DEPARTMENT OF AGRICULTURAL ENTOMOLOGY,
DR. BALASAHEB SAWANT KONKAN KRISHI VIDYAPEETH, DAPOLI

Thesis title : Bionomics and management of Bean pod Borer *Maruca vitrata* (Fabricius) (Lepidoptera : Crambidae)

Name of the student : Miss. Karmarkar Meghana Suresh

Regd. No. : 1680

Research Guide : Prof. S.K. Mehendale

Year of award of degree : 2006

THESIS ABSTRACT

The present study entitled, "Bionomics and management of Bean pod Borer *Maruca vitrata* (Fabricius) (Lepidoptera : Crambidae)" was undertaken with specific objectives *viz*., Bionomics of Bean Pod Borer, Management of Bean Pod Borer in the field and to study the knockdown effect of insecticides (72 hours after treatment).

Studies on bionomics was conducted at Department of Agricultural Entomology, College of Agriculture, Dapoli. The mean pre-oviposition, oviposition and post-oviposition period lasted for 3.0, 3.0 and 1.3 days, respectively while the incubation period of eggs on buds and tender pods was found 3.24 days on an average. Total larval, prepupal and pupal period lasted for 12, 2.1 and 8.9 days, respectively. One generation completed within 30.0 and 34.6 days for male and female, respectively.

The field experiment conducted at C.E.S., Wakawali to evaluate the efficacy of some insecticides against *Maruca vitrata* and observations were recorded after 7, 14 and 28 days after treatment on the basis of per cent bud and per cent pod damage. The treatment with cypermethrin + profenophos 44 EC (0.04%) and Emamectin benzoate 5 SG (0.002%) were found significantly superior over rest of the treatments at all the three sprays. These findings were supported by getting maximum yield from these two treatments. The observations on the knockdown effect were recorded in the field (72 hours) after each spray to judge the immediate action of insecticides. Here also, the treatment with cypermethrin + profenophos 44 EC (0.04%) recorded maximum per cent larva mortality with average of 61.33 per cent followed by 0.002 per cent Emamectin benzoate (5 SG) with an average mortality of 56.89 per cent.

ACKNOWLEDGEMENT

As the end of post graduation is in sight of sudden realization makes me ponder over the last two years and I sit today retrospect. I now wonder how in spite of it, as I walk down the memory lane the first name strikes distinctively with a deep sense of gratitude to Prof. S. K. Mehendale, Jr. Entomologist, AICRP on Tuber Crops, Central Experiment Station, Wakawali, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. I heartly express my sincere gratitude and virtual veneration to him for his generosity constant inspiration, constructive criticism, straight forward approach, valuable suggestions and guidance in spite of his busy schedule, which guided me throughout the course of this investigation and during the preparation of this manuscript and its successful culmination.

It is my proud privilege to place on record my sincere and grateful thanks to the members of my advisory committee, Dr. A. L. Narangalkar, Associate Professor, Department of agriculture Entomology and Dr. M. P. Diwakar, Associate Professor, Department of plant Pathology, College of Agriculture, Dapoli for their valuable guidance and cooperation time to time during the course of present investigation.

I wish to express my deep sense of gratitude to Dr. P. D. Patil, Head, Department of Agricultural Entomology, Dr. B. S. K. K. V., Dapoli, for his encouragement and helpful discussion during this study.

I express my grateful thanks to Dr. S. K. Godse, Professor, Dr. C. S. Dalvi, Associate Professor, Prof. (Mrs.) K. V. Naik, Prof. Dr. V. S. Desai, Assistant professor, Prof. R. S. Patil, Prof. M. S. Karmarkar, Assistant Professor, Department of Agricultural Entomology, College of Agriculture, Dapoli, for their moral support immense help and constant encouragement during post graduation.

I am also thankful to Shri. N. R. Bhagwat, Assistant Horticulturist, AICRP on tuber crops, C.E.S., Wakawali and Dr. Waghmare, Vegetable Specialist, Vegetable Improvement Scheme C.E.S., Wakawali and all other staff of C.E.S., Wakawali, for providing labour and other necessary facilities timely for conducting filed trial.

I also express my special thanks to Prof. U. A. Gadre, Jr. Plant Pathologist, AICRP on spices, College of Agriculture, Dapoli, for their co-operation and help during the course of investigation.

I also express my special heartful thanks to Mr. and Mrs. Krishnaji Mehendale and Mrs. Swati Shekhar Mehendale for their co-operation, moral support and help during my post graduation.

I wish to express my special thanks to my cheerful and helpful friends, Sampada, Priya, Deepa, Mugdha, Purnima, Seema, Prasad, Swaroop, Sushant, Mandar who have given my wholehearted help, moral support. I also extend my thanks to my batch mates Suresh, Pravin, Shaligram, Vinod, Yogesh and other friends, Sarika, Pallavi, Jayram, Jitu, Bahubali, Rahul, Harshad, Neha, Deepali, who offered their excellent company throughout my post graduation study.

Words can hardly convey my indebtedness and gratitude towards my beloved father, Shri. Suresh Laxman Karmarkar, mother Mrs. Shaila Suresh Karmarkar who strived to give me the best things in my life. They left no stone unturned. I am thankful to them beyond human recognizing in their endeavor to help me in all possible ways to develop my educational career. I express my hearted thanks to my sisters, Mohana and Angali and brother Amey whose love and affection have brought my cherished dream come true.

I am thankful to Pendse, Karmarkar, Agharkar, Joshi and Abhyankar families for their continuous encouragement and moral support.

Lastly, I am thankful to Pallavi mone and Sachin Sandye for neat typing.

Place : Dapoli

Date : May, 2006 **(M.S. Karmarkar)**

APPENDIX I

ABBREVATIONS USED

%	:	per cent
/	:	per
®	:	Registered
^{0}C	:	Degree Celsius
C.D. at 5%	:	Critical difference at 5 per cent level of significance
cm	:	centimeter
DAT	:	Days after treatment
EC	:	Emulsifiable Concentration
et al.	:	and other
Fig.	:	Figure
g	:	gram
ha	:	hectare
i.e.	:	that is
ml	:	millilitre
mm	:	millimeter
MT	:	million tonnes
RH	:	Relative Humidity
S.E.	:	Standard Error
SG	:	Soluble Granules
viz.	:	Namely

CHAPTER I

INTRODUCTION

Dolichos bean, *Lablab purpureus* L. Sweet is commonly called as Lablab bean or Hycinth bean or Wal. It is a native of India and grown in many pockets of India.

Dolichos bean is a pulse crop belongs to family Leguminaceae. India grows a variety of pulse crops under a wide range of agro-climatic conditions and is recognized globally as a major contributor of pulses having about 25 per cent share in the global production. Latest estimates for 2004-05 indicate that the production of pulses in the country is 26.38 million tones from an area of 24.45 million hectares. The most important states for the pulses are Madhya Pradesh, Uttar Pradesh, Maharashtra, Andhra Pradesh, Karnataka and Bihar, which together account for 80 per cent production of pulses in India (Ali and ShivKumar, 2005).

The dolichos bean is cultivated on small area in our country scattered in small pockets. This is commonly grown for vegetable purpose and also used as a fodder for milking animals. It has high nutritive value. The grain contains proteins 21.6-27.2 per cent (Kadwe *et al*. 1974), carbohydrates 56.16 per cent, fats 2-5 per cent, minerals 2.75 per cent and crude fibres 2.8 - 3.24 per cent on dry weight basis (Bednarki *et al*., 1985).

Being a legume crop, it improves soil fertility and water holding capacity of soil. It is a short duration crop of 110 days which is taken after the harvest of *kharif* rice on residual moisture in Konkan region of Maharashtra. Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli has released one nonviney variety “Konkan Bhushan” (C.V. DPL D.I.) which is cultivated successfully in Maharashtra.

Subba Rao *et al*. (1972) reported the important pests attacking dolichos bean *viz*., pod borers, *Heliothis armigera* Hubner, *Maruca testulalis* Geyer, aphids, *Aphis craccivora* Kotch, Leaf miner, *Cosmopteryx mimetis* Meyer etc. These pests take a heavy toll of the crop. Among them *Maruca vitrata* (*testulalis*) Fabricius which is a major pest reported from thirty nine plant species out of which, thirty seven are leguminous (Rathore and Lal, 1998). It takes a heavy toll of dolichos bean (David, 2002). Zhang (1994) changed the name of *Maruca testulalis* Geyer to *Maruca vitrata* (Fabricius) and from family Pyralidae to family Crambidae of order Lepidoptera.

Its nature of damage is exhibited by weaving unopened buds and flowers. Larva further damages the reproductive parts of flower leading to poor pod setting and pod formation. In later period of crop growth, it behaves as a pod borer and completes its larval and pupal stages inside the pod. While feeding on the grains inside the pod, the entry hole is plugged by larval excreta. These two features i.e. poor pod formation and damaged pods reduces the yield and market value of the pods.

Dolichos bean, one of the precious *rabi* crop of Konkan region is severely affected due to the said pest since last few years. But no much research work is available on it in this region. Thus, quantification of damage, life cycle of the pest and its control measures needs to be studied in detail under the agroclimatic conditions of Konkan region.

Therefore, the present research work has been undertaken with the following objectives:

1. To study the bionomics of *M. vitrata* in the laboratory.
2. Management of *M. vitrata* in the field.
3. To study the knock down effect of different insecticides against *M. vitrata*.

4. CHAPTER III

5. MATERIALS AND METHODS

6.

7. Laboratory investigations on bionomics of Bean pod borer, *Maruca vitrata* (F.) was carried out during the year 2005-06 at the Department of Agril. Entomology, College of Agriculture, Dapoli, Dist. Ratnagiri. Similarly, a field experiment was conducted to study the efficacy of some insecticides against bean pod borer at Central Experiment Station, Wakawali.

8. A brief account of the methodology employed in present study is given under the following headings.

9. 3.1 Bionomics of *M. vitrata*

10. 3.2 Management of *M. vitrata*

11. 3.3 To study the knock down effect of different insecticides

12. **3.1 Bionomics of *M. vitrata***

13. A detailed study on bionomics of Bean pod borer, *M. vitrata* was conducted at the Department of Agril. Entomology, College of Agriculture, Dapoli under laboratory conditions.

14. A brief account of techniques employed and materials used in the present study is described below.

15. **3.1.1 Maintenance of culture**

16. The initial culture of the bean pod borer was obtained from the field of dolichos bean at Central Experiment Station, Wakawali, Dist. Ratnagiri in the month of November, 2005. Large number of infested buds were collected from field and kept in a wide glass jar for pupation. The pupa were separated and kept in glass tube for emergence of adults. The same adults were used for further study.

17.

18.

19. **3.1.2 Mating**

20. To study mating behaviour ten pairs of freshly emerged male and female adult were confined individually into the glass jar. The cotton swab soaked in 5 per cent honey solution was tied in suspended position in the glass jar, as adult food. The observations on mating at different hours during the day and night and duration of coitus were recorded.

21. **3.1.3 Preoviposition period**

22. To investigate the preoviposition period, male and female were separated after mating and only gravid females were kept in glass jar. The period between mating and commencement of egg laying was recorded from ten females. To ascertain whether eggs were laid, the shoot of inflorescence of dolichos bean and inserted coloured paper in glass jar were checked timely with 10X hand lens to record the possible egg laying.

23. **3.1.4 Oviposition period**

24. To work out the mean oviposition period, number of days from the first to the last egg laid was recorded for ten females. To ascertain the presence of eggs on the shoot of inflorescence and coloured paper, they were changed daily and critically observed under 10X lens.

25. **3.1.5 Post oviposition period**

26. To compute mean postoviposition period, the number of days from the last egg laid by female till its death was recorded. Ten females were kept under observations.

27. **3.1.6 Fecundity**

28. To study the mean fecundity, total number of eggs laid by each female during its lifespan were counted while recording the observations on oviposition period. Ten females were observed.

29. **3.1.7 Site of oviposition**

30. Microscopic observations on the site of oviposition under captivity were made while working out the oviposition period. All the plant parts and the paper surface, glass jar surface were viewed critically.

31. **3.1.8 Egg morphometrics**

32. Measurements on length and breadth were recorded by using micrometer scale. In all, ten eggs were examined. Observations on shape and colour of an egg were undertaken, while studying egg morphometrics. From these observations, mean egg length and breadth was calculated in mm.

33. **3.1.9 Incubation period**

34. To study the mean incubation period, the number of days from an egg till the emergence of larva was counted. A set of ten eggs was kept under observation.

35. **3.1.10 Larval period, instars and morphometrics**

36. A newly emerged larva was transferred to a fresh bud of dolichos bean with the help of microcamel hair brush and kept on wet paper in petridish (9 cm diameter and 1.5 cm height). The fresh bud of dolichos bean was provided as a food to larva everyday. The prominent features of larva were described. The number of days from emergence of larva from an egg upto prepupal stage was counted to work out larval period. Top record the number of instars, the larva was critically observed daily under binocular microscope for observing change in size, shape and colour. The

observations on duration, length and breadth of each instar using micrometer scale were recorded. Ten larva were observed.

37. **3.1.11 Prepupal period**

38. The period from ceasation of larval feeding till the formation of pupa was considered as prepupal stage. The prominent features of prepupa were described. Ten prepupa were measured using micrometer scale to workout the mean length and breadth. The duration of prepupa was also recorded.

39. **3.1.12 Pupal period**

40. The colour, shape and size of pupa were described. The number of days from the termination of prepupal stage upto the emergence of an adult was counted to record the pupal period. The observations on length and breadth of ten pupa were also recorded using micrometer scale.

41. **3.1.13 Adult longevity**

42. Longevity of adult male and female was studied separately. A newly emerged adult was confined to a glass jar. The inflorescence shoot of dolichos bean and cotton swab soaked in 5 per cent honey solution were kept inside the glass jar. To work out adult life span, the number of days from emergence of adult till its death was recorded

43. **3.1.14 Adult morphometrics**

44. The prominent features of male and female adults were described. Measurements on body length, breadth and wing expanse of ten adults were recorded using micrometer scale. Body breadth was recorded across the abdomen at its broadest region. To record the wing expanse, the forewing of either right or left was spread horizontally at right angle to the body. Body length was considered from head upto the tip of abdomen.

45. **3.1.15 Sex ratio**

46. To determine the sex ratio, hundred adults emerging from randomly selected pupa from laboratory maintained culture were observed and differentiated into sexes, based on differentiating morphological characteristics.

47.

48. **3.1.16 Life cycle**

49. The total period required for the completion of life cycle and generation was worked out based on the duration of egg, larval, prepupal, pupal and adult stages.

