INVESTIGATIONS ON WHITE MUSCARDINE DISEASE DUE TO *Beauveria bassiana* (Bals.) Vuill, ON MULBERRY SILKWORM, *Bombyx mori* Linnaeus

Thesis submitted in part fulfilment of the requirements for the award of MASTER OF SCIENCE IN SERICULTURE to the Tamil Nadu Agricultural University

Coimbatore 641 003

BY

RANGASWAMY, B.Sc.(Seri.)

I.D.No. 93-627-008

DEPARTMENT OF SERICULTURE

CENTRE FOR PLANT PROTECTION STUDIES

TAMIL NADU AGRICULTURAL UNIVERSITY

COIMBATORE 641 003

1996

CERTIFICATE

This is to certify that the thesis entitled "INVESTIGATIONS ON WHITE MUSCARDINE DISEASE DUE TO Beauveria bassiana (Bals) Vuill. ON MULBERRY SILKWORM, Bombyx mori Linnaeus" submitted in part fulfilment of the requirements for the award of the degree of **MASTER OF SCIENCE IN SERICULTURE**, to the Tamil Nadu Agricultural University, Coimbatore is a bona fide record of the work carried out by **RANGASWAMY** under my supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or other similar titles and that the work has not been published in part or full in any scientific or popular journal or magazine.

Place: Coimbatore -3.

Date : 31-10-96

P.C. Sundara Babu

(Dr. P.C. SUNDARA BABU)

APPROVED BY

Chairman: P.C. Sundara Babu 17/12/96

(Dr.P.C.SUNDARA BABU)

Members:

N. Chandramohan

(Dr.N.CHANDRAMOHAN)

(Dr.SABITHA DURAISAMY)

EXTERNAL EXAMINER

Date: 17/12/1996

AFFECTIONATELY DEDICATED TO

MY BELOVED PARENTS

ABSTRACT

ABSTRACT

INVESTIGATIONS ON WHITE MUSCARDINE DISEASE DUE TO Beauveria bassiana (Bals.) Vuill. ON MULBERRY SILKWORM, Bombyx mori Linnaeus

By

RANGASWAMY

Degree : Master of Science (Sericulture)

Chairman: Dr.P.C.SUNDARA BABU
Professor of Entomology
Tamil Nadu Agricultural University
Coimbatore 641 003
1996

Investigations on white muscardine disease due to Beauveria bassiana (Bals.) Vuill. on mulberry silkworm, Bombyx mori L. were carried out. Field survey was conducted to know the occurrence of the muscardine disease caused by B.bassiana in Dharmapuri, Salem and Coimbatore districts of Tamil Nadu. Laboratory experiments were conducted to study the relative susceptibility of five silkworm races viz., Kalimpong A (KA), NB_{18}, NB_4D_2, Pure Mysore and Tamil Nadu White (TW). Experiments were taken up to assess the management practices for the white muscardine disease.

The prevalence of white muscardine disease in the districts of Dharmapuri, Salem and Coimbatore, was very low ranging from 0.00 to 4.00 per cent. Among the different races,

the bivoltine was more susceptible to B.bassiana at all the four spore loads (10^6, 10^7, 10^8 and 10^9) in third, fourth and fifth instars. Among the bivoltine races, the susceptibility was KA > NB_4D_2 > NB_{18}. In multivoltine it was TN > PM. Among the instars, fifth instar was more susceptible than fourth and third instars in all the five races. As spore load concentration increased, fungal infection also increased proportionately. The rearing bed made out of newspaper recorded lower white muscardine infection, while it was maximum in banana leaf bed. Maintenance of spacing of 60, 180 and 360 sq.ft./100 dfls for third, fourth and fifth instar larvae resulted in lower white muscardine infection in all the races.

Use of lime at 3 g/sq.ft. for third instar larvae and 5 g/sq.ft. for fourth and fifth instar larvae of all the five races at all the spore loads minimised the white muscardine fungal infection.

Dithane M-45 at 2 per cent concentration was the most effective fungicide for minimizing the white muscardine fungus on all the five races, on third, fourth and fifth instars at the spore load of 10^6 to 10^9. Thiram at 2 per cent was the next in order of efficacy.

ACKNOWLEDGEMENT

ACKNOWLEDGEMENT

I sincerely express my deep sense of gratitude and heartfelt thanks to Dr.P.C.Sundara Babu, Professor, Department of Entomology, Tamil Nadu Agricultural University, Coimbatore, the Chairman of my Advisory Committee for his constant guidance, critical comments and continuous encouragement during the preparation and completion of research work.

I am grateful to the members of my Advisory Committee, Dr.N.Chandramohan, Professor and Head, Department of Sericulture, Tamil Nadu Agricultural University, Coimbatore and Dr.Sabitha Duraisamy, Professor, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore, for their critical comments and suggestions regarding my research work for its improvement.

I am thankful to Dr.A.Subramaniam, Professor, Department of Sericulture, Dr.N.Sivaprakasam, Associate Professor, Dr.G.L.Justin and Dr.P.Marimuthu, Assistant Professors, Department of Sericulture, Tamil Nadu Agricultural University, Coimbatore, for their warm encouragement and cooperation during each stage of research work.

I am deeply respectful to my beloved parents, Shri K.M.Rathnaiah, Srimathi Lingamma and sisters and brothers for their everlasting affection and grace which inspired me in successful completion of objective.

My heartfelt thanks are due to all my friends, classmates and junior friends for their spontaneous help and cooperation throughout the study.

(RANGASWAMY)

CONTENTS

LIST OF TABLES

LIST OF PLATES

INTRODUCTION

1. INTRODUCTION

In India, silkworm rearing is practised since time immemorial. At present, the extent of mulberry cultivation is 3,13,109 hectares. Mulberry silk production is mainly confined to the states of Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal and Jammu and Kashmir. Of these states, Karnataka ranks first in silk production followed by Andhra Pradesh and Tamil Nadu (Dandin and Halliyal, 1992).

In Tamil Nadu, sericulture is mainly practised in the districts of Dharmapuri, Salem, Coimbatore and Periyar. Of late, mulberry cultivation has been introduced in the districts of Madurai, Tirunelveli Kattabomman, Kanyakumari, Dindigul Anna and North Arcot Ambedkar. Out of 16,812 villages in Tamil Nadu, sericulture is carried out in 4,985 villages. An area of 36,856 hectares was under mulberry in the state and raw silk production was 7.49 lakh kg during the year 1993-94 (Mohanty and Dhas, 1995).

Even with the production constraints in the country, India occupies second place in the world. Its silk yield per 100 dfls is comparatively low mainly due to crop losses on account of the incidence of diseases and pests (Jayaramaiah and Hanumappa, 1986).

Mulberry silkworm, Bombyx mori is prone to several virulent and infectious diseases like muscardine, flacherie, grasserie and pebrine. The survey conducted by Central Sericultural Research and Training Institute, Mysore in 1985 indicated that different diseases on silkworm were muscardine (0.48%), pebrine (2.3%), nuclear polyhedrosis (5.0%) and cytoplasmic polyhedrosis (27.88%) (Annual Report, 1992-93). Though the loss due to infection of muscardine is generally very low, in severe cases, it may be as high as 70.0 per cent (Samson et al., 1990).

Among the diseases, muscardine is one of the important and earliest known diseases of silkworm. About 20 species of entomopathogenic fungi were reported to cause muscardine diseases (Steinhaus, 1949; Krishnaswami et al., 1973). Of these, Beauveria bassiana was probably the first entomogenous fungus observed as early as 1835 by Bassi causing the white muscardine disease in silkworm (Bassi, 1835). Silkworm diseases are best prevented than cured. Different protection methods are followed during the silkworm rearing to prevent these diseases.

The present study was taken up on five races of silkworm viz., Kalimpong A (KA), NB_{18}, NB_4D_2, Pure Mysore and Tamil Nadu White to know their susceptibility to the disease and

to identify the management of white muscardine in these races for effective control with the following objectives.

a) To study the occurrence of the fungal disease viz., white muscardine of silkworm in Dharmapuri, Salem and Coimbatore districts of Tamil Nadu.

b) To study the relative susceptibility of the five races of silkworm to white muscardine.

c) To evolve management practices for the white muscardine disease of silkworm.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Although voluminous information is available on various aspects of the white muscardine disease (Beauveria bassiana) of mulberry silkworms, the information available on the ecology and management aspects of the disease only have been reviewed and presented here as the scope of the present study pertains on these aspects.

2.1. Studies on growth and sporulation of the fungus in various media

Samsinakova (1966) determined the composition of the media best suitable for the submerged cultivation of the entomopathogenic fungus, B.bassiana by its growth and production of blastospores. Barnes et al. (1975) studied two entomogenous fungi, B.bassiana and Metarrhizium anisopliae Met chnikoff to determine the effect of the sources of peptone on growth and sporulation, cultured in liquid media. Each fungus responded differently to the various peptone sources.

Campbell et al. (1978) studied two natural isolates of B.bassiana in liquid media containing 24 amino acids and KNO_3 to determine their effect on growth and sporulation. In addition, the growth and medium pH changes for each isolate grown on an

asparagine containing medium were compared. They found that tryptophan and alanine were the most effective for growth and sporulation of B.bassiana.

Smith and Grula (1981) reported that nutritional requirements for germination and growth of the entomopathogenic fungus B.bassiana were not complex. For germination, a utilizable source of carbon must be present, however, a nitrogen source is needed for continued hyphal growth.

Samson and Baig (1993) made studies on suitable media for the culture of B. bassiana through enrichment of population media for the culture of fungus. Four media were tried by enriching the media with larval and pupal extracts at 5 and 10 per cent respectively. Results indicated that the incorporation of larval and pupal extracts in medium improved mycelial growth by 161.36 to 368.18 per cent.

2.2. Studies on infection and infected larvae of the silkworm with B.bassiana

Yanagita and Iwashita (1987) studied the possibility of oral infection of larvae of B.mori with B.bassiana and the pathological changes in the alimentary canal of the silkworm larvae when observed by light and electron microscopy.

yanagita (1987) studied the infection of the silkworm larvae by oral inoculation of conidia of B.bassiana at the time of feeding. Germination of the fungal conidia and their hyphal growth were observed in the digestive juice of the silkworm larvae used as medium. Dipping of the larvae subjected to oral inoculation of the fungus in 70 per cent ethanol solution was effective in disinfecting the body surface of the larvae after oral inoculation. Conidia on the body surface of the larvae were killed by dipping in 70 per cent ethanol solution. The number of larvae which died due to oral inoculation of the fungus was lower than in the case of cutaneous inoculation. Fungal disease occurred chronically in the case of oral inoculation and the infected larvae died mainly during the period of moulting. When fifth instar larvae were subjected to the oral inoculation of the fungus, the silkworms died at the stage when pupae were incompletely exuviated and did not spin a cocoon. B.bassiana was recovered from the alimentary canal of a large number of silkworms.

2.3. Effect of temperature and relative humidity

Khramova and Popou (1984) studied the effect of temperature, relative humidity and pH on B.bassiana. The growth and development of nine local strains of the fungus, B.bassiana was affected by environmental factors. Lower and upper

temperature limits were also effective for spore germination and sporulation of B.bassiana.

2.4. Relative susceptibility of silkworm races to white muscardine disease

Steinhaus (1949) reported that in silkworm rearing, fifth instar larva was more susceptible to disease when compared to first, second, third and fourth instars.

Venkataramana Reddy and Veeresh (1978a) recorded that the mortality rate due to B.bassiana was 5.7, 99.9, 40.9 and 78.1 per cent in egg, larva, pupa and adult stages of the silkworm, respectively. The fifth instar larva was the most susceptible especially in its first two days as it showed 99.55 per cent mortality as compared to 45.92, 36.25, 60.20 and 88.67 per cent mortality in first, second, third and fourth instar larvae, respectively.

Venkataramana Reddy and Veeresh (1978b) found that mortality percentage of the silkworm larvae was on the increase with increase in the concentration of spores of B.bassiana. The median lethal concentration (LC_{50}) spores was 1598.0, 1410.0, 1171.0, 601.6 and 435.0 and the median lethal time (LT_{50}) at 10^3 spores/ml suspension was 11.89, 11.15, 13.57, 13.18 and 8.27 days

in first, second, third, fourth and fifth instar larvae, respectively. The mortality of pupae formed by the infected larvae showed no relationship with the spore concentration. The LT_{50} increased with decrease in the concentration of spores in fourth and fifth instar larvae of the silkworm.

Chinnaswamy and Devaiah (1984) tested the four silkworm races viz., Kalimpong A, NB_4D_2, Hosa Mysore and Pure Mysore, for their susceptibility to aspergillosis caused by Aspergillus tamarii Kita. Infectivity test indicated that all the four races were susceptible, but the degree of susceptibility varied. Pure Mysore was less susceptible whereas Kalimpong A was the most susceptible followed by NB_4D_2 race. The Hosa Mysore race had not differed significantly in its susceptibility from Pure Mysore race.

Raghavaiah and Jayaramaiah (1989) studied the median lethal concentration of the fungus, B.bassiana. The mortality was minimum in C.Nichi during both fourth (7.71×10^2) and fifth (4.03×10^2 spores/ml) instars, while the same was maximum (1.66×10^2 and 0.65×10^2 spores/ml) in NB_{18} indicating the least and highly susceptible nature to the infection. The results further confirmed that the fifth instar larvae of all the races were highly susceptible to B.bassiana compared to fourth instar larvae.

2.5. Effect of rearing condition on fungal infection

2.5.1. Rearing beds

Rajan et al. (1993) reported that paraffin paper was used during chawki rearing to maintain microclimatic conditions and to preserve moisture content in mulberry leaf. Due to its natural wear and tear and high cost, polythene paper as an alternative to paraffin paper in silkworm rearing was used because of its durability and easy availability. Results indicated that the use of blue polythene during young age rearing was effective in maintaining optimum temperature and relative humidity, reduction in leaf dryage and larval duration and also increase in larval weight, survival rate and cocoon characters. In addition to the above said beneficial characters it can be reused after washing and disinfection.

Das (1994) concluded that the banana leaf usually contained more than 90 per cent of water content. The moisturised glossy banana leaf was an ideal medium to increase and retain required humidity in the silkworm bed.

2.5.2. Spacing

Rapusas and Gabriel (1976) reared the silkworm in identical rearing trays of 21 x 15 x 7.5 cm in batches of 10, 20

and 50 larvae/tray giving a rearing space of 31.5, 15.75 and 6.3 sq.cm./larva, respectively. The silkworms performed better when the larvae were reared with higher space than in a limited space.

2.6. Management of white muscardine on silkworm

2.6.1. Use of bed disinfectants

Narasimhanna et al. (1976a) reported that formalin chaff (0.4 to 0.88%) gave best results when applied every day with least larval mortality percentage of 0.88. The next in order was paraformaldehyde, applied on alternate days with 5.63 per cent mortality. The mortality was 5.87 per cent in formalin chaff applied on alternate days.

Narasimhanna et al. (1976b) found that bleaching powder at 1.0 per cent gave the best results followed by 0.5 per cent, recording larval mortality of only 2.13 and 2.38 per cent due to muscardine. Daily application of Dithane M-45 at four and two per cent resulted in 3.33 and 3.85 per cent mortality, respectively without affecting the cocoon weight. Ziride was not effective in any of the concentrations tested. Pafsol treated batches resulted in 96.5 per cent mortality.

Narasimhanna et al. (1976c) tested formalin chaff against muscardine disease on fifth instar larvae at 0.8 per cent

which showed positive results and it was found non-hazardous to worms but Dithane Z-78 used at 9.0 and 10.0 per cent concentrations for the same purpose showed toxic effects on worms.

Balavenkatasubbaiah et al. (1989) indicated that exposure of contaminated rearing appliances to sunlight lowered the disease indicating its efficacy. Asiphor 2.0 per cent disinfection was effective against not only white muscardine but also other diseases like grasserie and pebrine.

Subbarao et al. (1992) tested bleaching powder solution (5% w/v) as spray for disinfection before rearing of silkworm and during the course of rearing. Lime and bleaching powder mixture (97:3) dusted daily once as bed disinfectant on muscardine inoculated silkworms increased the survival by 20 to 75 per cent over control.

Baig et al. (1993) found that a dust formulation consisting of Captan, Paraformaldehyde, Benzoic acid and lime (1:1:2:96) was effective against both muscardine and nuclear polyhedrosis diseases.

2.6.2. Use of insecticides and fungicides

Samson and Baig (1977) reported that the zone of inhibition of B.bassiana was maximum in formalin at 0.1 per cent concentration and it was much more effective than 0.5 per cent Thiram. In formalin, the zone of inhibition increased with increase in the concentration and it was 3.1, 7.8 and 10.3 mm at 0.1, 0.5 and 1.0 per cent concentrations, respectively. Thiram ranked next with a range of 2.2 to 3.3 mm for the different concentrations tested. Inhibition zone was less than 1.0 mm in Hexacap, Captan, $MnSO_4$ and Dithane M-45 at their highest concentration. However, Ziram recorded more than one mm at its highest concentration. Mortality of 1.1 to 2.5 per cent was recorded in Captan for different schedules tested. Captan plus Dithane M-45, Dithane M-45 and formalin chaff for the different schedules resulted in mortality of 1.5 to 3.4, 1.1 to 10.4 and 3.7 to 19.8 per cent, respectively.

Krishnaprasad et al. (1978) concluded that Bavistin had not inhibited the growth of B.bassiana at 1, 2 and 5 ppm except at 10 ppm (12.55 mm). The size of inhibition zone increased correspondingly with the increase in the dosage and it was 23.9, 32.8, 41.3 and 49.8 mm at 100, 200, 500 and 1000 ppm, respectively.

Gardener et al. (1979) evaluated the effect of six selected pesticides on the growth of B.bassiana in broth cultures with respect to increasing concentrations of Benomyl, Mancozeb, Methyl parathion, Carbaryl, Methomyl and Diflubenzuron. Mancozeb was reported to have 100 per cent inhibitory effect on B.bassiana at all the concentrations. Complete inhibition occurred at 0.40 per cent of benomyl, methomyl and diflubenzuron and partial inhibition occurred at 0.40 per cent of carbaryl and methyl parathion. However, 0.04 per cent and 0.16 per cent of methomyl and diflubenzuron had no significant effect on B.bassiana growth.

