

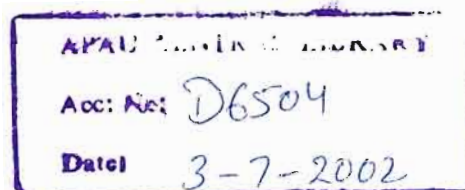
BIOECOLOGY AND MANAGEMENT OF SPOTTED POD BORER, *Maruca vitrata* (Geyer) ON BLACKGRAM

By
S. Dilli Rao, B. Sc.,(Ag.)



Thesis submitted to the
Acharya N.G. Ranga Agricultural University
in partial fulfilment of requirements
for the award of the Degree of

Master of Science in Agriculture




DEPARTMENT OF ENTOMOLOGY
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CERTIFICATE

Mr. S. Dilli Rao as satisfactorily prosecuted the course of research and that the thesis entitled “**BIOECOLOGY AND MANAGEMENT OF SPOTTED POD BORER, *Maruca vitrata* (Geyer) ON BLACKGRAM**” submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any university.

Place : Bapatla
Date : 15-11-01


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CERTIFICATE

This is to certify that the thesis entitled “**BIO-ECOLOGY AND MANAGEMENT OF SPOTTED POD BORER, *Maruca (testulalis) vitrata* (Geyer) ON BLACKGRAM**” submitted in partial fulfilment of the requirements for the degree of **Master of Science** in Agriculture in the major field of Entomology of the Acharya N. G. Ranga Agricultural University, Hyderabad is a record of the bonafide research work carried out by Mr. **S. Dilli Rao** under our guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All the assistance and help received during the course of the investigation have been duly acknowledged by the author of the thesis.

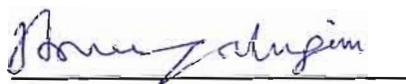


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List of Abbreviations and Symbols

@	:	at the rate of
a.i.	:	active ingredient
AF	:	aqua flow
CD	:	critical difference
cm	:	centimetre
DAS	:	days after sowing
DAT	:	days after treatment
DMRT	:	duncan's multiple range test
EC	:	emulsifiable concentrate
etc	:	et cetra
et. al.	:	and others
Fig.	:	figure
FYM	:	farm yard manure
g	:	gram
ha	:	hectare
h	:	hour
i.e.	:	that is
l	:	litre
LC ₅₀	:	lethal concentration
Ltd.,	:	limited
kg	:	kilogram
m	:	metre
m ²	:	square metre
ml	:	millilitre
mm	:	millimetre
M/s	:	Messrs
N	:	nitrogen
no.	:	number
ppm	:	parts per million
RH	:	relative humidity
SD	:	standard deviation
SE _m	:	standard error of mean
Sig.	:	significant
SP	:	soluble powder
sp.	:	species
SSP	:	single super phosphate
t	:	tonnes
US	:	united states
U-V	:	ultraviolet radiation
var.	:	variety
Viz.,	:	namely
WP	:	wettable powder
w/v	:	weight / volume
%	:	per cent
°C	:	degree celsius
\$:	dollar

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Place : **Bapatla**
Date : **15-11-2001.**


(S. DILLI RAO)

DECLARATION

I, S. Dilli Rao hereby declare that the thesis entitled “**Bioecology and Management of Spotted Pod Borer, *Maruca vitrata* (Geyer) on Blackgram**” submitted to the Acharya N. G. Ranga Agricultural University for the degree of Master of Science in Agriculture in the major field of **Entomology** is the result of original research work done by me. I also declare that any material contained in the theisis has not been published earlier.

Place : Bapatla

Date : 15-11-2001.



(S. DILLI RAO)

ABSTRACT

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Degree to which the thesis is submitted : M. Sc., (Ag).

Faculty : Agriculture

Discipline : Entomology

Major Advisor : **Dr. B. NAGALINGAM**

University : Acharya N.G. Ranga Agricultural University.

Year of submission : 2001

Studies on “Bioecology and management of spotted pod borer, *Maruca vitrata* (Geyer) on blackgram” were conducted at college farm and in the laboratory, Department of Entomology, Agricultural College, Bapatla during rabi 2000-2001.

Laboratory studies on biology of *M. vitrata* on blackgram at a temperature of $29 \pm 2^\circ\text{C}$ and RH of $87 \pm 2\%$ showed that eggs were laid singly or in small groups of 2-18 mostly on flower buds and flowers. Mean fecundity was 55.5 eggs. Oviposition period lasted 4.25 days and incubation period 2.98 days. The larva had five instars with mean larval duration of 11.36 days. Growth ratio through different instars varied from 1.063 to 1.600. Full grown larva preferred pods for pupation. Pre-pupal and pupal periods lasted 2.54 and 9.07 days respectively. Sexual dimorphism was observed in pupal stage. Adults emerged mostly between 20.00 and 24.00 h with a sex ratio of 1.2 : 1.0 (F : M) Longevity of female and male moths was 9.04 and 7.24 days respectively. Total life cycle lasted 25.98 days.

Larval incidence on blackgram (var. LBG-685) in rice fallows was first noticed on 30th of December and reached a peak on 24th of January coinciding with the maximum flowering and pod formation stage, thereafter population gradually declined.

Multiple Linear Regression analysis indicated that all the weather variables (maximum and minimum temperatures, morning and evening RH and sunshine hours) together accounted for 71.7 per cent variation in larval population ($R^2 = 0.717$) which was significant. However, only minimum temperature and sunshine hours showed significant influence independently on variation in larval population.

Larval parasitoid, *Apanteles taragama* (Veir.) and fungal pathogen, *Nomuraea rileyi* (Farlow) Samson were recorded on larvae of *M. vitrata* during the season.

Among eleven treatments including biorationals evaluated for their efficacy against *M. vitrata*, combination treatments like DDVP (0.038%) + chlorpyrifos (0.04%) and DDVP (0.038%) + quinalphos (0.05%) were more effective in suppressing the larval population. Next effective treatments were Nurelle D 505 (chlorpyrifos 50% + cypermethrin 5%), Koranda (acephate 22% + fenvalerate 3%), thiodicarb and acephate. Endosulfan, diflubenzuron, Halt (*B.t.*) and Neemgold (azadirachtin 1500 ppm) were least effective. However, bio-efficacy of diflubenzuron and Halt (*B.t.*) was observed only at 10 days after treatment and were superior to the rest of the treatments in reducing the larval population.

Higher yields were obtained in plots treated with DDVP + chlorpyrifos (1.3033 kg plot⁻¹ or 1086.08 kg ha⁻¹) and DDVP + quinalphos (1.2900 kg plot⁻¹ or 1075.00 kg ha⁻¹).

Introduction

INTRODUCTION

Blackgram (*Vigna mungo* (L.) Hepper) is the fourth important pulse crop in India and second most important in Andhra Pradesh in terms of extent of cultivation. In India it is cultivated in about 3.5 million ha with a production of only 1.63 million tonnes and productivity of about 470 kg ha⁻¹, thus accounting for 11 per cent of the total pulse production. In Andhra Pradesh it is cultivated in an area of 4.30 lakh ha with an annual production of 2.62 lakh tonnes and productivity of 609 kg ha⁻¹ (Economic and Statistical Bulletin, 1999).

Blackgram, commonly known as Urd bean / Mash is cultivated throughout the country especially in the states of Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Uttar Pradesh and West Bengal in both *kharif* and *rabi* seasons. In Andhra Pradesh though it is grown in many districts in *rabi*, rice fallows blackgram is mostly grown in Krishna, Guntur, Prakasham, Nellore, Khammam and Godavari districts.

Seeds of blackgram are very rich in protein (24%) and is the richest in phosphoric acid (385 mg/100g) among pulses. Blackgram is used in different food items all over the world. It is also used as a medicine both externally and internally in paralysis, rheumatism and affection of the nervous system (DhanPal Singh, 1991). Its green fodder is very nutritive and specially fed to milch cattle (Jeswani and Baldev, 1990).

Blackgram is subjected to direct and indirect damage by as many as 60 species of insect pests (Lal, 1987). Of these aphid, *Aphis craccivora* Koch; white fly, *Bemesia tabaci* Gennadius; leafhopper, *Empoasca kerri* Pruthi; galerucid beetles, *Madurasia obscurella* Jacoby; stem fly, *Ophiomyia phaseoli* Spencer and pod borers like spotted pod borer, *Maruca vitrata* (Geyer); Lycaenid borers, *Catechrysops cnejus* (Fab.) and *Lampydes boeticus* (Linn.) are important in different regions of India.

Losses in grain yield of 20 to 60 per cent due to *Maruca* damage in grain legumes have been reported by Singh and Allen (1980). In Bangladesh the pod borer damage has

been estimated to be 54.4 per cent during harvest but yield loss was less than 20 per cent in cowpea (Ohno and Alam, 1989). In pigeonpea, losses due to *M. vitrata* have been estimated to be \$ US 30 million annually (ICRISAT, 1992). The pod borer has been reported to cause up to 84 per cent damage in pigeonpea in Sri Lanka (Dharmasena *et. al.*, 1992; Dharmasena, 1993).

Seasonal incidence and biology of *M. vitrata* was earlier studied on pigeonpea (Vishakantaiah and Jagadeesh Babu, 1980; Lalasangi, 1988; Srivastava *et. al.*, 1992; Ganapathy, 1996; Fellows *et. al.*, 1977) and cowpea (Ramdas Rai, 1983; Jagginavar *et. al.*, 1990; Alghali, 1993; Veeranna *et. al.*, 1997). However, information on blackgram is scanty. Studies on the population fluctuation of the pest in the context of its environment especially abiotic components reveal vital information needed for formulating IPM strategies.

In the management of *M. vitrata*, several insecticides have been evaluated either alone or in combinations earlier on pigeonpea (Sontakke and Mishra, 1991; Yelshetty *et. al.*, 1999 and Krishna *et. al.*, 2000), cowpea (Jaiswal and Patil, 1993), blackgram and greengram (Avinashkumar *et. al.*, 1996; Nath and Yein, 1996; Ganapathy and Durairaj, 2000). However there is a need to evaluate newer molecules, readymix formulations, biorational insecticides that are released into the market every year. Of late, *M. vitrata* is gaining importance on blackgram in Andhra Pradesh both in uplands and rice fallows. Keeping this in view the present studies were designed with the following objectives.

1. To study the biology of *M. vitrata* on blackgram under laboratory conditions.
2. To study the influence of weather parameters on population fluctuations of *M. vitrata*.
3. To record the natural enemies of *M. vitrata* under field conditions.
4. To evaluate certain insecticides against *M. vitrata* on blackgram.

Review of Literature

REVIEW OF LITERATURE

Literature pertaining to biology, seasonal incidence and insecticidal control of spotted pod borer, *Maruca vitrata* (Geyer) has been collected up to date and presented.

2.1 BIOLOGY

Observations on the biology of *M. vitrata* was first made by Dietz in 1914 on cowpea. Later, on lima beans by Wolcott (1933) and on cowpea by Djamin (1961), Taylor (1967), Akinfenwa (1975), Okeyo – Owuor and Ochieng (1981), Jackai and Singh (1983) and Sharma and Franzmann (2000) in pigeonpea and adzuki bean.

In India, the details of biology on pigeonpea were described by Vishakantaiah and Jagadeesh Babu (1980), Ramdas Rai (1983) on cowpea and Lalasangi (1988) on pigeonpea. Its comparative biology was studied on pigeonpea, lab lab and cowpea (Ramasubramanian and Sundarababu, 1989) on cowpea, pigeonpea, blackgram and greengram (Ganapathy, 1996). Veeranna *et. al.* (1999) studied its detailed biology on cowpea.

2.1.1 Mating behaviour

Mating was observed one to two days after emergence of moths in Northern Nigeria (Djamin, 1961). In India it was observed two to three days (Vishakantaiah and Jagadeesh Babu, 1980; Ramasubramanian and Sundarababu, 1989) and two days (Veeranna *et. al.*, 1999) after adult emergence.

Ramdas Rai (1983) reported that copulation took place within two to three days after emergence during night. The peak number of mating pairs was observed between 20.00 to 01.30 hrs. The female mated only once in her life while male can mate more than once. Ganapathy (1996) reported that the adults were nocturnal and sensitive, mating occurred during night from 22.00 h to 04.00 h. Veeranna *et. al.* (1999) reported that maximum number of mating pairs was observed between 20.00 h to 24.00 h. The mating pairs were found to remain for 2 to 3 hours.

2.1.2 Site of oviposition

The moths laid eggs usually on the flower buds and flowers. Oviposition on young partially opened leaves, terminal shoots, leaf axils, abscission scars, peduncles, stem and young pods was also reported (Dietz, 1914; Taylor, 1967). Jackai (1981) observed that 80 per cent of the eggs were deposited on the calyx tube of flower and flower buds and abscission scars, where as Okeyo-Owuor and Ochieng (1981) observed that 79 per cent of the eggs were laid on leaves of cowpea especially on lower surface.

2.1.3 Oviposition

The female moth laid eggs one to two days after mating and continued up to six to seven days (Vishakantaiah and Jagadeesh Babu, 1980). Okeyo-Owuor and Ochieng (1981) observed egg laying was three to seven days after emergence. If virgin moths were paired soon after emergence, fertile eggs were laid after 24 to 48 hours. They further stated that oviposition continued for 10 to 18 days. At temperature below 22°C, oviposition was impaired and if any eggs were laid, hatchability was very low. Ramasubramanian and Sundara Babu (1989) reported moth laid eggs two days after mating and oviposition period lasted for 4 days. Ganapathy (1996) observed pre-oviposition and oviposition periods were lasted for 2.5 and 4.0 days respectively. Veeranna *et. al.* (1999) reported that oviposition starts two days after mating and it lasted for 7 days.

2.1.4 Eggs

Eggs were flat, slightly elongate, pale yellowish, translucent with faint reticulate sculpturing on thin and delicate chorion (Taylor, 1978; Vishakantaiah and Jagadeesh Babu, 1980 and Ramdas Rai, 1983).

On cowpea, Taylor (1967) recorded a maximum of 140 eggs by a female moth and the number of eggs ranged form 6 to 189 (Akinfenwa, 1975). Ochieng *et. al.* (1981) and Okeyo-Owuor and Ochieng (1981) observed the egg numbers ranged form 174 to

194 which hatched in 2.3 days. On an artificial diet, the eggs hatched in 2.5 days (Ochieng and Bungu, 1983). Arulmozhi (1990) recorded 176 eggs on cowpea, 93 eggs on soybean flour diet and 91 eggs on cowpea flour diet with the egg period ranging from 3.3 to 3.7 days.

In pigeonpea, Vishakantaiah and Jagadeesh Babu (1980) observed that the female moths laid 5 to 15 egg masses which hatched in 3.3 days. Ramdas Rai (1983) observed highest number of eggs were laid by the moths reared on winged bean (305.50 eggs) followed by cowpea (185.16 eggs), field bean (156.16 eggs), redgram (118.33 eggs) and greengram (58.16 eggs). Lalasangi (1988) recorded as high as 338 eggs per female on pigeonpea flower buds. Ramasubramanian and Sundarababu (1989) recorded an average of 35.3 eggs on redgram, 37.60 on cowpea and 38.30 on lab lab which hatched in about 2.9, 3.10 and 3.10 days respectively. Ganapathy (1996) reported the mean number of egg masses laid by each female ranged from 2.9 in blackgram and 4.1 in cowpea. In pigeonpea and greengram, a mean of 3.2 and 3.8 egg masses per female were observed. The mean number of eggs per egg mass was the highest in greengram (37.6 egg) followed by cowpea (36.3), pigeonpea (35.4) and blackgram (33.9 eggs). Veeranna *et. al.* (1999) reported that the eggs were deposited in batches of 2 to 10 on the under surface of leaves, terminal shoots and flower buds. Freshly laid eggs were milky white and later became translucent.

The measurements of egg as given by Taylor (1978), Vishakantaiah and Jagadeesh Babu (1980), Okeyo-Owuor and Ochieng (1981), Jackai (1981), Ramdas Rai (1983) and Veeranna *et. al.* (1999) were 0.65 mm x 0.45 mm, 0.53 mm x 0.38 mm, 0.69 mm x 0.02 mm, 0.19 mm x 0.01 mm, 0.66 mm x 0.43 mm and 0.67 mm x 0.44 mm, respectively.

2.1.5 Larva

M. vitrata larvae passed through five instars both on redgram (Vishakantaiah and Jagadeesh Babu, 1980) and on cowpea (Okeyo - Owuor and Ochieng, 1981; Ramdas Rai, 1983 and Veeranna *et. al.*, 1999).

I Instar

Ramdas Rai (1983) reported that the larvae were creamy white except the head and prothoracic segment which are dark brown. The first instar lasted 1.59 days. The larvae measured 1.25 mm in length and 0.17 mm in breadth. Ganapathy (1996) reported its durations and measurements were 2.5, 3.1, 2.8, 2.5 days and 3.16 mm x 0.75 mm, 3.03 mm x 0.74 mm, 3.21 mm x 0.72 mm and 3.31 mm x 0.75 mm on cowpea, pigeonpea, blackgram and greengram, respectively. Veeranna *et. al.* (1999) reported the I instar duration was 1.94 days. The larvae measured 1.24 mm in length and 0.17 mm in breadth.

II Instar

Ramdas Rai (1983) reported that II instar duration was 1.55 days on cowpea. The larvae measured 2.55 mm in length and 0.38 mm in breadth. Ganapathy (1996) observed its duration was 2.1, 2.8, 3.6 and 2.5 days on cowpea, pigeonpea, blackgram and greengram respectively. The larva measured on an average 4.71 mm x 0.83 mm on cowpea, 4.77 mm x 0.95 mm on pigeonpea, 4.65 mm x 0.95 mm on blackgram and 4.77 mm x 0.96 mm on greengram. Veeranna *et. al.* (1999) reported the larva was 2.59 mm in length and 0.39 mm in breadth with a duration of 1.78 days on cowpea.

III Instar

Ramdas Rai (1983) reported the larva was 5.26 mm in length and 0.83 mm in breadth and its duration was 1.64 days on cowpea. Ganapathy (1996) reported the larvae measured on an average 9.28 mm x 1.68 mm, 9.20 mm x 1.75 mm, 9.36 mm x 1.68 mm and 9.41 mm x 1.72 mm on cowpea, pigeonpea blackgram and greengram, respectively. Its duration was 2.3 days on cowpea, 3.1 days on pigeonpea, 2.7 days on blackgram and 3.2 days on greengram. Veeranna *et. al.* (1999) reported the length and breadth of larvae were 5.27 mm and 0.86 mm respectively with a duration of 1.80 days.

IV Instar

Ramdas Rai (1983) reported the length and breadth of larvae were 10.54 mm and 1.64 mm respectively with a duration of 1.85 days. Ganapathy (1996) reported the length and breadth of larvae were 11.50 mm x 2.74 mm, 11.52 mm x 2.85 mm, 11.45 mm x 2.82 mm and 11.47 mm x 2.87 mm in cowpea, pigeonpea, blackgram and greengram, respectively. Veeranna *et. al.* (1999) reported that the larva was creamy white / dull white with distinctly visible dark spots and took .89 days to complete its development. The larva measured 10.55 mm in length and 1.65 mm in breadth.

V Instar

Ramdas Rai (1983) reported the larva of V instar was brownish with dark brown head and prothoracic shield. Dark spots on body are distinctly visible. The larva took 3.37 days to complete its development on cowpea and measured 16.19 mm in length and 2.50 mm in breadth. Ganapathy (1996) reported its duration was 2.7, 3.4, 3.8 and 3.3 days on cowpea, pigeonpea, blackgram and greengram, respectively. The larva measured on an average 15.48 mm x 3.42 mm, 15.50 mm x 3.45 mm, 15.53 mm x 3.47 mm and 15.62 mm x 3.52 mm on cowpea, pigeonpea, blackgram and greengram respectively. Veeranna *et. al.* (1999) reported that larva was brownish with dark brown head and measured 16.12 mm in length and 2.51 mm in breadth. It took 3.62 days to complete its development on cowpea. Larva

Total larval period lasted for 12.65 days on redgram (Vishakantaiah and Jagadeesh Babu, 1980) 8 to 14 days in cowpea (Ochieng *et. al.*, 1981; Okeyo - Owuor and Ochieng, 1981). Jackai and Singh (1983) registered a larval period of 7.3 days in cowpea, 16.4 days in pigeonpea, 21 days in *Crotalaria juncea*, 19.9 days in *C. miserensis*, 16.9 days in *C. mucronata*, 14.0 days in *C. palliana* and 13.2 days in *C. amazonas*. On an artificial diet, the larval period ranged from 13.5 to 14.3 days (Ochieng and Bungu, 1983). Ramdas Rai (1983) studied the biology of *M. vitrata* on cowpea and reported a larval

period of 10 days only. Ramasubramanian and Sundarababu (1989) recorded, a larval period of 13.9 days in cowpea, 13.3 days in pigeonpea and 12.9 days on hyacinth bean. According to Arulmozhi (1990), larval period lasted for 11.1 days on cowpea, 16.5 days on cowpea flour diet and 14.4 days on soybean flour diet. Ganapathy (1996) studied its comparative biology on cowpea, pigeonpea, blackgram and greengram. He observed that the total larval development was 11.9, 14.7, 16.5 and 15.4 days respectively on cowpea, pigeonpea, blackgram and greengram. Veeranna *et. al.* (1999) reported that the total larval period on cowpea was 11 days. Sharma and Franzmann (2000) observed 12 days on pigeonpea and 11.7 days on adzuki bean.

2.1.6 Pre - pupa

Fullgrown larva stopped feeding before pupation and spun translucent silken web and constructed a cocoon made of silken material and transformed into pupa (Vishakantaiah and Jagadeesh Babu, 1980).

The pre-pupa occupied on an average of 2.05 days (Vishakantaiah and Jagadeesh Babu, 1980). Ramdas Rai (1983) reported that pre-pupal period lasted for 1.93 days to 2.58 days and measured 13.02 mm in length and 2.57 mm in breadth. Ramasubramanian and Sundarababu (1989) observed pre-pupal periods as 1.52, 1.80 and 1.46 days on pigeonpea, cowpea and lab lab respectively. Ganapathy (1996) studied the comparative biology on cowpea, pigeonpea, blackgram and greengram and reported pre-pupal period of 1.6, 1.4, 1.5 and 1.2 days, respectively. The lengths of pre-pupa was 14.48 mm on cowpea, 14.18 mm on pigeonpea, 14.37 mm on blackgram and greengram where as breadth of pre-pupae were 3.39, 3.27, 3.41 and 3.43 mm, respectively. Veeranna *et. al.*, (1999). reported an average pre-pupal period of 2.30 days (2.06-2.55) while the average measurements of pre-pupa was 13.00 mm in length and 2.59 mm in breadth.

2.1.7 Pupa

The freshly formed pupa was green, pale yellow/ light brown and changed to brick brown/ greyish brown and finally before adult emergence turned to dark brown, mottled with black and yellow (Taylor, 1967; Okeyo-Owuor and Ochieng, 1981).

Taylor (1978) reported that the pupation took place on the surface of soil in a double walled pupal cell consisting of an outer wall of silk, sand particles and other debris and inner wall of larval strands of white silk woven in a fishing net fashion upon the anterior end, whereas Vishakantaiah and Jagadeesh Babu (1980) reported that the pupation occurred on plant parts only. Ramdas Rai (1983) observed that pupa measured 11.81 mm in length and 2.75 mm in breadth. There was no difference in size between male and female pupa. Ganapathy (1996) reported that length and breadth of pupae did not show any marked variation. The length and breadth were the highest in greengram (13.49 mm x 2.34 mm) followed by cowpea, blackgram and pigeonpea. Veeranna *et. al.* (1999) reported that on an average pupa measured 11.59 mm in length and 2.83 mm in breadth on cowpea.

Pupal period varied from 9 to 10 days in Indonesia (Dietz, 1914), 7 to 14 days in India (Fletcher, 1914), 6 to 11 days in Uganda (Nyiira, 1971), 6 to 9 days in Nigeria (Taylor, 1979), 8 to 10 days in South India (Vishakantaiah and Jagadeesh Babu, 1980), 5 to 11 days in Kenya (Okeyo- Owuor and Ochieng, 1981) and 6.68 to 10.00 days in Bangalore (Ramdas Rai, 1983). According to Ramasubramanian and Sundarababu (1989) pupal period was minimum (6.4 days) in pigeonpea followed by cowpea (6.9 days) and lab lab (7.5 days). Arulmozhi (1990) recorded the maximum pupal period of 5.9 days on cowpea. Ganapathy (1996) recorded mean pupal period on four legumes as, 6.6 days on cowpea, 6.6 days on pigeonpea, 6.8 days on blackgram and 7.8 days on greengram. Veeranna *et. al.* (1999) observed pupal period of 8.50 days in Bangalore on cowpea.

2.1.8 Total developmental period

Booker (1965) observed that the total life cycle lasted for about 30 to 35 days while Akinfenwa (1975) recorded 23 to 30 days on cowpea in Northern Nigeria. In Southern Nigeria, it varied from 18 to 25 days (Taylor, 1978) Okeyo-Owuor and Ochieng (1981) recorded the total life cycle ranged from 20 to 57 days on cowpea.