50. **3.2 Management of *M. vitrata***

51. A field experiment was conducted during *rabi* season of 2005-06 to study the effectiveness of insecticides against bean pod borer, *M. vitrata* infesting dolichos bean (*var*. Konkan Bhushan). The details of experiment are as given below.

52. The seeds of dolichos bean (*var*. Konkan bhushan) were sown on flat beds. All agronomic practices including application of manures and fertilizers were followed as per the recommendations.

53. The quantity of spray suspension required for each treatment was caliberated by spraying water over three plots in the experiment prior to the application of insecticides. Spray suspension of desired strength of each insecticide was prepared and applied using manually operated knapsack sprayer.

54. The fresh extract of serni plant was prepared for spraying in the field. The fresh plant twigs were collected and chopped into pieces with knife. The chopped parts were crushed in the mixer to make the paste

(100 gm) which further taken in a beaker (2000 ml capacity) in which 1000 ml of distilled water was added. The mixture was stirred thoroughly and kept undisturbed for 24 hours. Then, it was filtered through Whatman's filter paper (No. 1). Total volume was made to 1000 ml and this was sprayed in the plot.

55. Location : Central Experiment Station, Wakawali, Tal. Dapoli, Dist. Ratnagiri (M.S.).
56. Design : Randomized Block Design (RBD)
57. Replications : Three
58. Treatments : Nine
59. 1) Cypermethrin (40%) + Profenophos (4%) 44 EC 0.04%
60. 2) Quinalphos 25 EC 0.04%
61. 3) Dipel (*B. thuringiensis*) 8 L 0.1%
62. 4) Dipel (*B. thuringiensis*) 8 L 0.2%
63. 5) Emamectin Benzoate 5SG 0.002%
64. 6) Neem insecticide 10000 ppm 0.2%
65. 7) Carbaryl 50 WP 1.0%
66. 8) Serni plant (*Homonoia viporia*) aqueous extract 10.0%
67. 9) Control
68. Period of study : October, 2005 to February, 2006
69. Crop : Dolichos bean
70. Variety : Konkan Bhushan (C.V. DPL D.I.)
71. Spacing : 45 cm × 45 cm
72. Gross plot : 3.75 m × 3.75 m
73. Net plot : 3.60 × 3.60 m
74. Date of sowing : 19th October, 2005.
75. Three sprays of each insecticide were applied at initiation of flowering, 50 per cent flowering and 50 per cent pod filling stage.

The details of each insecticide used in the present investigation are given in Table 1.

76. **Table 1. Details of insecticide evaluated against *M. vitrata* in the field**

Sr. No.	Common Name	Trade name	Chemical name	Formulation	Concentration used (%)	Source
1.	Cypermethrin 40% + Profenophos 4%	Polytrin-C®	--	44EC	0.04%	Syngenta India Ltd. 14 J tata Road, Mumbai-400 020
2.	Quinalphos	Ekalux®	0,0-diethyl 0-2, Quinoxalinyl (2-phosphorothiorate)	25EC	0.04%	Syngenta India Ltd. 14 J tata Road, Mumbai-400 020
3.	Dipel (*Bacillus thuringiensis*)	Dipel®	--	8L	0.1%	Cheminova India Ltd. Bandra (E.), Mumbai-400 051
4.	Dipel (*Bacillus thurengiensis*)	Dipel®	--	8L	0.2%	Cheminova India Ltd. Bandra (E.), Mumbai-400 051
5.	Emamectin Benzoate Ba	Proclaim®	4^{a}-deoxy-4^{b} (methyl amino) (4^{b} R)-avermectin-B_1-benzoate	5SG	0.002%	Syngenta India Ltd. 14 J tata Road, Mumbai-400 020
6.	Neem insecticide Neemazal	Neemfighter®	--	10000ppm	0.2%	EID Parry (India) Ltd., Dare House, Chemmai-600 001
7.	Carbaryl	Sevin®	1-napthyl-N-methyl carbamate	50 WP	1.0%	S.S. Crop Care Ltd. 10, Industrial Area govind Pura, Bhopal-462 023
8.	Serni (*Homonoia viporia*)	--	--	--	10%	Local collection from nearly river area
9.	Control	--	--	--	--	--

77. To study the efficacy of insecticides, total number of buds, flowers and pods and number of damaged buds, flowers and pods were counted as per their availability and crop growth stage. The observations were taken from five randomly selected plants from each plot at seven days interval after application of insecticide. One observation was recorded 24 hours before application of first spray as a precount. The data on mean per cent damaged buds and pods of nine observations were pooled over and subjected to statistical analysis after calculating arcsin values.

78. **3.3 To study the knock down effect of different insecticides**

79. The observations for per cent larval mortality were taken at 72 hours after spraying in the field, to judge the knock down effect of insecticides.

80. For recording the mortality of larvae, 50 freshly damaged buds or pods were collected from each treated plot. They were inspected critically by slightly opening the buds or pod. The number of dead larva were counted and the data were presented on per cent basis.

81. The per cent larval mortality was worked out and the data were subjected to arc sin transformation.

CHAPTER IV
RESULTS AND DISCUSSION

The present investigations were undertaken to study the bionomics and management of bean pod borer, *Maruca vitrata* (Fabricius). The results are discussed under the following headings.

4.1 Bionomics of *M. vitrata*

4.2 Management of *M. vitrata*

4.3 To study the knock down effect of different insecticides against *M. vitrata*

4.1 Bionomics of *M. vitrata*

The studies on bionomics of the bean pod borer were conducted in the laboratory of the Department of Agricultural Entomology, College of Agriculture, Dapoli, Dist. Ratnagiri during the *rabi* season of 2005-06 and the results are summarized here under.

4.1.1 Mating

During the present study mating was observed during night hours between 21:00 to 00:40 hours. The duration of coitus ranged from 35 to 50 minutes.

The observations on time of mating and coitus duration are presented in Table 2.

The present findings are in conformity with those made by ChiChung and WuKang (2001) who recorded that the adults started to mate at 21:00 hours and mating period lasted for 44.4 minutes.

Table 2. Mating in *M. vitrata*

Pair No.	Mating time (P.M.)		Coitus period (mins.)
	From	To	
1.	22:00	22:40	40
2.	22:10	22:52	42
3.	21:45	22:25	40
4.	23:00	23:40	40
5.	21:00	21:42	42
6.	23:50	00:40	50
7.	23:30	00:05	35
8.	00:00	00:40	40
9.	21:20	22:00	40
10.	23:25	00:05	40
Range	21:00 – 00:00	21:42 – 00:40	35 – 50
Mean	22:48	23:08	40.9 min.

4.1.2 Preoviposition, oviposition and postoviposition period

The preoviposition, oviposition and postoviposition period were recorded and the results are presented in Table 3.

It was revealed that the preoviposition period was 3 to 4 days with an average of 3.30 days. The oviposition period ranged between 2 to 4 days with an average of 3 days. The postoviposition period was recorded only of 1 to 2 days with an average of 1.30 days.

These findings are comparable with Chinnabhai *et al*. (2002) who reported the preoviposition, oviposition and postoviposition period of 1.71, 3.53 and 1.71 days, respectively when studied the biology of *M. vitrata* on green gram. While studying biology of *M. vitrata* on black gram, they reported preoviposition, oviposition and postoviposition period of 1.56, 3.53 and 1.03 days, respectively.

Table 3. Preoviposition, oviposition, postoviposition periods and fecundity of *M. vitrata*

Pair No.	Preoviposition period (days)	Oviposition period (days)	Postoviposition period (days)	Fecundity
1.	3	4	1	81
2.	3	4	1	78
3.	4	3	2	67
4.	3	3	2	59
5.	3	3	1	56
6.	3	3	1	61
7.	3	2	1	37
8.	4	3	1	63
9.	4	3	2	58
10.	3	2	1	42
Range	3-4	2-4	1-2	37-81
Mean	3.30	3.00	1.30	60.2

4.1.3 Fecundity

The data recorded on fecundity of bean pod borer, *M. vitrata* (Table 3) indicated that the total number of eggs laid by female in her lifespan varied from 37 to 81 with an average of 60.2.

The findings are comparative with ChiChung and WuKang (2001) who recorded 67 eggs deposition by female when studied biology on black gram.

4.1.4 Site of oviposition

The female usually laid eggs on flower buds singly or in groups of 2 to 3. Eggs were also observed on the walls of glass jar and coloured paper as well as on a muslin cloth used as a cover for glass jar.

The present observations are in confirmity with those reported earlier by Atwal and Dhaliwal (1997) that the eggs are laid on buds or on tender pods singly.

4.1.5 Eggs

The freshly laid eggs were oval and yellowish white or creamy white in colour and glued to the surface of bud (Plate III). The colour of the eggs changed gradually to white just before hatching. The eggs measured 0.57 to 0.59 mm in length with an average of 0.58 mm and 0.38 to 0.39 mm in breadth with an average of 0.38 mm (Table 4).

Table 4. Morphometrics of eggs of *M. vitrata*

Pair No.	Length (mm)	Breadth (mm)
1.	0.58	0.39
2.	0.57	0.38
3.	0.58	0.39
4.	0.58	0.39
5.	0.59	0.38
6.	0.59	0.38
7.	0.58	0.38
8.	0.58	0.38
9.	0.57	0.38
10.	0.59	0.38
Range	0.57 – 0.59	0.38 – 0.39
Mean	0.58 mm	0.38 mm

The present findings of colour and size of eggs are in conformity with Vishakantaiah and Jagadeesh Babu (1980) who reported pale yellow white colour of egg with 0.58 mm length and 0.38 mm width.

4.1.6 Incubation period and hatching percentage

The data on incubation period and hatching percentage are presented in Table 5. It was evident from the data that the incubation period ranged from 3 to 3.5 days with a mean of 3.40 days.

Chinnabhai *et al*. (2001) also observed the incubation period of 3.14 days on green gram.

The hatching percentage ranged between 60-100 per cent with an average of 80 (Table 5).

Table 5. Incubation period and hatching percentage of *M. vitrata*

Pair No.	No. of eggs observed	No. of eggs hatched (days)				Total eggs hatched	Hatcing %	Avg. incubation period
		1	2	3	4	5		
1.	10	--	--	5	3	8	80	3.5
2.	10	--	--	4	3	7	70	3.5
3.	10	--	--	6	2	8	80	3.5
4.	10	--	--	4	6	10	100	3.5
5.	10	--	--	8	--	8	80	3.0
6.	10	--	--	6	--	6	60	3.0
7.	10	--	--	7	1	8	80	3.5
8.	10	--	--	4	4	8	80	3.5
9.	10	--	--	2	5	7	70	3.5
10.	10	--	--	7	3	10	100	3.5
Range						6-10	60-100	3.0 - 3.5
Mean						8.0	80%	3.40

4.1.7 Larval development and morphometrics

The observations on larval development and morphometrics are presented in Table 6 and 7. The developmental period for larva ranged from 11 to 14 days with an average of 12.0 days. The present observations are in close conformity with earlier reports of Chinnabhai *et al*. (2002) who recorded larval period of 11.12 days on green gram. Atwal and Dhaliwal (1997) reported that the larval development completed within 15 to 20 days.

During the developmental period larva moulted for four times and thus passed through five instars (Plate IV) before reaching pupation. The instar wise description is presented below.

First instar

The newly hatched larva was active, white coloured with brown head. The period ranged from 2 to 3 days with an average of 2.30 days. The larva measured from 3.1 to 3.3 mm with an average of 3.19 mm in length and 0.70 to 0.71 mm in breadth with an average of 0.70 mm. Head capsule width of first instar was recorded between 0.60 to 0.61 mm with a mean of 0.60 mm.

The first instar larval development is in comparable with the studies conducted by Vishakantaiah and Jagadeesh Babu (1980) as they measured length 3.2 mm and width 0.70 mm.

Second instar

The second instar larva was very active, white in colour with dark brown spots on the body. The head was dark brown. The larval period ranged from 2 to 3 days with an average of 2.20 days. The larva measured 4.2 to 4.4 mm in length with an average of 4.31 mm and breadth from 0.76 to 0.77 mm with an average of 0.76 mm. the head capsule width was recorded between 0.67 to 0.68 mm with a mean of 0.68 mm.

These findings are in close conformity with the observations recorded by Vishakantaiah and Jagadeesh Babu (1980) who reported that the second instar larva measured 4.37 mm and 0.75 mm in length and width, respectively with an average period of 2.4 days.

Third instar

The third instar was very active, deep white in colour with dark brown spots and the sparsely hairy body. The head was dark brown. The larval period ranged from 2-3 days with an average of 2.10 days. The larva measured 8.5-8.6 mm with an average of 8.56 in length. Breadth varied from 1.4 to 1.6 mm with a mean of 1.53 mm. While the head width ranged from 0.91 to 0.92 mm with a mean of 0.91.

The findings are in comparison with those of Vishakantaiah and Jagadeesh Babu (1980) who recorded the body length of 9 mm and width of 1.9 mm with a mean period of 2.35 days.

Table 6. Larval development period of *M. vitrata*

Pair No.	Duration of larval instars (days)					Total larval period (days)
	I	II	III	IV	V	
1.	3	2	2	2	3	12
2.	2	2	2	2	4	12
3.	2	2	2	2	3	11
4.	2	2	2	2	3	11
5.	2	3	3	2	3	13
6.	3	3	2	2	4	14
7.	2	2	2	2	3	11
8.	2	2	2	2	3	11
9.	3	2	2	3	3	13
10.	2	2	2	2	4	12
Range	2-3	2-3	2-3	2-3	3-4	11-14
Mean	2.30	2.20	2.10	2.10	3.30	12.00

Fourth instar

The fourth instar larva was very active. The sparse hairs were observed all over the body positioned at each brown spot. The head was dark brown whereas the body colour was deep white. The period ranged between 2 to 3 days with an average of 2.1 days.

The body length and breadth ranged from 11.7 to 11.8 mm with an average of 11.74 mm and 2.5 to 2.6 mm with an average of 2.52 mm, respectively.