Twelve fungicides were screened by Siddaramaiah et al. (1979) for their fungitoxicity against B.bassiana causing white muscardine disease in silkworm under laboratory conditions. Brestan was the most effective fungicide even at lower concentration of 0.0025 per cent inhibiting the growth of the fungus on potato dextrose agar. Hexaferb, Thiram, Difolatan, Dithane M-45, Dithane Z-78, Aureofungin, Captan and Morestan were effective in inhibiting the growth of the fungus.

Calixin inhibited conidia formation in muscardine fungus in vitro (Annual Report 1980).

Anderson and Roberts (1984) tested six B.bassiana isolates and 13 insecticides to find out compatible combinations

between B.bassiana isolates. Emulsifiable concentrates of insecticide formulation using xylene based aromatic solvents were the most inhibitory towards B.bassiana. Wettable powder formulations often increased colony counts. Pyrethroids (Permethrin and fenvalerate) were inhibitory as both formulated and technical materials. Most B.bassiana inhibition occurred within four hours of mixing. Separate application of B.bassiana and insecticides greatly mitigated B.bassiana inhibition.

Loria et al. (1984) tested four commercially used fungicides for the control of foliar diseases of potato, in vitro and under field conditions for their effects on survival of spores of B.bassiana, a pathogen of the Colorado potato beetle. Mancozeb, the most detrimental of the fungicides, substantially reduced survival in both laboratory and field studies. Metiram was only slightly less inhibitory to B.bassiana than Mancozeb in vitro, but was not different from the control under field conditions. Chlorothalonil and Metalaxyl were not detrimental to spore survival under any of the condition examined.

Samson et al. (1986) tested Captan, Dithane M-45 and formalin for their efficacy against white muscardine of silkworm. According to their findings, every day application of 1.0 per cent Captan upto third stage and 2.0 per cent during fourth and fifth stages had been found to be the most effective with 1.5 per

cent mortality due to muscardine. Every day application of formalin chaff at a concentration of 0.6 per cent upto third stage and 0.8 per cent on fourth and fifth stages resulted in 3.2 per cent mortality. Application of Dithane M-45 1.0 per cent once upto third stage and 2.0 per cent during fourth and fifth instars ensured better results by arresting the muscardine disease to a certain extent. Comparative efficacy of all the three chemicals indicated Captan as the most effective in arresting the conidial viability followed by formalin chaff and Dithane M-45.

Sreedhara et al. (1991) tested the efficacy of the Triazole compounds Triadimefon and Uniconazole for the control of white muscardine disease in B.mori. In silkworms inoculated with muscardine spores, the incidence of disease was maximum in the triazole treated worms and there was no significant toxicity with topical application. Triadimefon was observed to be more effective than Uniconazole when compared to the control worms. It is concluded that muscardine disease of silkworm can be effectively controlled by triazoles without any detrimental effects on the commercial characteristics of the silkworms.

Soaf et al. (1994) reported that seven fungicides viz., Bavistin, Blitox, Captan, Derosal, Dithane M-45, Foltaf and Topsin-M were tested at 1, 2 and 3 per cent concentrations for

the control of white muscardine disease of silkworm B.mori. Results showed that all the fungicide treatments effectively controlled the muscardine disease which otherwise caused 91.10 per cent mortality in control. Comparative efficacy of all the tested fungicides indicated that Captan 3 per cent treatment was the most effective followed by Foltaf 3 per cent which respectively showed 2.22 and 2.44 per cent mortality due to muscardine. Bavistin 1 per cent treatment showed higher mortality rate of 23.10 per cent. No adverse effect on the economical characters of cocoons due to fungicide treatments was observed. Silkworms treated with Dithane M-45, 1 per cent showed higher silk ratio of 20 to 24 per cent and denier of 2.587 while Blitox and Dersoal treated silkworms showed better filament length.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present investigation on the white muscardine disease of the silkworm, Bombyx mori, caused by the entomogenous fungus, Beauveria bassiana was carried out during the period from 1994 to 1996 in the Department of Sericulture, Tamil Nadu Agricultural University, Coimbatore.

3.1. Silkworm rearing

All the experiments were conducted by using the pure bivoltine races of KA, NB_{18} and NB_4D_2 and the multivoltine pure races of Pure Mysore and Tamil Nadu White. The dfls were initially obtained from the Central Sericultural Research and Training Institute (CSR & TI), Mysore and the cultures were maintained at the Sericulture Department.

3.1.1. Disinfection of rearing equipments and room

Before the commencement of rearing, the room, rearing tools and appliances were cleaned, then properly disinfected with 2.0 per cent formalin solution at the rate of 800 ml per 10 square metre by using a foot pump. The floor of the rearing room was washed thoroughly by using 5.0 per cent bleaching powder. After the disinfection, the room was kept closed for 24 hours for

effective diffusion of formaldehyde fumes. Later the doors and windows of the room were kept open for 24 hours before the commencement of rearing.

3.1.2. Incubation of eggs

Silkworm eggs were transported from the grainage during the cooler hours of the day. The eggs were spread in single layer on paraffin paper in wooden trays. Temperature of 25^{o}C and relative humidity of 80 per cent were maintained by keeping wet foam rubber strips all around the egg cards and the wooden trays were closed with another paraffin paper.

3.1.3. Brushing

Transferring the newly hatched young silkworm larvae into a wooden tray was done as follows. Selected tender mulberry leaves of 0.5 cm square size were sprinkled on the silkworm egg cards and were turned down and later the larvae with the leaves were shifted to paraffin paper. Then egg cards were removed after some time.

3.1.4. Chawki rearing

The larvae were reared in the wooden trays of size 3' x 2' x 3' till the end of second stage. The larvae were fed four times during each day i.e., at 8 AM, 12 Noon, 4 PM and 8 PM.

3.1.5. Late age worm rearing

The third, fourth and fifth instar silkworms were used for the experimental purpose and they were reared in bamboo trays of 100 cm diameter. Before the treatment, the larvae were shifted to small bamboo trays of 30 cm diameter at the rate of 50 larvae per tray (Jolly, 1987).

3.1.6. Sterilization

The glasswares used in the experiments were sterilized in hot air oven at 160^{o}C for two hours whereas the agar medium was sterilized by autoclaving for 15 minutes at 15 lbs pressure.

3.2. Fungus culture

3.2.1. Collection, isolation and culture of the fungus

The fungus was isolated from the muscardined silkworm cadavars collected from the districts of Dharmapuri, Salem and

Coimbatore in Tamil Nadu State. Potato Dextrose Agar (PDA) was used for isolation. Twenty ml of the medium was used for each plate. After cooling, the plates were inoculated and incubated at 25^{o}C for a week. The colonies developed as white fluffy mass were purified by pour plate technique. The inoculated plates were incubated at room temperature. The conidia from a single colony of the fungus were transferred to sterile PDA slants and the fungus was maintained by repeated transfers every month. Culture of the fungus was raised on PDA plates and incubated for one week at room temperature. Fungal discs of spores taken from one week old culture were used depending on the requirement of the experiments (Rangasami, 1984).

3.2.2. Preparation of spore suspension

The spores were transferred to the sterilized conical flask with distilled water and mixed well for 10 minutes. The suspension was strained through a double layered sterile cheese cloth. The Neubauer improved ruling haemocytometer was used for counting the spores of B.bassiana (Rangasami, 1984).

3.3. Survey of white muscardine fungal disease of silkworm, B.mori and its symptoms

A survey was conducted in Dharmapuri, Salem and Coimbatore districts of Tamil Nadu State. In each district, 10 sericulture units were visited and from each unit, the prevalence of the disease was recorded. During the months of September to February, survey was undertaken every month. During the period of March to August the units were visited once in two months. During each visit, 25 bamboo trays were examined in each unit to collect and record the fungal infected larvae. The infected specimens were brought and reared under the laboratory conditions at Coimbatore and the observations were recorded.

3.4. Relative susceptibility of different races of the silkworm to fungal infection

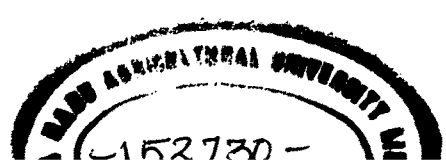
The third, fourth and fifth instar larvae of the following races were tested separately for their resistance/susceptibility to the white muscardine disease.

Bivoltine pure race;

a) Kalimpong A

b) NB_{18}

c) NB_4D_2



Multivoltine pure races:

d) Pure Mysore

e) Tamil Nadu White

These were tested against four concentrations of B.bassiana spores viz., 10^6, 10^7, 10^8 and 10^9 and compared with untreated control.

The spore suspension was sprayed with an automizer for infecting the worms. Each treatment was replicated four times and 50 larvae were used in each replication. The per cent fungal infection of the larvae was recorded and analysed with the transformed data.

3.5. Effect of rearing conditions on fungal infection

3.5.1. Effect of different rearing beds

Four types of rearing beds were used namely (a) newspaper, (b) wax paper, (c) polythene sheet and (d) banana leaf. The five races of silkworm were treated with B.bassiana at the spore concentrations of 10^6, 10^7, 10^8 and 10^9 and compared against untreated control which included the third, fourth and fifth instar larvae. There were four replications and each replication had 50 larvae of B.mori. The fungal infection per cent in each instar was observed and subjected to statistical analysis.

3.5.2. Effect of spacing

The silkworm races were treated with B.bassiana at the spore concentrations of 10^6, 10^7, 10^8 and 10^9 and compared against untreated control. The test was carried out for third, fourth and fifth instar larvae of silkworm. Each instar in a different spacing as mentioned below was maintained.

Third instar - 10, 15, 45 and 60 sq.ft. per 100 dfls
Fourth instar - 30, 45, 60 and 180 sq.ft. per 100 dfls
Fifth instar - 50, 60, 180 and 360 sq.ft. per 100 dfls

The experiment was carried out with five treatments and four replications. Fifty larvae were used in each replication. The fungal infection per cent in each instar was observed and subjected to statistical analysis.

3.6. Management of white muscardine on silkworm

3.6.1. Effect of liming on rearing bed

This experiment was carried out with two types of treatments viz., with lime and without lime and four spore concentrations of 10^6, 10^7, 10^8 and 10^9 for each of the five races of silkworm. Lime was used in third instar at 3 g/sq.ft. and for fourth and fifth instar at 5 g/sq.ft. The treatments

were replicated four times and 50 larvae were maintained for each replication. The fungal infection percentage for each instar in all the races was observed and subjected to statistical analysis.

3.6.2. Effect of fungicides

B.bassiana with spore concentrations of 10^6, 10^7, 10^8 and 10^9 with untreated control were used. The third, fourth and fifth instar larvae of the five races were treated as follows which constituted nine treatments with three replications with 50 larvae per replication.

i)	Dithane M-45 (Mancozeb)	...	1 %
ii)	Dithane M-45	...	2 %
iii)	Thiram (Thiram)	...	1 %
iv)	Thiram	...	2 %
v)	Cuman L (Ziram)	...	1 %
vi)	Cuman L	...	2 %
vii)	Kavach (Chlorothalonil)	...	1 %
viii)	Kavach	...	2 %
ix)	Control		

The initial mortality counts were taken 48 h after treatments and continued upto the spinning stage and the percentage survival of worms was computed. The data were analysed statistically.

3.7. Statistical analysis

The data collected in various experiments were statistically analysed using Completely Randomized Design (CRD) as described by Panse and Sukhatme (1957). The data were transformed to Arcsin percentage for the purpose of analysis. Duncan's Multiple Range Test (DMRT) was applied for comparing the treatment means (Duncan, 1951).

EXPERIMENTAL RESULTS

4. EXPERIMENTAL RESULTS

The results of the studies carried out on survey for the occurrence of white muscardine disease in Dharmapuri, Salem and Coimbatore districts of Tamil Nadu; susceptibility of various races of silkworm to the different spore loads of fungal inoculum; the effect of spacing and rearing beds on fungal infection and the management of fungal infection with liming and fungicides at Tamil Nadu Agricultural University, Coimbatore during 1994-96 are presented.

4.1. Survey on white muscardine disease of silkworm

Survey on white muscardine infection in sericulture units in Dharmapuri, Salem and Coimbatore districts was undertaken. Almost all the sericulturists maintained cross breed. A few of them (two) maintained NB_4D_2 and three had Pure Mysore race. In each district, 10 units were surveyed and in each unit, 1000 larvae were examined. The survey showed that in Dharmapuri district, the fungal infection ranged from 0.40 to 4.00 per cent under improper rearing condition. In Salem and Coimbatore districts, the fungal infection under the same condition ranged from 0.30 to 2.10 and 0.00 to 1.50 per cent, respectively (Tables 1 to 3). In general, the occurrence of

Table 1. Survey on white muscardine disease of silkworm in Dharmapuri district (1000 larvae screened/unit)

Sericulturist	Infection		Rearing conditions*						
	No.	%	1	2	3	4	5	6	7
Angappan	16	1.60	O	Y	IP	IP	RP	Y	N
Gopal	10	1.00	O	Y	IP	IP	RP	N	N
Krishnan	20	2.00	S	Y	IP	IP	RP	N	N
Madhavan	10	1.00	S	Y	IP	IP	RP	N	N
Muniappan	14	1.40	S	Y	IP	RP	SP	N	N
Palanisamy	40	4.00	S	Y	IP	IP	RP	N	N
Parasuraman	12	1.20	O	Y	IP	IP	RP	N	Y
Selvam	9	0.90	S	Y	IP	IP	SP	Y	N
Sundaram	20	2.00	S	Y	IP	IP	RP	N	N
Vadivel	4	0.40	S	Y	IP	IP	RP	N	N

* Rearing conditions

1. Type of rearing house: Separate (S)/Open (O)
2. Disinfection: Yes(y)/No(N)
3. Larval spacing: Proper(P)/Improper (IP)
4. Disposal of diseased larvae: Proper(P)/Improper (IP)
5. Leaf preservation: Rearing place (RP)/Separate place(SP)
6. Application of bed disinfectants: Yes(Y)/NO(N)
7. Maintenance of hygiene: Yes(Y)/NO(N)

Table 2. Survey on white muscardine disease of silkworm in Salem district (1000 larvae screened/unit)

Sericulturist	Infection		Rearing conditions*						
	No.	%	1	2	3	4	5	6	7
Chandran	9	0.90	S	Y	IP	P	RP	N	Y
Govindasamy	10	1.00	O	Y	IP	P	SP	N	Y
Kuppyal	4	0.40	S	Y	IP	P	RP	Y	N
Lakshmanan	3	0.30	O	Y	IP	IP	SR	Y	N
Palaniamma	10	1.00	S	Y	IP	P	RP	Y	N
Rajendran	21	2.10	S	Y	IP	IP	RP	N	N
Raju	7	0.70	O	Y	IP	IP	RP	N	N
Ramakrishnan	8	0.80	S	Y	IP	IP	RP	N	N
Subramanian	12	1.20	S	Y	IP	IP	RP	N	Y
Sumathi	14	1.40	S	Y	IP	P	RP	N	N

* Rearing conditions

1. Type of rearing house: Separate (S)/Open (O)
2. Disinfection: Yes(y)/No(N)
3. Larval spacing: Proper(P)/Improper (IP)
4. Disposal of diseased larvae: Proper(P)/Improper (IP)
5. Leaf preservation: Rearing place (RP)/Separate place(SP)
6. Application of bed disinfectants: Yes(Y)/NO(N)
7. Maintenance of hygiene: Yes(Y)/NO(N)

Table 3. Survey on white muscardine disease of silkworm in Coimbatore district (1000 larvae screened/unit)

Sericulturist	Infection		Rearing conditions*						
	No.	%	1	2	3	4	5	6	7
Arumugam	6	0.60	S	Y	IP	P	SR	N	N
Devaraju	0	0.00	O	Y	IP	P	RP	N	Y
Doraisamy	6	0.60	S	Y	IP	IP	RP	N	N
Mallika	3	0.30	S	Y	IP	IP	RP	N	N
Marudakutti	8	0.80	S	Y	IP	IP	RP	N	N
Rangasamy	0	0.00	S	Y	IP	IP	SR	Y	N
Shanmugam	15	1.50	O	Y	IP	IP	RP	Y	N
Santhamani	15	1.50	O	Y	IP	IP	SR	N	N
Sivaraju	10	1.00	S	Y	IP	P	SR	N	N
Subbaiah	4	0.40	O	Y	IP	IP	RP	Y	Y

* Rearing conditions

1. Type of rearing house: Separate (S)/Open (O)
2. Disinfection: Yes(y)/No(N)
3. Larval spacing: Proper(P)/Improper (IP)
4. Disposal of diseased larvae: Proper(P)/Improper (IP)
5. Leaf preservation: Rearing place (RP)/Separate place(SP)
6. Application of bed disinfectants: Yes(Y)/NO(N)
7. Maintenance of hygiene: Yes(Y)/NO(N)

white muscardine disease in these districts was very low. The symptoms of white muscardine were as follows:

At the early stage of infection, symptoms were not distinct, but as the disease advanced, moist specks appeared on the skin. At this stage, larvae lost appetite and became inactive. The body of the larvae became limp, lost its skin elasticity, movement and finally they died. The body was covered with a white mass of fungal hyphae and spores.

4.2. Relative susceptibility of silkworm races to white muscardine fungal infection

In the experiments conducted to assess the fungal infection under different spore loads of B.bassiana on the third, fourth and fifth instar larvae of different races of silkworm, the general trend was that with increase in spore load, there was a concomitant increase in per cent fungal infection within an instar. The fungal infection progressively increased from third to fifth instar in all the races studied. The fungal infection was higher in the three bivoltine races compared to the two multivoltine races. The variations noted in each race are presented below.

4.2.1. Bivoltine races

Kalimpong A (KA)

The per cent fungal infection varied from 38.00 to 54.50 in third instar, 58.00 to 72.00 in fourth instar and 71.50 to 83.50 in fifth instar (Table 4). As the spore load increased the per cent fungal infection also increased. The later instars were more susceptible than the early instar. Fifth instar was highly susceptible followed by fourth and third instar.

