although, all the treatments except T₇, were at par with T₂.

After third spray application, observations were recorded at (95-100) Das. All the treatments except T₆ (three sprays of garlic extract), were

found statistically superior over check (no spray). The maximum intensity of white rust on leaf (20.4%) was seen in T₂, followed by T₁ (23.2%) and T₃ (23.8%). Among botanicals T₄ (27.6%) was observed superior.

Table 4.6 : Effect of various spray schedules on the intensity of white rust and yield of mustard (Varuna).

Treatments	Effect on leaf infection (per cent)			Effect on systemic infection (per cent)			Effect on yield (kg/ha)
	(65-70) DAS	(80-85) DAS	(95-100) DAS	(80-85) DAS	(95-100) DAS	(100-110) DAS	
T ₁	19.20 (25.60)	25.6 (30.29)	23.20 (28.26)	21.1 (28.04)	20.10 (26.57)	23.05 (28.66)	995
T ₂	17.4 (24.31)	23.4 (28.83)	20.40 (26.55)	12.58 (20.79)	17.53 (24.74)	19.43 (28.11)	1042
T ₃	19.38 (25.96)	26.5 (30.40)	23.80 (29.09)	23.08 (28.73)	21.50 (27.61)	23.10 (28.70)	993
T ₄	19.60 (26.18)	27.38 (31.30)	27.60 (31.35)	24.68 (29.80)	21.93 (27.91)	22.05 (27.91)	982
T ₅	21.40 (27.48)	29.6 (32.75)	28.20 (31.70)	25.43 (30.25)	23.05 (28.66)	24.13 (29.37)	933
T ₆	24.75 (29.81)	30.8 (33.67)	32.00 (34.33)	25.68 (30.46)	24.63 (29.75)	25.43 (30.21)	890
T ₇	24.86 (35.43)	42.6 (40.74)	44.60 (41.90)	36.2 (36.99)	28.75 (32.40)	32.78 (34.87)	786
SEm (±)	1.978	2.251	2.817	2.679	0.767	1.181	48.72
CD (at 5%)	5.87	6.689	8.371	7.96	2.281	3.511	144.75

Note : Data are the mean of four replications. Data in parenthesis are angular transformed values on which the statistical analysis is based.

5.2 Effect on systemic infection (staghead) :

The formation of staghead was recorded at (80-85) DAS, (95 -100) DAS and (100-110) DAS. The data are summarized in Table 4.6.

It is evident from the data in Table 4.6 that at the stage of 80-85 DAS, the first three treatments (fungitoxicants) T₁, T₂ and T₃ were significantly superior to the treatment T₇ (Check). The minimum intensity of systemic infection was observed in T₂ (12.58%), followed by T₁ (21.1%) and T₃ (23.08%). Botanical treatments were not found statistically superior to treatment T₇ (Check). However, among botanicals T₄ (24.68%) was superior.

The data in Table 4.6 indicate that at the stage 95-100 DAS, all the treatments i.e. fungitoxicants and botanicals, were significantly superior to treatment T₇ (Check). All the fungitoxicants and botanicals were at par regarding systemic infection (staged). However, the minimum intensity of systemic infection was reported in T₂ (17.53%) followed by T₁ (20.10%). Among botanicals, treatment T₄ (21.93%) was superior.

The data in Table 4.6 reveal that at the stage 100-110 DAS, all the treatments were significantly superior to treatment T₇ (Check). All the six spray schedules were similarly effective statistically. However, the minimum intensity of systemic infection (staghead) was observed in T₂ (19.43%), followed by T₁ (22.05%) and T₃ (23.05%). Among botanicals T₄ (23.10%) was superior.

5.3 Effect on yield :

The data in Table 4.6 indicate that all the six spray schedules except T₆ (three sprays of garlic extract) increased the yield of mustard significantly. The maximum yield was recorded in T₂ (1042 kg/ha), followed by T₁ (995 kg/ha) and T₃ (993 kg/ha). However, treatments T₂, T₁, T₃, T₄ and T₅ were at par in relation to the yield of mustard. The treatment T₆ (890 kg/ha) was at par with check treatment (786 kg/ha). Among botanicals, higher yield was recorded in T₄ (982 kg/ha). Due to late sowing, the yield of mustard was low.