Table 7. Morphometrics of larva of *M. vitrata*

Sr. No.	First instar			Second instar			Third instar			Fourth instar			Fifth instar		
	B.L. mm	B.B. mm	H.W. mm	B.L. mm	B.B. mm	H.W. mm	B.L. mm	B.B. mm	H.W. mm	B.L. mm	B.B. mm	H.W. mm	B.L. mm	B.B. mm	H.W. mm
1.	3.1	0.70	0.61	4.2	0.76	0.68	8.5	1.4	0.91	11.8	2.5	1.9	16.0	2.9	2.4
2.	3.1	0.70	0.60	4.3	0.77	0.67	8.5	1.4	0.91	11.7	2.5	1.9	16.0	2.9	2.4
3.	3.1	0.70	0.60	4.3	0.77	0.67	8.5	1.5	0.91	11.7	2.6	2.0	16.0	2.9	2.4
4.	3.2	0.71	0.61	4.4	0.76	0.68	8.6	1.5	0.92	11.8	2.5	1.9	15.8	2.9	2.4
5.	3.3	0.70	0.60	4.4	0.76	0.68	8.5	1.6	0.91	11.8	2.6	1.9	15.9	3.0	2.4
6.	3.2	0.70	0.60	4.3	0.77	0.68	8.6	1.5	0.91	11.8	2.5	1.9	15.9	3.0	2.5
7.	3.2	0.70	0.60	4.3	0.76	0.68	8.6	1.6	0.92	11.7	2.5	1.9	15.9	2.9	2.4
8.	3.2	0.71	0.60	4.3	0.77	0.68	8.6	1.6	0.92	11.7	2.5	1.9	15.9	3.0	2.5
9.	3.2	0.71	0.60	4.3	0.76	0.68	8.6	1.6	0.91	11.7	2.5	1.9	15.9	3.0	2.4
10.	3.3	0.70	0.60	4.3	0.76	0.68	8.6	1.6	0.91	11.7	2.5	1.9	15.9	2.9	2.4
Range	3.1-3.3	0.70-0.71	0.60-0.61	4.2-4.4	0.76-0.77	0.67-0.68	8.5-8.6	1.4-1.6	0.91-0.92	11.7-11.8	2.5-2.6	1.9-2.0	15.8-16.0	2.9-3.0	2.4-2.5
Mean	3.19	0.70	0.60	4.31	0.76	0.68	8.56	1.53	0.91	11.74	2.52	1.92	15.92	2.94	2.42

The head width recorded was 1.9 to 2.0 mm with a mean of 1.92 mm.

These findings are in close comparison with those made by Vishakantaiah and Jagadeesh Babu (1980) who recorded 11.5 mm length and 2.56 mm body width and period 2.18 days.

Fifth instar

The fifth instar larva was very active. The colour of larva was white with dark brown spots all over the body and sparse hairs were also noticed.

The period ranged from 3 to 4 days with an average of 3.30 days. The full grown larva measured 15.8 to 16.0 mm in length with an average of 15.92 mm and breadth 2.9 to 3.0 mm with an average of 2.94 mm. The head width recorded was 2.4 to 2.5 with an average of 2.42 mm.

The larval description and measurements are matching to the earlier reports of Vishakantaiah and Jagadeesh Babu (1980) and Chinnabhai *et al*. (2002).

4.1.8 Nature of damage

The larva soon after hatching, started boring the bud or tender pod. The larva reached to the reproductive parts of flowers i.e. anthers and ovary and fed on them. The entry hole was plugged with the fecal material. Larva damaged the buds by webbing together the adjoining buds and fed voraciously on them by living inside. Thus, the webbing of buds and flowers and drying of inflorescence further was an important symptom of the attack of *M. vitrata* (Plate V a).

Similarly, the larva bored the tender pods, it damaged the developing grains. Thus, the empty pods full of excreta were seen in the plot (Plate V b).

Thus, feeding on the buds initially reduced the pod formation and continued damage on pods reduced the grain yield.

Earlier, some observations on the nature of damage of the bean pod borer were made by Vishakantaiah and Jagadeesh Babu (1980), Atwal and Dhaliwal (1997), Sharma and Frenzmann (2000) and David (2002), which are more or less similar as observed during the present investigations.

4.1.9 Pupation

The observations on the developmental period of prepupa and pupa are presented in Table 8.

Table 8. Prepupal and pupal period and morphometrics

Pair No.	Prepupal period (days)	Pupal period (days)	Morphometrics of					Adult emerged
			Prepupa			Pupa		
			B.L. mm	B.B. mm	H.W. mm	B.L. mm	B.B. mm	
1.	2	9	13.2	3.2	2.2	12.3	2.9	Female
2.	2	9	13.2	3.3	2.2	12.3	2.9	Female
3.	2	8	13.2	3.3	2.2	12.3	3.0	Female
4.	2	10	13.2	3.3	2.2	12.2	3.0	Male
5.	3	9	13.1	3.3	2.2	12.2	3.0	Male
6.	2	9	13.1	3.2	2.3	12.2	3.0	Male
7.	2	9	13.1	3.3	2.3	12.2	3.1	Female
8.	2	9	13.1	3.3	2.2	12.2	3.1	Female
9.	2	8	13.1	3.3	22	12.2	2.9	Female
10.	2	9	13.2	3.3	2.2	12.2	2.9	Male
Range	2-3	8-10	13.1-13.2	3.2-3.3	2.2-2.3	12.2-12.3	2.9-3.1	
Mean	2.1	8.9	13.15	3.28	2.22	12.23	2.98	

4.1.9 a. Prepupal period

The full grown larva before pupation passed through a prepupal stage, it stopped feeding and gradually shrunk in length and became sluggish. The colour changed from deep white to green. It constructed a loose silken netting with the buds and flower petals and transformed into a pupa (Plate VI a).

The prepupal period lasted for 2 to 3 days with an average of 2.1 days. The length of prepupa varied from 13.1 to 13.2 mm with an average of 13.15 mm whereas, breadth varied from 3.2 to 3.3 with an average of 3.28 mm. The head width ranged between 2.2 to 2.3 mm with an average of 2.22 mm.

4.1.9 b. Pupal period

The larva before pupation became complete green and considerably decreased in length. The freshly formed pupa was green and gradually turned into brown colour. The pupa was obtect type, broader anteriorly and tapering posteriorly (Plate VI b). The duration of pupal period ranged from 8 to 10 days with an average of 8.9 days. The pupa measured from 12.2 to 12.3 mm in length with an average of 12.23 mm and the breadth ranged from 2.9 to 3.1 with an average of 2.98 mm.

Earlier Atwal and Dhaliwal (1997) reported pupal period of 8 to 9 days. ChChung and WuKang (2001) recorded pupal period of 6.56 days. The findings of pupal length and breadth are in close conformity with those of Vishakantaiah and Jagadeesh Babu (1980) who recorded the length of 12.5 mm and breadth of 3 mm with a pupal period of 8-10 days.

4.1.10 Adult longevity

The adult longevity was studied in laboratory for both the sexes with and without food. The observations are presented in table 9. Male moth was generally short lived. They lived without food for 1 to 2 days with an average of 1.3 days while females lived without food for 1 to 3 days with an average of 1.6 days. However, when fed with 5 per cent

Table 9. Longevity of adult of *M. vitrata*

Pair No.	Without food (days)		With food (days)	
	Male	Female	Male	Female
1.	1	1	5	10
2.	1	2	5	8
3.	1	1	4	8
4.	1	2	4	8
5.	2	2	4	8
6.	2	3	5	8
7.	1	2	4	8
8.	2	1	5	8
9.	1	1	5	8
10.	1	1	5	8
Range	1-2	1-3	4-5	8-10
Mean	1.3	1.6	4.6	8.2

Table 10. Morphometrics of adult of *M. vitrata*

Pair No.	Female			Male		
	Body length (mm)	Body breadth (mm)	Wing expanse (mm)	Body length (mm)	Body breadth (mm)	Wing expanse (mm)
1.	11.8	2.4	26.2	10.9	2.2	24.1
2.	11.9	2.1	25.8	10.8	2.0	24.1
3.	11.8	2.1	24.9	10.9	2.1	23.5
4.	11.6	2.1	24.9	11.1	2.1	23.9
5.	11.9	2.6	25.6	11.4	2.1	24.2
6.	12.4	2.0	26.1	11.2	2.4	24.5
7.	12.0	2.2	24.8	11.2	2.2	24.3
8.	11.9	2.2	24.9	11.1	2.1	24.3
9.	11.9	2.2	25.4	10.9	2.1	24.2
10.	11.9	2.1	24.8	10.9	2.0	23.5
Range	11.6-12.4	2.0-2.6	24.8-26.2	10.8-11.4	2.0-2.4	23.5-24.5
Mean	11.91	2.2	25.34	11.04	2.13	24.06

honey solution the adult longevity (male and female moths) increased considerably and ranged from 4 to 5 days with an average of 4.6 days for males, while for the female moths ranged from 8 to 10 days with an average of 8.2 days.

The present findings are in close conformity with those made by ChiChung and WuKang (2001) who reported life span of female 9 ± 2.6 days and male 7.9 ± 2 days with food.

4.1.11 Adults

The adult moth of *M. vitrata* was slender, medium sized and brown in colour. Forewings were brown with a white spot across the wing.

Hind wings were white in colour with brown border. The hind wings were smaller and broader than forewing. The female abdomen was slightly broader than male and with an opening at the tip while the tip of male abdomen was black, curved and longer than female abdomen (Plate VII).

Almost similar description of adult moths has been given in literature (Atwal and Dhaliwal, 1997).

The measurements on the length, breadth and wing expanse of female moth ranged from 11.6 to 12.4 mm (average 11.91 mm), 2.0 to 2.6 mm (average 2.2 mm) and 24.8 to 26.2 mm (average 25.34 mm), respectively.

The male moth was 10.8 to 11.4 mm (average 11.04 mm) in length 2.0 to 2.4 mm (average 2.13 mm) in breadth and 23.5 to 24.5 mm (average 24.06 mm) in wing expanse (Plate VII).

4.1.12 Sex ratio

During the present study sex ratio was worked out by examining 100 adults. Out of 100 adults examined 48 and 52 were males and females, respectively. The male to female sex ratio was 1 : 1.08.

Table 11. Sex ratio in *M. vitrata*

Pair No.	No. of adults examined	Female moths	Male moths
1.	10	6	4
2.	10	5	5
3.	10	5	5
4.	10	5	5
5.	10	4	6
6.	10	7	3
7.	10	5	5
8.	10	6	4
9.	10	5	5
10.	10	4	6
Total	100	52	48

Sex raio Male : Female
48 : 52
1 : 1.08

4.1.13 Life cycle

The observations on the life cycle of *M. vitrata* presented in Table 12, revealed that the total period required to complete one life cycle from eggs to emergence of adults varied from 24 to 30.5 days with an average of 26.4 days. Whereas, the generation from egg to death of male and female was found to be completed within 28 to 35.5 days (average of 31.0 days) and 32 to 40.5 days (average of 34.6 days), respectively (Plate VIII).

Table 12. Life cycle of *M. vitrata*

Life cycle	Duration (days)		
	Minimum	Maximum	Mean
Egg	3	3.5	3.4
Larva	11	14	12.0
Prepupa	2	3	2.1
Pupa	8	10	8.9
Life cycle (egg to emergence of adult)	24	30.5	26.4
Male (with food)	4	5	4.6
Female (with food)	8	10	8.2
Generation (egg laying to the death of adult)			
Male	28	35.5	31.0
Female	32	40.5	34.6

4.2 Management of *M. vitrata*

The field trial with eight insecticides and control was conducted with a view to test their efficacy against bean pod borer, *M. vitrata*. The three sprays were applied at initiation of flowering, 50 per cent flowering and 50 per cent pod filling stage of the crop. The results are summarized as under.

4.2.1 Per cent bud damage-first spray (at initiation of flowering)

The data recorded on the per cent bud damage in various insecticidal treatments at 7, 14 and 21 days after treatment (DAT) are presented in Table 13 and graphically represented in Fig. 1.

The results at 7 DAT revealed that all the insecticides tested were significantly superior over control except serni plant. The treatment with cypermethrin + profenophos was found to be the best followed by emamectin benzoate and 0.2 per cent dipel. Dipel 0.1 per cent and quinalphos were found at 4th and 5th place in reducing per cent bud damage, respectively, while carbaryl and 10000 ppm neem insecticide placed at 6th and 7th place, respectively in reducing per cent bud damage at 7 DAT. The serni plant extract was ineffective and at par with the control.

Table 13. Per cent bud damage – first spray (at initiation of flowering)

Tr. No.	Treatment	Conc. (%)	Per cent bud damage (%)*			
			Precount	7 DAT	14 DAT	21 DAT
T_1	Cypermethrin (40%) + profenophos (4%) 44 EC	0.04	18.12 (25.19)**	11.12 (19.36)	11.78 (20.07)	19.37 (26.02)
T_2	Quinalphos 25 EC	0.04	21.16 (27.37)	15.18 (22.94)	23.93 (29.28)	24.54 (29.65)
T_3	Dipel 8L	0.1	22.35 (28.16)	15.38 (22.88)	20.42 (26.84)	25.44 (30.19)
T_4	Dipel 8L	0.2	15.83 (23.43)	13.62 (21.55)	19.33 (26.07)	20.86 (27.16)
T_5	Emamectin benzoate 5 SG	0.002	15.10 (22.87)	12.08 (20.14)	12.07 (20.33)	20.42 (26.86)
T_6	Neem insecticide (10000 ppm) neemazal	0.2	17.55 (24.62)	16.47 (23.81)	24.08 (29.36)	33.28 (35.20)
T_7	Carbaryl 50 WP	1.0	15.14 (22.77)	15.48 (23.16)	23.25 (28.82)	25.71 (30.46)
T_8	Serni plant extract	10	17.07 (23.58)	18.93 (25.77)	28.27 (32.10)	33.60 (35.41)
T_9	Control	--	19.31 (26.06)	25.10 (30.02)	35.97 (36.85)	41.47 (40.08)
	S.E. ±		1.32	1.54	0.70	1.30
	C.D. at 5%		3.94	4.60	2.10	3.89
			N.S.	--	--	--

* Mean of three replications.

**Figures in parenthesis are arc sin value

DAT – Days after treatment.

The observations on per cent bud damage at 14 DAT indicated that all the treatments were significantly superior over control. The lowest per cent bud damage was recorded in treatment with cypermethrin + profenophos followed by emamectin benzoate, 0.2 per cent dipel, 0.1 per cent dipel. While, treatments with carbaryl, quinalphos, 10000 ppm neem insecticide and 10 per cent serni plant extract followed in the order.

The first spray observations were continued upto 21 DAT. All treatments eventhough were significantly superior over control, there was increase in per cent bud damage in all treatments except cypermethrin + profenophos, emamectin benzoate and dipel 0.2 per cent where, the per cent bud damage was considerably at low level.

The present findings are in conformity with those of Decri and Hadi (2000) who reported 0.05 per cent cypermethrin was effective against *M. vitrata* and with those made by Akhauri and Yadav (2002) who found 0.01 per cent fenvalerate as the best treatment giving maximum reduction in pod damage.

4.2.2 Per cent bud and pod damage - second spray (at 50 per cent flowering)

At the time of second spraying, the buds as well as pods were present in the field. Thus, the observations on per cent pod damage were also recorded at 7, 14 and 21 days after spraying at 50 per cent flowering. and presented in Table 14.

