INSECT COMMUNITY ANALYSIS IN CUCURBITACEOUS VEGETABLES AND IMPACT OF INSECTICIDES ON INSECT POLLINATORS

JANGAIAH . V

Thesis submitted in partial fulfillment of the requirement for the degree of

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University, Thrissur

2007

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM - 695 522

DECLARATION

I hereby declare that this thesis entitled **"Insect community analysis in cucurbitaceous vegetables and impact of insecticides on insect pollinators"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellayani,
15-9-2007

Jangaiah .V
(2005-11-108)

CERTIFICATE

Certified that this thesis entitled **"Insect community analysis in cucurbitaceous vegetables and impact of insecticides on insect pollinators"** is a record of research work done independently by Mr. Jangaiah, V. (2005-11-108) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

Vellayani,
15/9/-2007.

Dr. S. DEVANESAN 15/9/07
(Chairman, Advisory Committee)
Professor,
Department of Agricultural Entomology
College of Agriculture, Vellayani
Thiruvananthapuram – 695 522.

Approved by

Chairman :

Dr. S. DEVANESAN
Professor,
Department of Agricultural Entomology,
College of Agriculture, Vellayani,
Thiruvananthapuram – 695 522.

16/2/08

Members :

Dr. T. NALINAKUMARI
Professor and Head,
Department of Agricultural Entomology,
College of Agriculture, Vellayani,
Thiruvananthapuram – 695 522.

16.2.08

Dr. S. NASEEMA BEEVI
Professor,
Department of Agricultural Entomology,
College of Agriculture, Vellayani,
Thiruvananthapuram – 695 522.

16/2/08

Dr. V. A . CELINE
Professor,
Department of Olericulture,
College of Agriculture, Vellayani,
Thiruvananthapuram – 695 522.

16/2/08

External Examiner :

Dr. P. Sivasubramanian
Professor,
Department of Agricultural Entomology,
Tamil Nadu Agricultural University,
Coimbatore - 641003

16/2/08

Acknowledgement

I consider it as a blessing, to have worked under the guidance of Dr. S. Devanesan, *Professor, Department of Agricultural Entomology. His valuable guidance, encouragement, amicability and fatherly affection positively motivated me in the successful completion of this endeavour.*

With utmost reverence and deep sense of adoration, I express my heartfelt thanks to Dr. T. Nalinakumari, *Professor and Head, Department of Agricultural Entomology, for her expert advice, valuable suggestions and constructive criticism given during the preparation of the thesis. Above all, her compassionate words and ways will be a treasured memory of mine.*

I wish to express my profound sense of gratitude to Dr. S. Naseema Beevi, *Professor, Department of Agricultural Entomology, for her ever willing help, kind and patient approach, valuable suggestions and critical scrutiny of the manuscript. Her concern and moral support during a critical stage of my work will be gratefully remembered.*

I express my sincere thanks to Dr. V. A. Celine, *Professor, Department of Olericulture, for her kind help rendered during the study period and critical suggestions in the preparation of the thesis.*

I wish to express my heartfelt gratitude to Dr. K. D. Prathapan, *Assistant Professor, Department of Entomology, for his kind help in the identification of the insect specimens. The word 'thanks' would simply be an understatement for his unimaginable patience in teaching things.*

It will be an unredeemable fault on my part if I fail to express my heartfelt thanks to Dr. Hebsy Bai, *Professor and* Dr. K. S. Premila, *Associate Professor of Department of Agricultural Entomology, Vellayani for their critical comments and constructive suggestions throughout the study.*

I am grateful to all the teaching and non-teaching staff of the Department of Entomology, for their help and cooperation given during the course of work.

I am grateful to Mr. C .E. Ajithkumar for his kind help rendered during the statistical analysis and interpretation of the experimental data.

I convey my sincere thanks to the staff of the library for their ever-willing help and cooperation offered throughout the study period.

I express my affection and indebtedness to my friends at the PG hostel, Vignesh, Jithesh, Vimarsh, Thamilvel, Hari, Kumaran, Kumanan, Prabhu, Sriram, jagat, Mathew, Selvaraju, *and* Ashitraj, *Who made the life in campus memorable.*

My hearty thanks are due to Madhu *and* Reddy *for their ever-willing help and good company throughout the study period.*

At this moment, I recall with love and gratitude, the constant encouragement and inspiration given to me by my parents and relatives. I am deeply indebted to them in making this endeavour a success.

I am grateful to KAU granting me the junior research fellowship for the post graduate programme.

Above all, I owe my life to all my little and big animal friends who siphoned out my blues and kept me going, at many a tough time endured during this period of study.

V. Jangaiah

DEDICATED TO MY BELOVED

PARENTS & TEACHERS

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDIX

LIST OF ABBREVIATIONS

%	Per cent
$/m^2$	Per square metre
@	At the rate of
a.i	Active ingredient
CD	Critical difference
cm	Centimetre(s)
DAS	Days after sowing
DAT	Days after treatment
EC	Emulsifiable concentrate
et al.	And others
Fig.	Figure
g	Gram
h	Hour
ha^{-1}	Per hectare
Kg	Kilogram
m	Metre
min	Minutes
ml	Millilitre
sec	Seconds
SC	Suspension concentrates
SL	Soluble concentrates
sp.	Species
spp.	Different species
viz.	Namely

INTRODUCTION

1. INTRODUCTION

Tremendous attention has been paid to increase the vegetable production in India. As a result, the country has emerged as the second largest producer of vegetables after China. The production has touched new heights in the recent past, reaching 90 million tonnes. However, as the country's population is increasing @ 1.8 per cent, our vegetable requirement up to 2010 will be around 135 million tonnes. In Kerala, the production is much less than the requirement, if balanced diet is provided to every individual. Kerala depends on neighbouring states to meet the requirement of vegetables. Hence it is an urgent need to increase the vegetable production substantially to attain self sufficiency by bringing additional area under vegetable crops, using hybrid seeds and use of improved agro- techniques. Another potential approach to increase the vegetable production is enhancing the pollination process and promotion of integrated pest management practices in cross pollinated vegetables.

The cucurbit crops form one of the largest groups in the vegetable kingdom with their wide adaptation from arid to the humid tropic environments. The Asian and Pacific region produce many edible cucurbits and is considered to be the centre of origin for some of them. Cucurbits is considered as one of the largest botanical families of vegetables produced and consumed (Prem, 2007).

Cucurbitaceae with its unisexuality stands unique as entomophilous family since insect pollination is chiefly of wide occurrence in bisexual plants. Thus cucurbits represent an unique case where unisexuality is marked with synchronous co evolution of stamens, carpel's and their pollinating insects (Shrivastava and Shrivastava 1991). The dense and sticky pollen needs to be transferred to the female flowers to ensure fruitset, well shaped fruits thus to optimize yield. Fruit size and shape is related to the number of seeds produced and each seed requires one or more pollen grains. Flowers are usually open and attractive to bees for only one day and pollination must take place on the day at anthesis. Ensuring the presence of 1 to 3 honeybee colonies per acre was a reliable method of pollination in the mid-Atlantic (Chris Wien, 2006).

Pest incidence is a major constraint in vegetable production which impaired both quantity and quality of vegetables. In cucurbits, crop loss up to 95 per cent may occur due to melon fruit fly (Rajpoot et al., 2002). Leaf feeders and pumpkin beetles were also serious problems in cucurbits and they caused crop loss up to 47.49 per cent (Reeta, et al., 2003a).

Farmers usually use various pesticides especially synthetic pyrethroids in an unscientific and haphazard manner to control the pests. While considering the production and productivity of cucurbits, both pollination by insects as well as protection of the crop from pests are equally important. The unscientific management practices result in the decline of pollinators and other beneficial insects causing great economic loss. Hence, there is an urgent need for protecting the pollinators and beneficial insects by avoiding the indiscriminate use of pesticides. Under such a situation, knowledge on the insect community associated with cucurbits, foraging activity of pollinators, natural enemies of pests and the nature and extent of damage caused by pests is essential. Therefore, the present study was undertaken with the following objectives.

- To document the different insects, mite and spider species present on the cucurbitaceous vegetable ecosystem.
- To find out the foraging activity of insect pollinators.
- To assess the impact of insecticides on insect pollinators, natural enemies and pests.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The yield of agricultural crops can be significantly increased through good management practices including effective pollination. Cucurbits mainly depend on insects for pollination because of their monoecious flowers. The pesticides, which are applied for the management of pests of cucurbits are found to cause deleterious effects on the pollinators and natural enemies. The literature related to the insect community, pollinators, foraging behavior of bees, the occurrence of pests and natural enemies and impact of insecticides on pollinators, pests and natural enemies is reviewed here under.

2.1 INSECT COMMUNITY

Nevkryta (1937) recorded 63 species of Hymenoptera, 16 species of Diptera, 7 species of Lepidoptera, one species each of Hemiptera and Coleoptera on cucurbit flowers. Atwal (1970) recorded more than 23 species of bee visiting cucurbitaceous flowers at Ludhiana. He also observed that *Apis dorsata* Fabr. was the most abundant species visiting the flowers followed by *Apis florea* Fabr., *Apis cerana indica* Fab., *Xylocopa pubescens* (Spinola), *Nomiodea* sp. and halticina bees. According to Marinturriza et al.(1995) entomofauna associated with the cucumber was 52 species belonging to 38 families and 9 orders and of these 67.12 per cent was phytophagous, 18.78 per cent predators, 6.07 per cent parasitoids and 8.10 per cent pollinators. Melendez Ramierz et al. (2002) recorded bees belonging to 6 families, 29 genera and 58 species from cucurbits. Seven species (6 genera) of Apidae, Anthophoridae and Halticidae comprised around 80 per cent of all the individuals collected from pumpkin, cucumber, melon and water melon.

2.1.1 Insect pollinators

Pollinating insects *viz*., bees, wasps, beetles, flies, butterflies and moths provided almost incalculable economic and ecological benefits to humans, flowering plants and wild life (Ascher and Buchmann, 2005). Muller (2007) recognized different species of insects which included beetles, bees, wasps, ants, butterflies and moths, of these bees pollinate the largest number of plant species.

Coleoptera

Although beetles are the largest order of insects, they have been often overlooked as pollinators because the pollination process (Cantharophily) is relatively low due to the lack of specialization (Faegri and Van der Pijl , 1979).

According to Andrews et al. (2007) striped cucumber beetle *Acalymma vittatum* Fabr. fed on cucurbits and were attracted to several volatiles emitted by cucurbit blossoms. However, the effect of these volatiles on pollinator attraction is unknown.

Diptera

Flies are important pollinators under certain climatic conditions because they are present throughout the year. Some plants flowering at odd times of the year may be completely dependent on flies for pollination (Hagerup, 1951 and Kevan, 1972).

The hoverfly, *Bombylius* sp. hover in the air as they fed on pollen and flowers (Baker, 1957). Adult flies fed on pollen and nectar and the females require the amino acids in the pollen for the maturation of their reproductive system (Wratten et al. 1995).

Lepidoptera

Lepidoptera are one of the best known and most visible insect and are effective pollinators by pollen is often involuntarily stuck to the proboscis or on body parts of the insects.

According to Morimoto (2004) bottle gourd flower visitors comprised of hawk moths *Hippotion celerio* (L.), *Agrius convoluli* (L.), and Skipper butterfly *Gorgyra johnstoni* (L.).

Hymenoptera

Bees, wasps and ants under the order hymenoptera comprised of some of the most important pollinating insects and among them, bees are better adapted for pollination and they ranged from the simple solitary bee to the complex social bees.

Girish (1981) reported that *Apis* spp. were the most important pollinators of summer squash *viz., A. cerana indica, A. dorsata* and *A. florea* which contributed 87, 10 and 3 per cent, respectively from around Bangalore. Bumble bee visiting flowers consistently had lower abortion rates and higher seed sets in cucumber and watermelon than honey bee visiting flowers. It was concluded that bumble bees have a great potential to serve as a supplemental pollinator for cucumbers, water melons and possibly other vine crops, while honey bees were available for rental in limited supply (Stanghellini et al., 1998; Dasgan et al., 1999). Gingras et al. (1999) studied the presence of honeybee *Apis mellifera* L. and found that the number of bees present and cumulative duration of their visits to the flowers were important in pollination and influenced both the quality and quantity of cucumber production.

Kremen et al. (2002) reported that in organic farms near natural habitat, the native bee communities could provide full pollination services even for a crop with heavy pollination requirements *viz.*, watermelon, *Citrullus lanatus* (Thunb.) without the intervention of managed honey bees. They found that other farms experienced greatly reduced diversity and abundance of native bees, resulting in insufficient pollination services in farms. They also found that diversity was essential for sustaining the service, because of year-to-year variation in community composition. Continued degradation of the agro-natural landscape will destroy this "free" service, but conservation and restoration of bee habitat are potentially viable economic alternatives for reducing dependence on managed honey bees.

2.1.2 Insect pests

***Bactrocera* spp.**

The melon fruit fly (*Bactrocera cucurbitae* Coq.) is distributed widely in temperate, tropical and sub tropical regions of the world. It has been reported to damage 81 host plants and is a major pest of cucurbitaceous vegetables, particularly bittergourd, muskmelon, snapmelon and snakegourd (Dhillona et al., 2005).

The melon fruit fly has been reported to infest 95 per cent of bittergourd fruits, 90 per cent snakegourd and 60 to 87 per cent pumpkin fruits (Hollingsworth et al., 1997; Rajpoot et al., 2002). Pankaj- Ingoley et al. (2002) reported high fruit infestation in June under mean maximum temperature, minimum temperature, relative humidity and rainfall of 27.10° C, 17.70 to 19.00° C, 72.00 to 84.00 % and 53.3 to 61.5 mm, respectively.

Aulacophora **spp.**

Aulacophora sp. reported as a pest of cucurbits during all stages of development (Hoffmann et al., 2003; Mahmood et al., 2005). *Aulacophora foveicollis* Lucas adults showed poor feeding response on ridge gourd *Luffa acutangula* cv. Kalitori (L.) and sponge gourd *Luffa cylindrica* cv.Ghaitori (L.) when leaf disc were offered separately and alternately with the standard plant bitter gourd *Momordica charantia* cv. Kerala (L.) Adults showed a higher preference index *viz.*, 2.53 , 2.45, 1.05 and 1.03 on pumpkin *Cucurbita maxima* cv. Kerala Duchense and Musk melon *Cucumis melo* cv. Khabooza (L.), respectively (Reeta – Jhori et al., 2003 b).

The seasonal abundance of beetle on cucurbit plants revealed that the peak infestation (47.49 per cent) and the least infestation (3.92 per cent) were in the month of July and February when relative humidity ranged at 70.55 and 60.60 per cent respectively. The highest damage potential by the beetle was in the germinating plants in March to May (Borah et al., 1997; Reeta – Jhori et al., 2003 c).

High infestation of the beetle *A. foveicollis* was observed in the seedling stage, especially at cotyledonary leaf stage. They made holes in the cotyledonary leaves, although they attacked the vines in the grown up stage also. Musk melon, bottle gourd, pumpkin, cucumber and watermelon were severely attacked by the beetles than bitter gourd (Bose et al., 1993; Nair, 1999; David, 2002; KAU 2002).

Diaphania indica **Saunders**

The highest infestation of the pest being observed in little gourd *Coccinia indica* Wight, followed by bitter gourd *Momordicha charantia* (L.) and pointed gourd *Tricosanthes dioica* Roxb (Jhala et al ., 2005).

Peter and David (1991a) reported that the peak incidence of *D. indica* was observed in April to September and low population in November to February.

The young larvae fed on chlorophyll and skeletonized the leaves of all the three cucurbits studied, while the older larvae folded and webbed together the leaves and fed from with in. All stages of the larvae were observed feeding on flowers and boring in to the ovaries, new tender shoots and all stages of the fruits young and developing as well as mature fruits in the case of littlegourd and bittergourd (Nair et al., 1999; Nandakumar, 1999; Krishnamoorthy and Krishna kumar, 2001; Jhala et al., 2004; Kargnar et al., 2004).

The adult of the *D. indica* laid eggs more on mature leaves than on aged and developing leaves. The larvae showed their preference to cucurbits in the order of cucumber *C. sativus* > gourd *Lagenaria scicerar*ia (Molina) > water melon *C. lantus* > oriental melon *C. melo* var. Makuwa > sponge cucumber *L. cylindrica* > cotton *Gossypium indicum* Medik. (Choidongchil, 2003).

***Aphis* spp.**

These small green insects (*Aphis sp.*) damage the plants by sucking cell sap. As a result of attack, seedling stage cotyledonary leaves crinkle and in severe cases the plants wither and in the grown up vines, the leaves turn yellow and plant loses its vigour and yield. Both melon aphid *Aphis gossypii* Glover and peach aphid *Myzus persicae* Sulzer attack the cucurbits (Bose et al., 1993; Nair, 1999; David, 2002; Perdikish, 2003).

Vansteenis (1995) found that *A. gossypii* was an important pest in glass house cucumber crops 20, 25 and 30 ° C on two cucumber cultivars.

***Liriomyza trifolii* Burgess**

Drying and dropping of leaves due to severe infestation of serpentine leaf miner *L. trifolii* was observed by Nair,1999; Nandakumar,1999 and Regupathy et al., 2003.

***Henosepilachna* spp.**

The beetle was reported to feed on cucurbits, bitter gourd and snake gourd (Tewari and Krishnamurthy, 1983; Nair, 1999; Nandakumar, 1999). In cucurbits the damage was caused by the adults and grubs feeding on the leaf surface. Initially leaves presented a lace like appearance and they turned brown, dried and fell off resulted in complete defoliation (Atwal, 1986; Nair, 1999).

2.1.3 Natural Enemies

Twenty species of natural enemies were found associated with the pumpkin caterpillar *D. indica*. Of these 16 were parasitoids belonging to the families Braconidae, Ichneumonidae, Bethylidae, Elasmidae and Chalcididae and four species of the predators *viz*., ants and spiders. *Apantles microsporidia* (L.) was also recorded for the first time on *D. indica* (Perter and David, 1991 b). Duan and Messing (1997) reported that two opiine parasitoids *Diachasmimorpha longicaudata* (Ashmead) and *Psyttalia fletcheri* (Silvestri) were effective in controlling *B. dorsalis* and *B. cucurbitae*. Jacobson and Croft, (1998) and Einat et al. (2006) established two methods of adoption of parasitoid *Aphidius colemani* Viereck in cucumber crop prior to invasion of the aphids. Synder and David (1999) reported that spotted cucumber beetle reduced their feeding and damage to host plants in the presence of the large wolf spider *Hogna helluo* (Walckenaer).

Leandro baui et al. (2006) reported a more suitable sampling system for the larvae of *D. indica* in cucumber plants. The more suitable sampling system was for hymenoptera parasitoids in cucumber plants to directly count the adults on one leaf of the mean third of the canopy.

Spiders

The occurrence of spiders *Tetragnatha* sp. and *Oxyopes* sp. from bitter gourd was reported by Nandakumar and Saradamma (1996). The orb – web weavers Araneidae and Tetragnathidae fed on Homoptera such as leaf hoppers and Orthoptera, especially grass hoppers in cucurbits (Sunderland, 1999). Chinta (2002) studied on pests and beneficial arthropods on pointed gourd and found that *Coccinella transversalis* Fabr., *Brumus suturallis* (F.), *Micraspis discolor* (Fabr.), *Casnoidea indica*, *Paederus fuscipes* Curtis *and Pardosa birmanica* Simon comprised of the predatory species with *P. birmanica* being the important spider through out the cropping season. Manu and Hebsybai (2006) reported that about thirty species of spiders belonging to nine families in vegetables and the major being *O. javanus, O. shweta and Thomisus* sp. and among them *O. javanus* appeared from the vegetative stage up to maturity stage.

Coccinellid beetles

There were reports of coccinellids dominantly predated on aphids than the insects of any other group. Both the larvae and adults are voracious feeders of aphids (Haque and Islam, 1978; Anand, 1983; Agarwala and Ghosh, 1998).

Parasitoids

Patel and Kulkarny (1956) reported the parasitisation of *Apanteles* sp. on *D. indica* and the highest parasitism was reported on coccina and bitter gourd. The pest was parasitized by large number of parasitoids, among them important being *A. taragammae and Goniozus sensorious* Gordh (Peter and David, 1991 b). They also observed that the combined action of the parasitoids during January to March and October to December lowered the pest population. A total of 12 species of parasitoids were recorded as natural enemies of *L. trifolii*, including one Braconidae, one Eucoilidae, two Pheromalidae and eight Eulophidae (Arakaki and Kinjio, 1998).

2.2 FORAGING BEHAVIOUR OF BEES

Bee activity is one of the most important factors which aids in pollination. In the process of evolution, flowers have adopted to secrete or produce and offer nectar and / or pollen in large amounts to attract bees in large numbers. Bee visits, almost coincide with the presence of viable pollen and at the time when the stigma is most receptive. Atwal (1970) reported that the highest bee visiting cucurbit flowers was from 0700 to 1030 hr in Ludhiana. The foraging activities in honey bee colonies were greatly influenced by rainy days, high humidity and other uncomfortable weather parameters (Naim and Phadke, 1976). Girish (1981) observed that during February *A. cerana indica* began foraging on summer squash at 0620 hr and *A. dorsata* and *A. florea* at about 1200hr. During May and June all the bees began and ceased foraging earlier in the day compared to other months.

Cervanica and Bergonia (1990) reported that common flower visitors of cucumber were *A.dorsata, Xylopa chlorinae* Smith, *Xylopa philippinensis* Smith, *Megachile atrata* Smith. They were most abundant from 1000 hr to 1100 hr. Sattigi et al. (1996) reported that foraging activity was noticed throughout the day but it was at the peak between 0800 hr to 1100 hr in summer and 0800 hr to 1200 hr in monsoon. The foraging activity was low during other hours of the day in different seasons. Devanesan et al. (2002) reported that foraging activity of *Trigona iridipennis* Smith started around at 0700 hr and a gradual rise in activity was observed at 1300 hr then increased and reached its second peak at 1500 hr and there was almost no activity at 1800 hr, around Kerala.

Jyothi (2003) recorded foraging activity of *A. mellifera* peaked between 1000 and 1300 hr (35.7 to 37.7 bees) and of *A.cerana indica* (24.3 to 26.7 bees) and then decreased to 3.6 and 0.0 bees for *A. mellifera* and A. cerana *indica*, respectively, at 1800 hr, around Bangalore.

Sajjanar et al. (2004) reported that in cucumber flowers, *A. dorsata* was the most frequent visitor and started activity around 0600 hr whereas all other insect visitors started foraging activity by 0800 hr. Foraging activity was at its peak by 1000 h but declined later. However, the activity again picked up by around 1500 hr and reached a peak by 16.00 hr but declined later. They also found that under caged conditions, pollen foragers of *A. cerana indica* initiated activity by 0600 hr, the activity was at a peak (6 bees/m^2/5 min) by 1000 hr, declined gradually till 1800 hr, whereas, nectar foragers initiated activity by 0700 hr, remained in low numbers initially but picked up activity by noon to attain a peak by 1300 hr, with 6.89 bees/m^2/5 min, followed by a gradual decline in the activity.

Time spent by bee for the collection of nectar and pollen

Girish (1981) reported that there was very little difference in the time spent for collection of nectar from pistillate and staminate flowers in summer squash and it was ranged between 34 and 38 sec. for both *A. cerana indica* and *A. dorsata*, respectively.

According to Ankita et al. (2003) the time spent by *A. dorsata* workers was the least (31.4 sec.) followed by *A. mellifera* (31.7 sec), *A. cerana indica* (33.3 sec.) and *A. florea* (43.9 sec.) in Indian mustard . The time spent by *A. florea* on each flower (18.33 sec.) was longer compared with *A. dorsata* (6.66 sec.) and *A. mellifera* (11.33 sec.) in sesamum (Yogesh a et al., 2003).

Sajjanar et al. (2004) reported that the time spent by *A. dorsata* on pistillate cucumber flowers was 27.5 to 41.69 sec. during different day hours where as *A. cerana indica* spent 32.75 to 47.69 sec. on staminate flowers, nectar foragers *A. dorsata* spent 26.13 to 38.00 sec. and *A. cerana indica* 30.44 and 43.44 sec.

2.3 IMPACT OF INSECTICIDES

2.3.1 Insect Pollinators

Effect of pesticides on honey bees

Stevenson and Walker (1974) reported that accidental poisoning of honeybees by insecticides was due to the spray application of organophosphates applied on crops during their flowering period. Carbaryl was lethal to honey bees on the day of application (Stanger and Winterlin, 1975). Fiedler (1987) reported that the intake of small amounts of insecticides resulted in increased mortality and reduced consumption in honey bees.

Bielza et al. (2001) reported that conifidor 20 %SL was safe to bumble bees pollinating green house tomatoes. Stefanidous et al . (2003) reported that poisoning of bee pollinators had a serious adverse effect which led to a decrease in insect pollination, reduction in the honey yield.

Ladurner et al.(2003) showed that the flower method was the most effective for evaluation of pesticide effect on bees compared with film conister and glass vial methods. Sterk and Benuzzi (2004) showed that all the microbial insecticides were completely safe to bumble bees, while the chemical pesticides proved more variable in their effects.

A. mellifera

Mclaren et al. (1987) showed that mortality of *A. mellifera* was higher in those bees exposed to microencapsulated formulation than those exposed to emulsifiable concentrate formulation of insecticides. The order of toxicity was dimethoate > malathion > carbaryl > neem oil. The result showed that neem oil was safest insecticide to *A. mellifera* (Sontakke and Dash, 1996; Abrol and Andorta, 1997). Jimenez et al. (1997) showed that fenvalerate and carbaryl insecticides caused adult bee mortality, even eleven weeks after spraying, greatest mortalities were recorded during the initial twenty five days.

Abrol and Rajivkumar (2000) reported that there was significant reduction in the number of bees in the order of dimethoate > carbaryl > fenvalerate. According to Angeli et al. (2002) open field application of the insecticides fenitrothion on *Phacelia tanacetifolia* showed lower adult mortality with the treatments before than during the bloom period. Toxicity of pesticides while foraging and also inside the hive due to presence of pesticide residues in nectar and pollen was reported by Kashyap and Kumar, 2002.

Gowda et al. (2002) showed that fenvalerate were moderately toxic to *A. mellifera* when fed orally whereas carbaryl was toxic in the case of topical application method. Mall and Rathore (2003) reported that dimethoate was repelling chemicals where less number of bees visited. Angeli et al. (2003) studied the effect of insecticides used on fruit crop grape and observed that dimethoate was highly toxic to *A. mellifera*.

Johnson et al. (2006) reported that honey bee *A. mellifera* often thought to be extremely susceptible to insecticides in general, exhibit considerable variation in tolerance to pyrethroid insecticides, although lambda-cyhalothrin was highly toxic to honey bees.

Marie et al.(2006) initiated a field survey on French apiaries to monitor the weakness of honey bee, *A. mellifera* colonies. Apiaries were evenly distributed in five sites located on continental France. Pollen loads from traps were collected at each visit. Multiresidue analyses were performed in pollen to search residues of 36 different molecules. Specific analyses were conducted to search fipronil and its metabolites and also imidacloprid metabolites. Residues of imidacloprid and 6-chloronicotinic acid were found in 69 per cent of samples. Imidacloprid contents were quantified in 11 samples with values ranging from 1.1 to 5.7 μg/kg. 6-chloronicotinic acid content was superior to the limit of quantification in 28 samples with values ranging from 0.6 to 9.3 μg/kg.

A. cerana indica

Singh et al. (1974) reported that carbaryl and dimethoate proved highly toxic to the worker bee of *A. cerana indica*. Singh et al. (1989) showed that the maximum cumulative mortality of bees was recorded in the treatment with dimethoate followed by DDVP, malathion, endosulfan and phosalone . The immediate effect of spraying was most pronounced in the case of dimethoate and malathion. The cypermethrin and permethrin were highly toxic to foraging workers of *A.cerana indica* (Reddy et al. 1997).

All chemical insecticides were toxic to *A. cerana indica* in both oral feeding and contact method treatments (Nataraja et al. 2002). Raju (2002) reported that insecticides like carbaryl, dimethoate were highly toxic and malathion being moderately toxic to *A. cerana indica.* The median lethal time of 16.69 hrs was observed in lambda-cyhalothrin and imidacloprid 12.19 hrs (Khan and Dethe, 2004).

Venkat Reddy and Chandrashekhara Reddy (2006) observed that the oral toxicity in *A.cerana indica* in the descending order *viz.*, carbaryl > dimethoate > fenvalerate > malathion.

2.3.2 Insect Pests

B.cucurbitae

Gupta and Verma (1982) reported that fenitrothion 0.025 per cent in combination with protein hydrolysate 0.25 per cent reduced fruit fly damage 8.7 per cent as compared to 43.3 per cent damage in untreated control. The application of molasses with malathion and water in the ratio 1: 0.1: 100 provides good control of melon fruit fly (Agarwal et al., 1987; Bose et al., 1993 and Akhtaruzzamman et al., 2000).

Bhatnagar and Yadava (1992) reported malathion 0.5 per cent to be more effective than carbaryl 0.2 per cent and quinalphos 0.2 per cent on bottle gourd, sponge gourd and ridge gourd. Neem oil 1.2 per cent has also been reported to be as effective as dichlorovos 0.2 per cent (Ranganath et al., 1997). Protein bait spray / traps to be economically viable, environmentally sensitive, sustainable and has suppressed fruit flies below economic threshold with the minimum use of organophosphates and carbamate insecticides (Wood, 2001; Vargas et al., 2003; Jiji et al., 2005; Klungness et al., 2005; Thomas et al., 2005).

The synthetic pyrethriod treatments deltamethrin (Decis 2.8 E.C 375 g a.i./ ha), cypermethrin (cybil 25 E.C 75 g a.i./ ha) gave significantly less fruit infestation of cucurbit fruit fly up to 14 days when sprayed on summer squash compared to malathion (Massithion 20 E.C at 375 g a.i./ha) (Sharma and Nitinsood, 2004).

***Aulacophora* spp.**

Allen et al. (2001) reported that cucumber seeds treated with imidacloprid (GAUCHO) effective control for striped cucumber beetle. According to Krishnamoorthy and Krishnakumar (2001) quinalphos 0.05 per cent was effective in controlling *Aulacophora* sp.

Babu et al. (2002) reported that beta – cyfluthrin was effective against red pumpkin beetle. Rajak and Singh (2002) reported that among the plant leaf powder, Neem *Azardirachata indica* L. was most effective against red pumpkin beetle. Regupathy et al. (2003) recommended malathion 0.5 per cent and dimethoate 0.05 per cent for controlling the leaf beetles.

D. indica

Schreiner (1991) reported that carbaryl and dimethoate were effective in reducing caterpillar population of *D. indica*. Zhou wei et al. (2005) determined the efficiency of insecticides *viz*., fenvalerate, acephate and dimethoate aganist *Diaphania perspectalis* (Walker).

***Aphis* spp.**

Neem Azal was highly effective against *A. gossypii* in okra (Chandrasekaran, 2001). Malathion 0.05 per cent gave protection against aphid in cucurbits (KAU, 2002). According to Regupathy et al. (2003) neem based formulation 2 ml / 1 was effective against aphids. Imidacloprid 0.002 per cent and dimethoate 0.05 per cent were very effective against aphids (Regupathy et al., 2003; Bridar and Shaila, 2004).

L. trifolii

Rushtapakornchai et al., (1996) reported that two application of acephate gave significant control of *L. trifolii*. Neem oil 50 E.C (TNAU formulation), resulted in high larval mortality at 24 hours after treatment (Jeyakumar and Uthamaswamy, 1997).

***Henosepilachna* spp.**

Carbaryl > malathion showed high toxicity to the grubs of Epilachna beetle (Jayakumari, 1967). Quinalphos 25 EC was effective against Epilachna sp. for twenty days (Raj gopal and Trivedi, 1989). Malathion 0.1 % protected foliage from beetle damage (Jhansirani, 2001).

2.3.3 Natural Enemies

Murray (2006) reported that botanical insecticides have long been attractive alternatives to synthetic chemical insecticides for pest management because botanicals reputedly pose little threat to natural enemies. Neem products are well established commercially, that are cost-effective and relatively safe compared with their predecessors.

Spiders

Neem products were safe to *Tetragnatha* sp. and *Oxyopes* sp. (Nandakumar and Saradamma, 1996). In general spiders are more sensitive than many pests to some pesticides, such as the synthetic pyrethriods, cypermethrin and deltamethrin, the organo phosphates, dimethoate and malathion and the carbamate, carbaryl and a decrease in spider population was observed than as pests (Brine et al., 1998; Huusela – veistola, 1998: Yardim and Edwards, 1998; Holland et al., 2000; Tanaka et al., 2000). Abundance of spiders was unaffected by imidacloprid (Kunel et al., 1999). According to Mishra and Mishra (2002) spider population in okra field was un affected by malathion application where as the reports of Manu (2005) showed that malathion 0.1 per cent was toxic to spiders and imidacloprid 0.002 per cent proved less toxic to spiders.

Coccinellid beetles

Bozsik (2006) reported that imidacloprid seem to be safest for *Cocinella septempunctata* (L.) adults. Tenczar and Krischik (2006) reported that bio rational foliar sprays and a novel application method of soaking transplants in imidacloprid conserved of coccinellid predators.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

A survey was under taken in cucurbitaceous vegetable gardens to record the population of insect pollinators, pests and their natural enemies and to assess their seasonal occurrence in Kalliyoor panchayat of Thiruvananthapuram district during March 2006 to February 2007. A field experiment was also conducted in the Instructional farm, College of Agriculture, Vellayani for assessing the impact of insecticides on the insect pollinators, pests and their natural enemies. The materials used and the methods adopted are described here under.

3.1 INSECT COMMUNITY

3.1.1 Documentation

The cucurbitaceous vegetable crops *viz.,* snake gourd (*T. anguina*), bitter gourd (*M. charantia*) and oriental pickling melon (*C. melo* var; *conomon* Mak.) were selected for studying the insects associated with the crops. Three farmer's field of five cents each for each crop was identified in Kalliyoor panchayat of Thiruvananthapuram district. Five plants were selected at random in each farmer's field for each crop and the population of the insect pollinators, pests and their natural enemies were recorded at weekly intervals during summer and rainy season using standard methods as detailed below.