In pigeonpea, the total life-cycle extended upto 27 days (Vishakantaiah and Jagadeesh Babu, 1980). Ramdas Rai (1983) reported 21.25 to 24.37 days on cowpea in Bangalore. According to Ramasubramanian and Sundarababu (1989) the total developmental period varied from 24.10, 25.66, 24.94 days on redgram, cowpea and lab lab respectively. Ganapathy (1996) observed 23.3, 25.5, 28 and 27.5 days on cowpea, pigeonpea, blackgram and greengram respectively. Veeranna *et. al.* (1999) found that the total life cycle was completed in 24.92 days on cowpea.

2.1.9 Adult emergence

Most of the moths emerged between 20.00 h and 24.00 h and only a few after midnight. The moths were active and rest with wings spread out horizontally [Okeyo-Owuor and Ochieng, 1981 and Veeranna *et. al.* (1999)].

Ganapathy (1996) reported that the percentage of adults emerged from the pupae was the highest in cowpea (87.0%) followed by pigeonpea (76.0%), blackgram (74.0%) and greengram (71.0%).

2.1.10 Sex ratio (Female : Male)

Ganapathy (1996) studied its comparative biology on cowpea, pigeonpea, blackgram and greengram. The sex ratio was the highest in blackgram (1 : 0.850) followed by pigeonpea (1:0.809), green gram (1:0.714) and cowpea (1:0.526). Veeranna *et. al.* (1999) observed the sex ratio was 1 : 1 on cowpea.

2.1.11 Adult morphology

The moth is medium sized, greyish brown in colour with long legs. The wings are dark greyish with white and brown patterns more conspicuous on the fore wings than on the hind wings, the hind wings are silvery white with a brown spot at the apical margin across the wing (Vishakantaiah and Jagadeesh Babu, 1980). Fore wings bearing a lunulate black-edged, white spot in the end of the cell. A black edged, semi-hyaline band beyond the cell from below the costa was conspicuous. Hind wings were semi-hyaline white, with a basal fuscous area and a spot at the upper angle of the cell. A marginal fulvous brown fuscous band from costa to vein 1c with an irregular edge was very distinct. Both sexes were morphologically similar (Hampson, 1976).

The moths were small dark grey in colour with white brown patterns on the wings. The colour patterns were more conspicuous on the fore wings than the hind wings with a silvery white brown spot at the apical margin. The female had brownish abdomen with bifid hairy ovipositor. Okeyo-Owuor and Ochieng (1981) reported that the adults are medium sized measuring 11.59 mm long (from head to abdominal tip) with a wing expanse of 24.35 mm in case of the female and 11.72 mm long and 23.65 mm across the wings in case of the male. Veeranna *et. al.* (1999) reported that the males on an average measured 13 mm in length and 9 mm in breadth with a wing expansion of 26 mm while the females on an average measured 11.00 mm in length and 8.00 mm in breadth with a wing expansion of 23 mm.

2.1.12 Adult longevity

The average life-span of both sexes varied on different hosts. Ochieng *et. al.* (1981) observed that the female moths lived for a longer period of 9.5 days than the males which lived only for 7.7 days on cowpea.

On artificial diet, the longevity was reduced to 7.1 days in females and 6.3 days in males (Ochieng and Bungu, 1983). Ramasubramanian and Sundarababu (1989) observed

that the longevity of male was 6.10 days on pigeonpea, 5.90 days on cowpea and 6.10 days on lab lab while female longevity was 8.50, 8.60 and 10.00 days on pigeonpea, cowpea and lab lab respectively. On soybean flour diet, the female and male moths lived for 8.3 days and 5.8 days respectively. Ganapathy (1996) found that females lived for 8.5, 8.6, 9.11 and 8.5 days on cowpea, pigeonpea, blackgram and greengram respectively where as male longevity was 6.3, 5.8, 5.9 and 5.9 days on cowpea, pigeonpea blackgram and greengram respectively. According to Veeranna *et. al.* (1999) male moths lived for 9.30 days where as female moths lived for 11.33 days on cowpea.

2.2 ECOLOGY

2.2.1 Nature of damage

The larvae were found to feed on anthers, filaments, styles, stigma and ovaries of flowers (Taylor, 1967; Akinfenwa, 1975; Singh and Allen, 1980). Jackai (1981) observed that the infestation started from the terminal shoots of cowpea 21 days after planting and then spread to reproductive parts. The intensity was highest on flowers followed by flower buds, terminal shoots and pods. Goud and Vastarad (1992) observed the young larvae bored the stems of blackgram from leaf - axils of branches causing wilting. In pigeonpea, the larvae damaged the leaves by rolling and webbing and continued feeding inside the rolled leaves. At flowering stage, larva fed on buds and flowers by webbing them (Sharma, 1996).

2.2.2 Seasonal incidence and influence of weather parameters

The seasonal incidence of *M. vitrata* on blackgram is not available and hence its incidence on cowpea, pigeonpea and greengram was collected and presented.

2.2.2.1 On cowpea

According to Taylor (1967), initial infestation on cowpea was from the adult time of emergence from alternative host plants and from the flowers of early crop, with the peak during June-July. The first generation adults emerged between July and September. The

loss on late crop was more than the earlier crop. Peak larval incidence was recorded in August and the peak adult catches were in November in Nigeria (Akinfenwa, 1975). In cowpea, pests reached their peaks during September- October in Western Nigeria (Nangju *et. al.*, 1979). Field damage was heavy in April - May, low in June-July but again high in August - September plantings (Akingboughbe, 1982). Ezuch (1982) also found that cowpea planted between June and October suffered heavy damage by *M. testulalis* with maximum in August and least in April plantings in Nigeria. Lalasang (1988) recorded the peak incidence of *M. vitrata* during July, August and October in cowpea at Dharward, Karnataka. Arulmozhi (1990) found that maximum incidence and damage occurred in August sown crops at Coimbatore. Relative humidity had significant positive influence and maximum temperature had significant negative influence on the incidence of pod borer. Jagginavar *et. al.* (1990) observed low incidence of *M. vitrata* on cowpea sown in the first week of October in Dharward, Karnataka. The percentage of seed and pod damage was also lowest in an early October sowing.

Alghali (1993) conducted field studies in Nigeria to examine the effects of four agrometeorological factors on population fluctuations of *M. vitrata* on two cowpea varieties. Small peaks on crops planted between 5th May and 1st June and again between 29th June and 13th July and a larger peak on those planted between 24th August and 7th September. These two peaks coincided with the peak rainfall. The results suggested that the distribution of rainfall overtime was more crucial than the total amount in determining the fluctuations in the numbers of *M. vitrata*. Veeranna *et. al.* (1997) observed the incidence of the borer on terminal shoots of cowpea showed two peaks, the first being the highest in second week of September with 84.72 per cent infestation and second one with small peak showing 41.91 per cent infestation in 5th week of November, 1992 at Bangalore. He also observed during summer season, which commenced in February the infestation was nil in the beginning but showed upward trend towards the end of the season on all parts of cowpea plants examined. Infestation reaching maximum of 72.30 per cent by the fifth week of March, 1993. The

incidence of borer on terminal shoots during *kharij*, 1993 ranged from 6.14 per cent in fourth week of July to 45.50 per cent in second week of September. On flower buds and pods also the trend was almost similar. Correlation worked for the infestation in different seasons and weather parameters showed that both per cent flower buds and pods infested were positively correlated with mean minimum and maximum temperature.

2.2.2.2 On pigeonpea

In Sri Lanka, high pod borer density has been observed during the Maha (main season) (Dec-Mar) (Fellows *et. al.*, 1977). At ICRISAT Hyderabad, Srivastava *et. al.* (1992) recorded more moth catches in light traps from early November to mid December with the peak during 46th and 47th standard weeks in November. A second peak was recorded in September during 37th and 38th standard weeks. The third and smallest peak occurred in early February (6th standard week). At Hisar, moth activity was observed from mid September to mid October (37th to 43rd standard weeks). However there was no secondary peak at Hisar.

In Sri Lanka, Saxena *et. al.* (1992) studied the population dynamics of pod borer complex in pigeonpea during 1990-91 'Maha' season. Larval population was high in mid-October and gradually decreasing towards mid-November. Grain yield of pigeonpea planted in the month of November was high because of low pest incidence. But grain yield in 'Yala' season was comparatively higher due to low pod borer damage. *M. vitrata* incidence was high in pigeonpea crop planted with the onset of 'Maha, rains in mid October. A delay in planting pigeonpea to mid-November reduced the damage by pod borers. In Sri Lanka, larval population was high in pigeonpea crops planted in mid-October, and gradually decreased in the crop planted in mid November (Dharmasena *et. al.* 1992). High humidity and low temperatures experienced during this period may be conducive to the build up of *M. vitrata* populations on pigeonpea. Akhauri *et. al.* (1994) found that the pest was active between the second week of October and the last week of December at Dholi, Bihar, India. It attained and maintained its peak activity during November in both crop

seasons of pigeonpea by recording mean larval populations from 7.67 to 12.73 and 8.53 to 17.60 / plant in 1990-91 and 1991-92 respectively. For population build up, a decline in average maximum and minimum temperature from 30.50°C to 26.25°C and 16.15°C to 10.35°C respectively and the relative humidity around 70 per cent proved to be conducive. No significant correlation existed between pest populations and the temperatures (maximum & minimum). However, a highly significant negative correlation with relative humidity meant a greater pest activity during the drier season.

Bajpai *et. al.* (1995) carried out a study on pigeonpea during *kharif* 1991-92 in Uttar Pradesh, India, to evaluate susceptibility to *M. vitrata*. Early flowering cultivars were more susceptible to damage than late flowering cultivars. Incidence of *M. vitrata* started in early September, peaked in mid-October and declined towards the end of that month. Ganapathy (1996) found that flower damage in early maturing pigeonpea types was more at 50 per cent flowering and the field incidence started from 38th standard week peak during 40th and 42nd standard weeks at Madurai. Maximum and minimum temperatures were negatively correlated with incidence.

2.2.2.3 On greengram

Vignaraja (1978) observed two peaks of *M. vitrata* on green gram in Sri Lanka, the major one during December to February and minor during June.

2.2.3 Natural enemies

The extent of parasitism on the larvae ranged from 5.7 to 6.8 per cent by *Phanertoma* sp. and *Braunoia* sp. (Don Pedro, 1983). A total of 27 parasitoids, 20 predators, two protozoans, two bacteria and one fungus were reported so far on the egg, larva, pupa and adult of *M. vitrata* as listed in Table 1.

Table:1 A list of Natural enemies recorded on different stages of *M. vitrata*

Natural enemy	Stage attacked	Reference
I. PARASITOIDS		
A. Order : Diptera		
Tachinidae		
<i>Exorista xanthaspis</i> (Wiedemann)	Larva	Barrion <i>et. al.</i> (1987)
<i>Palexorista solemnis</i> (Walker)	Larva	Barrion <i>et. al.</i> (1987)
<i>Peirbaea orbata</i> (Wiedemann)	Larva	Barrion <i>et. al.</i> (1987)
<i>Zygobothria atropivora</i> (Rob. Desv)	Larva	Barrion <i>et. al.</i> (1987)
<i>Zygobothria ciliata</i> (Wulp)	Larva	Barrion <i>et. al.</i> (1987)
<i>Thelairosoma</i> sp.	Larva	Usua and Singh (1977)
<i>Pseudoporichaeta</i> sp.	Larva	Usua and Singh (1977)
<i>Pseudoporichaeta</i> sp.	Larva	Usua and Singh (1977)
B. Order Hymenoptera		
(i) Braconidae		
<i>Apanteles</i> sp.	Larva	Okeyo - Owuor <i>et. al.</i> (1991)
<i>Apanteles taragamae</i> (Veir)	Larva	Sahoo & Senapati (1998)
<i>Bracon greeni</i> Ashm.	Larva	ICRISAT (1981)
<i>Bracon</i> sp.	Larva	Okeyo - Owuor <i>et. al.</i> (1991)
<i>Braunsia</i> sp.	Larva	Okeyo - Owuor <i>et. al.</i> (1991)
<i>Microdes</i> sp.	Larva - pupa	Sahoo & Senapati (1998)
<i>Cardiochiles philippinensis</i>	Larva - pupa	Barrion <i>et. al.</i> (1987)
<i>Chelonus</i> sp.	Larva - pupa	Barrion <i>et. al.</i> (1987)
<i>Cremnops</i> sp.	Larva - pupa	Barrion <i>et. al.</i> (1987)
<i>Snellenins manilae</i> Ashm.	Larva	Barrion <i>et. al.</i> (1987)
<i>Phanertoma</i> sp.	Larva	Usua and Singh (1977)

Contd....

Natural Enemy	Stage attacked	Reference
(ii). Chalcididae		
<i>Antrocephalus</i> sp.	Larva	Okeyo - Owuor <i>et. al.</i> (1991)
<i>Brachymeria</i> sp. A	larva - pupa	Barrion <i>et. al.</i> (1987)
<i>Brachymeria</i> sp. B	larva - pupa	Barrion <i>et. al.</i> (1987)
(iii). Eulophidae		
<i>Tetrastichus sesamiae</i> Risbec	Pupa	Okeyo - Owuor <i>et. al.</i> (1991)
<i>Tetrastichus</i> sp.	Pupa	Barrion <i>et. al.</i> (1987) Usua and Singh (1977)
(iv). Ichneumonidae		
<i>Caenopimpla arealis</i> (Cushman)	Larva	Barrion <i>et. al.</i> (1987) Usua and Singh (1977)
<i>Charops nigrita</i> (Gupta & Maheswary)	Larva	Barrion <i>et. al.</i> (1987) Usua and Singh (1977)
<i>Meloboris sinicus</i> (Holmgren)	Larva	Barrion <i>et. al.</i> (1987) Usua and Singh (1977)
<i>Metopius rufus browni</i> Ashm.	Larva	Barrion <i>et. al.</i> (1987) Usua and Singh (1977)
(V). Pteromalidae		
<i>Trichomalopsis</i> sp.	Larva - pupa	Barrion <i>et. al.</i> (1987) Usua and Singh (1977)
2. PREDATORS		
A) Dermaptera		
<i>Diaperastichus erythrocephla</i> Ol.	Larva - pupa	Okeyo - Owuor <i>et. al.</i> (1991)
B) Dictyoptera		
<i>Polyspilota</i> sp.	Moths	Usua and Singh (1977)
<i>Spodromantis</i> sp.	Moths	Usua and Singh (1977)
C) Coleoptera		
<i>Chlaenius</i> sp. A	Larva	Barrion <i>et. al.</i> (1987)
<i>Chlaenius</i> sp. B	Larva	Barrion <i>et. al.</i> (1987)
<i>Cicindela lacrymosa</i> (Fab.)	Larva	Barrion <i>et. al.</i> (1987)
Coccinellidae		
<i>Coccinella repanda</i> (Thunbergi)	Larva	Barrion <i>et. al.</i> (1987)
<i>Synhasmonia octomaculata</i> (F.)	Larva	Barrion <i>et. al.</i> (1987)

Contd....

Natural Enemy	Stage attacked	Reference
D) Hemiptera		
<i>Anthocorida tantillus</i> Motsch	Eggs & larva	Barrion <i>et. al.</i> (1987)
E) Hymenoptera		
i) Formicidae		
<i>Camponotus sericeus</i> Fab.	Larva	Usua and Singh (1977)
<i>Camponotus rufoglaucus</i> (Jerd.)	Larva	Okeyo - Owuor <i>et. al.</i> (1991)
ii) Vespidae		
<i>Delta conoideum</i>	Larva	Sahoo & Senapati (1998)
<i>Delta campaniforme</i>	Larva	Sahoo & Senapati (1998)
<i>Delta pyriforme</i>	Larva	Sahoo & Senapati (1998)
<i>Eumenses</i> sp.	Larva	Barrion <i>et. al.</i> (1987)
<i>Ropalida flavopicta</i> <i>flavobrunnea</i> Van der Vecht.	Larva	Barrion <i>et. al.</i> (1987)
F) Araneida		
(i) Selenopidae		
<i>Selenops radiatus</i>	Larva and adult	Usua and Singh (1977)
(ii) Araneidae		
<i>Nephila maculata</i> (L.)	Adult	Barrion <i>et. al.</i> (1987)
(iii) Oxyopidae		
<i>Oxyopes javanus</i> Thorell	Larva and adult	Barrion <i>et. al.</i> (1987)
(iv) Salticidae		
<i>Ivarcha</i> sp	Adult	Barrion <i>et. al.</i> (1987)
<i>Marpissa bengalensis</i> Tikader	Adult	Barrion <i>et. al.</i> (1987)
<i>Marpissa calcuttaensis</i> Tikader	Adult	Barrion <i>et. al.</i> (1987)
(v) Sparassidae		
<i>Heteropoda venatoria</i> (L)	Adult	Barrion <i>et. al.</i> (1987)
3. PATHOGENS		
A) Protozoa		
<i>Mettesia</i> sp.	Larva - pupa	Okeyo - Owuor <i>et. al.</i> (1991)
<i>Nosema</i> sp.	Larva - pupa	Okeyo - Owuor <i>et. al.</i> (1991)

Contd....

Natural Enemy	Stage attacked	Reference
B) Bacteria		
<i>Bacillus</i> sp.	Larva - pupa	Okeyo - Owuor <i>et. al.</i> (1991)
<i>Colostridium</i> sp.	Larva - pupa	Okeyo - Owuor <i>et. al.</i> (1991)
C) Fungi		
<i>Aspergillus</i> sp.	Larva - pupa	Sharma (1998)

2.3 Insecticidal control of *M. vitrata*

ENDOSULFAN

Endosulfan is both a chlorinated hydrocarbon and an organic sulphite. It is a contact and stomach insecticide with slight fumigant action (David and Kumaraswamy, 1988).

Effective control of *M. vitrata* on cowpea has been achieved with endosulfan 0.07 per cent applied at 35 DAS twice at weekly intervals (Jackai, 1983). Sprays of triazophos (0.07%), endosulfan (0.07%) and monocrotophos (0.04%) and four per cent dust formulations of phoxim, endosulfan and phosalone gave effective control of pod borer on pigeonpea (Sundarababu and Rajasekharan, 1985). Venkaria and Vyas (1985) reported that the least number of pods of greengram were damaged in plots treated with fenvalerate (0.01%) + miraculan (a plant growth stimulant), endosulfan (0.07%) + miraculan, followed by those treated with fenvalerate (0.01%), endosulfan (0.07%) and monocrotophos (0.04%). Samolo and Patnaik (1986) reported that among six insecticides tested, monocrotophos and endosulfan (0.5 kg a.i. ha⁻¹) were most effective, and three applications of endosulfan (0.07%) starting at flower initiation (at 20 days interval) of pigeonpea were most effective against pod borers.

Cypermethrin (75 g a.i. ha⁻¹) sprayed three times has been found effective against pod borers of pigeonpea followed by decamethrin (12.5 g a.i. ha⁻¹), fenvalerate (150 g a.i. ha⁻¹), and endosulfan (400 g a.i. ha⁻¹) (Sontakke and Mishra, 1991).

Ramasubramanian and Sundarababu (1991) reported that **endosulfan** (0.518 kg a.i. ha⁻¹) was the most effective insecticide, followed by monocrotophos (0.296 kg a.i. ha⁻¹) for the control of *M. vitrata* on lab lab. Venkateswarlu *et. al.* (1992) reported that spray application of neem oil (0.1%) in combination with **endosulfan** (0.07%) was the most effective treatment in reducing infestation of pod borer complex of blackgram and increasing yields. However, the best cost : benefit ratio (1:1.68) was obtained with **endosulfan** (0.07%) alone.

Jaiswal and Patil (1993) evaluated the efficacy of different insecticides for the control of *M. testulalis* on cowpea and reported that the maximum increase in yield (50.74%) with **endosulfan** (0.05%) followed by monocrotophos (0.04%) with 41.48 per cent increase in yield over untreated control. Avinashkumar *et. al.* (1996) reported that spraying with **endosulfan** (0.07%) dusting with methyl parathion (2%) were significantly superior in minimising damage due to *M. testulalis*, *Empoasca kerri* Pruthi and *Spilosoma obliqua* Walker in blackgram. Nath and Yein (1996) reported that **endosulfan** (0.07%) gave an effective control of *M. vitrata* infesting blackgram which resulted in significantly higher grain yield than untreated control. Chaudhary and Sachan (1997) reported that spraying with **endosulfan** (0.07%) at flowering, pod formation and pod maturation stages of pigeonpea gave an effective control of pod borer complex. Ram Ujagir and Ujagir (1999) reported that foliar spray of **endosulfan** (0.07%) gave an effective control of pod borers and higher grain yield in pigeonpea compared to untreated control.

DICHLORVOS (DDVP)

It is an aliphatic organophosphorus compound. It is a contact and stomach poison with fumigant and penetration action. It brings quick knock down effect (Nayar *et. al.*, 1976).

Ke *et. al.* (1985) reported that **dichlorvos** 76 EC @ 0.076 per cent was effective against *M. vitrata* in long bean.

Literature on the efficacy of dichlorvos on *M. vitrata* is meagre and hence the bio-efficacy of dichlorvos on other internal feeders and pod boders are presented below.

Foliar spray of endosulfan (0.07%) was the most effective, followed by carbaryl (0.05%), malathion (0.05%), dichlorvos (0.05%) and fenitrothion (0.05%) for the control of the pyralid borer, *Chilo partellus* (Swinhoe) on sorghum (Singh *et. al.*, 1986). Shevale (1991) reported that dichlorvos 80 EC @ 0.08 per cent was the most effective treatment followed by monocrotophos @ 0.08 per cent, fenvalerate @ 0.04 per cent and carbaryl @ 1.0 per cent for the control of *Indarbela quadrinotata* (Walker) on pomegranate. Monocrotophos was the most effective treatment and gave maximum pod yield against *Proaerema modicella* Deventer on groundnut. Where as phosphamidon (0.1%) and dichlorvos (0.08%) were the most economical treatments and significantly controlled the pest population [Somasekhar *et. al.* (1991)].

Butani and Mittal (1993) reported that spray application of malathion, NSK suspension, phenthoate, fenitrothion, chlorpyrifos, DDVP and carbaryl significantly reduced the population of gram pod borer, *H. armigera* on chickpea. Wali-Ur-Rahman (1994) reported that malathion (0.05%) cypermethrin (0.005%), DDVP (0.08%) and Laser (a pyrethroid) were 100 per cent effective on *H. armigera* infesting fruits of the medicinal plant *Nigela sativa*. Spray application of dichlorvos (0.076%) or deltamethrin (0.006%) gave good control against pyralid, *Dichocrocis punctiferalis* (Guenee) on plums [Wang *et. al.* (1991)].

CHLORPYRIPHOS

It is non-systemic, broad spectrum organophosphorus insecticide with moderate persistence. It is a contact and stomach insecticide with slight fumigant action (Gupta, 1999).

Nath and Yein (1996) reported that chlorpyrifos (0.05%) gave effective control of *M. vitrata* infesting blackgram and resulted in significantly higher grain yield than untreated control. Sanap and Patil (1998) reported that chlorpyrifos (0.05%) was effective against pigeonpea pod borers. Krishna *et. al.* (2000) studies on the influence of plant protection chemicals on pigeonpea seed quality revealed the suitability of chlorpyrifos 20 EC (0.05%) and chlorpyrifos 1.5 per cent dust for controlling pigeonpea pod borer complex.

QUINALPHOS

It is an organophosphorus compound with contact and good penetrating power. It has also acaricidal properties (Nayar *et. al.*, 1976).

Samalo and Patnaik (1986) reported that 3 sprays of quinalphos (0.5 kg a.i. ha⁻¹) at 20 days interval starting at flower initiation gave an effective control of pod borers infesting pigeonpea. Bhat *et. al.* (1988a) reported that spray application of quinalphos at 250 ml ha⁻¹ gave an effective control of pod borers in cowpea. However, dust formulation of quinalphos 5 per cent @ 20 kg a.i. ha⁻¹ was less effective than spray formulation. Bhat *et. al.* (1988b) reported that among seven insecticides tested monocrotophos (0.05%), quinalphos (0.05%) or 5 per cent Neem Seed Extract (NSE) were most effective while the dust formulation of folidol 2 per cent, carbaryl 10 per cent, quinalphos 5 per cent and toxaphene 2 per cent were ineffective against pod borer complex of greengram. Sontakke and Mishra (1991) reported that spray application of quinalphos at 300 g a.i. ha⁻¹ was effective against pod borer complex in pigeonpea.

Senapati *et. al.* (1992) reported quinalphos 25 EC @ 0.05 per cent significantly controlled the pod borer complex in pigeonpea and gave higher yields. Avinashkumar *et. al.* (1996) reported that spray application of quinalphos 25 EC @ 0.05 per cent was significantly controlled *M. vitrata* in mungbean. However, dusting with quinalphos 1.5 per cent was less effective than spraying. Ram Ujagir and Ujagir (1999) reported that foliar

sprays of **quinalphos** (0.05%), fenvalerate (0.007% and 0.004%) and deltamethrin (0.002 and 0.006%) were effective in reducing pod borers in early pigeonpea and losses in grain yield. Ganapathy and Durairaj (2000) reported that the cumulative pod borer damage caused by *M. vitrata* in blackgram was the lowest in **quinalphos** 20 AF (0.04%) followed by profenofos 50 EC (0.1%), alanycarb 30 EC (0.06%), endosulfan 35 EC (0.07%), dimethoate 30 EC (0.03%) and acephate 75 WP (0.075%). Grain yield was also maximum in **quinalphos** (0.04%) with high cost: benefit ratio (1 : 2.9).