A decorative border with a repeating floral and vine pattern, featuring small leaves and scrolls, framing the central text.

Discussion

CHAPTER – V

DISCUSSION

An attempt has been made in this chapter to explain the experimental finding with possible reasons in the light of the literature available on different aspects under study.

1. Survey of white rust

In the present investigation seventeen blocks of Morena, Gwalior and Bhind districts of Madhya Pradesh, Gwalior and Bhind districts of Madhya Pradesh, were surveyed to assess the intensity of white rust on farmers' field. The intensity of white rust leaf infection ranged from 24.94 per cent (Sabalgarh block of Morena district) to 37.85 per cent (Morena block of Morena district). Whereas, the incidence of systemic infection (staghead) was in the range of 3.7 per cent (Gohad block of Bhind district) on the basis of average incidence of white rust in mustard. Maximum intensity of leaf infection (32.82%) was observed in Bhind district, followed by Morena district (30.63%) and Gwalior district (26.84%). The staghead incidence was maximum in Gwalior district (5.74%), followed by Bhind district (5.05%) and Morena district (4.86%). The said variation in leaf infection and staghead incidence in the above district might be due to various factors viz. high plant population, host susceptibility, heavy nitrogen doses, contiguous area under monoculture, sowing time or prevailing environmental condition.

Pandya (1996) and Ghasolia *et al.* (2004) also reported that disease appeared in varying proportion on rapeseed-mustard crop in India.

2. Loss assessment

In the present study, a relationship between staghead incidence and yield was worked out. A highly significant and negative correlation (-0.9462) was found between staghead percent (x) and grain yield (y). This negative correlation indicates that grain yield decreases with the increase in incidence of staghead. The fitted regression equation $y = 1999.26 - 35.26x$ indicates a decrease of 35.26 kg/ha grain yield of mustard due to unit increase in the incidence of staghead.

Bisht *et al.* (1994) also tested 11 genotypes of *B. juncea* and found that yield loss due to staghead varied from 2.4 to 28.6 per cent depending upon the incidence of staghead.

3. Pot screening with artificial inoculation condition against white rust

The experiment was conducted with thirty six Brassica cultivars. Seven cultivars viz. PBC-2002-2(B), TMB-2005, TMB-2006, TRM-2002, NPC-14, ONK-1 and JTC-55 were observed free from leaf infection at both the stages of 75 DAS and 100 Das. The other cultivars like NDT-031, JM-2, JM-WR-946-3-13, ORT (M)-5-2 and JM-1 also performed well under artificial inoculation. Sixteen cultivars viz. PBC-2002- 2 (B), TMB-2005, TMB-2006, RTM-2002, NPC-14, ONK-1, JTC-55, NDT-031, JM-WR-946-3-13, JM-2, ORT(M)-5-2, JM-1, BAUSM-92-1-1, HYDR-47, RH-204 and LET-17 were significantly superior over susceptible check (Varuna) in respect of leaf infection.

Earlier Gupta *et al.* (2001), Gupta *et al.* (2002) and Khunti *et al.* (2003) also identified some resistant lines of mustard but still there is need to identify some stable white rust resistant sources which can be incorporated into promising lines to evolve agronomically superior varieties.

4. Field screening of germplasm of mustard against white rust

The experiment was conducted with 35 Brassica cultivars for screening against white rust. Out of these cultivars, eight cultivars viz., PBC-2002-2(B), eight cultivars viz. PBC-2002-2(B), TMB-2005, TMB-2006, ORT (M)-5-2, RTM-2002, NPC-14, ONK-1 and JTC-55 were free from leaf infection at the stages of 75 DAS and 100 DAS under natural condition. Fifteen entries viz. NDT-031, BIO-322-93, PBC-2002-2 (B) , TMB-2005, PBR-253, JM-WR-946-3-13, TMB-2006, RGN-94, ORT (M)-5-2, RTM-2002, NPC-14, SKM-139, RH-007, ONK-1, JTC-55, and JM-2 were significantly superior over susceptible check (Varuna) in respect of leaf infection.