4.2.2 a. Per cent bud damage at second spray (at 50 per cent flowering)

The first observation on per cent bud damage after second spray was recorded 7 DAT (Fig. 2a). Here, all treatments were significantly superior over control. Emamectin benzoate and cypermethrin + profenophos were significantly superior over all other treatments. The efficacy of treatment followed in the order was emamectin benzoate, cypermethrin + profenophos, 10000 ppm neem insecticide, serni plant extract 0.2 per cent dipel, 0.1 per cent dipel, quinalphos, carbaryl and control.

Table 14. Per cent bud and pod damage at second spray (50 % flowering)

Sr. No.	Treatment	Per cent bud damage (%)*			Per cent pod damage (%)*		
		7 DAT	14 DAT	21 DAT	7 DAT	14 DAT	21 DAT
1.	T_1	13.78 (21.45) **	10.70 (18.01)	14.26 (22.16)	8.19 (16.85)**	7.46 (15.79)	9.49 (17.93)
2.	T_2	21.23 (27.41)	15.50 (23.18)	20.96 (27.22)	16.77 (23.48)	12.11 (20.24)	12.05 (20.21)
3.	T_3	19.77 (26.37)	16.22 (23.74)	21.82 (27.84)	17.43 (24.57)	14.09 (22.04)	19.82 (26.37)
4.	T_4	19.09 (25.80)	14.99 (22.76)	20.98 (27.15)	15.08 (22.85)	11.10 (19.46)	16.13 (23.55)
5.	T_5	12.45 (20.64)	10.42 (18.83)	14.94 (22.72)	8.98 (17.42)	7.86 (16.27)	10.67 (19.05)
6.	T_6	17.24 (24.52)	15.55 (23.21)	26.48 (30.96)	19.75 (26.26)	10.99 (18.34)	20.80 (27.13)
7.	T_7	21.95 (27.93)	18.89 (25.75)	26.36 (30.87)	19.06 (25.82)	14.46 (22.18)	17.23 (24.51)
8.	T_8	17.41 (24.64)	22.40 (28.24)	26.94 (31.24)	16.56 (23.78)	12.61 (20.78)	22.72 (28.37)
9.	T_9	35.62 (36.64)	35.99 (36.85)	36.44 (37.12)	23.69 (28.09)	16.09 (23.65)	25.23 (30.14)
	S.E. ±	1.08	0.75	1.09	1.16	0.80	1.23
	C.D. at 5%	3.23	2.23	3.26	3.47	2.41	3.69
	C.D. at 1%	4.45	3.08	4.50	4.78	3.32	5.08

* Mean of three replications.

**Figures in parenthesis are arc sin value

DAT – Days after treatment.

All treatments were significantly superior over control at 14 DAT. There were two treatments *viz*., cypermethrin + profenophos and emamectin benzoate superior over all other treatments. The effectiveness of all other treatments followed in the order was 0.2 per cent dipel, quinalphos, 10000 ppm neem insecticide, 0.1 per cent dipel which were at par with each other. While treatment with carbaryl, serni plant extract were placed at 7th and 8th followed by control.

The observations were recorded at 21 DAT. All treatments were significantly superior over control. The superiority of treatment followed in the order was cypermethrin + profenophos, emamectin benzoate, 0.2 per cent dipel, quinalphos, 0.1 per cent dipel, carbaryl, 10000 ppm neem insecticide then serni plant extract and control. However, treatments except cypermethrin + profenophos and emamectin benzoate could not maintain their efficiency for a longer period as indicated by increase in the per cent bud damage at 21 DAT. This clearly indicated that the efficiency of treatments except cypermethrin + profenophos and emamectin benzoate remains upto 14 DAT.

The present findings are in conformity with those made by Sharma *et al*. (1999) who reported *B. thuringiensis* play an important role in regulating *M. vitrata* under field conditions and with those made by Decri and Hadi (2000) who found 0.05 per cent cypermethrin (synthetic pyrethroid) was effective against *M. vitrata* in cowpea.

4.2.2 b. Per cent pod damage-second spray (at 50 per cent flowering)

The data were recorded at 7, 14 and 21 DAT. At the time of second spray, tender pods were preset in the field. Thus, the observations on per cent pod damage were also recorded and presented in Table 14 and Fig. 2(b).

The results revealed that at 7 DAT, the treatments *viz*., cypermethrin + profenophos and emamectin benzoate were at par with each other and significantly superior over rest of the treatments. The other treatments followed in the order of effectiveness were 0.2 per cent dipel, quinalphos, serni plant extract, 0.1 per cent dipel, carbaryl and 10000 ppm neem insecticide. All treatments were significantly superior over control.

At 14 DAT, the treatments cypermethrin + prophenophos and emamectin benzoate proved to be the most effective and at par with each other. The other treatments followed in the order, 10000 ppm neem insecticide, 0.2 per cent dipel, quinalphos, serni plant extract, 0.1 per cent dipel, carbaryl and control. All treatments were significantly superior over control.

The observations on per cent pod damage were continued on 21 DAT. The treatments cypermethrin + profenophos, emamectin benzoate and quinalphos were found best and at par with each other.

The treatments 0.2 per cent dipel, carbaryl, 0.1 per cent dipel and neem insecticide 10000 ppm were next and superior over control. The serni plant extract was ineffective and at par with control.

4.2.3 Per cent pod damage third spray (at 50 per cent pod filling)

The data were recorded at 7, 14 and 21 DAT. At the time of third spray, the pods were formed in the field and not much flowering remained in the field. Thus, the observations only on pod damage were recorded and presented in Table 15 and Fig. 3.

The results revealed that at 7 DAT the treatments *viz*., emamectin benzoate, cypermethrin + profenophos, 0.2 per cent dipel, 0.1 per cent dipel were at par with each other and significantly superior over rest of the treatments in protecting pod damage. The rest of the treatments failed to check the pod damage as were seen at par with control.

At 14 DAT, the treatments *viz*., emamectin benzoate, cypermethrin + profenophos, 0.2 per cent dipel, quinalphos, 0.1 per cent dipel, 10000 ppm neem insecticide and carbaryl were at par with each other and significantly superior over rest of the treatments i.e. serni plant extract and control which were ineffective.

Table 15. Per cent pod damage at third spray (50 % pod filling)

Tr. No.	Treatment	Per cent pod damage (%)*			Yield (q/ha)
		7 DAT	14 DAT	21 DAT	
1.	T_1	5.96 (14.12)	5.69 (14.40)	6.61 (14.89)	8.42
2.	T_2	8.55 (16.83)	7.08 (15.51)	9.91 (18.30)	8.09
3.	T_3	7.15 (15.48)	7.26 (15.51)	12.22 (20.43)	6.36
4.	T_4	6.52 (14.79)	6.20 (14.40)	11.58 (19.87)	7.57
5.	T_5	5.75 (13.83)	5.79 (14.01)	6.94 (15.27)	8.29
6.	T_6	8.53 (16.96)	7.36 (16.02)	12.43 (20.62)	8.11
7.	T_7	8.59 (16.94)	7.92 (16.44)	12.39 (20.58)	7.46
8.	T_8	8.42 (17.53)	8.96 (17.57)	11.63 (19.92)	6.84
9.	T_9	10.47 (18.88)	10.44 (18.82)	14.95 (22.70)	6.35
	S.E. ±	1.00	0.93	0.74	
	C.D. at 5%	2.98	2.80	2.21	

* Mean of three replications.

**Figures in parenthesis are arc sin value

DAT – Days after treatment.

However, at 21 DAT, only two treatments remained effective to check the pod damage, which were cypermethrin + profenophos and emamectin benzoate. In these two treatments, there was no much increase in per cent pod damage as reflected in the observations. The remaining treatments *viz*., quinalphos, 0.2 per cent dipel, serni plant extract and 0.1 per cent dipel, even though superior over control, were not much promising as significant increase in the per cent pod damage was evidenced in all of them.

The two treatments *viz*., carbaryl and 10000 ppm neem insecticide were also non-productive as were at par with control. The effectiveness of different treatments was reflected in the yield obtained from the treated plots. The maximum yield obtained from the plot treated with cypermethrin + profenophos (8.42 q/ha) followed by emamectin benzoate (8.29 q/ha).

The above results clearly indicated that cypermethrin + profenophos and emamectin benzoate were the best and only significant treatments which kept their prolonged effect upto 21 DAT.

The effectiveness of these two treatments not only was seen in protecting pod damage but also reflected at 1st spraying i.e. at initiation of flowering, then at 50 per cent flowering and at last 50 per cent pod filling stage. Thus, these two treatments emerged as over all most effective in management of *M. vitrata* in the field.

4.3 To study the knock down effect of different insecticides against *M. vitrata*

The larval mortality count was taken in the field 72 hours after the treatment. The number of dead larva out of total collected was converted in per cent mortality. The data are presented in Table 16 and graphically in Fig. 4.

The results indicated that all the insecticides tested were significantly superior over control in reducing larval population at 72 hours after each spray *viz*., at initiation of flowering, 50 per cent flowering and 50 per cent pod filling stage.

The post treatment observations recorded at 72 hours after application of the insecticides revealed that the treatments with cypermethrin + profenophos and emamectin benzoate were significantly superior over remaining treatments and at par with each other.

Table 16. Per cent Larval mortality of *M. vitrata* (72 hrs. after treatment)

Tr. No.	Treatment	Conc. (%)	Per cent larval mortality *		
			Ist spray	IInd spray	IIIrd spray
T_1	Cypermethrin + profenophos	0.04	56.00* (48.45)**	60.00* (50.79)**	68.00* (55.61)**
T_2	Quinalphos	0.04	34.66 (36.05)	41.33 (40.05)	43.33 (41.16)
T_3	Dipel	0.1	38.00 938.00)	31.33 (33.97)	42.00 (40.26)
T_4	Dipel	0.2	40.00 (39.23)	45.33 (42.27)	39.33 (38.82)
T_5	Emamectin benzoate	0.002	50.00 (45.00)	51.33 (45.80)	62.00 (52.42)
T_6	Neem insecticide 10000 ppm	0.2	28.00 (31.78)	34.00 (35.42)	27.33 (31.45)
T_7	Carbaryl	1.0	10.00 (18.37)	18.00 (24.73)	20.00 (26.49)
T_8	Serni plant extract	10.0	31.33 (34.01)	35.33 (36.44)	38.66 (38.42)
T_9	Control	--	3.33 (10.40)	6.00 (14.04)	7.22 (15.79)
		S.E. ±	1.47	2.74	2.25
		C.D. at 5%	4.41	8.23	6.73

* Mean of three replications.

**Figures in parenthesis are arc sin value

The remaining treatments were observed least effective. However, the order of efficacy at first spray was cypermethrin + profenophos, emamectin benzoate, 0.2 per cent dipel, 0.1 per cent dipel, quinalphos, serni plant extract, neem insecticide (10000 ppm), carbaryl followed by control.

While at the time of second spray, the efficacy of insecticides was in the order of cypermethrin + profenophos at par with ememectin benzoate and other treatments followed in the order 0.2 per cent dipel, quinalphos, serni plant extract, neem insecticide (10000 ppm), 0.1 per cent dipel, carbaryl and control.

At the time of third spray, post treatment observations revealed that cypermethrin + profenophos and emamectin benzoate were proved most effective and at par over all other treatments. Further, the treatments quinalphos, 0.2 per cent dipel, 0.1 per cent dipel, serni plant extract were at par with each other. These were followed by neem insecticide (10000 ppm) and carbaryl which were also at par. All the treatments proved significantly superior over control.

The effectiveness of cypermethrin + profenophos and emamectin benzoate proved best may be because cypermethrin + profenophos is a combination product of a synthetic pyrethroid and a systemic insecticide in which synthetic pyrethroid i.e. cypermethrin has a quick knock down action. Similarly profenophos has a translaminar movement which might accelerated the mortality effect. In case of emamectin benzoate, it is a metabolic product derived from actinomycets. It is a strong stomach poison with quick knock down effect. It has a little potential to move across the tissue of plant i.e. translaminar action which have increased its potential very effectively.

CHAPTER II

REVIEW OF LITERATURE

The bean pod borer, *Maruca vitrata* (Fab.) is one of the important pest infesting dolichos bean and all other pulses. The available literature on various aspects of bionomics and management of *M. vitrata* is reviewed and presented here.

2.1 Bionomics of *M. vitrata*

Taylor (1967) studied the biology of *M. vitrata* on cowpea and reported that the preoviposition period was 5 to 7 days and female moth deposited 8 to 140 eggs during its lifespan and in the masses of 2-16. He also found that larva passed through five instars and larval, prepupal and pupal period ranged 8 to 13, 1 to 2 and 8 to 13 days, respectively.

Vishakantaiah and Jagadeesh Babu (1980) studied life history of *Maruca testulalis* on tur. They found the incubation period of 3.13 days and larval period of 12.65 days with prepupal and pupal period of 2.05 and 8.73 days, respectively and life cycle completed within 26.53 days. The eggs colour was pale yellowish white and measured 0.58 mm and 0.38 mm in length and width. They also observed that, the five larval instars measured 3.2 mm, 4.37 mm, 9.0 mm, 11.5 mm and 15.66 mm in length while 0.70 mm, 0.75 mm, 1.9 mm, 2.56 mm and 3.0 mm in width, respectively.

The adult wing expanse of 26.5 mm was recorded. The sex ratio was 1:0.42. The mating observed 2-3 days after adult emergence and 1-2 days after that egg laying started which continued till 6-7 days.

Ramasubramanian and Babu (1988) studied the biology of *M. vitrata* on different host plants *viz.*, hyacinth bean, pigeonpea and cowpea and recorded preoviposition period of 2.7, 1.7 and 1.7 days, respectively. They reported oviposition period of female moth as 3.9 days in hyacinth bean and pigeonpea and 3.6 days in cowpea with 1 to 3 days mating period. The larva passed through five instars with a period of 12.9, 13.32 and 13.66 days on hyacinth bean, pigeonpea and cowpea, respectively. The prepupal and pupal period was 1.46, 1.52 and 1.8 days and 7.48, 6.36 and 6.9 days, when reared on hyacinth bean, pigeonpea and cowpea, respectively. They reported that the adult longevity of male moth was higher in pigeonpea and hyacinth bean with 6.1 days and 5.9 days in cowpea. In female, the longevity was 10.0, 8.5 and 8.6 days in hyacinth bean, pigeonpea and cowpea, respectively.

Atwal and Dhaliwal (1997) reported that female laid eggs on buds or on tender pods singly. Egg, larval and pupal period lasted for 5 to 6, 15 to 20, 8 to 10 days, respectively. An adult lived for 5 to 8 days.

Sharma and Frenzmann (2000) noticed that the post embryonic development was completed in 20.6 to 22.6 days.