ACEPHATE

It is an organophosphorus compound with systemic action and effective against lepidopteran borers and sucking pests (Gupta, 1999).

Pawar *et. al.* (1993) reported that spray application of **acephate** 75 SP 1.0 kg a.i. ha⁻¹ alone decreased larval population of *Helicoverpa armigera* Hubner. From 4.2 (pretreatment) to 0.4 (14 days after application) larvae plant⁻¹. However, combination of **acephate** 75 SP 0.25 kg + cypermethrin 10 EC 0.75 litre proved effective as well as economical to control the pod borer in chickpea. Foliar spray of Biobit WP (1.0 and 1.5 kg/ha), fenvalerate (0.02%), cypermethrin (0.025%), **acephate** (0.1%) and a tank mixture of fenvalerate (0.023%) + dimethoate (0.04%) were significantly reduced the larval population of *H. armigera* in cotton compared to untreated control (Shankar *et. al.*, 1993). Pawar *et. al.* (1994) reported that spray application of **acephate** 75 SP 2.0 kg ha⁻¹ gave an effective control of *H. armigera* on chickpea. Nath and Yein (1996) reported that application of **acephate** 75 SP @ 0.075% gave an effective control of *M. testulalis* infesting blackgram and resulted in significantly higher grain yields than untreated control.

THIODICARB

Thiodicarb is an oxime carbamate compound with predominantly stomach and limited contact action. It was introduced recently in Indian market as an effective insecticide against caterpillars.

Bhadauria *et. al.* (1988) reported that the treatments thiodicarb (650 g a.i. ha⁻¹), monocrotophos (0.5 kg a.i. ha⁻¹), carbaryl (1.0 kg a.i. ha⁻¹) and fenvalerate (150 g a.i. ha⁻¹) were on par and recorded 9.40 to 12.69 per cent pod damage in pigeonpea due to pod fly, *Melanagromyza obtusa* (Malloch) and other pod borers. Maximum ovicidal activity of thiodicarb (0.075%), methomyl (0.048%) and triazophos (0.08%) was observed against *H. armigera* on chickpea by dipping and spraying methods (Mala *et. al.*, 1992). Mann *et. al.* (1995) reported that thiodicarb (0.075%) is the most effective alternative for synthetic pyrethroids against *Heliothis zea* (Boddie) and *H. virescens* (Fab.) on cotton. Two sprays of thiodicarb at 300 g ha⁻¹ resulted in pod damage of only 24.7 per cent due to gram pod borer and the highest seed yield of chickpea when compared to the other treatments. (Biradar *et. al.*, 1999). Yelshetty *et. al.* (1999) reported that based on yield and cost-benefit ratio thiodicarb @650 g ha⁻¹ has been recommended as an effective chemical for the management of the pod borers in pigeonpea.

DIFLUBENZURON (DFB)

Diflubenzuron 1-[4 chlorophenyl-3 (2, 6 - difluorobenzoyl) urea] is a chitin synthesis inhibitor with stomach and contact action. It interferes with cuticle deposition at larval-larval, larval-pupal, pupal-adult moulting stages (Mulder and 'Gijswijt, 1973; Wellinga *et. al.*, 1973). Literature on the efficacy of diflubenzuron on *M. vitrata* is inadequate and hence the bio-efficacy of diflubenzuron on other lepidopterous pests are presented below.

Balasubramanian *et. al.*, (1980) reported that diflubenzuron (2.5, 5, 10, 20, 40, 60, 80 and 100 ppm) acted effectively by interfering with the chitin deposition in the larvae of *Spodoptera litura* Fab. and *H. armigera*. Diflubenzuron at 100, 250, 500 and 1000 ppm was found effective against first instar larvae and pupae resulting in reduced adult emergence in tobacco caterpillar, *S. litura* and castor semilooper, *Achoea janata* Linn. (David Jayapaul, 1987).

Ananthkrishnaswamy and Punnaiah (1983) reported that DFB at 0.01 per cent gave complete inhibition of egg hatch and very effective in killing the early instar larvae of

S. litura. **DFB** at 100 ppm and above was found effective and caused 67 to 100 per cent reduction in a adult emergence in both *A. janata* and *S. litura* (Rao and Reddy, 1984). Sehna *et. al.* (1986) reported that **DFB** at 0.03 μg larva⁻¹ caused 50 per cent mortality of *S. littoralis* Boistd. Before adult emergence and 90.1 to 94.8 per cent sterility in the resulting adults.

Alexander Jesudasan *et. al.* (1986) reported that **DFB** at 100 g a.i. ha⁻¹ was effective against groundnut leaf miner *A. modicella*. Mayuravalli *et. al.* (1987) recorded 0.58 per cent and 0.064 per cent as LC₅₀ values for **DFB** against first and fifth instar larvae of *S. litura*, respectively and also reported that early instar larvae showed greater mortality than older larvae, especially with higher concentrations of **DFB**. Khalid Ahmed *et. al.* (1990) reported that **DFB** @0.0075 per cent showed significant ovicidal toxicity in the eggs of *H. armigera*. Vaisampayan and Verma (1992) observed that **DFB** @ 0.0125 per cent was highly effective against all instars of *S. litura*. Mortality was 100 per cent after 5-7 days of feeding even with the lowest concentration of 0.00625 per cent. However, in field trial the survival of larval population in 0.025 per cent and 0.0125 per cent **DFB** treated crop after 5 days was 6.33 and 18.17 per cent, respectively.

NEEM

Neem oil reported to have insecticidal, growth regulatory, antifeedant and repellent properties against a widerange of insect pests. It was reported to have certain diverse array of biological active principles, of which azadirachtin is one of the best known (Jones *et. al.*, 1989). The apparent harmlessness of neem pesticides to beneficial species and systemic activity, limited persistence are attracting entomologists (Schmulterer, 1990).

Cobbinah and Osei-Owusu (1998) reported aqueous- methanol extracts of defatted neem seed powder applied as dust on soil around the plant reduced the incidence of *M. testulalis* and increased pod yield in cowpea. Cost: benefit ratio was

greatest for neem seed bitters at 5000 ppm for the control of *M. testulalis* on mungbean (Kareem *et. al.*, 1988). Jackai and Oyediran (1991) reported that the different concentrations of neem oil emulsifiable concentrate (5, 10 and 20%) exhibited a high degree of insecticidal activity on *M. testulalis* larvae. All the treated flowers were protected from larval damage after two days of treatment as compared to cent per cent damage recorded on untreated flowers. Aqueous extracts of neem seeds and leaf extracts had an adverse effect on the biology of *M. testulalis* (Tanzubil, 1991). Venkateswarulu *et. al.* (1992) tested neem oil, alone and in combination with endosulfan (0.07%) and monocrotophos (0.04%) and reported that neem oil (0.1%) in combination with endosulfan 35EC (0.07%) was the most effective treatment in reducing infestation and in increasing yield.

Jackai *et. al.* (1992) reported that neem proved effective in acting as an insecticide and affected the rates of development of *M. testulalis* at a concentration as low as 9 per cent solution (wt/vol). Latif *et. al.* (1996) reported that Nimbecidine (0.3%) sprayed thrice at 12 days interval was effective in controlling the major insect pests of pigeonpea at pod initiation stage. Durairaj and Ganapathy (1998) reported that Neem Seed Kernel Extract (NSKE) 5 per cent and Neem oil 5% registered low pod borer damage levels of 16.3 and 16.8 per cent respectively, while the commercial botanicals like Neemolin and Neemol registered comparatively higher damage levels of 19.0 and 21.3 per cent respectively however it was 35 per cent in untreated control. Emosairue and Ubana (1998) reported that two concentrations of NSKE at 5 per cent and 10 per cent were effective against pod borer, *M. testulalis* and found that 5 per cent NSKE gave a better cost-benefit ratio.

Bacillus thuringiensis var. kurstaki

Bacillus thuringiensis Berliner is a microbial insecticide effective against a number of lepidopterous and coleopterous insect pests (Hall and Andres, 1959).

Karel and Schoonhoven (1986) reported that two applications of *B.t.k* during the post-flowering stage of bean plants controlled the larvae of *M. testulalis* and *H.armigera*

as effectively as two applications of lindane or carbaryl. *Bacillus thuringiensis* (*B.t.*) preparations 8401 (emulsion), BT₁ (emulsion), HD-1 (liquid) and 7216 (powder) were tested in the laboratory and observed 73.3 - 80.0 per cent of individuals of *M. vitrata* died within 48 hours after eating leaf blades soaked in a 0.05 per cent to 0.20 per cent solutions (Wang *et. al.*, 1989). Pawar and Gunjal (1995) reported that **Halt** @ 2000, 1500, 1000 g ha⁻¹ and **Delfin** @ 1000 g ha⁻¹ were equally effective in reducing pod damage caused by lepidopterous borers in pigeonpea, and also obtained highest yield with **Halt** (Wock-01) WP @ 2000 g ha⁻¹. Manjula and Padmavathamma (1996) observed that, the highest reduction (53.18%) of *M. vitrata* larval population with *B.t.k.* (0.2%) + monocrotophos (0.025%).

Toxicity of *B.t.* to other related lepidopteran pests

Purohit and Deshpande (1991) evaluated the efficacy of *B.t.* var *kurstaki* against III instar larvae of *H. armigera* and reported LC₅₀ as 0.179 per cent. Pawar *et. al.* (1999) evaluated **Halt** (Wock-01) @ 1000 g ha⁻¹ against *H. armigera* on chickpea and recorded only 6.75 per cent pod damage which is consistently at par with fenvalerate 100 ml ha⁻¹ (6.48 %).

NURELLE D 505

It is a combination product of chlorpyrifos 50 EC and cypermethrin 5 EC. Chlorpyrifos is an organophosphorus compound with contact and stomach poison where as cypermethrin is a synthetic pyrethroid.

Literature on the efficacy of **Nurelle D 505** on *M. vitrata* is meagre and hence the bio-efficacy of **Nurelle D-505** on other internal feeders and pod borers are presented below.

Srinivasan *et. al.* (1995) reported that chlorpyrifos 22.5 EC + cypermethrin 2.5 EC, a combination product was better at a dose of 450 + 50 g a.i. ha⁻¹ @ 2.0 lit.

formulation ha^{-1} than the use of either chlorpyrifos 20EC at 500 g a.i. ha^{-1} or cypermethrin at 50 g a.i. ha^{-1} in controlling cotton bollworms and increasing seed cotton yield. Tambe *et. al.* (1997) reported that, the combination product of chlorpyrifos + alpha cypermethrin at a higher dose of 3125 ml ha^{-1} was the most effective in reducing bollworm damage on cotton.

Pawar and Mali (1997) carried out a laboratory test to evaluate the bio-efficacy of insecticide mixtures in comparison with individual insecticides against *H. armigera* on cotton. The treatment with chlorpyrifos 0.08% + alphamethrin 0.004% was found most effective and registered 93.33 per cent mortality of larvae. However, the treatment with cypermethrin 0.008% + chlorpyrifos 0.08 % was at par with it. They reported that, the insecticide mixtures of synthetic pyrethroids either with chlorpyrifos, triazophos, endosulfan and monocrotophos were more effective against *H. armigera* in comparison with their sole use. Giraddi *et. al.* (1998) reported that chlorpyrifos + cypermethrin at 1000 + 100 g a.i. ha^{-1} resulted in lowest fruit damage (12%) by Bhandi fruit borer, *Earias vitella* Fab. Mane *et. al.* (2000) conducted laboratory studies of some individual insecticides, ready-mix and tank-mix insecticides against the larvae of *H. armigera*. These studies revealed that cypermethrin + chlorpyrifos was the most toxic combination.

KORANDA

It is a ready mix formulation of acephate 22 per cent SP and fenvalerate 3 per cent EC. Acephate is an organophosphorus compound with systemic action whereas fenvalerate is a synthetic pyrethroid with contact action.

Reports pertaining to the efficacy of Koranda on pod borer, *M. vitrata* are inadequate, hence literature available on the efficacy of fenvalerate is reviewed here under.

Sontakke and Mishra (1991) reported that fenvalerate 150 g a.i. ha^{-1} , decamethrin 12.5 g a.i. ha^{-1} and cypermethrin 75 g a.i. ha^{-1} when applied thrice effectively controlled the pod borer complex of pigeonpea. Ganapathy and Durairaj (1994) reported minimum

damage by *M. vitrata* and maximum grain yield in pigeonpea with a sequence of monocrotophos (0.04%) fenvalerate (0.02%) and dimethoate (0.03%) applied at 14 days interval. Borah (1995) reported that spray application of cypermethrin (0.01 and 0.015%), deltamethrin (0.0028 and 0.0042%) and fenvalerate (0.004% and 0.006%) gave an effective control of *M. vitrata* and other sucking pest complex of greengram.

Avinashkumar *et. al.* (1996) found that dusting 4 per cent fenvalerate twice during the crop season effectively controlled the borer, *M. testulalis* and other sucking pests in blackgram. Nath and Yein (1996) reported that spray application of fenvalerate 20 EC (0.005%) gave an effective control of *M. vitrata* infesting blackgram and resulted in significantly higher grain yields. Ram Ujagir and Ujagir (1999) found that fenvalerate spray (0.004% and 0.006%) and dust (4%) gave an effective control of pod borers of pigeonpea and obtained higher grain yield.

Materials and Methods

MATERIALS AND METHODS

Studies on the “Bioecology and Management of *Maruca vitrata* (Geyer) on Blackgram” were conducted at college farm and in the laboratory, Department of Entomology, Agri. College, Bapatla during *rabi* 2000-2001. Materials utilized and methods employed in conducting the experiments are given below.

3.1 CULTIVATION ASPECTS

The A.N.G.R. Agricultural University, A.P. recommendations on Agronomical Practices were followed in growing the crop.

3.1.1 Preparatory cultivation

Prior to sowing the land (sandy loam) was ploughed twice with a tractor drawn cultivator and twice with power tiller to obtain good tilth. Levelling was done with human labour and the field experiment was laid out in Randomised Block Design (RBD) (Fig.1).

3.1.2 Sowing

The popular local variety LBG-685 was selected and the seed obtained from the Agricultural College Farm, Bapatla. Sowing was taken up on 30.11.2000 by adopting a spacing of 30 cm x 10cm. Gap filling was done seven days after sowing and thinning was done 10 days after germination.

3.1.3 Fertilization

Recommended manurial dosage of 10 tonnes of FYM ha^{-1} , 20 kg N ha^{-1} (in the form of Urea) 50 kg P_2O_5 ha^{-1} (in the form of SSP) and 40 kg K_2O ha^{-1} (in the form of Murate of Potash) was adopted. Total FYM, half of nitrogen, total phosphorus and potash were applied as basal dose and the rest of the nitrogen was given one month after sowing.

3.1.4 Weeding

Two hand weedings were given after three and six weeks of sowing.

3.1.5 Irrigation

Two irrigations, the first immediately after sowings and the second at 30 days after sowing were given.

3.2 BIOLOGY OF THE SPOTTED POD BORER, *M. vitrata*

3.2.1 Mass rearing

Periodically field collected larvae served as initial culture which were reared till pupation on fresh flowers and tender pods of blackgram in rearing jars (20 cm x 9 cm). After pupation, the pupae were transferred into clean specimen tubes (10 cm x 2 cm) for adult emergence. The newly emerged moths were enclosed in pairs in glass chimneys for mating and cotton swab soaked in 10 per cent honey was provided to serve as adult food (Ochieng and Bungu, 1983). Shoot tips of blackgram containing inflorescence were provided inside the chimneys for oviposition. The cut ends of the shoots were kept in glass vials containing water. The eggs laid on plant parts were removed daily and kept separately for hatching. The newly hatched larvae were transferred into glass tubes (10 cm x 1.5 cm) with fresh blackgram flowers and tender pods. Rearing was continued till the emergence of the adults. The eggs laid by these adults and the larvae obtained from these eggs were used for biology studies.

3.2.2 Biology on blackgram

Detailed biology of *M. vitrata* was studied in the laboratory on blackgram flowers and tender pods for two generations starting from November 2000 to February 2001 at mean temperature of $29 \pm 2^\circ\text{C}$ and relative humidity of 87 ± 2 per cent.

3.2.2.1 Pre-natal periods

Freshly emerged adults were collected and one pair was confined in plastic container (5 cm diameter and 10 cm height) wrapped with a black paper to induce mating (Okeyo-Owuor and Ochieng, 1981). Inside the container, inflorescence of blackgram stalk dipped in a vial of water was provided. The inflorescences were replaced daily. Cotton swab dipped in 10 per cent honey solution was provided as adult food. The pre-natal periods were noted by observing the daily activities of 10 adult pairs.

3.2.2.1.1 Premating period

After emergence from pupae, the moths were observed to mating. The time between emergence of moth and starting of mating was recorded as premating period.

3.2.2.1.2 Mating period

The time between the first mating and last mating gave the mating period.

3.2.2.1.3 Pre-oviposition period

The time between last mating and first oviposition was registered as the pre-oviposition period.

3.2.2.1.4 Oviposition period

The time between first oviposition and last oviposition was recorded as oviposition period.

3.2.2.1.5 Eggs laid

The eggs are laid singly and in small groups. The flower buds and the walls of the containers were carefully observed for the presence of tiny, globular, scaly, overlapping eggs. The number of eggs laid were recorded. From the observations of 10 pairs, the mean number of eggs laid by a single female was calculated.

3.2.2.1.6 Egg period

Eggs were removed carefully with fine tipped camel hair brush and kept separately and observed for hatching. The time taken between oviposition and egg hatching was considered as egg period.

3.2.3 Post-natal stages and periods

3.2.3.1 Larval period

The neonate larvae were transferred singly into clean glass vials and provided with blackgram flower buds. The flower buds were replaced daily. The larvae were carefully observed periodically for moulting. The number of larval instars, duration of each instar, length, breadth of head capsules and each larval instar, total larval period and morphological characters of each larval instar were recorded.

3.2.3.2 Pre-pupal period

Cessation of feeding and reduction in size and disappearance of larval markings are the characteristics of pre-pupa. The pre-pupa began to construct a silken gauze-like cocoon around the body. The flower debris and excreta provided the camouflage. Pre-pupal period and its measurements were recorded.

3.2.3.3 Pupal period

The period between the time of pupation and adult emergence was recorded for 10 pupae and the mean was worked out. The length and breadth of 10 pupae were also measured.

3.2.4 Adult

3.2.4.1 Adult longevity

Ten freshly emerged female moths and male moths were introduced in to separate mating cages (45 cm x 25 cm) at the rate of one pair of moths in a cage and provided 10 per cent honey swab as food and they were maintained till they died. The male and female longevity periods were recorded separately.

3.2.4.2 Sex ratio

For the assessment of sex ratio, freshly laid eggs of 10 female moths were collected on a moist filter paper. The neonate larvae obtained from these eggs were reared on host flower buds till pupation and the pupae thus obtained were kept in wide mouthed glass jars (24 cm x 12 cm) till adult emergence. The male and female moths were counted separately and the sex ratio was worked out.

Data on morphometrics of egg, larval instars, head capsules of larval instars, pre-pupa, pupa and adult of *M. vitrata* were subjected to statistical scrutiny to obtain mean, standard deviation (Snedecor and Cochran, 1967).

3.3 ECOLOGICAL STUDIES

3.3.1 Seasonal incidence

Seasonal incidence of spotted pod borer, *M. vitrata* was studied during *rabi* on blackgram grown in rice fallows (2000-2001) at Agricultural College Farm, Bapatla.

For this purpose, a blackgram was sown during *rabi* in rice fallows with variety LBG-685 in 400 m² area. Four selected spots, each one square metre were ear marked (50 plants). The data was recorded at three days interval starting from the first field infestation. Total larvae present from these 50 plants were recorded.

The influence of weather parameters viz., maximum temperature, minimum temperature, morning RH, evening RH and sunshine hours on *M. vitrata* incidence was analysed statistically by Multiple Linear Regression (MLR) analysis.

3.3.2 Natural Enemies

Periodically field collected larvae were brought to the laboratory and reared on blackgram flowers / tender pods for observing the emergence of parasitoids. The parasitoids emerged from these field collected larvae were identified by the Director, Project Directorate of Biological Control, Bangalore. To identify the fungal disease naturally infected larvae

were brought to the laboratory, spores were isolated and grown on Potato Dextrose Agar (PDA). Based on mycelia growth and spore characters the organisms were identified.

3.4 EVALUATION OF CERTAIN INSECTICIDES

3.4.1 Layout of the experimental plot

The experiment was laid out in a Randomised Block Design (RBD) with 11 treatments including untreated control (Fig. 1) and replicated thrice. The size of each plot was 12 m² (4m x 3m). A view of the experimental plot is shown in Plate 1. The details of the test insecticides used are given in Table 2.

3.4.2 Preparation of spray fluid

The required quantity of insecticides were measured and mixed well with small quantity of water and later made up to get the required volume of spray fluid. The spray fluid was stirred thoroughly before spraying. The concentrations of the test insecticides are given in the Table 3.

3.4.3 Application of insecticides

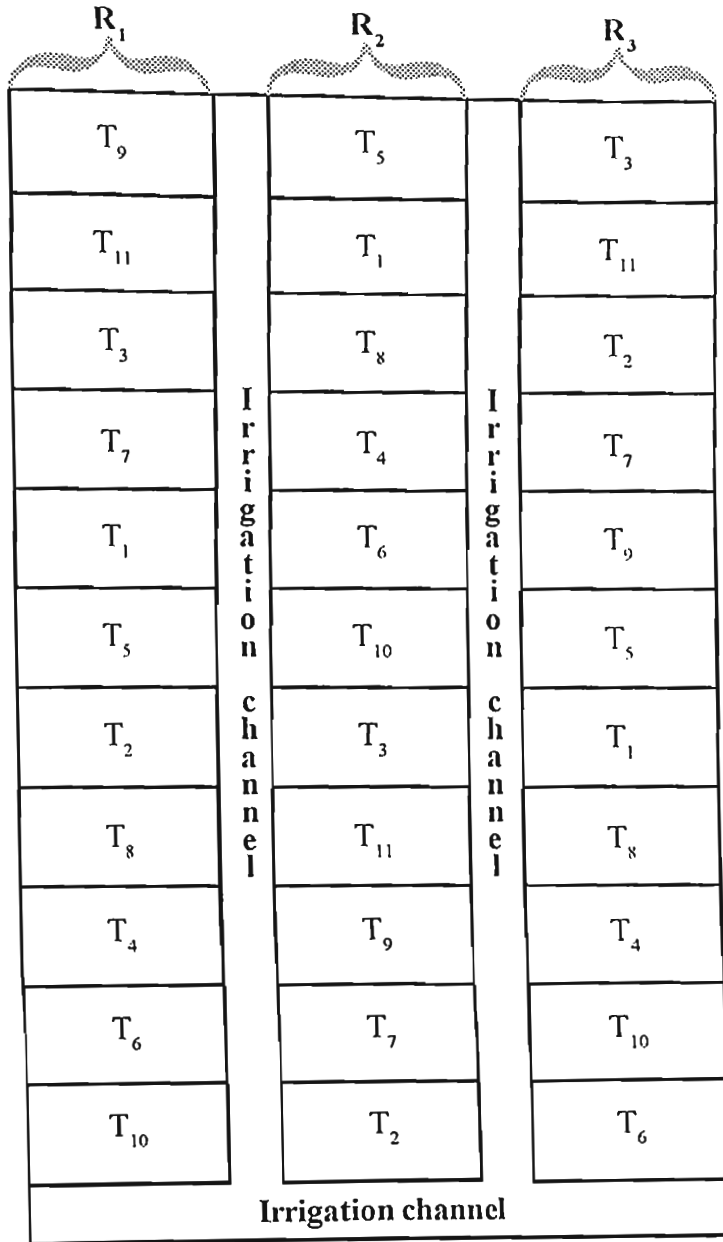
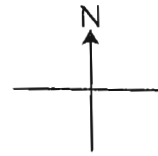
The treatments were applied twice at 40 and 50 days after sowing the crop. The foliar sprayings were given at evening about 4 PM when the weather was still. A hand compression sprayer was used for applying the insecticides. The sprayer and container used for preparing spray fluid were thoroughly cleaned with water before changing the insecticide and rinsed with spray fluid to be sprayed next. The plants were covered thoroughly with the spray fluid to the point of run off. Each plot (12 m²) received 0.6 litres of spray fluid.