Eighteen entries viz. NDT-03-1, BIO-Q-442-99, PBC-2002-2(B), TMB-2005, PBR-253, JM-WR-946-3-13, TMB-2006, RGN-94, ORT(M)-5-2, RAUROL-02-01, RTM-2002, NPC-14, SKM-9928, RH-204, ONK-1, NRCDR-2, JTC-55 and JM-2 were free from systemic infection. All the entries except RM-101, CS-101-4-P₂, SKM-109, SKM-125 and BPR-558, were observed significantly superior over check (Varuna).

Malik (1989), Thiyagarajan (1994), Yadav *et al.* (1999), Velazhahan and Pathak and Godika (2002) also identified some resistant lines of mustard under natural field condition.

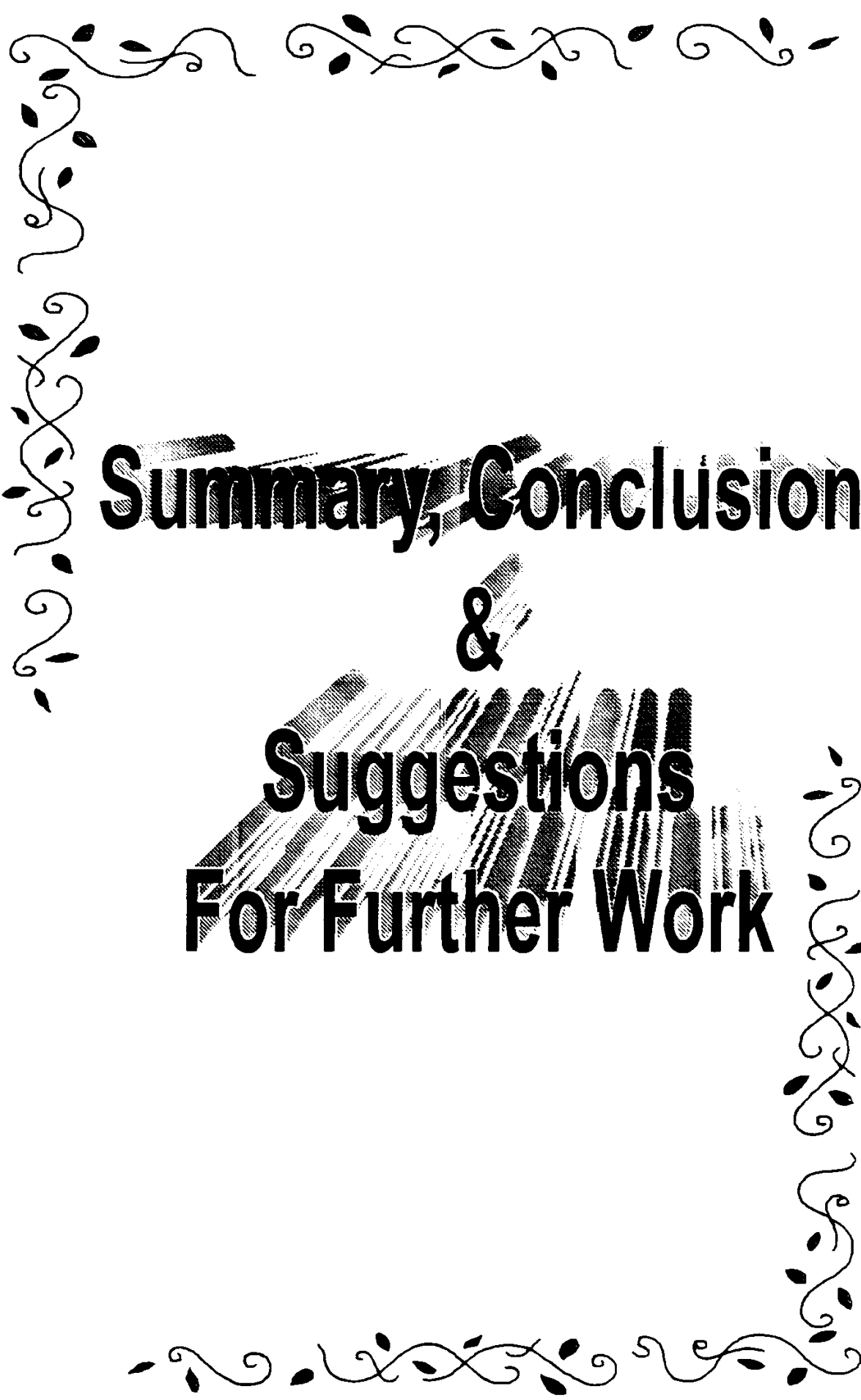
5. Evaluation of fungicides and botanicals against white rust in rapeseed-mustard