ChiChung and WuKang (2001) studied the emergence, mating and oviposition of bean pod borer in laboratory and reported that the adults emerged throughout the day but approximately 55 per cent of females and 31 per cent males emerged at night. The emergence peaked at 3 to 5 and 13 to 15 hours for females and males, respectively with sex ratio 1:0.49. The premating, preoviposition and oviposition periods of female were 3.8, 4.5 and 3.4 days, respectively. The highest mating frequency occurred in 3 days old female and mating started at 21:00 hours, the period lasted for 44.4 minutes. Female laid 67 eggs in her lifespan of 9.0 ± 2.6 days while male lived for 7.9 ± 2.0 days.

Chinnabhai *et al*. (2002) studied the biology of *M. vitrata* on blackgram and green gram. The larva webbed the leaves, flower buds and shoot tips with silken threads. The preoviposition, oviposition, postoviposition, incubation, larval (five instars), pupal periods, adult longevity of male and female and total lifecycle recorded were 1.56, 3.53, 1.03, 3.03, 10.35, 6.02, 4.77 and 6.09 and 25.38 days, respectively and the sex ratio (male : female) and fecundity recorded were 1:1.3 and 60.48 eggs per day per female when reared on black gram.

When they studied the biology of *M. vitrata* on green gram, the preoviposition, oviposition, postoviposition and incubation period recorded were 1.71, 3.53, 1.71 and 3.14 days, respectively. The larval, pupal periods, adult longevity of male and female and total lifecycle recorded were 11.12, 6.56, 5.67 and 6.77 and 26.78 days, respectively. The sex ratio and fecundity recorded were 1:1.3 and 55.45 eggs per day per female.

David (2002) reported that the moth has a white cross band on dark brown forewings and dark border on white hind wings. The larva has a brown head and short dark hairs on black warts on the body.

2.2 Management of Bean Pod Borer *M. vitrata*

Subba Rao *et al*. (1972) tested carbaryl, DDT, BHC, endrin, trichlorvas, carbophenothion and imidan against pod borers of field bean and concluded that 10 per cent carbaryl and 5 per cent DDT dust gave minimum infestation.

Dina (1977) found that two applications of monocrotophos 0.07 per cent at flowering were adequate to reduce the damage caused by *Maruca vitrata* (F.) in cowpea under Nigeria conditions in the field. According to Dina (1981) monocrotophos 0.08 per cent gave the best result in terms of reduction of pod damage due to *M. testulalis* and it has increased the yield of cowpea under Nigeria conditions.

Karel and Schoonhoven (1986) conducted a field trial on use of chemical and microbial insecticides against pests of common beans, *Phaseolus vulgaris* L. and reported that the two applications of *Bacillus thuringiensis* (Bt.) during the post flowering growth stage of bean plants controlled the larvae of pod borer, *M. testulalis* and *Heliothis armigera* (Hub.) as effectively as two applications of lindane 20 EC @ 2 g a.i. per lit water and carbaryl 85 WP 2.25 g a.i. per lit water over the same period.

Mhase *et al*. (1987) studied the efficacy of different insecticides against pod borer complex, *H. armigera*, *Exelastic atmosa* (Wlsm.) and *Melangromyza obtusa* (Mall.) on pigeonpea. They reported that one application of 0.05 per cent endosulfan spray at pod formation stage in T-21 variety and two applications at 15 days interval starting from pod formation stage in C-11 variety proved to be the most effective by reducing per cent pod damage.

In a field trial, it was found that decamethrin 0.004 per cent, quinalphos 0.05 per cent, cypermethrin 0.004 per cent and fenvalerate 0.04 per cent proved effective against *M. testulalis* on cowpea (Anonymous, 1987).

Bhat *et al*. (1988) evaluated various insecticides against *M. testulalis* on cowpea and observed the lowest pod borer incidence of 29.97 per cent in the plots treated with monocrotophos 0.02 per cent followed by neem seed extract 4 per cent (42.34%), phosalone 0.2 per cent (43.06%) and quinalphos 0.01 per cent (44.83%) with grain yields of 5.75, 4.79, 4.70 and 4.14 q ha^{-1}, respectively.

Lalsangi (1988) revealed that quinalphos 0.05 per cent gave the best protection against *M. testulalis* on cowpea in the field.

Patel (1997) revealed that cypermethrin 0.009 per cent, chlorpyriphos 0.04 per cent, alphamethrin 0.005 per cent, quinalphos 0.05 per cent and monocrotophos 0.04 per cent were highly effective for the control of *M. testulalis* in the field.

Decri and Hadi (2000) found that cypermethrin, dimethoate and monocrotophos each at 0.05 per cent concentration were effective against the pests of cowpea including *M. vitrata*.

Oparaeke *et al*. (2000) conducted a field trial to evaluate the efficacy of extracts of garlic (*A. sativum*) bulb and African nut-meg (*Monodora myristica*) seed each at 10 per cent concentration against the pests of cowpea. These both recorded minimum pod damage caused by *M. vitrata* and pod sucking Hemipterans.

Amesh and Ogunwolu (2000) conducted a field trial to determine the efficacy of aqueous extracts of *Annona senegalensis* root bark, *Azadirachta indica* seeds, *Clausena anisata* leaves and root bark applied three times at 5 per cent concentration at 10 days interval against cowpea pests. These all extracts reduced the pod damage by *M. vitrata* but the efficacy of cyhalothrin (Karate) @ 20 gm a.i. ha^{-1} was found better than aqueous plant extracts.

Sahu and Suapali (2000) tried different synthetic insecticides and plant products against pod borers in pigeonpea. The observations indicated that endosulfan 35 EC at 0.5 kg a.i. ha^{-1} was the most effective treatment with the pod damage 9.00 to 12.99 per cent, seed damage 5.93 to 7.30 per cent and seed loss 4.9 to 6.87 per cent followed by acephate and triozophos each at 0.5 kg a.i. ha^{-1}.

Reddy *et al*. (2001) reported that the efficacy of the insecticides can be increased by manipulating the timing and frequency of their application in pigeonpea. The treatments involved the spray of fenvalerate @ 0.02 per cent at different stages of crop growth. The treatment with three sprays (at flower initiation, 50 per cent flowering and 50 per cent pod filling stage) and two spray treatment (at 50 per cent flowering and 50 per cent pod filling stage) were most effective against pod borer complex *viz.*, *H. armigera, M. vitrata, E. atmosa* and *M. obtusa*.

Reddy *et al*. (2001) tested some insecticides, biopesticides and their combinations against pod borers in pigeonpea. A study on bioefficacy of two synthetic pyrethroids *viz.*, deltamethrin and fenvalerate, two biopesticides *viz.*, *Bacillus thuringiensis* (Dipel) and *Beauveria bassiana* (Dispel) and their judicious combinations revealed that the combination of dipel with deltamethrin (0.004% or 0.002%) was most effective in reducing the damage due to pod borers. These treatments also gave highest net profit and were rated as most cost effective management strategy.

Chandrakar and Shrivastava (2001) conducted a field trial to compare the efficacy of dipel 8 EL @ 500 ml ha^{-1}, NSKE 2 per cent and monocrotophos 36 EC @ 750 ml ha^{-1}, sprayed singly and in combination at 30, 45 and 60 days after sowing to control pod borer complex i.e. *H. armigera*, *M. vitrata* of urd bean. It was effectively controlled by monocrotophos followed by dipel during 30 and 45 days after sowing, respectively.

Singh and Singh (2001) conducted a field trial during *Kharif* and found that decamethrin (0.004%), methomyl (0.1%) and fenvalerate (0.02%) were the most effective treatments in protecting pigeonpea crop from pod borers *viz.*, *H. armigera, M. testulalis, E. atomosa* and pod fly *M. obtusa*.

Mohapatra and Srivastava (2002) conducted a field trial to study the efficacy of chemical and biorational insecticides against the incidence of legume pod borer, *M. vitrata* in pigeonpea. At 50 per cent flowering first spraying was given and other two sprays were given at 10 days interval. The spraying of betacyfluthrin 25 SC @ 18.75 g a.i. ha^{-1}, lambda cyhalothrin 5 EC @ 25 g a.i. ha^{-1} attributed to higher yield and less larval incidence. Among biorationals, methoxyfenocide 2 F @ 30 g a.i. ha^{-1}, lufeneron 5 EC @ 60 g a.i. ha^{-1} and Bt @ 1 kg a.i. ha^{-1} provided good protection and significantly lesser incidence of *M. vitrata* and higher yield over control.

Akhuri and Yadav (2002) found fenvalerate (0.01%) as the best treatment giving maximum reduction in pod damage (73.7%) and increase in grain yield (78.3%) of pigeonpea. They also reported that endosulfan (0.07%) followed by fenvalerate (0.01%), neem oil (2.0%) and chlorpyriphos (0.04%) proved superior amongst the tested ones.

Ekesi *et al*. (2002) recorded that the spray application of hyphomycetes fungus at two concentrations 1×10^6 and 1×10^8 conidia ml^{-1} significantly reduce the number of emerging borers and the percentage of damaged pod and seeds.

Minja *et al*. (2002) noticed that the pigeonpea plots sprayed with dimethoate at 0.05 per cent a.i. and *Tephrosia vogelii* leaf extract showed significant reduction in seed damage at early and late pod formation stages and at pod maturity againsts the pests *viz*., *H. armigera, M. vitrata, E. zinckenella* and *Lampides* sp.

Owolade *et al*. (2004) found that the aqueous leaf extract of papaya proved effective by reducing the incidence and severity of *M. vitrata* with high yield in pigeonpea.

Bhoyar *et al*. (2004) conducted a trial in pigeonpea plot for the management of pod borer complex. The treatment of spinosad (25 EC) and endosulfan (35 EC) 0.07 per cent were the most promising treatments in terms of least mean pod damage of 13.51 and 20.41 per cent, respectively.

The insecticidal efficacy of *Gmelina arborea* L. product extract was sprayed for suitability in controlling the legume pod borer, *M. vitrata* in cowpea field. The field trial showed that extract of *G. arborea* fruit at 10 per cent (w/v) caused impressive reduction of pest and protected the pods from serious damage (Oparaeke, 2005).

2.3 To study the knock down effect of different insecticides against *M. vitrata*

Karel (1985) evaluated that the number of larva of *M. vitrata* collected from flowers of common bean, *Phaseolus vulgaris* L. were significantly lower in the plots treated with endosulfan, carbaryl and lindane.

Ivbijaro and Bolaji (1990) reported that cypermethrin + dimethoate was the most effective treatment for reducing the population densities of *M. testulalis* larvae, followed by foliar treatments with *P. guineense* and *A. indica* extracts.

Manjula and Padmavathanma (1996) conducted a field trial and reported that the maximum reduction in the larval population of *M. vitrata* was recorded with the treatment of *Bacillus thuringinensis* (1×10^7 spore per ml) + monocrotophos (0.025%).

Sharma *et al*. (1999) reported that the pathogens such as *Bacillus thuringiensis*, *Nosema* sp. and *Aspergillus* sp. played important role in regulating *M. vitrata* population.

Machuka *et al*. (1999) reported that *Listera ovata agglutinin* (LOA) (Orchidaceae) and *Gealanthus nivalis* (Amaryllidaceae) agglutinin were effective against *Maruca* pod borer larva causing a larval mortality and feeding inhibition above 60 per cent by the most active lectin LOA under laboratory conditions.

Ekesi (2000) studied the effect of volatiles and aqueous extracts of black pepper, neem seed, garlic bulb and onion bulb under laboratory conditions. Volatiles of onion bulb and neem seed had no effect on egg hatch. When aqueous extracts of the plant materials were tested at 5, 10 and 15 per cent, extracts of black pepper, neem seed and garlic bulb caused severe reduction in egg hatch, with black pepper and garlic bulb providing the highest reduction at all concentrations tested in *M. vitrata*.

Lakshmi *et al*. (2002) recorded the maximum per cent reduction of *M. vitrata* larval population by applying spinosad 0.005 per cent when the observations taken at 2, 5 and 8 days after spraying in urd bean.

Tokare (2005) conducted the laboratory experiment to evaluate the efficacy of some insecticides against *Nephopteryx* sp. in cashew nut. The observations recorded 7 days after application indicated that 0.07 per cent polytrin-C (i.e. cypermethrin + profenophos 44 EC), 0.002 per cent proclaim (i.e. emamectin benzoate 5 SG), 0.05 per cent quinalphos showed 100 per cent larval mortality under laboratory conditions. He obtained the same results after 15 days of treatment.

CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

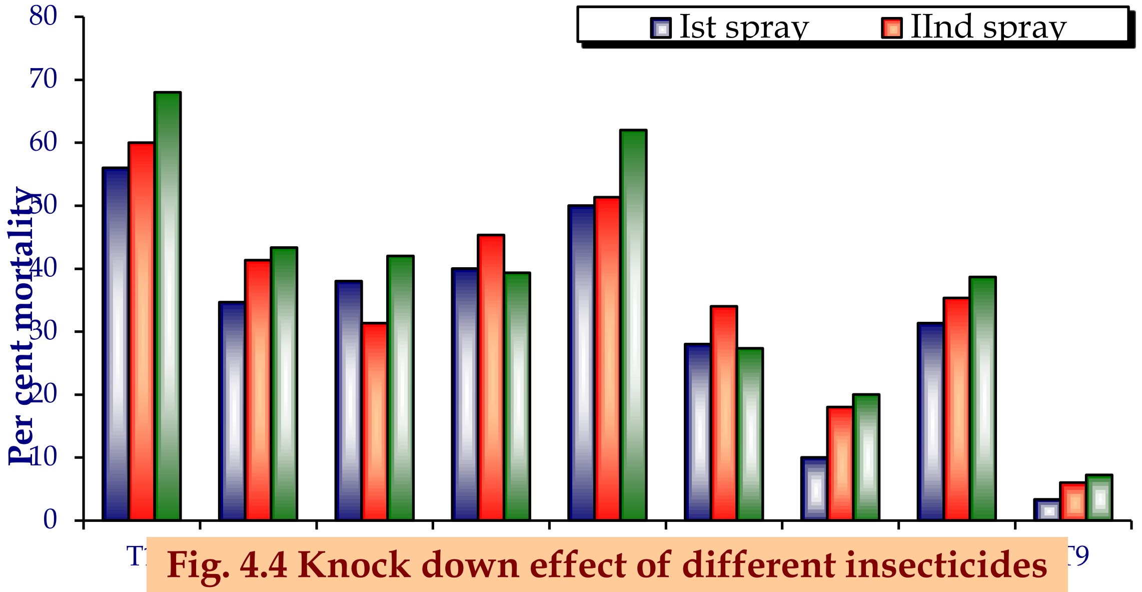

Fig. 4.4 Knock down effect of different insecticides (per cent larval mortality) against *M. vitrata* (72 hrs. after treatment)

LITERATURE CITED

*Anonymous (1987). Annual Research Report, NARP, Pulse Research Station, GAU, Junagadh.