3.4.4. Recording data

Ten plants were selected at random from each plot and tagged. The larval populations were recorded from those ten tagged plants at one day before and third,

Treatments

T ₁	DDVP 0.038% + chlorpyriphos 0.04%
T ₂	DDVP 0.038% + quinalphos 0.05%
T ₃	Nurelle D 505 (chlorpyriphos 0.05% + cyper nethrin 0.005%)
T ₄	Koranda (acephate 0.075 % + fenvalerate 0.009%)
T ₅	Thiodicarb 0.075%
T ₆	Acephate 0.075%
T ₇	Endosulfan 0.07%
T ₈	Diflubenzuron 0.025%
T ₉	Halt (B.t.k) 0.2%
T ₁₀	Neemgold 0.2%
T ₁₁	Untreated control



Variety : LBG 685
Spacing : 30 cm x 10 cm
Plot size : 4 m x 3 m
Design : Randomized Block Design (RBD)
Treatments : 11
Replications : 3

Fig. 1 Layout of the experimental plot



Plate 1: View of the experimental plot

TABLE : 2 DETAILS OF THE TEST INSECTICIDES

S.No.	Common Name	Chemical Name	Trade Name	Source
1.	Dichlorvos (OP compound)	2, 2-dichlorovinyl dimethyl phosphate	Suchlor 76 EC	Sudharshan Chemical Industries Ltd., PUNE.
2.	Chlorpyrifos (OP compound)	0, 0-- diethyl 0-(3, 5, 6- trichloro -2-pyridyl) phosphorothiate	Dursban 20 EC	De-Nocil crop protection Ltd., Mumbai.
3.	Quinalphos (OP compound)	0, 0-diethyl 0-quinoxalin-2-yl phosphrothiate	Bayursil 25 EC	Bayer (India) Ltd., Powai, Mumbai.
4.	Acephate (OP compound)	0, s-dimethyl acetyl phosphoramidothiate	Starthene 75 WP	Shaw wallace and company Ltd., Chennai.
5.	Thiodicarb (oxime carbamate)	Dimethyl N, N- [thiobis (methyl imino) carboxyl oxy]] bis (ethanimidothioate)	Larvin 75 WP	Aventis Crop Science, Hoechst centre, Andheri, Mumbai.
6.	Endosulfan (organo chlorine compound)	1, 4, 5, 6, 7, 7 hexachloro - 8, 9, 10- trinoborn -5-en-2, 3-ylenedimethyl sulphite	Speed 35 EC	Nagarjuna Fertilizer and Chemicals, Hyderabad.
7.	Nurelle D-505 (chlorpyrifos 50 EC + cypermethrin 5 EC) (Ready mix formulation)	0, 0-diethyl 0-(3, 5, 6- trichloro - 2 -pyridyl) phosphorothiate + (RS) -a- cyano-3- phenoxybenzyl-(1RS)-cis, trans-3-(2,2 dichloro vinyl)-2, 2-dimethyl cyclopropane carboxylate.	Nurelle D-505	De-Nocil crop protection Ltd., Mumbai.

Contd...

S.No.	Common Name	Chemical Name	Trade Name	Source
8.	Koranda (Acephate 25 SP + Fenvalerate 3 EC) (Ready mix formulation)	O, S- dimethyl acetyl phosphoramidate thioate + (RS) - a-cyano-3- phenoxy benzyl (RS)- 2-(4, -chlorophenyl)-3- methyl butyrate.	Koranda	Rallis India Ltd., Mumbai.
9.	Diflubenzuron (chitin inhibitor)	1-(4-chlorophenyl)-3-(2,6-difluoro benzoyl) urea.	Dimilin 25 WP	Dhanuka pesticides Ltd., Karol Bagh New Delhi - 5.
10.	<i>Bacillus thuringiensis</i> var. <i>kurstaki</i> (Microbial insecticide)	--	Halt 5 WP	M/s Wockhardt Ltd., Mumbai.
11.	Neem (Botanical insecticide)	Azadirachtin	Neemgold 1500 ppm (0.15 EC)	Vijayalakshmi insecticides and pesticides, Hyderabad- 82.

TABLE 3 CONCENTRATIONS OF THE TEST INSECTICIDES

Treatment	Qty. of chemical per litre of water	Conc. of spray fluid
T ₁ -Dichlorvos 76 EC + chlorpyriphos 20 EC	0.5 ml + 2.0 ml	0.038% + 0.04%
T ₂ -Dichlorvos 76 EC + quinalphos 25 EC	0.5 ml + 2.0 ml	0.038% + 0.05%
T ₃ -Nurelle D-505 (chlorpyriphos 50 EC + cypermethrin 5 EC)	1.5 ml	0.05% + 0.005%
T ₄ -Koranda (acephate 25 SP + fenvalerate 3 EC)	3.0 ml	0.075% + 0.009%
T ₅ - Thiodicarb 75 WP	1.0 g	0.075%
T ₆ - Acephate 75 SP	1.0 g	0.075%
T ₇ -Endosulfan 35 EC	2.0 ml	0.07%
T ₈ -Diflubenzuron 25 WP	1.0 g	0.025%
T ₉ - B.t. formulation (Halt 5 WP) (<i>B. thuringiensis</i> var. <i>kurstaki</i>)	2.0 g	0.2%
T ₁₀ - Neemgold 1500 ppm	2.0 ml	0.2%
T ₁₁ -Untreated control	--	--

Results

RESULTS

The findings of the experiments conducted on the biology, ecology and management of spotted pod borer, *Maruca vitrata* (Geyer) on blackgram are presented below.

4.1 BIOLOGY OF THE SPOTTED POD BORER, *M. vitrata*

The biology of the spotted pod borer, *M. vitrata* was studied for two generations on blackgram under laboratory conditions during November 2000 to February 2001 in the Department of Entomology, Agricultural College, Bapatla and the results are presented below.

4.1.1 Moth emergence and mating

The moths emerged between 20.00 to 24.00 h and rarely at midnight. Immediately after emergence both sexes were very active, flying scatterly along the walls of the glass chimneys for 2.0 to 2.20 days and then mated in end to end position. Maximum number of mating pairs were observed between 20.00 to 24.00 h. The mating process continued for 2 to 3 hours. Female laid eggs only during night by pressing its ovipositor into under surface of leaves, terminal shoots, flower buds and tender pods.

Premating period was found to be 2.19 days and mating period was 2.00 days when studied for two generations (Table 5).

4.1.2 Pre - oviposition period

The pre-oviposition period was found to be 1.23 days (Table 5).

4.1.3 Oviposition period

The moths deposited eggs, scattered, singly or in batches of 2 to 18. The total number of eggs laid by a single female moth on an average was 55.55. The egg laying started on fourth day after emergence and continued up to tenth day after emergence. The oviposition period was found to be 4.25 days when studied for two generations (Table 5).

4.1.4 Egg

Freshly laid eggs were pale yellowish, scale like and were laid singly/in small groups on the flower buds, tender pods and also on the walls of the container. The eggs were dorso-ventrally flat and were not easily visible to naked eye (Plate 2).

The egg measured 0.67 mm in length and 0.44 mm in breadth (Table 4). The colour of the egg changed gradually from milky white to yellowish cream. One to two hours before hatching the larva started moving its head to and fro and sideward. The larva cut the wall of the chorion and widened the exit hole with mandibles. Though the hatching was generally observed during night, it also occurred during day. The incubation period under laboratory condition was 2.98 days (Table 5).

4.1.5 Larva

The first and second instar larva did not exhibit the typical brownish black spots on the mid-dorsal line while from the third instar onwards a pair of dark spots in each segment was very conspicuous. During its larval period, the caterpillar moulted four times and thus had five instars. The characteristics of and the period occupied by each instar were noted (Table 5). Length and breadth of the each instar body and head capsule were recorded (Table 4).

4.1.5.1 I Instar

The neonate larvae were minute, glistening with pinkish head capsule and actively moved for about 15 to 30 minutes before feeding. Under field condition they were observed to bore into the unopened flowers. Full grown larva is creamy white in colour, except head and prothoracic segment and had series of dark brown sclerites on the thoracic and abdominal segments. (Plate 3). The prothoracic segment bears dorsally a broad chitinised brown plate with six setae on each half. A long prominent setae arises from each lateral side of meso and metathoracic segments. The ninth abdominal segment consists of one median and one

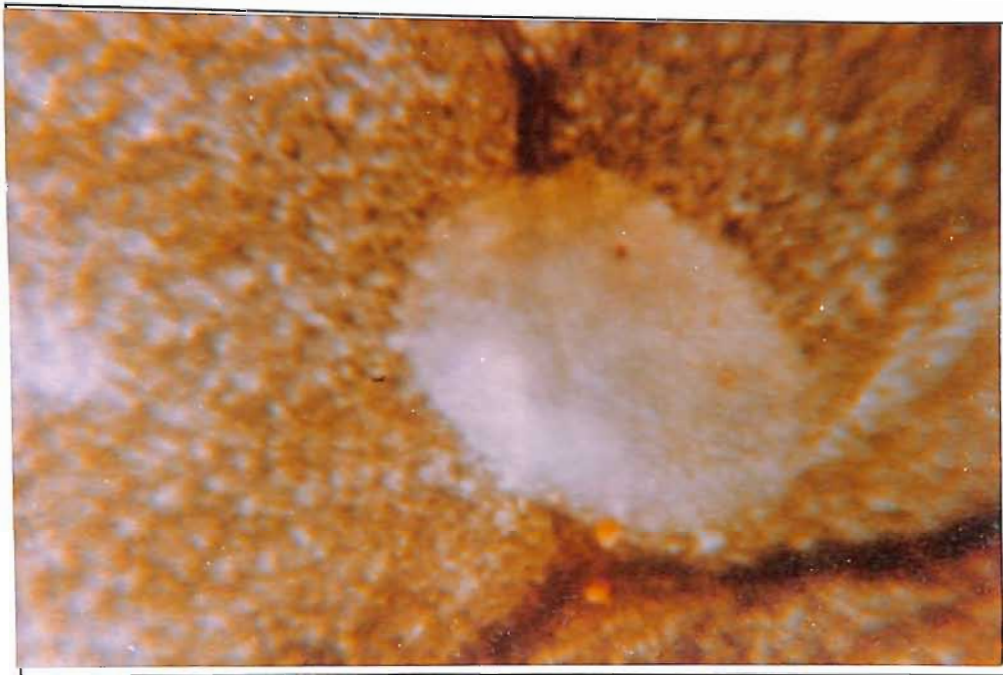


Plate 2: Egg of *M. vitrata*

lateral brown sclerite at each side with a long prominent seta. The tenth segment bears two long conspicuous setae. The third to sixth and tenth abdominal segments each bear a pair of ventral prolegs.

The I instar larva measured on an average 2.37 mm in length and 0.49 mm in breadth (Table 4). The head capsule measured on an average of 0.16 mm in length and 0.20 mm in breadth (Table 6). The size of the larvae increased towards moulting and the abdomen became more or less cylindrical in shape. The I instar larva occupied on an average of 2.02 days to complete its development (Table 5).

4.1.5.2 II instar

The head and body of the freshly moulted larva was creamy white, except eyes and mandibles which were dark brown. Later the body became dirty white in colour (Plate 4). The larva measured on an average 3.90 mm in length and 0.70 mm in breadth (Table 4). The head capsule measured on an average 0.41 mm in length and 0.52 mm in breadth (Table 6). The larval period on an average was 1.82 days (Table 5).

4.1.5.3 III instar

The structure of the III instar larva was similar to that of II instar, except its size which is larger. The colouration of head and prothoracic shield were darker (Plate 5). The larva on an average was 7.09 mm in length and 1.295 mm in breadth. The head capsule measured on an average 0.89 mm in length and 0.92 mm in breadth (Table 6). It took on an average 1.87 days to complete its development (Table 5).

4.1.5.4 IV instar

Freshly moulted larva is creamy white in colour, except eyes and mandibles. Later the head and prothoracic shield become dark brown and the body was dull white and similar to third instar, except bigger in size (Plate 6). The larva measured on an average 0.49 mm in length and 1.90 mm in breadth (Table 4). The head capsule on an average was



Plate 3: I instar of *M. vitrata*



Plate 4: II instar of *M. vitrata*

1.37 mm in length and 1.39 mm in breadth (Table 6). The larva took on an average 1.94 days to complete its development (Table 5).

4.1.5.5 V instar

It measured on an average 16.10 mm in length and 2.43 mm in breadth (Table 4). The head capsule on an average was 1.66 mm in length and 1.89 mm in breadth (Table 6). The larva occupied on an average 3.71 days to complete its development (Table 5).

The head capsule measurement indicated that the growth ratio in the successive instars varied from 1.063 to 1.600 (Table 6). The V instar had the highest head capsule breadth and also had the longest duration of 3.71 days.

Mature larva is creamy white to brownish green with dark brown segmentally arranged sclerites, where as the head is light yellowish brown with irregular light brown markings. The body slightly tapers towards both ends with maximum width in the middle (Plate 7). The head is some what oval, and bears 21 setae of which four are microscopic and 10 punctures on each half.

4.1.6 Pre-pupa

Full grown larva stopped feeding and became quiescent with reduced body size and disintegrated dorsal spotting. The colour of the pre-pupa turned to light green. The full grown larva moved to the corner of rearing container and then spun silken thread in net fashion around it to transform into pupa. The pre- pupa measured on an average 13.00 mm in length and 2.59 mm in breadth (Table 4). Pre-pupal period was about 2.54 days. (Table 5).

4.1.8 Pupa

The pre-pupa changed its colour from light grey to light brown before transforming into pupa (Plate 8). Pupation occurred in dried leaves or sand or pod itself under laboratory conditions. Under field conditions pupation occurred inside the pods only. The pupa measured on an average 11.60 mm in length and 2.86 mm in breadth (Table 4). Pupal period was about 9.07 days (Table 5).



Plate 5: III instar of *M. vitrata*

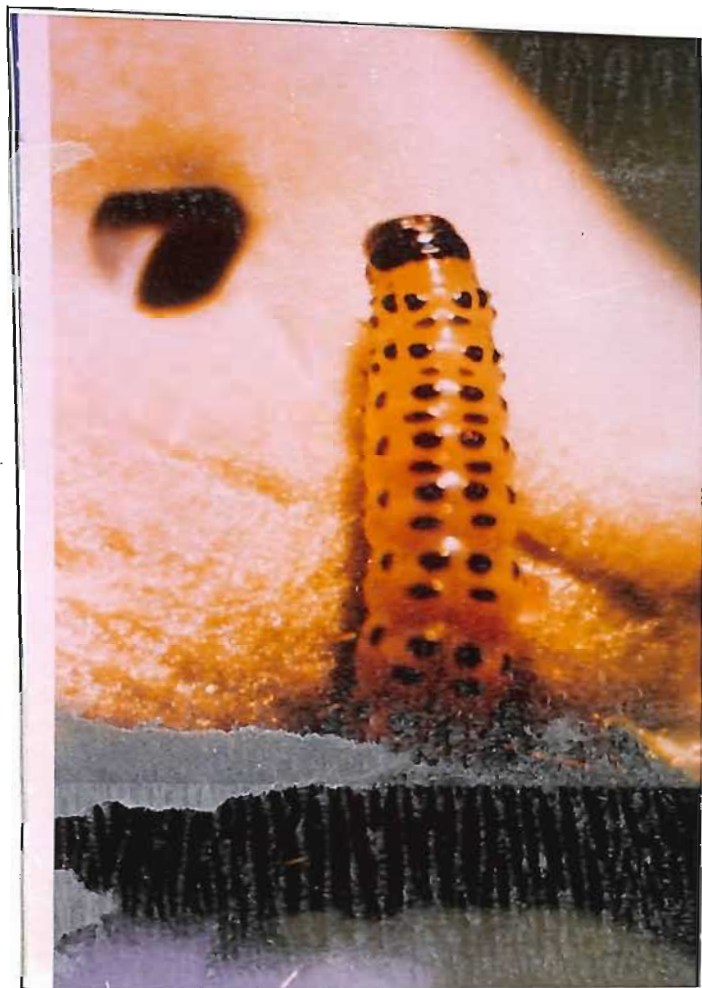


Plate 6: IV instar of *M. vitrata*

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Plate 7: V instar of *M. vitrata*



Plate 8: Pupae of *M. vitrata*

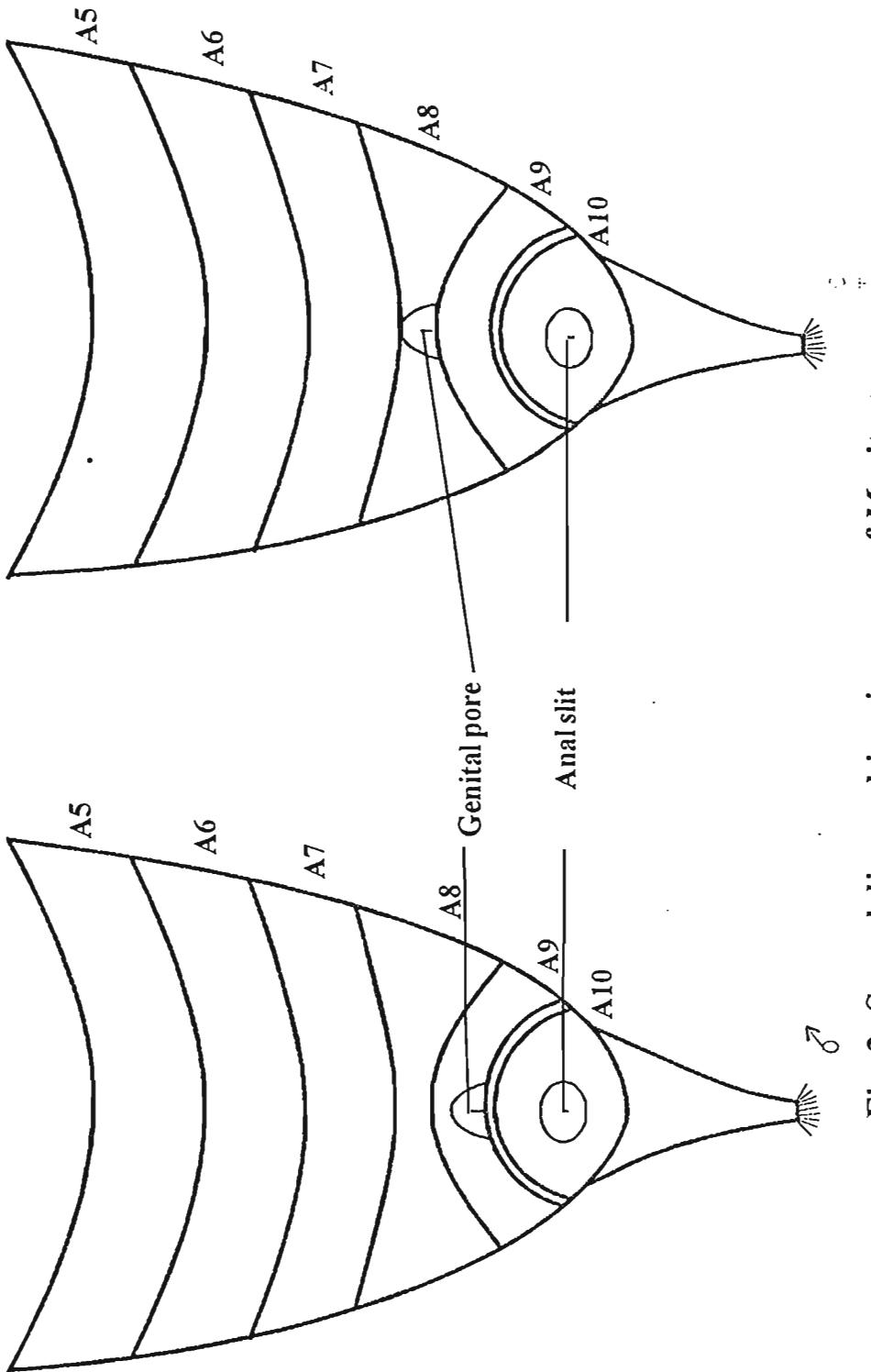


Fig. 2 Sexual dimorphism in pupae of *M. vitrata*

Both male and female pupae were of equal size. In male pupa, the genital opening is situated ventrally on the posterior margin of IX segment, close to the anal slit present on X segment whereas in female pupa, the genital opening is situated ventrally on the posterior margin of VIII segment and is away from the anal slit (Fig. 2).

4.1.9 Adult

Moths were medium sized, with brown fore wings dotted with a single black-eyed white spot. Hind wings were semi-hyaline, white with a basal brownish area. Though both sexes were morphologically similar, the abdominal tip in females was broad and bulged whereas in males it was telescopic (Plate 9). Adults measured 11.31 mm in length (from head to abdominal tip) with a wing expanse of 24.27 mm in case of female whereas in case of male the body length was 11.49 mm and with wing expanse of 23.37 mm across the wings.

4.1.10 Sex ratio

The sex ratio was 1.2 : 1.0 (female : male) under laboratory conditions.

4.1.11 Total developmental period

M. vitrata took on an average of 25.98 days on blackgram to complete its life cycle under laboratory conditions (Table 5).

4.1.12 Longevity of adults

The longevity of female moth was 9.04 days while that of male was 7.47 days when studied for two generations (Table 5).

4.1.13 Number of generations

In the field, different stages of larvae and pupae were observed simultaneously during the cropping season. It was difficult to separate the generations since they overlapped considerably. However, the present study indicates that a generation cycle took about 26 days. It is, therefore, possible to have two generations in each of *kharif* and *rabi* seasons.



Plate 9: Adults of *M. vitrata*

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Table :4 Biometrics (mm) of different developmental stages of *M. vitrata* reared on blackgram*

Growth stages	Generation		Average (Mean \pm SD)
	I (Mean \pm SD)	II (Mean \pm SD)	
<i>Egg</i>			
Length	0.67 \pm 0.007	0.67 \pm 0.007	0.67 \pm 0.008
Breadth	0.44 \pm 0.008	0.44 \pm 0.007	0.44 \pm 0.02
<i>I instar</i>			
Length	2.4 \pm 0.16	2.35 \pm 0.14	2.37 \pm 0.16
Breadth	0.49 \pm 0.03	0.48 \pm 0.05	0.49 \pm 0.05
<i>II instar</i>			
Length	3.93 \pm 0.19	3.87 \pm 0.19	3.90 \pm 0.19
Breadth	0.70 \pm 0.02	0.69 \pm 0.02	0.7 \pm 0.02
<i>III instar</i>			
Length	7.18 \pm 0.22	7.01 \pm 0.21	7.09 \pm 0.20
Breadth	1.30 \pm 0.02	1.29 \pm 0.02	1.295 \pm 0.02
<i>IV instar</i>			
Length	10.52 \pm 0.05	10.50 \pm 0.05	10.49 \pm 0.08
Breadth	1.91 \pm 0.04	1.89 \pm 0.04	1.9 \pm 0.05
<i>V instar</i>			
Length	16.16 \pm 0.10	16.05 \pm 0.23	16.1 \pm 0.6
Breadth	2.43 \pm 0.02	2.42 \pm 0.04	2.43 \pm 0.03
<i>Pre-pupa</i>			
Length	13.03 \pm 0.07	12.98 \pm 0.06	13.0 \pm 0.13
Breadth	2.60 \pm 0.03	2.59 \pm 0.03	2.595 \pm 0.03
<i>Pupa</i>			
Length	11.61 \pm 0.05	11.58 \pm 0.04	11.6 \pm 0.05
Breadth	2.87 \pm 0.05	2.85 \pm 0.02	2.86 \pm 0.03
<i>Adult</i>			
Female			
Length	11.34 \pm 0.14	11.28 \pm 0.15	11.31 \pm 0.15
Wing expansion	24.2 \pm 0.52	24.41 \pm 0.77	24.27 \pm 0.67
Male			
Length	11.49 \pm 0.08	11.50 \pm 0.06	11.49 \pm 0.08
Wing expansion	23.30 \pm 0.84	23.46 \pm 0.83	23.37 \pm 0.77

* Mean of 10 samples

Table :5 Duration (days) of different developmental stages of *M. vitrata* reared on blackgram*

Developmental stage	Generation		Average (Mean \pm SD)
	I (Mean \pm SD)	II (Mean \pm SD)	
Premating period	2.19 \pm 0.11	2.18 \pm 0.10	2.19 \pm 0.13
Mating period	2.00 \pm 0.00	2.00 \pm 0.00	2.00 \pm 0.00
Pre-oviposition period	1.22 \pm 0.09	1.23 \pm 0.06	1.23 \pm 0.08
Oviposition period	4.28 \pm 0.18	4.22 \pm 0.19	4.25 \pm 0.19
Incubation period	2.99 \pm 0.14	2.98 \pm 0.09	2.98 \pm 0.11
Larval period			
I instar	2.00 \pm 0.09	2.03 \pm 0.08	2.02 \pm 0.08
II instar	1.82 \pm 0.03	1.82 \pm 0.02	1.82 \pm 0.027
III instar	1.87 \pm 0.03	1.88 \pm 0.02	1.87 \pm 0.03
IV instar	1.92 \pm 0.06	1.95 \pm 0.07	1.94 \pm 0.08
V instar	3.72 \pm 0.07	3.70 \pm 0.04	3.71 \pm 0.06
Total larval period	11.33 \pm 0.07	11.39 \pm 0.013	11.36 \pm 0.11
Pre-pupal period	2.56 \pm 0.05	2.53 \pm 0.06	2.54 \pm 0.055
Pupal period	9.11 \pm 0.24	9.03 \pm 0.22	9.07 \pm 0.23
Total developmental period	26.04 \pm 0.20	25.94 \pm 0.24	25.98 \pm 0.23
Fecundity	56.4 \pm 3.88	54.7 \pm 3.85	55.55 \pm 3.95
Longevity			
Male	7.41 \pm 0.36	7.54 \pm 0.32	7.47 \pm 0.34
Female	8.99 \pm 0.19	9.07 \pm 0.20	9.04 \pm 0.20

* Mean of 10 samples

Table : 6 Head capsule biometrics of larval instars of *M. vitrata* reared on blackgram*

Instars	Mean length (mm) (Mean \pm SD)	Mean breadth (mm) (Mean \pm SD)	Increase in breadth (mm)	Growth ratio
I	0.16 \pm 0.006	0.20 \pm 0.01	--	--
II	0.41 \pm 0.02	0.52 \pm 0.02	0.32	1.600
III	0.89 \pm 0.04	0.92 \pm 0.01	0.40	1.250
IV	1.37 \pm 0.05	1.39 \pm 0.02	0.47	1.175
V	1.66 \pm 0.04	1.89 \pm 0.02	0.50	1.063

* Mean of 10 samples

4.2 ECOLOGY

4.2.1 Nature and symptoms of damage

The infestation of *M. vitrata* was first noticed in the vegetative stage of the crop where it webs the tender leaves at growing tip and fed on the chlorophyll content and made small holes, then the insect shifted to the inflorescence and webbed the floral parts and fed on them (Plate 10). Due to which flower buds fail to open and dropped off from the inflorescence. Then the larvae preferred the tender pods which were webbed and bored into them through pedicle and fed on the developing seeds (Plate 11). The clustered pods are more vulnerable since the webbing can easily be made by the larvae. The damaged pods invariably had an entry hole plugged with frass and faecal pellets.