In the present study, seven treatments i.e. Three fungicidal spray schedules, three botanical spray schedules and one check (no spray) were evaluated against the occurrence of white rust of leaf and systemic infection. All the six tested spray schedules reduced the white rust of leaf and systemic infection (staghead) and also increased the grain yield. After first, second and third spray applications, minimum intensity of white rust on leaf was recorded in treatment T₂ (First spray of ridomil mz 72 wp 0.25% followed by two sprays of carbendazim 0.05% + mancozeb 0.2%), followed by T₁ (First spray of ridomil mz 72 wp 0.25% just after appearance of white rust followed by two sprays of mancozeb 0.2% at 15 days interval), and T₃ (First spray of carbendazim 0.05% + mancozeb 0.2% followed by two sprays of mancozeb). Among the botanicals, treatment T₄ (Three sprays of neem leaf extract) was observed superior.

All the six spray schedules were significantly superior to treatment T₇ (Check) regarding systemic infection (staghead). However, the minimum intensity of systemic infection (staghead) was recorded in T₂ (first spray of ridomil mz 72wp 0.25% followed by two sprays of carbendazim 0.05% + mancozeb 0.2%), followed by T₁ (first spray of ridomil mz 72 wp 0.25% just after appearance of white rust followed by two sprays of mancozeb 0.2% at 15 days interval) and T₃ (first spray of carbendazim 0.05% + mancozeb 0.2% followed by two sprays of mancozeb). Among the botanicals, treatment T₄ (three sprays of neem leaf extract) was observed superior.

All the six spray schedules except T₆ (three sprays of garlic extract) increased the grain yield of mustard significantly. The maximum yield was recorded in T₂ (1042 kg/ha), followed by T₁ (995 kg/ha) and T₂ (993 kg/ha). Whereas, minimum yield was recorded in control treatment (786 kg/ha). Among botanicals higher yield was recorded in T₄ (982 kg/ha). Due to late sowing, the yield of mustard was recorded low.

The present finding is supported with those of Khunti *et al.* (2001 b), Godika and Pathak (2002) and Meena *et al.* (2003) who reported an effective control of white rust with the foliar application of ridomil. An effective control of neem leaf extract was reported by Meena *et al.* (2004).

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**Summary, Conclusion
&
Suggestions
For Further Work**

CHAPTER – VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

1. Summary

Rapeseed and mustard are the major rabi oilseed crops in India. They occupy a prominent place being important next to groundnut. These crops are grown both in subtropical and tropical countries. India occupies the first position with regards to acreage and production of rapeseed and mustard in the world.

The pathogen (*A. candida*) produces two types of infection, i.e. general or systemic and local. Local infection are manifested by scattered zoosporangial pustules on the under surfaces of leaves, and on stems or pod blisters containing oospores. The symptoms of general or systemic infection are distortion, hypertrophy, hyperplasia, sterility of inflorescences (stagheads). Yield loss is greater from systemic than local infections.

The present investigation on white rust was proposed with following objectives :

- (6) Survey of white rust disease in Morena, Bhind and Gwalior district.
- (7) Study of yield losses due to the disease.
- (8) Pot screening of rapeseed-mustard lines against white rust under artificial inoculation condition.
- (9) Field screening of germplasm of mustard against white rust.
- (10) Evaluation of fungicides and botanicals against white rust in mustard.