3.1.1.1 *Insect Pollinators*

Different species of insects visiting the cucurbitaceous flowers were observed initially for five days to get a generalized view about their foraging behaviour. Flying insects *viz.,* bees, wasps, flies and moths were collected using a sweep net having 20 cm, 50 cm and 30 cm as diameter of the frame, length of the cloth and length of the handle, respectively. The non flying insects *viz.,* ants, beetles and earwigs were hand picked in a polythene cover and tied with a rubber band. The collected insects were then brought to the laboratory, killed using chloroform, sorted, labelled and preserved for identification.

Five plants in five square metre area were demarked as one replication and the different species of insect pollinators visiting the flowers in the plants for five minutes during 1000 to 1100 hr was recorded by visual observation at weekly intervals during the entire flowering period, from fifth week after sowing to eighth week after sowing. The mean population was worked out to determine the relative abundance of the flower visitors. Similar observations on the flower visitors was made from an insecticide free crops of the vegetables maintained in the Instructional farm, College of Agriculture, Vellayani.

3.1.1.2 ***Insect pests***

The insects found damaging the different parts of the plants were collected and identify the pests of the crops. The population of insect pests was counted from each plant and the number of leaves damaged by different insect pests were recorded out of ten leaves sampled at random from each plant and the percentage of infestation was worked out. Similarly, the percentage of fruits infestation was calculated from ten fruits sampled at random from five plants.

3.1.1.3 ***Natural Enemies***

The predators found feeding on the pests in the field were collected and were confined in petridish along with the their respective hosts in the laboratory for confirmation of their predatory nature. Their population were recorded per plant.

The parasitized larvae of pests were collected from the field, placed in a perforated polythene bag, sealed, labeled and kept for the emergence of parasitoids. The parasitoids emerged were identified and their population were recorded per plant.

3.2 FORAGING ACTIVITY OF INSECT POLLINATORS

The snake gourd, bitter gourd and oriental pickling melon were grown in the Instructional farm, Vellayani with out applying insecticides.

The insect pollinators were recorded from 0600 to 1800 hr at an hourly interval for five minutes during the peak flowering period. Five plants were selected at random which served as replication in Instructional farm field for each crop and the mean population was worked out.

3.3 IMPACT OF INSECTICIDES

A field experiment was conducted to assess the impact of commonly used insecticides on insect pollinators in cucurbitaceous vegetables. Based on the studies on foraging activity of the pollinator fauna, oriental pickling melon was selected for the trial as it showed the maximum activity of the pollinators.

3.3.1 Raising Crop

Seeds of the local variety of oriental pickling melon obtained from the Instructional farm, College of Agriculture, Vellayani was used for the experiment. The trail was laid out as detailed below.

Design: RBD

Plot size: 15 sq. m

Spacing: 2.5 × 1 m

Number of observation plants per plot: 4

Replications: 3

Treatments: 9

The treatments were:

T_1 – Neem oil 2.0 per cent

T_2 – Malathion 0.2 per cent + Jaggery 10 gm / l

T_3 – Acephate 0.05 per cent

T_4 – Dimethoate 0.05 per cent

T_5 – Carbaryl 0.1 per cent

T_6 – Lambda- cyhalothrin 0.01 per cent

T_7 – Fenvalerate 0.02 per cent

T_8 – Imidacloprid 0.002 per cent

T_9 – Control

The crop husbandry practices were done as envisaged in the package of practices recommendations of the Kerala Agricultural University (KAU, 2002). The insecticides were sprayed twice during vegetative and peak flowering stage. Observations on the population of the insect pollinators, natural enemies and pests were taken one, three, five, seven, fourteen and twenty one days after each application. The extent of damage caused by different pests was recorded fourteen days after spraying.

3.3.2 Preparation of Spray Solution

Neem oil

The botanical insecticide neem oil 2.0 per cent was prepared by mixing 200 ml of Juerken and 50 gm of soap in 10 liters of water.

Malathion + Jaggery

The commercial formulation Malathion 50 EC supplied by Sree Ramicides Chemicals Private Limited was used for the experiment. Malathion 0.2 per cent was prepared by mixing 40 ml of Malathion 50 EC formulation in 10 liters of water.

Acephate

The commercial formulation Asataf 75 SP supplied by Rallis Tata Enterprise Private Limited was used for the experiment. Acephate 0.05 per cent was prepared by mixing 7 ml Asataf SP in 10 liters of water.

Dimethoate

The commercial formulation Rogor 30 EC supplied by Sree Ramicides Chemicals Private Limited was used for the experiment. Dimethoate 0.05 per cent was prepered by mixing 17 ml Rogor 30 EC formulation in 10 liters of water.

Carbaryl

The commercial formulation Sevin 50 WDP supplied by Bayer Crop Science India Limited was used for the experiment. Carbaryl 0.1 per cent prepared by mixing 20 gm of Sevin 50 WDP formulation in 10 liters of water.

Lambda-cyhalothrin

The commercial formulation Command 5 EC supplied by Tropical agro system India Ltd., was used for the experiment. Lambda-cyhalothrin 0.01 per cent was prepared by mixing 20 ml Of Command 5 EC formulation in 10 liters of water.

Fenvalerate

The commercial formulation Arfen 20 EC supplied by Sree Ramicides Chemicals Private Limited was used for the experiment. Fenvalerate 0.02 per cent was prepared by mixing 10 ml of Arfen 20 EC formulation in 10 liters of water.

Imidacloprid

The commercial formulation Confidor 200SL supplied by Bayer Crop Science India Limited was used for the experiment. Imidacloprid 0.002 per cent was prepared by mixing 0.1 ml of Confidor 200 SL formulation in 10 liters of water.

3.3.3 Assessment of Population of Insect pollinators

The population of insect pollinators were recorded as described in 3.1.1.1 The time when forager bee landing on the flower till leaving was recorded by using a stop clock and was considered as time spent by the bee / flower. Similarly, observations were made on nectar collection in pistillate and staminate flowers. Pollen collection in staminate flowers were observed during the peak pollination time (1000 to 1100 hr). The mean time spent by each bee was expressed in seconds.

3.3.4 Assessment of Population of Pests

The count of *Aulacophora* sp., *D. indica* and *A. peponis* population were recorded one day prior to spraying and one, three, five, seven and fourteen days after spraying from the observation plants in each treatment and the mean number per plant was worked out.

3.3.5 Assessment of Extent of Damage Caused by Various Pests

Ten leaves were collected at random from the observation plants in each treatment and the number of leaves infested by *Henosepilachna* sp., *Aulacophora* sp., *A. peponis, D. indica, L. trifolii and A. gossypii* was recorded. The percentage of leaves infested was worked out.

3.3.6 Assessment of Population of Natural Enemies

The number of spiders and coccinellid beetles were recorded one day prior to spraying and one, three, five, seven and fourteen days after spraying from the observation plants in each treatment and the mean number per plant was worked out.

3.4.7 Yield

The matured fruits were harvested separately from each treatment and the weight recorded at each harvest. The total yield was calculated and expressed in kilograms.

Four ripened fruits were randomly selected from each treatment and the pulp surrounding the seed was removed smoothly by using knife. The seeds were weighted using electronic digital balance. The mean weight of the seeds was calculated and expressed in grams.

3.4.8 Seed Germination Percentage

The rate of germination was assessed by sowing ten seeds from each treatment in soil filled in polythene cover. The germination of seeds was recorded and expressed in percentage by using the formula.

$$\text{Germination percentage} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

3.4 Statistical Analysis

The data were subjected to analysis of variance and interaction studies (Panse and Sukhatme, 1985). Wherever the results were significant, the critical difference was worked out at five per cent probability.

RESULT

4. RESULTS

The results of the study conducted to document the various insects on three cucurbitaceous vegetables (snake gourd, bitter gourd and oriental pickling melon) in the farmer's field and in the field experiment to find out the impact of insecticides on the population, foraging behaviour of insect pollinators, population of natural enemies, pests and their extent of damage on oriental pickling melon are presented in this chapter.

4.1 INSECT COMMUNITY

4.1.1 Documentation

The insects, mite and spiders were observed on the cucurbitaceous vegetables during the entire study period is presented in Table 1. Forty seven insect species in several orders were recorded during the period of study from March 2006 to February 2007 and were represented by the following orders; Hymenoptera (13), Coleoptera (10), Lepidoptera (9), Hemiptera (8), Diptera (5), Orthoptera (1) and Thysanoptera (1).

Red spider mite alone represented the order Acariformes, while two species of spiders belonged to the order Araneae. Category wise comparison of the population indicated that the most predominant group was insect pollinators (29), followed by pests (19) and their natural enemies (7).

Insect pollinators / flower visitors

The total number of different species of insect visitors recorded on the flowers of three cucurbits was found to be 29. Of these, Hymenoptera, Lepidoptera, Coleoptera, Diptera, Hemiptera, and Thysanoptera (Plate 3) were represented by 11, 6, 5, 4, 2, and 1, respectively. The hymenopterans consisted of three species from the family Apidae, one species each from Halticidae, Anthophoridae, Ichneumonidae, Vespidae, Sphecidae, Megachilidae, Xylocopidae and two species from Formicidae. The six lepidopterans recorded were represented by one species each from the families of Papilionidae, Lycaenidae, Amatidae, Hesperiidae, Nymphalidae and Pieridae. The five coleopterans included three species from the family Chrysomelidae

Table 1. Occurrence of different insect pollinators, pests and their natural enemies on cucurbitaceous vegetables

Common name	Scientific name	Family	order
Insect pollinators / flower visitors			
Bees	*Apis cerana indica* Fab.	Apidae	Hymenoptera
	Apis mellifera L.		
	Trigona sp.		
Solitary bees	*Anderna* sp. Bruce	Anthophoridae	
Ichneumon flies	Un identified	Ichneumonidae	
Wasps	*Vespa* sp.	Vespidae	
	Chalybion bengalense Dahlbom	Sphecidae	
Ants	*Camponotus rufoglacus* Jerdon	Formicidae	
	Oecophylla smaragdina Fabr.		
Leaf cutter bees	*Megachile* sp.	Megachilidae	
Carpenter bees	*Xylocopa* sp.	Xylocopidae	
Swallow tails	*Papilio polytes stichius* Hubner	Papilionidae	Lepidoptera
Blue and coppers	*Lampides boeticus* L.	Lycaenidae	
Moth	*Euchromia polymena* L.	Amatidae	
Coconut leaf roller	*Suastus gremius* Fab.	Hesperiidae	
Brush footed butterfly	*Precis atlites atlites* L.	Nymphalidae	
Yellow and whites	*Catopsilla pyranthi* L.	Pieridae	
Pumpkin beetles	*Aulacophora foveicollis* Lucas *Aulacophora lewesi* Baly *Aulacophora stevensi* Baly	Chrysomelidae	Coleoptera
Rose chafer beetles	*Oxycetonia* sp.	Cetoniidae	
	Un identified	Nitidulidae	
Flies	*Bactrocera cucurbitae* Coq.	Tephritidae	Diptera
	Musca domestica Linn.	Muscidae	

Flies	Un identified	Statiomyidae	Diptera
	Graptomyza brevirostris Weidemann	Syrphidae	
Jassids	*Hishimonus phycitis* Dist.	Cicadellidae	Hemiptera
Mirid bug	Un identified	Miridae	
Thrips	Un identified	Thripidae	Thysonoptera
Insect pests			
Melon aphid	*Aphis gossypii* Glover	Aphididae	Hemiptera
Spiralling white fly	*Aleurodicus dispersus* Russell	Aleurodidae	
Leaf footed bug	*Leptoglossus australis* F.	Coreidae	
Pentatomid bug	*Aspgopus janus* F.	Pentatomidae	
Green stink bug	*Nezara viridula* Linn.		
Mealy bug	*Ferrisia virgata* (Ckll.)	Pseudococcidae	
Leaf hoppers	*Hishimonus phycitis* Dist.	Cicadellidae	
Pumpkin beetles	*Aulacophora foveicollis* Lucas	Chrysomelidae	Coleoptera
	Aulacophora lewesi Baly		
	Aulacophora stevensi Baly		
Epilachna beetle	*Henosepilachna* sp.	Coccinellidae	
Flower beetle	*Mylabris pustulata* Thn.	Meloidae	
Melon fly	*Bactrocera cucurbitae* Coq.	Tephritidae	Diptera
American serpentine leaf miner	*Liriomyza trifolii* Burgess	Agromyzidae	
Pumpkin caterpillar	*Diaphania indica* Saunders	Pyraustidae	Lepidoptera
Snake gourd caterpillar	*Anadevedia peponis* Fb.	Noctuidae	
Plume moth	*Sphenarches caffer* Zeller	Pterophoridae	
Green grass hopper	*Atractomorpha crenulata* Fabr.	Acridiidae	Orthoptera
Red spider mite	*Tetranychus* Sp.	Tetranychidae	Acariformes
Natural enemies			
Coccinellid beetles	*Menochilus sexmaculatus* Fab.	Coccinellidae	Coleoptera
	Synharmonia octomaculata Fab.		
	Micraspis crocea Mulsant		
Spiders	*Oxyopes javanus* Thorell	Oxyopidae	Araneae
	Lycosa pseudoannulata Boes et. st.	Lycosidae	
Parasitoids	*Apanteles* sp.	Braconidae	Hymenoptera
	Chrysocharis johnsonii Walker	Eulophidae	

and one each from Nitidulidae and Cetoniidae. The dipterans were represented by one species each from the families of Tephritidae, Muscidae, Statiomyidae and Syrphidae. Hemiptera were represented by one species each from the family of Cicadellidae, Miridae and Thysonoptera represented by one species from the family of Thripidae. Among all these, the major insect pollinators were *A. cerana indica*, *A. mellifera*, *Trigona* sp. and *Anderna* sp. belonging to the Apidae and Anthophoridae under Hymenoptera (Plate 1). *P. polytes stichus*, *L. boeticus*, *S. gremius* and *C. pyranthi* were the major pollinators belonging to the lepidopterans (Plate 2). The major pollinators of the coleopterans included *A. foveicollis*, *A. lewesi* and *A. stevensi*. *B. cucurbitae* (Plate 2) and *G. brevirostris* were the dipteran pollinators in the cucurbits.

Insect Pests

The total number of insect pests recorded on cucurbits was found to be 18. Of these, seven belonged to the order Hemiptera, five belonged to Coleoptera, three to Lepidoptera, two to Diptera and one to Orthoptera. The Hemiptera consisted of one species each from the family of Aphididae, Aleurodidae, Coreidae, Pseudococcidae, Cicadellidae and two species from the family of Pentatomidae. There were three species from the family of Chrysomelidae and one species each from Coccinellidae and Meloidae in Coleoptera. The lepidopterans were from the families Pyraustidae, Noctuidae and Pterophoridae. There was one species from Orthoptera which belonged to the familiy Acrididae. Among all these, the major pests were *Aulacophora* sp. and *Henosepilachna* sp. belonging to the coleopterans. *D. indica* and *A. peponis* were leaf feeders belonging to the lepidopterans. *L. trifolii* and *A. gossypii* were also major insect pests belonging to the Diptera and Hemiptera, respectively (Plate 4).

Acariform pest

Tetranychus sp. (Tetranychidae) was the only one mite pest found associated with the cucurbitaceous vegetables.

Natural Enemies

There were five species of predators and two species of parasitoids found on cucurbitaceous vegetables. The three species of predators belonged to the order

A. cerana indica

A. mellifera

Trigona sp.

Anderna sp.

Chalybion bengalense

Camponotus rufoglacus

Plate 1. Hymenopterans visiting on the cucurbitaceous flowers

Aulacophora foveicollis

Aulacophora lewesi

Oxycetonia sp

Papilio polytes

Catopsilla pyranthi

Euchromia polymena

Plate 2. Coleoptera and lepidopterans visiting on the cucurbitaceous flowers

Bactrocera cucurbitae

Musca domestica

Hishimonus phycitis

Thripidae sp.

Plate 3. Diptera, Hemiptera and Thysanoptera visiting on the cucurbitaceous flowers

Leaf damage *by A. foveicollis*

Fruit infested by *B. cucurbitae*

Leaf damage by *Aphis* sp.

Leaf damage by *L. trifolii*

Larvae of *A. peponis*

Larvae of *D. indica*

Plate 4. Major pests of cucurbits and their symptoms

Synharmonia octomaculata

Menochilus sexmaculatus

Pupal case of *Apanteles* sp.

Plate 5. Natural enemies of pests of cucurbits

Coleoptera and were from the family of Coccinellidae. Two species (*Apanteles* sp. and *C. johnsonii*) of parasitoids from the order Hymenoptera belonged to the family of Braconidae and Eulophidae, respectively.

The two species of spider (*O. javanus* and *L. pseudoannulata*) predators found on cucurbits belonged to the family of Oxyopidae and Lycosidae in the order Araneae (Plate 5).

4.1.1.1 Population of insect species on cucurbits

Insect pollinators

Insect pollinators visiting the snake gourd, bitter gourd and oriental pickling melon flowers during the summer and rainy season are depicted in Table 2.

Snake gourd

Summer season

Observations on the relative abundance of different insect pollinators visiting snake gourd flowers revealed the maximum mean population of *A. cerana indica* (2.17) which was significantly higher than other insect pollinators. *Trigona* sp. recorded the second highest insect pollinator population (1.70) which was on par with the population of *Anderna* sp. (1.53). Population of lepidopterans and coleopterans were 0.95 and 0.60, respectively. The lowest population of 0.30 was observed in *A. mellifera* which was on par with the population of dipterans (0.33) and other insects (0.38).

The highest mean population of insect pollinators (1.32) was observed at seventh week after sowing which was significantly higher than other weeks. The lowest population of insect pollinators (0.71) was observed at eighth week after sowing which was significantly lower than the other weeks. There was no significant difference between the population in fifth (0.91) and sixth week after sowing (1.04).

The data on the fifth week after sowing showed the highest population of *A. cerana indica* (2.00) which was significantly higher than other insect pollinators. Lepidopterans (1.33) and *Anderna* sp. (1.33) were the second highest insect pollinators which was on par with the population of *Trigona* sp. (1.27). The lowest

Table 2. Insect pollinators visiting cucurbitaceous flowers during various seasons in the farmer's field of Kalliyoor panchayat (Mean number / m ^{2} / 5 min).

Pollinators	Summer season (WAS)				Mean	Rainy season (WAS)				Mean
	V	VI	VII	VIII		V	VI	VII	VIII	
Snake gourd										
A. cerana indica	2.00	2.00	2.93	1.73	2.17	1.60	1.73	1.87	1.00	1.55
A. mellifera	0.27	0.20	0.67	0.07	0.30	0.20	0.07	0.27	0.07	0.15
Trigona sp.	1.27	1.93	2.00	1.60	1.70	1.00	0.47	0.67	0.27	0.60
Anderna sp.	1.33	2.00	1.93	0.87	1.53	0.40	0.40	0.53	0.07	0.35
Coleopterans	0.53	0.67	1.00	0.20	0.60	0.20	0.60	0.73	0.20	0.43
Dipterans	0.33	0.20	0.13	0.67	0.33	0.20	0.87	1.07	0.80	0.73
Lepidopterans	1.33	0.67	1.53	0.27	0.95	1.07	0.87	1.33	0.47	0.93
Other insects	0.20	0.67	0.40	0.27	0.38	0.07	0.20	0.20	0.13	0.15
Mean	0.91	1.04	1.32	0.71	-	0.59	0.65	0.83	0.38	-
Bitter gourd										
A. cerana indica	2.53	3.27	3.53	3.00	3.08	2.13	2.33	2.73	1.80	2.25
A. mellifera	0.60	1.80	1.33	0.33	1.02	0.27	0.80	0.53	0.20	0.45
Trigona sp.	2.93	3.13	3.67	2.53	3.07	2.33	2.27	2.53	2.00	2.28
Anderna sp.	0.47	1.20	1.67	0.73	1.02	0.27	0.87	2.07	0.40	0.90
Coleopterans	0.53	1.07	1.73	0.53	0.97	0.40	0.33	1.67	0.20	0.65
Dipterans	0.47	0.47	1.00	0.13	0.52	1.07	2.13	0.67	1.33	1.30
Lepidopterans	2.07	2.40	2.47	1.47	2.10	1.80	2.20	1.87	1.80	1.92
Other insects	0.93	1.53	1.20	0.60	1.07	0.53	1.20	2.27	0.40	1.10
Mean	1.32	1.86	2.08	1.17	-	1.10	1.52	1.79	1.02	-
Oriental pickling melon										
A. cerana indica	3.07	5.20	5.47	3.87	4.40	2.87	2.67	3.60	2.27	2.85
A. mellifera	1.27	1.53	1.20	0.80	1.20	0.93	1.20	1.47	0.60	1.05
Trigona sp.	1.80	3.07	2.73	2.27	2.47	1.60	2.13	1.93	1.47	1.78
Anderna sp.	1.73	3.47	3.13	1.93	2.57	1.13	1.47	2.33	0.80	1.43
Coleopterans	1.60	2.07	1.47	0.93	1.52	0.80	1.00	1.67	0.60	1.02
Dipterans	1.20	1.27	1.40	0.80	1.17	1.67	2.13	2.00	1.73	1.88
Lepidopterans	1.67	2.00	1.73	1.13	1.63	1.67	2.13	1.80	1.47	1.77
Other insects	1.00	1.93	1.60	0.80	1.33	0.67	1.40	1.47	0.47	1.00
Mean	1.67	2.57	2.34	1.57	-	1.42	1.77	2.03	1.17	-

WAS : Weeks after sowing

CD(0.05)		Snake gourd	Bitter gourd	Oriental pickling melon
Pollinators mean	:	0.223	0.293	0.317
Season × period	:	0.162	0.207	0.224
pollinators × season × period	:	0.458	0.586	0.633

population was observed in other insects (0.20) and was on par with the population of *A. mellifera* (0.27), dipterans (0.33) and coleopterans (0.53).

Highest population of *A. cerana indica* (2.00) and *Anderna* sp. (2.00) was observed in sixth week after sowing and was on par with the population of *Trigona* sp. (1.93). The lowest population was observed in *A. mellifera* (0.20) and dipterans (0.20) which was on par with the population of lepidopterans and other insects (0.67 each).

Significantly highest population of *A. cerana indica* (2.93) was observed in seventh week after sowing which showed higher trend than other insect pollinators. *Trigona* sp., *Anderna* sp., lepidopterans and coleopterans were the second highest insect pollinators, the population being 2.00, 1.93, 1.53 and 1.00, respectively. The lowest population was showed in dipterans (0.13) and was on par with the population of other insects (0.40) and *A. mellifera* (0.67).

Observations on eighth week after sowing showed the highest population of *A. cerana indica* (1.73) which was on par with the population of *Trigona* sp. (1.60). *Anderna* sp. (0.87) and dipterans (0.67) were the second highest insect pollinators. The lowest population was observed in *A. mellifera* (0.07) which was on par with the population of coleopterans (0.20), lepidopterans (0.27) and other insects (0.27).

The maximum population of *A. cerana indica*, *Trigona* sp., *A. mellifera*, coleopterans and lepidopterans were observed at seventh week after sowing in the summer season. Maximum population of *Anderna* sp., dipterans and other insects were observed at sixth week after sowing.

Rainy season

Observation on the relative abundance of different insect pollinators visiting snake gourd flowers revealed the maximum mean population of *A. cerana indica* (1.55) which was significantly higher than other insect pollinators. Lepidopterans, dipterans, *Trigona* sp., coleopterans and *Anderna* sp. were the second highest insect pollinators population 0.93, 0.73, 0.60, 0.43 and 0.35, respectively. The lowest population was observed in *A. mellifera* (0.15) and other insects (0.15).

The highest mean population of insect pollinators (0.83) was observed at seventh week after sowing which was significantly higher than other weeks. The lowest mean population of insect pollinators (0.38) was observed at eighth week after sowing. Fifth and sixth week after sowing, the population being 0.59 and 0.65, respectively.

The data on the fifth week after sowing showed the highest population of *A. cerana indica* (1.60) which was significantly higher than other insect pollinators. Lepidopterans recorded population of 1.07 which was on par with the population of *Trigona* sp. (1.00). The lowest population was observed in other insects (0.07) and was on par with the population of *A. mellifera* (0.20), coleopterans (0.20), dipterans (0.20) and *Anderna* sp. (0.40).

The highest mean population of *A. cerana indica* (1.73) was recorded on sixth week after sowing, showed significantly higher population than other insect pollinators. Lepidopterans (0.87) and dipterans (0.87) were the second highest insect pollinators. They were on par with the population of coleopterans (0.60). The lowest population was observed in *A. mellifera* (0.07) which was on par with the population of other insects (0.20), *Anderna* sp. (0.40) and *Trigona* sp. (0.47).

On seventh week after sowing showed the highest population of *A. cerana indica* (1.87) which was significantly higher population than other insect pollinators. Lepidopterans, dipterans, coleopterans and *Trigona* sp. were the second highest insect pollinators, the population being 1.33, 1.07, 0.73 and 0.67, respectively. The lowest population was observed in other insects (0.20) which was statistically on par with the population of *A. mellifera* (0.27) and *Anderna* sp. (0.53).

Significantly higher mean population of *A. cerana indica* (1.00) was observed in eighth week after sowing showed no statistical difference with the population of dipterans (0.80). The lowest population was observed in *A. mellifera* (0.07) and *Anderna* sp. (0.07) which was on par with the population of other insects (0.13), *Trigona* sp. (0.27), coleopterans (0.20) and lepidopterans (0.47).

The maximum population of insect pollinators were observed at seventh week after sowing and the minimum population of insect pollinators were observed at eighth week after sowing.

Bitter gourd

Summer season

Observations on the relative abundance of different insect pollinators visiting bitter gourd flowers revealed the maximum mean population of *A. cerana indica* (3.08) which was on par with the population of *Trigona* sp. (3.07). *A. mellifera*, *Anderna* sp., coleopterans and other insects population being 1.02, 1.02, 0.97 and 1.07, respectively and they were on par with each other. The lowest population was observed in dipterans (0.52) which was significantly lower than rest of the pollinators.

The highest mean population of insect pollinators (2.08) were observed at seventh week after sowing and was on par with the population recorded at sixth week after sowing (1.86). The lowest population of insect pollinators (1.17) was observed at eighth week after sowing which showed no statistically difference with the population of fifth week after sowing (1.32).

Trigona sp. recorded the highest population (2.93) during fifth week after sowing and was on par with the population on of *A. cerana indica* (2.53). The next higher population was observed in lepidopterans (2.07). The lowest population was observed in *Anderna* sp. (0.47) and dipterans (0.47) which was on par with the population of coleopterans (0.53), *A. mellifera* (0.60) and other insects (0.93).

The data on the sixth week after sowing showed the highest population of *A. cerana indica* (3.27) which was statistically at par with the population of *Trigona* sp. (3.13). Lepidopterans, *A. mellifera*, other insects, *Anderna* sp. and coleopterans were the second highest insect pollinators recorded, the population being 2.40, 1.80, 1.53, 1.20 and 1.07, respectively. The lowest population was observed in dipterans (0.47).

On seventh week after sowing the highest population of *Trigona* sp. (3.67) was observed and was statistically on par with the population of *A. cerana indica* (3.53). Lepidopterans, coleopterans and *Anderna* sp. were the second highest insect pollinators, the population recorded was 2.47, 1.73, 1.53, and 1.63, respectively. The lowest population was observed in dipterans (1.00) which was on par with the population of other insects (1.20) and *A. mellifera* (1.33).

Eighth week after sowing showed the highest population of *A. cerana indica* (3.00) which was on par with the population of *Trigona* sp. (2.53). Lepidopterans and *Anderna* sp. were the second highest insect pollinators, the population being 1.47 and 0.73, respectively. The lowest population was observed in dipterans (0.13) which was on par with the population of *A. mellifera* (0.33), coleopterans (0.53) and other insects (0.60).

The maximum population of *A. cerana indica, Trigona* sp., *Anderna* sp., coleopterans, dipterans and lepidopterans were observed at seventh week after sowing in the summer season. Higher population of *A. mellifera* and other insects the were observed at sixth week after sowing. The minimum population of insect pollinators were recorded at eighth week after sowing.

Rainy season

Observations on the relative abundance of different insect pollinators visiting bitter gourd flowers revealed the maximum mean population of *Trigona* sp.(2.28) which was on par with the population *A. cerana indica* (2.25). Lepidopterans, dipterans and other insects were the next highest insect pollinators, the population being 1.92, 1.30 and 1.10, respectively. The lowest population was observed in *A. mellifera* (0.45) which was on par with the population of coleopterans (0.65).

The highest mean population of insect pollinators (1.79) was observed at seventh week after sowing which was significantly higher than other weeks. The lowest population of insect pollinators (1.02) was observed at eighth week after sowing which was on par with the population of fifth week after sowing.

Trigona sp. recorded the highest population (2.33) on fifth week after sowing which was on par with the population of *A. cerana indica* (2.13) and lepidopterans (1.80). The lowest population were observed in *A. mellifera* and *Anderna* sp. (0.27 each) which was on par with the population of coleopterans (0.40) and other insects (0.53).

The data on the sixth week after sowing showed the highest population of *A. cerana indica* (2.33) which was on par with the population of *Trigona* sp. (2.27), lepidopterans (2.20) and dipterans (2.13). The lowest population was observed in coleopterans (0.33) and was on par with the population of *A. mellifera* (0.80) and *Anderna* sp. (0.87).

The highest population of *A. cerana indica* (2.73) was recorded on seventh week after sowing and was on par with the population of *Trigona* sp. (2.53) and other insects (2.27). *Anderna* sp., lepidopterans and coleopterans were the next highest insect pollinators, the population being 2.07, 1.87 and 1.67, respectively. The lowest population observed in other insects was 0.53 which did not show any statistical variation with the population of dipterans (0.67).

On eighth week after sowing showed the highest population of *Trigona* sp. (2.00) which was on par with the population of *A. cerana indica* (1.80) and lepidopterans (1.80). The lowest population was observed in *A. mellifera* and coleopterans (0.20 each) and was on par with the population of *Anderna* sp. and other insects (0.40 each).

Maximum population of *A. cerana indica, Trigona* sp., *Anderna* sp., coleopterans and other insects were observed at seventh week after sowing in the rainy season. In dipterans and lepidopterans maximum population as observed at sixth week after sowing. Among the insect pollinators, the minimum population as observed at eighth week after sowing.

Oriental pickling melon

Summer season

Observations on the relative abundance of different insect pollinators visiting oriental pickling melon flowers revealed the maximum mean population of *A. cerana indica* (4.40) which was significantly higher than the population of all other insect pollinators. The next higher population was observed in *Anderna* sp. (2.57) which was on par with the population of *Trigona* sp. (2.47). The lowest population was observed in dipterans (1.17) which was on par with the population of *A. mellifera* (1.20) and other insects (1.33).

The highest mean population of insect pollinators (2.57) was observed at sixth week after sowing and was on par with the population of insect pollinators (2.34) observed at seventh week after sowing. The lowest population of insect pollinators (1.57) was observed at eighth week after sowing which was on par with the population of fifth week after sowing (1.67).

Significantly highest population of *A. cerana indica* (3.07) was observed in the fifth week after sowing. The second highest insect pollinators was observed in *Trigona* sp. (1.80) and was on par with population of lepidopterans (1.67), *Anderna* sp. (1.73), coleopterans (1.20), and dipterans (1.20). The lowest population was recorded in other insects (1.00).

Sixth week after sowing recorded the highest population of *A. cerana indica* (5.20) which was significantly higher than other insect pollinators. *Anderna* sp., *Trigona* sp., coleopterans and lepidopterans were second highest insect pollinators observed, the population being 3.47, 2.07 and 2.00, respectively. The lowest population was observed in dipterans (1.27) which was on par with the population of (1.53) and other insect pollinators (1.93).

The data on the seventh week after sowing showed the highest population of *A. cerana indica* (5.47) which was significantly higher than other insect pollinators. The second highest insect pollinator was observed in *Anderna* sp. (3.13) which was on par with the population of *Trigona* sp. (2.73). The lowest population was observed in *A. mellifera* (1.20) which was on par with the population of dipterans (1.40), colopterans (1.47), other insects (1.60) and lepidopterans (1.73).

The highest population of *A. cerana indica* (3.87) was recorded on eighth week after sowing which was significantly higher than other insect pollinators. The second highest insect pollinators was observed in *Trigona* sp. (2.27) which was on par with the population of *Anderna* sp. (1.93). Significantly lower population was observed in dipterans and other insects (0.80 each) which was on par with the population of coleopterans (0.93) and lepidopterans (1.13).

In *A. cerana indica* and dipterans maximum population were observed at seventh week after sowing in the summer season. *Trigona* sp., *Anderna* sp., coleopterans, lepidopterans and other insects maximum population were observed at sixth week after sowing. *A. cerana indica, Trigona* sp. and *Anderna* sp., the minimum population were observed at fifth week after sowing. In the case of coleopterans, dipterans, lepidopterans and other insects, the minimum population as observed at eighth week after sowing.

Rainy season

Observations on the relative abundance of different insect pollinators visiting oriental pickling melon flowers revealed the maximum mean population of *A. cerana indica* (2.85) which was significantly higher than the population of all other insect pollinators. Dipterans recorded mean population of 1.88 which was on par with the *Trigona* sp. (1.78) and lepidopterans (1.77). The lowest population was observed in other insects (1.00) and was on par with the population of coleopterans (1.02) and *A. mellifera* (1.05).

The highest mean population of insect pollinators (2.03) was observed at seventh week after sowing which was significantly higher than other weeks. The lowest mean population of insect pollinators (1.17) was observed at eighth week after sowing which was significantly lower than other weeks.

The data on the fifth week after sowing showed that *A. cerana indica* recorded the highest population (2.87) which was significantly higher than other insect pollinators. Dipterans, lepidopterans, *Trigona* sp. and *Anderna* sp. were the second highest insect pollinators, the population being 1.67, 1.67, 1.60 and 1.13 respectively. The lowest population was observed in other insects (0.67) which was on par with the population of coleopterans (0.80) and *A. mellifera* (0.93).

A. cerana indica recorded the highest population (2.67) on the sixth week after sowing which was on par with the population of *Trigona* sp., dipterans and lepidopterans (2.13 each). The lowest population was observed in coleopterans (1.00) and which was on par with the population of *A. mellifera* (1.20), *Anderna* sp. (1.47) and other insects (1.40).

The highest population of *A. cerana indica* (3.60) was recorded on seventh week after sowing which was significantly higher than the other insect pollinators.