NB_{18}

In each instar, an increase in spore load resulted in an increase in per cent fungal infection viz., 34.00 to 50.50 in third instar, 54.00 to 66.50 in fourth instar and 67.50 to 78.00 in fifth instar (Table 5).

NB_4D_2

The fungal infection ranged from 36.00 to 52.50 (third instar), 56.00 to 68.50 (fourth instar) and 69.50 to 80.00 per cent (fifth instar) indicating a similar trend as in other races (Table 6).

1 White muscardine on Kalimpong A (KA) race

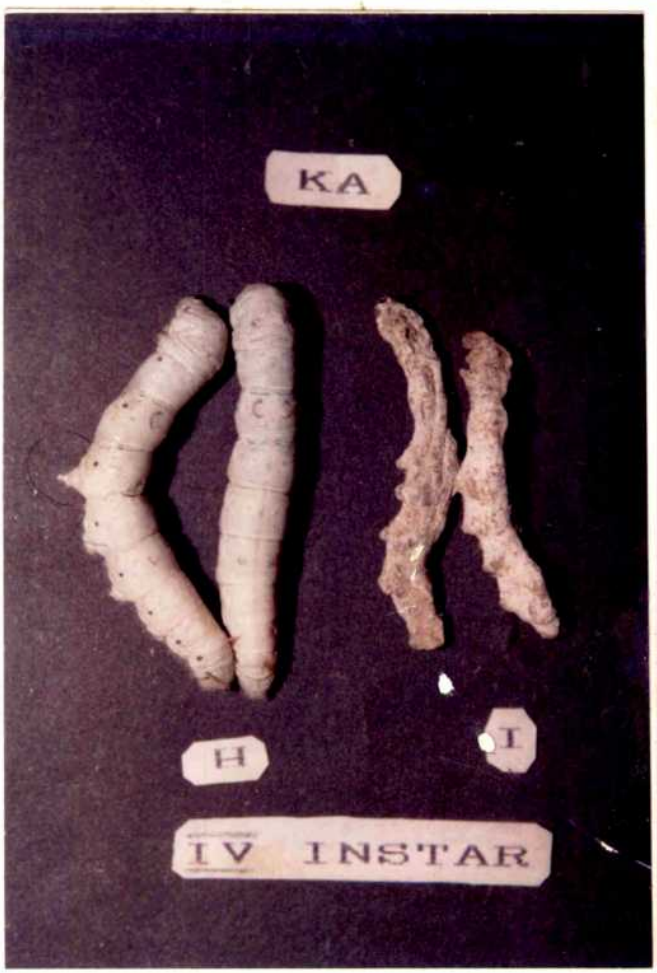
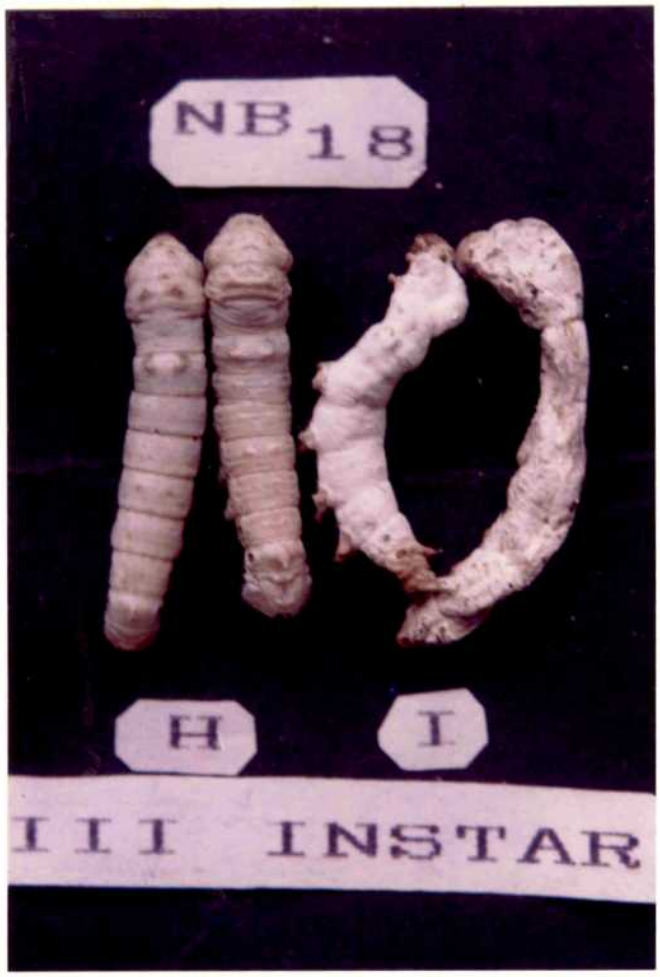


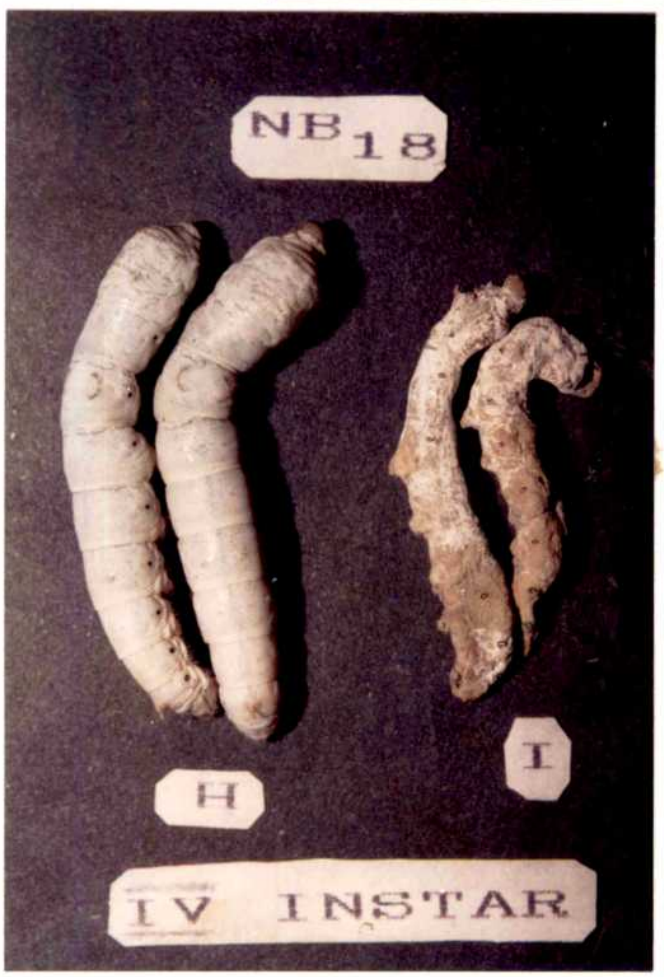
Table 4. Relative susceptibility of silkworm larvae to different spore loads of B.bassiana - Kalimpong A (KA) race

Spore load/ml	Fungal infection (%)*		
	Third instar	Fourth instar	Fifth instar
10^6	38.00 (38.05)^d	58.00 (49.60)^d	71.50 (57.74)^c
10^7	43.50 (41.26)^c	62.25 (52.09)^c	74.00 (59.35)^c
10^8	48.50 (44.13)^b	68.00 (55.55)^b	77.50 (61.69)^b
10^9	54.50 (47.58)^a	72.00 (58.05)^a	83.50 (66.06)^a
Control	0.50 (4.06)^e	0.50 (4.06)^e	0.50 (4.06)^d

* Mean of four replications

Figures in parentheses are angular transformed values. In a column, means followed by a common letter are not significantly different at 5% level by DMRT.


NB18
H
I
III INSTAR


NB18
H
I
IV INSTAR

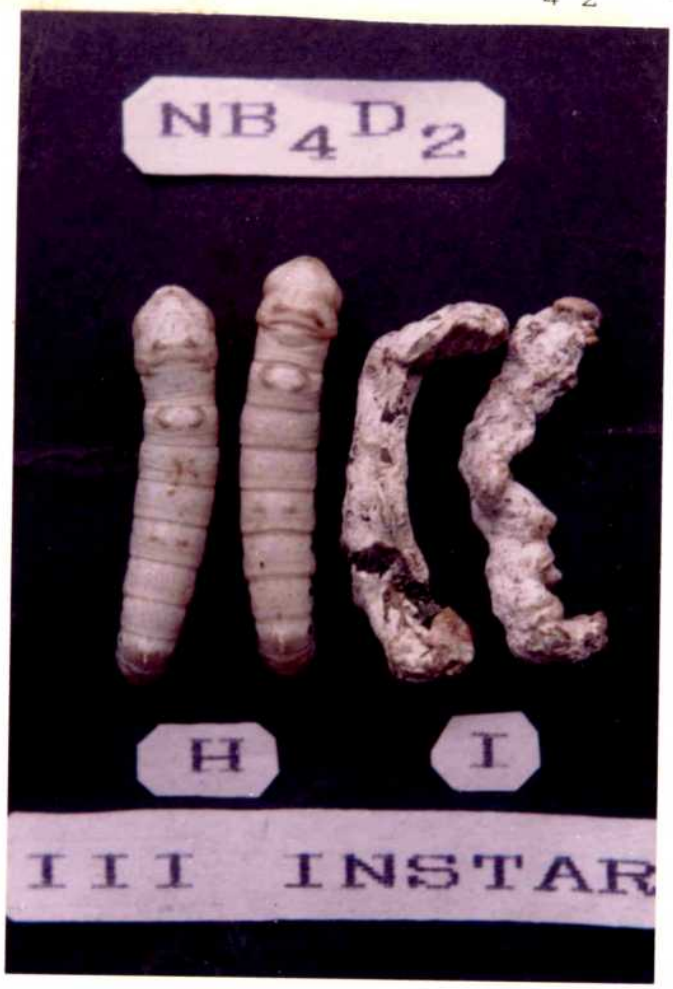

NB18
H
I
V INSTAR

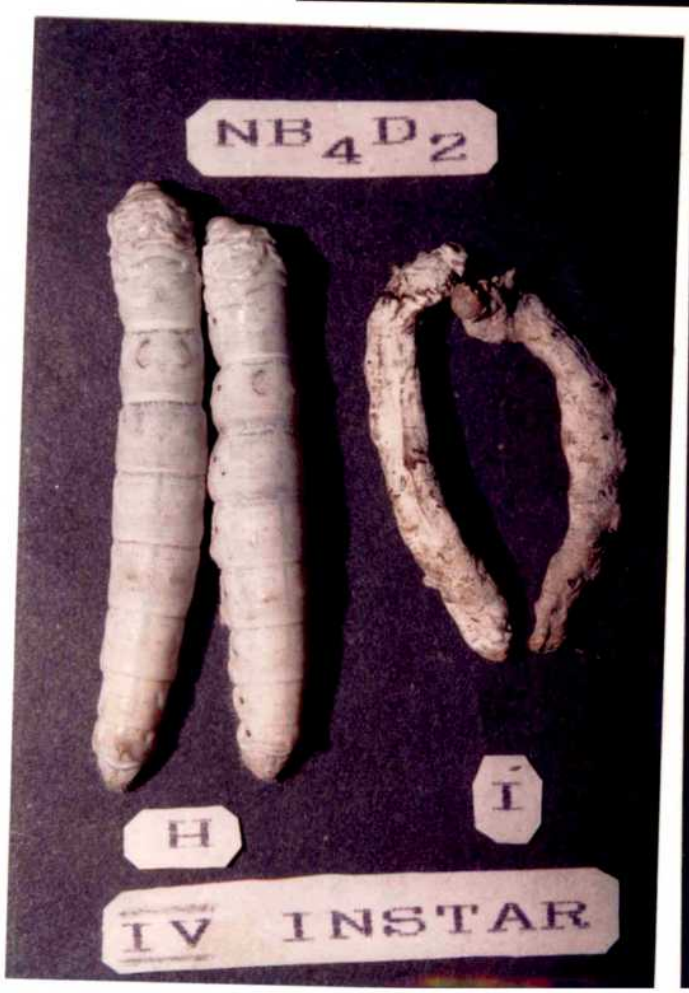
Table 5. Relative susceptibility of silkworm larvae to different spore loads of B.bassiana - NB_{18} race

Spore load/ml	Fungal infection (%)*		
	Third instar	Fourth instar	Fifth instar
10^6	34.00 (35.66)^d	54.00 (47.29)^c	67.50 (55.25)^c
10^7	39.50 (38.93)^c	57.50 (49.31)^b	70.00 (56.79)^c
10^8	44.50 (41.84)^b	64.50 (53.43)^a	73.50 (59.02)^b
10^9	50.50 (45.28)^a	66.50 (54.64)^a	78.00 (62.03)^a
Control	0.50 (4.06)^e	0.50 (4.06)^d	0.50 (4.06)^d

* Mean of four replications

Figures in parentheses are angular transformed values. In a column, means followed by a common letter are not significantly different at 5% level by DMRT.


NB4D2
H
I
III INSTAR


NB4D2
H
I
IV INSTAR


NB4D2
H
I
V INSTAR

Table 6. Relative susceptibility of silkworm larvae to different spore loads of B.bassiana - NB_4D_2 race

Spore load/ml	Fungal infection (%)*		
	Third instar	Fourth instar	Fifth instar
10^6	36.00 (36.86)^d	56.00 (48.44)^d	69.50 (56.48)^c
10^7	41.50 (40.10)^c	59.50 (50.47)^c	72.00 (58.05)^c
10^8	46.50 (42.99)^b	66.50 (54.64)^b	75.50 (60.34)^b
10^9	52.50 (46.43)^a	68.50 (55.86)^a	80.00 (63.44)^a
Control	0.50 (4.06)^e	0.50 (4.06)^e	0.50 (4.06)^d

* Mean of four replications

Figures in parentheses are angular transformed values. In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

4.2.2. Multivoltine races

Pure Mysore

In third instar, fungal infection ranged from 30.00 to 46.50 per cent at 10^6 to 10^9 spores/ml. A similar trend was seen in fourth (50 to 63%) and fifth instar (63.50 to 74.00%) larvae also (Table 7).

Tamil Nadu White

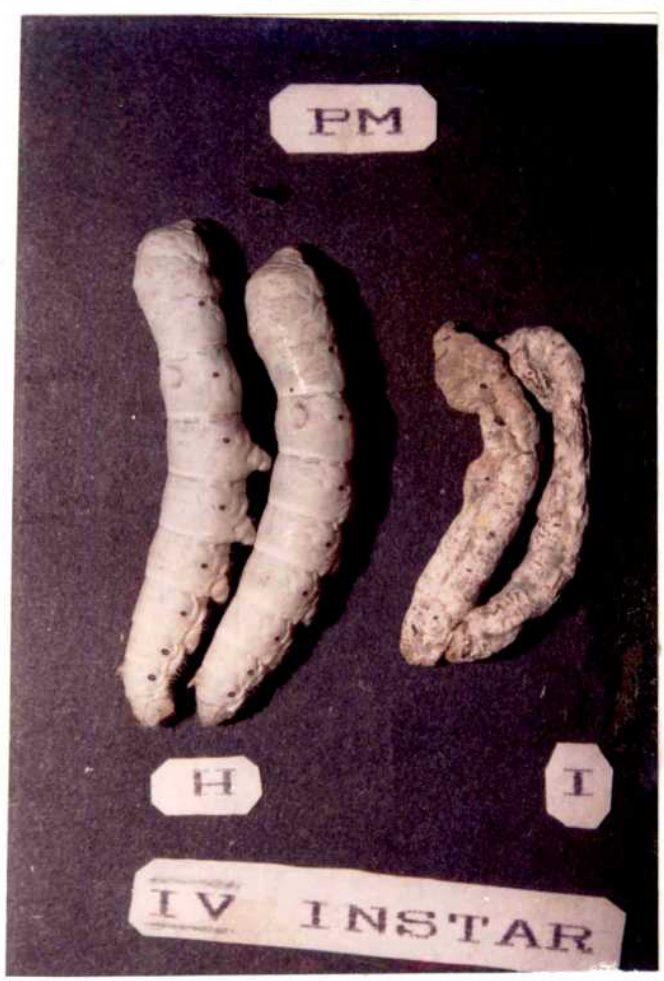
Similar variation in fungal infection ranging from a minimum of 32.00 per cent in third instar to a maximum of 76.00 per cent in fifth instar larvae was noted (Table 8).

4.3. Effect of rearing bed on white muscardine fungal infection

The results obtained in the experiments conducted to study the influence of four types of rearing beds viz., newspaper, wax paper, polythene sheet and banana leaf and four spore loads viz., 10^6, 10^7, 10^8 and 10^9 spores/ml on fungal infection on third, fourth and fifth instar larvae of five silkworm races are presented.