The webbed leaves, flower buds and tender pods; the entry hole near pedicle of the pods plugged with frass and faecal pellets were the notable symptoms caused by the pest.

4.2.2 Seasonal abundance of *M. vitrata* in relation to weather parameters.

The spotted pod borer (SPB) incidence on blackgram, and the corresponding meteorological data were analysed to understand the relationship between *M. vitrata* and weather parameters.

Highest population of spotted pod borer was observed during last week of January, thereafter the pest load declined gradually with rise in maximum and minimum temperature. The population reached minimum by the first week of March (Table 7). Multiple regression analysis between weather parameters (maximum temperature, minimum temperature, morning and evening relative humidities and sunshine hours) and larval incidence revealed that, all the weather variables together accounted for 71.7 per cent variation in larval population ($R^2 = 0.717$) which was significant. Minimum temperature and sunshine hours were found to exert independent effect on variation in larval population while remaining three weather variable viz., maximum temperature, morning RH and evening RH were non significant (Table 8).



Plate 10: *M. vitrata* larva feeding on flower buds of blackgram



Plate 11: Pod damage on blackgram by *M. vitrata*

Table: 7 Influence of weather parameters on population fluctuation of *M. vitrata* on blackgram during rabi 2000-2001

Date	No. of larvae per 50 plants	Temperature ($^{\circ}$ C)		Relative Humidity (%)		Sunshine hours (X_7)
		Maximum (X_1)	Minimum (X_2)	Morning (X_3)	Evening (X_4)	
30 th Dec.	8	29.3	18.2	82	63	8.9
2 nd Jan.	32	2.0	18.5	83.6	72.6	3.5
5 th Jan.	48	29.16	19.5	91	68	2.6
8 th Jan.	64	28.73	17.83	92.6	71.6	4.5
11 th Jan.	68	29.26	17.4	94	71	8.5
14 th Jan.	76	29.2	18.1	95	71.3	7.2
18 th Jan.	96	29.62	17.62	95	69	6.6
21 st Jan.	112	29.76	17.67	94.3	67	7.4
24 th Jan.	128	29.67	16.43	94.6	70.6	5.9
27 th Jan.	120	31.35	16.1	84.3	64	6.4
30 th Jan.	112	28.76	15.5	89	62.32	3.5
2 nd Feb.	96	29.33	14.36	95.3	67.3	9.3
5 th Feb.	96	29.2	15.53	96	71	9.8
8 th Feb.	84	31.8	17.5	93.3	62.6	8.5
11 th Feb.	72	32.96	18.43	92.6	66.6	8.1
14 th Feb.	72	29.96	18.63	97.3	69	8.0
17 th Feb.	64	30.06	16.46	94.6	64.6	9.7
20 th Feb.	44	31.06	19.73	97.3	73	9.1
23 rd Feb.	32	31.53	21.3	94.3	74.6	8.4
26 th Feb.	20	31.86	20.76	91.3	76.6	8.2
1 st Mar.	12	31.46	23.76	78	72.6	8.7
4 th Mar.	4	30.93	18.93	80.6	66.6	9.8

Table: 8 Multiple linear regression analysis of larval population of *M. vitrata* on certain weather parameters

Variable	Partial regression co-efficient	Standard error	t value
X ₁ Maximum temperature (°C)	8.9941	0.1798	1.629
X ₂ Minimum temperature (°C)	-13.040**	0.2263	3.196
X ₃ Morning Relative Humidity (%)	2.21	0.1646	2.041
X ₄ Evening Relative Humidity (%)	-0.1495	0.1913	0.084
X ₅ Sunshine hours	-5.9566*	0.1528	2.244

MLR equation :

$$Y = -116.06 + 8.99 X_1 - 13.04^{**} X_2 + 2.21 X_3 - 0.14 X_4 - 5.95^* X_5$$

Intercept : -116.06

F value : 8.11

R² Value : 0.717

** — Significant at 1% level

* — Significant at 5% level



Plate 12: A larval parasitoid *Apanteles taragame* on *M. vitrata*



Plate 13: *M. vitrata* larva infected by fungal pathogen, *Nomuraea rileyi*

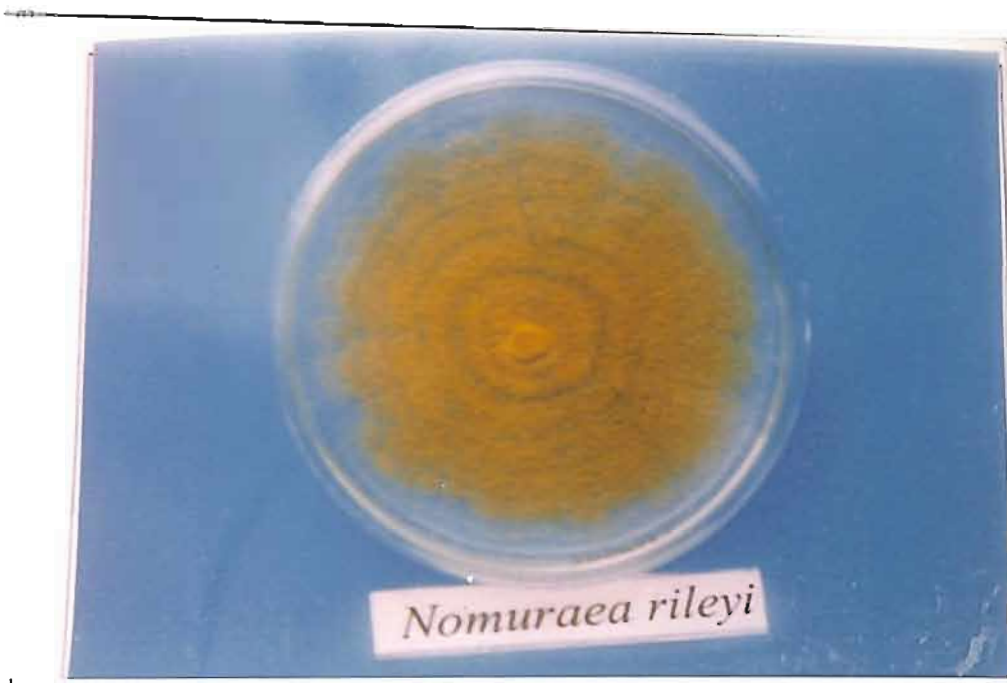


Plate 14: Culture of *Nomuraea rileyi*

The following multiple regression equation could be fitted to predict the population fluctuation of *M. vitrata* on blackgram based on weather variables in question.

$$Y = -116.06 + 8.99 X_1 - 13.04 X_2 + 2.21 X_3 - 0.14 X_4 - 5.95 X_5$$

Thus, 1°C rise in minimum temperature over mean level is expected to bring down the larval population by 13.04. Similarly a rise of one hour sunshine is expected to bring down the larval population by 5.95.

4.2.3 Natural enemies

Periodical observations made during the crop growing season of blackgram around Bapatla for the incidence of parasites / predators / pathogens of *M. vitrata* revealed that the activity of natural enemies in blackgram ecosystem was very low. During the month of January on the rice fallow blackgram, the late larval instars were observed to be parasitized by *Apanteles taragame* (Veir.) (Plate 12). However, the extent of parasitism was negligible. The larvae of *M. vitrata* were naturally found to be infected by fungal pathogen, *Nomuraea rileyi* (Farlow) Samson during January 2001 when the atmospheric humidity was high. However, the extent of infection was very low (Plate 13).

4.3 EFFICACY OF SELECTED INSECTICIDES AGAINST *M. vitrata* UNDER FIELD CONDITIONS

The field experiment was conducted during *rabi* season of 2000-2001 with as many as 11 treatments. The treatments were given twice during the crop growth at 40 and 50 DAS of the crop. The results of the experiment are presented here under.

First spray

The data pertaining to the efficacy of the treatments after first round of application are presented in Table 9 and Fig 3. The mean number of *M. vitrata* larval population ranged between 20.67 and 25.00 per 10 (ten) plants one day prior to spray indicated their uniform distribution throughout the experimental plot.

The data recorded on the number of live larvae per ten plants on third day after first spray showed that DDVP + chlorpyrifos was the most effective treatment, however it was on par with DDVP + quinalphos which recorded 85.41 per cent and 84.13 per cent mean population reduction of larvae, respectively over untreated control. The next best treatment was Nurelle D 505 (80.22%) which was at par with DDVP + quinalphos. The next best treatments were Koranda (77.24%), thiodicarb (76.77%) and acephate (75.26%) which were at par with one another and first two viz., Koranda and thiodicarb were at par with Nurelle D505. The next best one is endosulfan (56.08%) which is significantly superior to untreated control in bringing down the pest population at third day after treatment.

The data recorded at seventh day after treatment revealed that the performance of DDVP + chlorpyrifos was the best treatment however it is on par with DDVP+ quinalphos and recorded 61.66 per cent and 60.23 per cent mean larval reduction, respectively over untreated control. The next best treatment was diflubenzuron (53.42%) which in turn on par with DDVP + quinalphos. The next best treatments were Nurelle D 505 (50.60%), Halt (48.07), acephate (47.96) and thiodicarb (47.63%) which were on par with diflubenzuron. The treatments endosulfan (41.97%) and Neemgold (36.72%) were least effective in reducing the larval populations, however, they were superior to untreated control.

Perusal of data clearly indicated that efficacy of Halt and diflubenzuron improved from three days after treatment to seven days after treatment.

The data recorded on tenth day after first spray revealed that among the treatments diflubenzuron (46.41%) and Halt (42.86%) recorded the highest reduction of larval population of *M. vitrata* and were on par with each other, however, Halt is on par with DDVP+ chlorpyrifos (40.21%). The next best treatments were DDVP+ quinalphos (37.71%), Nurelle D 505 (34.36), acephate (32.52%), Koranda (31.45%) and thiodicarb (31.40%). The remaining treatments endosulfan (23.07%) and Neemgold (19.89%) were least effective and registered less than 24 per cent reduction of larval population over

Table: 9 Efficacy of treatments against *M. vitrata* after first spraying

S. No.	Treatments	Mean popul. before spray (10 plants)	Per cent reduction over control			
			3 DAT	7 DAT	10 DAT	Overall mean
T ₁	DDVP 0.038% + chlorpyrifos 0.04%	25.33	85.41 ^A ✓ (67.59)	61.16 ^A (51.47)	40.21 ^{BC} (39.34)	62.26 ^A (52.10)
T ₂	DDVP 0.038% + quinalphos 0.05%	22.67	84.13 ^{AB} ✓ (66.56)	60.23 ^{AB} (50.91)	37.71 ^{CD} (37.87)	60.68 ^{AB} (51.17)
T ₃	Nurelle D 505 (chlorpyrifos 0.05% + cypermethrin 0.005%)	21.67	80.22 ^{BC} (63.65)	50.60 ^C (45.34)	34.36 ^{DE} (35.88)	55.06 ^{BC} (47.90)
T ₄	Koranda (acephate 0.075% + fenvalerate 0.009%)	24.67	77.24 ^{CD} (61.57)	46.83 ^{CD} (43.17)	31.45 ^E (34.10)	51.84 ^C (46.05)
T ₅	Thiodicarb 0.075%	20.67	76.77 ^{CD} (61.19)	47.63 ^{CD} (43.64)	31.40 ^E (34.06)	51.93 ^C (46.10)
T ₆	Acephate 0.075%	24.33	75.26 ^D (60.19)	47.96 ^{CD} (43.82)	32.52 ^E (34.75)	51.91 ^C (46.09)
T ₇	Endosulfan 0.07%	24.00	56.08 ^E (48.49)	41.97 ^{DE} (40.36)	23.07 ^F (28.68)	40.37 ^D (39.44)
T ₈	Diflubenzuron 0.025%	20.33	17.98 ^G (25.00)	53.42 ^{BC} (46.96)	46.41 ^A (42.94)	39.27 ^D (38.80)
T ₉	Halt (B.t.k) 0.2%	23.00	16.94 ^G (24.24)	48.07 ^{CD} (43.89)	42.86 ^{AB} (40.89)	35.95 ^E (36.83)
T ₁₀	Necmgold 0.2%	21.67	25.05 ^F (30.01)	36.72 ^E (37.28)	19.89 ^F (26.44)	27.23 ^F (31.45)

F-test	Sig.	Sig.	Sig.	Sig.
SEm ±	1.08	1.46	0.97	0.65
CD (5%)	3.20	4.31	2.88	1.93

Figures in parentheses are $\sqrt{\text{arc sine}}$ transformed values

Mean separation by DMRT at 5% level.

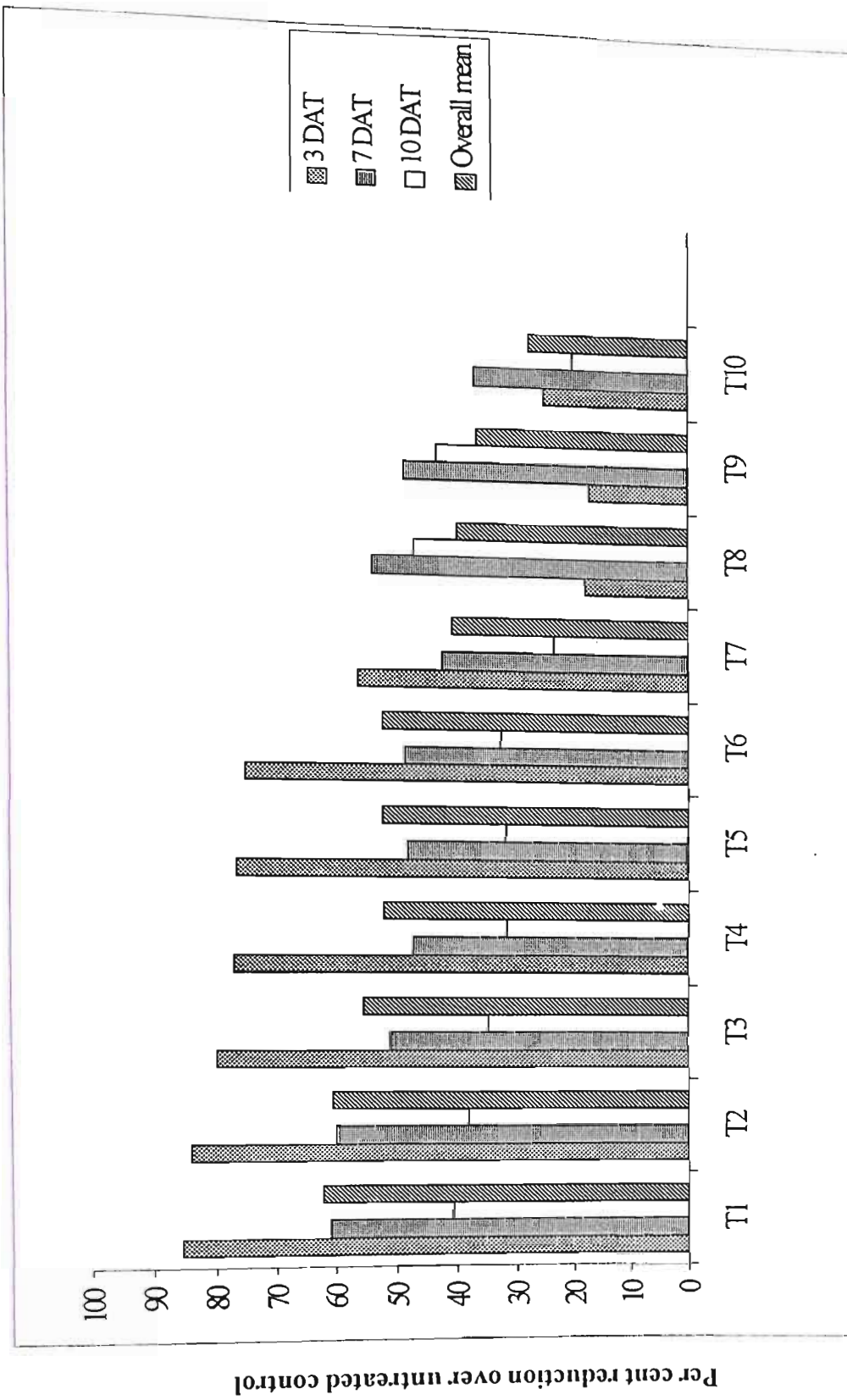


Fig. 3 Efficacy of treatments against *M. vitrata* after first spraying

untreated control. However, all the treatments were significantly superior over untreated control in reducing the larval population of *M. vitrata* even at on tenth day after treatment.

The overall efficacy of the three observations made at three, seven and ten days after first spraying showed that DDVP + chlorpyrifos (62.26%) and DDVP + quinalphos (60.68%) performed significantly better than the other treatments in reducing the larval population of *M. vitrata* however they were on par with Nurelle D 505 (55.06%). The next best were thiodicarb (51.93%), acephate (51.91%) and Koranda (51.84) with more than 50 per cent reduction of larval population over untreated control and were on a par with one another, followed by endosulfan (40.37%), diflubenzuron (39.27%). The least effective treatments were Halt (35.95%) and Neemgold (27.23%). However, all the treatments were effective and significantly superior in reducing the larval population of *M. vitrata* over untreated control.

Second Spray

The results with regard to the efficacy of treatments after second round of application is presented in Table 10 & Fig. 4. The mean reduction of *M. vitrata* larval population after the second spray was more or less similar to that after first spray and all the treatments significantly reduced the larval population over untreated control. The observations made on third day after second spraying showed that DDVP+ chlorpyrifos and DDVP + quinalphos were on a par and they were most effective and recorded 84.67 and 82.96 per cent mean larval reduction, respectively, over untreated control. However, DDVP+ quinalphos was on par with Nurelle D 505 (79.17%). The next best treatments were Koranda (77.74%), thiodicarb (76.19%) and acephate (74.87%) which were at par with one another followed by endosulfan with 54.41 per cent mean population reduction of larvae over untreated control and also significantly superior to rest of the treatments. The treatments Neemgold (24.39%), diflubenzuron (19.16%) and Halt (18.56%) were least effective among treatments. However, all the treatments were significantly superior over untreated control in bringing down the pest population on third day after second spraying.

The data recorded at seventh day after second spray showed that DDVP + chlorpyriphos and DDVP + quinalphos were on par and significantly superior over the rest of treatments which recorded 61.49 per cent and 61.23 per cent reduction of larval population over untreated control. The other treatments that followed in the descending order of efficacy with more than 47 per cent reduction of larval population over untreated control were Nurelle D 505 (51.94%), diflubenzuron (48.76%), acephate (48.29%), Koranda (47.83%), thiodicarb (47.63%) and Halt (47.40%), however they were on par with one another and significantly superior over remaining treatments. Among the treatments endosulfan (41.31%) and Neemgold (38.39%) were least effective. All the treatments, however, were significantly superior over untreated control in reducing the larval population of *M. vitrata* over untreated control on seventh day after treatment.

The data obtained on tenth day after second spray showed that, diflubenzuron was most effective with more than 48 per cent reduction of larval population over untreated control followed by Halt (44.523%) which were on par. The next best treatment was DDVP + chlorpyriphos (42.21%) with more than 42 per cent reduction of larval population over untreated control, however it was on par with Halt. The next best treatment was DDVP + quinalphos (39.71%) which again was on par with DDVP + chlorpyriphos. The next effective treatments were Nurelle D 505 (36.03%), acephate (34.19%), Koranda (33.11%) and thiodicarb (33.06%) which were on par with one another and registered more than 33 per cent reduction of larval population over untreated control even at tenth day after second spray. Among the treatments endosulfan (25.0%) and Neemgold (20.56%) were least effective. However, all the treatments were significantly superior over untreated control in reducing the larval population of *M. vitrata* at tenth day after treatment.

The overall efficacy of the treatments after second spray showed that DDVP + chlorpyriphos (62.79%) and DDVP + quinalphos (61.29%) were the best treatments and significantly superior over all other treatments. The next best treatments were Nurelle D 505 (55.71%), Koranda (52.89%) and acephate (52.45%) which were on par with one

Table: 10 Efficacy of treatments against *M. vitrata* after second spraying

S. No.	Treatments	Mean popu. before spray (10 plants)	Per cent reduction over control			
			3 DAT	7 DAT	10 DAT	Overall mean
T ₁	DDVP 0.038% + chlorpyrifos 0.04%	13.33	84.67 ^A (67.05)	61.49 ^A (51.66)	42.21 ^{BC} (40.51)	62.79 ^A (52.41)
T ₂	DDVP 0.038% + quinalphos 0.05%	12.42	82.96 ^{AB} (65.65)	61.23 ^A (51.49)	39.71 ^{BC} (39.05)	61.29 ^A (51.53)
T ₃	Nurelle D 505 (chlorpyrifos 0.05% + cypermethrin 0.005%)	12.51	79.17 ^{BC} (62.90)	51.94 ^{BC} (46.11)	36.02 ^D (36.88)	55.71 ^B (48.28)
T ₄	Koranda (acephate 0.075% + fenvalerate 0.009%)	14.88	77.74 ^{CD} (61.88)	47.83 ^{CD} (43.75)	33.11 ^D (35.12)	52.89 ^{BC} (46.66)
T ₅	Thiodicarb 0.075%	12.47	76.19 ^{CD} (60.85)	47.63 ^{CD} (43.64)	33.06 ^D (35.08)	52.29 ^{BC} (46.31)
T ₆	Accphate 0.075%	14.44	74.87 ^{CD} (59.94)	48.29 ^{BC} (44.03)	34.19 ^D (35.77)	52.45 ^{BC} (46.40)
T ₇	Endosulfan 0.07%	16.26	54.41 ^E (47.54)	41.31 ^{DE} (39.99)	25.07 ^E (30.02)	40.23 ^D (39.36)
T ₈	Diiflubenzuron 0.025%	9.58	19.16 ^{FG} (25.95)	48.76 ^{BC} (44.28)	48.07 ^A (43.89)	38.66 ^{DE} (38.44)
T ₉	Halt (B.t.k) 0.2%	11.56	18.56 ^{GHI} (25.50)	47.40 ^{CD} (43.50)	44.52 ^{AB} (41.85)	36.83 ^E (37.35)
T ₁₀	Necmgold 0.2%	15.25	24.39 ^F (29.59)	38.39 ^{EF} (38.37)	20.56 ^F (26.94)	27.78 ^F (31.79)

F-test

Sig.

Sig.

Sig.

Sig.

SEm ±

1.24

1.35

0.93

0.64

CD (5%)

3.66

3.98

2.75

1.90

Figures in parentheses are $\sqrt{\text{arc sine}}$ transformed values

Mean separation by DMRT at 5% level.