To assess the intensity of white rust on farmer's field, the present study was carried out by surveying 17 blocks of Morena, Gwalior and Bhind districts. The intensity of white rust leaf infection ranged from 24.94 per cent (Sabalgarh block of Morena district) to 37.87 per cent (Morena block of Morena district). Whereas, the incidence of systemic infection (staghead) was in the range of 3.7 per cent (Gohad block of Bhind district) to 7.4 per cent (Dabra block of Gwalior district).

A highly significant and negative correlation (-0.9462) was found between staghead percent (x) and grain yield (y). This negative correlation indicates that grain yield decreases with the increase in incidence of staghead. The fitted regression equation $y = 1999.26 - 35.26 x$ indicates a decrease of 35.26 kg/ha grain yield of mustard due to unit increase in the incidence of staghead.

Out of the thirty six cultivars of rapeseed-mustard, seven cultivars viz. PBC-2002-2(B), TMB-2005, TMB-2006, RTM-2002, NPC-14, ONK-1, and JTC-55 were observed free from white rust leaf and staghead infection under natural as well as artificial inoculation. This indicates that these are the useful donor parents for white rust resistant crop breeding programme.

All the fungicidal and botanical schedules except three sprays of garlic extract, were statistically superior over untreated check (no spray). The minimum intensity of white rust on leaf (20.4%) was seen in first spray of ridomil mz 72 wp 0.25% followed by two sprays of carbendazim 0.05% + mancozeb 0.2%. Among botanicals three sprays of neem leaf extract was observed superior to other botanicals. All the six spray schedules were significantly superior to treatment in relation to reduction of systemic infection. However, the minimum intensity of systemic infection (staghead) was observed in first spray of ridomil mz 72 wp 0.25% followed by two sprays of carbendazim 0.05% + mancozeb 0.2%. (19.43%). Among botanicals, three sprays of neem leaf extract. (23.10%) was superior to other botanicals.

2. Conclusion

On the basis of the findings of the study, the following conclusions were drawn :

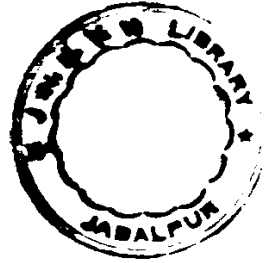
1. In the areas of Morena, Gwalior and Bhind districts, white rust is a major disease of mustard (*B. juncea*) which appears to affect the crop throughout the region in varying proportions.
2. Considerable variations in the expression of external symptoms were observed in local and in systemic infection.
3. A loss of 35.26 kg ha⁻¹ in grain yield was estimated due to unit increase percent in the staghead incidence.

4. The minimum incidence of white rust was recorded with first spray of ridomil mz 72 wp 0.25% just after appearance of white rust followed by two sprays of mancozeb 0.2% at 15 days interval.
5. Seven cultivars viz. PBC-2002-2(B), TMB-2005, TMB-2006, RTM-2002, NPC-14, ONK-1, and JTC-55 were free from white rust under natural and artificial inoculation conditions.

3. Suggestions for further work

In view of this investigation, following points are suggested for further research work.

- (1) The study was confined to Morena, Gwalior and Bhind districts. Similar studies may be undertaken to cover other districts of the state to confirm the findings of this study and usefulness in those region.
- (2) Similar studies should be conducted with a larger sample of villages in the blocks for good representation point of view.
- (3) In Northern Madhya Pradesh, white rust is a very destructive disease of rapeseed-mustard, hence there is a need to test a large number of agronomically superior Indian mustard cultivars on artificially inoculated condition.
- (4) The white rust can be controlled by the application of fungicides but these are hazardous to human being. Whereas, botanicals are very safe and eco-friendly, hence there is a need to test large number of botanicals against the disease as an alternative source for the management of the disease.



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A decorative border with a repeating floral and vine pattern, featuring small leaves and scrolls, framing the central text.