Anderna sp., *Trigona* sp. and dipterans were the second highest insect pollinators population 2.33, 1.93 and 2.00 being respectively.The lowest population was observed in other insects (1.47) which was on par with the population of coleopterans (1.67).

On eighth week after sowing the highest population of *A. cerana indica* (2.27) was recorded and was on par with the population of dipterans (1.73). The population of *Trigona* sp. and lepidopterans observed was 1.47 in both cases. The lowest population was observed in other insects (0.47) which was on par with the population of *A. mellifera* (0.60) and *Anderna* sp. (0.80).

A. cerana indica, Anderna sp., coleopterans and other insects maximum population were observed at seventh week after sowing, where as *Trigona* sp., dipterans and lepidopterans maximum population were observed at sixth week after sowing in the rainy season. The minimum insect pollinators were observed at eighth week after sowing.

4.1.2 Pesticide free condition

Insect pollinators visiting snake gourd, bitter gourd and oriental pickling melon flowers during various seasons under pesticide free conditions in the Instructional farm are presented in Table 3.

Snake gourd

Summer season

Observations on the relative abundance of different insect pollinators visiting snake gourd flowers revealed the maximum mean population of *Anderna* sp. (2.60) and was statistically on par with the lepidopterans (2.15) and *A. cerana indica* (1.75). The least population was recorded in dipterans (0.65) which was on par with the population of *A. mellifera* (0.75).

The highest mean population of insect pollinators (2.18) was observed at seventh week after sowing during the summer season and was significantly higher than all other weeks population. The lowest population of insect pollinators (1.10) was observed at eighth week after sowing and was statistically on par with the

Table 3. Insect pollinators visiting cucurbitaceous flowers during various seasons under pesticide free conditions in the Instructional farm (Mean number / m ^{2} / 5 min).

Pollinators	Summer season (WAS)				Mean	Rainy season (WAS)				Mean
	V	VI	VII	VIII		V	VI	VII	VIII	
Snake gourd										
A. cerana indica	1.20	1.60	2.80	1.40	1.75	1.00	1.60	2.00	1.20	1.45
A. mellifera	0.40	0.80	1.00	0.80	0.75	0.00	0.40	0.40	0.20	0.25
Trigona sp.	1.80	2.20	2.20	1.40	1.90	1.00	1.60	2.40	1.20	1.55
Anderna sp.	1.60	2.80	3.80	2.20	2.60	1.00	1.20	2.20	1.40	1.45
Coleopterans	1.60	1.80	1.40	1.00	1.45	0.80	1.00	1.60	1.40	1.20
Dipterans	0.20	1.00	0.80	0.60	0.65	1.00	1.00	1.40	1.00	1.10
Lepidopterans	1.80	2.80	3.00	1.00	2.15	1.60	1.00	2.00	1.40	1.50
Other insects	2.00	1.40	2.40	0.40	1.55	1.20	1.40	2.00	0.80	1.35
Mean	1.33	1.80	2.18	1.10	-	0.95	1.15	1.75	1.08	-
Bitter gourd										
A. cerana indica	2.00	3.20	3.80	2.60	2.90	1.80	2.60	3.00	2.00	2.35
A. mellifera	1.00	1.40	2.20	1.00	1.40	0.60	1.00	1.40	0.60	0.90
Trigona sp.	4.00	4.20	5.20	3.60	4.25	2.40	3.00	3.60	2.80	2.95
Anderna sp.	1.00	1.40	2.00	1.60	1.50	0.40	1.00	1.20	0.60	0.80
Coleopterans	1.40	1.40	1.80	1.00	1.40	0.60	0.80	1.60	0.80	0.95
Dipterans	0.40	0.60	0.80	0.40	0.55	0.40	1.20	1.40	1.60	1.15
Lepidopterans	2.00	1.40	2.20	1.20	1.70	0.60	1.00	1.40	1.20	1.05
Other insects	1.80	2.20	3.20	1.80	2.25	0.80	1.80	2.60	1.40	1.65
Mean	1.70	1.98	2.65	1.65	-	0.95	1.55	2.03	1.38	-
Oriental pickling melon										
A. cerana indica	4.60	7.20	5.20	4.80	5.45	3.20	3.60	4.80	3.00	3.65
A. mellifera	1.80	2.20	1.60	0.80	1.60	1.40	1.60	1.80	1.00	1.45
Trigona sp.	1.40	3.60	2.60	2.00	2.40	0.60	1.60	1.60	0.80	1.15
Anderna sp.	1.40	4.00	3.40	2.60	2.85	0.80	2.00	2.40	1.20	1.60
Coleopterans	2.40	3.20	2.80	2.40	2.70	1.40	2.60	2.80	1.60	2.10
Dipterans	0.60	1.00	0.40	0.60	0.65	1.60	1.40	2.40	1.20	1.65
Lepidopterans	2.40	2.80	2.00	1.80	2.25	1.40	1.40	2.60	1.80	1.80
Other insects	1.60	2.60	1.20	0.80	1.55	0.60	1.80	1.80	0.80	1.25
Mean	2.03	2.33	2.40	1.98	-	1.38	2.00	2.53	1.43	-

WAS : Weeks after sowing

CD(0.05) :

	Snake gourd	Bitter gourd	Oriental pickling melon
Pollinators mean	: 0.223	0.293	0.317
Season × period	: 0.162	0 .207	0.224
pollinators × season × period	: 0.458	0.586	0.633

population of fifth (1.23) and sixth (1.80) week after sowing.

The data on the fifth week after sowing showed the highest population of other insects (2.00) and was statistically on par with the population of lepidopterans, *Trigona* sp.(1.80 each), *Anderna* sp. and coleopterans (1.60 each). The lowest population (0.20) was recorded in dipterans and was on par with the population of *A. mellifera* (0.40).

The highest population of lepidopterans and *Anderna* sp. (2.80 each) was recorded on sixth week after sowing which was statistically on par with the population of *Trigona* sp. (2.20). The lowest population (0.20) was recorded in *A. mellifera* which was on par with the population of dipterans, other insects, *A. cerana indica* and coleopterans, the population being 1.00, 1.40, 1.60 and 1.80, respectively.

In the case of seventh week after sowing the highest population of *Anderna* sp. (3.80) was recorded and was statistically on par with the population of lepidopterans (3.00). The population of *A. cerana indica* (2.80), other insects (2.40) and *Trigona* sp. (2.20) were on par with each other. The lowest population (0.80) was recorded in dipterans which was on par with the population of *A. mellifera* (1.00) and coleopterans (1.40).

Anderna sp. recorded the highest population (2.20) on eighth week after sowing and was statistically on par with the population of *A. cerana indica* and *Trigona* sp.(1.40 each). The lowest population (0.40) was recorded in other insects (0.40) which was on par with the population of dipterans (0.60), *A. mellifera* (0.80) and coleopterans (1.00).

The maximum population of coleopterans and dipterans were recorded at sixth week after sowing and remaining other insect pollinators were observed at seventh week after sowing. The minimum population of *A. cerana indica*, *A. mellifera*, *Anderna* sp. and dipterans was recorded in fifth week after sowing during the summer season.

Rainy season

Observations on the relative abundance of different insect pollinators visiting snake gourd flowers revealed the maximum mean population of *Trigona* sp. (1.55) and was on par with the lepidopterans, *Anderna* sp., *A. cerana indica,* other insects and coleopterans, the population being 1.50, 1.45, 1.45, 1.35 and 1.20, respectively. Significantly lower population was observed in *A. mellifera* (0.25).

The highest mean population of insect pollinators (1.75) was observed in seventh week after sowing during the rainy season which was significantly higher than the population observed in other weeks. The lowest population of insect pollinators (0.95) was observed in fifth week after sowing and was statistically on par with the population of sixth (1.15) and eighth week after sowing (1.08).

The data on the fifth week after sowing showed the highest population of lepidopterans (1.60) and was statistically on par with the population of other insects (1.20), *A. cerana indica*, *Trigona* sp., *Anderna* sp. and dipterans (1.00 each). None of the population was recorded in *A. mellifera* which was on par with the population of coleopterans (0.80).

In case of sixth week after sowing showed the highest population of *A. cerana indica* and *Trigona* sp. (1.60 each) and was statistically on par with the population of *Anderna* sp. (1.20) and other insects (1.40). The lowest population was recorded in *A. mellifera* (0.40) and was on par with the population of coleopterans, dipterans and lepidopterans (1.00 each).

Trigona sp. was recorded as the highest population (2.40) on seventh week after sowing and was on par with the population of *Anderna* sp. (2.20), *A. cerana indica,* lepidopterans and other insects (2.00 each). The lowest population was recorded in *A. mellifera* (0.40) which was significantly lower than population of all other insect pollinators.

On eighth week after sowing showed the highest population (1.40) of *Anderna* sp., coleopterans and lepidopterans and was statistically on par with the population of *Trigona* sp., *A. cerana indica* (1.20 each) and dipterans (1.00). The lowest population (0.25) was recorded in *A. mellifera* and was statistically on par with the population of all other insect pollinators (0.80).

The maximum mean population of all insect pollinators were recorded in the seventh week after sowing during the rainy season. *A. cerana indica*, *A. mellifera*, *Trigona* sp., *Anderna* sp., coleopterans and dipterans, the minimum population was recorded in the fifth week after sowing. The minimum population of other insects and lepidopterans recorded were in the eighth week after sowing.

Bitter gourd

Summer season

Significantly higher mean population of *Trigona* sp. (4.25) was observed when compared to all other insect pollinators. *A. cerana indica* (2.90) was the second highest insect pollinator which was on par with the population of other insects (2.25). There was no significant difference in the population of *A. mellifera*, coleopterans (1.40 each), *Anderna* sp. (1.50) and lepidopterans (1.70). Significantly lowest population was recorded in dipterans (0.55).

The highest mean population of insect pollinators (2.65) were observed in seventh week after sowing during the summer season and was significantly higher than all other weeks. The lowest population of insect pollinators (1.65) was observed in eighth week after sowing and was on par with the population of fifth week after sowing (1.70).

Trigona sp. recorded the highest population (4.00) on fifth week after sowing and was significantly higher than the population of all other insect pollinators. *A. cerana indica* and lepidopteran (2.00 each) population were the second highest insect pollinators which was on par with the population of other insects (1.80) and coleopterans (1.40). The lowest population was recorded in dipterans (0.40) and was on par with the population of *A. mellifera* and *Anderna* sp. (1.00 each).

In the case of sixth week after sowing, the highest population of *Trigona* sp. recorded was 3.20 and was significantly higher than the population of all other insect pollinators. *A. cerana indica* (3.20) was statistically the second highest insect pollinator. There was no significant difference in the population of other insects, *A. mellifera*, *Anderna* sp., coleopterans and lepidopterans (1.40 each).

The data on the seventh week after sowing showed the highest population of *Trigona* sp. (5.20) and *A. cerana indica* (3.20) was the second highest insect pollinator which was on par with the population of other insects (1.80). The lowest population was recorded in dipterans (0.80) which was statistically on par with the population of lepidopterans (1.20), *A. mellifera* and coleopterans (1.00 each).

On eighth week after sowing showed the highest population of *Trigona* sp. (3.60) and was significantly higher than the population of all other insect pollinators recorded. *A. cerana indica* (2.60) was the second highest insect pollinator which was statistically on par with the population of other insects (1.80). The lowest population was observed in dipterans (0.40) which was statistically on par with the population of lepidopterans (1.20), *A. mellifera* and coleopterans (1.00 each).

The maximum mean population of all insect pollinators were recorded in seventh week after sowing during the summer season. The minimum population of *A. cerana indica*, *Trigona* sp., *Anderna* sp., coleopterans and dipterans were recorded in fifth week after sowing and *A. mellifera*, coleopterans, lepidopterans and other insects were recorded in eighth week after sowing during the summer season.

Rainy season

Observations on the relative abundance of different insect pollinators visiting bitter gourd flowers revealed the maximum mean population of *Trigona* sp. (2.95) which was significantly higher than the population of all other insect pollinators. The lowest population observed in *Anderna* sp. was 0.80 and was statistically on par with the population of *A. mellifera*, coleopterans and lepidopterans, the population being 0.90, 0.95 and 1.05, respectively.

The highest mean population of insect pollinators (2.03) was observed in seventh week after sowing which was significantly higher than all other weeks. The lowest population of insect pollinators (1.95) was observed in fifth week after sowing which was significantly lower than the population in all other weeks.

The data on the fifth week after sowing showed the highest level of *Trigona* sp. (2.40) and was statistically on par with the population of *A. cerana indica* (1.80).

The lowest population was recorded in dipterans (0.40) and had no significant difference with the population recorded in *A. mellifera*, coleopterans, lepidopterans (0.60 each) and other insects (0.80).

The highest population of *Trigona* sp. (3.00) was recorded on sixth week after sowing and was on par with the population of *A. cerana indica* (2.60). The lowest population was recorded in coleopterans (0.80) and had no significant difference with the population recorded in *A. mellifera*, *Anderna* sp., lepidopterans (1.00 each) and dipterans (1.20).

In the case of seventh week after sowing, the highest population of *Trigona* sp. recorded was 3.60 and was on par with the population of *A. cerana indica* (3.00). The lowest population was recorded in *Anderna* sp. (1.20) and had no significant difference with the population recorded in *A. mellifera*, dipterans, lepidopterans (1.40 each) and coleopterans (1.60).

Significantly highest population of *Trigona* sp. (2.80) was observed in eighth week after sowing and was statistically on par with the population of *A. cerana indica* (2.00). The lowest population (0.60) was recorded in *A. mellifera* and *Anderna* sp. (1.20) and was on par with the population of coleopterans (0.80), lepidopterans (1.20) and other insects (1.40).

The maximum mean population of all insect pollinators were recorded in seventh week after sowing and the minimum in fifth week after sowing during the rainy season.

Oriental pickling melon

Summer season

Observations on the relative abundance of different insect pollinators visiting oriental pickling melon flowers revealed the maximum mean population of *A. cerana indica* (5.45) which was significantly higher than the population of all the insect pollinators recorded. Coleopterans (2.85) and *Anderna* sp. (2.70) were the second highest insect pollinators and was significantly varied with the other insect pollinators. There was no significant difference in *Trigona* sp., lepidopterans, *A. mellifera* and other insects, the population being 2.40, 2.25.1.60 and 1.55, respectively. The lowest population was observed in dipterans (0.65) and was significantly lower than all of other insect pollinators.

The highest mean population of insect pollinators (2.40) was observed in seventh week after sowing during the rainy season and was on par with the population of pollinators in sixth week after sowing (2.33). The lowest population of insect pollinators (1.98) was observed in eighth week after sowing which was on par with the population at fifth week after sowing (2.03).

Significantly highest population of *A. cerana indica* (4.60) was observed in fifth week after sowing which was higher than the population of all other insect pollinators. Coleopterans and dipterans (2.40 each) were the second highest insect pollinators which was statistically on par with the population of *A. mellifera* (1.80) and other insects (1.60). The lowest population (0.60) was recorded in dipterans and was significantly lower than the population of all other insect pollinators.

The data on the sixth week after sowing showed the highest population of *A. cerana indica* (7.20) which was significantly higher than the population of all other insect pollinators. *Anderna* sp. (4.00) was the second highest insect pollinator which was statistically on par with the population of *Trigona* sp. (3.60) and coleopterans (3.20). There was no significant difference in the population of lepidopterans,. other insects and *A. mellifera* (2.20 each). Significantly lower population (1.00) was recorded in dipterans.

Significantly, the highest population of *A. cerana indica* (5.20) was observed on seventh week after sowing when compared with population of all other insect pollinators recorded. *Anderna* sp. (3.40) was the second highest insect pollinator. There was no significant difference in the population of coleopterans (2.80), *Trigona* sp. (2.60) and lepidopterans (2.00). The lowest population (0.40) was recorded in dipterans and was on par with the population of other insects (1.20).

On eighth week after sowing the highest population of *A. cerana indica* (4.80) was significantly higher than the population of all other insect pollinators. *Anderna* sp. (2.60) was the second highest insect pollinator and was on par with the population of coleopterans (2.40) and *Trigona* sp. (2.00). The lowest population (0.60) was recorded in dipterans and was on par with the population of *A. mellifera* (0.80).

The maximum mean population of all insect pollinators were recorded in seventh week after sowing and the minimum population of insect pollinators were recorded in fifth and eighth week after sowing during the summer season.

Rainy season

Observations on the relative abundance of different insect pollinators visiting oriental pickling melon flowers revealed the maximum mean population of *A. cerana indica* (3.65) which was significantly higher than the population of all other insect pollinators. Coleopterans (2.10) were second highest insect pollinators and was on par with the population of lepidopterans (1.80). There was no significant difference in dipterans, *Anderna* sp. and *A. mellifera*, the population being 1.65, 1.60 and 1.45, respectively. The lowest population was observed in *Trigona* sp. (1.15) and was on par with the population of other insects (1.25).

The highest mean population of insect pollinators (2.53) was observed in seventh week after sowing during the rainy season and was significantly higher than all other weeks. The lowest population of insect pollinators (1.38) was observed in fifth week after sowing which was on par with the population at eighth week after sowing (1.43).

The data on the fifth week after sowing showed the highest population of *A. cerana indica* (3.20) and was significantly higher than the population of all other insect pollinators. There was no significant difference in the population of dipterans (1.60), lepidopterans, coleopterans and *A. mellifera* (1.40 each) and were the second highest insect pollinating group observed. The lowest population (0.60) was recorded in other insects and *Trigona* sp. which was statistically varied with other insect pollinators.

Significantly highest population of *A. cerana indica* (3.60) was observed on sixth week after sowing which was higher than the population of all other insect pollinators. Coleopterans (2.60) was the second highest insect pollinator which was on par with the population of *Anderna* sp. (2.00). The lowest population (1.40) was recorded in dipterans and lepidopterans and was on par with the population of

A. mellifera, *Trigona* sp. and other insects, the population being 1.60, 1.60 and 1.80, respectively.

In the case of seventh week after sowing showed the highest population of *A. cerana indica* (4.80) which was significantly higher than the population of all other insect pollinators. Coleopteran (2.80) was the second highest insect pollinator and was statistically on par with the population of lepidopterans (2.60) and *Anderna* sp., dipterans (2.40 each). The lowest population (1.60) was recorded in *Trigona* sp. and was on par with the *A. mellifera* and other insects (1.80 each).

A. cerana indica recorded the highest population (3.00) on eighth week after sowing and was significantly higher than the population of all other insect pollinators. Lepidopterans (1.80) was the second highest insect pollinator and had no significant variation with the population recorded in coleopterans (1.60) and *Anderna* sp., dipterans (1.20 each). The lowest population (0.80) was recorded in other insects and was on par with the population of *A. mellifera* (1.00).

The maximum mean population of all insect pollinators was recorded in seventh week after sowing and the minimum population recorded in fifth and eighth week after sowing during the rainy season.

4.1.3 Extent of damage, population of pests and their natural enemies of cucurbits

Snake gourd

The extent of damage caused by various pests, population of pests and their natural enemies of snake gourd are presented in Table 4.

Extent of damage caused by pests

Summer season

The maximum mean percentage of damage to the leaves of snake gourd by the various pests was occurred during the fifth week after sowing (21.83) which was statistically similar to the percentage damage caused during fourth (19.00) and sixth (20.83) week after sowing. The minimum mean percentage damage on the leaves was recorded during the eighth week after sowing (14.17) and was statistically on par with

Table 4. The extent of damage caused by various pests, population of pests and their natural enemies of snake gourd recorded in the farmer's field of Kalliyoor panchayat (Mean population / plant)

Pests / Natural enemies	Summer season (Weeks after sowing)						Mean	Rainy season (Weeks after sowing)						Mean
	III	IV	V	VI	VII	VIII		III	IV	V	VI	VII	VIII	
Extent of damage caused by pest (Percentage)														
Aulacophora sp.	10.00	20.00	29.33	34.00	20.67	20.67	22.44	12.00	25.33	30.00	33.33	17.33	20.00	23.00
Henosepilachana sp.	21.33	22.67	28.67	26.00	22.67	20.67	23.67	16.00	22.00	24.67	20.00	20.00	16.00	19.78
Aphis gossypii	16.00	20.00	18.67	14.67	12.00	10.00	15.22	10.00	12.67	10.67	7.33	6.67	5.33	8.78
Liriomyza trifolii	10.67	13.33	10.67	8.67	6.67	5.33	9.22	6.00	7.33	4.00	4.00	4.00	2.67	4.67
Mean	14.50	19.00	21.83	20.83	15.50	14.17	-	11.00	16.83	17.33	16.17	12.00	11.00	-
Population of Pests														
Aulacophora sp.	1.13	2.47	3.40	2.13	2.33	1.87	2.22	1.00	2.40	2.87	2.20	2.07	2.47	2.17
Anadevidia peponis	1.40	3.00	4.40	4.60	3.33	2.80	3.26	1.20	2.67	3.53	4.27	3.33	3.33	3.06
Diaphania indica	1.87	3.00	3.33	3.53	3.33	2.93	3.00	0.53	0.80	1.73	1.13	0.87	0.80	0.98
Population of Natural enemies														
Coccinellid beetles	0.93	0.93	1.47	1.80	2.73	3.00	1.81	0.27	0.60	0.80	1.13	1.40	1.60	0.97
Apanteles sp.	0.40	0.80	2.27	2.53	3.00	3.07	2.01	0.33	0.80	1.33	1.40	2.00	2.27	1.36
Spiders	0.33	0.60	0.87	1.27	1.53	2.07	1.11	0.13	0.53	1.00	1.33	1.80	1.93	1.12
Mean	1.01	1.80	2.62	2.64	2.71	2.62	-	0.58	1.30	1.88	1.91	1.91	2.07	-

CD (0.05) :	Population of pests and Natural enemies	Extent of damage
Insect mean	: 0.316	2.249
Season × period	: 0.316	2.755
Insect × Season × Period	: 0.773	5.510

the third (14.50) and seventh (15.50) week after sowing.

The highest mean percentage of damage to the leaves caused by *Henosepilachna* sp was 23.67 and was on par with the percentage damage caused by *Aulacophora* sp. (22.44) and *A. gossypii* (15.22). The lowest infestation caused by *L. trifolii* was 9.22.

The percentage damage caused to the leaves by *Aulacophora* sp. during the summer season ranged from 10.00 to 34 .00. The infestation was highest during sixth week after sowing and the damage was statistically on par with the damage caused during fifth week after sowing (29.33) and followed in the fourth (20.00), seventh and eighth week after sowing (20.67 each). Significantly lower infestation was observed during the third week after sowing (10.00).

The infestation by *Henosepilachna* sp. during summer season ranged from 20.67 to 28.67. The highest infestation by the pest was observed during the fifth week after sowing which was on par with the damage caused during sixth week after sowing (26.00). The lowest damage to the leaves occurred during eighth week after sowing (20.67) and was on par with the third (21.33), fourth and seventh week after sowing, the percentage damage being (22.67 each).

The damage caused by *A. gossypii* to the leaves of snake gourd during the summer season ranged from 10.00 to 20.00 per cent. The lowest damage was recorded during the eighth week after sowing and was statistically similar with the damage observed in seventh (12.00) and sixth (14.67) week after sowing. Maximum damage was recorded during fourth week after sowing and was on par with the damage recorded in third (16.00) and fifth (18.67) week after sowing.

The damage of the *L. trifolii* during the summer season ranged from 5.33 to 13.33. The highest damage was noticed during fourth week after sowing and was statistically similar to that of third and fifth week after sowing (10.67 each). The lowest percentage of infestation was recorded in eighth week after sowing (5.33) and was on par with the seventh (6.67) and sixth (8.67) week after sowing.

Rainy season

The maximum mean percentage damage to the leaves by the various pests was occurred during the fifth week after sowing (17.33) which was statistically similar to the percentage damage caused during fourth (16.83) and sixth (16.17) week after sowing. The minimum mean percentage damage on the leaves was recorded during the third and eighth week after sowing (11.00 each) and was statistically on par with the seventh week after sowing (12.00).

The highest mean damage percentage to the leaves by *Aulacophora* sp. (23.00) and was significantly the highest percentage damage compared to rest of the pests. The lowest infestation damage caused by *L. trifolii* (4.67) which was statistically on par with the *A. gossypii* (8.78).

The percentage damage to the leaves by *Aulacophora* sp. during the rainy season ranged from 12.00 to 33.33. The infestation was the highest during the sixth week after sowing and the damage was statistically on par with the damage caused during fourth and eighth week after sowing, the percentage of damage being 25.33 and 20.00, respectively. The lowest infestation was the during third week after sowing and the leaf damage was statistically on par with the damage occurred during seventh week after sowing (17.33).

The infestation by *Henosepilachna* sp. during rainy season ranged from 16.00 to 24.67. The highest infestation by the pest was observed during the fifth week after sowing which was statistically on par with the damage caused during fourth week after sowing (22.00). The lowest damage to the leaves occurred during third and eighth week after sowing (16.00 each) and was statistically on par with the sixth week after sowing, the percentage damage being (20.00).

The damage caused by *A. gossypii* to the leaves of oriental pickling melon during the rainy season ranged from 5.33 to 12.67 per cent. The lowest damage was recorded during the eighth week after sowing and was statistically similar with the damage observed in sixth (7.33) and seventh (6.67) week after sowing. Maximum damage was recorded during fourth week after sowing and was on par with the damage recorded in third (10.00) and fifth (10.67) week after sowing.

L. trifolii caused 2.67 to 7.33 per cent damage during the rainy season. The highest damage was noticed during fourth week after sowing and was statistically similar to that of third week after sowing (6.00). The lowest percentage of infestation was recorded in fifth, sixth and seventh week after sowing (4.00 each).

Insect pests

Summer season

The highest population of *Aulacophora* sp. (3.40) was observed at fifth week after sowing which was significantly higher than other weeks *viz.,* fourth, seventh and sixth weeks after sowing, the population being 2.47, 2.33 and 2.13, respectively. They were on par with each other. The lowest population (1.13) was observed at third week after sowing and was statistically on par with the population of eighth week after sowing (1.87).

The population of *A. peponis* recorded during the summer season ranged from 1.40 to 4.60. The highest population was observed at sixth week after sowing which was on par with the population of fifth week after sowing (4.40). Fourth, seventh and eighth week after sowing, the population was 3.00, 3.33 and 2.80, respectively. They were on par with each other. The significantly lowest population was observed at third week after sowing.

D. indica recorded during the summer season ranged from 1.87 to 3.53. The highest population was observed at sixth week after sowing which was on par with the population of fifth, seventh (3.33 each), fourth (3.00) and eighth week after sowing (2.93). The lowest population was observed at third week after sowing which was significantly lower than the other weeks.

Rainy season

The population of *Aulacophora* sp. recorded during the rainy season ranged from1.00 to 2.87. The highest population of the beetle was observed at fifth week after sowing which was on par with the population of fourth (2.40) and sixth (2.20) week after sowing. The lowest population (1.00) was observed at third week after sowing.

A. peponis recorded during the rainy season ranged from 1.20 to 4.27. The highest population was observed at sixth week after sowing and was on par with the population of fifth (3.53), seventh and eighth (3.33 each) week after sowing. The lowest population (1.20) was observed at the third week after sowing.

The population of *D. indica* caterpillar recorded during the rainy season ranged from 0.53 to 1.73. The highest population was recorded at fifth week after sowing which was on par with the population of sixth week after sowing (1.13). The lowest population (0.53) was observed at third week after sowing which was on par with the population of fourth, seventh and eighth week after sowing, the population being 0.80, 0.87 and 0.80, respectively.

Natural enemies

Summer season

The population of coccinellid beetles recorded during the summer season ranged from 0.93 to 3.00. The highest population was observed at eighth week after sowing which was on par with the population of seventh week after sowing (2.73). There was no significant difference in the population of fifth (1.47) and sixth (1.80) week after sowing. The lowest population (0.93) was observed at third and fourth week after sowing.

The highest population of *Apanteles* sp. (3.07) was observed at eighth week after sowing which was on par with the population of sixth (2.53) and fifth (2.27) week after sowing. The lowest population (0.40) was observed at third week after sowing which was on par with the population of fourth week after sowing (0.80).

Spiders recorded during the summer season ranged from 0.33 to 2.07. The highest population was observed at eighth week after sowing and was on par with the population of seventh (1.53). The lowest population was observed at third week after sowing and was on par with the population of fourth (0.60) and fifth week after sowing (0.87).

Rainy season

The population of the coccinellid beetles recorded during the rainy season ranged from 0.27 to 1.60. The highest population was observed at eighth week after sowing which was on par with the population of sixth (1.13) and seventh (1.40) week after sowing. The lowest population was observed at third week after sowing which was on par with the population of fourth (0.60) and fifth (0.80) week after sowing.

The population of *Apanteles* sp. recorded during the rainy season varied from 0.33 to 2.27. The highest population was observed at eighth week after sowing and was on par with the population of seventh week after sowing (2.00). There was no significant difference in the population of fifth (1.33) and sixth (1.40) week after sowing. The lowest population was observed at third week after sowing which was on par with the population of fourth week after sowing (0.80).

The spiders recorded during the rainy season ranged from 0.13 to 1.93. The highest population was observed at eighth week after sowing and was at par with the population of seventh (1.80) and sixth (1.33) week after sowing. The lowest population was observed at third week after sowing which did not show any statistical variation with the population of fourth week after sowing (0.53).

Insect pests × Natural enemies

Summer season

The maximum mean population (2.71) of insect pests and their natural enemies were observed at seventh week after sowing which was on par with the population of sixth (2.64), fifth and eighth week after sowing (2.62 each). The lowest population (1.01) was observed at third week after sowing which was significantly lower than the population recorded in other weeks.

The highest mean population of 3.26 was observed by *A. peponis* during the summer season and followed by *D. indica* (3.00). There was no significant difference in the population of *Aulacophora* sp. and coccinellid beetles, the population ranged from 1.81 to 2.22. The lowest population (1.11) was observed in spiders and significantly lower than the other pests and natural enemies.

Rainy season

The maximum mean population (2.07) of insect pests and their natural enemies were observed at eighth week after sowing which was on par with the population of seventh, sixth and eighth week after sowing, the population being 1.91, 1.91 and 1.88, respectively. Significantly lowest population of 0.58 was observed at third week after sowing.

The highest mean population (3.06) observed in *A. peponis* and was significantly higher than the other insect pests and natural enemies followed by *Aulacophora* sp. (2.17). The lowest population (0.97) was observed in coccinellid beetles and was statistically on par with the spiders (1.12) and *Apanteles* sp. (1.36).

Bitter gourd

The extent of damage caused by various pests, population of pests and their natural enemies of bitter gourd are presented in Table 5.

Extent of damage caused by various pests

Summer season

The infestation by *Henosepilachna* sp. during summer season ranged from 14.67 to 22.67 per cent. The highest infestation by the pest was observed during the fifth week after sowing which was statistically on par with the damage caused during fourth (19.33) and sixth (21.33) week after sowing. The lowest damage to the leaves occurred during eighth week after sowing and was statistically on par with the damage percentage observed at seventh week after sowing (17.33).

The damage caused by *A. gossypii* to the leaves of bitter gourd during the summer season varied from 14.67 to 23.33 per cent. The lowest damage was recorded during the eighth week after sowing and was statistically similar with the damage observed in seventh (16.67) week after sowing. Maximum damage was recorded during fourth week after sowing and was on par with the damage recorded during third (21.33), fifth and sixth week after sowing (19.33 each).

Table 5. The extent of damage caused by various pests, population of pests and their natural enemies of bitter gourd recorded in the farmer's field of Kalliyoor panchayat (Mean population / plant)

Pests / Natural enemies	Summer season (Weeks after sowing)						Mean	Rainy season (Weeks after sowing)						Mean
	III	IV	V	VI	VII	VIII		III	IV	V	VI	VII	VIII	
Extent of damage caused by pest (Percentage)														
Henosepilachana sp.	16.00	19.33	22.67	21.33	17.33	14.67	18.56	13.33	16.00	18.67	20.00	16.00	14.67	16.44
Aphis gossypii	21.33	23.33	19.33	19.33	16.67	14.67	19.11	12.00	16.67	12.00	11.33	10.00	7.33	11.56
Liriomyza trifolii	16.67	20.67	17.33	14.00	12.67	11.33	15.44	12.00	14.00	10.67	10.00	8.00	6.00	10.11
Mean	18.00	21.11	19.78	18.22	15.56	13.56	-	12.44	15.56	13.78	13.78	11.33	9.33	-
Population of Pests														
Anadevidia peponis	1.33	2.67	3.73	4.27	2.73	2.40	2.86	0.87	2.47	3.67	4.07	2.60	2.33	2.67
Diaphania indica	0.80	2.33	3.13	3.07	2.73	2.27	2.39	0.40	0.93	1.47	1.80	1.53	1.27	1.23
Population of Natural enemies														
Coccinellid beetles	0.73	1.00	1.27	1.73	2.13	2.67	1.59	0.40	0.60	0.87	1.20	1.33	1.40	0.97
Apanteles sp.	0.47	1.00	1.93	2.53	2.87	3.13	1.99	0.27	0.67	1.67	2.20	2.47	2.40	1.61
Spiders	0.33	0.60	1.27	1.47	1.73	2.00	1.23	0.33	0.67	0.87	1.13	1.27	1.27	0.92
Mean	0.73	1.52	2.27	2.61	2.44	2.49	-	0.45	1.07	1.71	2.08	1.84	1.73	-

CD (0.05) :	Population of pests and Natural enemies	Extent of damage
Insect mean	: 0.267	2.825
Season × period	: 0.295	3.995
Insect × Season × Period	: 0.660	6.921

L. trifolii caused damage to the bitter gourd leaves and it ranged from 11.33 to 20.67 per cent during the summer season. The highest damage was noticed during fourth week after sowing and was statistically similar to that of third (16.67) and fifth (17.33) week after sowing. The lowest percentage of infestation was recorded in eighth week after sowing which was on par with the sixth (14.07) and seventh (12.67) week after sowing.

The maximum mean percentage damage to the leaves by the various pests was occurred during fourth week after sowing (21.11) which was statistically similar to the damage caused during third (18.00), fifth (17.33) and sixth (18.22) week after sowing. The minimum mean percentage damage was recorded during eighth week after sowing (13.56) and was statistically on par with damage caused in seventh week after sowing (15.56).

The highest mean percentage damage caused to the leaves by *A. gossypii* (19.11) and was on par with the percentage damage caused by *Henosepilachna* sp. (18.56). Infestation caused by *L. trifolii* was significantly lowest (15.44).