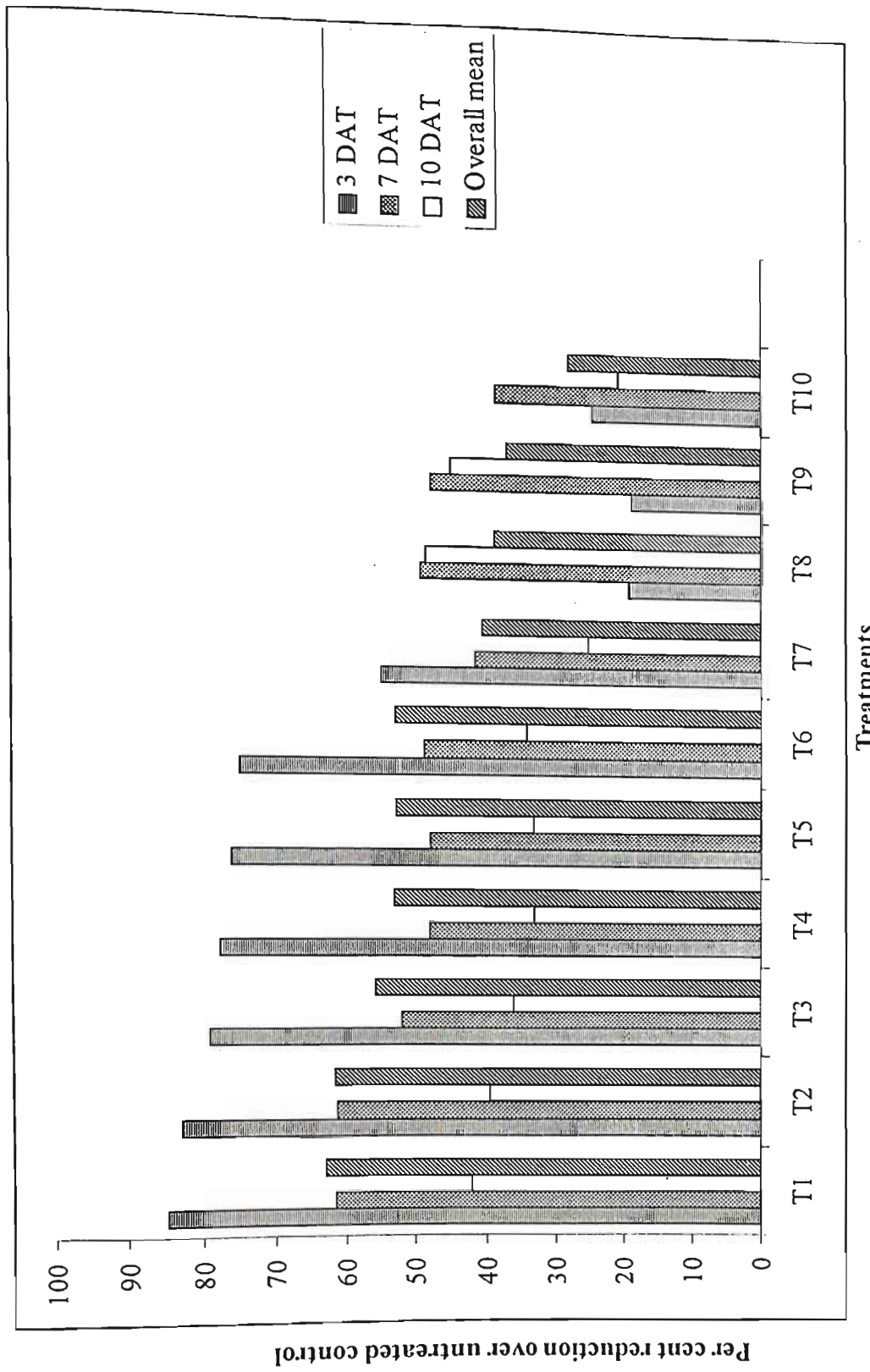


Fig. 4 Efficacy of treatments against *M. vitrata* after second spraying

another with more than 52 per cent reduction of larval population over untreated control. The next best treatment was thiodicarb (52.29%) followed by endosulfan (40.23%), diflubenzuron (38.66%) and Halt (36.83%) with more than 36 per cent reduction in larval population over untreated control. Among the treatments Neemgold (27.78%) was the least effective with less than 28 per cent mean reduction of larval population over untreated control and significantly inferior to all the treatments. However, all the treatments were significantly superior over untreated control with regard to the reduction of larval population of *M. vitrata* even after second spraying.

Cumulative efficacy of two sprays

The data pertaining to the two sprays were pooled together and the cumulative efficacy of the treatments against the larval population of *M. vitrata* are presented in Table 11 & Fig. 5.

The data recorded on third day after application of two sprayings treatments showed that all the treatments were significantly superior over untreated control. However, the most effective treatments were DDVP + chlorpyrifos (85.04%) and DDVP + quinalphos (83.54%) which were on par with each other. The next best treatment was Nurelle D 505 with 76.69 per cent reduction of larval population over untreated control and was on par with DDVP+ quinalphos. Koranda (77.49%) and thiodicarb (76.48%) were the next best treatments and they were on a par with each other and showed more than 76 per cent reduction in larval population over untreated control. However, Koranda and thiodicarb were on par with Nurelle D 505. The next best treatment was acephate (75.06%) in reducing the larval population over untreated control which was on par with Koranda and thiodicarb followed by endosulfan (55.25%). The least effective among the treatments in the descending order of efficacy were Neemgold (24.72%), diflubenzuron (18.57%) and Halt (17.75%) with less than 25 per cent reduction of larval population over untreated control.

The observations made at seventh day after two sprayings revealed that DDVP + chlorpyrifos (61.33%) and DDVP+ quinalphos (60.73%) were more effective and significantly superior over the rest of other treatments. The next best treatments were Nurelle D 505 (51.27%) and diflubenzuron (51.09%) with more than 51 per cent mean reduction of larval population over untreated control. The treatments that followed in the descending order of efficacy were acephate (48.12%), Halt (47.74%), thiodicarb (47.64%) and Koranda (47.33%) with more than 47 per cent reduction of larval population over untreated control, but all were are on par with one another and with Nurelle D 505 and diflubenzuron. Among the treatments endosulfan (41.64%) and Neemgold (37.57%) were least effective. However, all the treatments were significantly superior over untreated control in reducing the larval population of *M. vitrata* on seventh day after cumulative spray.

The cumulative data recorded on tenth day after treatment showed that the chitin synthesis inhibitor diflubenzuron was most effective with more than 47 per cent reduction in larval population even at tenth day after treatment followed by Halt (43.69%) which was on par with diflubenzuron. The next best treatment was DDVP + chlorpyrifos (41.21%) which was on par with Halt. The next effective treatment was DDVP + quinalphos (38.71%) which was on par with DDVP + chlorpyrifos. The other treatments moderately effective were Nurelle D-505 (35.19%), acephate (33.35%), Koranda (32.28%) and thiodicarb (32.23%). Among treatments endosulfan (24.07%) and Neemgold (20.23%) were least effective which were on par and significantly inferior to the rest of the treatments. However, all the treatments were significantly superior over untreated control in reducing the larval population of *M. vitrata* at tenth day after treatment.

The overall efficacy of the three observations made at three, seven and ten days after two sprays showed that DDVP + chlorpyrifos and DDVP + quinalphos were significantly superior over rest of the treatments and showed more than 60 per cent mean reduction of larval population. The next best were Nurelle D505 (55.38%) and Koranda

Table: Cumulative efficacy of treatments against *M. vitrata* after two sprayings

S. No.	Treatments	Mean popu. before spray (10 plants)	Per cent reduction over control			
			3 DAT	7 DAT	10 DAT	Overall mean
T ₁	DDVP 0.038% + chlorpyriphos 0.04%	19.33	85.04 ^A (67.31)	61.33 ^A (51.56)	41.21 ^{IK} (39.93)	62.52 ^A (52.26)
T ₂	DDVP 0.038% + quinalphos 0.05%	17.54	83.54 ^{AB} (66.09)	60.73 ^A (51.19)	38.71 ^{CD} (38.46)	60.99 ^A (51.35)
T ₃	Nurelle D 505 (chlorpyriphos 0.05% + cypermethrin 0.005%)	17.9	79.69 ^{BC} (63.27)	51.27 ^B (45.73)	35.19 ^{DE} (36.38)	55.38 ^B (48.09)
T ₄	Koranda (acephate 0.075% + fenvalerate 0.009%)	19.77	77.49 ^{CD} (61.72)	47.33 ^{IC} (43.47)	32.28 ^E (34.61)	52.36 ^{IK} (46.35)
T ₅	Thiodicarb 0.075%	16.57	76.48 ^{CD} (61.01)	47.64 ^{BC} (43.64)	32.23 ^E (34.57)	52.11 ^C (46.21)
T ₆	Acephate 0.075%	19.38	75.06 ^D (60.06)	48.12 ^{BC} (43.92)	33.35 ^E (35.26)	52.13 ^C (46.22)
T ₇	Endosulfan 0.07%	20.13	55.25 ^E (48.01)	41.64 ^{CD} (40.18)	24.07 ^F (29.36)	40.32 ^D (39.41)
T ₈	Disflubenzuron 0.025%	14.95	18.57 ^G (25.49)	51.09 ^B (45.62)	47.24 ^A (43.41)	38.96 ^{DE} (38.62)
T ₉	Halt (B.t.k) 0.2%	17.28	17.75 ^G (24.91)	47.74 ^{BC} (43.70)	43.69 ^{AB} (41.37)	36.39 ^E (37.09)
T ₁₀	Neemgold 0.2%	18.47	24.72 ^F (29.80)	37.57 ^D (37.79)	20.23 ^F (26.69)	27.50 ^F (31.62)

F-test	Sig.	Sig.	Sig.	Sig.
SEm ±	1.05	1.34	0.95	0.62
CD (5%)	3.11	3.97	2.80	1.84

Figures in parentheses are $\sqrt{\text{arc sine}}$ transformed values
 Mean separation by DMRT at 5% level.

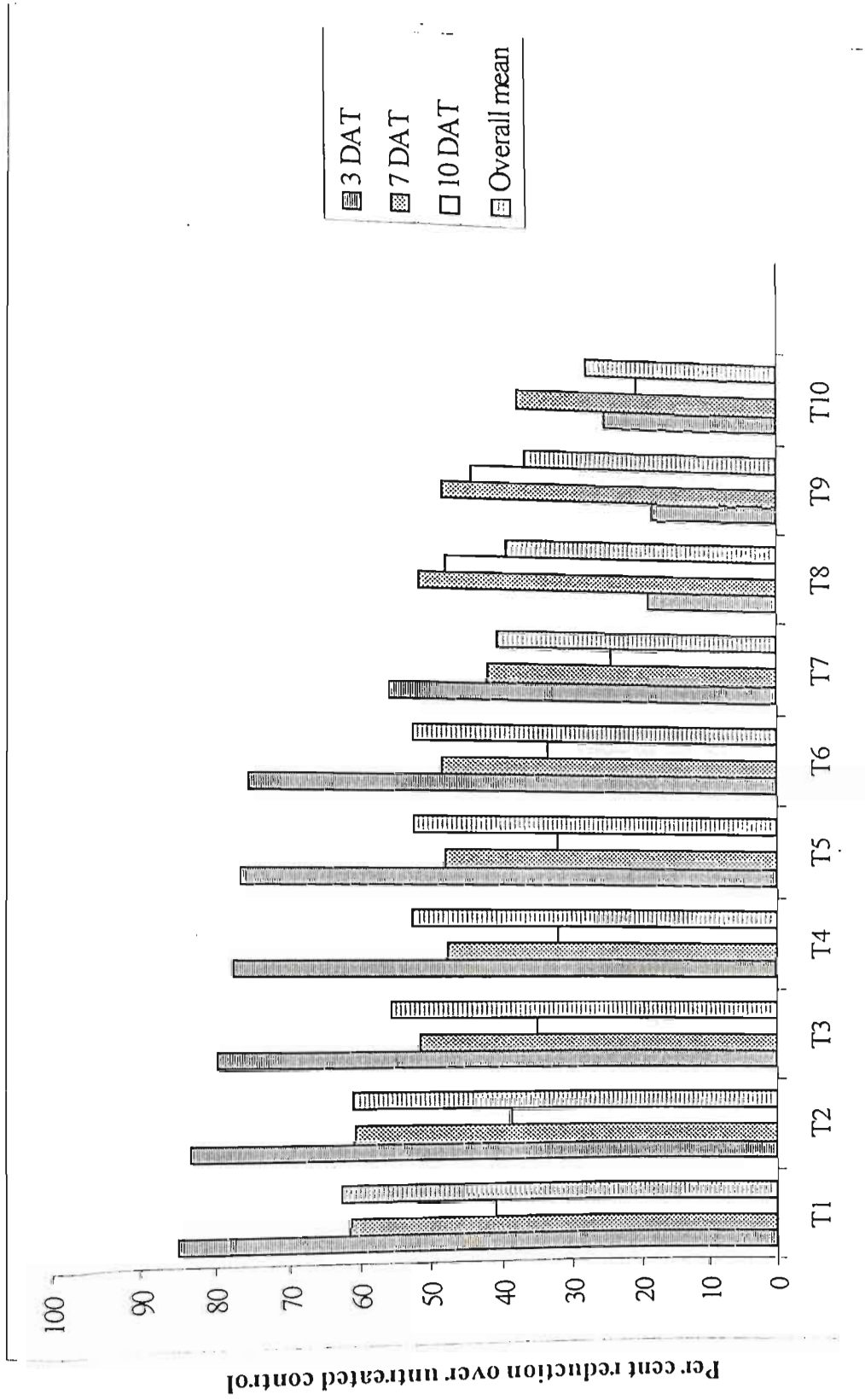


Fig. 5 Efficacy of treatments against *M. vitrata* after two sprays

(52.36%) which were on par, however, Koranda was also on par with acephate (52.13%) and thiodicarb (52.11%) which showed moderate efficacy and reduced more than 52 per cent of larval population. The treatments that showed less efficacy were endosulfan (40.32%), diflubenzuron (38.96%), Halt (36.39%) and Neemgold (27.50%). Among the treatments Neemgold (27.50%) was the least effective one and registered less than 28 per cent reduction of larval population over untreated control. However, the overall efficacy showed that all the treatments were significantly superior over untreated control in reducing the larval population of *M. vitrata* on blackgram.

4.4 EFFECT OF INSECTICIDAL TREATMENTS ON POD DAMAGE

The data pertaining to the pod damage caused by *M. vitrata* (Table 12) indicated that all the treatments were significantly superior in reducing the pod damage over untreated control. The data further indicated that DDVP + chlorpyrifos (21.41%), DDVP + quinalphos (21.93%) with 55.45 and 54.37 per cent reduction over untreated control, respectively and they were on par and significantly superior over the rest of treatments by recording less than 22 per cent pod damage. The order of efficacy of the other treatments that followed was acephate (26.03%), thiodicarb (26.27%) and Nurelle D505 (27.72%) with mean pod damage ranged between 26 and 28 per cent with 45.83, 45.33 and 42.32 per cent reduction over untreated control, respectively and they were on par with one another, however, Nurelle D505 was on par with Koranda. Among combination products Nurelle D 505 (27.72%) performed slight better than Koranda (28.26%) but they were on par with each other. The next best treatment was endosulfan which had moderate effect and registered 30 per cent pod damage with 37.18 per cent reduction over untreated control. Diflubenzuron (34.84%) and Halt (*B.i.k.*) (35.24%) were less effective and inferior to the earlier treatments with 27.50 and 26.67 per cent reduction over untreated control, respectively. Among the treatments Necmgold was least effective and registered 38.04 per cent pod damage with 20.84 per cent reduction over untreated control.

Table: 12 Effect of treatments on pod damage

S. No.	Treatments	% Pod damage	% reduction over untreated control
T ₁	DDVP 0.038%+ chlorpyriphos 0.04%	21.41 ^A (13.36)	55.45
T ₂	DDVP 0.038% + quinalphos 0.05%	21.93 ^A (14.00)	54.37
T ₃	Nurelle D 505 (chlorpyriphos 0.05% + cypermethrin 0.005%)	27.72 ^{BC} (21.70)	42.32
T ₄	Koranda (acephate 0.075 % + fenvalerate 0.009%)	28.26 ^C (22.46)	41.19
T ₅	Thiodicarb 0.075%	26.27 ^B (19.66)	45.33
T ₆	Acephate 0.075%	26.03 ^B (19.33)	45.83
T ₇	Endosulfan 0.07%	30.19 ^D (25.3)	37.18
T ₈	Diflubenzuron 0.025%	34.84 ^E (32.66)	27.50
T ₉	Halt (B.t.k) 0.2%	35.24 ^E (33.33)	26.67
T ₁₀	Neemgold 0.2%	38.04 ^F (38.00)	20.84
T ₁₁	Untreated control	48.06 ^G (55.33)	0.00

F-test

Sig.

SEm ±

0.8828

CD (5%)

2.604

Figures in parentheses are $\sqrt{\text{arc sine}}$ transformed values

Mean separation by DMRT at 5% level.

4.5 EFFECT OF INSECTICIDAL TREATMENTS ON YIELD

The data on grain yield were furnished in Table 13.

The yield data revealed that the performance of DDVP + chlorpyrifos was better and registered a grain yield of $1.3033 \text{ kg plot}^{-1}$ ($1086.08 \text{ kg ha}^{-1}$) and recorded 69.99 per cent increase over untreated control, however, it was on par with DDVP + quinalphos ($1.2900 \text{ kg plot}^{-1}$) and Nurelle D 505 ($1.263 \text{ kg plot}^{-1}$).

Treatments that were moderately better in recording the higher yields were Koranda ($1.253 \text{ kg plot}^{-1}$ or $1044.42 \text{ kg ha}^{-1}$), thiodicarb ($1.2400 \text{ kg plot}^{-1}$ or $1033.33 \text{ kg ha}^{-1}$), acephate ($1.22 \text{ kg plot}^{-1}$ or $1016.60 \text{ kg ha}^{-1}$), endosulfan ($1.193 \text{ kg plot}^{-1}$ or $994.42 \text{ kg ha}^{-1}$), diflubenzuron ($1.1833 \text{ kg plot}^{-1}$ or $986.08 \text{ kg ha}^{-1}$) with 63.47, 61.73, 59.73, 59.12, 55.64 and 54.34 per cent increase in yield over untreated control respectively.

Among the treatments Halt and Neemgold ($1.1600 \text{ kg plot}^{-1}$ or $966.67 \text{ kg ha}^{-1}$ and $1.0767 \text{ kg plot}^{-1}$ or $897.25 \text{ kg ha}^{-1}$) were least effective and recorded the lowest yield of 51.30 and 40.43 per cent increase over untreated control, respectively and they were significantly inferior to rest of the treatments. However, all the treatments were significantly superior over untreated control in recording higher yields.

Table : 13 Effect of treatments on yield

S. No.	Treatments	Mean yield (kg plot ⁻¹)	Yield (kg ha ⁻¹)	% increase over control
T ₁	DDVP 0.038%+ chlorpyriphos 0.04%	1.3033 ^A	1086.08	69.99
T ₂	DDVP 0.038% + quinalphos 0.05%	1.2900 ^A	1075.00	68.25
T ₃	Nurelle D 505 (chlorpyriphos 0.05% + cypermethrin 0.005%)	1.2633 ^{AB}	1052.75	64.77
T ₄	Koranda (acephate 0.075 % + fenvalerate 0.009%)	1.2533 ^{ABC}	1044.42	63.47
T ₅	Thiodicarb 0.075%	1.2400 ^{ABC}	1033.33	61.73
T ₆	Acephate 0.075%	1.2200 ^{ABC}	1016.66	59.12
T ₇	Endosulfan 0.07%	1.1933 ^{BC}	994.42	55.64
T ₈	Diflubenzuron 0.025%	1.1833 ^{BC}	986.08	54.34
T ₉	Halt (B.t.k) 0.2%	1.1600 ^{CD}	966.67	51.30
T ₁₀	Neemgold 0.2%	1.0767 ^D	897.25	40.43
T ₁₁	Untreated control	0.7667 ^E	638.92	0.00

F-test

Sig.

SEm ±

0.016

CD (5%)

0.0473

Mean separation by DMRT at 5% level.

Discussion

DISCUSSION

The experimental findings of the studies conducted on the biology, ecology and management of spotted pod borer, *Maruca vitrata* (Geyer) on blackgram are discussed in the light of available literature and presented here under.

5.1 BIOLOGY

5.1.1 Mating and oviposition

In the laboratory the moths emerged between 20.00 to 24.00 h and rarely at mid night, which confirms the observation of Okeyo-Owuor and Ochieng (1981) who reported the moth emergence mostly between 20.00 and 23.00 h, and very few after mid night, However, Veeranna *et. al.* (1999) reported the moth emergence between 20.00 and 2.00 h. The moths mated 2 days after emergence during night and maximum number of mating pairs were observed between 20.00 to 2.00 h and mated in end to end position. Djamin (1961), Vishakantaiah and Jagadeesh Babu (1980) and Veeranna *et. al.* (1999) reported that the moths mated 1 to 2 days, 2 to 3 days and 2 days after emergence, respectively. The mated females started laying eggs 1.23 days after mating. However, on cowpea Vishakantaiah and Jagadeesh Babu (1980) reported that females laid eggs 1 to 2 days after mating, while Okeyo-Owuor and Ochieng (1981) observed 3 to 5 days after mating.

The egg laying started on fourth day after emergence and continued up to tenth day. The maximum number of eggs were laid during the first two days of oviposition. The oviposition period was recorded on an average of 4.25 days during the present study, where as Okeyo-Owuor and Ochieng (1981) reported prolonged oviposition period of 10 to 18 days on cowpea under Kenya conditions and Ganapathy (1996) from 4.6 to 5.6 days on blackgram from Madurai. The difference in oviposition period may be due to the differences in the host plants used, micro climate prevailed at the time of rearing and also may be due to geographical variation.

Eggs were usually laid on flower buds, flowers, tender pods and under surface of leaves but maximum number of eggs were found on flower buds. This was in agreement with Taylor (1967), Nyiira (1971) and Jackai (1981) who reported maximum eggs laid on terminal shoots, abscission scars, peduncles, flower buds and young pods while Okeyo-Owuor and Ochieng (1981) observed 79 per cent of the eggs were laid on leaves of cowpea.

The moths deposited eggs scattered singly or in batches of 2 to 18. This is in conformity with the observation of Veeranna *et. al.* (1999) who reported that the egg were deposited singly / in batches of 2 to 10 on the under surface of leaves, terminal shoots and flower buds of cowpea. Similar observations were also reported earlier by Vishakantaiah and Jagadeesh Babu (1980) on redgram and Ramdas Rai (1983) on cowpea. The total number of eggs laid by a female moth on an average was 55.55. The total number of eggs laid by a female moth were recorded as 98.31 on blackgram (Ganapathy, 1996), 140 on cowpea (Taylor, 1967) and the highest of 338 on pigeonpea (Lalasangi, 1988).

5.1.2 Eggs

Various workers gave the egg measurements ranging from 0.58 to 0.80 mm in length and 0.38 to 0.50 mm in breadth [Mills and Leonard, 1931; Nyiira, 1971; Taylor, 1978; Okeyo - Owuor and Ochieng, 1981 and Veeranna *et. al.*, 1999]. However, during the present study the egg measured 0.67 mm in length and 0.44 mm in breadth (Table 4).

5.1.3 Larval instars

The larva passed through five instars which tally with the observations of Taylor (1967), Nyiira (1971), Ramdas Rai (1983) and Veeranna *et. al.* (1999).

5.1.3.1 I instar

The neonate larvae were minute, glistening with pinkish head capsule and active, moving for about 15 to 30 minutes before feeding. Full grown larvae is creamy white in colour, except head and prothoracic segment. The sclerites of the body were dark brown in colour. The above observations were comparable with the description of Vishakantaiah and Jagadeesh Babu (1980), Ramdas Rai (1983) and Veeranna *et. al.* (1999). Veeranna *et. al.* (1999) that the newly hatched larvae moved on the surface of leaves, flower buds and on flowers for 15 to 20 minutes before starting to feed. The larvae were creamy white except head and prothoracic segments.

The first instar larva measured 2.37 mm in length and 0.49 mm in breadth. Vishakantaiah and Jagadeesh Babu (1980) reported that the larva measured 3.2 mm in length and 0.7 mm in breadth, which appear to be on the higher side while Veeranna *et. al.* (1999) reported 1.28 mm in length and 0.17 mm in breadth, which appear to be on lower side. The larval period of I instar was 2.02 days which concur with the observations of Veeranna *et. al.* (1999) who reported 1.94 days on cowpea during *rabi* season.

5.1.3.2 II instar

The II instar larva was creamy white, but for eyes and mandibles which were dark brown. Later the body became dirty white in colour. Vishakantaiah and Jagadeesh Babu (1980) reported that the body is creamy white with dark patches.

The larva measured 3.9 mm in length and 0.70 mm in breadth. Vishakantaiah and Jagadeesh Babu (1980) reported that the larva measured 4.37 mm and 0.75 mm in length and breadth, respectively which appear to be on the higher side while Veeranna *et. al.* (1999) reported that 2.59 (2.56 – 2.64) mm and 0.39 (0.36 – 0.41) mm in length and breadth, respectively, which appear to be on lower side. The developmental period of II instar larva was 1.82 days. Veeranna *et. al.* (1999) reported that II instar took 1.78 days when reared on cowpea during *rabi* season.