Akhauri, R.K. and Yadav, R.P. (2002). Population dynamics, damage pattern and management of spotted borer (*Maruca testulalis* Geyer.) in early pigeonpea under North Bihar conditions. *J. Ent. Res.*, **26**(2): 179-182.

Ali, M. and ShivKumar (2005). Pulses - Yet to see a breakthrough. *The Hindu Survey of Ind. Agri*. Jan., 2005. pp. 54-56.

*Amesh, S.A. and Ogunwolu, E.O. (2000). Comparative effectiveness of aqueous pant extracts and lambda cyhalothrin in controlling post flowering insect pests of cowpea in the Southern Guinea Savanna of Nigeria. Entomology in nation building, the Nigerian experience. The proceedings of ESN. 30th Annual Conference held at Kano, Nigeria. 175-180.

Atwal, A.S. and Dhaliwal, G.S. (1997). Pess of pulse crop 'Agricultural Pests of South Asia and Their Management' Kalyani Publishers.

Bednarski, W.; Tomasik, J. and Piatkowsha (1985). Processing, suitability and nutritive value of field bean seeds after germination. *J. Sci. Fd. Sci. Agric.*, **36**: 745-751.

Bhat, N.S.; Raju, G.T.T.; Manjunatha, M.; Nagabhushana, G.G. and Deshpande, V.P. (1988). Chemical control of cowpea pod borers. *Indian J. Plant Prot.*, **16**(2): 197-200.

Bhoyar, A.S.; Siddhabhatti, R.M.l; Wadaskar, R.M. and Khan, M.I. (2004). Studies on seasonal incidence and biointensive management of pigeonpea pod borer complex. *Pestology*, **28**(9): 32-36.

Chandrakar, S.K. and Shrivastava, S.K. (2001). Relevance of pesticidal spray at various crop stages to control pod borer complex in urdbean. *Environment and Ecology*, **19**(2): 466-468.

ChiChung, H. and Wukang, P. (2001). Emergence, mating and oviposition of the bean pod borer, *Maruca vitrata* (F.) (Lepidoptera pyralidae). *Formosan Entomologist*, **21**(1): 37-45.

Chinnabhai, C.; Venkataiah, M. and Reddy, M.V. (2002). Biology of spotted pod borer *Maruca vitrata* (Gyer.) (Pyralidae : Lepidoptera) on black gram and greengram. *Journal of Applied Zoological Researches*, **3**(2/3): 149-151.

David, V.R. (2002). Pests of pulses 'A Text Book of Applied Entomology' Vol. **II**.

*Decri, M.M. and Hadi, H.M. (2000). Field evaluation and economics of some insecticides against the major insect pests of cowpea (*Vigna unguiculata* Walp) in Bauchi, Nigeria, Entomology in Nation building, the Nigerian experience. The proceedings of ESN. 30th Annual Conference held at Kano, Nigeria. 113-118.

Dina, S.O. (1977). Effects of monocrotophos on insect damage and yield of cowpea (*Vigna unguiculata*) in South Nigeria. *Experimental Agriculture*, **13**(2): 155-159.

Dina, S.O. (1981). Response of three cowpea varieties to organophosphorus insecticides. *Trop. Grain Legume Bull.*, **23**: 6-10.

Ekesi, S. (2000). Effect of volatiles and crude extracts of different plant materials on egg viability of *Maruca vitrata* and *Clavigralla tomentosicollis*. *Phytoparasitica,* **28**(4): 305-310.

Ekesi, S.; Adamu, R.S. and Maniania, M.K. (2002). Ovicidal activity of entomophathogenic hyphomycetes to the legume pod borer, *Maruca vitrata* and the pod sucking bug, *Clavigralla tomentosicollis*. *Crop Protection*, **21**(7): 589-595.

Ivbijara, M.F. and Bolji, O.O. (1990). Effects of cypermethrin + dimethoate and extracts of piper guineese and azadirachtin indica on the pests and yields of cowpea *Vigna unguiculata*. *J. Agril. Sci*., **115**(2): 227-231.

Kadwe, R.S.; Thakare, K.K. and Badhe, .N. (1974). A note on the protein content and mineral composition of twenty five varieties of pulses. *The Indian J. Nutr. Diet*, **11**: 83-85.

Karel, A.K. (1985). Yield losses from and control of bean pod borer, *Maruca testulalis* (Lepidoptera : Pyralidae) and *Heliothis armigera* (Lepidoptera : Coctuidae). **78**: 1323-1326.

Karel, A.K. and Schoohoven, A.V. (1986). Use of chemical and microbial insecticide against pests of common bean. *J. of Economic Entomology*, **79**: 1692-1696.

Lakshmi, P.S.P.; Sekhar, P.R. and Rao, R. (2002). Bioefficacy of certain insecticides against spotted pod borer on urdbean. *Indian J. of Pulses Research*, **15**(2): 201-202.

Lalsangi, M.S. (1988). Bionomics, loss estimation and control of the pod borer, *Maruca testulalis* (Geyer) (Lepidoptera : Pyralidae). *Mysore J. Agric. Sci*., **22**(Sullp.) : 187-188.

Machuka, J.; Damme, E.J.M. Van; Peumans, W.J.; Jackai, L.E.N. (1999). Effect of plant lectins on larval development of the legume pod borer, *Maruca vitrata*. *Entomologia Experimentalis et. Applicata*, **93**(2): 179-187.

Manjula, K. and Padmavathamma, K. (1996). Effect of microbial insecticides on the control of *Maruca testulalis* and on the predators of redgram pest complex. *Entomon.*, **21**(3/4): 269-271.

Mhase, N.L.; Kadam, M.V. and Ajri, D.S. (1987). Chemical control of pod borer complex on pigeonpea. *Curr. Res. Report,* **3**(1): 32-38.

*Minja, E.M.; Silim, S.N. and Karuru, O.M. (2002). Efficacy of *Tephrosia vogelii* crude leaf extract on insects feeding on pigeonpea in kenya. International chickpea and pigeonpea-Newsletter, **9**: 49-51.

Mohapatra, S.D. and Srivastava, C.P. (2002). Bioefficacy of chemical and biorational insecticides against incidence of legume pod borer, *Maruca vitrata* (Geyer) in short duration pigeonea. *Indian J. Plant Prot*. **30**(1): 22-25.

Oparaeke (2005). Studies on insecticidal potential of extracts of Gemelina arborea products for control of field pests of cowpea, *Vigna unguiculata* (L.) Walp. The pod borer, *Maruca vitrata* and the coreid bug, *Clavigralla tomentosicollis*. *J. Plant Prot. Res.*, **45**(1): 1-7.

*Oparaeke, A.M.; Dike, M.C. and Amatobi, C.I. (2000). Insecticide potential of extracts of garlic, *Allium sativum* (Linneous) bulb and African nutmeg, *Monodora myristica* (Gaertn.) Dunal seed for insect pest control on cowpea. Entomology in nation building, the Nigerian experience. The proceedings of ESN. 30th Annual Conference held at Kano, Nigeria. 169-174.

*Owolade, O.F.; Alabi, B.S.; Osikanlu, Y.O.K. and Odeyemi, O.O. (2004). On farm evaluation of some plant extracts as biofungicide and bioinsecticide on cowpea in South West Nigeria, **2**(2): 237-240.

Patel, A.G. (1977). Population dynamics, varietal screening and chemical control of pest complex of cowpea (*Vigna unguiculata* Walper) Thesis submitted to Gujrat Agricultural University, Sardar, Krushingar (Unpubl.).

Ramasubramanian, G.V. and Sundara Babu, P.C. (1988). Effect of host plants on some biological aspects of spotted pod borer (*Maruca testulalis*) (Lepidoptera : Pyralidae). *Indian J. Agric. Sci*., **58**: 618-620.

Rathore, Y.S. and Lal, S.S. (1989). Phylogenetic relationship of host plants of *Maruca vitrata*. *Indian J. Pulses Res*. **11**(2): 152-155.

Reddy, C.N.; Singh, J.; Dureja, P. and Singh, V.S. (2001). Effect of time of spray on pod borer management in pigeonpea. *Indian J. Ent*., **63**(2): 130-136.

Reddy, C.N.; Singh, Y.; Dureja, P. and Singh, V.S. (2001). Bioefficacy of insecticides, biopesticides and their combinations against podborers in pigeonpea. *Indian J. Ent*., **63**(2): 137-143.

Sahu, B.K. and Suapali, B. (2000). Efficacy and economics of synthetic insecticides and plant products for the control of pod borers incidence in pigeonpea. **62**(4): 346-352.

Sharma, H.C. and Frenzmann, B.A. (2000). Biology of the legume pod borer, *Maruca vitrata* (Fabricius) and its damage to pigeonpea and Adzuki bean. *Insect Science and its Application*., **20**(2): 99-108.

Sharma, H.C.; Saxena, K.B. and Bhagwat, V.R. (1999). The legume pod borer *Maruca vitrata*. Bionomics and management. ICRISAT Information Bulletin, **55**: 37.

Singh, S.P. and Singh, Y. (2001). Control of pod borers on pigeonpea. *Indian J. Ent*., **63**(3): 356-359.

Subba Rao, P.V.; Rangarajan, A.V. and Azeez Barsha (1972). A note on control of pod borers of field bean. *Sci. Cult*., **38**(4): 204.

Taylor, T.A. (1967). The bionomics of *Maruca testulalis* Geyer (Lepidoptera : Pyralidae), a major pest of cowpea in Nigeria. *W. Afr. Sci. Ass*., **12**: 111-129.

Tokare, J.S. (2005). Bioecology and chemical control of cashew apple and nut borer, *Nephopteryx sp*. (Lepidoptera : Pyralidae).

Vishakantaiah, M. and Jagadeesh Babu, C.S. (1980). Bionomics of Tur Webworm, *Maruca testulalis* Geyer (Lepidoptera : Pyralidae). *Mysore J. Agric. Sci*., **14**: 529-532.

Zhang (1994). *Maruca vitrata* is the new name for *Maruca testulalis* downloaded from website.

---

*Original not seen.