Rainy season

The infestation by *Henosepilachna* sp. during rainy season ranged from 13.33 to 20.00 per cent. The highest infestation by the pest was observed during the sixth week after sowing which was statistically on par with the damage caused during fifth week after sowing (18.67). The lowest damage to the leaves occurred during third week after sowing and was on par with the fourth, sixth (16.00 each) and eighth week after sowing (14.67).

The damage caused by *A. gossypii* to the leaves of bitter gourd ranged from 7.33 to 16.67 per cent during the summer season. The lowest damage was recorded during the eighth week after sowing and was statistically similar with the damage observed in sixth (11.33) and seventh (10.00) weeks after sowing. Maximum damage was recorded during fourth week after sowing (16.67) and was on par with the damage recorded during third and fifth weeks after sowing (12.00 each).

L. trifolii caused the damage on bitter gourd leaves which ranged from 6.00 to 14.00 per cent during the rainy season. The highest damage was noticed during fourth week after sowing and was statistically similar that of third (12.00) and fifth (10.67) weeks after sowing. The lowest percentage of infestation was recorded in eighth week after sowing which was on par with the sixth (10.00) and seventh (8.00) weeks after sowing.

The maximum mean percentage damage to the leaves by the various pests was occurred during the fourth week after sowing (15.56) which was statistically similar to that caused during fifth and sixth weeks after sowing (13.78 each). The minimum mean percentage damage was recorded during the eighth week after sowing (9.33) and was on par with the seventh week after sowing, the percentage damage being 8.00.

The highest mean percentage damage to the leaves by *Henosepilalchna* sp. (16.44) when compared to other pests. The lowest percentage of infestation caused by *L. trifolii* (10.11) which was statistically on par with the *A. gossypii* (11.56) .

Insect pests

Summer season

The population of *A. peponis* recorded during the summer season ranged from 1.33 to 4.27. The highest population (4.27) was observed at sixth week after sowing which was on par with the population observed during fifth week after sowing (3.73). The lowest population was observed at third week after sowing and was significantly lower than all other observations.

D. indica was recorded during the summer season, the population ranged from 0.80 to 3.13. The highest population of 3.13 was observed at fifth week after sowing which was on par with the population of sixth (3.07) and seventh (2.73) week after sowing. Significantly lower population (0.80) was observed at the third week after sowing.

Rainy season

A. peponis recorded during the rainy season ranged from 0.87 to 4.07. The highest population was observed at sixth week after sowing which was on par with the population of fifth week after sowing (3.67). Significantly lower population (0.87) was observed at third week after sowing.

The observed population of *D. indica* ranged from 0.40 to 1.80. The highest population was observed at sixth week after sowing which was on par with the population noticed during seventh, fifth, and eighth week after sowing (1.53, 1.47 and 1.27 respectively). Significantly lower population (0.93) was observed at third week after sowing.

Natural enemies

Summer season

The population of coccinellid beetles was recorded during the summer season ranged from 0.73 to 2.67. The highest population was observed at eighth week after sowing and was on par with the population of seventh week after sowing (2.13). The lowest population of 0.73 was observed at third week after sowing which was on par with the population of fourth week after sowing (1.00) .

Apanteles sp. was recorded during the summer season, the population ranged from 0.47 to 3.13. The highest population was observed at eighth week after sowing and was on par with the population of seventh week after sowing (2.87). The lowest population was observed at third week after sowing and was on par with the population of fourth week after sowing (1.00).

The highest population of spiders (2.00) was observed at eighth week after sowing which was on par with the population of seventh week after sowing (1.73). The lowest population (0.33) was observed at third week after sowing and was on par with the population of fourth week after sowing (0.60). The mean population of the spiders recorded during the summer season ranged from 0.33 to 2.00.

Rainy season

The highest population of coccinellid beetles (1.40) were observed at eighth week after sowing and was on par with the population of seventh (1.33) and sixth week after sowing (1.20). The lowest population (0.40) was observed at third week after sowing which was on par with the population of fourth (0.60) and fifth week after sowing (0.87) .

Apanteles sp. recorded during the rainy season ranged from 0.27 to 2.47. The highest population was observed at seventh week after sowing which was on par with the population of eighth (2.40) and sixth (2.20) week after sowing. The lowest population (0.27) was observed at third week after sowing which did not show statistical variation with the population of fourth week after sowing (0.67).

Spiders recorded during the rainy season ranged from 0.33 to 1.27. The highest population was observed at the seventh and eighth week after sowing which was on par with the population of sixth week after sowing (1.13). The lowest population was observed at third week after sowing and was statistically same as the population recorded in fourth (0.67) and fifth week after sowing (0.87).

Insect pests × Natural enemies

Summer season

The maximum mean population of insect pests and natural enemies (2.61) was observed at sixth week after sowing which was on par with the population of seventh week after sowing (2.44) and eighth (2.49) week after sowing. The lowest population (0.73) was observed in third week after sowing which was significantly lower than the insect pests and natural enemies observed in all other weeks.

The highest mean population (2.86) observed in *A. peponis* during the summer season which was significantly higher than the population of all other insect pests and natural enemies. *D. indica*, *Apanteles* sp. and coccinellid beetles population were 2.39, 1.99 and 1.59, respectively and they were on par with each other. The lowest population (1.23) was observed in spiders which was significantly lower than the all other insect pests and natural enemies.

Rainy season

The maximum mean population of insect pests and natural enemies (2.08) were observed at sixth week after sowing which was on par with the population recorded at seventh week after sowing (1.84). Eighth, fifth and fourth weeks after sowing population was 1.73, 1.71 and 1.07 respectively. The lowest population (0.45) was observed at the third week after sowing which was significantly lower than the other weeks of population.

The highest mean population of *A. peponis* observed during the rainy season which was 2.67 which was significantly higher than the population of all other pests and natural enemies . The population of *D. indica* and *Apanteles* sp. was 1.23 and 1.61 respectively. The lowest population of spiders was 0.92 which was on par with the population of coccinellid beetles (0.97).

Oriental pickling melon

The extent of damage caused by various pests, population of pests and their natural enemies of oriental pickling melon is presented in Table 6.

Extent of damage caused by various pests

Summer season

The maximum mean percentage damage to the leaves by the various pests was occurred during the fifth week after sowing (29.17) which was statistically similar to the percentage damage caused during fourth (27.33) and sixth week after sowing (28.00). The minimum mean percentage damage to the leaves was recorded during the eighth week after sowing (20.17) and was statistically on par with the third and seventh week after sowing, the percentage damage being 23.50 and 22.50, respectively.

The mean population of various pests recorded in six observations showed the highest damage caused by *A. gossypii* in the leaves was 29.78 per cent which was statistically on par with the *Aulacophora* sp. (28.89) and followed by *Henosepilalchna* sp. (21.89). Significantly lower infestation percentage was caused by *L. trifolii* (19.89).

Table 6. The extent of damage caused by various pests, population of pests and their natural enemies of oriental pickling melon recorded in the farmer's field of Kalliyoor panchayat (Mean population / plant)

Pests / Natural enemies	Summer season (Weeks after sowing)						Mean	Rainy season (Weeks after sowing)						Mean
	III	IV	V	VI	VII	VIII		III	IV	V	VI	VII	VIII	
Extent of damage caused by pest (Percentage)														
Aulacophora sp.	13.33	24.00	37.33	42.00	27.33	29.33	28.89	10.00	24.00	20.67	25.33	16.67	13.33	18.33
Henosepilachana sp.	21.33	25.33	26.67	22.00	20.00	16.00	21.89	17.33	22.00	24.67	21.33	16.67	14.67	19.44
Aphis gossypii	36.67	34.67	31.33	29.33	26.00	20.67	29.78	22.67	20.67	18.00	16.67	14.00	11.33	17.22
Liriomyza trifolii	22.67	25.33	21.33	18.67	16.67	14.67	19.80	16.00	21.33	16.00	11.33	9.33	7.33	13.56
Mean	23.50	27.33	29.17	28.00	22.50	20.17	-	16.50	22.00	19.83	18.67	14.17	11.67	-
Population of Pests														
Aulacophora sp.	1.33	2.60	3.93	3.73	3.13	2.53	2.88	1.47	1.53	2.33	2.07	1.60	1.40	1.73
Anadevidia peponis	1.33	2.20	3.60	2.73	1.87	1.73	2.24	0.80	2.07	3.27	2.80	2.47	1.80	2.20
Diaphania indica	1.27	2.33	2.80	2.33	2.33	1.87	2.16	0.60	1.13	1.67	1.27	1.00	0.73	1.07
Population of Natural enemies														
Coccinellid beetles	0.80	1.27	1.73	2.20	2.80	3.20	2.00	0.60	0.80	1.00	1.27	1.47	1.80	1.16
Apanteles sp.	0.33	0.67	1.27	1.40	2.00	2.20	1.31	0.07	0.33	0.53	0.73	1.13	1.27	0.68
Spiders	0.73	1.27	2.07	2.87	2.80	2.93	2.11	0.40	0.73	1.53	2.67	3.13	3.07	1.92
Mean	0.97	1.72	2.57	2.54	2.49	2.41	-	0.66	1.10	1.72	1.80	1.80	1.68	-

CD (0.05) :	Population of pests and Natural enemies	Extent of damage
Insect mean	: 0.349	2.842
Season × period	: 0.349	4.923
Insect × season × period	: 0.855	9.846

The percentage damage to the leaves by *Aulacophora* sp. during the summer season ranged from 13.33 to 42.00. The infestation was the highest during the sixth week after sowing and the damage was statistically on par with the damage caused during fifth week after sowing (37.33). There was no significant difference in the percentage damage caused in seventh (27.33) and eighth weeks after sowing (29.33). The lowest infestation was the during third week after sowing and the leaf damage was statistically on par with the fourth week after sowing (24.00).

The infestation caused by *Henosepilachna* sp. during summer season ranged from 16.00 to 26.67. The highest infestation by the pest was observed during fifth week after sowing which was statistically on par with the damage caused during fourth, sixth and third weeks after sowing, the percentage infestation being 25.33, 22.00 and 21.33, respectively. The lowest damage to the leaves occurred during eighth week after sowing and was on par with the seventh week after sowing (20.00).

The damage caused by *A. gossypii* to the leaves of oriental pickling melon during the summer season ranged from 20.67 to 36.67 per cent. The lowest damage was recorded during the eighth week after sowing and was statistically similar with the damage observed in seventh week after sowing (26.00). Maximum damage was recorded during third week after sowing and was on par with the damage recorded during fourth (34.67), fifth (31.33) and seventh (26.00) week after sowing.

A damage level of 14.67 to 25.33 per cent caused by *L. trifolii* was observed during the summer season. The highest damage was noticed during fourth week after sowing and was statistically similar to that of third (22.67) and fifth weeks after sowing (21.33). The lowest percentage of infestation recorded in eighth week after sowing was 14.67 which was on par with the sixth (18.67) and seventh (16.67) week after sowing.

Rainy season

The damage caused to the leaves by *Aulacophora* sp. during the rainy season ranged from 10.00 to 25.33 per cent. The infestation was the highest during the sixth week after sowing and the damage was statistically on par with the damage caused during fourth and fifth weeks after sowing, the percentage of damage being 24.00 and 20.67, respectively. The lowest infestation was during the third week after sowing and the leaf damage was statistically on par with the seventh (16.67) and eighth (13.33) weeks after sowing.

The infestation by *Henosepilachna* sp. during rainy season ranged from 14.67 to 24.67. The highest infestation by the pest was observed during the fifth week after sowing which was statistically on par with the damage caused during fourth (22.00) and sixth (21.33) week after sowing. The lowest damage to the leaves occurred during eighth week after sowing (14.67) and was on par with the seventh and third weeks after sowing, the percentage damage being 16.67 and 17.33 respectively.

The damage caused by *A. gossypii* to the leaves of oriental pickling melon during the rainy season ranged from 11.33 to 22.67 per cent. The lowest damage was recorded during the eighth week after sowing (11.33) and was statistically similar with the damage observed in sixth (16.67) and seventh (14.00) weeks after sowing. Maximum damage was recorded during third week after sowing and was on par with the damage recorded during fourth (20.67) and fifth (18.00) weeks after sowing.

The damage caused by *L. trifolii* ranged from 7.33 to 21.33 per cent during the rainy season. The highest damage was noticed during fourth week after sowing and was statistically similar to that of third and fifth week after sowing (16.00 each). The lowest percentage of infestation recorded in eighth week after sowing was 7.33 which was on par with the percentage of infestation observed in seventh week after sowing (9.33).

The maximum mean percentage damage to the leaves caused by the various pests was occurred during fourth week after sowing (22.00) which was statistically similar to the percentage damage caused during fifth (19.83) and sixth (18.67) weeks after sowing. The minimum mean percentage damage to the leaves was recorded during the eighth week after sowing (11.67) and was on par with the third and seventh weeks after sowing, the percentage damage being 16.50 and 14.17, respectively.

The highest percentage damage to the leaves by *Henosepilalchna* sp. was 19.44 and followed by *A. gossypii* (17.22) and *Aulacophora* sp. (18.33). Significantly lower damage was caused by *L. trifolii* (13.56).

Insect pests

Summer season

The population of the *Aulacophora* sp. recorded during the summer season ranged from 1.33 to 3.93. The highest population was observed at fifth week after sowing which was on par with the population of sixth (3.73) and seventh (3.13) weeks after sowing. The lowest population was observed at third week after sowing which was significantly lower than the population at all other weeks.

The population of the *A. peponis* recorded during the summer season varied from 1.33 to 3.60. The highest population was observed at fifth week after sowing which was significantly higher than all other weeks. The lowest population was observed at third week after sowing which was on par with the population of seventh (1.87) and eighth (1.73) weeks after sowing.

The population of the *D. indica* recorded during the summer season ranged from 1.27 to 2.80. The highest population was observed at fifth week after sowing which was on par with the population of fourth, sixth and seventh weeks after sowing (2.33 each). The lowest population was observed at third week after sowing and was on par with the population of eighth week after sowing (1.87).

Rainy season

The population of *Aulacophora* sp. recorded during the rainy season ranged from 1.40 to 2.33. The highest population of *Aulacophora* sp. was observed at fifth week after sowing which was on par with the population of sixth, seventh and fourth weeks after sowing, The population being 2.07, 1.60 and 1.53, respectively. The lowest population (1.40) was observed at the eighth week after sowing and was at par with the population of third week after sowing (1.47).

The population of *A. peponis* recorded during the rainy season ranged from 0.80 to 3.27. The highest population was observed at fifth week after sowing which was statistically same as the population of sixth (2.80) and seventh (2.47) weeks after sowing. The next higher population (2.07) was observed at fourth week after sowing which was on par with the population of eighth week after sowing (1.80). The lowest population was observed at third week after sowing which was significantly lower than the other weeks.

The highest population of *D. indica* (1.67) was observed at fifth week after sowing which was at par with the population of sixth, fourth and seventh weeks after sowing which were 1.27, 1.13 and 1.00 respectively. The lowest population (0.60) was observed at third week after sowing and was on par with the population of eighth week after sowing (0.73).

Natural enemies

Summer season

The population of the coccinellid beetles recorded during the summer season ranged from 0.80 to 3.20. The highest population was observed at eighth week after sowing which was on par with the population of seventh week after sowing (2.80). The lowest population was observed at third week after sowing and was on par with the population of fourth week after sowing (1.27).

The population of the *Apanteles* sp. recorded during the summer season ranged from 0.33 to 2.20. The highest population was observed at eighth week after sowing which was on par with the population of seventh (2.00) and sixth week after sowing (1.40). The lowest population was observed at third week after sowing which was on par with the population of fourth week after sowing (0.67).

The population of the spiders recorded during the summer season ranged from 0.73 to 2.93. The highest population was observed at eighth week after sowing which did not show any significant difference with the population of sixth (2.87) and seventh (2.80) weeks after sowing. The lowest population (0.73) was observed at third week after sowing which was statistically on par with the population of fourth week after sowing (1.27).

Rainy season

Coccinellid beetles recorded during the rainy season ranged from 0.60 to 1.80. The highest population was observed at eighth week after sowing which was on par with the population at seventh, sixth and fifth weeks after sowing which were 1.47, 1.27 and 1.00 respectively. The lowest population (0.60) was observed at third week after sowing and was on par with the population of fourth week after sowing (0.80).

The highest population of *Apanteles* sp.(1.27) was noticed at eighth week after sowing which was on par with the population of seventh, sixth and fifth weeks after sowing and were 1.13, 0.73 and 0.53 respectively. The lowest population (0.07) was observed at third week after sowing and was on par with the population of fourth week after sowing (0.53).

The population of spiders recorded during the rainy season ranged from 0.40 to 3.13. The highest population was observed at seventh week after sowing and was statistically same as that of eighth (3.07) and sixth (2.67) week after sowing. The lowest population (0.40) was recorded at third week after sowing and was on par with the population of fourth week after sowing (0.73).

Insect pests × Natural enemies

Summer season

The maximum mean population (2.57) of insect pests and natural enemies were observed at fifth week after sowing which was on par with the population of sixth, seventh and eighth weeks after sowing which were 2.54, 2.49 and 2.41, respectively. The lowest population (0.97) was observed at third week after sowing and was significantly lower than the population recorded in all other weeks.

The highest mean population (2.88) of *Aulacophora* sp. observed during the summer season and was significantly higher than the population of all other insect pests and natural enemies. *A. peponis*, *D. indica*, spiders and coccinellid beetles, the population were 2.24, 2.16, 2.11 and 2.00, respectively and they were on par with each other. The lowest population of *Apanteles* sp. observed was 1.31 which was significantly lower than all other pests and natural enemies of oriental pickling melon.

Rainy season

Significantly similar same population of insect pests and natural enemies were observed at sixth, seventh and eighth weeks after sowing and the population was 1.80, 1.80 and 1.68 respectively. The lowest population (0.66) was observed at third week after sowing which was significantly lower than the other weeks.

The highest population of *A. peponis* was observed during the rainy season (2.20) which was on par with the population of spiders (1.92). The population of *Aulacophora* sp., *D. indica* and coccinellid beetles was 1.73, 1.07 and 1.16 respectively. The lowest population of *Apanteles* sp was observed 0.68 which was significantly lower than the all other pests and natural enemies of oriental pickling melon.

4. 2 FORAGING ACTIVITY OF INSECT POLLINATORS

The data presented in Tables 7 to 9 showed the foraging activity of insect pollinators in three cucurbitaceous vegetables under pesticide free condition in the Instructional farm, College of Agriculture, Vellayani.

Assessment of peak time of insect visit

Snake gourd

The population of insect pollinators visited on snake gourd flowers was recorded at different time intervals on the seventh week after sowing (peak flowering stage) and expressed as number of bees / m ^{2} / 5 min and the data depicted in Table 7.

A. cerana indica and *Anderna* sp. started their activity at 0600 hr and continued up to 1800 hr where as *A. mellifera* and *Trigona* sp. began their activity at 0700 hr and continued up to 1600 and 1700 hr, respectively.

The maximum foraging activity of *A. cerana indica* was recorded at 0900 hr with mean number (3.20) and was on par with the foraging activity at 1000 hr (2.60). The second peak activity was observed at 0800 hr and 1100 hr (2.00 each) which was on par with the foraging activity at 1600 hr and 1800 hr (1.20 each). The minimum foraging activity was recorded at 1300 hr (0.20) which was on par with the 0600 hr, 1500 hr (0.40 each), 1700 hr (0.80), 0700 hr and 1200 hr (1.00 each).

Table 7. Relative abundance of insect pollinators visiting snake gourd flowers during various times of a day under pesticide free condition in the Instructional farm (Mean number / m ^{2} / 5 min)

Time (hrs)	*A.cerana indica*	*A.mellifera*	*Trigona* sp.	*Anderna* sp.	Coleopterans	Dipterans	Lepidopterans	Other insects
6.00	0.40	0.00	0.00	0.40	0.00	0.20	0.60	0.00
7.00	1.00	0.00	0.40	0.60	0.20	0.60	1.00	0.40
8.00	2.00	0.60	1.20	1.00	0.80	1.00	1.80	1.20
9.00	3.20	1.00	1.80	1.60	1.00	1.80	3.40	1.60
10:00	2.60	1.40	2.20	0.80	2.20	2.60	4.60	2.20
11.00	2.00	1.00	1.40	0.00	1.20	2.00	1.60	1.20
12.00	1.00	0.00	0.60	0.00	0.80	0.80	1.20	0.60
13.00	0.20	0.00	0.00	0.40	0.40	0.00	0.00	0.20
14.00	0.00	0.00	0.20	0.00	0.00	0.40	0.40	0.00
15.00	0.40	0.40	0.40	0.20	0.40	0.00	0.80	0.80
16.00	1.20	1.00	0.60	1.20	0.80	2.00	2.20	1.40
17.00	0.80	0.00	0.60	1.20	1.20	0.40	1.60	1.00
18.00	1.20	0.00	0.00	0.60	0.00	0.00	0.00	0.40
CD	0.856	0.485	0.714	0.687	0.789	0.772	0.871	0.864

The maximum foraging activity of *A. mellifera* was recorded at 1000 hr with mean number 1.40 and was on par with the foraging activity at 0900 hr, 1100 hr and 1600 hr (1.00 each). The minimum foraging activity was recorded at 0800 hr (0.60) and it was significantly lower population than rest of the hours of a day.

In case of *Trigona* sp. the recorded maximum foraging activity was at 1000 hr with mean number 2.20 and was on par with the foraging activity at 0900 hr(1.80). The second peak activity was observed at 1100 hr (1.40) and was on par with the foraging activity at 0800 hr (1.20). The minimum foraging activity was recorded at 1400 hr (0.20) and was at par with the foraging activity at 0700 hr, 1500 hr (0.40 each), 1600 hr and 1700 hr (0.60 each) respectively.

The highest foraging activity of *Anderna* sp. was observed at 0900 hr with mean number 1.60 and was on par with the foraging activity at 1600 hr and 1700 hr (1.20 each). The minimum foraging activity was recorded at 1500 hr (0.20) and was on par with 0600 hr (0.40), 0700 hr and 1800 hr (0.60 each).

The maximum foraging activity of coleopterans was recorded at 1000 hr with mean number 2.20 and was significantly higher than the rest of the hours of a day. The second peak of foraging activity was at 1100 hr and 1700 hr (1.20 each) and were on par with the foraging activity at 0800 hr, 1200 hr and 1600 hr (0.80 each). The minimum foraging activity was recorded at 0700 hr (0.20) which was on par with the foraging activity at 1300 and 1500 hr (0.40 each).

The foraging activity of dipterans was maximum at 1000 hr with mean number 2.60 and was on par with the foraging activity at 1600 hr (2.00) and 0900 hr (1.80). The minimum foraging activity was recorded at 0600 hr (0.20) which was on par with the foraging activity at 0700 hr (0.60), 1200 hr (0.80), 1400 hr and 1700 hr (0.40 each).

In the case of lepidopterans the maximum foraging activity was recorded at 1000 hr with mean number 4.60 and was significantly higher than the rest of the hours of a day. The second peak foraging activity was at 0900 hr (3.40) which was significantly higher than the rest of the hours of a day. There was no significant difference between the foraging activity at 0800 hr, 1100 hr, 1200 hr, 1600 hr and

1700 hr, the population ranged from 1.20 to 2.20. The minimum foraging activity was recorded at 1400 hr (0.40) which was on par with the foraging activity at 0600 hr (0.60) and 1500 hr (0.80).

The highest foraging activity of other insects was observed at 1000 hr with mean number 2.20 and was significantly higher than the rest of the hours of a day. The second peak foraging activity was at 0900 hr (1.60) which was on par with the foraging activity at 1600 hr (1.40), 0800 hr and 1100 hr (1.20 each). The minimum foraging activity was recorded at 1300 hr (0.20) which was on par with the foraging activity at 0700 hr (0.40), 1200 hr (0.60) and1500 hr (0.80) respectively.

There were two peak foraging hours, first peak was in the morning and the second was in the evening hours. The first peak and maximum foraging activity of *A. cerana indica*, *Anderna* sp., *A. mellifera* and *Trigona* sp. recorded at 0900 hr, 0900 hr, 1000 hr and 1000 hr with mean number 3.20, 1.60, 1.40 and 2.20, respectively. The second peak activity of these bees was with mean number of 1.20, 1.20, 1.00 and 0.60, respectively.

The first peak of coleopterans, dipterans, lepidopterans and other insects were recoded at 1000 hr with mean number 2.20, 2.60, 4.60 and 2:20, respectively. The second peak activity of these group of insects was at 1600 hr with mean number 0.80, 2.00, 2.20 and 1.40, respectively.

Bitter gourd

The population of insect pollinators visited on bitter gourd flowers was recorded at different time intervals on the seventh week after sowing (peak flowering stage) and expressed as number of bees / m^2 / 5 min and is depicted in Table 8.

A. cerana indica and *Anderna* sp. started their activity at 0600 hr and continued up to 1800 hr whereas *A. mellifera* and *Trigona* sp. began their activity at 0700 hr and continued up to 1700 hr.

The maximum foraging activity of *A. cerana indica* was observed at 1000 hr (4.00) and was on par with at 1100 hr and 1600 hr with mean number (3.60 each). The second peak activity was at 1700 hr (2.80) and was on par with the foraging activity at 1200 hr and 1500 hr (2.40 each). The minimum foraging activity was recorded at

Table 8. Relative abundance of insect pollinators visiting bitter gourd flowers during various times of a day under pesticide free condition in the Instructional farm (Mean number / m^2 / 5 min).

Time (hrs)	*A. cerana indica*	*A. mellifera*	*Trigona* sp.	*Anderna* sp.	Coleopterans	Dipterans	Lepidopterans	Other insects
6.00	0.40	0.00	1.00	0.40	0.00	1.00	0.00	0.00
7.00	0.60	0.40	1.00	0.60	0.40	0.80	0.80	0.40
8.00	1.20	0.60	2.60	1.20	1.00	1.00	1.00	0.80
9.00	3.40	1.20	3.80	1.40	1.40	1.40	2.20	1.60
10.00	4.00	2.40	4.60	2.0.	1.60	3.20	2.40	1.00
11.00	3.60	1.20	7.80	1.40	0.40	3.00	1.40	0.60
12.00	2.40	0.60	5.00	0.80	0.00	1.40	0.80	0.00
13.00	1.40	0.00	3.60	0.40	0.00	1.20	0.00	0.00
14.00	1.20	0.20	2.00	0.60	0.60	0.80	0.40	0.60
15.00	2.40	1.00	3.80	1.00	1.00	1.20	1.00	0.80
16.00	3.60	1.40	6.20	1.60	1.20	2.00	2.00	1.00
17.00	2.80	0.60	3.80	0.80	0.20	1.00	0.80	0.00
18.00	1.20	0.00	1.40	0.00	0.00	0.00	0.00	0.00
CD	0.764	0.600	1.001	0.722	0.486	0.871	0.678	0.796

0600 hr (0.40) and was on par with the population observed at 0700 hr (0.60), 1400 hr and 1800 hr with mean number (1.20 each).

The maximum foraging activity of *A. mellifera* was recorded at 1000 hr with mean number 2.40 and was significantly higher than rest of the hours of the day. The second peak activity was at 1600 hr (1.40) which was on par with the foraging activity at 0900 hr, 1100 hr (1.20 each). The minimum foraging activity was recorded at 0700 hr (0.40) and was on par with 0800 hr, 1700 hr and 1200 hr (0.60 each).

In the case of *Trigona* sp. the maximum foraging activity was recorded at 1100 hr with mean number 7.80 and was significantly higher than rest of the hours of a day. There was no significant difference between the 1000 hr, 0900 hr, 1300 hr, 1500 hr and 1700 hr, the population ranged from 3.60 to 4.60. The minimum foraging activity was recorded at 0600 hr and 0700 hr (1.00 each) and was on par with 1800 hr (1.40 each).

The highest foraging activity of *Anderna* sp. was observed at 1000 hr with mean number 2.00 and was on par with the foraging activity at 1600 hr (1.60), 0900 hr and 1100 hr (1.40 each). The minimum foraging activity was recorded at 0600 hr and1300 hr (0.40 each) which was on par with the population observed at 0700 hr, 1400 hr (0.60 each) and 1700 hr (0.80).

The maximum foraging activity coleopterans was recorded at 1000 hr with mean number 1.60 and was on par with the foraging activity at 0900 hr (1.40) and 1600 hr (1.20). The minimum foraging activity was recorded at 1700 hr (0.20) which was on par with the foraging activity at 0700 and 1100 hr (0.40 each).

The maximum foraging activity of dipterans was observed at 1000 hr with mean number 3.20 and was on par with the foraging activity at 1100 hr (3.00). The second peak activity was at 1600 hr (2.00) which was on par with the foraging activity at 0900 hr and 1200 hr and 1600 hr (1.40 each), 1300 hr and 1500 hr (1.20 each). The minimum foraging activity was recorded at 0700 hr and 1400 hr (0.80 each) and was on par with the activity at 0600, 0800 and 1700 hr (1.00 each).

In the case of lepidopterans, the maximum foraging activity was observed at 1000 hr with mean number 2.40 and was on par with the foraging activity at 0900 hr

(2.20) and 1600 hr (2.00). The minimum foraging activity was recorded at 0700 hr, 1200 hr and 1700 hr (0.80 each) and 1100 hr (1.40).

The highest foraging activity of other insects was observed at 0900 hr with mean number 1.60 and was on par with the foraging activity at 1000 and 1600 hr (1.00 each). The minimum foraging activity was recorded at 0700 hr (0.40) which was on par with the foraging activity at 1100 hr, 1400 hr (0.60each), 0800hr and 1500 hr (0.80 each).

There were two peak foraging hours, the first peak and maximum foraging activity of *A. cerana indica*, *Trigona* sp. and *Anderna* sp. were at 1100 hr with mean number 3.60, 7.80 and 1.40, respectively. The second peak activity of these bees was with mean number of 3.60, 6.20 and 1.60, respectively. Similarly the first and maximum peak activity of *A. mellifera* was recorded at 1000 hr (2.40) and the second peak was at 1600 hr (1.40).

The first peak of coleopterans, dipterans, lepidopterans and other insects was recorded at 1000 and 0900 hr with mean number 1.60, 3.20, 2.40 and 1.60, respectively. The second peak activity of these species was at 1600 hr with mean number 1.20, 2.00, 2.00 and 1.00, respectively. Similarly the first peak and maximum activity of lepidopterans was recorded at 0900 hr and 1100 hr (1.40 each) and the second peak activity recorded at 1600 hr (1.60).

Oriental pickling melon

The population of insect pollinators visited on oriental pickling melon flowers was recorded at different time intervals on the sixth week after sowing (peak flowering stage) and expressed as number of bees / m^2/5 min and depicted in Table 9.

A. cerana indica and *Anderna* sp. started their activity at 0600 hr and continued up to 1800 hr whereas *A. mellifera* and *Trigona* sp. began their activity at 0700 hr and continued up to 1700 hr.

The maximum foraging activity of *A. cerana indica* was observed at 1000 hr with mean number 8.60 and was significantly higher than the rest of the hours of a day. The second peak activity was at 1100 hr (7.20) and was significantly varied with the rest of the hours of a day. There was no significant difference in the foraging

Table 9. Relative abundance of insect pollinators visiting oriental pickling melon flowers during various times of a day under pesticide free condition in the Instructional farm (Mean number / m ^{2} / 5 min)

Time (hrs)	*A.cerana indica*	*A.mellifera*	*Trigona* sp.	*Anderna* sp.	Coleopterans	Dipterans	Lepidopterans	Other insects
6.00	1.00	0.00	0.00	0.20	0.40	0.00	0.00	0.20
7.00	1.80	0.20	3.80	1.00	1.20	0.40	0.40	0.00
8.00	2.60	0.40	1.40	2.20	1.80	1.00	0.60	1.20
9.00	6.00	0.80	2.00	3.00	2.80	2.00	1.40	1.40
10.00	8.60	1.60	3.60	4.80	3.40	3.60	2.00	2.00
11.00	7.20	2.00	5.20	3.40	1.60	2.20	1.40	1.20
12.00	4.40	1.00	2.40	3.80	1.40	1.40	0.40	0.60
13.00	2.20	1.00	2.40	1.60	1.20	0.60	0.00	0.20
14.00	2.20	0.80	1.60	1.40	1.40	0.40	0.20	0.60
15.00	3.20	1.00	2.40	2.80	2.00	1.40	1.20	0.80
16.00	4.60	1.60	4.00	3.20	2.60	2.60	1.60	1.40
17.00	5.40	0.40	1.00	3.40	1.40	1.00	1.00	0.60
18.00	1.00	0.00	0.00	1.20	0.60	0.60	0.00	0.00
CD	0.933	0.919	1.098	1.092	0.878	0.756	0.764	0.748

activity at 0900 hr (6.00) and 1700 hr (5.40). The minimum foraging activity was recorded at 0600 and 1800 hr with mean number (1.00 each) and was on par with the foraging activity at 0700 hr (1.80).

In the case of *A. mellifera* maximum foraging activity was recorded at 1100 hr with mean number 2.00 and was on par with the foraging activity at 1000 hr and 1600 hr (1.60 each). The minimum foraging activity was recorded at 0700 hr (0.20) and was on par with the 0800 hr, 1700 hr (0.40 each), 1200 hr, 1300 hr and 1500 hr (1.00 each).

The highest foraging activity of *Trigona* sp. was observed at 1100 hr with mean number 5.20 and was significantly higher than rest of the hours of a day. The second peak activity was at 1600 hr (4.00) and was on par with the foraging activity at 0700 hr and 1000 hr with mean number being 3.80 and 3.60, respectively. The minimum foraging activity was recorded at 1700 hr (1.00) and was on par with the 0800, 1400 and 0900 hr, the population being 1.40, 1.60 and 2.00, respectively.

Anderna sp. was recorded the maximum foraging activity at 1000 hr with mean number 4.80 and was on par with the foraging activity at 1200 hr (3.80). The second peak activity was at 1100 hr and 1700 hr (3.40 each) which was on par with the foraging activity at 1600, 0900 and 1500 hr with population being 3.20, 3.00 and 2.80, respectively. The minimum foraging activity was recorded at 1600 hr (0.20) and was on par with the 0700 hr (1.00) and 1800 hr (1.20).