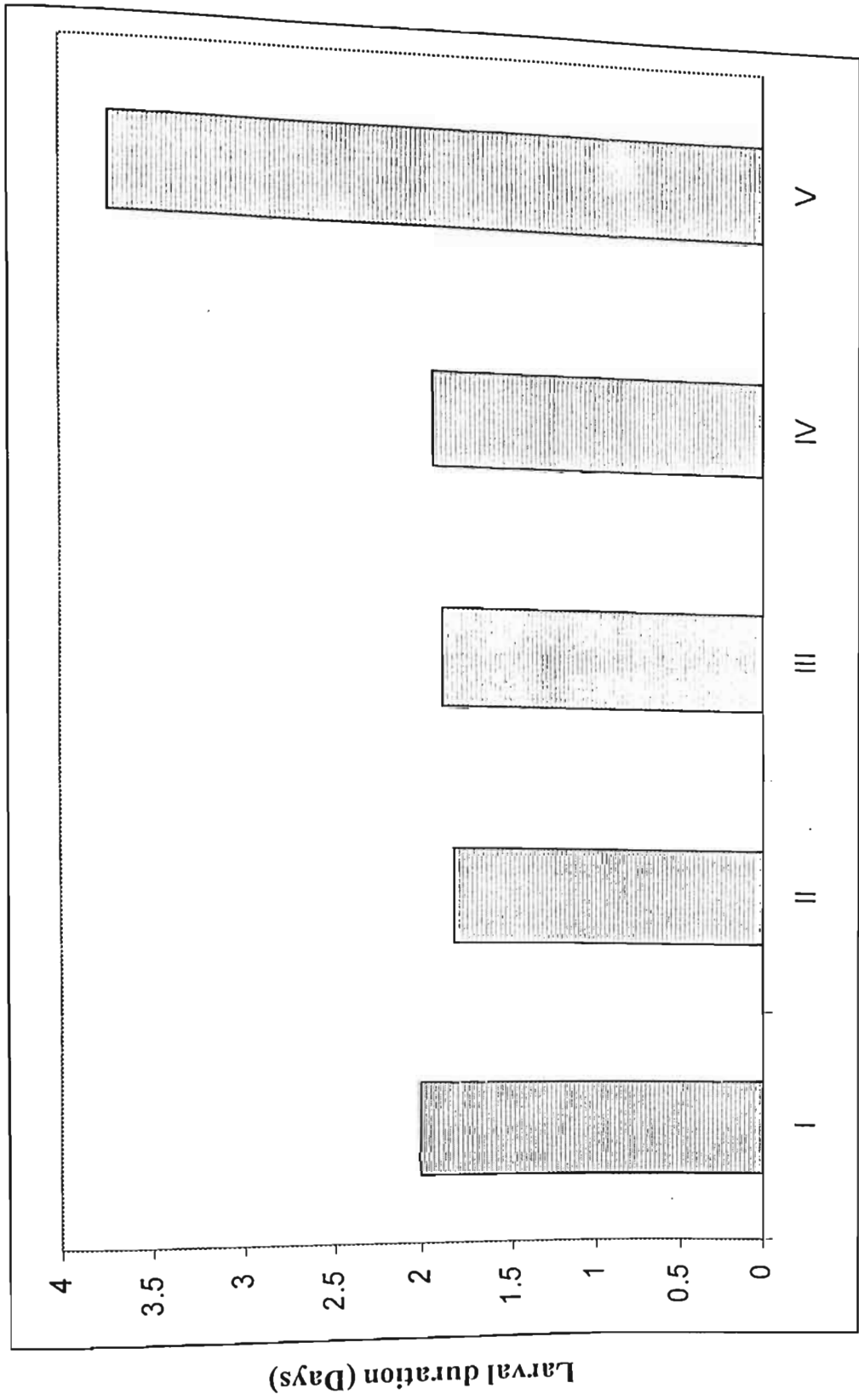


Fig. 6 Duration of larval instars of *M. vitrata*

5.1.3.3 III instar

The III instar larva was similar to that of II instar, except its size which is longer. The colouration of head and prothoracic shield were darker. The larvae exhibited aggressive behaviour when disturbed. However, Veeranna *et. al.* (1999) reported that the III instar larva was brownish with dark brown head, prothoracic shield and sclerites. The tubercles on the body were deep dark and distinctly visible.

The larva measured 7.09 mm in length and 1.295 mm in breadth. Vishakantaiah and Jagadeesh Babu (1980) reported that the larva measured 9.00 mm and 1.90 mm in length and breadth, respectively, which appear to be on the higher side while Veeranna *et. al.* (1999) reported that 5.27 mm in length and 0.86 mm in breadth when reared on cowpea, which appear to be on lower side than present observation. The developmental period of III instar larva was 1.87 days while Vishakantaiah and Jagadeesh Babu (1980) and Veeranna *et. al.* (1999) reported 2.3 and 1.8 days respectively on pigeonpea and cowpea. The report of the latter is in agreement with the present observation.

5.1.3.4 IV instar

The IV instar larva was creamy white in colour with distinctly visible spots on the body. The above observation is in agreement with the description of Veeranna *et. al.* (1999). The larva measured 10.49 mm in length and 1.90 mm in breadth and occupied an average of 1.94 days being shorter in size (11.5 mm x 2.56 mm) and faster in growth (2.18 days) than the observation made by Vishakantaiah and Jagadesh Babu (1980) while it is in line with the findings of Veeranna *et. al.* (1999) who reported 10.55 mm in length and 1.65 mm in breadth.

5.1.3.5 V instar

The larva was brownish with distinctly visible spots on the body. The above description was in agreement with the report of Veeranna *et. al.* (1999).

The V instar larva was 16.10 mm in length and 2.43 mm in breadth and completed on an average of 3.71 days which was slightly longer (15.66 mm in length) than that reported by Vishakantaiah and Jagadeesh Babu (1980), but the developmental period of 3.71 days observed in the present studies was more or less in agreement with the reports (3.66 days) of the above workers.

5.1.3.6 Head capsule

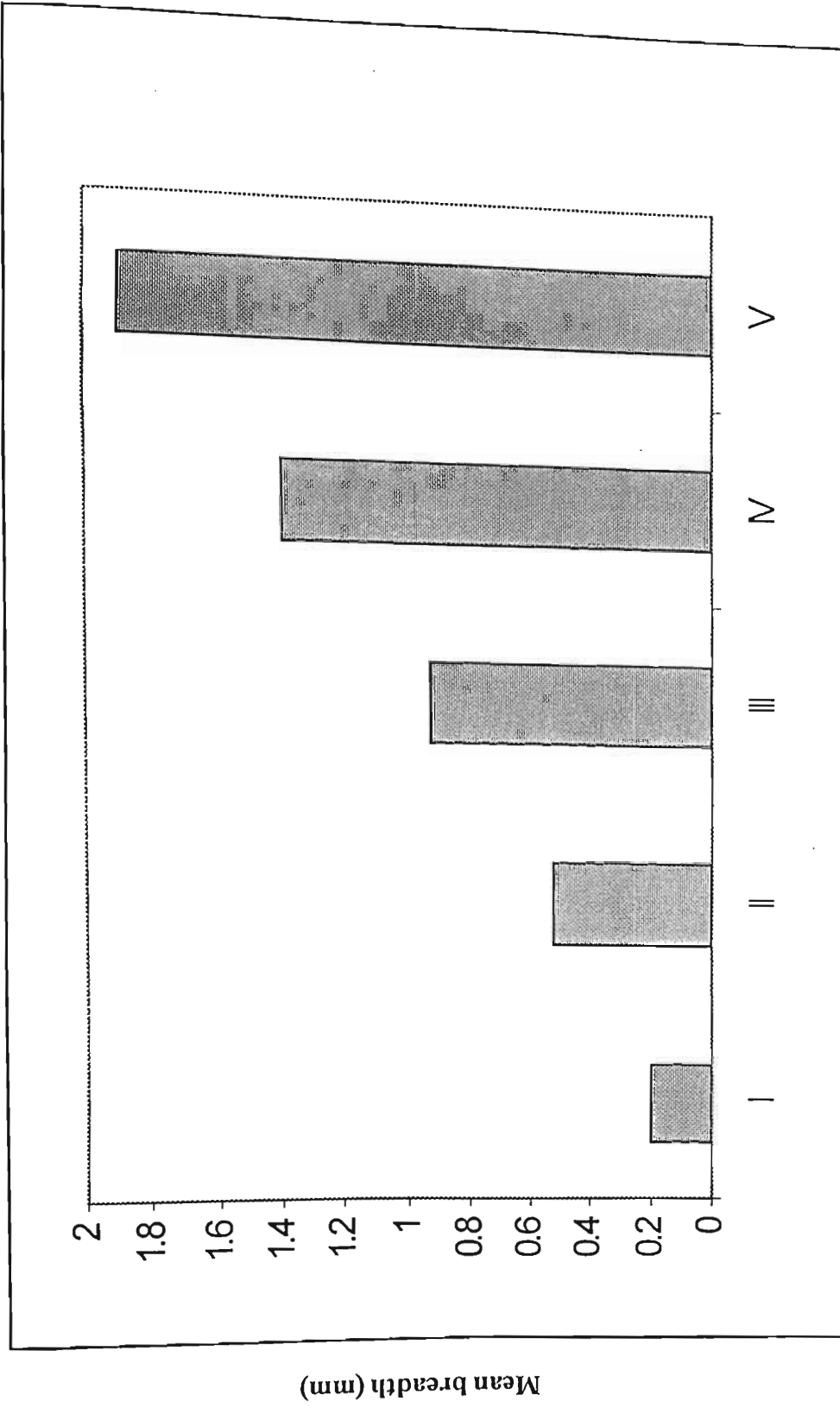
The I, II, III, IV and V instar larval head capsules measured on an average of 0.16 mm x 0.20 mm, 0.41 mm x 0.52 mm, 0.89 mm x 0.92 mm, 1.37 mm x 1.39 mm, 1.66 mm x 1.89 mm in length x breadth, respectively which satisfies the rule given by Dyar i.e. head capsule of larva grows in geometrical progression, increasing in width at each moult by a ratio usually about 1.4 (Wigglesworth, 1938).

5.1.3.7 Total larval period

Under laboratory conditions the total larval period lasted for 11.36 days. Taylor (1967) reported shorter larval period of 8.13 days whereas Akinfenwa (1975) observed 10 to 14 days from Southern and Northern Nigeria respectively on cowpea. However, in India it was observed to be 12.65 days (Vishakantaiah and Jagadeesh Babu, 1980) and 11.02 days on cowpea (Veeranna *et. al.*, 1999). The marginal difference in size and developmental periods of different instars and total larval period might be attributable to the difference in the host plants and the part of the plant it fed and also may be due to environmental conditions prevailed at the time of rearing.

5.1.4 Pre-pupa, pupation and pupa

The pre-pupa measured on an average 13.00 mm in length and 2.59 mm in breadth (Table 4). Pre-pupal period lasted about 2.54 days. Vishakantaiah and Jagadeesh Babu (1980) reported the pre-pupal size was 12.5 mm in length and 3.00 mm in breadth and pre-pupal period as 2.05 days which is slightly shorter than the present findings.



Instars
Fig. 7 Head capsule measurements in larval instars of *M. vitrata*

The pupation was observed inside the leaf web/pod which is in agreement with the findings of Vishakantaiah and Jagadeesh Babu (1980) who reported the pupation on the plant. However, Dietz (1914), Mackie (1931), Caldwell (1945), Nyiira (1971), Taylor (1978), Okeyo-Owuor and Ochieng (1981), Ramdas Rai (1983) and Veeranna *et. al.* (1999) reported the pupation on the soil surface which is contrary to the present observations.

The pupa measured 11.60 mm in length and 2.86 mm in breadth, which agree with the observation of Ramadas Rai (1983) and Veeranna *et. al.* (1999). However, Vishakantaiah and Jagadeesh Babu (1980) reported slightly higher measurements of 12.5 mm x 3.00 mm length and breadth.

The pupal period of 9.07 days observed in the present studies is almost in agreement with that of Dietz (1915) who reported 9 to 10 days. However, shorter pupal period of 6 to 8 days were observed by Leonard and Mills (1931).

Though both male and female pupae were of equal size, sexual dimorphism is distinct. In male pupa, the genital opening is situated ventrally on the posterior margin of the IX segment, close to the anal slit present on X segment (Fig. 2) where as in female pupa, the genital opening is situated ventrally on the posterior margin of the VIII segment and is away from the anal slit (Fig. 2). Above findings are parallel with the observation of Ramdas Rai (1983).

5.1.6 Adult

Moths were medium sized, with brown forewings dotted with a single black-eyed white spot. Hind wings are semi-hyaline, white with a basal brownish area. Though both sexes were morphologically similar, the sex difference in moths were observed based on abdominal characters. The abdomen in females was abroad and bulged with bifid apex where as in males it was telescopic. Similar descriptions were made by Okeyo-Owuor and Ochieng (1981) and Ganapathy (1996).

Adult females were slightly bigger than males. The female measured 11.31 mm in length (from head to abdominal tip) with a wing expanse of 24.27 mm whereas the males measure 11.49 mm in length and 23.37 mm across the wings. These findings are more or less agree with the observations of Okeyo-Owuor and Ochieng (1981) and Ramdas Rai (1983).

However, Vishakantaiah and Jagadeesh Babu (1980) recorded higher wing expanse (26.50 mm) when reared on redgram. Contrary to the present observations, Veeranna *et. al.* (1999) reported that males are bigger and measure 13 mm in length with a wing expansion of 26 mm and females are smaller with on an average of 11.00 mm in length and 23 mm wing expansion when reared on cowpea.

Females preponderated over the male both in the laboratory and in field conditions. The sex ratio of female to male was in the order of 1.2 : 1.0. These observations are in conformity with the earlier reports but for slight variation in ratio. Vishakantaiah and Jagadeesh Babu (1980) reported a sex ratio (F : M) of 1 : 0.850, 1 : 0.526, 1:0.714 on blackgram, cowpea and greengram respectively.

The female moths lived on an average 9.04 days while the male moths on an average of 7.47 days. Taylor (1978) recorded lesser longevity of 4 to 8 days, while Okeyo-Owuor and Ochieng (1981) reported greater longevity of 12 to 14 days. Variations in the longevity of moths might be due to the type of food they fed and the environmental factor prevailing in that area. The longevity of adults may be enhanced by providing nutritious food to adults. The nutrition of host plant on which the larvae were fed may also contribute to adult longevity (Ochieng *et. al.*, 1981).

5.1.5 The total developmental period

The total period occupied from egg to adult was 25.98 days for two generations. Booker (1965) observed longer life cycle of 30 to 35 days in Northern Nigeria while Akinfenwa (1975) reported 23 to 30 days on cowpea in Nigeria. Ramdas rai (1983)

reported 21.25 to 24.37 days on cowpea in Bangalore, 24.12 days on cowpea (Veeranna *et. al.*, 1999) and 28.00 days on blackgram (Ganapathy, 1996). These variations in developmental period of the insect might be attributed to the variations in climate, season, food and geographical situation under which it was studied.

5.2 ECOLOGY

5.2.1 Nature and symptoms of damage

Initially during vegetative stage of the crop the larva of *M. vitrata* acted as leaf webber and fed on the chlorophyll content of the terminal shoots and made holes on tender leaves. At flowering stage it webbed the flower buds and fed on the essential parts of flowers. Finally at pod formation stage tender pods were webbed, bored into them and fed on the developing seeds.

The succession of pest infestation was in agreement with the reports of Jackai (1981) who observed the infestation starts in the terminal shoots of cowpea about 21 days after planting and then spreading to reproductive parts. The intensity was the highest on flowers followed by flower buds, pods and terminal shoots. Contrary to the above Goud and Vastard (1992) observed the stem boring nature of the larvae in blackgram.

5.2.2 Seasonal incidence

Information on the seasonal occurrence of the pest with reference to phenology of the crop growth suitable for feeding as well as breeding will give a definite clue as to the period of peak occurrence as well its low level of activity. This knowledge can be utilized to adjust sowing date or to make acceptable modification in the cropping system and also to time the various approaches for the control to have an ecologically sound method to check the pest.

The larval incidence reached its peak during last week of January coinciding with the maximum flowering and pod initiation stage and gradually declined by first week of

March when pods were ripened. The peak occurrence of SPB during January month is in agreement with the findings of Vignaraja (1978) who observed peak population of *M. vitrata* during December-February months on greengram in Sri Lanka.

Maximum population of SPB coincided with the decline in maximum and minimum temperatures and with higher RH. Similar observation was made by Ahauri *et. al.* (1996) with regard to temperature. Sharma (1996) stated that high humidity and lower temperature might be conducive for build up of SPB.

Minimum temperature and sunshine hours were found to exert independent effect on variation in larval population of *M. vitrata*. The population decreased with the increase in temperature and sunshine hour was reported by Ganapathy (1996), is in agreement with the present observation.

Thus, the results showed that the minimum temperature is the most important abiotic component of environment on the incidence of *M. vitrata* in rice fallow blackgram.

5.2.3 Natural enemies

Apanteles taragame (Veir.) a larval parasitoid parasitizing the late instar larvae of *M. vitrata* was observed in the blackgram ecosystem during January 2001. Sahoo and Senapati (1998) reported the parasitization of *A. taragame* on *M. vitrata* which agree with the present observation.

The larvae of *M. vitrata* were naturally infected by fungal pathogen *Nomuraea rileyi* (Farlow) Samson during January 2001 when the atmospheric humidity was high. Sharma (1998) reported that pathogens played an important role in regulating the larval populations of *M. vitrata* under field conditions. Though several parasitoids, predators and pathogens were reported by several workers on *M. vitrata* (Table 1) only *A. taragame* and *N. rileyi* were observed in blackgram ecosystem under Bapatla conditions. The low profile of natural enemies observed may be due to the adoption of regular plant protection measures with persistent and toxic insecticides by the farmers.

5.3 EFFICACY OF SELECTED INSECTICIDES AGAINST *M.vitrata* UNDER FIELD CONDITIONS

The efficacy of certain insecticides belonging to different groups were tested under field conditions against *M. vitrata* on blackgram during *rabi* 2000-2001. The results obtained are discussed below with the available literature.

The overall cumulative efficacy of the three observations made at three, seven and ten days after two application of treatments at 10 days interval showed that DDVP + chlorpyrifos (62.52%) and DDVP + quinalphos (60.99%) were significantly superior over rest of the treatments and showed more than 60 per cent mean reduction of larval population (Table 11 & Fig.8).

The most effectiveness exhibited by DDVP + chlorpyrifos may be due to their combination. Both DDVP and chlorpyrifos are not only contact and stomach poisons but also having fumigant action, hence its application showed good knock down effect. Due to their fumigant action they can be expected to penetrate better into the pods and gave quick kill of the insect. The next best treatment was DDVP + quinalphos which is less efficacious than the earlier due to lack of fumigant action of quinalphos unlike chlorpyrifos. There were no reports available suggesting the effectiveness of combined use of DDVP + chlorpyrifos and DDVP + quinalphos against *M. vitrata* on blackgram. However, the efficacy of individual insecticides against *M. vitrata* are available. DDVP was found effective against *H. armigera* on chickpea (Butani and Mittal, 1993). Chlorpyrifos was effective against *M. vitrata* on blackgram (Nath and Yein, 1996). Sanap and Patil (1998) reported that spray application of chlorpyrifos recorded 44.13 per cent lower pod damage over untreated control against pigeonpea pod borers. Samalo and Patnaik (1986) found that spray application of quinalphos was effective against pigeonpea pod borers and Bhat *et. al.* (1988a) reported that spray application of quinalphos at 250 ml ha⁻¹ gave an effective control of pod borers in cowpea.

Treatments

T ₁	DDVP 0.038% + chlorpyriphos 0.04%
T ₂	DDVP 0.038% + quinalphos 0.05%
T ₃	Nurelle D 505 (chlorpyriphos 0.05% + cypermethrin 0.005%)
T ₄	Koranda (acephate 0.075 % + fenvalerate 0.009%)
T ₅	Thiodicarb 0.075%
T ₆	Acephate 0.075%
T ₇	Endosulfan 0.07%
T ₈	Diflubenzuron 0.025%
T ₉	Halt (B.t.k) 0.2%
T ₁₀	Neemgold 0.2%
T ₁₁	Untreated control

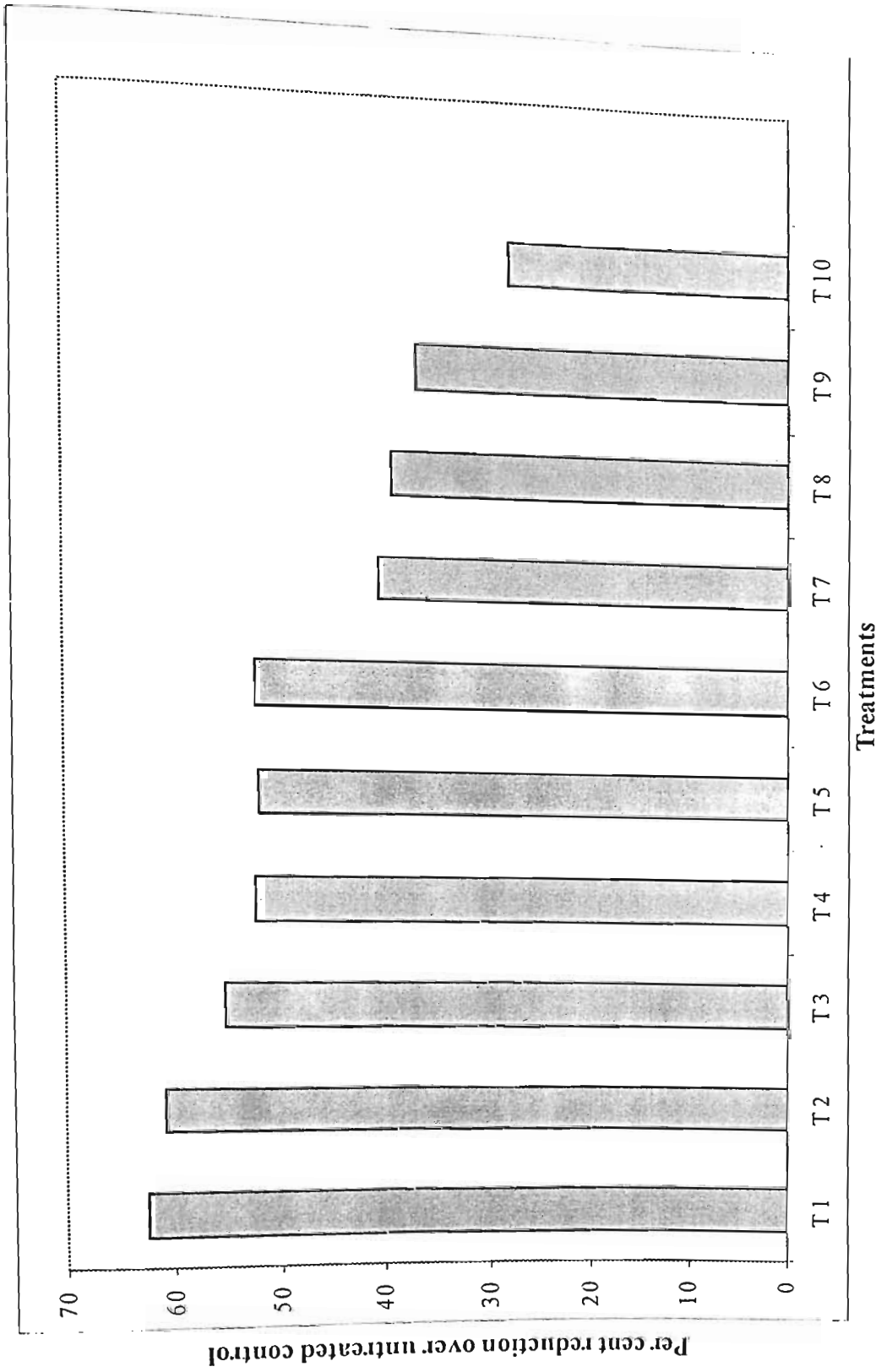


Fig. 8 Overall efficacy of treatments against *M. vitrata* after two sprayings

The next best treatments were Nurelle D505 (55.38%) and Koranda (52.36%) however the latter is on par with thiodicarb (52.11%) and acephate (52.13%). All these treatments showed moderate efficacy and gave more than 50 per cent reduction of larval populations (Table 11 & Fig.8). The good performance of readymix formulations may be due to the combination of conventional insecticide and synthetic pyrethroid. There were no reports available suggesting the effectiveness of Nurelle D505 against *M. vitrata* on blackgram. However, the efficacy of Nurelle D505 against other lepidopteran borers are available. Chlorpyrifos 22.5 EC + cypermethrin 2.5 EC, a combination product was found effective against cotton bollworms (Srinivasan *et. al.*, 1995). Pawar and Mali (1997) reported that, the insecticide mixtures of synthetic pyrethroids either with chlorpyrifos, triazophos and endosulfan were more effective against *H. armigera* in comparison with their sole use. There were no reports available suggesting the effectiveness of Koranda against *M. vitrata* on blackgram. Better performance of thiodicarb against *M. vitrata* is in conformity with the results of Yelshetty *et. al.* (1999), Mann *et. al.* (1995) and Biradar *et. al.* (1999). The efficacy of acephate against *M. vitrata* observed on blackgram in the present study is in agreement with the reports of Nath and Yein (1996) and against *H. armigera* on chickpea (Pawar *et. al.*, 1993).