Among the four substrates used as rearing bed, the larvae reared on the bed of newspaper consistently recorded lower


PM
H
I
III INSTAR


PM
H
I
IV INSTAR

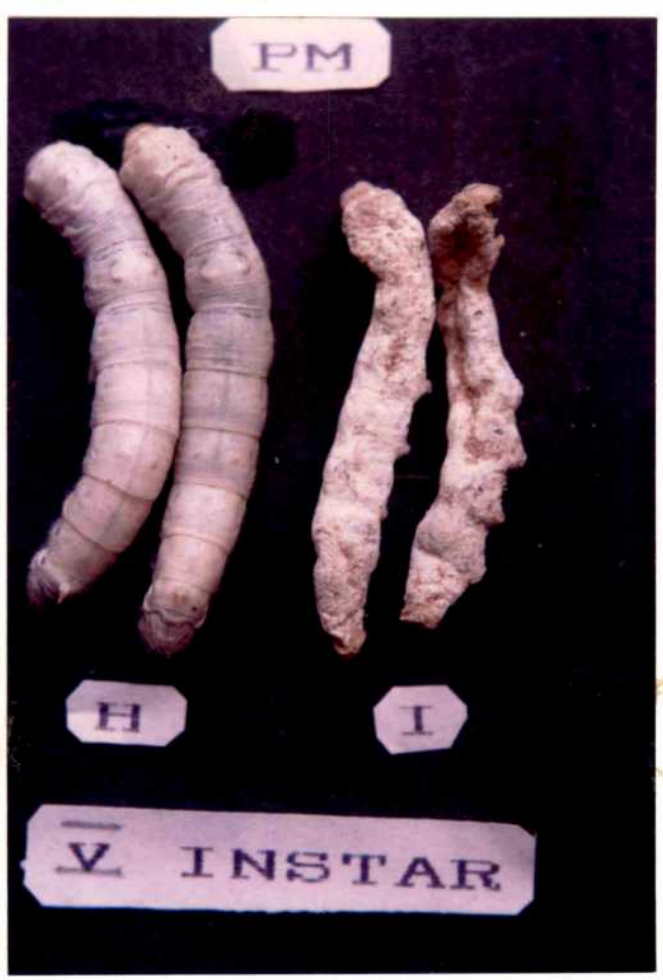

PM
H
I
V INSTAR

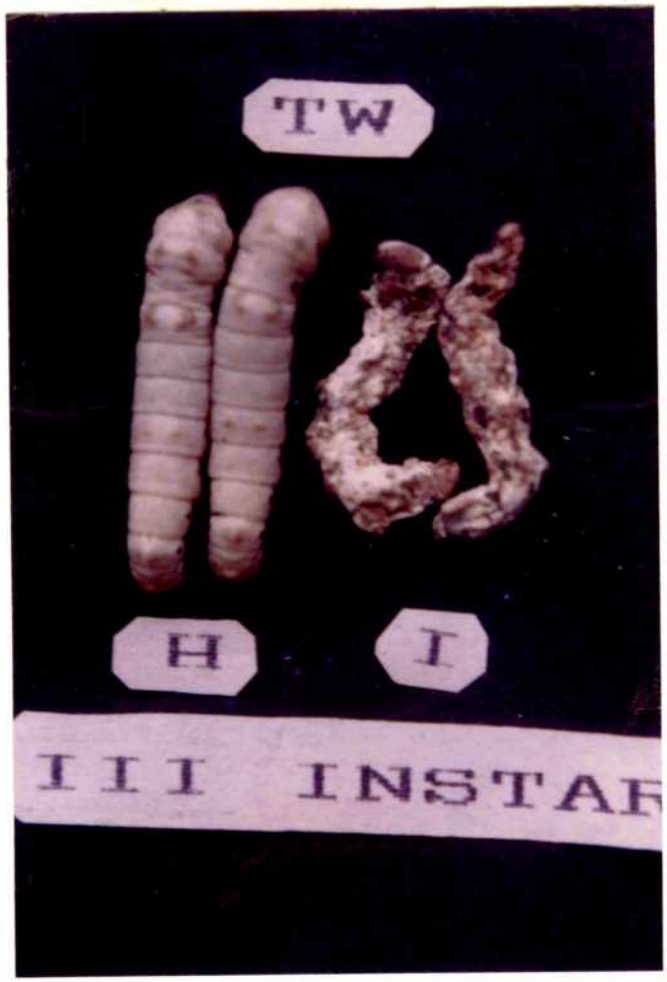
Table 7. Relative susceptibility of silkworm larvae to different spore loads of B.bassiana - Pure Mysore race

Spore load/ml	Fungal infection (%)*		
	Third instar	Fourth instar	Fifth instar
10^6	30.00 (33.20)^d	50.00 (44.99)^d	63.50 (52.83)^d
10^7	35.50 (36.56)^c	53.50 (47.00)^c	66.00 (54.33)^c
10^8	41.25 (39.95)^b	60.50 (51.06)^b	70.00 (56.79)^b
10^9	46.50 (42.99)^a	63.00 (52.53)^a	74.00 (59.35)^a
Control	0.50 (4.06)^e	0.50 (4.06)^e	0.50 (4.06)^e

* Mean of four replications

Figures in parentheses are angular transformed values. In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

5 White muscardine on Tamil Nadu white race



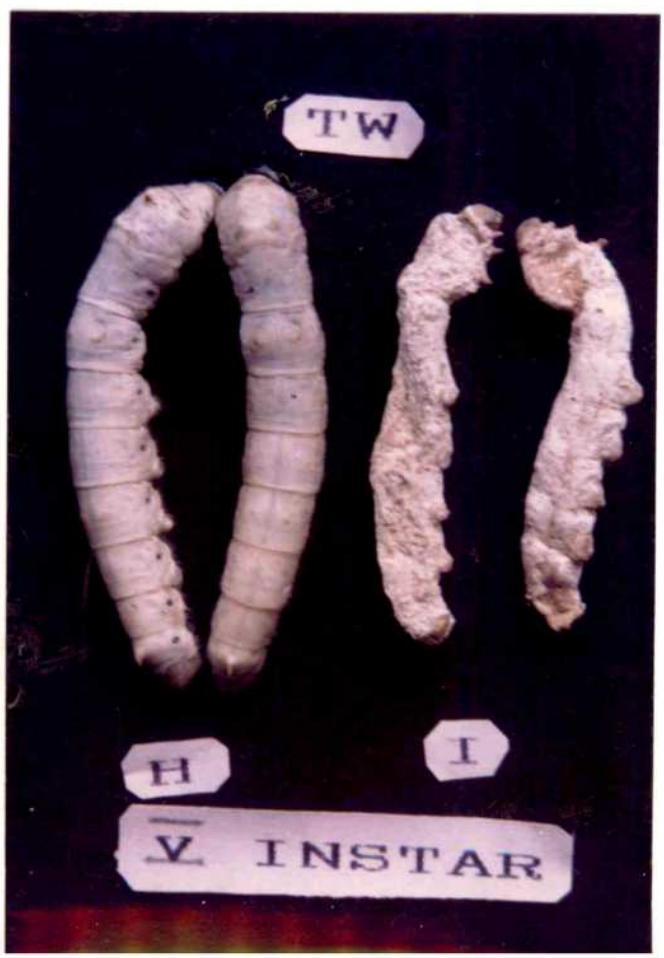


Table 8. Relative susceptibility of silkworm larvae to different spore loads of B.bassiana - Tamil Nadu White race

Spore load/ml	Fungal infection (%)*		
	Third instar	Fourth instar	Fifth instar
10^6	32.00 (34.44)^d	52.00 (46.14)^d	66.50 (54.64)^d
10^7	37.50 (37.75)^c	55.50 (48.15)^c	69.00 (56.64)^c
10^8	42.50 (40.68)^b	65.00 (53.73)^b	72.00 (58.05)^b
10^9	48.50 (44.13)^a	66.50 (54.64)^a	76.00 (60.67)^a
Control	0.50 (4.06)^e	0.50 (4.06)^e	0.50 (4.06)^e

* Mean of four replications

Figures in parentheses are angular transformed values. In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

fungal infection in all the instars, races and fungal spore loads. Similarly the larvae reared on banana leaf bed recorded the maximum fungal infection in all the races at all the spore loads tried followed by polythene sheet and wax paper. The picture in each of the races is presented.

4.3.1. Bivoltine race,

Kalimpong A (KA)

In all the three instars namely, third, fourth and fifth, the fungal infection was lower when newspaper was used as the substrate for the rearing bed irrespective of the spore load of the fungal inoculum. The fungal infection increased as indicated namely, banana leaf > polythene sheet > wax paper > newspaper. In third instar, the fungal infection ranged from 42.50 per cent in newspaper substrate at 10^6 spores/ml to 74.50 per cent in banana leaf substrate at 10^9 spores/ml. In fourth instar, the range was 50.50 to 85.00 per cent and in fifth instar it ranged from 57.00 to 88.50 per cent.

In all the substrates the per cent fungal infection increased as the age of the larvae progressed and the spore load increased from 10^6 to 10^9 spores/ml. However, in certain cases like banana leaf, spore load of 10^8 and 10^9 were on par, with reference to third instar larvae. In fifth instar in banana leaf

substrate, 10^7 and 10^8 spores/ml load were on par in the production of fungal infection (Table 9).

NB_{18}

In this race also, there was lower fungal infection in newspaper rearing bed and higher fungal infection in banana leaf rearing bed. The range was newspaper < wax paper < polythene sheet< banana leaf. With reference to spore load it was $10^9 > 10^8 > 10^7 > 10^6$ spores/ml and among the instars fifth> fourth > third in all the spore loads and beds.

The per cent fungal infection ranged from 35.00 to 67.50 in third instar, 39.00 to 79.00 in fourth instar and 49.00 to 81.50 in fifth instar. However, in certain individual cases statistical parity was noted (Table 10).

NB_4D_2

The repetition of results on fungal infection was seen in the race. The per cent fungal infection ranged as follows: third instar 39.00 to 66.50, fourth instar 46.00 to 83.00 and fifth instar 52.50 to 85.50. In this race also, newspaper bed invariably recorded lower fungal infection irrespective of the spore load or instar. Banana leaf bed recorded the higher fungal infection (Table 11).

Table 9. Effect of rearing bed on white muscardine fungal infection - Kalimpong A (KA)

Spore load/ ml	Fungal infection (%)*											
	Third instar				Fourth instar				Fifth instar			
	Rearing bed				Rearing bed				Rearing bed			
	News paper	Wax paper	Poly-thene sheet	Banana leaf	News paper	Wax paper	Poly-thene sheet	Banana leaf	News paper	Wax paper	Poly-thene sheet	Banana leaf
10^6	42.50 (40.68)^{d}	46.00 (42.70)^{d}	52.50 (46.43)^{d}	57.00 (49.02)^{c}	50.50 (45.28)^{c}	57.00 (49.02)^{d}	61.00 (51.36)^{d}	66.50 (54.66)^{d}	57.00 (49.02)^{c}	65.50 (54.04)^{c}	66.00 (54.33)^{d}	72.50 (58.41)^{c}
10^7	49.00 (44.42)^{c}	53.00 (46.72)^{c}	58.50 (49.89)^{c}	64.50 (53.45)^{b}	55.50 (48.16)^{b}	62.50 (52.24)^{c}	67.50 (55.26)^{c}	73.50 (59.05)^{c}	63.00 (52.55)^{b}	70.50 (57.13)^{b}	72.50 (58.38)^{c}	82.00 (64.97)^{b}
10^8	53.00 (46.72)^{b}	58.00 (49.60)^{b}	65.50 (54.04)^{b}	71.50 (57.76)^{a}	60.00 (50.77)^{b}	69.50 (56.50)^{b}	72.50 (58.41)^{b}	78.50 (62.44)^{b}	67.00 (54.95)^{ab}	74.50 (59.72)^{b}	78.50 (62.44)^{b}	84.50 (66.94)^{b}
10^9	59.00 (50.19)^{a}	63.50 (52.84)^{a}	69.50 (56.50)^{a}	74.50 (59.72)^{a}	67.50 (55.26)^{a}	74.50 (59.72)^{a}	77.50 (61.73)^{a}	85.00 (67.36)^{a}	71.00 (57.76)^{a}	79.50 (63.13)^{a}	83.00 (65.69)^{a}	88.50 (70.40)^{a}
Control	0.50 (4.05)^{e}	0.50 (4.05)^{e}	0.50 (4.05)^{e}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{e}	0.50 (4.05)^{e}	0.50 (4.05)^{e}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{e}	0.50 (4.05)^{d}

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Table 10. Effect of rearing bed on white muscardine fungal infection - NB_{18}

Spore load/ ml	Fungal infection (%)*											
	Third instar				Fourth instar				Fifth instar			
	Rearing bed				Rearing bed				Rearing bed			
	News paper	Wax paper	Poly-thene sheet	Banana leaf	News paper	Wax paper	Poly-thene sheet	Banana leaf	News paper	Wax paper	Poly-thene sheet	Banana leaf
10^6	35.00 (36.26)^{c}	38.25 (38.19)^{c}	45.00 (42.12)^{c}	41.00 (39.59)^{c}	39.00 (38.64)^{d}	49.00 (44.42)^{d}	52.00 (46.14)^{d}	58.50 (49.89)^{d}	49.00 (44.42)^{c}	55.00 (47.87)^{c}	57.50 (49.32)^{c}	63.00 (52.55)^{c}
10^7	41.50 (40.10)^{b}	45.00 (42.12)^{b}	49.00 (44.42)^{bc}	53.50 (47.01)^{b}	49.50 (44.71)^{c}	54.00 (47.29)^{c}	58.50 (49.89)^{c}	65.00 (53.73)^{c}	55.50 (48.15)^{b}	60.00 (50.78)^{b}	65.50 (54.04)^{b}	71.00 (57.43)^{b}
10^8	45.50 (42.41)^{ab}	51.00 (45.57)^{a}	53.50 (47.01)^{b}	63.00 (52.54)^{a}	53.50 (47.01)^{b}	61.50 (51.65)^{b}	63.00 (52.54)^{b}	71.00 (57.43)^{b}	60.00 (50.78)^{ab}	64.50 (53.45)^{b}	68.00 (55.58)^{ab}	79.50 (63.13)^{a}
10^9	49.00 (44.42)^{a}	54.00 (47.29)^{a}	60.00 (50.78)^{a}	67.50 (55.26)^{a}	57.50 (49.31)^{a}	68.00 (55.55)^{a}	69.50 (56.50)^{a}	79.00 (62.75)^{a}	64.50 (53.44)^{a}	70.50 (57.13)^{a}	72.00 (58.07)^{a}	81.50 (64.57)^{a}
Control	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{e}	0.50 (4.05)^{e}	0.50 (4.05)^{e}	0.50 (4.05)^{e}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{d}

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Table 11. Effect of rearing bed on white muscardine fungal infection - NB_4D_2

Spore load/ ml	Fungal infection (%)*											
	Third instar				Fourth instar				Fifth instar			
	Rearing bed				Rearing bed				Rearing bed			
	News paper	Wax paper	Poly-thene sheet	Banana leaf	News paper	Wax paper	Poly-thene sheet	Banana leaf	News paper	Wax paper	Poly-thene sheet	Banana leaf
10^6	39.00 (38.63)^{c}	37.00 (37.22)^{c}	49.00 (44.42)^{c}	53.00 (46.72)^{b}	46.00 (42.70)^{d}	53.50 (47.00)^{d}	57.00 (49.02)^{c}	64.00 (53.14)^{d}	52.50 (46.43)^{c}	58.00 (49.60)^{c}	61.50 (51.66)^{d}	67.50 (55.26)^{d}
10^7	44.50 (41.84)^{bc}	48.50 (44.13)^{b}	57.50 (49.32)^{b}	61.00 (51.36)^{a}	51.50 (45.86)^{c}	58.00 (49.60)^{c}	63.50 (52.84)^{b}	69.50 (56.48)^{c}	58.00 (49.60)^{b}	67.50 (55.26)^{b}	69.50 (56.50)^{c}	75.00 (60.02)^{c}
10^8	49.00 (44.42)^{ab}	55.00 (47.87)^{ab}	61.50 (51.66)^{ab}	67.50 (55.26)^{a}	57.00 (49.02)^{b}	64.00 (53.13)^{b}	69.50 (56.50)^{a}	75.50 (60.37)^{b}	65.50 (54.05)^{a}	71.50 (57.76)^{ab}	75.50 (60.37)^{ab}	81.00 (64.23)^{a}
10^9	54.00 (47.29)^{a}	59.00 (50.20)^{a}	65.50 (54.04)^{a}	66.50 (54.78)^{a}	63.50 (52.83)^{a}	71.50 (57.76)^{a}	72.50 (58.40)^{a}	83.00 (65.69)^{a}	67.00 (54.95)^{a}	75.00 (60.02)^{a}	79.50 (63.13)^{a}	85.50 (67.69)^{a}
Control	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{c}	0.50 (4.05)^{e}	0.50 (4.05)^{e}	0.50 (4.05)^{d}	0.50 (4.05)^{e}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{e}	0.50 (4.05)^{e}

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

4.3.2. Multivoltine races

Pure Mysore

Newspaper bed was again found to be the suitable one with lower fungal infection in all the instars and all the spore loads. Similarly banana bed was highly favourable for higher fungal infection in all the instars and at all spore loads. The range of fungal infection was 24.00 to 59.00 per cent in third instar, 34.50 to 71.50 per cent in fourth instar and 40.00 to 75.00 per cent in fifth instar (Table 12).

Tamil Nadu White

In all the instars and all the rearing beds, 10^9 spores/ml recorded the highest fungal infection and 10^6 spores/ml recorded the lowest fungal infection. Among the instars, the fifth instar recorded the highest fungal infection followed by fourth and third instars. Among the four types of beds, banana leaf bed recorded the highest fungal infection while newspaper-bed recorded the lowest fungal infection. The per cent fungal infection ranged from 29.50 to 63.50 in third instar, 37.50 to 75.00 in fourth and 45.00 to 78.00 in fifth instar (Table 13).