The maximum foraging activity of coleopterans was observed at 1000 hr with mean number 3.40 and was on par with the foraging activity at 0900 hr (2.80) and 1600 hr (2.60). There was no significant difference in the foraging activity at 0700, 0800, 1100, 1200, 1300, 1400, 1500 and 1700 hr with the population ranged from 1.20 to 2.00. The minimum foraging activity was recorded at 0600 hr (0.40) and was on par with the 1800 hr (0.60).

The maximum foraging activity of dipterans was recorded at 1000 hr with mean number 3.60 and was significantly higher than rest of the hours of the day. There was no significant difference in the foraging activity at 1600, 1100 and 0900 hr, the mean number being 2.60, 2.20 and 2.00, respectively. The minimum foraging activity was recorded at 0700 hr and 1400 hr (0.40 each) and was on par with the 1800 and 1300 hr (0.60 each) and 1700 hr (1.00).

In the case of lepidopterans, the maximum foraging activity was observed at 1000 hr with mean number 2.00 and was on par with the foraging activity at 1600, 1100, 0900 and 1500 hr, the population being 1.60, 1.40, 1.40 and 1.20, respectively. The minimum foraging activity was recorded at 1400 hr (0.20) and was on par with the 0700 hr (0.40), 0800 hr (0.60) and 1700 hr (1.00) respectively.

The maximum foraging activity of other insects was observed at 1000 hr with mean number 2.00 and was on par with the foraging activity at 0900 and 1600 hr (1.40 each) 0800 and 1100 hr (1.20 each). The minimum foraging activity was recorded at 0600and 1300 hr (0.20 each) and was on par with the 1500hr (0.80), 1200 hr, 1400 hr and 1700 hr (0.60 each) .

There were two peak foraging hours observed, first peak was in the morning and the second was in the evening hours. The first peak and maximum foraging activity of *A. cerana indica*, *A. mellifera* and *Anderna* sp. recorded at 1000 hr with mean number 8.60, 1.60 and 4.80, respectively. The second peak activity of these species was at 1700 hr, 1600 hr and 1700 hr with mean number of 5.40, 1.60 and 3.40. Similarly the first and maximum peak activity of *Trigona* sp. was recorded at 1100 hr (5.20).

The maximum population and first peak of coleopterans, dipterans and other insects was recorded at 1000 hr with mean number 3.40, 3.60 and 1.40, respectively. The second peak activity of these species was at 1600 hr with mean number 2.60, 2.60 and 1.40, respectively. Similarly the first peak and maximum activity of lepidopterans was recorded at 0900 hr and 1100 hr (1.40 each) and the second peak activity at 1600 hr (1.60).

4.3 IMPACT OF INSECTICIDES

The result of the study conducted to assess the effect of the commonly used insecticides on the major pollinators, pests and their natural enemies are presented in Table 10 to 17.

4.3.1 Insect Pollinators

The population of *A. cerana indica*, *Anderna* sp. and *Trigona* sp. at different intervals after application of treatments, expressed as number of bees / m ^{2} / 5 min and is depicted in Table 10.

A. cerana indica

Significantly lower mean population was observed in all the treatments when compared with control. Fenvalerate 0.02 per cent was significantly the most toxic chemical to *A. cerana indica* when compared to all other treatments and the population observed was 2.31. Lambda cyhalothrin 0.01 per cent (2.60) was the second most toxic chemical which was significantly toxic to rest of the treatments. There was no significant difference in the population on observed treatments with acephate 0.05 per cent (3.32), carbaryl 0.1 per cent (3.29) and dimethoate 0.05 per cent (3.28). Neem oil 2.0 per cent and imidacloprid 0.002 per cent caused less reduction, comparatively safe insecticides to the bee population 4.31 and 4.18, respectively.

On the first day after spraying, there was significant reduction in the bee population in all the treatments over control (3.67). The lowest population *A. cerana indica* (0.42) recorded in fenvalerate 0.02 per cent which was significantly lower than all other treatments. The order of toxicity of different insecticides to the population of *A. cerana indica* was lambdacyhalothrin 0.01 per cent (1.00) > dimethoate 0.05 per cent (1.58) > carbaryl 0.1 per cent (1.92) > acephate 0.05 per cent (2.25) > malathion 0.2 per cent (2.58) > imidacloprid 0.002 per cent (3.08). The highest bee population (3.42) was recorded in neem oil 2.0 per cent and was statistically on par with the population of control (3.67). A similar condition was observed in third, fifth, and seventh days after spraying.

The lowest population of *A. cerana indica* (3.25) was recorded in fenvalerate 0.02 per cent on fourteenth day after spraying which was statistically on par with the population of lambdacyhalothrin 0.01 per cent (3.58) and acephate 0.05 per cent (3.67). The highest bee population (5.25) was recorded in control which was

Table 10. Population of *A. cerana indica*, *Anderna* sp. and *Trigona* sp. on oriental pickling melon flowers at different intervals after insecticide spraying (Mean number/m^2/5 min)

Treatments	Days after pesticide application						Mean
	1	3	5	7	14	21	
A. cerana indica							
Neem oil 2.0 %	3.42	3.83	4.00	3.92	5.08	5.58	4.31
Malathion 0.2 %	2.58	3.17	3.25	4.00	4.75	5.33	3.85
Acephate 0.05 %	2.25	2.75	2.92	3.17	3.67	5.17	3.32
Dimethoate 0.05%	1.58	2.33	2.42	3.75	4.25	5.33	3.28
Carbaryl 0.1%	1.92	2.67	2.83	3.42	3.92	5.00	3.29
Lambdacyhalothrin 0.01%	1.00	1.92	2.08	2.42	3.58	4.58	2.60
Fenvalerate 0.02%	0.42	1.25	1.58	2.92	3.25	4.42	2.31
Imidacloprid 0.002%	3.08	3.67	3.83	4.33	5.00	5.17	4.18
Control	3.67	4.08	4.67	5.00	5.25	4.83	4.58
***Anderna* sp.**							
Neem oil 2.0 %	2.25	3.08	3.75	4.00	3.92	4.00	3.50
Malathion 0.2 %	2.00	2.25	3.00	3.67	3.92	3.92	3.13
Acephate 0.05 %	1.75	2.08	2.58	3.67	3.83	3.75	2.94
Dimethoate 0.05%	0.75	1.17	2.00	2.75	3.58	3.67	2.32
Carbaryl 0.1%	1.00	1.33	2.25	3.17	3.92	3.83	2.58
Lambdacyhalothrin 0.01%	0.42	0.83	1.33	2.17	3.75	3.92	2.07
Fenvalerate 0.02%	0.25	0.50	1.00	1.75	3.67	3.75	1.82
Imidacloprid 0.002%	2.08	2.75	3.75	4.00	4.25	4.75	3.60
Control	4.17	4.33	4.17	3.92	4.08	4.00	4.11
***Trigona* sp.**							
Neem oil 2.0 %	2.08	2.58	3.75	4.00	4.50	3.75	3.44
Malathion 0.2 %	1.50	2.08	2.92	3.75	4.33	3.75	3.06
Acephate 0.05 %	1.33	1.75	2.58	3.42	4.00	3.25	2.72
Dimethoate 0.05%	0.58	1.08	1.75	3.00	4.33	3.75	2.42
Carbaryl 0.1%	0.75	1.25	2.33	3.25	4.25	3.33	2.53
Lambdacyhalothrin 0.01%	0.42	0.75	1.58	2.58	3.58	3.25	2.03
Fenvalerate 0.02%	0.25	0.58	1.08	2.17	3.92	3.33	1.89
Imidacloprid 0.002%	1.75	2.42	2.75	3.67	4.42	3.67	3.11
Control	3.08	3.08	3.83	4.00	4.75	3.58	3.72

CD (0.05) :	*A. cerana indica*	*Anderna* sp.	*Trigona* sp.
Treatment mean :	0.167	0.176	0.223
Treatment × days :	0.480	0.552	0.444

statistically on par with the population of neem oil 2.0 per cent (5.08) and imidacloprid 0.002 per cent (5.00).

On twenty first day after spraying, significantly higher population of *A. cerana indica* recorded in all the treatments when compared with control (4.83). The highest population (5.58) was recorded in neem oil 2.0 per cent which was statistically on par with the population of malathion 0.2 per cent, dimethoate 0.05 per cent (5.33 each), acephate 0.05 per cent and imidacloprid 0.002 per cent (5.17 each).

***Anderna* sp.**

Significantly lower mean population was observed in all the treatments when compared with control. Fenvalerate 0.02 per cent was the most toxic chemical to *Anderna* sp. and the bee population observed was 1.82 which showed the highest reduction when compared to all other treatments. Lambdacyhalothrin 0.01 per cent (2.07) was the second most toxic chemical which was significantly varied with the rest of the treatments. The trend in the toxicity of different insecticides to *Anderna* sp. dimethoate 0.05 per cent (2.32) > carbaryl 0.1 per cent (2.58) > acephate 0.05 per cent (2.94) > malathion 0.2 per cent (3.13). Neem oil 2.0 per cent caused less reduction in the bee population (3.50) which was statistically on par with the population of imidacloprid 0.002 per cent (3.60) and therefore were found to be comparatively safe insecticides.

On the first day after spraying, there was significant reduction in bee population in all the treatments over control (4.17). *Anderna* sp. recorded the lowest population (0.25) in fenvalerate 0.02 per cent which was statistically on par with the population of lambdacyhalothrin 0.01 per cent (0.42), dimethoate 0.05 per cent (0.75) and carbaryl 0.1 per cent (0.42). The highest bee population (2.25) was recorded in neem oil 2.0 per cent and was statistically on par with the population of imidacloprid 0.002 per cent (2.08), malathion 0.2 per cent (2.00) and acephate 0.05 per cent (1.75). A similar trend was observed in the third, fifth and seventh days after spraying.

The data on the population observed at fourteenth and twenty first day after spraying showed that there was no significant difference between them. They were on par with the control.

Trigona sp.

Fenvalerate 0.02 per cent (1.89) was the most toxic chemical to *Trigona* sp. and was on par with the population of lambdacyhalothrin (2.03). Dimethoate 0.05 per cent (2.42) was the second most toxic which was statistically on par with the population of carbaryl 0.1 per cent (2.53) and acephate 0.05 per cent (2.72). The highest population (2.53) was recorded in control and which was statistically on par with the population of malathion 0.2 per cent and imidacloprid 0.002 per cent, the population being 3.06 and 3.11, respectively.

On the first day after spraying, there was significant reduction in the bee population in all the treatments over control (3.08). The lowest population of *Trigona* sp. 0.25 was observed in fenvalerate 0.02 per cent which was statistically on par with the population of lambdacyhalothrin 0.01 per cent (0.42), dimethoate 0.05 per cent (0.58) and carbaryl 0.1 per cent (0.75). The highest bee population was recorded in neem oil 2.0 per cent 1.75. A similar trend was observed in the third, fifth and seventh days after spraying.

Data on the fourteenth and twenty first days after spraying indicated that all the treatments were on par with the control.

A. cerana indica

Time spent by *A. cerana indica* for collection of nectar and pollen from staminate and pistillate flowers at different intervals after insecticide spraying and expressed as number of seconds / single visit on flower is presented in Table 11.

Staminate flowers

There was significant reduction in the mean time spent by *A. cerana indica* in staminate flowers in all the treatments over control (14.11) after insecticide spraying, the time spent ranged from 5.33 to 10.39. The lowest time spent by *A. cerana indica* was recorded in fenvalerate 0.02 per cent and was statistically on par with the lambdacyhalothrin 0.01 per cent (5.78). The lowest order of time spent by bees carbaryl 0.01 per cent (6.67) > acephate 0.05 per cent (7.11) > dimethoate 0.05 per cent (7.94) > malathion 0.2 per cent (8.50). The highest time spent by *A. cerana indica* recorded in neem oil 2.0 per cent (10.39) which was significantly varied with

Tab1 1. Time spent by *A. cerana indica* for collection of nectar and pollen from staminate and pistillate flowers at different intervals after insecticide spraying (Number of seconds / single visit on flower)

Treatments	Days after pesticide application						Mean
	1	3	5	7	14	21	
Staminate flowers							
Neem oil 2.0 %	6.00	7.67	9.33	12.33	13.33	13.67	10.39
Malathion 0.2 %	4.67	5.33	8.00	9.00	11.33	12.67	8.50
Acephate 0.05 %	3.00	4.00	6.33	8.00	8.67	12.67	7.11
Dimethoate 0.05%	4.00	4.67	7.00	8.67	9.67	13.67	7.94
Carbaryl 0.1%	2.67	3.67	5.67	7.33	8.00	12.67	6.67
Lambdacyhalothrin 0.01%	3.00	2.67	4.67	6.00	7.67	10.67	5.78
Fenvalerate 0.02%	2.67	2.33	4.33	5.00	7.33	10.33	5.33
Imidacloprid 0.002%	4.67	6.33	8.33	10.33	11.67	13.00	9.06
Control	13.33	14.00	4.67	15.00	14.00	13.67	14.11
Pistillate flowers							
Neem oil 2.0 %	9.67	14.00	22.67	29.33	33.00	35.00	23.94
Malathion 0.2 %	5.33	6.67	9.33	11.00	29.67	33.33	15.89
Acephate 0.05 %	4.33	5.67	6.67	8.33	27.67	31.67	14.06
Dimethoate 0.05%	4.33	6.00	8.33	10.67	28.67	33.33	15.22
Carbaryl 0.1%	3.67	5.00	6.33	7.67	26.33	34.00	13.83
Lambdacyhalothrin 0.01%	3.33	4.33	5.33	7.00	24.33	30.33	12.44
Fenvalerate 0.02%	2.33	3.67	4.67	6.00	21.67	29.33	11.28
Imidacloprid 0.002%	6.00	8.67	12.00	15.67	30.33	32.00	17.44
Control	30.33	33.00	34.33	33.00	35.00	35.67	33.56

CD (0.05) :	Staminate flowers	Pistillate flowers
Treatment mean :	0.612	5.048
Treatment × days :	1.204	1.484

the other treatments.

There was significant reduction in the time spent by bee in all the treatments over control (13.33 sec.) on the first day after spraying. The lowest time spent by *A. cerana indica* was recorded in fenvalerate 0.02 per cent and carbaryl 0.1 per cent (2.67each) and was statistically on par with the lambdacyhalothrin 0.01 per cent (3.00). There was no significant difference in the time spent by bee in dimethoate 0.05 per cent, malathion 0.2 per cent and imidacloprid 0.002 per cent, the duration being 4.00, 4.67 and 4.67, respectively. The highest time spent by *A. cerana indica* recorded was in neem oil 2.0 per cent (6.00) which was significantly varied with the other treatments. A similar trend was observed in the third, fifth, seventh and fourteenth days after spraying.

On twenty first days after spraying, the lowest time spent by *A. cerana indica* recorded in fenvalerate 0.02 per cent was 10.33 and was statistically on par with the lambdacyhalothrin 0.01 per cent (10.67). There was no significant varied in dimethoate 0.05 per cent, malathion 0.2 per cent, imidacloprid 0.002 per cent, acephate 0.05 per cent, carbaryl 0.1 per cent and neem oil 2.0 per cent, the time spent varied from 12.67 to 13.67.

Pistillate flowers

There was significant reduction in the mean time spent by *A. cerana indica* on pistillate flowers in all the treatments over control (33.56sec.) after insecticide spraying. The lowest time spent by *A. cerana indica* was recorded in fenvalerate 0.02 per cent (11.28) and was statistically on par with the lambdacyhalothrin 0.01 per cent, carbaryl 0.1 per cent, acephate 0.05 per cent, dimethoate 0.05 per cent and malathion 0.2 per cent, time spent being 12.44, 13.83, 14.06, 15.22 and 15.89, respectively. The highest time spent by *A. cerana indica* recorded in neem oil 2.0 per cent (23.94) which was statistically on par with the imidacloprid (17.44) and they were safe to bees.

The data recorded on the first day after spraying, there was significant reduction in the time spent by the bee in all the treatments over control (30.33). The lowest time spent by *A. cerana indica* was recorded in fenvalerate 0.02 per cent (2.33) and was on par with the lambdacyhalothrin 0.01 per cent (3.33). There was no significant difference reduction in the time spent by bee in carbaryl 0.1 per cent, dimethoate 0.05 per cent and acephate 0.05 per cent, the duration being 3.67, 4.33 and 4.33, respectively. Malathion 0.2 per cent and imidacloprid 0.002 per cent had no statistically difference between them, the duration being 5.33 and 6.00, respectively. The highest time spent by *A. cerana indica* recorded in neem oil 2.0 per cent (9.67) and was significantly higher than the other treatments.

In the case of third day after spraying, the lowest time spent by *A. cerana indica* was recorded in fenvalerate 0.02 per cent (3.67) and was on par with the lambdacyhalothrin 0.01 per cent (4.33) and carbaryl 0.1 per cent (5.00). There was no significant difference reduction in the time spent by bee in acephate 0.05 per cent, dimethoate 0.05 per cent and malathion 0.2 per cent, the duration was 5.67, 6.00 and 6.67, respectively. The highest time spent by *A. cerana indica* recorded in neem oil 2.0 per cent (14.00) and was significantly varied with the other treatments.

On fifth day after spraying, the lowest time spent by the bee was recorded in fenvalerate 0.02 per cent (4.67) and was on par with the lambdacyhalothrin 0.01 per cent (5.33). There was no significant difference in reduction the time spent by bee in carbaryl 0.1 per cent (6.63) and acephate 0.05 per cent (6.67). The highest time spent by *A. cerana indica* recorded was in neem oil 2.0 per cent (22.67) and was significantly varied with the other treatments. A similar trend was observed in the seventh and fourteenth days after spraying.

The data on the twenty first day after spraying, the lowest time spent by the bee was recorded in fenvalerate 0.02 per cent (29.33) and was on par with the lambdacyhalothrin 0.01 per cent (30.33). There was no significant difference reduction in the time spent by bee in imidacloprid 0.002 per cent, malathion 0.2 per cent and dimethoate 0.05 per cent, the duration was 32.00, 33.33 and 33.33, respectively. The highest time spent by *A. cerana indica* recorded was in neem oil 2.0 per cent (35.00) and was on par with the control (35.67).

4.3.2 Population of Insect Pests

***Aulacophora* spp.**

The population of *Aulacophora* sp. assessed as number of beetles per plant is given in Table 12.

After first spraying

On the first day after spraying, there was significant reduction in the population in all the treatments over control (4.00). The lowest population was recorded in the plot which received imidacloprid 0.002 per cent, the mean being (0.08). It was at par with the population in plots sprayed with carbaryl 0.1 per cent (0.17) and dimethoate 0.05 per cent (0.58). The next lowest population was recorded with lambdacyhalothrin (0.83) which was on par with the fenvalerate 0.02 per cent (1.00) and malathion 0.2 per cent (1.25). Treatments with neem oil 2.0 per cent and acephate 0.05 percent were comparatively less effective to the pumpkin beetles and the population recorded in the treatments were 1.75 and 1.58, respectively.

Significant reduction in the population of all the treatments over control (3.75) was observed on third day after spraying. The lowest population was recorded in plot which received imidacloprid 0.002 per cent, the mean being (0.25). It was at par with the population in plots sprayed with carbaryl 0.1 per cent (0.67). There was no significant difference between population recorded in dimethoate 0.05 per cent (1.08), lambdacyhalothrin 0.01 per cent (1.50) and fenvalerate 0.02 per cent (1.75). Treatments with neem oil 2.0 per cent (2.25) and acephate 0.05 percent (2.08) were comparatively less effective in controlling the pumpkin beetles.

In the case of fifth day after spraying, there was significant reduction in the population in all the treatments over control. The lowest population was recorded in imidacloprid 0.002 per cent, the mean being (1.08) which was statistically same with the cabaryl 0.1 per cent (1.67). There was no significant difference between population recorded in dimethoate 0.05 per cent, lambdacyhalothrin 0.01 per cent, fenvalerate 0.02 per cent and malathion 0.1 per cent, the population being 2.08, 2.42, 2.75 and 2.83, respectively. Treatments with neem oil 2.0 per cent (3.58) and acephate 0.05 percent (3.08) were comparatively less effective to control the pumpkin beetles.

Table 12. Mean population of *Aulacophora* sp. at different intervals after insecticide spraying (Mean number / plant)

Treatments	Days after first spray					Days after second spray					Mean
	1	3	5	7	14	1	3	5	7	14	
Neem oil 2.0 %	1.75	2.25	3.58	4.00	4.00	2.92	3.08	3.58	4.17	5.00	3.43
Malathion 0.2 %	1.25	2.00	2.83	3.00	3.92	2.33	3.00	3.25	3.50	4.67	2.98
Acephate 0.05 %	1.58	2.08	3.08	3.25	4.33	2.58	3.17	3.42	3.58	5.00	3.21
Dimethoate 0.05%	0.58	1.08	2.08	2.25	4.17	0.75	0.92	1.67	1.92	4.50	1.99
Carbaryl 0.1%	0.17	0.67	1.67	1.92	4.33	0.33	0.42	1.00	1.33	4.42	1.63
Lambdacyhalothrin 0.01%	0.83	1.50	2.42	2.50	4.42	1.58	1.75	2.08	2.42	4.42	2.39
Fenvalerate 0.02%	1.00	1.75	2.75	3.00	4.50	1.83	2.00	2.58	3.17	4.58	2.72
Imidacloprid 0.002%	0.08	0.25	1.08	1.75	4.58	0.25	0.33	0.75	1.33	4.75	1.52
Control	4.00	3.75	4.58	4.08	4.92	4.50	4.67	4.33	4.58	5.08	4.45

CD (0.05) :
Treatment mean : 0.175

Treatment × days : 0.641

The data on the seventh day after spraying, there was significant reduction in the population in all the treatments over control. The lowest population was recorded in plot which received imidacloprid 0.002 per cent, the mean being (1.75). It was at par with the population in plots sprayed with carbaryl 0.1 per cent (1.92). There was no significant difference between population recorded in dimethoate 0.05 per cent (2.25), lambdacyhalothrin 0.01 per cent (2.50), acephate (3.25) malathion 0.1 per cent and fenvalerate 0.02 per cent (3.00 each). Treatments with neem oil 2.0 per cent (4.00) was statistically on par with the population of control (4.08).

On fourteenth day after spraying, all the treatments were found to be statistically similar with that observed in control plot.

After second spraying

On the first day after spraying, there was significant reduction in the population of the beetles in all the treatments over control (4.50). The lowest population was recorded in plot which received imidacloprid 0.002 per cent, the mean being (0.25). It was at par with the population in plots sprayed with carbaryl 0.1 per cent (0.33) and dimethoate 0.05 per cent (0.75). The next lowest population was recorded in lambdacyhalothrin 0.1 per cent (1.58) and was on par with the fenvalerate (1.83). Treatments with neem oil 2.0 per cent acephate 0.05 percent and malathion 0.2 per cent were comparatively less effective to the pumpkin beetles and the population recorded in the treatments being 2.92, 2.58 and 2.33, respectively. A similar condition was observed in the third, fifth and seventh days after spraying, the population ranged from 0.33 to 3.08, 0.75 to 3.58 and 1.33 to 4.17, respectively. On the fourteenth day after spraying, all the treatments were found to be statistically similar with the control.

There was significant reduction in the mean population of *Aulacophora* sp. in all the treatments over control (4.45), the population ranged from 1.52 to 3.43. The lowest population was recorded in imidacloprid 0.002 per cent and was on par with the population in plots sprayed with carbaryl 0.1 per cent (1.63). Neem oil 2.0 per cent was the least effective treatment with the mean population of 3.43 and significantly varied with the other treatments.

D. indica

The population of *D. indica* estimated as number of larvae per plant is given in Table 13.

After first spraying

There was significant reduction in the population of *D. indica* in all the treatments over control (3.92) on the first day after spraying. The lowest population was recorded in plot received fenvalerate 0.02 per cent, the population being (0.08). It was at par with the population in plots sprayed with lambdacyhalothrin 0.01per cent (0.25) and imidacloprid 0.002 per cent (0.42). The next lowest population was recorded in dimethoate 0.05 per cent (0.67) which was on par with the carbaryl 0.1 per cent (0.15) and acephate 0.05 per cent (1.17). Treatments with neem oil 2.0 per cent (1.67) was comparatively less effective to the pumpkin caterpillar and which showed significant variation with the other treatments. A similar condition was observed in three days after spraying except acephate 0.05 per cent which was on par with the neem oil 2.0 per cent. In case of fifth day after spraying similar condition was observed with the first day after spraying except neem oil 2.0 per cent and was on par with control. The population observed at third and fifth day after spraying ranged from 0.25 to 2.25 and 0.75 to 3.25, respectively.

The data on the seventh day after spraying, the lowest population was recorded in fenvalerate 0.02 per cent, the population being (1.75). It was at par with the population of lambdacyhalothrin 0.01per cent (1.92) and imidacloprid 0.002 per cent (2.25). Malathion 0.2 per cent, acephate 0.05 per cent and neem oil 2.0 per cent were less effective in controlling pumpkin caterpillar, the population being 3.25, 2.42 and 3.92, respectively.

On fourteenth day after spraying, all the treatments were found to be statistically similar with the control except fenvalerate 0.02 per cent and lamdacyhalothrin 0.01 per cent were continued the same trend in reduced the population even fourteenth days after spraying.

Table 13. Mean population of *D. indica* at different intervals after insecticide spraying (Mean number of larvae / plant)

Treatments	Days after pesticide 1 application					Days after pesticide 2 application					Mean
	1	3	5	7	14	1	3	5	7	14	
Neem oil 2.0 %	1.67	2.25	3.25	3.92	4.00	1.92	2.25	2.75	3.08	3.08	2.82
Malathion 0.2 %	1.00	1.75	2.33	3.25	3.50	1.00	1.58	2.08	2.42	2.83	2.18
Acephate 0.05 %	1.17	2.00	2.42	3.42	3.58	1.25	1.92	2.42	2.75	3.00	2.39
Dimethoate 0.05%	0.67	1.25	1.92	2.67	4.00	0.58	0.75	1.58	2.25	3.00	1.87
Carbaryl 0.1%	0.75	1.42	2.17	2.92	3.92	0.92	1.17	2.25	2.67	2.83	2.10
Lambdacyhalothrin 0.01%	0.25	0.42	1.08	1.92	3.08	0.08	0.33	1.08	2.08	3.08	1.34
Fenvalerate 0.02%	0.08	0.25	0.75	1.75	2.50	0.00	0.08	0.75	1.92	2.92	1.10
Imidacloprid 0.002%	0.42	0.58	1.25	2.25	3.92	0.08	0.25	1.25	2.25	3.00	1.53
Control	3.92	3.50	3.67	4.00	4.08	3.75	3.42	2.92	3.00	3.42	3.57

CD (0.05) :

Treatment mean : 0.153

Treatment× days : 0.525

After second spraying

On the first day after spraying, there was significant reduction in the population in all the treatments over control (3.75). There was no population recorded in the plot received fenvalerate 0.02 per cent followed by lambdacyhalothrin 0.01per cent and imidacloprid 0.002 per cent (0.08 each). The next lowest population recorded was with dimethoate 0.05 per cent (0.58) and was significantly on par with the carbaryl 0.1 per (0.92), malathion 0.2 per cent (1.00) and acephate 0.05 per cent (1.25). The highest population (1.92) was recorded in neem oil 2.0 per cent and significantly varied with the other treatments .The population build up was established and gradually increased from third day after spraying to fourteenth day after spraying. A similar condition was observed in third and fifth day after spraying, the population ranged from 0.08 to 2.25 and 0.75 to 2.75, respectively.

In the case of seventh day after spraying, the lowest population was recorded in the plot, which received fenvalerate 0.02 per cent, the population being (1.92). It was at par with the population in plots sprayed with lambdacyhalothrin 0.01per cent (2.08), imidacloprid 0.002 per cent, dimethoate. 0.05 per cent (2.25 each) and malathion 0.2 per cent (2.42). There was no significant difference in the population of neem oil 2.0 per cent (3.08), acephate 0.05 per cent (2.75), carbaryl (2.67) and control (3.00) and these insecticides were less effective in controlling pumpkin caterpillar. The data on the fourteenth day after spraying, all the treatments were statistically on par with the control.

All the treatments significantly reduced the mean population of *D. indica* over control (3. 57), the population ranged from 1.10 to 2.82. The lowest population recorded in fenvalerate 0.02 per cent and this was followed by lambdacyhalothrin 0.01 per cent (1.34) which varied significantly with the other treatments. The highest population was recorded in neem oil 2.0 per cent and significantly varied with the all other treatments.

A. peponis

The population of *A. peponis* estimated as number of larvae per plant is given in Table 14.

Table 14. Mean population of *A. peponis* at different intervals after insecticide spraying (Mean number of larvae / plant)

Treatments	Days after first spray					Days after second spray					Mean
	1	3	5	7	14	1	3	5	7	14	
Neem oil 2.0 %	1.42	2.00	2.75	2.92	3.08	1.50	1.75	2.33	3.08	2.08	2.29
Malathion 0.2 %	1.08	1.25	2.25	2.58	2.83	1.00	1.58	2.00	2.25	1.92	1.88
Acephate 0.05 %	1.33	1.50	1.83	2.58	3.00	1.17	1.75	2.00	2.42	2.17	1.98
Dimethoate 0.05%	0.67	1.08	1.17	2.08	3.00	0.58	0.92	1.25	1.75	2.00	1.45
Carbaryl 0.1%	1.00	1.42	1.75	2.25	2.98	0.83	1.58	1.42	2.17	2.25	1.77
Lambdacyhalothrin 0.01%	0.17	0.25	0.67	1.00	2.33	0.00	0.17	0.75	1.17	1.83	0.83
Fenvalerate 0.02%	0.08	0.17	0.33	0.83	2.08	0.00	0.00	0.50	1.08	1.75	0.68
Imidacloprid 0.002%	0.33	0.58	0.83	1.42	2.42	0.17	0.42	1.08	1.67	1.75	1.07
Control	2.50	3.08	3.08	2.58	2.67	2.92	2.75	2.75	2.75	2.42	2.75

CD (0.05) :
Treatment mean : 0.164

Treatment× days : 0.514

After first spraying

Significant reduction in the population of all the treatments over control (2.50) was observed on one day after spraying. The lowest population was recorded in the plot which received fenvalerate 0.02 per cent, the population being 0.08. It was at par with the population in plots sprayed with lambdacyhalothrin 0.01per cent (0.17), imidacloprid 0.002 per cent (0.33) and dimethoate 0.05 per cent (0.67), Carbaryl 0.1 per cent, malathion 0.2 per cent, acephate 0.05 per cent and neem oil 2.0 per cent were less effective control of *A. peponis* and statistically on par with each other, the population being 1.00, 1.08, 1.33 and 1.42, respectively.

In case of third day after spraying, the lowest population was recorded in plot received fenvalerate 0.02 per cent, the data being (0.17). It was on par with the population recorded with lambdacyhalothrin 0.01per cent (0.25) and imidacloprid 0.002 per cent (0.58). There was no significant difference in the population observed in malathion 0.2 per cent sprayed plots, dimethoate 0.05 per cent and acephate 0.05 per cent, the population being1.05, 1.08 and 1.50, respectively. Neem oil 2.0 per cent (2.00) was less effective when compared to other treatments.

The data on the fifth day after spraying, the lowest population was recorded in the plot, which received fenvalerate 0.02 per cent, the population being (0.33). It was at par with the population in plots sprayed with lambdacyhalothrin 0.01per cent (0.67) and imidacloprid 0.002 per cent (0.83). The population reduction observed in dimethoate 0.05 per cent, carbaryl 0.1 per cent, acephate 0.05 per cent and malathion 0.2 per cent, the population was1.67, 1.75, 1.83 and 2.25, respectively. Treatments with neem oil 2.0 per cent (2.75) was statistically on par with the population of control (3.08).

The lowest population of *A. peponis* was recorded in the plot received fenvalerate 0.02 per cent, the mean being (0.83) on the seventh day after spraying. It was statistically same with the population in plots sprayed with lambdacyhalothrin 0.01per cent (0.10) and imidacloprid 0.002 per cent (1.42). There was no significant difference the population sprayed with dimethoate 0.05 per cent (2.10), carbaryl 0.1 per cent (2.25), neem oil 2.0 per cent (2.92), malathion 0.2 per cent, acephate 0.05 per cent and control (2.58 each).

On fourteenth day after spraying, the lowest population of *A. peponis* was recorded was in fenvalerate 0.02 per cent, the population being (2.08) and was on par with the population in plots sprayed with lambdacyhalothrin 0.01per cent (2.33) and imidacloprid 0.002 per cent (2.42). Statistically same population was recorded in plots sprayed with neem oil 2.0 per cent, carbaryl 0.1 per cent, acephate 0.05 per cent and dimethoate 0.05 per cent, the population being 3.08, 2.98, 2.83, 3.00 and 3.00, respectively and were higher than the population observed in control (2.67).

After second spraying

No pest was observed in plots which received fenvalerate 0.02 per cent and lambdacyhalothrin 0.01 per cent on one day after spraying. It was statistically on par with the population in imidacloprid (0.17). Carbaryl 0.1 per cent (0.83), dimethoate 0.05 per cent (0.58), malathion 0.2 per cent (1.00), acephate 0.05 per cent (1.17) and neem oil 2.0 per cent (1.50) were significantly reduced the population of *A. peponis* when compared to control (2.92). A similar condition was observed in third and fifth days after spraying, the population ranged from 0.00 to 1.75 and 0.50 to 2.33, respectively.

On seventh day after spraying, The lowest population was recorded in fenvalerate 0.02 per cent, the population being (1.08). It was at par with the population in plots sprayed with lambdacyhalothrin 0.01per cent (1.17). There was no significant difference in the population observed in imidacloprid 0.002 per cent (1.67), dimethoate 0.05 per cent (1.75) and malathion 0.2 per cent (2.25). There was no significant difference in the plots treated with acephate 0.05 per cent (2.42), control (2.75) and neem oil 2.0 per cent (3.08).

On fourteenth day after spraying, the population build was established reaching on par with the control. All the treatments were on par with each other. None of the insecticide was found to control *A. peponis* even on fourteenth days after spraying.

There was significant reduction in the mean population of *A. peponis* in all the treatments over control (2.75), the population ranged from 0.68 to 2.29. The lowest population was recorded in fenvalerate 0.02 per cent and was on par with the population in plots sprayed with the lambdacyhalothrin 0.01per cent (0.83). Neem oil 2.0 per cent was the least effective treatment with the mean population of 2.29 and significantly varied with all the other treatments.