The treatments that showed less efficacy were endosulfan (40.32%), diflubenzuron (38.96%), Halt (36.39%) and Neemgold (27.50%) (Table 11 & Fig. 8). Among the conventional insecticides endosulfan showed least efficacy. The eco-friendly chemicals, diflubenzuron, Halt (Btk) and Neemgold were less effective at third day after spraying. This may be due to the fact that diflubenzuron acts only during moulting or immediately after moulting hence takes time to exhibit its action (Wellinga *et. al.*, 1973) while Halt requires certain incubation period to multiply in insect body for disintegrating the internal contents (Maddox, 1982). The poor performance of neem formulation might be that neem does not directly kill the larvae (Gill and Lewis, 1972) but impairs growth and development due to its antifeedant action (Guzar and Mehrotra, 1988). The poor performance of neem formulation

may also be due to its photodegradation by U-V radiation in the sunlight (Saxena *et. al.*, 1980 and Stokes and Redfen, 1982). Poor performance of neem formulation (Neemgold) was earlier reported by Singh *et. al.* (1985), Girhepuje *et. al.* (1997) and Sadawarte and Sarode (1997). However, neem formulations were reported to be effective against *M. vitrata* (Cobbinah and Osei-Owusu, 1988; Jackai and Oyediran, 1991; Durairaj and Ganapathy, 1998 and Emosairue and Ubana, 1998). The efficacy of diflubenzuron and Halt (Btk) at seventh and tenth day after spray application remarkably improved over third day after treatment indicating that they requires certain lag period for their activity. As observed in the present study less efficacy of Halt than DFB against *M. vitrata* is in conformity with the results of Karel and Schoonhoven (1986) and Pawar and Gujal (1995). In case of endosulfan, the present observation was in agreement with Sontakke and Mishra (1991) findings. However, endosulfan was found effective against *M. vitrata* on blackgram (Nath and Yein, 1996; Avinashkumar *et. al.*, 1996), cowpea (Jaiswal and Patil, 1993) and on lab lab (Ramasubramanian and Sundarababu, 1991).

5.4 EFFECT OF TREATMENTS ON POD DAMAGE

Among different treatments DDVP + chlorpyrifos (21.41%), DDVP+ quinalphos (21.93%) were on par and highly effective recording less than 25 per cent pod damage (Table 12 & Fig. 9). Nath and Yein (1996) reported that chlorpyrifos one of the combination of former treatment was highly effective in lowering the damage caused by *M. vitrata* in blackgram . Spray application of quinalphos one of the combination of latter treatment was most effective by recording only 6.2 per cent cumulative pod borer damage compared to other treatments against pod borer complex of blackgram (Ganapathy and Durairaj, 2000). Ram Ujagir and Ujagir (1999) reported that spray application of quinalphos (0.05%) was effective in reducing the pod borer damage and losses in grain yields in pigeonpea.

Treatments

T ₁	DDVP 0.038% + chlorpyriphos 0.04%
T ₂	DDVP 0.038% + quinalphos 0.05%
T ₃	Nurelle D 505 (chlorpyriphos 0.05% + cypermethrin 0.005%)
T ₄	Koranda (acephate 0.075 % + fenvalerate 0.009%)
T ₅	Thiodicarb 0.075%
T ₆	Acephate 0.075%
T ₇	Endosulfan 0.07%
T ₈	Diflubenzuron 0.025%
T ₉	Halt (B.t.k) 0.2%
T ₁₀	Neemgold 0.2%
T ₁₁	Untreated control

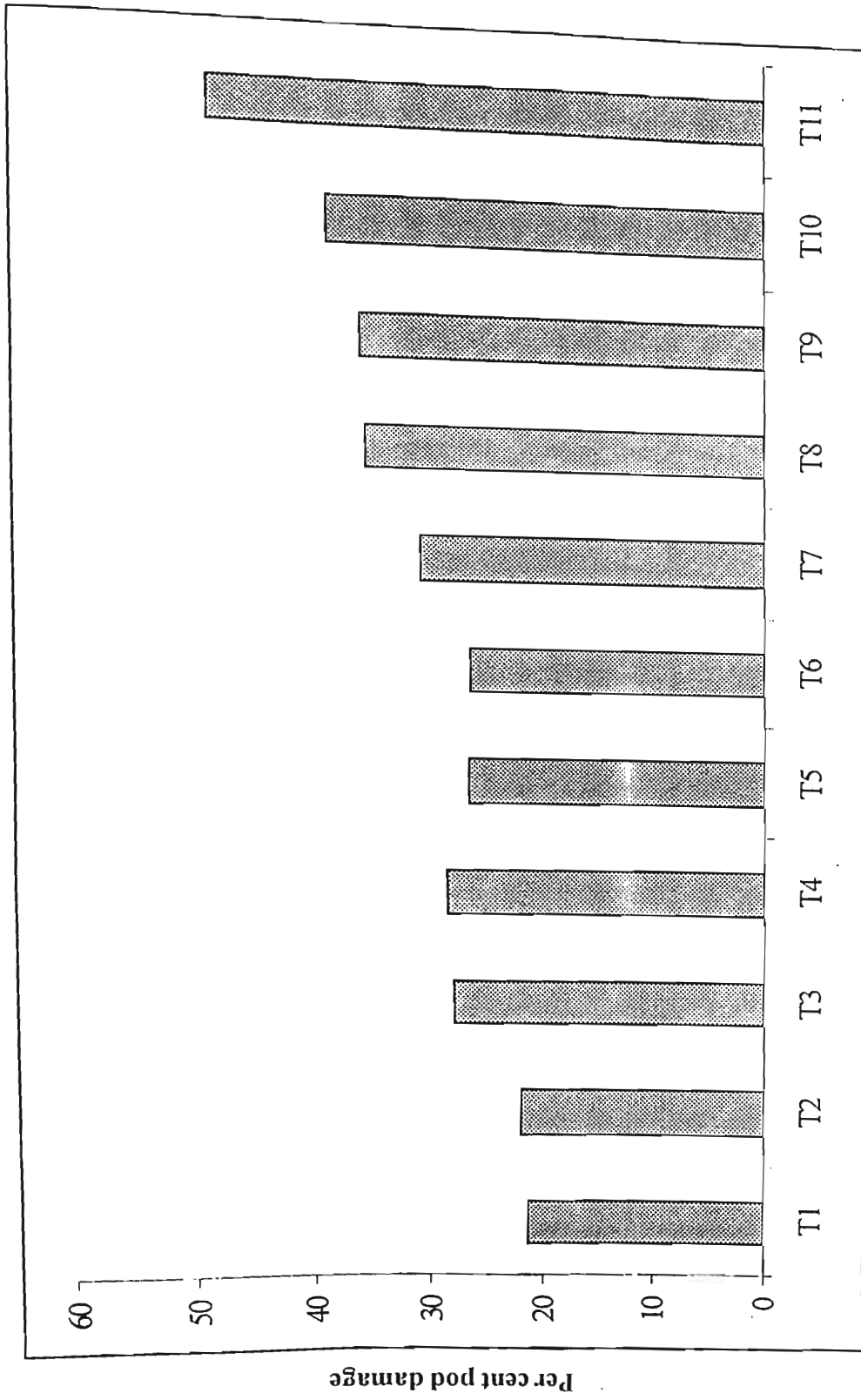


Fig. 9 Effect of treatments on pod damage

The order of efficacy of other treatments that followed was acephate (26.03%), thiodicarb (26.27%) and Nurelle D 505 (27.72%) with mean pod damage ranging between 26 and 28 per cent and they were on par with one another, however, the latter was on par with Koranda. The moderate effectiveness of acephate against *M. vitrata* is in conformity with the report of Ganapathy and Durairaj (2000) who reported that spray application of acephate (0.075%) was moderately effective in reducing pod borer damage (77%) in blackgram. The better performance of thiodicarb in reducing the pod damage is in conformity with the reports of Bhadauria *et. al.* (1988) and Biradar *et. al.* (1999) who reported that thiodicarb spray gave 9.40 per cent pod damage in pigeonpea due to pod fly, *Melanagromyza obtusa* (Malloch) and two sprays of thiodicarb at 300 g ha⁻¹ resulted in only 24.7 per cent pod damage due to gram pod borer. The next best treatments were Nurelle D 505 and Koranda. There were no reports available to support these findings. However, the effectiveness of these treatments on reduction of larval population were reported by many workers which was discussed earlier.

The treatments that registered more than 30 per cent pod damage were endosulfan (30.19%), diflubenzuron (34.84%) and Halt (35.24%) were less effective and inferior to the earlier treatments (Table 12 & Fig.9). The less effectiveness of endosulfan against *M. vitrata* resulted in more pod damage (30.19%) is in agreement with the observations of Sontakke and Mishra (1991). In contrary to the present observations Avinashkumar *et. al.* (1996) reported that endosulfan (0.07%) significantly reduced the damage due to *M. vitrata* on blackgram.

Among the eco-friendly chemicals diflubenzuron was found better in reducing the pod damage by *M. vitrata* which is in conformity with the results of Turkar *et. al.* (1998). The efficiency of Halt in reducing the pod damage is in agreement with Pawar and Gunjal (1995) who reported reduced pod damage due to lepidopterous borers in pigeonpea by the application of Halt. Neem formulation recorded more seed damage (48.06%) by *M. vitrata* compared to the other treatments and is in line with the reports of

Girhepuje *et. al.* (1997) who observed the least effectiveness of NSE 5 per cent was found to be least effective against pod borer complex of pigeonpea while Sadawarte and Sarode (1997) reported that the application of NSE 5 per cent + half dose of insecticide recorded maximum larval reduction of *H armigera* on redgram, where as the application of NSE alone was not effective against pod borer complex of pigeonpea.

5.5 EFFECT OF TREATMENTS ON YIELD

During the present investigation maximum pod yield ($1086.08 \text{ kg ha}^{-1}$) was obtained with DDVP+chlorpyriphos and DDVP+quinalphos (1075 kg ha^{-1}) (Table 13 & Fig. 10). However, Nath and Yein (1996) reported the effectiveness of chlorpyriphos one ingredient of the former was highly effective in lowering the damage caused by *M. vitrata* and obtained increased yield in blackgram. Senapati *et. al.* (1992) reported that spray application of quinalphos one of the ingredients of the latter gave effective control of pod borer complex in pigeonpea and gave higher yields (1502 kg ha^{-1}).

The ready mix formulations like Nurelle D 505 and Koranda also recorded good yields ($1052.75 \text{ kg ha}^{-1}$ and $1044.42 \text{ kg ha}^{-1}$ respectively) compared to the remaining treatments. These findings are in agreements with the reports of Srinivasan *et. al.* (1995) who reported maximum seed cotton yield (14.24 q ha^{-1}) in plots treated with the combination product chlorpyriphos 450 g. a.i + cypermethrin 50 g a.i. ha^{-1} . and Tambe *et. al.* (1997) reported that ready mix formulation of cypermethrin + triazophos ($6.25 + 437.5 \text{ g. a. i. ha}^{-1}$) was superior to remaining treatments in reducing the infestation of pigeonpea pod borers and also recorded highest yield (17.05 q ha^{-1}). Ram Ujagir and Ujagir (1999) reported that fenvalerate (0.006%) one of the ingredient of Koranda was moderately effective and gave better grain yield (2160 kg ha^{-1}) in pigeonpea. Thiodicarb also recorded better yields ($1033.33 \text{ kg ha}^{-1}$) which is in agreement with Yelshetty *et. al.* (1999) who reported highest grain yield of 5.74 q ha^{-1} with thiodicarb in pigeonpea. Acephate, gave moderate yield ($1016.66 \text{ kg ha}^{-1}$) which is in agreement with Ganapathy and Durairaj (2000) who reported

Treatments

T ₁	DDVP 0.038% + chlorpyrifos 0.04%
T ₂	DDVP 0.038% + quinalphos 0.05%
T ₃	Nurelle D 505 (chlorpyrifos 0.05% + cypermethrin 0.005%)
T ₄	Koranda (acephate 0.075 % + fenvalerate 0.009%)
T ₅	Thiodicarb 0.075%
T ₆	Acephate 0.075%
T ₇	Endosulfan 0.07%
T ₈	Diflubenzuron 0.025%
T ₉	Halt (B.t.k) 0.2%
T ₁₀	Neemgold 0.2%
T ₁₁	Untreated control

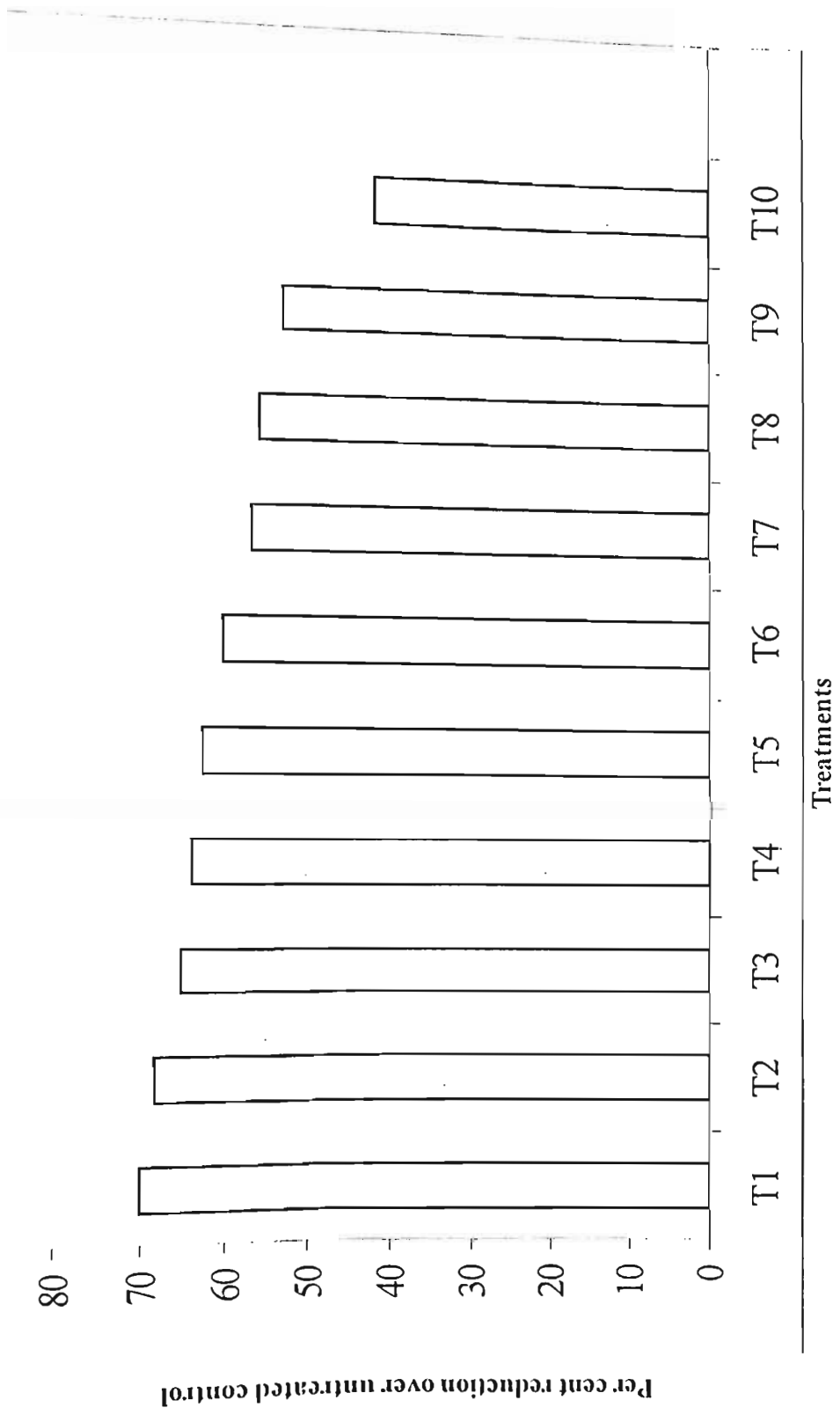


Fig. 10 Effect of treatments on yield

spray application of acephate was moderately effective in reducing pod borer damage in blackgram and gave satisfactory yield (366.7 kg ha^{-1}).

The low yields obtained in endosulfan ($994.42 \text{ kg ha}^{-1}$), diflubenzuron ($986.08 \text{ kg ha}^{-1}$), Halt ($966.67 \text{ kg ha}^{-1}$) and Neemgold ($897.25 \text{ kg ha}^{-1}$) may be attributable to their poor efficacy in reducing the larval population of *M. vitrata* in blackgram. Pawar *et. al.* (1994) reported that among different conventional insecticides tested against *H. armigera* on chickpea endosulfan was least effective and recorded lowest yield (680 kg ha^{-1}).

The low yield obtained in neem formulation ($897.25 \text{ kg ha}^{-1}$) was in agreement with the report of Durairaj and Ganapathy (1998) who reported sprays of Neemolin (567.5 kg ha^{-1}) and Neemol (337.5 kg ha^{-1}) registered comparatively lower yields over the best treatment, Lamda-cyhalothrin (963.5 kg ha^{-1}) in pigeonpea.

From the present investigations on bioecology and management of *Maruca vitrata* (Geyer) on blackgram, the following conclusions are drawn.

- *M. vitrata* laid eggs singly or in batches of 2-18 on the under surface of tender leaves, flower buds, flowers and pods. The mean fecundity was 55.55 eggs with a oviposition period of 4.25 days.
- *M. vitrata* passes through five larval instars with mean larval period of 11.36 days. Full grown larva measured 16.10 mm in length and 2.43 mm in breadth. Grownup larva is creamy white to brownish green with dark brown segmentally arranged sclerites with a pair of conspicuous dark spots on each segment.
- The grownup larva entered in to pupation inside the pods or webs under field conditions. The pupa measured on an average 11.60 mm in length and 2.86 mm in breadth with a duration of 9.07 days.
- Sexual dimorphism in pupae is evident. In male pupa, the genital opening is situated ventrally on the posterior margin of the IX segment close to the anal slit present on X segment. Whereas in female pupa, the genital opening is situated ventrally on the posterior margin of the VIII segment and is away from the anal slit.
- Moths are medium in size, with brown fore wings dotted with a single black-eyed white spot. Hind wings are semi-hyaline, white with a basal brownish area. The abdominal tip in females is broad and bulged whereas in males it is telescopic. Females were bigger with a wing expanse of 24.27 mm and lived longer (9.04 days) than males. Total life cycle from egg to adult emergence was 25.98 days.
- The larva webs the terminal shoots and leaves, flower buds and tender pods and feed on them. The pods are bored at the base of pedicel and bored hole is plugged with frass and excreta.

- Maximum incidence of *M. vitrata* was observed during the last week of January coinciding with the maximum flowering and pod formation stage.
- Multiple regression analysis between weather parameters and larval incidence revealed that, all the weather variables together accounted for 71.7 per cent variation in larval population ($R^2 = 0.717$) which was significant. Minimum temperature and sunshine hours were found to exert independent effect on variation in larval population.
- Larval parasitoid *Apanteles taragama* (Veir.) and fungal pathogen *Nomuraea rileyi* (Farlow) Samson were observed as natural enemies on *M. vitrata* under Bapatla conditions.
- DDVP 0.038% + chlorpyrifos 0.04% and DDVP 0.038% + quinalphos 0.05% were promising treatments for the control of SPB with 62.52 per cent and 60.99 per cent mean reduction of larval population over control.
- The lowest pod damage and highest pod yield were recorded in the treatments DDVP 0.038% + chlorpyrifos 0.04% (21.41% and 1086.08 kg ha⁻¹) and DDVP 0.038% + quinalophos 0.05% (21.93% and 1075 kg ha⁻¹).
- Nurelle D505 (chlorpyrifos 0.05% + cypermethrin 0.005%), Koranda (acephate 0.075% + fenvalerate 0.009%), thiodicarb (0.075%) and acephate (0.075%) were moderately effective while endosulfan (0.07%), diflubenzuron (0.025%), Halt (0.2%) and Neemgold (0.2%) were least effective.

Summary

SUMMARY

Studies on “Bioecology and management of *Maruca vitrata* (Geyer) on blackgram” were conducted at college farm and in the laboratory, Department of Entomology, Agricultural College, Bapatla during *rabi* 2000-2001.

The biology was studied for two generations at a mean temperature of $29 \pm 2^{\circ}\text{C}$ and relative humidity of 87 ± 2 per cent. Premating and mating periods were 2.19 and 2.00 days respectively. Moth laid eggs singly or in batches of 2-18 on the under surface of leaves, flower buds, flowers and pods, on an average 55.55 with an oviposition period of 4.25 days. Larvae passes through five instars in a period of 11.36 days. The first and second instar larvae were creamy white with no distinct markings. From third instar onwards its colour changed to brownish green with a pair of conspicuous dark spots on each segment. Full grown larvae were creamy white to brownish green with a pair of conspicuous dark brown spots on dorsal side of each segment and measured 16.10 mm x 2.43 mm in length and breadth respectively.

Mature larva spun silken thread in net fashion around it to transform into pupa and pupation occurred in dried leaves or webs or pods or sand under laboratory conditions while in field it was inside the pods and webs. The pre-pupa and pupa measured 13.0 mm x 2.59 mm and 11.6 mm x 2.86 mm in length x breadth with a duration of 2.54 and 9.07 days respectively. Sexual dimorphism is evident in pupae. In male pupa, genital opening is situated ventrally on the posterior margin of the IX segment while in female, the genital opening is situated ventrally on the posterior margin of the VIII segment.

Adults of *M. vitrata* are medium in size, with brown fore wings dotted with a single black-eyed white spot while hind wings are semi-hyaline, white with a basal brownish area. Females were bigger in size with a wing expanse of 24.27 mm and lived for 9.04 days. The sex ratio was 1.2 : 1.0 (female : male) and total life cycle from egg to adult was 25.98 days.

To study the seasonal incidence blackgram cv. LBG - 685 was grown in rice fallows in an area of 400 m². Larval incidence was recorded at three days interval on 50 randomly selected plants commencing its initial infestation. The larval incidence started in the 30th of December during vegetative stage and reached a peak during last week of January coinciding with the maximum flowering and pod formation stage of the crop and there after gradually declined by the first week of March.

Multiple regression analysis between weather parameters (minimum and maximum temperatures, morning and evening RH and sunshine hours) and larval incidence revealed that, all the weather variables together accounted for 71.7 per cent variation in *M. vitrata* population ($R^2= 0.717$) which was significant and only minimum temperature and sunshine hours were found to exert independent effect on variation in larval population. Rise in 1°C minimum temperature and one hour sunshine is expected to bring down the larval population by 13.04 and 5.95 respectively.

The larvae were found to infest the leaves, flower buds, flowers, pods and fold them with silken threads, feed on them by taking shelter with in the folds and also bore into pods and fed on developing seeds. One larval parasitoid, *Apanteles taragamae* (Veir.) and one fungal pathogen, *Nomuraea rileyi* (Farlow) Samson were recorded on larvae of *M. vitrata*.

An experiment with Randomized Block Design was conducted to test the efficacy of eleven treatments including untreated check replicated thrice. Insecticides were applied twice at 10 days interval at the rate of 0.5 lit. plot⁻¹ with knapsack sprayer and larval counts were taken one day before, third, seventh and 10th day after sprayings from ten tagged plants form each plot of 12m². Observations on total pods, damaged pods and yield were recorded at the time of harvest and results are as follows.

At three days after treatment DDVP + chlorpyrifos and DDVP + quinalphos were most effective against *M. vitrata* and registered 84.67 per cent and 82.96 per cent mean reduction of larval population respectively over untreated control. The conventional insecticides showed more efficacy than eco-friendly biorational insecticides.

At seven days after treatment also DDVP + chlorpyrifos (61.49%) and DDVP + quinalphos (61.23%) were most effective and reduced the larval population. The efficacy of conventional insecticides gradually reduced and eco-friendly chemicals like diflubenzuron (48.76%), Halt (47.63%) and Neemgold (38.39%) showed increased efficacy than on third day after treatment.

At ten days after treatment diflubenzuron (47.24%) and Halt (43.69%) were found better in reducing the larval population. However, the efficacy of conventional insecticides was reduced considerably.

The overall cumulative efficacy of the three observations made at three, seven and ten days after two sprays revealed that DDVP + chlorpyrifos and DDVP + quinalphos were significantly superior over the rest of the treatments with 62.52 per cent and 60.99 per cent mean reduction of larval population over untreated control. The next best were Nurelle D 505 [chlorpyrifos 0.05% + cypermethrin 0.005%] (55.38%), Koranda [acephate 0.075% + fenvalerate 0.009%] (52.36%), acephate (52.13%), thiodicarb (52.11%) which showed moderate efficacy and reduced more than 52 per cent of larval population. Endosulfan (40.32%), diflubenzuron (38.96%) and Halt (36.39%) were less effective and recorded more than 36 per cent larval reduction. Among treatments Neemgold (27.50%) was the least effective.

DDVP + chlorpyrifos and DDVP + quinalphos registered lowest pod damage of 21.41 per cent and 21.93 per cent respectively. Acephate (26.03%), thiodicarb (26.27%), Nurelle D 505(27.72%) and Koranda (28.26%) showed moderate pod damage . Neemgold was least effective among treatments and registered 38.04 per cent pod damage.

The highest yields were recorded in the treatments DDVP + chlorpyrifos (1086.08 kg ha⁻¹ and DDVP+ quinalphos (1075 kg ha⁻¹). Halt and Neemgold were least effective among treatments and recorded lowest yields (996.67 and 879.25 kg ha⁻¹ respectively). Remaining treatments registered moderate yields.

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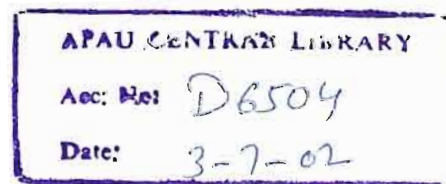
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* Original not seen

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