Thus, all the races studied behaved similarly in respect of lower fungal infection in newspaper bed and higher

Table 12. Effect of rearing bed on white muscardine fungal infection - Pure Mysore

Spore load/ ml	Fungal infection (%)*											
	Third instar				Fourth instar				Fifth instar			
	Rearing bed				Rearing bed				Rearing bed			
	News paper	Wax paper	Poly-thene sheet	Banana leaf	News paper	Wax paper	Poly-thene sheet	Banana leaf	News paper	Wax paper	Poly-thene sheet	Banana leaf
10^6	24.00 (29.32)^c	30.50 (33.51)^d	34.50 (35.95)^d	39.00 (38.63)^d	34.50 (35.96)^d	39.50 (38.92)^d	44.50 (41.83)^d	51.00 (45.57)^d	40.00 (39.22)^c	46.00 (42.70)^d	49.00 (44.42)^d	54.00 (47.29)^d
10^7	26.50 (30.97)^c	36.50 (37.15)^c	41.00 (39.80)^c	47.00 (43.27)^c	41.00 (39.80)^c	47.50 (43.56)^c	51.00 (45.57)^c	57.00 (49.03)^c	47.00 (43.27)^b	52.50 (46.43)^c	55.00 (47.87)^c	60.50 (51.06)^c
10^8	31.00 (33.81)^b	43.50 (41.25)^b	47.00 (43.27)^b	55.00 (47.87)^b	48.00 (43.85)^b	53.00 (46.72)^b	57.50 (49.31)^b	64.00 (53.14)^b	50.50 (45.28)^b	57.50 (49.32)^b	60.00 (50.77)^b	68.50 (55.87)^b
10^9	37.00 (37.45)^a	47.00 (43.27)^a	53.00 (46.72)^a	59.00 (50.19)^a	54.00 (47.29)^a	59.50 (50.48)^a	62.00 (51.94)^a	71.50 (57.76)^a	55.00 (47.87)^a	63.50 (52.84)^a	66.00 (54.36)^a	75.00 (60.02)^a
Control	0.50 (4.05)^d	0.50 (4.05)^e	0.50 (4.05)^e	0.50 (4.05)^e	0.50 (4.05)^e	0.50 (4.05)^e	0.50 (4.05)^e	0.50 (4.05)^e	0.50 (4.05)^d	0.50 (4.05)^e	0.50 (4.05)^e	0.50 (4.05)^e

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Table 13. Effect of rearing bed on white muscardine fungal infection - Tamil Nadu White

Spore load/ ml	Fungal infection (%)*											
	Third instar				Fourth instar				Fifth instar			
	Rearing bed				Rearing bed				Rearing bed			
	News paper	Wax paper	Poly-thene sheet	Banana leaf	News paper	Wax paper	Poly-thene sheet	Banana leaf	News paper	Wax paper	Poly-thene sheet	Banana leaf
10^6	29.50 (32.88)^{d}	35.00 (36.26)^{d}	39.00 (38.63)^{d}	43.00 (40.97)^{d}	37.50 (37.74)^{c}	45.00 (42.12)^{d}	48.00 (43.85)^{d}	55.00 (47.87)^{d}	45.00 (42.12)^{c}	51.00 (45.57)^{d}	54.00 (47.29)^{d}	58.00 (49.60)^{d}
10^7	34.50 (35.96)^{c}	40.50 (39.51)^{c}	44.00 (41.55)^{c}	51.00 (45.57)^{c}	45.00 (42.12)^{b}	50.00 (44.99)^{c}	54.50 (47.58)^{c}	60.50 (51.06)^{c}	51.00 (45.57)^{b}	56.00 (48.45)^{c}	59.00 (50.19)^{c}	65.00 (53.74)^{c}
10^8	39.00 (38.63)^{b}	45.50 (42.41)^{b}	51.00 (45.57)^{b}	59.00 (50.19)^{b}	49.00 (44.42)^{b}	57.50 (49.32)^{b}	60.00 (50.78)^{b}	67.50 (55.26)^{b}	57.00 (49.02)^{a}	60.50 (51.08)^{b}	65.50 (54.05)^{b}	73.50 (59.02)^{b}
10^9	43.50 (41.25)^{a}	51.00 (45.57)^{a}	57.00 (49.02)^{a}	63.50 (52.85)^{a}	55.00 (47.87)^{a}	62.50 (52.24)^{a}	65.00 (53.76)^{a}	75.00 (60.02)^{a}	60.50 (51.07)^{a}	66.00 (54.36)^{a}	70.00 (56.83)^{a}	78.00 (62.06)^{a}
Control	0.50 (4.05)^{e}	0.50 (4.05)^{e}	0.50 (4.05)^{e}	0.50 (4.05)^{e}	0.50 (4.05)^{d}	0.50 (4.05)^{e}	0.50 (4.05)^{e}	0.50 (4.05)^{e}	0.50 (4.05)^{d}	0.50 (4.05)^{e}	0.50 (4.05)^{e}	0.50 (4.05)^{e}

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

fungal infection in banana leaf bed. The order was Kalimpong A > NB_4D_2 > Tamil Nadu White > NB_{18} > Pure Mysore.

4.4 Effect of spacing on white muscardine fungal infection

The experiments on the effects of different spore loads and different spacing of rearing indicated that in all the races of silkworm studied and in all instars, lower spacing always recorded higher fungal infection and higher spacing recorded lower infection. As the spore load increased, irrespective of the spacing and instar, the fungal infection increased.

4.4.1. Bivoltine races

Kalimpong A (KA)

Both the spore loads and spacing between the rearing trays had influenced the fungal infection in third, fourth and fifth instar larvae. As the spore load increased, the fungal infection also increased. But as the spacing increased, the fungal infection decreased. In third instar, the fungal infection ranged from 33.50 per cent in 60 sq.ft. spacing and 10^6 spores/ml to 70.50 per cent in 10^9 spores/ml at a spacing of 10 sq.ft. Between the ranges of spacing, 10 sq.ft. spacing consistently recorded higher fungal infection in all the spore loads. In fourth and fifth instars, different spacings were

tried and even at this spacing, there was an increase in fungal infection with the increase in spore load. In these cases also, there was a decrease in fungal infection with increase in spacing between trays (Table 14).

NB_{18}

In this race also, a similar trend of increase in fungal infection with increase in fungal spore load and decrease in fungal infection with increased spacing was noted. Minor differences like statistical parity between spore loads as in 10^8 and 10^9 under 45 and 60 sq.ft. spacings and 10^7 and 10^8 in 180 sq.ft. spacing for fourth instar larvae was noted. Similar condition was noted in fifth instar larvae also (Table 15).

NB_4D_2

The tendency of increased fungal infection with an increase in spore load and decreased fungal infection with increase in spacing was noted in this race also. Minor variation was noted in third instar, under 10 sq.ft. spacing with 10^6, 10^7 and 10^8 spores/ml having fungal infection on par and in 15 and 60 sq.ft. at 10^6 and 10^7 and 10^8 and 10^9 were on par with reference to fungal infection (Table 16).

Table 14. Effect of spacing on white muscardine fungal infection - Kalimpong A

Spore load/ ml	Fungal infection (%)*											
	Third instar				Fourth instar				Fifth instar			
	10 Sq.ft.	15 Sq.ft.	45 Sq.ft.	60 Sq.ft.	30 Sq.ft.	45 Sq.ft.	60 Sq.ft.	180 Sq.ft.	50 Sq.ft.	60 Sq.ft.	180 Sq.ft.	360 Sq.ft.
10^6	52.50 (46.43)^{d}	48.50 (44.13)^{d}	36.50 (37.15)^{d}	33.50 (35.34)^{c}	43.50 (41.25)^{c}	39.50 (38.92)^{c}	35.50 (36.55)^{c}	29.50 (32.87)^{b}	41.50 (40.09)^{c}	36.50 (37.16)^{c}	31.50 (34.11)^{c}	25.00 (29.97)^{c}
10^7	59.00 (50.19)^{c}	52.50 (46.43)^{c}	41.00 (39.80)^{c}	37.50 (37.74)^{b}	47.50 (43.56)^{bc}	43.50 (41.25)^{bc}	39.50 (38.92)^{c}	32.00 (34.44)^{b}	45.00 (42.12)^{c}	41.50 (40.09)^{b}	35.50 (36.55)^{b}	31.50 (34.11)^{b}
10^8	63.50 (52.84)^{b}	58.00 (49.60)^{b}	46.50 (42.99)^{b}	40.50 (39.51)^{b}	51.00 (45.57)^{b}	47.00 (43.27)^{ab}	44.50 (41.82)^{b}	37.50 (37.74)^{a}	51.00 (45.57)^{b}	45.50 (42.40)^{a}	38.50 (38.34)^{b}	35.50 (36.55)^{a}
10^9	70.50 (57.13)^{a}	63.50 (52.84)^{a}	52.00 (46.14)^{a}	47.00 (43.27)^{a}	57.00 (49.02)^{a}	51.00 (45.57)^{a}	49.50 (44.71)^{a}	41.50 (40.10)^{a}	55.00 (47.87)^{a}	48.50 (44.13)^{a}	45.50 (42.41)^{a}	39.00 (38.63)^{a}
Control	0.50 (4.05)^{e}	0.50 (4.05)^{e}	0.50 (4.05)^{e}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{c}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{d}

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Table 15. Effect of spacing on white muscardine fungal infection - NB_{18}

Spore load/ ml	Fungal infection (%)*											
	Third instar				Fourth instar				Fifth instar			
	10 Sq.ft.	15 Sq.ft.	45 Sq.ft.	60 Sq.ft.	30 Sq.ft.	45 Sq.ft.	60 Sq.ft.	180 Sq.ft.	50 Sq.ft.	60 Sq.ft.	180 Sq.ft.	360 Sq.ft.
10^6	44.50 (41.83)^{d}	41.50 (40.09)^{c}	29.50 (32.87)^{d}	24.50 (29.64)^{d}	35.00 (36.26)^{c}	31.50 (34.11)^{c}	26.00 (30.64)^{c}	20.50 (26.89)^{c}	33.50 (35.34)^{b}	29.50 (32.87)^{c}	23.50 (28.95)^{c}	19.00 (26.14)^{b}
10^7	51.00 (45.57)^{c}	45.00 (42.12)^{c}	33.50 (35.34)^{c}	29.50 (32.87)^{c}	39.50 (38.92)^{b}	35.50 (36.55)^{b}	31.50 (34.11)^{b}	25.50 (30.31)^{b}	37.00 (37.45)^{b}	33.50 (35.34)^{b}	27.00 (31.28)^{c}	20.50 (26.89)^{b}
10^8	55.00 (47.87)^{b}	51.00 (45.57)^{b}	38.00 (38.05)^{b}	35.50 (36.55)^{b}	45.50 (42.41)^{a}	39.50 (38.92)^{a}	37.00 (37.45)^{b}	28.50 (32.25)^{b}	43.50 (41.25)^{a}	36.50 (37.14)^{b}	33.50 (35.34)^{b}	25.00 (29.97)^{a}
10^9	60.50 (51.06)^{a}	55.50 (48.15)^{a}	44.00 (41.54)^{a}	39.50 (38.92)^{a}	47.50 (43.56)^{a}	42.50 (40.67)^{a}	39.00 (38.63)^{a}	33.50 (35.34)^{a}	47.50 (43.56)^{a}	41.50 (40.10)^{a}	37.50 (37.74)^{a}	28.00 (31.94)^{a}
Control	0.50 (4.05)^{e}	0.50 (4.05)^{d}	0.50 (4.05)^{e}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{c}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{c}

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Table 16. Effect of spacing on white muscardine fungal infection - NB_4D_2

Spore load/ ml	Fungal infection (%)*											
	Third instar				Fourth instar				Fifth instar			
	10 Sq.ft.	15 Sq.ft.	45 Sq.ft.	60 Sq.ft.	30 Sq.ft.	45 Sq.ft.	60 Sq.ft.	180 Sq.ft.	50 Sq.ft.	60 Sq.ft.	180 Sq.ft.	360 Sq.ft.
10^6	49.50 (44.71)^b	44.50 (41.84)^b	32.50 (37.74)^c	28.50 (32.25)^b	38.50 (38.34)^d	34.50 (35.96)^d	31.00 (33.81)^d	23.00 (26.83)^d	36.00 (36.86)^d	32.50 (34.74)^d	26.00 (30.64)^d	22.00 (27.96)^d
10^7	54.00 (47.29)^b	48.00 (43.85)^b	36.00 (36.86)^{bc}	32.00 (34.44)^b	42.00 (40.39)^c	38.50 (38.34)^c	34.00 (35.66)^c	28.50 (32.25)^c	40.00 (39.22)^c	36.50 (37.16)^c	30.00 (33.23)^c	26.00 (30.64)^c
10^8	50.50 (45.21)^b	54.00 (47.29)^a	41.00 (39.80)^{ab}	38.50 (38.34)^a	46.00 (42.70)^b	44.00 (41.55)^b	40.00 (39.22)^b	32.00 (34.44)^b	45.50 (42.41)^b	40.50 (39.52)^b	34.50 (35.96)^b	30.50 (33.51)^b
10^9	64.00 (53.13)^a	59.00 (50.19)^a	46.00 (42.70)^a	42.00 (40.39)^a	52.00 (46.14)^a	48.50 (44.13)^a	44.00 (41.54)^a	39.00 (38.64)^a	49.50 (44.71)^a	44.00 (41.55)^a	40.00 (39.22)^a	34.50 (35.96)^a
Control	0.50 (4.05)^c	0.50 (4.05)^c	0.50 (4.05)^d	0.50 (4.05)^c	0.50 (4.05)^e	0.50 (4.05)^e	0.50 (4.05)^e	0.50 (4.05)^e	0.50 (4.05)^e	0.50 (4.05)^e	0.50 (4.05)^e	0.50 (4.05)^e

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

4.4.2. Multivoltine races

Pure Mysore

Though a similar trend of increased fungal infection with increase in spore loads and decreased fungal infection with increase in the spacing was noted, in some of the instars and spacing certain treatments were on par. For example, in third instar under 10 sq.ft. spacing, the spore loads of 10^9 and 10^8 were on par. Similar situation was noted in fourth instar under 45 sq.ft. and 180 sq.ft. spacings. But for these differences, the overall trend was the same (Table 17).

Tamil Nadu White

The fungal infection was influenced both by spore load and rearing space. In the former, the fungal infection increased with the increase in spore load while in the latter higher spacing resulted in lower fungal infection. Again in certain instances, statistical parity was noted (Table 18).

Though all the five races studied were influenced by the various conditions, the bivoltine races were more susceptible than the multivoltine races.

Table 17. Effect of spacing on white muscardine fungal infection - Pure Mysore

Spore load/ ml	Fungal infection (%)*											
	Third instar				Fourth instar				Fifth instar			
	10 Sq.ft.	15 Sq.ft.	45 Sq.ft.	60 Sq.ft.	30 Sq.ft.	45 Sq.ft.	60 Sq.ft.	180 Sq.ft.	50 Sq.ft.	60 Sq.ft.	180 Sq.ft.	360 Sq.ft.
10^6	38.00 (38.05)^{c}	32.00 (34.42)^{c}	20.50 (26.90)^{d}	17.00 (24.30)^{d}	27.00 (31.28)^{c}	19.50 (25.92)^{c}	18.00 (25.08)^{c}	12.50 (20.66)^{c}	25.50 (30.29)^{c}	20.50 (26.86)^{d}	15.50 (23.15)^{d}	11.00 (19.27)^{d}
10^7	42.50 (40.67)^{b}	37.00 (37.45)^{b}	24.50 (29.62)^{c}	20.50 (26.86)^{c}	30.50 (33.51)^{bc}	26.50 (30.97)^{b}	23.50 (28.98)^{b}	16.50 (23.87)^{b}	28.00 (31.92)^{c}	25.50 (30.31)^{c}	19.50 (26.14)^{c}	15.50 (23.15)^{c}
10^8	47.00 (43.27)^{a}	40.50 (39.51)^{ab}	29.50 (32.56)^{b}	24.00 (29.32)^{b}	34.50 (35.95)^{b}	31.50 (34.13)^{a}	26.50 (30.95)^{b}	21.50 (27.57)^{a}	32.50 (34.74)^{b}	29.50 (32.88)^{b}	23.50 (28.95)^{b}	19.00 (25.80)^{b}
10^9	50.50 (45.28)^{a}	42.50 (40.68)^{a}	35.00 (36.26)^{a}	28.50 (32.24)^{a}	39.50 (38.92)^{a}	35.00 (36.26)^{a}	31.50 (34.11)^{a}	22.50 (28.29)^{a}	36.50 (37.15)^{a}	33.50 (35.34)^{a}	27.50 (31.61)^{a}	22.50 (28.29)^{a}
Control	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{e}	0.50 (4.05)^{e}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{e}	0.50 (4.05)^{e}	0.50 (4.05)^{e}

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Table 18. Effect of spacing on white muscardine fungal infection - Tamil Nadu White

Spore load/ ml	Fungal infection (%)*											
	Third instar				Fourth instar				Fifth instar			
	10 Sq.ft.	15 Sq.ft.	45 Sq.ft.	60 Sq.ft.	30 Sq.ft.	45 Sq.ft.	60 Sq.ft.	180 Sq.ft.	50 Sq.ft.	60 Sq.ft.	180 Sq.ft.	360 Sq.ft.
10^6	40.50 (39.51)^{c}	37.00 (37.45)^{b}	24.50 (29.62)^{c}	21.00 (27.24)^{c}	31.50 (34.11)^{c}	27.50 (31.59)^{c}	23.50 (28.95)^{d}	17.00 (24.30)^{c}	29.50 (32.87)^{b}	25.00 (29.97)^{b}	19.50 (26.14)^{c}	14.50 (22.32)^{c}
10^7	46.50 (42.98)^{b}	36.50 (36.93)^{b}	29.50 (32.88)^{b}	24.50 (29.62)^{bc}	35.50 (36.55)^{b}	31.50 (34.11)^{b}	27.50 (31.59)^{c}	21.50 (27.60)^{b}	33.00 (35.04)^{b}	28.50 (32.25)^{b}	23.50 (28.95)^{b}	19.50 (26.14)^{b}
10^8	50.50 (45.28)^{ab}	45.50 (42.41)^{a}	33.50 (35.34)^{b}	29.00 (32.56)^{ab}	39.50 (38.92)^{ab}	34.50 (35.96)^{a}	31.50 (34.11)^{b}	24.50 (29.64)^{b}	37.50 (37.74)^{a}	33.50 (35.34)^{a}	26.00 (30.64)^{b}	23.00 (28.63)^{a}
10^9	54.00 (47.29)^{a}	49.50 (44.71)^{a}	39.50 (38.92)^{a}	33.50 (35.34)^{a}	42.50 (40.68)^{a}	39.00 (38.63)^{a}	35.50 (36.55)^{a}	29.50 (32.87)^{a}	40.50 (39.51)^{a}	37.50 (37.74)^{a}	31.50 (34.11)^{a}	25.50 (30.31)^{a}
Control	0.50 (4.05)^{d}	0.50 (4.05)^{c}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{d}	0.50 (4.05)^{e}	0.50 (4.05)^{d}	0.50 (4.05)^{c}	0.50 (4.05)^{c}	0.50 (4.05)^{d}	0.50 (4.05)^{d}

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

4.5. Effect of lime on white muscardine fungal infection

The data collected on the effect of lime on fungal infection at four different spore loads, three different instars of larvae of five silkworm races are presented. The results of experiments showed that the fungal infection was always less, when lime was applied over the silkworm after inoculation of the fungal spores. Comparatively higher fungal infection was noted on the inoculated larvae which had not received the lime treatment. Such a situation was noticed in all the races and all the instars studied under different spore loads.