4.3.2.1 Extent of damage caused by various pests

Effect of chemical insecticides on the extent of damage caused by various pests of oriental pickling melon is presented in Table 15.

***Aulacophora* spp.**

After first spraying

All the treatments except neem oil 2.0 per cent (58.33) significantly suppressed the damage caused by the pest on fifteenth day after spraying when compared to control. Imidacloprid 0.002 per cent (20.00) was most effective among the treatments and was statistically on par with the carbaryl 0.1 per cent, dimethoate 0.05 per cent and lambdacyhalothrin 0.01 per cent, the percentage damage was 23.33, 26.67 and 28.33, respectively. Malathion 0.2 per cent and acephate 0.05 per cent were statistically on par with each other, the percentage damage was 36.67 and 40.00, respectively.

After second spraying

Fifteen days after second spraying, imidacloprid 0.002 per cent, carbaryl 0.1 per cent, dimethoate 0.05 per cent, lambdacyhalothrin 0.1 per cent and fenvalerate 0.02 per cent were found to be effective when compared to control (65.00) and the percentage damage ranged from 15.00 to 26.67. There was no significant difference in plots treated with malathion (31.67) and acephate (35.00). Neem oil 2.0 per cent was the least effective treatment with a damage percentage of 53.33.

***Henosepilachna* sp.**

After first spraying

Maximum reduction in the extent of damage caused by *Henosepilachna* sp. was obtained with imidacloprid 0.002 per cent (6.67) which was statistically on par with the carbaryl 0.1 per cent (8.33) and lambdacyhalothrin 0.01 per cent (11.67). Fenvalerate 0.02 per cent, dimethoate 0.05 per cent, malathion 0.2 per cent and

Table 15. The extent of damage by various insect species observed at fifteen days after insecticide spraying (leaf and fruit damage %)

Treatments	15 days after first and second application										
	Aulacophora sp.		*Henosepilachna* sp.		*A. peponis* and *D. indica*		*B.cucurbitae* (Fruit damage %)	*A. gossypii*		*L. trifolii*	
	1	2	1	2	1	2	1	1	2	1	2
Neem oil 2.0 %	58.33	53.33	33.33	28.33	41.67	36.67	46.67	33.33	25.33	24.33	22.67
Malathion 0.2 %	36.67	31.67	21.67	16.67	31.67	26.67	16.67	25.33	15.33	9.33	6.00
Acephate 0.05 %	40.00	35.00	25.00	20.00	33.33	28.33	33.33	17.67	7.67	11.00	9.33
Dimethoate 0.05%	26.67	21.67	16.67	11.67	28.33	23.33	20.00	11.00	5.33	3.33	1.00
Carbaryl 0.1%	23.33	18.33	8.33	6.67	30.00	25.00	20.00	26.67	22.67	15.00	10.33
Lambdacyhalothrin 0.01%	28.33	23.33	11.67	6.67	18.33	13.33	26.67	22.67	12.67	7.67	6.00
Fenvalerate 0.02%	31.67	26.67	13.33	8.33	13.33	8.33	23.33	20.33	10.33	6.00	2.67
Imidacloprid 0.002%	20.00	15.00	6.67	5.00	20.00	15.00	13.33	9.33	2.67	1.67	0.00
Control	75.00	65.00	46.67	41.67	55.00	48.33	73.33	42.67	32.67	31.67	27.67

CD (0.05) :

Treatment× days : 5.786

1: first spraying
2: second spraying

acephate 0.05 per cent too recorded significant reduction in the damage compared to control (46.67) and the leaf damage in treatments ranged from 13.33 to 25.00 per cent. Significantly higher damage was observed by *Henosepilachna* sp. when neem oil 2.0 per cent (33.33) was sprayed .

After second spraying

All the treatments except neem oil 2.0 per cent (28.33) significantly suppressed the damage caused by the pest on fifteenth day after spraying when compared to control (41.67). Imidacloprid (5.00) was the most effective among the treatments and was on par with the carbaryl, dimethoate (6.67each) and fenvalerate (8.33).

A. peponis* and *D. indica

After first spraying

Fenvalerate 0.02 per cent (13.33) was the most effective treatment for reducing the damage caused by *A. peponis* and *D. indica* and was on par with the lambdacyhalothrin 0.01 per cent (18.33) and imidacloprid 0.002 per cent (20.00) on fifteen days after spraying. Dimethoate 0.05 per cent, carbaryl 0.1 per cent, malathion 0.2 per cent and acephate 0.05 per cent were found to be effective when compared to control (55.00) and the percentage damage ranged from 28.33 to 33.33. They were on par with each other. There was no significant reduction in the damage produced by neem oil 2.0 per cent (41.67) among the treatments.

After second spraying

The same trend was observed after the second spraying as in case of the first spray. Maximum reduction in the extent of damage by *A. peponis and D. indica* was obtained with fenvalerate 0.02 per cent (8.33) which recorded same effect as that of lambdacyhalothrin (13.33) and with lamdacyhalothrin 0.01 per cent, imidacloprid (15.00). The treatments *viz.,* malathion 0.2 per cent (26.67), acephate 0.05 per cent (28.33), dimethoate 0.05 per cent (23.33) and carbaryl (25.00) were on par with each other.

B. cucurbitae

After second spraying

The damage caused by the pest on fifteenth day after spraying ranged from 13.33 to 73.33. Maximum reduction in the extent of damage by *B. cucurbitae* was obtained with imidacloprid 0.002 per cent which recorded same effect as that of malathion 0.2 per cent (16.67), dimethoate 0.05 per cent and carbaryl 0.1 per cent (20.00 each). The treatments *viz.,* lamdacyhalothrin 0.01 per cent (26.67), acephate 0.05 per cent (33.33) and neem oil 2.0 per cent (46.67) were also found effective in controlling the damage by *B. cucurbitae* when compared to control .

A. gossypii

After first spraying

All the treatments significantly suppressed the damage caused by the pest on fifteenth day after spraying when compared to control (42.67). Maximum reduction in the extent of damage by *A. gossypii* was obtained with imidacloprid 0.002 per cent (9.33) which recorded same effect as that of dimethoate (11.00). Acephate 0.05 per cent, fenvalerate 0.02 per cent, lamdacyhalothrin 0.01 per cent, malathion 0.2 per cent and carbaryl 0.1 per cent were found to be significantly effective in controlling the damage by *A. gossypii.* The extent of damage was only 17.67, 20.33, 22.67, 25.33 and 26.67 per cent in the treatments, respectively at fifteen days after spraying. There was no significant reduction in the percent damage when neem oil 2.0 per cent (33.33) was sprayed when compared with all the treatments.

After second spraying

A similar trend was observed as that of first spraying, the percentage damage ranged from 2.67 to 25.33.

L. trifolii

After first spraying

All the treatments significantly suppressed the damage caused by the pest on fifteenth day after spraying when compared to control (31.67). Maximum reduction in the extent of damage by *L. trifolii* was obtained with imidacloprid 0.002 per cent

(1.67) which recorded same effect as that of dimethoate (3.33). fenvalerate 0.02 per cent (6.00), lamdacyhalothrin 0.01 per (7.67) and malathion 0.2 per cent (9.33). Carbaryl 0.1 per cent (15.00) and neem oil 2.0 per cent (24.33) were found to be less effective when compared to other treatments.

After second spraying

A similar condition was observed as that of first spraying, the percentage damage ranged from 0.00 to 22.67.

4.3.3 Natural Enemies

Spiders

The effect of different insecticides on spiders and coccinellid beetles are presented in Table 16.

After first spraying

On one day after spraying, there was significant reduction in the population of spiders in all the treatments over control (2.83). The lowest population was recorded in plot which received dimethoate 0.05 per cent and carbaryl 0.1 per (0.08each) which was statistically on par with the population of lambdacyhalothrin 0.1 per cent (0.33) and fenvalerate 0.02 per cent (0.42). There was no significant difference in the population with acephate 0.05 per cent (0.67), malathion 0.2 per cent (0.83), imidacloprid 0.002 per cent and neem oil 2.0 per cent (1.33 each). A similar condition was observed in third and fifth days after spraying, the population ranged from 0.17 to 2.42 and 0.75 to 2.58, respectively. A similar condition was observed in seventh day after spraying except the lowest population was recorded in treatment with carbaryl 0.1 per cent (1.17) and was significantly varied with the other treatments, the population ranged from 1.67 to 2.92. On fourteenth day after spraying, the population build was established reaching on par with the control.

After second spraying

On the first day after spraying, there was significant reduction in the population of all the treatments over control (3.92). The lowest population was recorded in the plot received carbaryl 0.1 per cent (0.17) which was statistically on

Table 16. Mean population of spiders and coccinellids at different intervals after insecticide spraying (Mean number / plant)

Treatments	Days after first spray					Days after second spray					Mean
	1	3	5	7	14	1	3	5	7	14	
Spiders											
Neem oil 2.0 %	1.33	2.42	2.58	2.92	2.58	1.92	3.00	3.42	3.42	3.42	2.70
Malathion 0.2 %	0.83	1.08	1.75	2.08	2.83	1.08	1.58	2.33	3.58	3.58	2.08
Acephate 0.05 %	0.67	0.92	1.33	1.92	2.75	0.92	1.42	2.08	3.17	3.33	1.85
Dimethoate 0.05%	0.08	0.33	0.58	1.75	2.92	0.33	0.50	1.42	2.33	3.17	1.34
Carbaryl 0.1%	0.08	0.17	0.75	1.17	3.00	0.17	0.42	0.92	1.58	3.00	1.13
Lambdacyhalothrin 0.01%	0.33	0.50	1.58	2.00	2.75	0.42	1.00	1.75	2.50	3.50	1.63
Fenvalerate 0.02%	0.42	0.58	1.08	2.50	3.00	0.75	1.17	1.92	2.67	3.75	1.78
Imidacloprid 0.002%	1.33	2.17	3.00	3.00	2.58	1.75	2.33	3.25	4.08	3.92	2.74
Control	2.83	2.83	2.42	2.75	2.67	3.92	3.67	3.58	3.83	3.25	3.18
Coccinellids											
Neem oil 2.0 %	1.92	2.00	3.00	3.33	3.08	2.00	2.17	3.58	3.92	4.00	2.90
Malathion 0.2 %	0.42	0.33	0.58	1.08	3.00	0.92	1.00	1.42	1.75	3.83	1.43
Acephate 0.05 %	0.25	0.33	0.67	1.25	3.08	0.67	0.83	1.08	1.42	4.08	1.37
Dimethoate 0.05%	0.08	0.08	0.33	0.75	2.83	0.50	0.67	0.75	1.08	3.58	1.07
Carbaryl 0.1%	0.00	0.08	0.42	0.92	2.75	0.17	0.25	0.58	0.92	3.58	0.97
Lambdacyhalothrin 0.01%	0.67	0.75	1.00	1.58	3.17	0.92	1.17	1.42	1.67	3.50	1.58
Fenvalerate 0.02%	0.92	1.00	1.75	1.42	2.92	1.08	1.25	1.50	1.75	3.58	1.72
Imidacloprid 0.002%	1.17	1.33	2.50	3.25	3.17	1.33	1.50	2.08	2.17	4.42	2.29
Control	3.00	2.92	3.08	3.00	2.92	3.58	3.75	4.00	4.08	3.75	3.41

CD (0.05) :	Spiders	Coccinellids
Treatment mean	: 0.248	0.277
Treatment × days	: 0.578	0.438

par with the dimethoate 0.05 per cent (0.33) and lambdacyhalothrin 0.1 per cent (0.42). Treatments with neem oil 2.0 per cent (1.92) was statistically on par with the population in imidacloprid 0.002 per cent (1.75).

In the case of third day after spraying, the lowest population was recorded in the plot received carbaryl 0.1 per (0.42) which was statistically on par with the dimethoate 0.05 per cent (0.50). Lambdacyhalothrin 0.1 per cent, acephate 0.05 per cent, fenvalerate 0.02 per cent and malathion 0.2 per cent showed the same effect as the population being 1.00, 1.42, 1.17 and 1.58, respectively. Treatments with neem oil 2.0 per cent (3.00) was recorded highest population and significantly varied with the other treatments. A similar condition was observed in the fifth day after spraying. The population ranged from 0.92 to 3.42.

The data on the seventh day after spraying showed significantly lower population recorded in carbaryl 0.1 per cent (1.58) when compared to all other treatments. The highest population (4.08) was recorded in imidacloprid 0.002 per cent and it was statistically on par with the population of malathion 0.2 per cent (3.58).

In the case of fourteenth day after spraying, the population build was established reaching on par with the control. All the treatments were on par with each other, the values ranged from 3.00 to 3.44.

All the treatments were significantly reduced the mean population of spiders over control (3.18). The lowest population recorded in carbaryl 0.1 per cent and was statistically on par with the dimethoate 0.05 per cent (1.34). There was no significant difference in the treatments lambdacyhalothrin 0.01 per cent, fenvalerate 0.02 per cent and acephate 0.05 per cent, the population was 1.63, 1.78 and 1.85, respectively. The highest population was observed in neem oil 2.0 per cent and significantly varied with the all other treatments.

Coccinellid beetles

After first spraying

On one day after spraying, there was significant reduction in the population of all the treatments over control (3.00). There was no coccinellid beetles population in carbaryl 0.1 per cent which was statistically on par with the dimethoate 0.05 per cent

(0.08), acephate 0.05 per cent (0.25) and malathion (0.42). There was no significant difference in the population in fenvalerate 0.02 per cent, imidacloprid 0.002 per cent and lambdacyhalothrin 0.1 per cent the population being 0.92, 1.17 and 0.67, respectively. Neem oil 2.0 per cent (1.92) was significantly safer than other treatments. A similar trend was observed in the third day after spraying, the population ranged from 0.83 to 2.00.

The lowest population was recorded in the plot which received dimethoate 0.05 per cent (0.33) on fifth day after spraying which was statistically on par with the carbaryl 0.1 per cent (0.42), malathion 0.2 per cent (0.58) and acephate (0.67) and were highly toxic to spiders. The highest population (3.00) was recorded in neem oil 2.0 per cent and was statistically on par with the population of control (3.08). A similar condition was observed in the seventh day after spraying, the population ranged from 0.75 to 3.33.

In the case of fourteenth day after spraying, the population build was established reaching on par with the control. All the treatments were on par with each other.

After second spraying

On one day after spraying, there was significant reduction in the population in all the treatments over control (3.58). The lowest population was recorded in the plot received carbaryl 0.1 per cent (0.17) which was statistically on par with the dimethoate 0.05 per cent (0.50), acephate 0.05 per cent (0.67), malathion 0.2 per cent, lambdacyhalothrin 0.01 per cent (0.92 each), fenvalerate 0.02 per cent (1.08) and imidacloprid 0.002 per cent (1.33) . Treatments with neem oil 2.0 per cent (2.00) was recorded highest population and significantly varied with the other treatments. A similar condition was observed in third and fifth days after spraying, the population ranged from 0.25 to 2.17 and 0.58 to 3.58, respectively.

In the case of seventh day after spraying, the lowest population was recorded in the plot received carbaryl 0.1 per cent (0.92) which was statistically on par with the dimethoate 0.05 per cent (1.08), acephate 0.05 per cent (1.42). Treatments with neem oil 2.0 per cent (3.92) was statistically on par with the population of control (4.08) and were comparatively safe to spider population.

There was no significant difference in the population observed in treated and control on fourteenth day after spraying, the population ranged from 3.50 to 4.42.

There was significant reduction in the mean population of coccinellids in all the treatments over control (3.41), the population ranged from 0.97 to 2.90. The lowest population was recorded in carbaryl 0.1 per cent and was on par with the population in plot sprayed with dimethoate 0.05 per cent (1.07). Higher population was observed in neem oil 2.0 per cent and significantly varied with the all other treatments.

Yield

The data on the yield, seed weight and seed germination of oriental pickling melon is given in Table 17.

The average healthy fruit yield per plot ranged from 3.23 kg in control to 9.57 kg in imidacloprid 0.002 per cent treated plot. The highest yield obtained in imidacloprid 0.002 per cent was followed by malathion 0.2 per cent and carbaryl 0.1 per cent which recorded 8.85 and 8.27 kg fruit yield, respectively and were on par with imidacloprid 0.002 per cent. The yield from the plot treated with fenvalerate 0.02 per cent was 7.77 kg which was on par with lambdacyhalothrin 0.01 per cent (6.97 kg) and acephate 0.05 per cent (6.75 kg). There was no significant difference in yield between the treated plot with dimethoate 0.05 per cent (5.13 kg) and neem oil 2.0 per cent (4.97 kg). The lowest yield (3.23 kg) recorded from control plot and was differed significantly with the rest of the treatments.

Seed weight

The average seed weight per fruit ranged from 6.86 g in control to 11.53 g in malathion 0.2 per cent treated plot. The seed weight was maximum in the plot sprayed with malathion 0.2 per cent. This was followed by carbaryl 0.1 per cent, lambdacyhalothrin 0.01 per cent and imidacloprid 0.002 per cent which recorded 11.22, 10.96 and 10.50 g fruit seed, respectively and were on par with malathion plot. The seed weight from the fruit treated with fenvalerate 0.02 per cent was 10.10 g which was on par with dimethoate 0.05 per cent, acephate 0.05 per cent and neem oil

Table 17. Effect of different insecticides on fruit yield, seed weight and germination of oriental pickling melon

Treatments	Fruit yield (Kg /plot)	Seed weight (g) / fruit	Seed germination (%)
Neem oil 2.0 %	4.97	9.33	90.00
Malathion 0.2 %	8.85	11.53	90.00
Acephate 0.05 %	6.75	9.76	90.00
Dimethoate 0.05 %	5.13	9.87	90.00
Carbaryl 0.1 %	8.27	11.22	90.00
Lambdacyhalothrin 0.01 %	6.97	10.96	90.00
Fenvalerate 0.02 %	7.77	10.10	90.00
Imidacloprid 0.002 %	9.57	10.50	90.00
Control	3.23	6.86	60.00
CD	0.929	1.277	-

2.0 per cent which recorded 9.87, 9.76 and 9.33 g fruit, respectively. The lowest seed weight 6.86 g fruit recorded in control which differed significantly with the rest of the treatments.

Seed germination percentage

All the treatments showed 90 per cent of germination of seeds whereas in control the germination was only 60 per cent. There was no significant difference between the treatments, except over the control.

DISCUSSION

5. DISCUSSION

Encouraging pollination process and protecting the crop from pests are equally important in enhancing production and productivity of cucurbits. Cucurbitacae with unisexuality stands unique entomophilous family since insect pollination is chiefly of wide occurrence in bisexual plants. Mostly, insects belonging to Hymenoptera, Diptera, Coleoptera and Lepidoptera are found to visit the flowers of such plants. Among these, hymenopterans more specifically honey bees are regarded as the most efficient pollinators of the plants. Farmers usually use various insecticides especially in an unscientific and haphazard manner to control the pest which may harm beneficial insects like the pollinators. Hence, there is an urgent need for protecting the pollinators and beneficial insects from indiscriminate use of insecticides. The study was to find out the insect pollinators, pests and their natural enemies and to assess the impact of insecticides on these insects. The results of the study are discussed here under.

5.1 INSECT COMMUNITY

The total number of different species of insects recorded on the cucurbitaceous vegetables was found to be 47. Of these, majority was represented by Hymenoptera (28.00 per cent) followed by Coleoptera (21.00 per cent), Lepidoptera (19.00 per cent), Hemiptera (17.00 per cent), Diptera (11.00 per cent), Orthoptera and Thysanoptera (2.00 per cent each) (Fig.1).

Besides the insects, two species of spiders (Araneae) and one species of mite (Acariformes) were observed in three cucurbits. Marinturriza et al. (1995) recorded 52 species of entomofauna belonging to 38 families and 9 orders in cucumber of which 67.12 per cent were phytophagous, 18.78 percent predators, 6.07 percent parasitoids and 8.10 per cent pollinators.

Pollinators

The cucurbits were visited by 29 species of insects belonging to the order Hymenoptera, Lepidoptera, Coleoptera, Diptera, Hemiptera and Thysanoptera. Hymenoptera (37.93 per cent) represented the most dominant insect order followed by

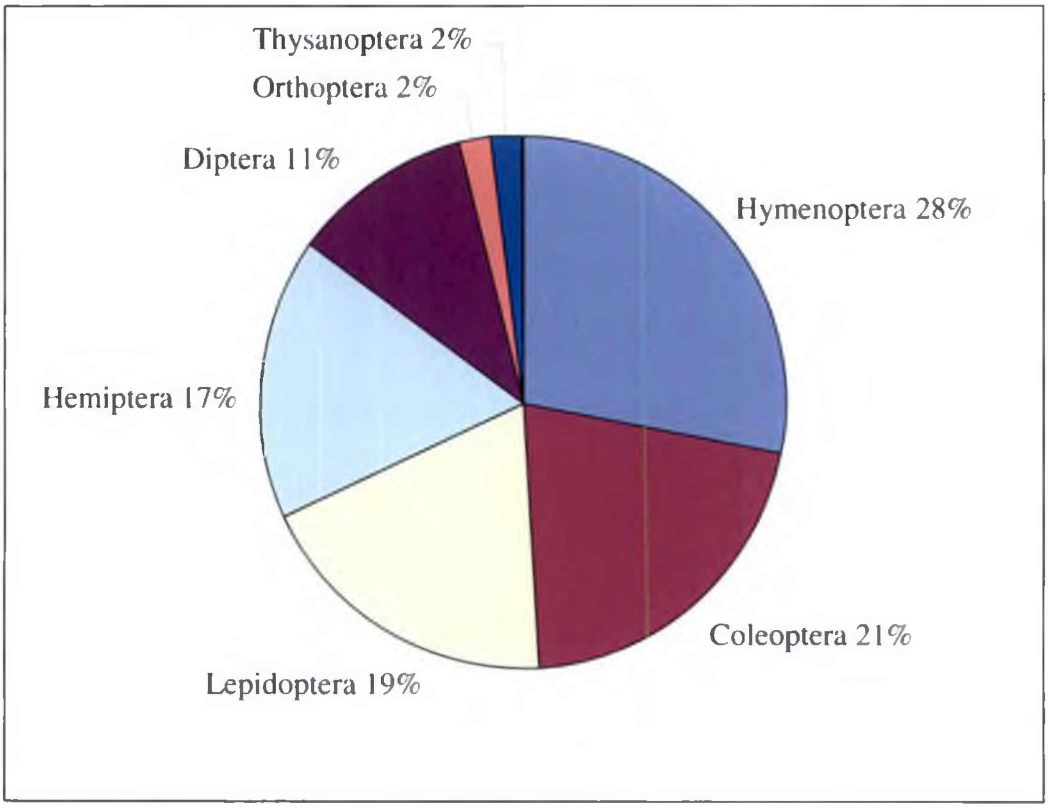


Fig.1. Different groups of insect species associated with the cucurbitaceous vegetables

Lepidoptera (20.68 per cent), Coleoptera (17.24 per cent), Diptera (13.79 per cent), Hemiptera (6.90 per cent) and Thysanoptera (3.44 per cent) (Fig.2). Nevkrytha (1937) recorded 63 species of Hymenoptera, 16 species of Diptera, seven species of Lepidoptera, one species each of Hemiptera and Coleoptera on cucurbit flowers in Ukarine region. Similar observations were also recorded by Atwal (1970) on cucurbitaceous flowers in Ludhiana. Evidently conservation of the hymenopterans especially the honey bees providing sufficient bee colonies in cucurbit gardens will invariably enhance the yield of the crop by way of increased pollination.

The snake gourd flowers were visited by different insect pollinators of which Hymenoptera (51.65 per cent) represented the most dominant insect order followed by Lepidoptera (16.11 per cent), other insects (12.80 per cent), Coleoptera (11.70 per cent) and Diptera (7.72 per cent). Among the four species of bees, *A. cerana indica* was the most abundant followed by *Trigona* sp. and solitary bees. *A. mellifera* was the least visitor of the crop (Fig.3).

The bitter gourd flowers were visited by different insect pollinators of which Hymenoptera (61.44 per cent) represented the most dominant insect order followed by other insects (14.05 per cent), Lepidoptera (9.90 per cent), Coleoptera (8.46 per cent) and Diptera (6.12 per cent). Among the four species of bees, *Trigona* sp. was the most abundant followed by *A. cerana indica*, *Anderna* sp. and *A. mellifera* (Fig.3).

In the present study, oriental pickling melon flowers were visited by different insect pollinators of which bees were predominant. Hymenoptera (59.10 per cent) represented the most dominant insect order followed by Coleoptera (14.07 per cent), Lepidoptera (11.80 per cent), Diptera (8.74 per cent), and other insects (8.21 per cent) (Fig.3). Among the four species of bees, *A. cerana indica* was the most abundant followed by *Trigona* sp. and *Anderna* sp. *A. mellifera* was the least visitor of the crop.

The present study indicated that while *A. cerana indica* was the dominant pollinator in oriental pickling melon and snake gourd, *Trigona* sp. was dominant in bitter gourd. Girish (1981) reported that *Apis* sp. were the most important pollinators of summer squash *viz., A. cerana indica, A. dorsata* and *A. florea*, which contributed

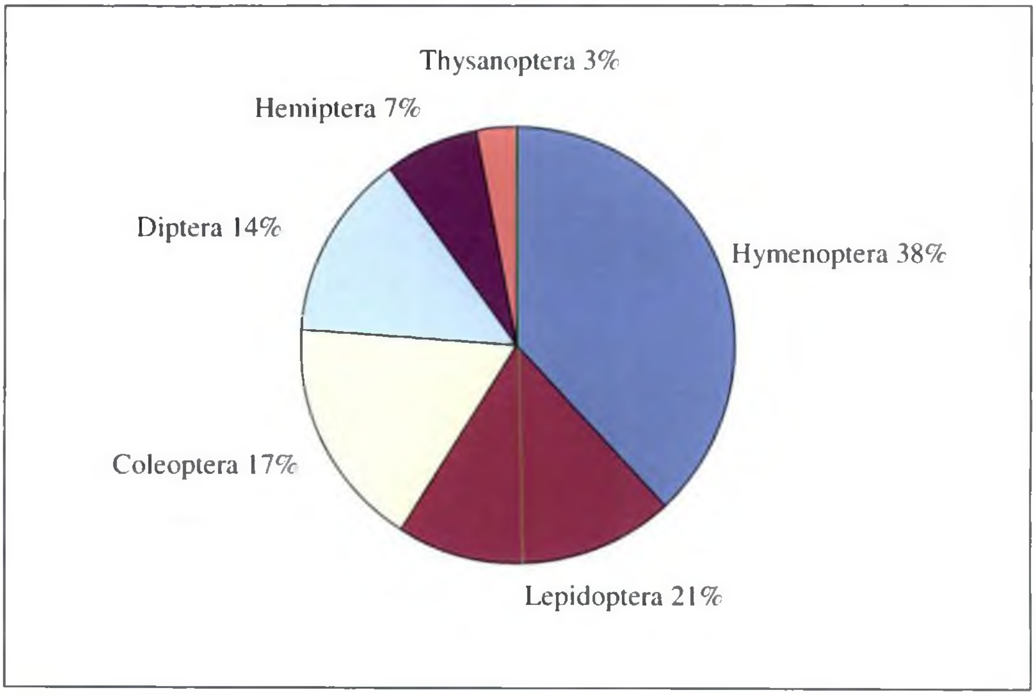


Fig.2. Different groups of insect pollinators visiting on cucurbitaceous vegetables

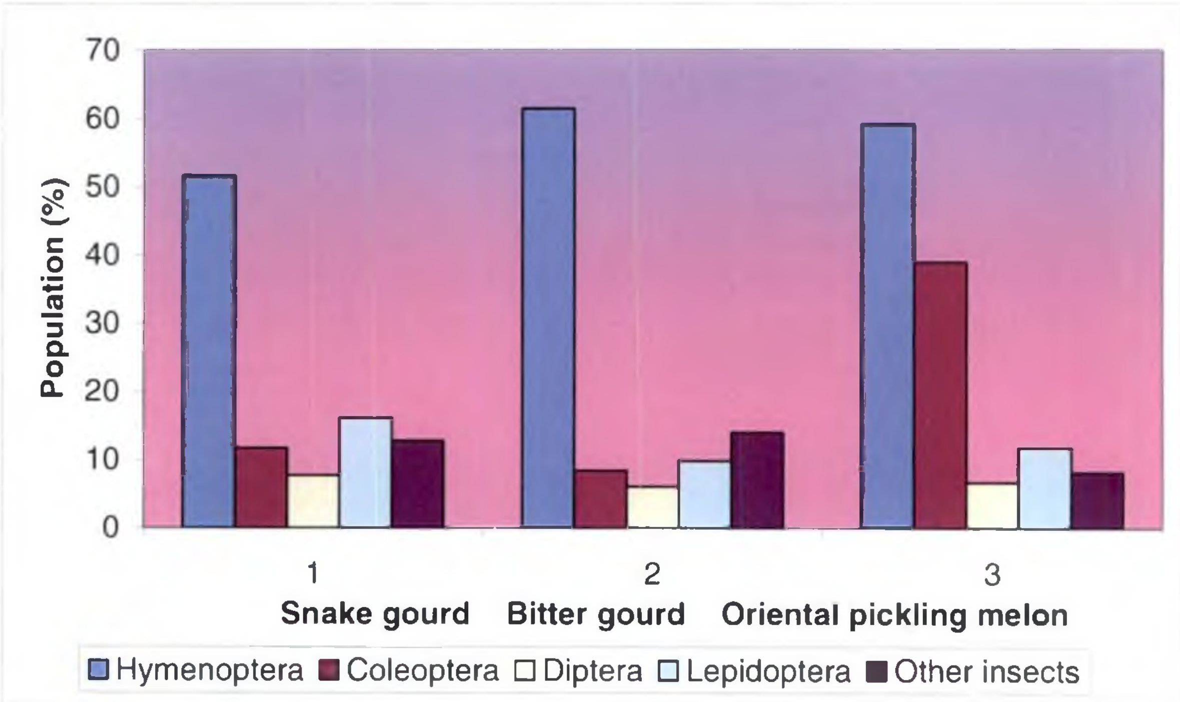


Fig.3. Relative abundance of different group of insect pollinators visiting three cucurbitaceous flowers.

87, 10 and 3 percent, respectively around Bangalore. The presence of this hymenoptera as insect visitor may help in enhancing the pollination of the crop.

The higher activity of insect pollinators was observed under pesticide free condition in the Instructional farm, when compared to farmer's field (Fig.4). The drastic decrease in the population of insect pollinators was 43.26 per cent, 14.75 per cent and 14.59 per cent reduction in snake gourd, oriental pickling melon and bitter gourd, respectively.

With the exception of dipterans; population of other groups of insect pollinators were high during the summer than rainy season, whereas dipterans were recorded in the rainy season. The decrease in the population of insect pollinators was 18.19, 14.07 and 13.03 per cent in bitter gourd, oriental pickling melon and snake gourd, respectively (Fig.5). According to Naim and Hadke (1976) the bee colonies were least active during the rainy days and high humidity.

Maximum number of pollinators were recorded in oriental pickling melon (17 / m^2 / 5 min) followed by bitter gourd (14 / m^2 / 5 min) and snake gourd (11 / m^2 /5 min). This might be due to the more nectar in oriental pickling melon when compared to the bitter gourd and snake gourd.

The maximum number of insect pollinators was recorded during the seventh week after sowing in oriental pickling melon (27.45 per cent), bitter gourd (33.20 per cent) and snake gourd (34.00 per cent) when compared to all other weeks. This might be due to prevalence of more flowers during the period (Fig. 6).

Pests

The total number of different species of insects and mite pests recorded from the three cucurbitaceous vegetables was found to be 29. Of these, the most dominant order Hemiptera represented 36.84 per cent followed by Coleoptera, Lepidoptera, Diptera, Orthoptera and Acariforms (Fig. 7). The major pests observed included the fruit fly, pumpkin beetle, epilachna beetle, pumpkin caterpillar, snake gourd semilooper, american serpentine leaf miner and *Aphis* sp.

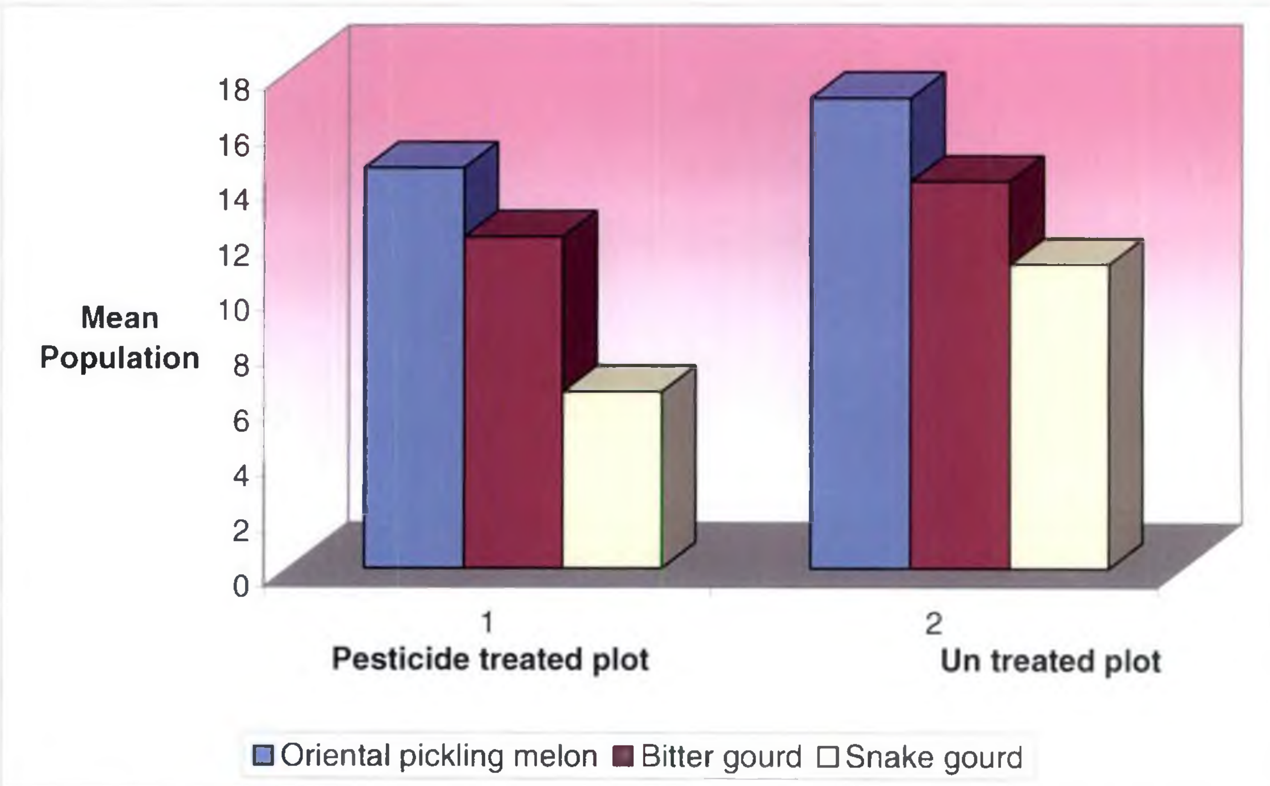


Fig.4. Relative abundance of insect pollinators in pesticide treated and untreated plots in three cucurbitaceous vegetables.