Appendix

APPENDIX

Effect of fungicidal and botanical schedules on the intensity of white
rust on leaf at (65 - 70) DAS

S. No.	R-I	R-II	R-III	R-IV	Mean
1	15.4 (18.81)	14.4 (22.30)	25.4 (30.92)	25.5 (30.45)	19.25 (25.50)
2	15.0 (23.58)	8.8 (17.25)	24.8 (29.87)	25.0 (29.56)	17.4 (24.31)
3	24.7 (29.30)	14.4 (22.30)	15.2 (22.95)	23.2 (28.79)	19.38 (25.96)
4	24.0 (29.33)	25.8 (27.13)	19.2 (25.99)	14.4 (22.30)	19.50 (25.18)
5	24.8 (29.87)	18.8 (24.20)	19.2 (25.99)	24.8 (29.87)	21.40 (27.48)
6	23.2 (28.79)	27.8 (31.82)	24.8 (29.87)	23.2 (28.79)	24.75 (29.81)
7	35.0 (36.87)	21.8 (27.83)	35.0 (36.87)	41.8 (45.18)	24.38 (35.43)
	SE _r (±)		1.875		
	CD (5%)		5.87		

Note : Data in Parentheses are angular transformed values on which
statistical analysis is based.

**Effect of fungicidal and botanical schedules on the intensity of white
rust on leaf at (80 - 85) DAS**

S. No.	R-I	R-II	R-III	R-IV	Mean
1.	19.2 (25.99)	24.8 (29.87)	25.6 (30.40)	32.8 (34.90)	25.6 (30.29)
2.	17.6 (24.80)	25.6 (30.40)	28.8 (32.46)	21.6 (27.69)	23.4 (28.83)
3.	37.6 (37.82)	16.0 (23.58)	24.4 (28.25)	28.0 (31.95)	26.5 (30.40)
4.	42.40 (40.63)	18.4 (25.40)	24.0 (29.33)	24.7 (29.87)	27.38 (31.30)
5.	44.8 (42.02)	25.6 (30.40)	26.4 (30.92)	21.6 (27.69)	29.6 (32.75)
6.	32.0 (34.45)	29.6 (32.96)	36.0 (36.87)	25.6 (30.40)	30.8 (33.67)
7.	45.6 (42.48)	43.2 (41.09)	40.8 (39.70)	40.8 (39.70)	42.6 (40.74)
	SEm (\pm)		2.251		
	CD (5%)		6.689		

Note : Data in Parentheses are angular transformed values on which statistical analysis is based

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**Effect of fungicidal and botanical schedules on the intensity of white
rust on leaf at (95 - 100) DAS**

S. No.	R-I	R-II	R-III	R-IV	Mean
1.	36.00 (36.87)	22.40 (28.25)	24.80 (29.87)	9.60 (18.05)	23.20 (28.26)
2.	12.80 (20.96)	18.40 (25.40)	32.00 (34.45)	18.40 (25.40)	20.40 (26.55)
3.	16.80 (24.20)	26.40 (30.92)	28.8 (32.46)	23.2 (28.79)	23.80 (29.09)
4.	41.6 (40.16)	17.6 (24.80)	32.0 (34.45)	19.2 (25.99)	27.60 (31.35)
5.	14.4 (22.30)	32.0 (34.45)	34.4 (35.91)	32.0 (34.45)	28.20 (31.70)
6.	22.4 (28.25)	30.4 (33.46)	36.8 (37.35)	38.4 (38.29)	32.00 (34.33)
7.	44.8 (42.02)	51.2 (45.69)	45.6 (42.48)	36.8 (37.35)	44.60 (41.90)
	SEm (\pm)		2.817		
	CD (5%)		8.371		

Note : Data in Parentheses are angular transformed values on which statistical analysis is based.