4.5.1. Bivoltine races

Kalimpong A (KA)

In this race, the third, fourth and fifth instar larvae showed lower fungal infection when treated with lime, while the fungal infection was higher when the larvae were not treated with lime. An increase in fungal infection concomitant with the increase in the spore load was noted irrespective of whether the larvae were treated with lime or not. Similarly the fungal infection was the highest in fifth instar larvae followed by fourth and third instar larvae. In third instar in lime treatment, the fungal infection ranged from 43.00 to 61.00 per cent while in the larvae which had not received the lime

treatment, it was 55.00 to 71.00 per cent. The range of fungal infection in fourth instar was 46.00 to 71.00 per cent in lime treatment and 59.00 to 84.50 per cent in without lime. The per cent fungal infection in fifth instar ranged from 54.00 to 76.00 in lime treatment and 65.00 to 91.00 in without lime (Table 19).

NB_{18}

In this race also, lime treatment resulted in lower fungal infection viz., 33.00 to 53.50 per cent in third instar, 39.00 to 60.00 per cent in fourth instar and 47.00 to 69.50 per cent in fifth instar. Higher fungal infection ranging from 56.00 to 80.50 per cent was recorded in fifth instar larvae not treated with lime. The fungal infection picture with reference to other parameters were as follows: fifth instar > fourth instar > third instar and $10^9 > 10^8 > 10^7 > 10^6$ spores/ml (Table 20).

NB_4D_2

When the larvae were treated with lime, they recorded lower fungal infection ranging from 38.50 to 72.00 per cent than those larvae which had not been treated with lime in which the fungal infection per cent ranged from 50.00 to 86.00. In all the instars, with increase in spore load there was an increase in the fungal infection both with lime and without lime. Among the

Table 19. Effect of lime on white muscardine fungal infection - Kalimpong A (KA)

Spore load/ ml	Fungal infection (%)*					
	Third instar		Fourth instar		Fifth instar	
	With lime	Without lime	With lime	Without lime	With lime	Without lime
10^6	43.00 (40.97)^d	55.00 (47.87)^d	46.00 (42.70)^d	59.00 (50.19)^d	54.00 (47.29)^c	65.00 (53.73)^d
10^7	47.00 (43.27)^c	59.00 (50.19)^c	53.00 (46.72)^c	68.00 (55.55)^c	58.50 (49.89)^c	71.00 (57.43)^c
10^8	55.00 (47.87)^b	66.00 (54.33)^b	61.50 (51.66)^b	73.00 (58.71)^b	71.00 (57.43)^b	79.00 (62.75)^b
10^9	61.00 (51.36)^a	71.00 (57.43)^a	71.00 (57.43)^a	84.50 (66.84)^a	76.00 (60.67)^a	91.00 (72.83)^a

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Table 20. Effect of lime on white muscardine fungal infection - NB_{18}

Spore load/ ml	Fungal infection (%)*					
	Third instar		Fourth instar		Fifth instar	
	With lime	Without lime	With lime	Without lime	With lime	Without lime
10^6	33.00 (35.04)^d	46.00 (42.69)^c	39.00 (38.63)^d	50.00 (45.00)^d	47.00 (43.27)^c	56.00 (48.45)^d
10^7	41.00 (39.80)^c	52.50 (46.43)^b	45.00 (42.12)^c	59.00 (50.19)^c	50.00 (45.00)^c	62.50 (52.25)^c
10^8	47.00 (43.27)^b	58.50 (49.89)^a	50.00 (44.99)^b	64.50 (53.43)^b	59.00 (50.19)^b	70.00 (56.80)^b
10^9	53.50 (47.01)^a	61.00 (51.35)^a	60.00 (50.78)^a	75.50 (60.37)^a	69.50 (56.50)^a	80.50 (63.96)^a

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

instars, fifth instar recorded the highest fungal infection followed by fourth and third instars (Table 21).

4.5.2. Multivoltine races

Pure Mysore

In Pure Mysore race in the third instar larvae treated with lime, the fungal infection was the highest (37%) at 10^9 spores/ml followed by 10^8 spores/ml (33.50%) and these two were on par. The spore loads of 10^7 and 10^6 were on par with 25.00 and 21.00 per cent fungal infection, respectively.

The same trend with higher fungal infection ranging from 35.00 to 51.50 per cent was noticed, when there was no lime treatment on third instar larvae. In the case of fourth and fifth instar larvae, the fungal infection ranged from 26.00 to 51.50 and 37.00 to 59.50 per cent respectively, in larvae which received lime treatment and all the spore loads were independent statistically. Similar trend with higher fungal infection was noticed in the larvae which had not received lime treatment (Table 22).

Table 21. Effect of lime on white muscardine fungal infection - NB_4D_2

Spore load/ ml	Fungal infection (%)*					
	Third instar		Fourth instar		Fifth instar	
	With lime	Without lime	With lime	Without lime	With lime	Without lime
10^6	38.50 (38.34)^d	50.00 (44.99)^c	45.00 (42.12)^c	54.50 (47.58)^c	50.00 (44.99)^c	61.00 (51.36)^d
10^7	43.00 (40.97)^c	55.00 (47.87)^b	48.00 (43.85)^c	65.50 (54.04)^b	55.00 (47.87)^c	67.50 (55.25)^c
10^8	50.00 (45.00)^b	63.00 (52.56)^a	54.50 (47.58)^b	69.50 (56.48)^b	64.50 (53.43)^b	75.00 (60.02)^b
10^9	57.00 (49.02)^a	66.50 (54.66)^a	65.50 (54.04)^a	79.50 (63.13)^a	72.00 (58.07)^a	86.00 (68.10)^a

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Table 22. Effect of lime on white muscardine fungal infection - Pure Mysore

Spore load/ ml	Fungal infection (%)*					
	Third instar		Fourth instar		Fifth instar	
	With lime	Without lime	With lime	Without lime	With lime	Without lime
10^6	21.00 (27.24)^b	35.00 (36.26)^b	26.00 (30.61)^d	40.00 (39.22)^d	37.00 (37.44)^d	47.00 (43.27)^d
10^7	25.00 (29.97)^b	39.50 (38.91)^b	33.50 (35.34)^c	49.00 (44.42)^c	43.00 (40.97)^c	55.00 (47.87)^c
10^8	33.50 (35.34)^a	47.00 (43.27)^a	40.50 (39.50)^b	55.00 (47.87)^b	48.50 (44.13)^b	61.50 (51.66)^b
10^9	37.00 (37.45)^a	51.50 (45.86)^a	51.50 (45.86)^a	65.50 (54.04)^a	59.50 (50.49)^a	73.50 (59.05)^a

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Tamil Nadu White

In third instar larvae, there was a progressive fungal infection as the spore load increased ranging from 28.50 per cent in 10^6 spores/ml to 47.50 per cent in 10^9 spores/ml. All the treatments were significantly different. The fungal infection was on par in 10^9 (59.00%) and 10^8 spores/ml (55.50%) and the other two treatments were independent in the fourth and fifth instars. Fungal infection increased as the spore load increased both in lime treatment and without lime (Table 23).

The above results have shown that lime treatment reduced fungal infection in all the races and instars studied and at all the spore loads of the fungus. The bivoltines had higher fungal infection than multivoltine races.

4.6. Effect of fungicides on white muscardine fungal infection

The results of the experiments conducted with four fungicides namely, Dithane M-45, Thiram, Cuman L and Kavach at two concentrations of 1 and 2 per cent compared with an untreated control on the fungal infection at different spore loads on the third, fourth and fifth instars of five silkworm races are presented.

Table 23. Effect of lime on white muscardine fungal infection - Tamil Nadu White

Spore load/ ml	Fungal infection (%)*					
	Third instar		Fourth instar		Fifth instar	
	With lime	Without lime	With lime	Without lime	With lime	Without lime
10^6	28.50 (32.25)^d	40.00 (39.21)^c	33.50 (35.34)^d	47.00 (43.27)^d	42.50 (40.68)^c	52.50 (46.43)^d
10^7	35.00 (36.26)^c	49.50 (44.71)^b	41.00 (39.80)^c	55.50 (48.16)^c	46.00 (42.70)^c	59.00 (50.19)^c
10^8	41.50 (40.10)^b	55.50 (48.16)^a	47.00 (43.27)^b	61.00 (51.36)^b	55.50 (48.16)^b	67.50 (55.26)^b
10^9	47.50 (43.56)^a	59.00 (50.19)^a	57.50 (49.31)^a	71.50 (57.76)^a	65.00 (53.73)^a	76.00 (60.73)^a

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

In all the five races among the treatments, Dithane M-45 at 2 per cent recorded the lowest fungal infection. Among the instars, maximum fungal infection was noted in fifth instar followed by fourth and third instars. Within an instar, as the fungal spores increased from 10^6 to 10^9, the fungal infection also increased. Untreated control always recorded the highest fungal infection.

4.6.1. Bivoltine races

Kalimpong A (KA)

In this race the fungal infection was the lowest (34.70%) in third instar at 10^6 spore load in Dithane M-45 at 2 per cent level. Kavach at 1 per cent recorded the highest fungal infection of 68.00 per cent at 10^9 spore load, among the fungicides tested. The per cent fungal infection ranged from 34.70 (Dithane M-45 2%) to 54.70 (Kavach 1%) in the third instar larvae at 10^6 spore load. In 10^7, the range was 40.00 per cent (Dithane M-45 2%) to 61.30 per cent (Kavach 1%). Similarly at 10^8 and 10^9 spore loads also, Dithane M-45 at 2 per cent recorded the lowest fungal infection (44.70 and 50.70%) and Kavach at 1 per cent recorded the highest (65.30 and 68.00%). Untreated control recorded the highest fungal infection in all the cases. In the fifth instar also, the same trend was noted namely, among the fungicide treatments, Dithane M-45 at 2 per cent recorded the

lowest fungal infection while Kavach at 1 per cent recorded the highest fungal infection. Dithane M-45 (1 per cent) and Thiram (2 per cent) were next in order to Dithane M-45 (2 per cent) in respect of fungal infection in all the instars and all the spore loads (Table 24).

NB_{18}

The lowest fungal infection of 24 per cent in Dithane M-45 (2 per cent) and the highest fungal infection of 63.30 per cent in Kavach (1 per cent) was noted. Among the different spore loads, there was an increase in fungal infection with an increase in the spore load. The behaviour of the instars is indicated as follows: fifth instar > fourth instar > third instar. Dithane M-45 (1 per cent) and Thiram (2 per cent) were next in merit with regard to fungal infection (Table 25).

NB_4D_2

Dithane M-45 (2 per cent) recorded the lowest fungal infection at all the spore loads and among the instars. Kavach (1 per cent) recorded the highest fungal infection among the fungicide treatments in all the cases. The picture with reference to spore load was $10^9 > 10^8 > 10^7 > 10^6$; among the instars third instar < fourth instar < fifth instar (Table 26).

Table 24. Effect of fungicides on white muscardine fungal infection - Kalimpong A (KA)

Fungicides	Third instar				Fourth instar				Fifth instar			
	Spore load/ml				Spore load/ml				Spore load/ml			
	10^6	10^7	10^8	10^9	10^6	10^7	10^8	10^9	10^6	10^7	10^8	10^9
Dithane M-45 1%	38.70 (38.44)^{de}	44.70 (41.93)^{de}	51.30 (45.77)^{c}	54.70 (47.68)^{de}	42.70 (40.78)^{de}	48.70 (44.24)^{ef}	53.30 (46.92)^{de}	59.30 (50.39)^{de}	46.70 (43.09)^{de}	51.40 (46.92)^{ef}	60.00 (50.78)^{de}	63.30 (52.75)^{de}
Dithane M-45 2%	34.70 (36.06)^{e}	40.00 (39.23)^{e}	44.70 (41.93)^{d}	50.70 (45.38)^{e}	38.70 (38.44)^{e}	44.70 (41.93)^{f}	49.30 (44.62)^{e}	54.70 (47.75)^{e}	42.70 (40.78)^{e}	49.30 (44.62)^{f}	53.30 (46.92)^{e}	59.30 (50.39)^{e}
Thiram 1%	44.70 (41.94)^{cd}	49.30 (44.62)^{cd}	54.70 (47.68)^{c}	58.70 (50.00)^{cd}	49.30 (44.62)^{cd}	52.70 (46.53)^{de}	59.30 (50.39)^{cd}	63.30 (52.75)^{cd}	53.30 (46.92)^{cd}	56.70 (48.84)^{def}	63.30 (52.75)^{cd}	67.30 (55.17)^{cd}
Thiram 2%	38.70 (38.44)^{de}	45.30 (42.32)^{de}	50.70 (45.38)^{cd}	56.70 (48.84)^{de}	44.70 (41.93)^{de}	49.30 (44.62)^{ef}	52.70 (45.53)^{de}	59.30 (50.39)^{de}	48.00 (43.84)^{de}	53.30 (46.92)^{ef}	59.30 (50.39)^{de}	63.30 (52.75)^{de}
Cuman L 1%	48.70 (44.24)^{bc}	55.30 (48.07)^{bc}	61.30 (51.57)^{ab}	66.70 (54.78)^{b}	56.70 (48.85)^{ab}	58.70 (50.00)^{cd}	65.30 (53.95)^{bc}	71.30 (57.69)^{b}	57.30 (49.23)^{bc}	63.30 (52.75)^{bcd}	69.30 (56.41)^{bc}	74.70 (59.81)^{b}
Cuman L 2%	45.30 (42.32)^{c}	50.70 (45.38)^{cd}	57.30 (49.23)^{bc}	63.30 (52.75)^{bc}	48.70 (44.24)^{cd}	55.30 (48.07)^{c}	61.30 (51.57)^{c}	64.70 (53.54)^{cd}	54.00 (47.30)^{cd}	59.30 (50.39)^{cde}	65.30 (53.95)^{cd}	70.70 (57.23)^{bc}
Kavach 1%	54.70 (47.68)^{ab}	61.30 (51.57)^{ab}	65.30 (53.95)^{a}	68.00 (55.58)^{ab}	58.70 (50.00)^{ab}	65.30 (53.95)^{ab}	68.70 (56.01)^{ab}	73.30 (58.92)^{ab}	63.30 (52.75)^{b}	69.30 (56.41)^{ab}	72.70 (58.50)^{b}	76.70 (61.15)^{b}
Kavach 2%	51.30 (45.77)^{bc}	57.30 (49.23)^{b}	61.30 (51.57)^{ab}	64.70 (53.59)^{bc}	54.70 (47.68)^{bc}	61.30 (59.57)^{bc}	65.30 (53.95)^{bc}	69.30 (56.41)^{bc}	58.70 (50.00)^{bc}	65.30 (53.95)^{bc}	68.70 (55.98)^{bc}	73.30 (58.96)^{bc}
Control	59.30 (50.39)^{a}	65.30 (53.95)^{a}	66.00 (54.34)^{a}	73.30 (58.96)^{a}	63.30 (52.75)^{a}	69.30 (56.41)^{a}	73.30 (58.96)^{a}	77.30 (61.63)^{a}	69.70 (56.73)^{a}	72.70 (58.50)^{a}	78.70 (62.53)^{a}	83.30 (66.02)^{a}

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Table 25. Effect of fungicides on white muscardine fungal infection - NB_{18}

Fungicides	Third instar				Fourth instar				Fifth instar			
	Spore load/ml				Spore load/ml				Spore load/ml			
	10^6	10^7	10^8	10^9	10^6	10^7	10^8	10^9	10^6	10^7	10^8	10^9
Dithane M-45 1%	30.70 (33.61)^{d}	34.70 (36.05)^{e}	40.70 (39.61)^{d}	46.00 (42.70)^{c}	35.30 (36.46)^{ef}	38.70 (38.44)^{fg}	44.00 (41.55)^{de}	50.70 (45.38)^{e}	38.70 (38.44)^{de}	44.70 (41.93)^{ef}	50.70 (45.38)^{de}	54.70 (47.68)^{c}
Dithane M-45 2%	24.00 (29.32)^{e}	33.30 (35.26)^{e}	34.70 (36.05)^{e}	40.00 (39.23)^{d}	31.30 (34.01)^{f}	34.00 (35.65)^{g}	38.70 (38.44)^{e}	42.70 (40.78)^{e}	34.70 (36.06)^{e}	40.00 (39.22)^{f}	44.70 (41.93)^{e}	52.00 (46.15)^{c}
Thiram 1%	37.30 (36.66)^{c}	43.30 (41.16)^{cd}	46.00 (42.70)^{d}	50.70 (45.38)^{bc}	40.70 (39.60)^{cde}	47.30 (43.47)^{cde}	48.70 (44.24)^{cd}	56.70 (48.85)^{cde}	44.00 (41.55)^{cd}	50.70 (45.38)^{cde}	56.70 (48.84)^{cd}	61.30 (51.57)^{b}
Thiram 2%	30.70 (33.61)^{d}	38.70 (38.43)^{de}	42.70 (40.77)^{d}	46.00 (42.70)^{c}	37.30 (37.64)^{def}	42.70 (40.78)^{ef}	46.70 (43.09)^{d}	52.00 (46.15)^{e}	39.30 (38.81)^{de}	47.30 (43.47)^{de}	50.70 (45.38)^{de}	54.70 (47.68)^{c}
Cuman L 1%	40.70 (39.61)^{c}	48.70 (44.23)^{bc}	54.00 (47.30)^{b}	61.30 (51.56)^{a}	46.70 (43.09)^{bc}	52.70 (46.53)^{bcd}	57.30 (49.23)^{bc}	61.30 (51.57)^{bcd}	50.00 (45.00)^{bc}	56.70 (48.84)^{bc}	61.30 (51.57)^{bc}	65.30 (53.95)^{b}
Cuman L 2%	36.00 (36.86)^{c}	43.30 (41.16)^{cd}	46.70 (43.09)^{cd}	53.30 (46.91)^{b}	40.70 (39.61)^{cde}	46.00 (42.70)^{def}	54.70 (47.68)^{bc}	54.00 (47.30)^{de}	44.00 (41.55)^{cd}	51.30 (45.76)^{cd}	56.00 (48.45)^{cd}	61.30 (51.57)^{b}
Kavach 1%	47.30 (43.47)^{b}	52.00 (46.15)^{b}	57.30 (49.22)^{ab}	63.30 (52.74)^{a}	50.00 (45.00)^{ab}	57.30 (49.23)^{ab}	61.30 (51.60)^{b}	67.30 (55.17)^{ab}	52.70 (46.53)^{ab}	61.30 (51.57)^{b}	65.30 (53.95)^{b}	71.30 (57.72)^{a}
Kavach 2%	40.70 (39.61)^{c}	47.30 (43.47)^{bc}	52.00 (46.15)^{bc}	54.00 (47.30)^{b}	44.70 (41.93)^{bcd}	54.70 (47.68)^{bc}	58.00 (49.64)^{b}	63.30 (52.75)^{bc}	48.00 (43.85)^{bc}	55.30 (48.07)^{bc}	56.70 (48.84)^{cd}	65.30 (53.95)^{b}
Control	53.30 (46.92)^{a}	59.30 (50.39)^{a}	60.70 (51.18)^{a}	66.00 (54.38)^{a}	56.70 (48.84)^{a}	64.00 (53.17)^{a}	69.30 (56.41)^{a}	73.00 (58.96)^{a}	56.70 (48.84)^{a}	67.30 (55.17)^{a}	71.30 (57.67)^{a}	74.00 (59.35)^{a}