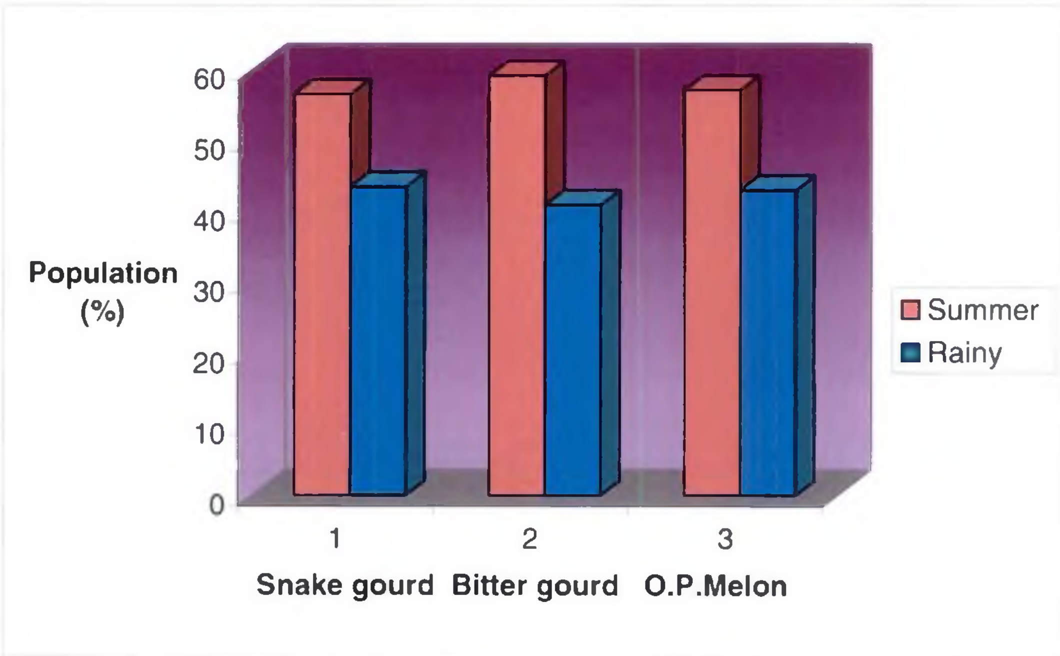


Fig.5. Comparison of insect pollinators in summer and rainy season

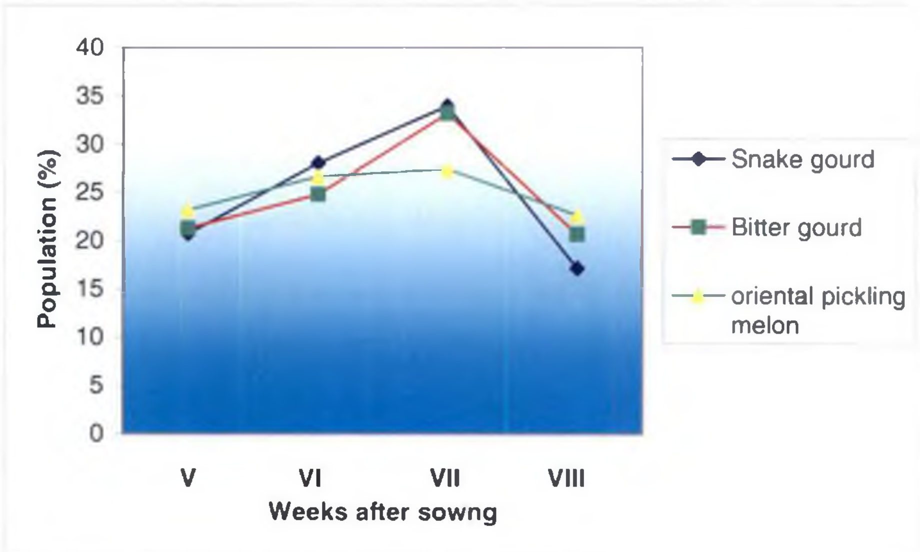


Fig.6. Foraging activity of insect pollinators at weekly intervals

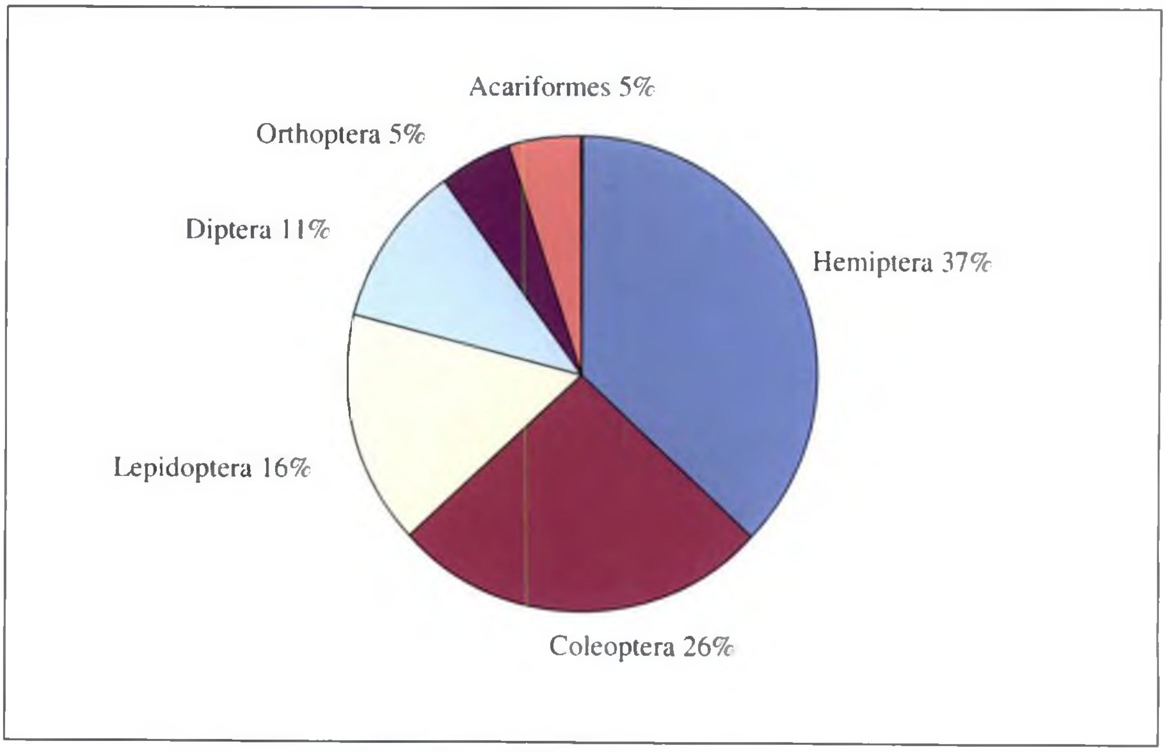


Fig.7. Different group of pests associated with the cucurbitaceous vegetables.

The pumpkin beetles mostly attacked the cucurbits at the seedling stage, especially at cotyledonary leaf stage. They make holes in cotyledonary leaves (plate 4.), though damage is caused at this stage, they attack the vines in the grown up stage till harvesting stage. Variation in the population of *Aulacophora* sp. was noticed in the three cucurbitaceous vegetables. Higher population was noted in oriental pickling melon followed by snake gourd. The pest was not observed in bitter gourd. The present study is in agreement with the findings of Reeta-Johri et al. (2003 b). The population of the pest varied significantly in rainy and summer seasons. An increase in the population was recorded during summer. The clear cut population fluctuation observed during the two seasons might be due to shorter life cycle and comparatively higher survival rate during summer and wash off of the various stages in rainy season. The present findings are in agreement with the earlier findings of Borah et al. (1997).

The epilachna beetle was recorded from all the three cucurbitaceous vegetables. Infested leaves presented a lace like appearance initially- later, they turned brown, dried up and fell off completely defoliating the plant.

The melon fruit fly damage is caused by the maggots tunneling and feeding with in the fruits of cucurbits resulting in oozing out of brown, resinous fluid from the distorted and malformed fruits and cause premature dropping (Plate 4). Variation in the extent of damage caused by *B. cucurbitae* was noted in the three cucurbitaceous vegetables. The highest infestation was noted in bitter gourd followed by snake gourd and oriental pickling melon. Hollingsworh et al. (1997) and Rajpoot et al. (2002) reported that the melon fruit fly has been found to infest 95 per cent of bitter gourd fruits, 90 per cent snake gourd fruits and 60 to 87 per cent pumpkin fruits. The percentage of damage of fruits observed in rainy and summer season clearly showed variation. The highest infestation was noted in summer when compared to rainy season. The results when compared to rainy with the observation of Pankaj – Ingoley et al. (2002) reported high fruit infestation in June occurred under mean maximum temperature, minimum temperature, relative humidity and rain fall of 27.10 ^{0} C , 17.70 to 19.00 ^{0} C, 72.00 to 84.00 per cent and 53.3 to 61.5 mm, respectively.

The young larvae of *D. indica* fed on chlorophyll and skeletonised the leaves of the three cucurbits. The young and older larvae (plate 4) were also observed feeding on the flowers and boring in to ovaries. Similar damage by the pest was reported (Nair et al., 1999; Shivakumar, 2001 and Jhala et al., 2004) in little gourd, snake gourd and bitter gourd. During the rainy season incidence of the pest was high in bitter gourd followed by oriental pickling melon and snake gourd. Contrarily in summer highest infestation was observed in snake gourd followed by bitter gourd and oriental pickling melon. Similar infestation by the pest was reported by Jhala et al. (2005) the highest infestation was observed in little gourd followed by bitter gourd and then snake gourd.

High infestation caused by *A. peonis* was observed in snake gourd followed by bitter gourd and oriental pickling melon in both seasons (plate 4). The highest population was noted in summer when compared to rainy season.

The small green insects (*Aphis* sp.) damage the plants by sucking the leaf sap. In young stage cotyledonary leaves crinkle and in severe cases the plants wither. In grown up vines, the leaves turn yellow and plant loses its vigour and yield. Similar damage by the pest was reported by Nair (1999) and Perdikish (2003). The incidence of the pest was high in oriental pickling melon (plate 4) followed by bitter gourd and snake gourd during both the seasons (rainy and summer).

Leaves with serpentine mines showed drying and dropping of leaves due to severe infestation by *L. trifolii,* observed in all the three cucurbitaceous vegetables. Similar observations were reported by Regupathy et al . (2003). The pest incidence was high in oriental pickling melon (plate 4) followed by bitter gourd and snake gourd during both the seasons (rainy and summer).

Natural Enemies

The predators recorded in the study included coccinellid beetles, spiders and parasitoids.

The three species of coccinellid beetles predating on aphids observed in the survey were *M. sexmaculatus, Micraspis* sp. and *S. octomaculata* (plate 5). Variation in the population of coccinellid beetles was noticed in the different cucurbitaceous vegetables. Maximum population was observed in oriental pickling melon followed by snake gourd and bitter gourd.

The three species of spiders observed were *O. shweta, Thomisus* sp. and *Tetragnatha* sp. The highest population of the spiders was noted in oriental pickling melon followed by bittergourd and snakegourd. *Tetragantha* sp. and *Oxyopes* sp. were reported from bittergourd (Nandakumar and Saradamma, 1996) and five other vegetable ecosystems (Manu and Hebsybai, 2006).

The larvae of *D. indica* were found parasitized by *Apanteles* sp. Earlier workers also reported parasitism of *Apanteles* sp. on *D. indica* in cucurbits (Leandrobaui et al., 2006). Variation in the population of the parasitoid was noted in three cucurbitaceous vegetables. The highest population was observed in snake gourd followed by bitter gourd and then snake gourd.

5. 2 FORAGING ACTIVITY OF INSECT POLLINATORS

The foraging activity of the insect pollinators was continuous from 0600 to 1800 hr of the day. The activity of was more during 1000 to 1100 hr and gradually decreased in the afternoon. This higher activity may be due to the abundant availability pollen and nectar in the mid morning hours. The foraging activity was low during other hours of the day in different seasons. The results obtained were in agreement with the findings of Cervanica and Bergonia (1990). They reported that the common flower visitors of cucumber were *A. dorsata, X. chlorinae, X. philippinensis, Megachile atrata* Smith and were most abundant from 1000 hr to 1100 hr. Similarly, Sattigi et al. (1996) reported that foraging activity was noticed throughout the day but it was at the peak between 0800 to 1100 hr in summer and 0800 to 1200 hr in monsoon.

5.3 IMPACT OF INSECTICIDES

Relative safety / Toxicity of insecticides to Insect pollinators

Assessment of the relative safety / toxicity of different chemical and a botanical insecticide under field conditions clearly showed that the botanical insecticide, neem oil 2.0 per cent was safer than chemical insecticides to the pollinators. The foraging activity of insect pollinators was highly reduced in plots which received with lambdacyhalothrin 0.01 per cent and fenvalerate 0.02 per cent. Application of dimethoate 0.05 per cent, carbaryl 0.1 per cent and acephate 0.05 per cent also reduced the foraging activity of insect pollinators (Fig 8a). The present findings revealed that above insecticides were comparatively toxicity to the insect pollinators. These findings are in agreement with Raju (2002) who reported that insecticides like carbaryl, dimethoate, quinalphos were highly toxic, malathion being moderately toxic and endosulfan being non toxic to *A. cerana indica*. Similarly, cypermethrin and permethrin were highly toxic to foraging workers of *A. cerana indica*, methyl demeton and phosphamidon were moderately toxic, while endosulfan least toxic to honey bees, reported by Reddy et al. (1997). Earlier, Mall and Rathore (2003) also reported that dimethoate and quinalphos were repelling chemicals where less number of bees visited when compared to control treatments. Though suppression of insect pollinators was observed in all the treatments up to three days after treatment, on fifth, seventh, fourteenth and twenty first day after application, a gradual increase was observed, the population intensity reaching equal to the control, whereas in lambdacyhalothrin 0.01 per cent and fenvalerate 0.02 per cent treated plots recorded low population even up to fourteenth day after spraying (Fig 8 b). Neem oil 2.0 per cent, imidacloprid 0.002 per cent and malathion 0.2 per cent treated plots were higher foraging activity of insect pollinators when compared to all other treatments. The present findings revealed that these insecticides were comparatively less toxic to the insect pollinators. Neem oil was safe to insect pollinators, earlier workers also reported that neem oil was safe to *A. mellifera* (Sontakke and Dash, 1996; Abrol and Andorta, 1997).

The time spent by *A. cerana indica* in collecting pollen and nectar from treated plots differed significantly. Less time was spent in fenvalerate 0.02 per cent,

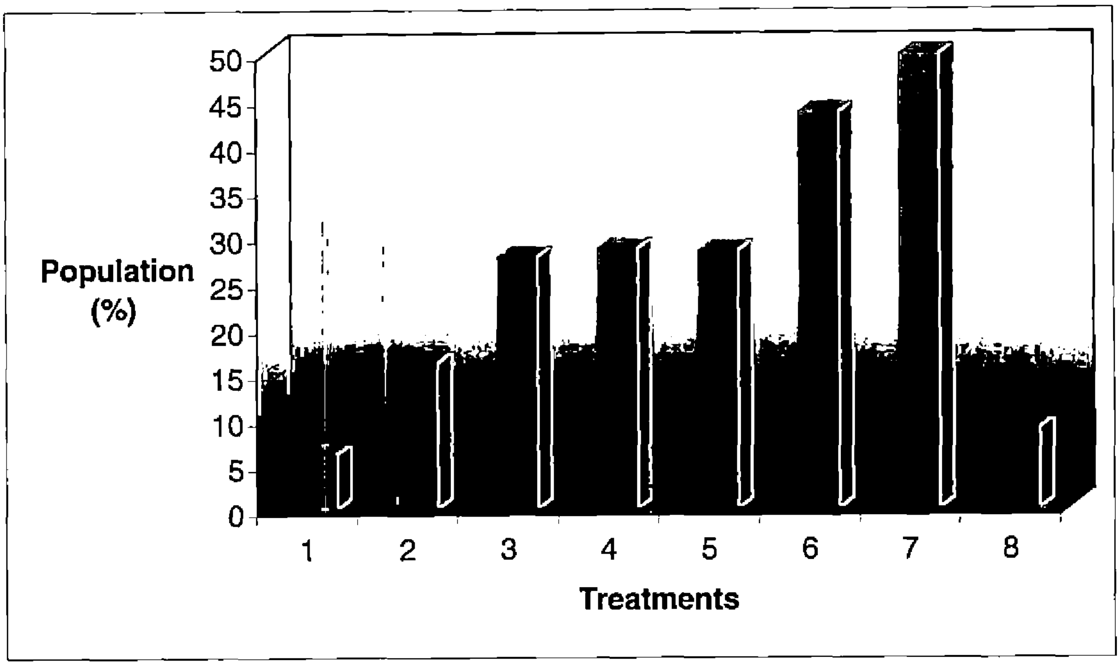


Fig. 8a

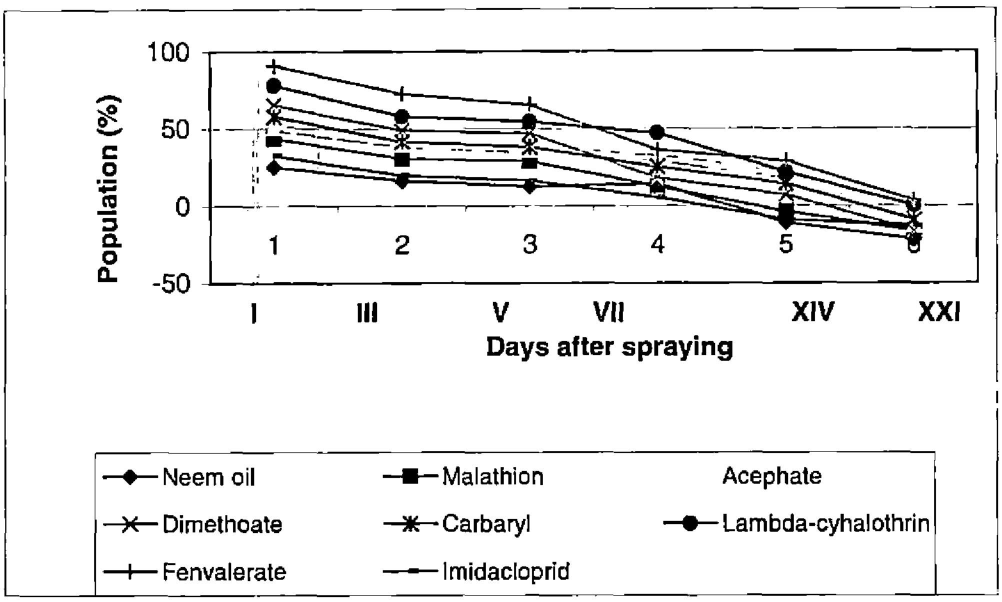


Fig. 8b

Treatments :

T1 – Neem oil 2.0 %	T5 - Carbaryl 0.1 %
T2 - Malathion 0.2 %	T6 – Lambda-cyhalothrin 0.01 %
T3 – Acephate 0.05 %	T7 - Fenvalerate 0.02 %
T4 – Dimethoate 0.05 %	T8 – Imidacloprid 0.002 %

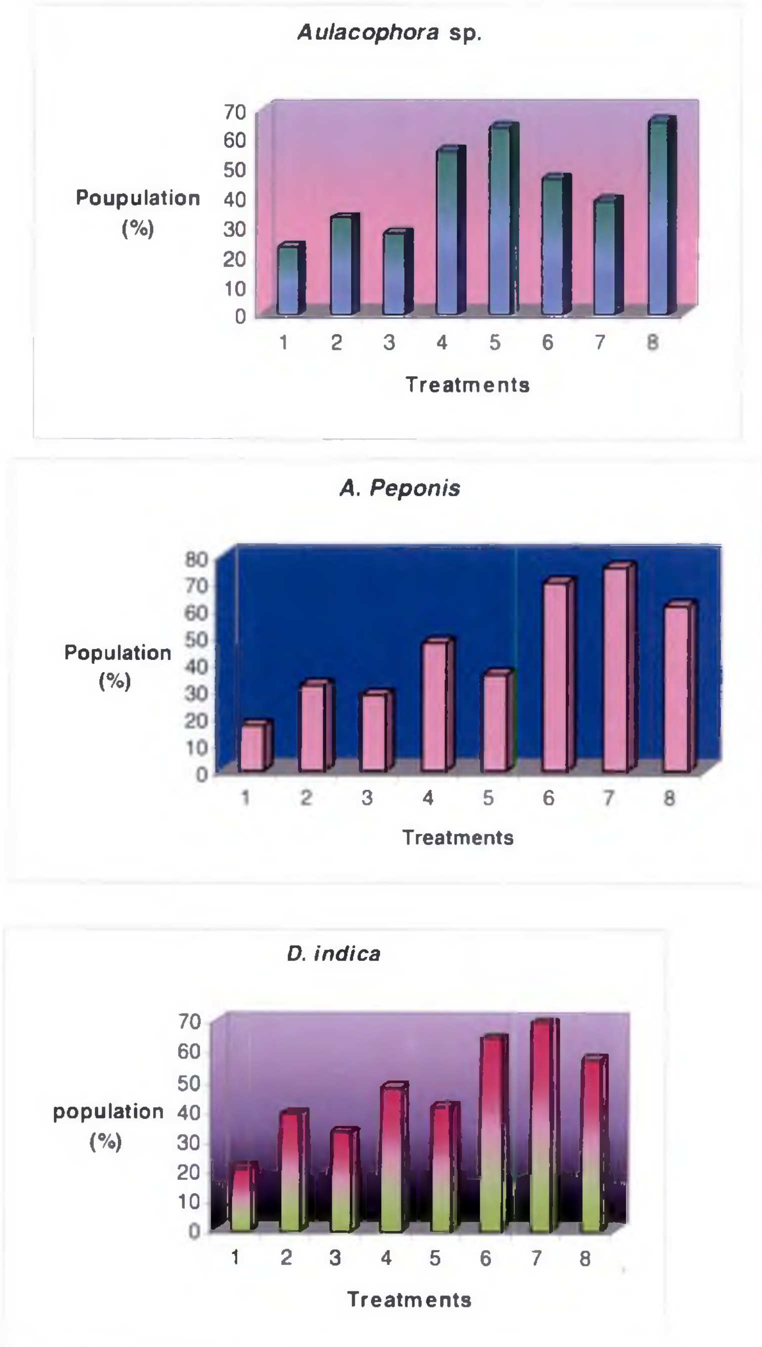
Fig.8. Extent of reduction in the population of *A. cerana indica* in insecticide treated plots.

lambdacyhalothrin 0.01 per cent, carbaryl 0.2 per cent and acephate 0.05 per cent treated plots. Though an immediate suppression of time spent by bees on flowers was observed in all the treatments on one and third day after treatment, on fifth, seventh, fourteenth and twenty first day after application a gradual increase was observed in the time spent by the bees. More time was spent by bees in neem oil 2.0 per cent, imidacloprid 0.002 per cent and malathion 0.2 per cent treated plots for collection of nectar and pollen from flowers. This might be due to the less repelling nature of these insecticides when compared to other insecticides. There was significant variation in the time spent by honey bees in collection of nectar from pistillate and staminate flowers. This might be due to greater quantity and sugar concentration in nectar of pistillate flowers. The present findings are in agreement with the findings of Girish (1981) who reported that there was a difference in the time spent for collecting nectar from pistillate and staminate flowers of *C. pepo* in Bangalore. Eshwarappa (2001) reported that sugar concentration in the nectar of pistillate flower (21.02 per cent) was high compared to staminate flowers (16.94 per cent).

Pests

Data generated in the present study revealed that chemical insecticides reduced the population of pumpkin beetles. Carbaryl 0.1 per cent, imidacloprid 0.002 per cent and dimethoate 0.05 per cent were found to be the most effective treatments against *Aulacophora* sp. Fig. (9). The observations are in line with the findings of Regupathy et al. (2003) who recommended malathion and dimethoate for controlling the leaf beetles. Studies conducted by Allen (2001) also observed that cucumber seeds treated with imidacloprid effectively controlled cucumber beetle.

The present study revealed that chemical insecticides reduced the damage by fruit flies. Imidacloprid 0.002 per cent was the most effective insecticide which reduced fruit fly damage by 73.33 per cent. All other chemical insecticides reduced the fruit fly damage, the extent of reduction ranging from 33.33 to 16.66 per cent (Table 12). Malathion 0.2 per cent, dimethoate 0.05 per cent and carbaryl 0.1 per cent also gave good control of fruit flies. The present findings are in agreement with those of Bhatnagar and Yadava (1992) who reported that malathion 0.5 per cent was more effective than carbaryl 0.2 per cent and quinalphos 0.2 per cent on bitter gourd and



Treatments :

T1 – Neem oil 2.0 %
T2 - Malathion 0.2 %
T3 – Acephate 0.05 %
T4 – Dimethoate 0.05 %
T5 - Carbaryl 0.1 %
T6 – Lambda-cyhalothrin 0.01 %
T7 - Fenvalerate 0.02 %
T8 – Imidacloprid 0.002 %

Fig.9. Reduction in the population of insect pests in insecticide treated plots.

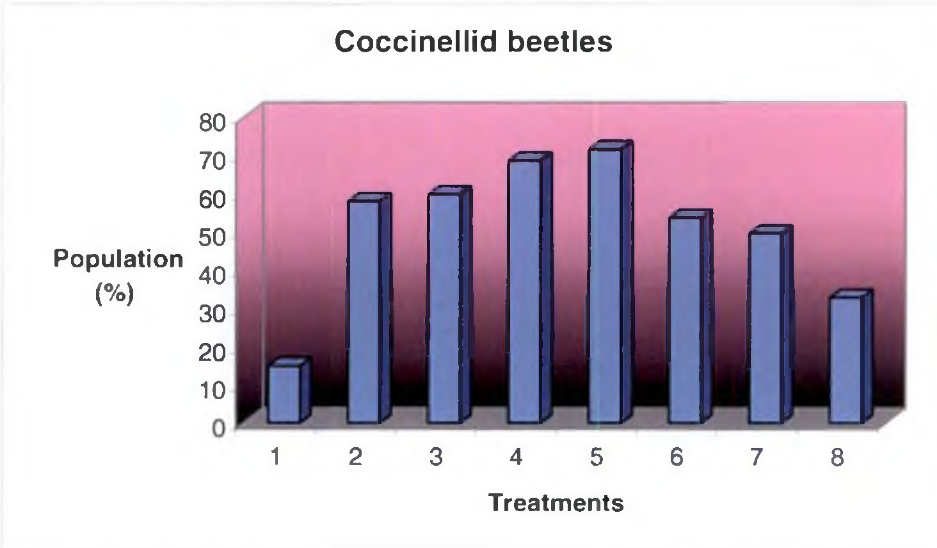
ring gourd. Similarly, Vijaysree (2006) studied imidacloproid being the most effective insecticide against the fruit fly control in coccinia.

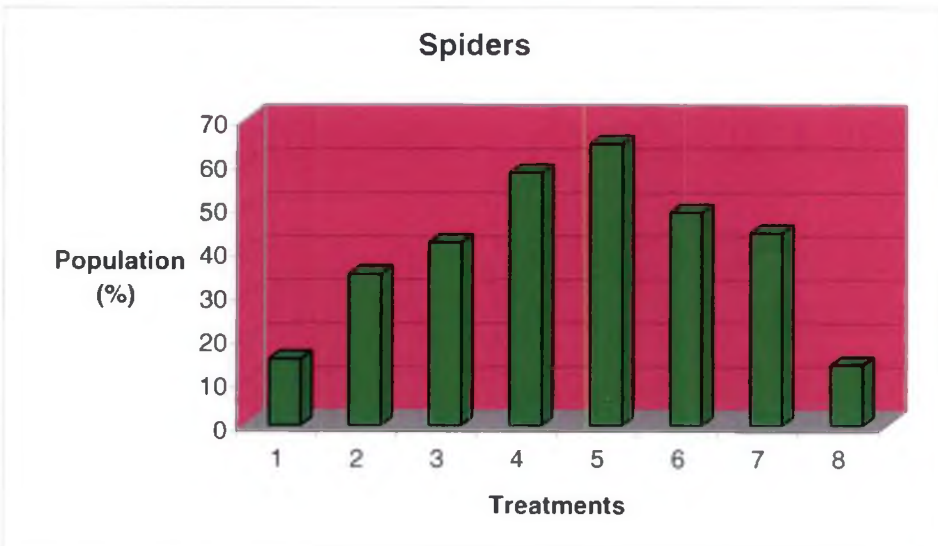
Fenvalerate 0.02 per cent, lambdacyhalothrin 0.01 per cent, dimethoate 0.05 per cent and imidacloprid 0.002 per cent were the most effective treatments against pumpkin caterpillar and snake gourd semilooper. Carbaryl 0.1 per cent and malathion 0.2 per cent also gave good control of larval population (Fig. 9). The present findings on the effectiveness of these chemicals are in agreement with those of Schreiner (1991) who reported the effectiveness of carbaryl and dimethoate in reducing caterpillar population.

In the present study, foliar application of imidacloprid 0.002 per cent and dimethoate 0.05 per cent were found to be the effective treatments against *A. gossypii* and *L. trifolii*. This may be explained interms of the systemic action. These findings are in agreement with KAU (2002). Efficacy of imidacloprid and dimethoate against aphids was reported by Regupathy et al. (2003) and Bridar and Shaila (2004). Similar observations were made by Rushtapakornchai et al. (1996) who reported that two application of fenitroparathin and acephate gave significant *L. trifolii* control.

Natural Enemies

The population of the major the predators *viz.,* coccinellids and spiders was more or less stable throughout the critical stages of crop growth in the case of neem oil 2.0 per cent and imidacloprid 0.002 per cent treatments (Fig.10). These findings agree with those of Kunel et al. (1999) and Tenczar et al. (2006) who reported that abundance of spiders was unaffected by imidacloprid. Immediate suppression of natural enemies was observed in all the treatments on first and third day after treatment, on fifth, seventh and fourteenth days after application a gradual increase was observed, the population intensity reaching equal to or more than the control. Among the synthetic insecticide treatments, foliar application of carbaryl 0.1 per cent and dimethoate 0.05 per cent were in general highly toxic to natural enemies followed by lambda-cyhalothrin 0.01 per cent and fenvalerate 0.02 per cent. The toxic effect of synthetic pyrethroids- cypermethrin and deltamethrin; the organo phosphates- dimethoate and malathion; and the carbamate- carbaryl showed a decrease in spider population earlier workers reported (Brine et al., 1998; Huusela – veistola, 1998:





Treatments :

T1 – Neem oil 2.0 %
T2 - Malathion 0.2 %
T3 – Acephate 0.05 %
T4 – Dimethoate 0.05 %
T5 - Carbaryl 0.1 %
T6 – Lambda-cyhalothrin 0.01 %
T7 - Fenvalerate 0.02 %
T8 – Imidacloprid 0.002 %

Fig.10. Reduction in the population of major predators in insecticide treated plots.

Yardim and Edwards, 1998; Holland et al., 2000; Tonaka et al., 2000). Similarly Bozsik (2006) reported that pyriproxifen, imidacloprid and B. *thringiensis* seem to be safe for *C. septempunctata* adults but deltamethrin and lambda-cyhalothrin were moderately harmful to them.

An over all assessment of the results indicated that bees (Hymenoptera) were the major pollinators of cucurbitaceous vegetables. Among the bees, *A. cerana indica* was the important pollinator of oriental pickling melon and snake gourd while *Trigona* sp. is the major pollinator of bitter gourd. Neem oil 2.0 per cent, imidacloprid 0.002 per cent and malathion 0.2 per cent were safer to the pollinators and predators, whereas fenvalerate 0.01 per cent, lambda-cyhalothrin 0.01 per cent, carbaryl 0.1 per cent and dimethoate 0.05 per cent were highly toxic to the pollinators and predator fauna of cucurbits. Imidacloprid 0.002 per cent and malathion 0.2 per cent which were identified as effective insecticides for the control of pests of cucurbitaceous vegetables proved to be safer to pollinators and predators. Thus control of the pests through the usage of such pollinator- predator friendly insecticides could enhance the yield of cucurbitaceous vegetables substantially.

SUMMARY

6. SUMMARY

The study was conducted to find out the insect pollinators, pests and their natural enemies, to determine the occurrence and distribution of these insects over a period of one year and to assess the impact of insecticides on insect pollinators, pests and their natural enemies. The results of the study are summarized as follows.

- The total number of different species of insects recorded on the cucurbitaceous vegetables was found to be 47. Of these, the groups were Hymenoptera (28 per cent), Coleoptera (21 per cent), Lepidoptera (19 per cent), Hemiptera (17 per cent), Diptera (11 per cent) followed by Orthoptera and Thysanoptera (2 per cent each). Besides the insects, two species of spiders (Araneae) and one species of mite (Acariformes) were observed in three cucurbits
- The cucurbit flowers were visited by 29 species of insects belonging to the orders Hymenoptera, Lepidoptera, Coleoptera, Diptera, Hemiptera, Thysanoptera and Orthoptera, respectively. Among the insect visitors, bees (Hymenoptera) were predominant in all the three vegetables. Among the four species of bees, *A. cerana indica* was the most dominant in oriental pickling melon and snake gourd. *Trigona* sp. was dominant in bitter gourd. *A. mellifera* least visited the three cucurbitaceous vegetables.