Plate I. Oviposition technique

Plate II. Field trial conducted at C.E.S., Wakawali

Plate III. Egg of *M. vitrata*

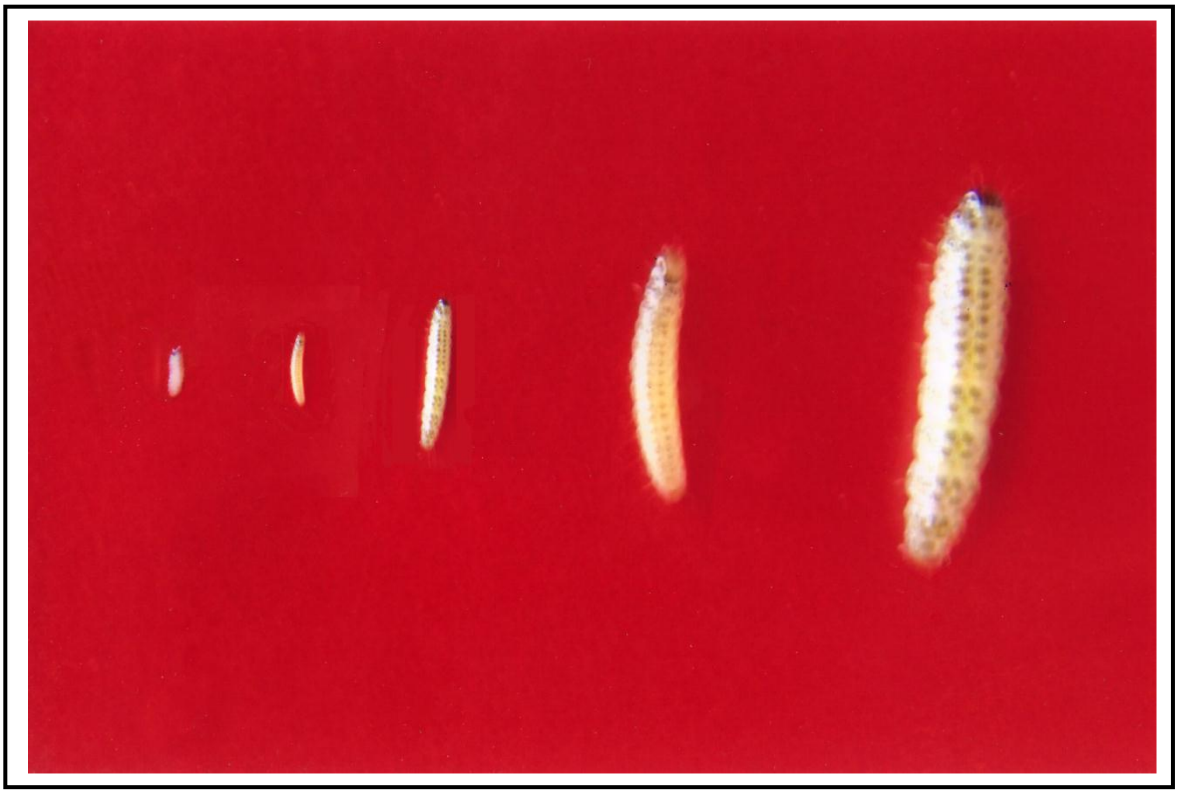

Plate IV. Larval instars of *M. vitrata*

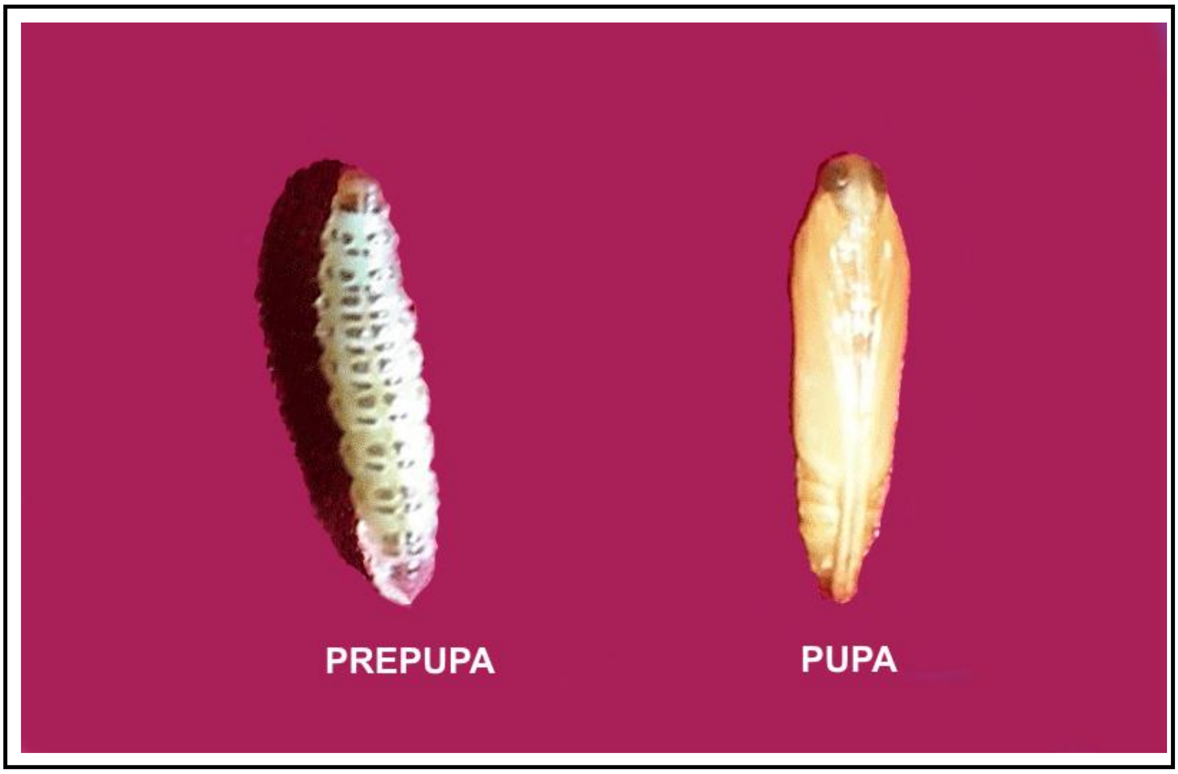

Plate VI. Prepupa and pupa of *M. vitrata*

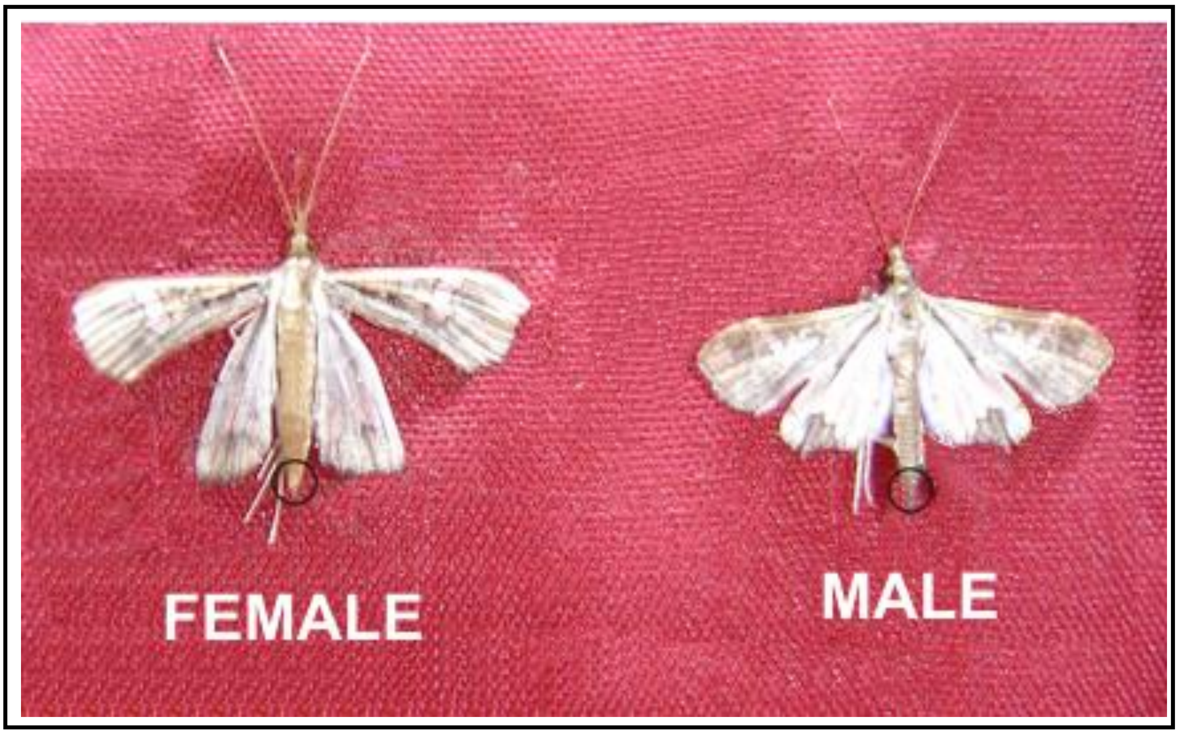

Plate VII. Adults of *M. vitrata*

(A) Webbing of buds

(B) Damaged pods

Plate V. Nature of damage

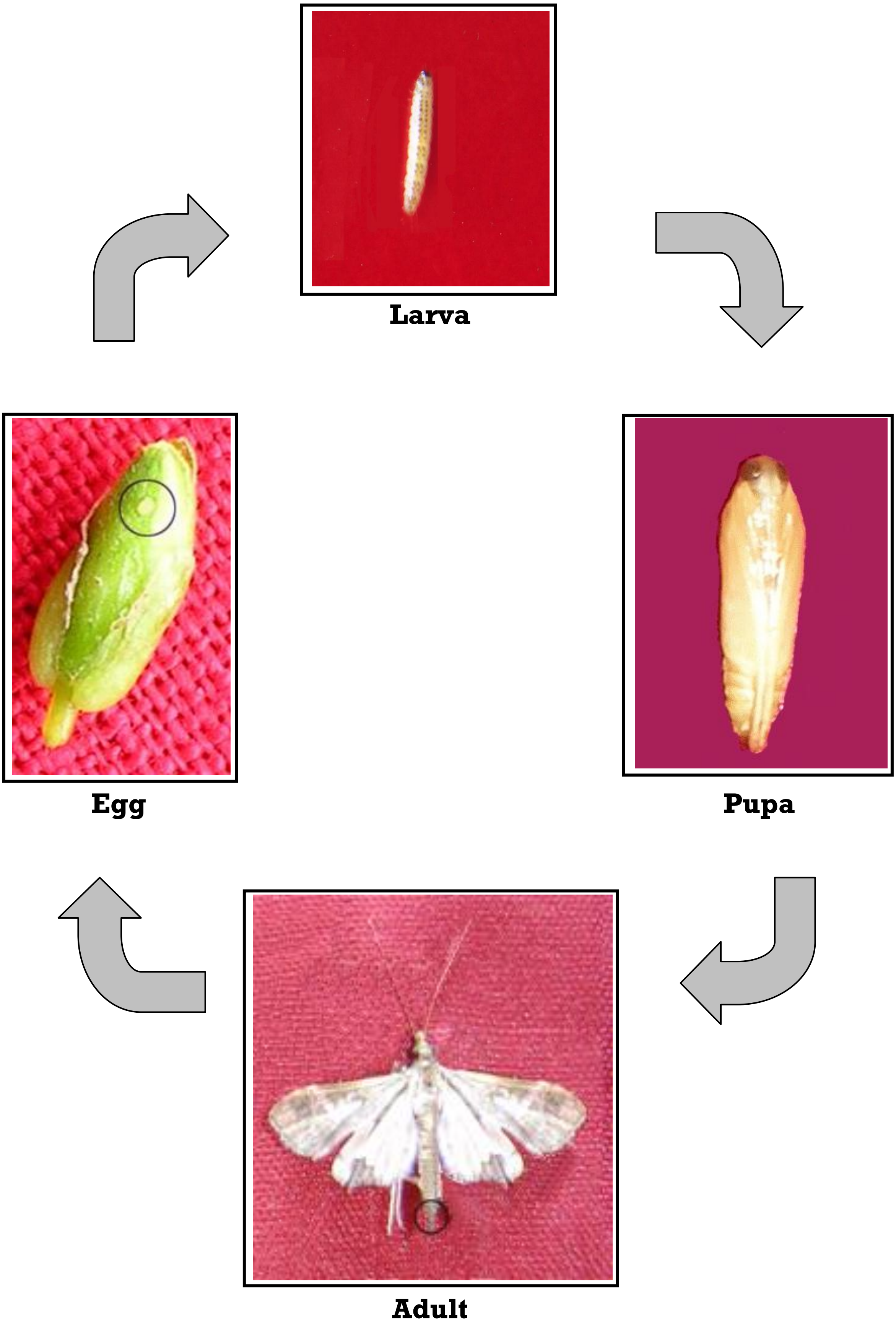

Plate VIII. Life stages of *M. vitrata*

CHAPTER V

SUMMARY AND CONCLUSION

The dolichos bean is important *rabi* crop of Konkan region which is cultivated after harvesting of *kharif* rice. Further, being a legume crop, it has many other advantages like improvement of soil fertility and increasing water holding capacity of soil. It has high nutritive value in human diet. The grain contains protein 21.6 – 27.2 per cent, carbohydrates 56.16 per cent, fats 2-5 per cent, minerals 2.75 per cent and crude fibre 2.8-3.24 per cent on dry weight basis. This crop is attacked by many insect pests during different stages of growth and development.

The bean pod borer, *Maruca vitrata* (Fabricius) is one of the important pod borer causing heavy losses in pod yield. No comprehensive information is available on this pest, particularly under the conditions of Konkan region. In view of the seriousness of the pest and scarcity of information the present investigation entitled, "Bionomics and management of Bean Pod Borer *Maruca vitrata* (Fabricius) (Lepidoptera : Crambidae)" was undertaken with some specific objectives *viz*., bionomics of Bean Pod Borer, management of bean pod borer in the field and to study the knock down effect of insecticides (72 hrs. after treatment). The results of the present studies are summarized below.

Studies on bionomics of the bean pod borer, *M. vitrata* revealed that mating occurred during night hours. The mean preoviposition, oviposition, postoviposition period lasted for 3.30, 3.0, 1.30 days, respectively. Eggs were deposited singly or in groups of 2-3, laid on the buds and tender pods. On an average female laid 60.2 eggs. Freshly laid eggs were oval and yellowish white which changed to white towards hatching. Average length and breadth of an egg was 0.58 and 0.38 mm, respectively. Incubation period ranged from 3 to 3.5 days with an average of 3.24 days. The hatching percentage varied from 60-100 with an average of 80 per cent. The newly hatched larva was very active, pale white. The larva moulted four times and passed through five larval instars. The average duration of first, second, third, fourth and fifth instars larva was 2.3, 2.2, 2.1, 2.1, 3.30 days, respectively. A total larval period varied from 11-14 days with an average of 12 days. The full grown larva was deep white in colour with dark brown head and dark brown spots on the body and measured 15.8 – 16.0 mm in length.

Freshly hatched larva entered into the bud and tender pod by preparing the entry hole which further, plugged by larval excreta. The entry hole gave the indication of the infestation. Pupation was observed in the infested bud and pod. Prepupal period ranged from 2-3 days with an average of 2.1 days. The freshly formed pupa was green at the beginning but later turned to dark brown in colour. The duration of pupal stage ranged from 8-10 days with an average of 8.9 days. The average length and breadth of pupa was 12.23 mm and 2.98 mm, respectively. The adult moth was slender, medium sized. Forewings brown in colur with a white spot while, hindwings white coloured with brown border. Sexual dimorphism revealed that male possessed slightly curved abdomen with black tip whereas, female possessed opening at the tip of abdomen and it was straight without black tip. Male moth measured 11.04 mm in length and 24.06 mm across the wings while, female moth measured 11.91 mm in length and 25.34 mm across the wings. The male to female ratio was 1:1.08. One generation was completed in 30.0 and 34.6 days for male and female, respectively.

The field experiment was conducted to evaluate the efficacy of some insecticides against *M. vitrata*. Post-treatment observations were recorded after 7, 14 and 21 days on the basis of per cent bud and pod damage. The treatment with cypermethrin + profenophos (44 EC) 0.04 per cent and emamectin benzoate (5 SG) 0.002 per cent were significantly superior over rest of the treatments at all the three sprays. The yield data recorded also showed the effectiveness of the insecticides providing maximum grain yield (8.42 q ha^{-1}) with treatment cyprmethrin + profenophos 0.04 per cent followed by emamectin benzoate 0.002 per cent (5 SG) 8.29 q ha^{-1}.

The observations on the knock down effect were recorded in the field 72 hours after each spray to judge the immediate action of an insecticide. Here also, the treatment with cypermethrin + profenophos recorded maximum per cent larval mortality with an average of 61.33 per cent followed by 0.002 per cent emamectin benzoate with an average mortality of 56.89 per cent.

Conclusion

The overall results revealed that eventhough *M. vitrata* is a serious pod borer on dolichos bean, can be managed very effectively if followed a spray schedule as experienced in the present findings. The insecticides *viz.*, cypermethrin + profenophos and biological material emamectin benzoate emerged as the best insecticides in protecting buds, tender pods and also producing quicker larval mortality which further produced higher yields. Thus, a spray schedule of either of these two insecticides at initiation of flowering, 50 per cent flowering and 50 per cent pod filling stage at an interval of 21 days would be effective.

However, further investigations are needed on the aspects such as studies on varietal screening, studies on natural enemies and some biopesticides mainly plant products, studies on seasonal incidence etc. This will generate the information in the formation of IPM schedule for the ecofriendly management of Bean Pod Borer, *Maruca vitrata* (Fabricius).

Table 2. Mating in *M. vitrata*

Pair No.	Mating time (P.M.)		Coitus period (mins.)
	From	To	
1.	22:00	22:40	40
2.	22:10	22:52	42
3.	21:45	22:25	40
4.	23:00	23:40	40
5.	21:00	21:42	42
6.	23:50	00:40	43
7.	23:30	00:05	35
8.	00:00	00:40	40
9.	21:20	22:00	40
10.	23:25	00:05	40
Range	21:00 – 00:00	21:42 – 00:40	35 - 43
Mean	22:48	23:08	40.2 min.