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Table 26. Effect of fungicides on white muscardine fungal infection - NB_4D_2

Fungicides	Third instar				Fourth instar				Fifth instar			
	Spore load/mm				Spore load/mm				Spore load/mm			
	10^6	10^7	10^8	10^9	10^6	10^7	10^8	10^9	10^6	10^7	10^8	10^9
Dithane M-45 1%	34.00 (35.66)^{de}	40.70 (39.61)^{cd}	47.70 (43.47)^{de}	50.70 (45.38)^{de}	38.70 (38.44)^{d}	44.70 (41.93)^{d}	51.30 (45.77)^{ef}	56.70 (48.84)^{d}	42.70 (40.78)^{de}	48.70 (44.23)^{de}	56.00 (48.45)^{de}	58.70 (50.00)^{d}
Dithane M-45 2%	30.00 (33.20)^{e}	36.70 (37.26)^{d}	40.70 (39.61)^{e}	44.70 (41.93)^{de}	32.00 (34.42)^{e}	39.30 (38.84)^{d}	44.70 (44.68)^{g}	50.70 (40.78)^{e}	38.00 (36.05)^{e}	45.30 (39.32)^{e}	50.70 (41.38)^{e}	55.30 (48.07)^{d}
Thiram 1%	42.00 (40.39)^{c}	44.70 (41.93)^{bcd}	54.70 (47.68)^{bcd}	57.30 (49.23)^{cd}	44.70 (41.93)^{c}	51.30 (45.77)^{c}	54.70 (47.24)^{def}	62.70 (52.35)^{cd}	48.70 (44.24)^{cd}	54.00 (47.30)^{cd}	59.30 (50.39)^{cd}	65.30 (53.95)^{c}
Thiram 2%	33.30 (35.26)^{de}	38.70 (38.44)^{cd}	44.70 (41.93)^{e}	50.70 (45.38)^{de}	38.70 (38.44)^{d}	44.70 (41.93)^{d}	48.70 (44.24)^{fg}	57.30 (49.22)^{cd}	43.30 (41.16)^{de}	50.70 (45.38)^{de}	55.30 (48.07)^{de}	58.70 (50.00)^{d}
Cuman L 1%	44.00 (41.55)^{bc}	50.70 (45.38)^{ab}	56.70 (48.84)^{abc}	62.70 (52.35)^{bc}	51.30 (45.77)^{b}	54.70 (47.68)^{c}	61.30 (51.57)^{bc}	68.70 (55.99)^{ab}	54.70 (47.68)^{bc}	59.30 (50.39)^{bc}	65.30 (53.95)^{bc}	69.30) (56.41)^{c}
Cuman L 2%	38.70 (38.44)^{cd}	46.70 (43.09)^{abc}	52.70 (46.53)^{cd}	57.30 (49.23)^{cd}	44.70 (41.93)^{c}	50.70 (45.38)^{c}	56.70 (48.84)^{cde}	60.00 (50.80)^{cd}	50.00 (45.00)^{c}	54.70 (47.68)^{cd}	61.30 (51.37)^{cd}	65.30 (53.95)^{c}
Kavach 1%	50.70 (45.38)^{ab}	53.30 (46.91)^{a}	61.30 (51.57)^{ab}	65.30 (53.95)^{ab}	54.70 (47.68)^{ab}	61.30 (51.57)^{b}	65.30 (53.95)^{b}	69.30 (56.41)^{a}	59.30 (50.39)^{ab}	65.30 (53.95)^{b}	68.00 (55.56)^{b}	75.30 (60.28)^{ab}
Kavach 2%	46.70 (43.09)^{bc}	49.30 (44.62)^{ab}	57.30 (49.23)^{abc}	61.30 (51.57)^{bc}	50.70 (45.38)^{b}	52.70 (46.53)^{c}	69.30 (50.39)^{bcd}	63.30 (52.75)^{bc}	55.30 (48.07)^{bc}	59.30 (50.39)^{bc}	66.30 (52.75)^{bc}	71.30 (57.67)^{bc}
Control	55.30 (48.07)^{a}	51.30 (45.72)^{ab}	64.00 (53.15)^{a}	70.70 (57.23)^{a}	58.70 (50.00)^{a}	67.30 (55.17)^{a}	71.30 (57.67)^{a}	74.00 (59.35)^{a}	65.30 (53.95)^{a}	71.30 (57.67)^{a}	74.00 (59.35)^{a}	79.30 (63.04)^{a}

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

4.6.2. Multivoltine races

Pure Mysore

In this race also, among the fungicide treatments, Dithane M-45 (2 per cent) recorded the lowest fungal infection in all the instars and at all the spore loads while Kavach (1 per cent) recorded the highest fungal infection among the fungicides. Dithane M-45 (1 per cent) was next in order with reference to lower fungal infection after Dithane M-45 (2 per cent). The manifestation of fungal infection increased with increase in spore load and decreased as the larvae advanced in instar (Table 27).

Tamil Nadu White

The trend of the lowest fungal infection in Dithane M-45 (2 per cent) in all the instars and at all the spore loads as well as the highest fungal infection among the fungicides in Kavach (1 per cent) was maintained in this race also. The fungal infection with reference to spore load was $10^9 > 10^8 > 10^7 > 10^6$ and in case of instars it was fifth instar > fourth instar > third instar (Table 28).

Among the five races, bivoltine races recorded higher fungal infection irrespective of the fungicide treatments, spore load and larval instars than multivoltine races.

Table 27. Effect of fungicides on white muscardine fungal infection - Pure Mysore

Fungicides	Third instar				Fourth instar				Fifth instar			
	Spore load/ml				Spore load/ml				Spore load/ml			
	10^6	10^7	10^8	10^9	10^6	10^7	10^8	10^9	10^6	10^7	10^8	10^9
Dithane M-45 1%	23.30 (28.85)^{de}	26.00 (30.65)^{e}	30.70 (33.61)^{ef}	38.00 (38.05)^{de}	27.30 (31.48)^{de}	30.70 (33.61)^{ef}	36.70 (37.27)^{e}	44.70 (41.93)^{def}	32.00 (34.44)^{e}	37.30 (37.65)^{d}	42.00 (40.39)^{d}	50.70 (45.38)^{de}
Dithane M-45 2%	17.30 (24.60)^{f}	22.70 (28.37)^{e}	26.00 (30.65)^{g}	32.00 (34.44)^{f}	20.00 (26.55)^{f}	26.00 (30.65)^{f}	30.70 (33.61)^{f}	31.30 (33.83)^{g}	27.30 (31.50)^{f}	32.00 (34.44)^{e}	39.30 (38.83)^{d}	44.00 (41.55)^{f}
Thiram 1%	26.70 (31.07)^{d}	31.30 (34.04)^{d}	36.70 (37.27)^{cd}	43.30 (41.16)^{bc}	30.00 (33.20)^{de}	37.30 (37.65)^{cd}	40.00 (39.23)^{de}	46.00 (42.70)^{de}	34.70 (36.06)^{cd}	42.00 (40.39)^{cd}	48.00 (43.85)^{bc}	53.30 (46.91)^{cd}
Thiram 2%	20.00 (26.55)^{ef}	25.30 (30.19)^{e}	28.70 (32.35)^{fg}	34.70 (36.06)^{ef}	26.00 (30.65)^{e}	30.00 (33.20)^{ef}	36.70 (37.26)^{e}	40.00 (39.23)^{f}	30.70 (33.60)^{ef}	38.00 (38.04)^{d}	42.70 (40.78)^{d}	47.30 (43.47)^{ef}
Cuman L 1%	32.00 (34.44)^{c}	37.30 (37.66)^{bc}	41.30 (40.00)^{bc}	44.00 (41.55)^{bc}	37.30 (37.65)^{bc}	42.00 (40.39)^{bc}	46.00 (42.70)^{bc}	52.00 (46.15)^{bc}	41.30 (40.00)^{c}	46.00 (42.70)^{c}	50.70 (45.38)^{b}	58.00 (49.61)^{bc}
Cuman L 2%	26.00 (30.65)^{d}	31.30 (34.02)^{d}	34.70 (36.06)^{de}	40.00 (39.23)^{cd}	32.00 (34.44)^{cd}	34.00 (35.66)^{de}	43.30 (41.16)^{cd}	44.00 (41.55)^{ef}	37.30 (37.65)^{cd}	41.30 (40.00)^{cd}	44.00 (41.55)^{cd}	48.70 (44.24)^{def}
Kavach 1%	37.30 (37.65)^{b}	40.70 (39.61)^{b}	44.70 (41.93)^{b}	48.00 (43.85)^{b}	42.00 (40.39)^{ab}	46.00 (42.70)^{ab}	51.30 (45.76)^{ab}	56.00 (48.45)^{b}	46.00 (42.70)^{b}	52.00 (46.15)^{b}	56.00 (48.45)^{a}	61.30 (51.55)^{b}
Kavach 2%	31.30 (34.02)^{c}	34.70 (36.05)^{cd}	38.00 (38.05)^{cd}	42.00 (40.39)^{cd}	37.30 (37.64)^{bc}	42.00 (40.39)^{bc}	46.00 (42.70)^{bc}	50.00 (45.00)^{cd}	44.00 (39.22)^{c}	44.70 (41.93)^{c}	49.30 (44.62)^{b}	53.30 (46.92)^{cd}
Control	43.30 (41.16)^{a}	47.30 (43.47)^{a}	52.00 (46.15)^{a}	54.70 (47.30)^{a}	46.00 (42.70)^{a}	50.70 (45.38)^{a}	56.00 (48.45)^{a}	63.00 (52.74)^{a}	52.70 (46.53)^{a}	56.70 (48.84)^{a}	60.00 (50.78)^{a}	66.00 (54.34)^{a}

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Table 28. Effect of fungicides on white muscardine fungal infection - Tamil Nadu White

Fungicides	Third instar				Fourth instar				Fifth instar			
	Spore load/ml				Spore load/ml				Spore load/ml			
	10^6	10^7	10^8	10^9	10^6	10^7	10^8	10^9	10^6	10^7	10^8	10^9
Dithane M-45 1%	26.70 (31.08)^{de}	30.70 (33.59)^{ef}	34.00 (35.66)^{e}	40.70 (39.61)^{de}	31.30 (34.02)^{de}	36.70 (37.26)^{efg}	38.00 (38.43)^{d}	44.00 (41.54)^{de}	36.00 (36.86)^{ef}	42.00 (40.38)^{de}	46.70 (43.08)^{ef}	50.00 (45.00)^{ef}
Dithane M-45 2%	22.70 (28.41)^{e}	26.70 (31.07)^{f}	30.70 (33.62)^{e}	36.70 (37.26)^{e}	26.00 (30.61)^{e}	31.30 (34.02)^{g}	37.30 (37.66)^{d}	39.30 (38.84)^{e}	31.30 (33.99)^{f}	36.70 (37.26)^{e}	40.70 (39.61)^{f}	45.30 (45.32)^{f}
Thiram 1%	30.70 (33.62)^{cd}	34.70 (36.05)^{de}	40.00 (39.22)^{d}	46.00 (42.70)^{cd}	35.30 (36.46)^{cd}	38.70 (38.43)^{def}	44.00 (41.54)^{cd}	50.70 (45.38)^{cd}	41.30 (40.00)^{cde}	46.70 (43.09)^{cd}	50.70 (45.38)^{de}	57.30 (49.23)^{cd}
Thiram 2%	26.00 (30.65)^{de}	30.70 (33.61)^{ef}	30.70 (33.53)^{e}	40.70 (39.60)^{de}	30.70 (33.61)^{de}	32.70 (34.84)^{fg}	39.30 (38.83)^{d}	46.00 (42.70)^{de}	36.00 (36.85)^{ef}	40.70 (39.61)^{de}	46.70 (43.09)^{ef}	51.30 (45.76)^{def}
Cuman L 1%	37.30 (37.65)^{b}	42.00 (40.39)^{bc}	46.70 (43.09)^{bc}	52.70 (46.53)^{b}	42.00 (40.39)^{bc}	46.70 (43.08)^{bc}	52.00 (46.15)^{b}	57.30 (49.23)^{bc}	46.70 (43.08)^{bc}	53.30 (46.91)^{b}	57.30 (49.22)^{bc}	61.30 (51.59)^{bc}
Cuman L 2%	32.00 (34.42)^{c}	37.30 (37.65)^{cd}	42.70 (40.78)^{cd}	45.30 (42.32)^{cd}	36.00 (36.86)^{cd}	42.70 (40.77)^{cde}	48.70 (44.23)^{bc}	50.70 (45.38)^{cd}	40.00 (39.23)^{de}	46.70 (43.09)^{cd}	51.30 (45.76)^{cde}	56.00 (48.45)^{cde}
Kavach 1%	42.00 (40.39)^{ab}	44.70 (41.93)^{b}	50.00 (45.00)^{b}	54.70 (47.68)^{b}	46.70 (43.08)^{ab}	50.00 (45.00)^{ab}	55.30 (48.07)^{ab}	60.00 (50.78)^{ab}	51.30 (45.76)^{ab}	56.70 (48.84)^{b}	61.30 (51.56)^{b}	66.70 (54.74)^{b}
Kavach 2%	38.70 (38.44)^{b}	40.70 (39.62)^{bc}	46.00 (42.70)^{bc}	50.00 (45.00)^{bc}	40.00 (39.21)^{bc}	44.70 (41.93)^{bcd}	51.30 (45.76)^{b}	64.00 (47.30)^{bc}	42.70 (40.78)^{cd}	51.30 (45.77)^{bc}	56.00 (48.45)^{bcd}	62.00 (51.95)^{bc}
Control	47.30 (43.47)^{a}	52.30 (46.15)^{a}	57.30 (49.22)^{a}	62.00 (51.95)^{a}	51.30 (45.77)^{a}	56.00 (48.45)^{a}	60.00 (50.77)^{a}	65.30 (53.98)^{a}	56.70 (48.84)^{a}	62.70 (52.35)^{a}	67.30 (55.18)^{a}	72.70 (58.50)^{a}

* Mean of four replications

Figures in parentheses are angular transformed values.

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

DISCUSSION

5. DISCUSSION

5.1. Survey on white muscardine infection

The preliminary survey conducted in the districts of Dharmapuri, Salem and Coimbatore in the private sericulture units revealed that the infection by white muscardine fungus was very low in all the three districts. In Dharmapuri district, it ranged from 0.40 to 4.00 per cent while in Salem district its range was from 0.30 to 1.40 per cent. In Coimbatore district, the maximum infection was 1.50 per cent. Thus it may be seen that in these three districts in private sericulture units, the white muscardine fungal infection was not a serious problem. In Karnataka, white muscardine was reported to be a serious problem (Baig et al., 1993). More detailed systematic survey in the sericulture districts of Tamil Nadu is needed.

5.2. Relative susceptibility of silkworm races to white muscardine fungal infection

All the five races of silkworm studied were susceptible to white muscardine. The general trend was, among the third, fourth and fifth instar larvae, the per cent fungal infection progressively increased from third to fourth and fifth instars. Among the spore loads, as the spore load increased from 10^6 to 10^9, the infection per cent also increased in all the five races

studied namely, KA, NB_{18}, NB_4D_2, PM and TW. Among the bivoltine races, maximum infection was noted in the fifth instar larvae of KA race which was inoculated with the spore load of 10^9 spores/ml. The race NB_{18} recorded the lowest infection of 78.00 per cent and NB_4D_2 race was in between the two. In KA race all the three instars namely third, fourth and fifth at all the spore loads recorded the highest fungal infection compared to the other two races. Similarly in NB_{18} race, all the three instars at all the spore load concentrations recorded the lowest infection. It may be concluded that among the three bivoltine races, KA race is the most susceptible followed by NB_4D_2 and NB_{18}.

Among the two multivoltine races studied, the maximum fungal infection (76.00%) was noted with fifth instar larvae of TW race which received 10^9 spore load/ml. The fungal infection was higher in all the three instars of TW race compared to PM race.