Effect of fungicidal and botanical schedules on the intensity of white rust on systemic infection (staghead) (80 - 85) DAS

S. No.	R-I	R-II	R-III	R-IV	Mean
1.	22.2 (28.11)	22.2 (28.11)	20.0 (26.56)	20.0 (26.56)	21.1 (28.04)
2.	14.2 (22.14)	21.9 (27.90)	14.2 (22.14)	0.00 (0.00)	12.58 (20.79)
3.	19.0 (25.84)	23.3 (28.86)	25.0 (30.00)	25.0 (30.00)	23.08 (28.73)
4.	20.0 (26.56)	33.7 (35.49)	25.0 (30.00)	20.0 (26.56)	24.68 (29.80)
5.	29.6 (32.96)	23.87 (29.13)	23.0 (28.66)	25.4 (30.26)	25.43 (30.25)
6.	22.2 (28.11)	22.2 (28.11)	33.3 (35.24)	25.0 (30.00)	25.68 (30.46)
7.	36.0 (36.87)	38.8 (38.53)	30.0 (33.21)	40.0 (39.23)	36.2 (36.99)
	SEm (\pm)		2.679		
	CD (5%)		7.96		

Note : Data in Parentheses are angular transformed values on which statistical analysis is based

Effect of fungicidal and botanical schedules on the intensity of white rust on systemic infection (staghead) (95-100) DAS

S. No.	R-I	R-II	R-III	R-IV	Mean
1.	18.8 (25.70)	16.6 (24.04)	25.0 (30.00)	20.0 (26.56)	20.10 (26.57)
2.	16.6 (24.04)	18.8 (25.70)	16.6 (24.04)	18.1 (25.18)	17.53 (24.74)
3.	20.0 (26.56)	22.0 (27.97)	23.0 (28.66)	21.0 (27.28)	21.50 (27.61)
4.	23.0 (28.66)	21.7 (27.76)	23.0 (28.66)	20.0 (26.56)	21.93 (27.91)
5.	25.0 (30.00)	22.2 (28.11)	20.0 (26.56)	25.0 (30.00)	23.05 (28.66)
6.	25.0 (30.00)	23.5 (29.00)	25.0 (30.00)	25.0 (30.00)	24.63 (29.75)
7.	28.5 (32.27)	31.5 (34.14)	30.0 (33.21)	25.00 (30.00)	28.75 (32.40)
	SEm (\pm)		0.767		
	CD (5%)		2.281		

Note : Data in Parentheses are angular transformed values on which statistical analysis is based.

Effect of fungicidal and botanical schedules on the intensity of white rust on systemic infection (staghead) (100-110) DAS

S. No.	R-I	R-II	R-III	R-IV	Mean
1.	25.0 (30.00)	22.2 (28.11)	20.0 (26.56)	25.0 (30.00)	23.05 (28.66)
2.	23.0 (28.66)	16.6 (24.04)	20.0 (26.56)	18.1 (25.18)	19.43 (28.11)
3.	22.2 (28.11)	22.2 (28.11)	21.4 (27.56)	26.6 (31.05)	23.10 (28.70)
4.	20.0 (26.56)	16.6 (24.04)	26.6 (31.05)	25.0 (30.00)	22.05 (27.91)
5.	28.5 (32.27)	23.0 (28.66)	25.0 (30.00)	20.0 (26.56)	24.13 (29.37)
6.	20.0 (26.56)	26.0 (30.66)	25.0 (30.00)	30.7 (33.65)	25.43 (30.21)
7.	26.6 (31.05)	36.3 (37.05)	30.7 (33.65)	37.5 (37.76)	32.78 (34.87)
	SEm (±)		1.181		
	CD (5%)		3.511		

Note : Data in Parentheses are angular transformed values on which statistical analysis is based

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ACADEMIC QUALIFICATION

Examination Passed	Name of Board/ University	Years of Passing	Division	Percentage
Higher Sec.	M.P. Board Bhopal	1997	I st	60%
B.Sc. (Ag.)	JNKVV, Jabalpur	2003	I st	OGPA 6.91
M.Sc. (Ag.)	JNKVV, Jabalpur	2005	I st	6.7 (Aprox.) out of 10 point scale about 67%

Other Qualification : One year computer course:

Place : Gwalior

Date : 19/12/2005


(Govind Verma)