Table 3. Preoviposition, oviposition, postoviposition periods and fecundity of *M. vitrata*

Pair No.	Preoviposition period (days)	Oviposition period (days)	Postoviposition period (days)	Fecundity
1.	3	4	1	81
2.	3	4	1	78
3.	4	3	2	67
4.	3	3	2	59
5.	3	3	1	56
6.	3	3	1	61
7.	3	2	1	37
8.	4	3	1	63
9.	4	3	2	58
10.	3	2	1	42
Range	3-4	2-4	1-2	37-81
Mean	3.30	3.00	1.30	60.2

Table 4. Morphometrics of eggs of *M. vitrata*

Pair No.	Length (mm)	Breadth (mm)
1.	0.58	0.39
2.	0.57	0.38
3.	0.58	0.39
4.	0.58	0.39
5.	0.59	0.38
6.	0.59	0.38
7.	0.58	0.38
8.	0.58	0.38
9.	0.57	0.38
10.	0.59	0.38
Range	0.57 – 0.59	0.38 – 0.39
Mean	0.58 mm	0.38 mm

Table 5. Incubation period and hatching percentage of *M. vitrata*

Pair No.	No. of eggs observed	No. of eggs hatched (days)				Total eggs hatched	Hatcing %	Avg. incubation period
		1	2	3	4	5		
1.	10	--	--	5	3	8	80	3.37
2.	10	--	--	4	3	7	70	3.43
3.	10	--	--	6	2	8	80	3.25
4.	10	--	--	4	6	10	100	3.60
5.	10	--	--	8	--	8	80	3.0
6.	10	--	--	6	--	6	60	3.0
7.	10	--	--	7	1	8	80	3.12
8.	10	--	--	4	4	8	80	3.5
9.	10	--	--	2	5	7	70	3.25
10.	10	--	--	7	3	10	100	3.30
Range						6-10	60-100	3.0-3.6
Mean						8.0	80%	3.28

Table 6. Larval development period of *M. vitrata*

Pair No.	Duration of larval instars (days)					Total larval period (days)
	I	II	III	IV	V	
1.	3	2	2	2	3	12
2.	2	2	2	2	4	12
3.	2	2	2	2	3	11
4.	2	2	2	2	3	11
5.	2	3	3	2	3	13
6.	3	3	2	2	4	14
7.	2	2	2	2	3	11
8.	2	2	2	2	3	11
9.	3	2	2	3	3	13
10.	2	2	2	2	4	12
Range	2-3	2-3	2-3	2-3	3-4	11-14
Mean	2.30	2.20	2.10	2.10	3.30	12.00

Table 8. Prepupal and pupal period and morphometrics

Pair No.	Prepupal period (days)	Pupal period (days)	Morphometrics of					Adult emerged
			Prepupa			Pupa		
			B.L. mm	B.B. mm	H.W. mm	B.L. mm	B.B. mm	
1.	2	9	13.2	3.2	2.2	12.3	2.9	Female
2.	2	9	13.2	3.3	2.2	12.3	2.9	Female
3.	2	8	13.2	3.3	2.2	12.3	3.0	Female
4.	2	10	13.2	3.3	2.2	12.2	3.0	Male
5.	3	9	13.1	3.3	2.2	12.2	3.0	Male
6.	2	9	13.1	3.2	2.3	12.2	3.0	Male
7.	2	9	13.1	3.3	2.3	12.2	3.1	Female
8.	2	9	13.1	3.3	2.2	12.2	3.1	Female
9.	2	8	13.1	3.3	22	12.2	2.9	Female
10.	2	9	13.2	3.3	2.2	12.2	2.9	Male
Range	2-3	8-10	13.1-13.2	3.2-3.3	2.2-2.3	12.2-12.3	2.9-3.1	
Mean	2.1	8.9	13.15	3.28	2.22	12.23	2.98	

Table 9. Longevity of adult of *M. vitrata*

Pair No.	Without food (days)		With food (days)	
	Male	**Female**	**Male**	**Female**
1.	1	1	5	10
2.	1	2	5	8
3.	1	1	4	8
4.	1	2	4	8
5.	2	2	4	8
6.	2	3	5	8
7.	1	2	4	8
8.	2	1	5	8
9.	1	1	5	8
10.	1	1	5	8
Range	1-2	1-3	4-5	8-10
Mean	1.3	1.6	4.6	8.2

Table 10. Morphometrics of adult of *M. vitrata*

Pair No.	Female			Male		
	Body length (mm)	Body breadth (mm)	Wing expanse (mm)	Body length (mm)	Body breadth (mm)	Wing expanse (mm)
1.	11.8	2.4	26.2	10.9	2.2	24.1
2.	11.9	2.1	25.8	10.8	2.0	24.1
3.	11.8	2.1	24.9	10.9	2.1	23.5
4.	11.6	2.1	24.9	11.1	2.1	23.9
5.	11.9	2.6	25.6	11.4	2.1	24.2
6.	12.4	2.0	26.1	11.2	2.4	24.5
7.	12.0	2.2	24.8	11.2	2.2	24.3
8.	11.9	2.2	24.9	11.1	2.1	24.3
9.	11.9	2.2	25.4	10.9	2.1	24.2
10.	11.9	2.1	24.8	10.9	2.0	23.5
Range	11.6-12.4	2.0-2.6	24.8-26.2	10.8-11.4	2.0-2.4	23.5-24.5
Mean	11.91	2.2	25.34	11.04	2.13	24.06

Table 11. Sex ratio in *M. vitrata*

Pair No.	No. of adults examined	Female moths	Male moths
1.	10	6	4
2.	10	5	5
3.	10	5	5
4.	10	5	5
5.	10	4	6
6.	10	7	3
7.	10	5	5
8.	10	6	4
9.	10	5	5
10.	10	4	6
Total	100	52	48

Sex raio Male : Female

48 : 52

1 : 1.08

Table 12. Life cycle of *M. vitrata*

Life cycle	**Duration**		
	Minimum	**Maximum**	**Mean**
Egg	3	4	3.8
Larva	11	14	12.0
Prepupa	2	3	2.1
Pupa	8	10	8.9
Life cycle (egg to emergence of adult)	24	31	26.8
Adult Male	4	5	4.6
Adult Female	8	10	8.2
Generation (egg laying to the death of adult)			
Male	28	36	31.4
Female	32	41	35.0

Table 13. Per cent bud damage – first spray (at initiation of flowering)

Tr. No.	Treatment	Conc. (%)	Per cent bud damage (%)*			
			Per cent	70 DAT	14 DAT	21 DAT
T_1	Cypermethrin (40%) + profenophos (4%) 44 EC	0.04	18.12 (25.19)**	11.12 (19.36)	11.78 (20.07)	19.37 (26.02)
T_2	Quinalphos 25 EC	0.04	21.16 (27.37)	15.18 (22.94)	23.93 (29.28)	24.54 (29.65)
T_3	Dipel 8L	0.1	22.35 (28.16)	13.62 (21.55)	20.42 (26.84)	25.44 (30.19)
T_4	Dipel 8L	0.2	15.83 (23.43)	15.38 (22.88)	19.33 (26.07)	20.86 (27.16)
T_5	Emamectin benzoate 5 SG	0.002	15.10 (22.87)	12.08 (20.14)	12.07 (20.33)	20.42 (26.86)
T_6	Neem insecticide (10000 ppm) neemazal)	0.2	17.55 (24.62)	16.47 (23.81)	24.08 (28.36)	33.28 (35.20)
T_7	Carbaryl 50 WP	1.0	23.75 (22.77)	15.48 (23.16)	23.25 (28.82)	25.71 (30.46)
T_8	Serni plant extract	10	17.07 (23.58)	18.93 (25.77)	28.27 (32.10)	33.60 (35.41)
T_9	Control	--	19.31 (26.06)	25.10 (30.02)	35.97 (36.85)	41.47 (40.08)
	S.E. ±		1.32	1.54	0.70	1.30
	C.D. at 5%		3.94	4.60	2.10	3.89
	C.D. at 1%		5.43	6.34	2.90	5.36
			N.S.	Sig.	Sig.	Sig.

* Mean of three observations.

**Figures in parenthesis are arc sin value

DAT – Days after treatment.

Table 14. Per cent bud and pod damage at second spray (50 % flowering)

Tr. No.	Treatment	Per cent bud damage (%)*			Per cent pod damage (%)*		
		7 DAT	**14 DAT**	**21 DAT**	**7 DAT**	**14 DAT**	**21 DAT**
1.	T_1	13.78 (21.45) **	10.70 (18.01)	14.26 (22.16)	8.19 (16.85)**	7.46 (15.79)	9.49 (17.93)
2.	T_2	21.23 (27.41)	15.50 (23.18)	20.96 (27.22)	16.77 (23.48)	12.11 (20.24)	12.05 (20.21)
3.	T_3	19.77 (26.37)	16.22 (23.74)	21.82 (27.84)	17.43 (24.57)	14.09 (22.04)	19.82 (26.37)
4.	T_4	19.09 (25.80)	14.99 (22.76)	20.98 (27.15)	15.08 (22.85)	11.10 (19.46)	16.13 (23.55)
5.	T_5	12.45 (20.64)	10.42 (18.83)	14.94 (22.72)	8.98 (17.42)	7.86 (16.27)	10.67 (19.05)
6.	T_6	17.24 (24.52)	15.55 (23.21)	26.48 (30.96)	19.75 (26.26)	10.99 (18.34)	20.80 (27.13)
7.	T_7	21.95 (27.93)	18.89 (25.75)	26.36 (30.87)	19.06 (25.82)	14.46 (22.18)	17.23 (24.51)
8.	T_8	17.41 (24.64)	22.40 (28.24)	26.94 (31.24)	16.56 (23.78)	12.61 (20.78)	22.72 (28.37)
9.	T_9	35.62 (36.64)	35.99 (36.85)	36.44 (37.12)	23.69 (28.09)	16.09 (23.65)	25.23 (30.14)
	S.E. ±	1.08	0.75	1.09	1.16	0.80	1.23
	C.D. at 5%	3.23	2.23	3.26	3.47	2.41	3.69
	C.D. at 1%	4.45	3.08	4.50	4.78	3.32	5.08

* Mean of three observations.

**Figures in parenthesis are arc sin value

DAT – Days after treatment.

Table 15. Per cent pod damage at third spray (50 % pod filling)

Tr. No.	Treatment	Per cent pod damage (%)*			Yield (q/ha)
		7 DAT	14 DAT	21 DAT	
1.	T_1	5.96 (14.12)	5.69 (14.40)	6.61 (14.89)	8.42
2.	T_2	8.55 (16.83)	7.08 (15.51)	9.91 (18.30)	8.09
3.	T_3	7.15 (15.48)	7.26 (15.51)	12.22 (20.43)	6.36
4.	T_4	6.52 (14.79)	6.20 (14.40)	11.58 (19.87)	7.57
5.	T_5	5.75 (13.83)	5.79 (14.01)	6.94 (15.27)	8.29
6.	T_6	8.53 (16.96)	7.36 (16.02)	12.43 (20.62)	8.11
7.	T_7	8.59 (16.94)	7.92 (16.44)	12.39 (20.58)	7.46
8.	T_8	8.42 (17.53)	8.96 (17.57)	1.63 (19.92)	6.84
9.	T_9	10.47 (18.88)	10.44 (18.82)	14.95 (22.70)	6.35
	S.E. ±	1.00	0.93	0.74	
	C.D. at 5%	2.98	2.80	2.21	
	C.D. at 1%	4.11	3.85	3.05	

* Mean of three observations.

**Figures in parenthesis are arc sin value

DAT – Days after treatment.

Table 16. Per cent mortality of *M. vitrata* (72 hrs. after treatment)

Tr. No.	Treatment	Conc. (%)	Per cent bud damage (%)*		
			Ist spray	IInd spray	IIIrd spray
T_1	Cypermethrin + profenophos	0.04	56.00* (48.45)**	60.00* (50.79)**	68.00* (55.61)**
T_2	Quinalphos	0.04	34.66 (36.05)	41.33 (40.05)	43.33 (41.16)
T_3	Dipel	0.1	38.00 938.00)	31.33 (33.97)	42.00 (40.26)
T_4	Dipel	0.2	40.00 (32.22)	45.33 (42.27)	39.33 (38.82)
T_5	Emamectin benzoate	0.002	50.00 (45.00)	51.33 (45.80)	62.00 (52.42)
T_6	Neem insecticide 10000 ppm	0.2	28.00 (31.78)	34.00 (35.42)	27.33 (31.45)
T_7	Carbaryl	1.0	10.00 (18.37)	18.00 (24.73)	20.00 (26.49)
T_8	Serni plant extract	10.0	31.33 (34.01)	35.33 (36.44)	38.66 (38.42)
T_9	Unsprayed control	--	3.33 (10.40)	6.00 (14.04)	7.22 (15.79)
		S.E. ±	1.47	2.74	2.25
		C.D. at 5%	4.41	8.23	6.73

* Mean of three observations.

**Figures in parenthesis are arc sin value

Table 7. Morphometrics of larva of *M. vitrata*

Sr. No.	First instar			Second instar			Third instar			Fourth instar			Fifth instar		
	B.L. mm	B.B. mm	H.W. mm	B.L. mm	B.B. mm	H.W. mm	B.L. mm	B.B. mm	H.W. mm	B.L. mm	B.B. mm	H.W. mm	B.L. mm	B.B. mm	H.W. mm
1.	3.1	0.70	0.61	4.2	0.76	0.68	8.5	1.4	0.91	11.8	2.5	1.9	16.0	2.9	2.4
2.	3.1	0.70	0.60	4.3	0.77	0.67	8.5	1.4	0.91	11.7	2.5	1.9	16.0	2.9	2.4
3.	3.1	0.70	0.60	4.3	0.77	0.67	8.5	1.5	0.91	11.7	2.6	2.0	16.0	2.9	2.4
4.	3.2	0.71	0.61	4.4	0.76	0.68	8.6	1.5	0.92	11.8	2.5	1.9	15.8	2.9	2.4
5.	3.3	0.70	0.60	4.4	0.76	0.68	8.5	1.6	0.91	11.8	2.6	1.9	15.9	3.0	2.4
6.	3.2	0.70	0.60	4.3	0.77	0.68	8.6	1.5	0.91	11.8	2.5	1.9	15.9	3.0	2.5
7.	3.2	0.70	0.60	4.3	0.76	0.68	8.6	1.6	0.92	11.7	2.5	1.9	15.9	2.9	2.4
8.	3.2	0.71	0.60	4.3	0.77	0.68	8.6	1.6	0.92	11.7	2.5	1.9	15.9	3.0	2.5
9.	3.2	0.71	0.60	4.3	0.76	0.68	8.6	1.6	0.91	11.7	2.5	1.9	15.9	3.0	2.4
10.	3.3	0.70	0.60	4.3	0.76	0.68	8.6	1.6	0.91	11.7	2.5	1.9	15.9	2.9	2.4
Range	3.1-3.3	0.70-0.71	0.60-0.61	4.2-4.4	0.76-0.77	0.67-0.68	8.5-8.6	1.4-1.6	0.91-0.92	11.7-11.8	2.5-2.6	1.9-2.0	15.8-16.0	2.9-3.0	2.4-2.5
Mean	3.19	0.70	0.60	4.31	0.76	0.68	8.56	1.53	0.91	11.74	2.52	1.92	15.92	2.94	2.42