The studies have indicated that all the five silkworm races were susceptible to B.bassiana infection. Venkataramana Reddy and Veeresh (1978b) reported that among the 11 races of silkworm screened against white muscardine disease, PM was least susceptible. In the present investigation also PM race recorded the lowest white muscardine infection. According to Raghavaiah and Jayaramaiah (1989), NB_{18} race was highly

susceptible to B.bassiana. However, in the present investigation NB_{18} race was moderately susceptible. Chinnaswamy and Devaiah (1984) reported the susceptibility of KA, NB_4D_2 and PM races to another muscardine fungus, Aspergillus tamarii. As spore loads were increased from 10^6 to 10^9/ml, the fungal infection was also increased in all the races. Increase in B.bassiana infection with increase in spore load was reported by Venkataramana Reddy and Veeresh (1978a). Among the instars, fifth instar larvae were highly susceptible compared to fourth and third instar. The higher susceptibility of fifth instar larvae to B.bassiana infection had been reported by several authors (Steinhaus, 1949; Venkataramana Reddy and Veeresh, 1978b; Raghavaiah and Jayaramaiah, 1989).

5.3. Effect of rearing bed on white muscardine fungal infection

The present investigations have very clearly indicated the superiority of newspaper bed in recording lower fungal infection compared to wax paper, polythene sheet and banana leaf in all the races, instars and spore loads.

During the survey, it was seen that several farmers used newspaper as a bed although most of them had not used any substrates for the bed. When newspaper is used, it may absorb the excess moisture and this may lead to a hygienic condition in

the rearing bed. Rajan et al. (1993) reported the usefulness of blue polythene sheet in the place of paraffin paper and Das (1994) advocated banana leaf for rearing of young age silkworm. However, these two beds resulted in higher fungal infection in the case of third, fourth and fifth instar larvae in the present investigation. Thus it is concluded that newspaper bed will be ideal for rearing the third, fourth and fifth instar larvae to reduce the fungal infection in the five silkworm races studied.

5.4. Effect of spacing on white muscardine fungal infection

When the spacing was lower, higher fungal infection was noted in all the five races of silkworms and all the instar and spore loads tried. Provision of adequate rearing space is of great importance for the vigorous and full growth of silkworms. As the worms grow in weight and size, the density in the rearing bed increases and conditions of overcrowding are faced. Therefore, it is essential that proper spacing is given. Overcrowding of silkworms in insufficient space will restrict the free movement and free feeding of the larvae. Overcrowding increases accumulation of gases, heat and fermentation of faecal matter due to high temperature and humidity in the rearing rooms. Unhygienic conditions will favour the development of fungal infection. Shimizu and Tazima (1972) and Krishnaswami et al. (1973) reported that silkworm races were sensitive to carbonic

acid gas, ammonia and other gases generated in the rearing tray. Moreover, because of the tendency of the larvae to move upward, they crawled over the leaves and fed on top thus soiling those at the bottom. In the present investigation as the spacing was increased the per cent fungal infection reduced. Higher spacing always facilitates normal movement and free feeding of the larvae. Rapusas and Gabriel (1976) reported that silkworms performed better when the larvae were reared in a spacious than in limited space. They reported that longer and broader cocoons were produced when the larvae were reared in a bigger space and rearing in crowded groups resulted in higher mortality. Wide rearing space also favoured good larval development, cocoon recovery, adult moth emergence and higher fecundity. Krishnaswami et al. (1973) recommended that ideal rearing space for commercial cocoon production was 9 sq. cm./larva during fifth instar. The present studies have shown that the ideal rearing space to reduce white muscardine will be a spacing of 60 sq.ft./100 dfls for third instar, 180 sq.ft./100 dfls for fourth instar and 360 sq.ft./100 dfls for fifth instar.

5.5. Effect of lime on white muscardine fungal infection

When lime was applied over the silkworm larvae after inoculation of the fungal spores, the manifestation of fungal infection was lower compared to the larvae which had not received

the lime treatment. Such condition was noticed in all the five races studied, the three instars and four spore loads.

Ignoffo and Dutky (1963) reported the effect of sodium hypochlorite on the viability and infectivity of Bacillus and Beauveria spores. Frobisher et al. (1974) found that 0.5 to 5.0 per cent aqueous solution of chloride of lime was excellent against muscardine disease of silkworms.

Byra Reddy et al. (1991) stated that the larval mortality due to B.bassiana fungal infection in trays treated with lime was very low. Subbarao et al. (1992) also reported the efficacy of lime and lime-bleaching powder against muscardine disease of silkworm.

5.6. Effect of fungicides on white muscardine fungal infection

From the studies with four fungicides namely, Dithane M-45, Thiram, Cuman L and Kavach at 1 and 2 per cent concentration on fungal infection at different spore loads on the third, fourth and fifth instar larvae of five races, it was noted that treatment of larvae with Dithane M-45 (2 per cent) at the rate of 3 g/ft^2 of third instar and 5 g/ft^2 for fourth and fifth instar larvae resulted in the lowest fungal infection in all the races and at all the spore loads. It was also noted that

the bivoltine races had higher fungal infection than multivoltine races.

Samson et al. (1986) reported that Dithane M-45 at 1 per cent once up to the third instar and 2 per cent during fourth and fifth instar was effective against white muscardine fungus. Soaf et al. (1994) found that Dithane M-45 at 1, 2 and 3 per cent effectively controlled muscardine disease on silkworm. They also reported that silkworms treated with Dithane M-45 showed the highest silk ratio. Chinnaswamy and Devaiah (1984) and Manjunatha Gowda (1994) reported the efficacy of Dithane M-45 against another muscardine disease, Aspergillus tamarii. In the present investigation, Thiram at 2 per cent was next in efficacy to Dithane M-45 2 per cent. This is in conformity with the results reported by Samson and Mummigutti (1979) and Siddaramaiah et al. (1979).

It may be concluded that Dithane M-45 at 2 per cent and Thiram at 2 per cent can be effectively used to minimise the infection by white muscardine fungus.

SUMMARY

6. SUMMARY

The results of the investigations carried out on the white muscardine disease of silkworm (B.mori) in the Department of Sericulture, Tamil Nadu Agricultural University, Coimbatore during 1994-96 are summarised below.

Survey

The incidence of white muscardine was very low in the districts of Dharmapuri, Salem and Coimbatore of Tamil Nadu, maximum being 4.00 per cent.

Susceptibility of races

All the five races of silkworm studied namely, KA, NB_{18}, NB_4D_2, PM and TW were susceptible to white muscardine. The bivoltine races namely, KA, NB_{18} and NB_4D_2 were more susceptible than the multivoltine races namely, PM and TW. With increase in the spore load, there was concomitant increase in fungal infection within an instar. The fungal infection was the highest in fifth instar larvae followed by fourth and third instar larvae.

In KA race, the fungal infection ranged from 38.00 to 83.50 per cent, in NB_{18} race, it was 34.00 to 78.00 per cent

while in NB_4D_2 the range was 36.00 to 80.00 per cent among the bivoltine races. PM race recorded 32.00 to 74.00 per cent and TW recorded 30.00 to 76.00 per cent fungal infection under multivoltine races.

Rearing beds

Among the four types of rearing beds studied namely, newspaper, wax paper, polythene sheet and banana leaf, the larvae reared on newspaper consistently recorded lower fungal infection. Banana leaf bed recorded the maximum fungal infection in all the instars and all the spore loads and all the races.

Spacing

In all the five races, the third, fourth and fifth instar larvae at all the spore loads recorded higher fungal infection at lower space and lower fungal infection at higher space. Bivoltine races were more susceptible than multivoltine races. The ideal rearing space to reduce the white muscardine will be 60, 180 and 360 sq.ft./100 dfls for third, fourth and fifth instar larvae, respectively.

Management of white muscardine

Use of lime at 3 g/sq.ft. for third instar larvae and 5 g/sq.ft. for fourth and fifth instar larvae of all the five races at all the spore loads minimised the white muscardine fungal infection.

Dithane M-45 at 2 per cent was the most effective fungicide for minimising the white muscardine fungus on all the five races, on third, fourth and fifth instar larvae at the spore load of 10^6 to 10^9. Thiram (2 per cent) was next in order.

REFERENCES

REFERENCES

Anderson, T.E. and Roberts, D.W. 1984. Compatibility of Beauveria bassiana isolates with insecticide formulations used in Colorado beetle (Leptinotarsa decemlineata (Coleoptera : Chrysomelidae) control. J.Econ.Entomol., 76(6):1437-1441.

Annual Report. 1980. Central Sericultural Research and Training Institute, Mysore, p. 131.

Annual Report. 1992-93. Central Sericultural Research and Training Institute, Mysore. pp. 34-36.

Baig, M., Samson, M.V., Sharma, S.D., Balavenkatasubbaiah, M., Sasidaran, T.O. and Jolly, M.S. 1993. Efficacy of certain bed disinfectants in different combinations against NPV and white muscardine disease of silkworm, Bombyx mori L. Sericologia, 33(1):53-60.

Balavenkatasubbaiah, M., Sharma, S.D., Baig, M., Singh, B.H., Venkatareddy, S. and Noamani, M.K.R. 1989. Role of disinfection of rearing appliances and sunlight exposure on the inactivation of disease causing pathogens of silkworm, Bombyx mori L. Indian J.Seric., 28:200-206.

Barnes, G.L., Boethel, D.J., Eikenbary, R.D., Criswell, J.T. and Gentry, C.R. 1975. Growth and sporulation of Metarrhizium anisopliae and Beauveria bassiana on media containing various peptone sources. J.Invertebr. Pathol., 25:301-305.

*Bassi, A. 1835. Delmal del sengo calcinaccio muscardine malattia che affligge i bachide seta. parte 1. Teorica Tip Orcessi.Lodi.

Byra Reddy, M.S., Devaiah, M.C., Narayanaswamy, T.K., Govindan, R. and Shyamala, M.B. 1991. Comparative efficacy of some rearing tray disinfectants in prevention of silkworm white muscardine caused by Beauveria bassiana (Bals.) Vuil. Sericologia, 31(3):539-541.

Campbell, R.K., Perring, T.M., Barnes, G.L., Eikenbary, R.D. and Gentry, C.R. 1978. Growth and sporulation of Beauveria bassiana and Metarrhizium anisopliae on media containing various amino acids. J.Invertebr.Pathol., 31:289-295.

Chinnaswamy, K.P. and Devaiah, M.C. 1984. Susceptibility of different races of silkworm Bombyx mori L. to Aspergillosis caused by Aspergillus tamarii Kita. National Conference of Mulberry Sericulture Research, Central Sericultural Research and Training Institute, Mysore, pp. 11-13.

Dandin, S.B. and Halliyal, V.G. 1992. IV All India Conference on Cytology and Genetics and symposium on silkworm and mulberry genetics and breeding. Souvenir, 1990-91, pp. 23-26.

Das, N.C. 1994. A new substitute for foam pads and paraffin papers. Indian Silk, 33(1):19-20.

* Duncan, . 1951. Quoted by Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedures for Agricultural Research, 2nd ed. A Wiley Interscience Publication, New York, 680 p.

Frobisher, M., Hinsdill, R.D., Carbtrce, K.T. and Goodheart, C.R. 1974. Fundamentals of Microbiology, W.B.Saunders Company, Philadelphia, p. 241.

Gardener, Wayne, A., Roy M.Sutton and Raymond Noblet. 1979. Evaluation of the effect of six selected pesticides on the growth of Nomuraea rileyi and Beauveria bassiana in broth cultures. J.Entomol.Soc., 14(2):106-113.

Ignoffo, C.M. and Dutky, S.R. 1963. The effect of sodium hypochlorite on the viability and infectivity of Bacillus and Beauveria spores and cabbage looper nuclear polyhedrosis virus. J.Insect Pathol., 5:422-426.

Jayaramaiah, M. and Hanumappa, M.G. 1986. White muscardine disease of silkworm and its management. Indian Silk, 10(5):109-110.

Jolly, S. 1987. Late age silkworm rearing. Appropriate Sericulture Techniques. Geetanjali Printers, Bangalore. pp. 90-99.

Khramova, T.V. and Popou, I.A. 1984. Effect of temperature, relative air humidity and medium pH on Beauveria bassiana development. Microbiol., 45(1):43-46.

Krishnaprasad, K.S., Siddaramaiah, A.L. and Kulkaranisrikant. 1978. Laboratory evaluation of Bavistin against muscardine disease. Indian J.Seric., 17:69-70.

Krishnaswami, S., Narasimhanna, M.N., Suryanarayan, S.K. and Kumararaj, S. 1973. Sericulture Manual 2. Silkworm Rearing, FAO, Rome, pp. 115-121.

Loria, R., Galaini, S. and Roberts, D.W. 1984. Survival of inoculum of the entomopathogenic fungus Beauveria bassiana as influenced by fungicides. Env.Entomol., 12(6):1724-1726.

Manjunatha Gowda. 1994. Efficacy of some antifungal agents on Aspergillosis of mulberry silkworm caused by Aspergillus tamarii Kita. M.Sc.(Seri.) Thesis, UAS, Bangalore. 77 p.

Mohanty, A.R. and Dhas, R.A.C. 1995. Prospects of sericulture Industry in Tamil Nadu by 2001. Indian Silk (March), 33(11):5-10.

Narasimhanna, M.N., Samson, M.V. and Baig, M. 1976a. Trials on reducing incidence of muscardine by using formalin chaff, paraformaldehyde and captan. Annual Report, Central Sericultural Research and Training Institute, Mysore, p. 107.

Narasimhanna, M.N., Samson, M.V. and Baig, M. 1976b. Effect of fungicides on the health of silkworm and rearing performance. Annual Report, Central Sericultural Research Training Institute, Mysore, p. 108.

Narasimhanna, M.N., Samson, M.V. and Baig, M. 1976c. Effect of Dithane M-45, Ziride, bleaching powder, Pafsol and Shinsel dust on muscardine. Annual Report, Central Sericultural Research and Training Institute, Mysore, pp. 109-110.

Panse, M.V. and Sukhatme, P.V. 1957. Statistical Methods for Agricultural Workers. ICAR Publication, New Delhi. 381 p.

Raghavaiah, G. and Jayaramaiah, M. 1989. Lethal concentration of white muscardine fungus Beauveria bassiana (Bals.) Vuill. to different races of mulberry silkworm. Indian J.Seric., 28:94-96.

Rajan, R.K., Himanthraju, M.T., Vindhya, G.S., Singh, G.B. and Kumar, V. 1993. Studies on the use of blue polythene sheet in place of paraffin paper during young age rearing. Annual Report, Central Sericultural Research and Training Institute, Mysore, p.88.

Rangasami, G. 1984. Diseases of Crop Plants in India. Prentice Hall of India Pvt.Ltd., New Delhi. 520 p.

Rapusas, H.R. and Gabriel, B.P. 1976. Suitable temperature, humidity and larval density in the rearing of Bombyx mori L. Phil.Agri., 60:130-138.

Samsinakova, A. 1966. Growth and sporulation of submerged cultures of the fungus Beauveria bassiana in various media. J.Invertebr.Pathol., 8:395-400.

Samson, M.V. and Baig, M. 1977. Screening of suitable fungicides in vitro against Beauveria bassiana. Annual Report, Central Sericultural Research and Training Institute, Mysore (1976-77), pp. 120-121.

Samson, M.V. and Baig, M. 1993. Studies on suitable media for the culture of Beauveria bassiana through enrichment of population media for the culture of fungus. J.Seric., 62:89-93.

Samson, M.V. and Mummigutti, S.G. 1979. In vitro screening of chemicals against Beauveria bassiana. Indian J.Seric., 18(1):48-50.

Samson, M.V., Baig, M., Sapru, M.L. and Narasimhanna, M.N. 1986. Efficacy of certain fungicides and disinfectants for the control of white muscardine in mulberry silkworm. Indian J.Seric., 2:78-83.

Samson, M.V., Baig, M., Sharma, S.D., Balavenkatasubbaiah, M., Sasidharan, T.O. and Jolly, M.S. 1990. Survey on the relative incidence of silkworm diseases in Karnataka. Indian J.Seric., 29(2):248-254.

Shimizu, M. and Tazima, Y. 1972. Hand Book of Silkworm Rearing. Agri-Manual 1. Fuji Publ.Co.Ltd., Tokyo, Japan. 319 p.

Siddaramaiah, A.L., Lingraraju, S. and Krishnaprasad, K.S. 1979. Preliminary studies on the effect of a few fungicides against Beauveria bassiana causing muscardine disease of silkworm. Indian J.Seri., 18:6-8.

Smith, R.J. and Grula, E.A. 1981. Nutritional requirements for conidial germination and hyphal growth of Beauveria bassiana. J.Invertebr.Pathol., 37:222-230.

Soaf, K.A., Trag, A.R., Khan, M.A. and Chishti, M.Z. 1994. Evaluation of fungicides against white muscardine disease of silkworm Bombyx mori L. caused by Beauveria bassiana (Bals.) Vuill. J.Seric., 2(1 & 2):10-16.

Sreedhara, M.V., Shree, M.P., Boraiah, G. and Fletcher, R.A. 1991. Muscardine disease of silkworm controlled by Triazoles. Sericologia, 31(3):423-426.

Steinhaus, E.A. 1949. Principles of Insect Pathology. McGraw Hill Book Co., Inc., New York. 757 p.

Subbarao, G., Chandra, A.K. and Bhattacharya, A.J. 1992. Effect of bleaching powder and lime against muscardine and Grasserie disease of silkworm Bombyx mori L. Indian J.Seric., 31(1):37-40.

Venkataramana Reddy, M.R. and Veeresh, G.K. 1978a. Effect of different concentrations of Beauveria bassiana spores on the silkworm Bombyx mori L. All India Symposium on Sericultural Sciences. UAS, Bangalore (Oct. 23-26), p. 40.

Venkataramana Reddy, M.R. and Veeresh, G.K. 1978b. Susceptibility of different stages and races of the silkworm to Beauveria bassiana(Bals.) Vuill. All India Symposium on Sericultural Sciences, UAS, Bangalore (Oct. 23-26), p. 41.

*Yanagita, T. 1987. Studies on oral infection of larvae of silkworm Bombyx mori L. J.Seric.Sci.Jpn, 56(4):279-284.

*Yanagita, T. and Iwashita, Y. 1987. Histological observations of larvae of the silkworm Bombyx mori, orally infected with Beauveria bassiana. J.Seric., 54(4):285-291.

* Originals not seen