- Higher activity of insect pollinators was observed under pesticide free condition when compared to farmer's field. Drastic decrease was observed on the population of insect pollinators in snake gourd, oriental pickling melon and bitter gourd fields treated with insecticides, the extent of reduction being 43.26 per cent, 14.75 per cent and 14.59 per cent, respectively.

- With the exception of dipterans, highest population of insect pollinators was recorded during summer than rainy season. Maximum population of dipterans was observed in the rainy season.

- The maximum number of insect pollinators was recorded during the seventh week after sowing in oriental pickling melon (27.45 per cent), bitter gourd (33.20 per cent) and snake gourd (34.00 per cent).

- The maximum foraging activity of different insect pollinators was recorded during 1000 hr to 1100 hr and was gradually reduced in the afternoon hours and again the second peak was recorded at 1500 hr to 1600 hr.

- Among the three cucurbitaceous vegetables, the oriental pickling melon ($17/m^2/5$min) recorded the most dominant insect pollinators activity followed by bitter gourd($13 / m^2 / 5$ min) and snake gourd ($11 / m^2 / 5$ min).

- Analysis of the pest fauna of cucurbits in the farmer's field at weekly interval showed that the crop was attacked by three species of Coleoptera, two species of Lepidoptera and one species of Diptera and thirteen other minor pests. The severe pests observed in cucurbits were *Aulacophora* sp. and *B. cucurbitae*.

- *B. cucurbitae* caused 28 per cent damage in oriental pickling melon, 34 per cent in snake gourd and 38.66 per cent in bitter gourd. The fruit fly infestation was higher in summer compared to rainy season.

- The pumpkin beetles attacked most of the cucurbits at seedling stage, especially at cotyledonary leaf stage, although they attacked the vines in the grown up stage too until harvest. The highest infestation was noted in oriental pickling melon (28.89 per cent) followed by snake gourd (22.44 per cent). No infestation was recorded in bitter gourd.

- Highest infestation of pumpkin caterpillar was observed in bitter gourd followed by oriental pickling melon and snake gourd.

- Highest infestation of *Aphis* sp. and *L. trifolii* was observed in oriental pickling melon followed by bitter gourd and snake gourd during both rainy and summer seasons.

- The natural enemies observed in the survey were two species of spider predators, three species of insect predators and two parasitoids.

- Neem oil 2.0 per cent, imidacloprid 0.002 per cent and malathion 0.2 per cent proved to be safer than other chemical insecticides to pollinators. Lambda-cyhalothrin 0.01 per cent and fenvalerate 0.02 per cent reduced the foraging activity of pollinators up to two weeks. Dimethoate 0.05 per cent, carbaryl 0.1 per cent and acephate 0.05 per cent also reduced the foraging activity of pollinators. There was significant reduction in the population of pollinators on one day after spraying and gradually increased the population from third to fourteenth day after spraying, whereas lambda-cyhalothrin 0.01 per cent and fenvalerate 0.02 per cent treated plots low population was observed even up to fourteenth day after spraying.

- Imidacloprid 0.002 per cent, malathion 0.2 per cent, dimethoate 0.05 per cent and carbaryl 0.1 per cent significantly reduced the fruit fly infestation.

- Carbaryl 0.1 per cent, imidacloprid 0.002 per cent and dimethoate 0.05 per cent were found to be the most effective insecticides against pumpkin beetles.

- Fenvalerate 0.02 per cent, lambda-cyhalothrin 0.01 per cent, dimethoate 0.05 per cent and imidacloprid 0.002 per cent were the more effective against the pumpkin caterpillar and snake gourd semilooper .

- Neem oil 2.0 per cent and imidacloprid 0.002 per cent proved safer to natural enemies, where as carbaryl 0.1 per cent and dimethoate 0.05 per cent were highly toxic to natural enemies followed by lambda-cyhalothrin 0.01 per cent and fenvalerate 0.02 per cent .

- The highest yield was noted in imidacloprid 0.002 per cent treatment followed by malathion 0.2 per cent and carbaryl 0.1 per cent.

The study established a positive relationship between the population of pollinators and yield of cucurbitaceous vegetables. Moreover imidacloprid 0.002 per cent and malathion 0.2 per cent which were identified as effective insecticides for the control of pests of cucurbitaceous vegetables proved to be safer to pollinators and predators. Thus control of the pests through the usage of such pollinator-predator friendly insecticides could enhance the yield of cucurbitaceous vegetables substantially.

REFERENCES

REFERENCES

Abrol, D.P. and Andotra, R.S. 1997. Contact toxicity of some pesticides to honey bee *Apis mellifera* L. Pest. mgmt. and Econ. Zool., 5 (1): 47-51.

Abrol, D.P. and Rajiv, K. 2000. Impact of pesticides on the brood rearing activity and foragers of honey bee, *Apis mellifera* L. visiting *Brassica campestris* L. var. Toriq. Indian Bee J., 62 (1-2): 19 – 22.

Agarwal, M.L., Sharma, D.D. and Rahman, O. 1987. Melon fruit fly and its control. Indian Horticulture., 32: 10-11.

Agarwal, B.K. and Ghosh, A.K. 1998. Prey records of aphidophagous coccinellidae in India. A review and bibliography. Trop. pest Mgmt., 34 (1): 1 – 14.

*Akhtaruzzaman, M.D., Zinnatul-Alam, M.D. and Ali-Sardar, M.M. 2000. Efficacy of different bait sprays for suppressing fruit fly on cucumber. Bull. Institute Trop. Agric., Kyushu-University, 23: 15-26.

Allen, J.K., Scott Dupree., Tolman, J.H. and Harris, C.R. 2001. Evaluation of application methods for the chemical control of striped cucumber beetle (Coleoptera: Chrysomelidae) attracting seedling cucurbits. J. Veg. Crop Production, 7(2): 83 – 95.

Anad, R.K. 1983. Predation of *Coccinella septempunctata* and *Menochilus sexmaculatus* Fab. on five species of Aphids. Pranikee, 4: 234 – 237.

Andrews, E.S., Theis, N. and Adler, L.S. 2007. Pollinator and Herbivore attraction to cucurbita floral volatiles. J. Chem. Ecol., 33 (7) : 1573 – 1561.

Angeli,G., Berti, M., Gottardini, E., Cristofolini, F., Forti, D., Vogt, H. and Heimbach, U. 2002. Side-effects of the microencapsulated Fenitrocap/IPM-400 (fenitrothion) and Pyrinex (chlorpyrifos ethyl) on *Apis mellifera* L. (Hymenoptera: Apidae). IOBC-WPRS Working Group 'Pesticides and Beneficial Organisms'. Proceedings of the meeting at San Michele All'Adige, Trento, Italy, 3-6 October, 2001. Bulletin-OILB-SROP, 25 (11): 89-95.

Angeli, G., Gottardini, E., Fanti, M., Baldessari, M. and Forti, D. 2003. Selectivity of pesticides to bees, Informatore Agrario, 59 (24): 79-81.

Ankita, P. Shikha, T. pandey, A. and Tripathi, S. 2003. Foraging activity of honey bees in mustard. Annals Pl. Prot. Sci., 11(2) 378 p.

Arakaki, N. and Kinjo, K. 1998. Notes on the parasitoid fauna of the serpentine leaf miner, *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) in Okinawa, southern Japan. Appl. Ent. Zool., 33 (4): 577-581.

Ascher, J.S. and Buchmann, S. 2005. The Plight of pollinating bees. Bee World, 86 (3): 71 – 74.

Atwal, A. S., 1970. Biology, ecology and utilization of insects other than honey bees in the pollination of crops. Final Res. Rept. (1965 – 70) of PL – 480 Project executed at Punjab Agric. Univ., Ludhiana (India), p. 115.

Atwal, A.S. 1986. *Agricultural pests of India and South East Asia*, Kalyani publishers, Ludhiana, 261 p.

Babu, P.G., Reddy, D.J., Jadhav, D.R., Chiranjeevi, C. and Khan, M.A.M. 2002. Comparative efficacy of selected insecticides against pests of watermelon. Pesticide Res.J., 14 (1): 57-62 .

Baker, H.G. 1957. Plant notes: *Calystegia*. Proc. Bot. Soc. Br. Isl., 2: 241-243.

Bhatnagar, K.N and Yadava, S.R.S. 1992. An insecticidal trial for reducing the damage of some cucurbitaceous fruits due to *Dacus cucurbitae* Coq. Indian J. Ent., 54: 66-69.

Bielza, P., Contreras, J., Guerrero, M.M. and Izquierdo, J.A. 2001. Effects of Confidor 20 LS and Nemacur CS on bumblebees pollinating greenhouse tomatoes . IOBC / wprs Bulletin OILB – SROP, 24 (4): 83 – 88.

* Birnie, L., Shaw, K., Pye, B. and Denholm, I. 1998. Considerations withthe use of multiple dose bioassays for assessing pesticide effects on non-target arthropods. In *Proceeding Brighton Crop Protection Conference Pests and Diseases.* 16-19 November, Brighton, UK. pp. 291- 296.

Borah, R.K. 1997. Effect of sowing dates on the incidence of *Raphidopalpa foveicollis* and yield of cucumber in the hills zone of Assam. Indian J. Ent., 59(4): 430-431.

Bose, T.K., Som, M.G. and Kabir, J. 1993. *Vegetable crops*. Navya Prakash Publication , Calcutta, India. pp: 103 – 105.

Bozsik, A. 2006. Susceptibility of adult *Coccinella septempunctata* (Coleoptera: Coccinellidae) to insecticides with different modes of action. Pest. mgmt. Sci., 62(7): 651 – 654.

Bridar, A.P. and Shaila, H.M. 2004. Management of *Aphis punicae passerini* (Homoptera: Aphididae) in Pomegranate. Pest Mgmt. Hort. Ecosyst., 10 (2) : 157 - 159.

Cervanica, C.R. and Bergonia , E. A., 1990. Insect pollinators of cucumber (*Cucumis sativus* L.) in the Philippines. In: The sixth International Symposium on pollination Tilburg, Netherlands, pp. 27–31.

Chandrasekaran, M. 2001. Development of integrated pest management on bhendi. PhD. Thesis, Tamil Nadu Agricultural University, Coimbatore, p.175.

Chinta, R.M., Das, R.K. and Mandal, S.K. 2002. Pests and beneficial arthropods occurring on pointed gourd *Trichosanthes dioica* Roxb. (Cucurbitacae). J. Interacademicia., 6 (2): 174 – 179.

Choidongchill, C. 2003. Oviposition and feeding preference of the cotton caterpillar, *Palpita indica* (Lepidoptera: Pyralidae), in cucurbitacae, J. Appl. Ent., 42 (2): 119 – 124.

Chris Wien, H. 2006. Maximizing yield by understanding vine crop pollination. Vegetable IPM News, Cornell cooperative Extension. http://www.ag.ohiostate.edu/~vegnet/ news/currentvn09-06.htm.

Dasgan, H.Y., Ozdogan, A.O., Abak, K., Kaftanoglu, O., Abak, K (ed.) and Buyu Kalaca, S. 1999. Comparision of honey bees (*Apis mellifera* L.) and Bumble bees (*Bombus terrestris*) as pollinators for melon (*Cucumis melo* L.) grown in green houses, Act. Hort. 492: 131 – 134.

David, B.V. 2002. *Elements of Economic Entomology*. Popular Book Depot. Madras, p.562.

Devanesan, S., Nisha, M.M., Bennet, R. and Shailaja, K.K. 2002. Foraging behaviour of stingless bee, *Trigona iridipennis* Smith. Insect Envi., 8(3): 131-133 .

Dhillon, M.K., Naresh, J.S., Ram, S. and Sharma, N.K. 2005. Evaluation of bitter gourd (*Momordica charantia* L.) genotypes to melon fruit fly, *Bactrocera cucurbitae* (Coquillett). Indian J. Pl. Pro., 33: 55-59.

Duan, J.J. and Messing, R.H. 1997. Effect of two opiine parasitiods (Hymenoptera: Braconidae) introduced for fruit fly control on a native Hawaiian tephritid , *Trupanea dubautiae* (Diptera : Tephritidae). Biologocal control, 8 (3): 177 – 184.

Eiant, B., Hopper, R.H. and Mosche, C. 2006. Host choice by *Aphidius colemani*: effects of plants, plant - aphid combinations and the presence of intra – guild predators. Ecol.Ent., 31(4): 331 – 336.

Eswarappa, G. 2001. Pollination potentiality of different species of honey bee increasing the productivity of chow-chow (*Sechium edule* (Jacq.) S. W.), M.Sc. (Agri.) thesis, University of Agricultural Sciences, Bangalore. 88 p.

Faegri, K. and Van der Pijl, L. 1979. The principles of pollination ecology. 3rd Ed. Pergamon Press, Oxford, 248p.

Fiedler, L. 1987. Acephate residues after pre-blossom treatments: Effects on small colonies of honey bees. Bull. Envi. Contamination and Toxicol., 38 (4) : 594 – 601 .

Gingras, D., Gingras, J. and Oliveira, D. 1999. Visits of honeybees (Hymenoptera: Apidae) and their effects on cucumber yields in the field. J. Econ. Ent., 92(2): 435-438 .

Girish, P.P. 1981. Role of bees and pollination of summer squash (*Cucurbita pepo* L.) with special reference to *Apis cerana* F. MSc (Agri.) thesis, University of Agricultural Sciences, Bangalore. p

Gowda, G., Shivakumar, B.R. and Mallikarjunappa, S. 2002. Relative toxicity of some insecticides to different honey bee species . Sixth Asian Apicultural Association International conference and World Apixepo – 2002, Bangalore, India. 24 Feb. – 1 Mar. Abstract: 183

Gupta, J.N and Verma, A.N. 1982. Effectiveness of fenitrothion bait sprays against melon fruit fly, *Dacus cucurbitae* Coquillett in bitter gourd. Indian J. Agric. Res. 16: 41-46.

Hagerup, O. 1951. Pollination in the Faroes-in spite of rain and poverty of insects. Biol. Medd., 18: 1-48.

*Haque, M.E. and Islam, M.A. 1978. Effect of three species of aphid on food and fecundity of ladybird beetle, *Menochilus sexmaculatus* Fab. Bangladesh J. Agric., 3: 373 – 376.

Hoffmann, M.P., Ayyappath, R. and Gardner, J. 2003. Effect of striped cucumber beetle (Coleoptera: Chrysomelidae) foliar feeding on pumpkin yield. J. Entomol. Sci., 38 (3): 439-448.

Holland, J.M., Winder, L., and Perry, J.N. 2000. The impact of dimethoate on the spatial distribution of beneficial arthropods in winter wheat. Ann. Appl. Biol. 136: 93-105.

Hollingsworth, R., Vagalo, M. and Tsatsia, F. 1997. Biology of melon fly, with special reference to the Solomon Islands. In: Allwood AJ and Drew RAI editors. Management of fruit flies in the Pacific Proceedings of Australian Country Industrial Agricultural Research, 76:140–144.

Huusela-Veistola, E. 1998. Effects of perennial grass strips on spiders (Araneae) in cereal fields and impact on pesticide side-effects. J. Appl. Ent., 122: 575- 583.

Jacobson, R.J. and Croft, P. 1998. Strategies for the control of *Aphis gossypii* Glover (Hom.: Aphididae) with *Aphidius colemani* viereck (Hym.: Braconidae) in protected cucumbers. Biocon. Sci. and Tech., 8: 377– 387.

Jayakumari, R. 1967. Studies on the toxicities of some insecticides to grass of *Epilachna vigntioctopunctata*. MSc (Agri.) thesis, Agricultural College and Research Institute, Vellayani, Thiruvananthapuram.

Jeyakumar, P. and Uthamasamy, S. 1997. Bio-efficacy of some synthetic insecticides and botanicals against *Liriomyza trifolii* . Indian J. Ent., 59 (4): 347-350.

Jhala, R.C., Patel, Y.C., Dabhi, M.V. and Patel, H.M. 2004. Upsurge of pumpkin caterpillar Margaronia indica (Saunders) in cucurbits in Anand District of Gujarat. Insect Envi., 10(3) p.122.

Jhala, R.c ., Patel, Y.C., Dabhi, M.V. and Patel, H.M. 2005. Pumpkin caterpillar *Margaronia indica* Saunders in cucurbits in Gujarat. Insect Envi., 11(1):18 – 19.

Jhansirani, B. 2001. Pest management in ornamental, medicinal and aromatic crops. In. *Integrated pest management in horticultural ecosystem* (eds. Parvatha Reddy, P., Abraham Verghese and Krishnakumar, N.E), Capital publishing Company, New Delhi, p.263.

Jhonson, R.M., Zhimou, W., Schuler, M.A. and Berenbaum, M.R. 2006. Mediation of Pyrethroid Insecticide Toxicity to Honey Bees (Hymenoptera: Apidae) by Cytochrome P450 Monooxygenases. J. Econ. Ent., 99(4):1046 -1050.

Jiji, T., Napoleon, A., Tamilvel, D., Senthilkumar, Satpathy, S., Rai, S., Shivalingaswamy, T.M., Verghese., A. Stonehouse, J.M., and Mumford, J.D. 2005. Laboratory and field effectiveness of fruit fly baits in Southern Kerala . Pest mgmt in Hort. Eco. , (2) : 102 – 109 .

Jimenez, R.M.T., Bustillo, P.A.E. and Luque, Z.J.E. 1997. Impact of endosulfan and chlorpyrifos on *Apis mellifera* in Colombian coffee ecosystems. Revista Colombiana-de-Entomologia., 23 (1-2): 19-23.

Jyothi, J.V.A. 2003. Pollen foraging activity of *Apis cerana* F. and *Apis mellifera L.* under tropical conditions of Karnataka, India. Envi. and Ecol., 21(2):417- 419.

Kargaonkar., Desai, B., Mule, R.S. and Mehendale, S.K. 2004. Studies on biology of little gourd leaf eating caterpillar *Diaphania indica* Saunders. Pestology, 28 (6): 34 – 35.

Kashyap, N.P. and Kumar,S. 2002. Determination of insecticide residues in nectar and pollen aganist, *A.mellifera* on mustard (*Brassica juncea*). Sixth Asian Apicultural Association International conference and World Apixepo – 2002, Bangalore India. 24 Feb. -1 Mar. Abstract: 188

KAU. 2002. *Package of Practices Recommendations*: Crops. Twelfth edition. Directorate of extension, Kerala Agricultural University, Thrissur, 278 p.

Kevan, P.G. 1972. Insect pollination of high arctic flowers. J. Ecol., 60: 831-847.

Khan, R.B. and Dethe, M.D. 2004. Median lethal time of new pesticides to foragers of honey bees. Pestology, 28(1): 28 – 29.

*Klungness, L.M., Jang, E.B., Mau, R.F.L., Vargas, R.I., Sugano, J.S., Fujitani, E. 2005. New approaches to sanitation in a cropping system susceptible to tephritid fruit flies (Diptera: Tephritidae) in Hawaii. J. Appl. Sci. and Envi. mgmt., 9: 5-15.

Krishnamuthy, P.N. and Krishnakumar, N.K. 2001. Integrated pest management in crucifer, legume and cucurbit vegetables. In: *Integrated pest management in horticultural* *ecosystem* (eds. Parvatha Reddy, P., Abraham Verghese and Krishnakumar, N.E), Capital publishing Company, New Delhi, p.263.

Kremen, C.,. Williams, N.M. and Robbin, W. 2002. Thorp Crop pollination from native bees at risk from agricultural intensification. PNAS, 99 (26): 16812-16816

Kunel, B.A., Held, D.W. and Potter, D.A. 1999. Impact of Halofenozide, imidacloprid and bendiocarb on beneficial invertebrates and predatory activity in turf grass. J. Econ. Ent., 92: 922 – 930.

Ladurner, E., Bosch, J., Maini, S. and William, P.K. 2003. A method of feeding individual bees (Hymenoptera : Apiformes) known amounts of pesticides. Apidologie, 34:597–602.

Leandro, B., Picanco, C.M., Moura, M.F., Della Lucia, T.M.C. and Semeao, A.A. 2006. Sampling plan for Diaphania Sp. (Lepidoptera: pyralidae) and for Hymenoptera parasiriods on cucumber. J. Econ. Ent., 99(6): 2177 - 2184.

*Mahmood, T., Khokhar, K.M., Hussain, S.I. and Jeelani, M.H. 2005. Host preference of red pumpkin beelte *Aulacophora* (Raphidopalpa) *foveicolis* among cucurbits crops, Sarhad J. Agric., 21 (3): 473- 475.

Mall, P. and Rathore, R.R.S. 2003. Impact of some commonly used insecticides with different doses on foraging of *A.mellifera*. International workshop on conservation and management of bees for sustainable development and Honey festival (Apixepo – 2003). 13 – 18 October, Bangalore, India. Abstract: 82

Manu. P.Mani. 2005. Major spiders in vegetable ecosystem and their predatory potential. MSc (Agri.) thesis, Kerala Agricultural University, Thrissur, 104p.

Manu. P. Mani and Hebsybai. 2006. Spider fauna in a vegetable ecosystem. Insect Environ., 11 (4): 180 – 181.

Marie, P.C., Jean, P.F., Anne, C.M., Julie, L., Nicolas, C. and Michel, A. 2006. A Survey of Pesticide Residues in Pollen Loads Collected by Honey Bees in France. J. Econ. Ent., 99(2):253 – 262 .

Marinturriza, M. Saldana, Y.H.I., Cortes, M.H. 1995. Entomofauna associated with cucumber (*Cucumis sativus* L.) in the control municipality, Tab. Revista – Chapingo, Serie – Horticultural, 1(4): 89 – 94.

Mclaren, D.A., Oldoroyol, B.P. and Goodman, R.D. 1987. Comparative toxicity of microencapsulated methyl parathion and emulsifiable concentrate methyl parathion to honey bees (*Apis mellifera* L.). American bee J., 127 (10): 718 – 720.

*Melendez Ramirez, V., Magana-Rueda, S., Parra-Tabla-V., Ayala-R. and Navarro , J. 2002. Diversity of native bee visitors of cucurbit crops (Cucurbitaceae) inYucatan, Mexico, Journal-of-Insect-Conservation., 6(3): 135-147.

Mishra, N.C. and Mishra, S.N. 2002. Impact of bio pesticides on insect pests and defenders of okra. Indian J. pl. prot., 30: 99 – 101.

Morimoto, Y., Gikungu, M. and Maundu, P. 2004. Pollinators of the bottle gourd (*Lagenaria Scieraria*) observed in Kenya. International J. Trop. Insect. Sci., 24(8): 79 – 86.

Muller, C.W. 2007. Pollinators and their importance– National pollinator Week. Horticulture update, Texas Cooperative Extension, Texas A&M University, College Station, Texas http://aggiehorticulture.tamu.edu/extension/newsletters/hortupdate/jun7/Pollin.html

Murray, B.I. 2006. Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. Ann. Rev. Ent., 51: 45 – 56.

Naim, M. and Phadke, K.G. 1976. Bee flora and seasonal activity of *Apis cerana indica* at Pusa. Indian Bee J., 38 (3): 13 – 19.

Nair, M.R.G.K. 1999. *A monograph on crop pests of Kerala and their control.* Third edition. KAU press, Mannuthy, 215p.

Nandakumar, C. 1999. Monitoring and management of pest complex of bitter gourd (*Momordica charantia* L.) PhD thesis, Kerala Agricultural University, Thrissur, 204p.

Nandakumar, C. and Saradamma, K. 1996. Botanical pesticide are benign to the natural enemies of epilachna beetle. Insect Environ., 2(1): 27 .

Nataraja, C.M., Rajagopal, D., Gowda, G. and Kencharaddi, R.N. 2002. Oral and contact toxicity of some insecticides to Indian honey bee, *A. cerana* F. Sixth Asian Apicultural Association International conference and World Apixepo – 2002, Bangalore India. 24 Feb. -1 Mar. Abstract: 186.

Nevkryta, A.N. 1937. On the fauna and ecology of insect pollinators of the family cucurbitacae. Acad. Sci. USSR Ukraine Inst. Zool. Biol., 14: 231 – 258.

Pankaj-Ingoley, Mehta, P.K., Verma, K.S. and Ingoley, P. 2002. Seasonal occurrence of fruit fly, *Bactrocera cucurbitae* Coq., on cucumber in midhills of Himachal Pradesh. Himachal J. Agric.Res., 28 (1-2): 48-53.

Panse, V.G. and Sukhatme, P.V. 1985. *Statistical methods of agricultural workers*. Fourteenth edition. Indian council for Agricultural Research, New Delhi.

Patel, K.C. and Kulkarny, K.L. 1956. Bionomics of the pumpkin caterpillar *Margaronia indica* Saunders. J. Bombay Nat. Hist. Soc., 54: 118 – 127.

* Perdikis, D.C. and Lykouressis, D.P. 2003. *Aphis gossypii* (Hemiptera: Aphididae) as a factor inhibiting the survival and population increase of the predator *Macrolophus pygmaeus* (Hemiptera: Miridae) on cucumber. Eur. J. Ent., 100(4): 501-508.

Peter, C. and David, B.V. 1991a. Biology of Goniozus sensorius Gordh (Hymenoptera: Bethylidae) a parasitiod of pumpkin caterpillar *Diaphania indica* (Saunders) (Lepidoptera: pyralidae). Insect- Sci.-Appl. Nairobi, Kenya: ICPE Scicence Press., 12(14): 339-345.

Peter, C. and David, B.V. 1991 b. Population dynamics of pumpkin caterpillar *Diaphania indica* (Saunders) (Lepidoptera: Pyralidae). Trop. pest mgmt., 37(1): 75 – 79.

Prem, N. 2007. Cucurbits – Every one's crop. Acta .Hort. (ISHS) , 731: 485 – 492.

Rahpoot, S.K.S., Sali and Rizvi, S.M. 2002. Relative population and host preference of fruit fly *Bactrocera dorsalis* on cucurbits, Annals Pl. Prot. Sci., 10(1): 62 – 64.

Raja gopal, D. and Trivedi, T.P. 1989. Status, bio ecology and management of Epilachna beetle, *Epilachna vigntioctopunctata* (Fab.) on potato in India. Tropical pest mgmt., 35: 410 – 413.

Rajak, D.C. and Singh, H.M. 2002. Comparative efficacy of pesticides against red pumpkin beetle, *Aulacophora foveicollis* on musk melon. Ann. Pl. Prot. Sci., 10(1): 147 – 148.

Raju, N. 2002. Essential safety environment to bees by biocides. Sixth Asian Apicultural Association International conference and World Apixepo – 2002, Bangalore India. 24 Feb.- 1 Mar. Abstract: 182.

* Ranganath, H.R., Suryanarayana, M.A. and Veenakumari, K. 1997. Management of melon fly (*Bactrocera* (*Zeugodacus*) *cucurbitae* in cucurbits in South Andaman. Insect Environ., 3: 32-33.

Reddy, C.S., Raju, A.J.S. and Atluri, J.B. 1997. Bee pollination on tamarind trees. Indian bee J., 59(3): 178 – 179.

Reeta, J., Johri, P.K. and Johri, R. 2003a. Seasonal biology, abundance and intensity of attack of red pumpkin beetle, *Aulacophora foveicollis* Lucas on cucurbit crops at Kanpur in Uttar Pradesh, J. Appl. Zool. Res., 14(2): 144-147.

Reeta, J., Johri, P.K. and Johri, R. 2003b. Growth values of red pumpkin beetle, *Aulacophora foveicollis* (Lucas) on different food substrates. J. Appl. Zool. Res., 14 (1): 84-85.

Reeta, J., Johri, P.K. and Johri, R. 2003c. Food preference of red pumpkin beetle, *Aulacophora foveicollis* Lucas at Kanpur in Uttar Pradesh. J. Appl. Zool. Res., 14(1): 80-81.

Regupathy, A., Palaniswamy, S., Chandramohan, N. and Gunathilagaraj, K. 2003. *A guide on crop pests*. Fourth edition. Soorya Desktop Publishers, Coimbatore, p.264

Rushtapakornchai, W., Petechwichit, P., Wiani, R. and Pakwipa, P. 1996. Efficiency of some insecticides for controlling tobacco white fly *Bemisia tabaci* and leaf miner *Liriomyza trifolii* on tomato , Kaen- Kaset Khon – Kaen – Agric. J., 24(4): 184 – 189.

Sajjanar, S.M., Kuberappa, G.C. and Prabhswamy, H.P. 2004. Insect visitors of cucumber (*Cucumis sativus* L.) and the role of honey bee, *Apis cerana* F. in its pollination. Pest mgmt. Econ. Zool., 12(1): 23 -31.

Sattigi, H.N., Lingappa, S. and Kulkarni, K.A. 1996. Seasonal variation of foraging behavior of Indian bee, *Apis cerana* Fab. J. Karnataka Uni. Sci., 1: 43-48.

Schreiner, I.H. 1991. Damage Threshold for *Diaphania indica* Saunders (Lepidoptera: Pyralidae) on cucumbers in Guam. Trop. pest Mgmt., 37: 17 – 20.

Sharma, D.C. and Nitin, S. 2004. Bioefficacy and persistent toxicity of different insecticides and neem derivatives against cucurbits fruit fly, *Bactrocera cucrbitae* Coq. on summer squash. Pesticide Res. J., 16 (2): 22 – 25.

Shrivastava, G.P. and Shrivastava, V. 1991. Coevoluation of stamens and carpels in cucurbits and of their insect pollinators. Acta. Hort. (ISHS), 288: 347- 353.

Singh, M., Sharma, P.L. and Dhaliwal, H.S. 1974. Toxicity of some insecticides to honey bee workers, *A. cerana indica* F. Pesticides, 8(12): 28 – 29.

Singh, W.J.K., Singh, R., Hameed, S.F. and Singh, B. 1989. Field toxicity of some insecticides to *Apis cerana indica* F. Indian Bee J., 62 (1-2): 19 – 22.

Sivakumar, T. 2001. Ecofrendily pest management in Snake gourd (*Tricosanthes anguina* L.). MSc (Agri.) thesis, KAU, Thrissur, P.85

Sontakke, B.K. and Dash, A.N. 1996. Studies on the effects of insecticides and neem formulation against major pests of mustard and their safety to honey bees. Indian J. Environ. and Toxicol., 6: (2): 87-88 .

Stanghellini, M.S., Ambrose, J. T., and Schultheis, J.R. 1998. Using commercial bumble bee colonies as backup pollinators for honey bees to produce cucumbers and watermelons .HortTechnology., 8 (4): 590-594.

Stanger, W. and Winterlin, W. 1975. Residues of the insecticides to honey bees, *Apis Florea F.* and *A. mellifera L.* J. Ent. Res., 9(2): 195 – 197.

Stefanidou, M., Athanaselis, S. and Kouutselinis, A. 2003. The toxicology of honey bee poisoning. Veterinary and Human toxicology, 45 (5): 261 – 265.

Sterk, G. and Benuzzi, M. 2004. New plant protection chemicals: tests of toxicity to bumble bees in the green house. Culture – Protette, 33 (1): 75 -77.

Stevenson, J.H. and Walker, J. 1974. Bee poisoning by insecticides in Britain 1966 – 1973. Bee Wld., 55 (2): 64 – 67.

Sunderland, K.D. 1999. Mechanisms underlying the effects of spiders on pest populations. J. Arachnol., 27:308 - 316.

Synder, E.W. and David, H.W. 1999. Anti predator behavior of spotted cucumber beetle (Coleoptera: chrysomelidae) in response to predators that pose varying risks. Environ. Ent., 9: 35 – 42.

Tanaka, K., Endo, S. and Kazano, H. 2000. Toxicity of insecticides to predators of rice planthoppers: spiders, the mired bug, and the dryinid wasp. Appl. Entomol. Zool., 35:177-187.

Tenczar, E.G. and Krischilk, V.A. 2006. Management of cotton wood leaf beetle (Coleoptera: Chrysomelidae) with a novel Trans plant soak and bio rational insecticides to conserve coccinellid beetles. J. Economic Ent., 99 (2): 102 – 108.

Tewari, G.C. and Krishnamurty, P.N. 1983. Effectiveness of newer insecticides against epilachna beetle *Henosepilachna vigintioctopunctata* (Fab.) (Coccinellidae: Coleoptera) and their safety to natural enemy pedobius foveolatua (Crawford) (Eulopidae: Hymenoptera). Indian J. Agric. Sci., 53: 1068 – 1070.

Thomas, J., Faleiro, R., Vidya, C.V., Satarkar, V.R., Stone house, J.M., Verghese, A. and Mumford, J.D. 2005. Melon fruit fly attraction and control by baits in central Kerala. Pest Mgmt. Hort. Ecosyt., 11 : 110 – 112.

Van Steenis, M.J. and Elkhawass, K.A.M.H. 1995. Life history of *Aphis gossypii* on cucumber: influence of temperature, host plant and parasitism. Entomologia Experimentalis et Applicata, 76 (2): 121 – 131.

* Vargas, R.I., Jang, E.B. and Klungness, L.M. 2003. Area-wide pest management of fruit flies in Hawaiian fruits and vegetables. In: Recent Trends on Sterile Insect Technique and Area-wide Integrated Pest Management, Research Institute of Subtropics, Okinawa, Japan, pp. 37-46.

Venkata Reddy, E. and Chandrashekhra Reddy, C. 2006. Oral and dermal toxicity of some insecticides to Indian honey bee, *A.cerana.*, J. Ent. Res., 30(1): 47 – 49.

Vijaysree, V. 2006. Pests of coccinia and their management. MSc (Agri.) thesis, KAU, Thrissur, p.68.

Wratten, S.D., White, A.J., Bowie, M.H., Berry, N.A. and Weigmann, U. 1995. Phenology and ecology of hoverflies (Diptera: Syrphidae) in New Zealand. Environ. Entomol. 24: 565-600.

* Wood, M. 2001. Forcing exotic, invasive insects into retreat: new IPM program targets Hawaii's fruit flies. Agricultural Research Washington, 49: 11-13.

Yardim, O.P. and Edwards, G.B. 1990. Spiders in United States field crops and their potential effect of on crop pests. J. Arachnol., 18: 1-27.

Yogesh, S., Praduman, B., Rachna, G., Sachdera, Y., Bhatnagar, P. and Gulati, R. 2003. Relative abundance and foraging behaviour of Apis spp. on sesamum (*Sesamum indicum*) flowers. Annals. Pl. Prot. Sci., 11 (2): 281 – 283.

*Zhouwei, X., Sun, X., Bing, Z., Xiaoping, L., Zhicheng, L. and Wang, Y. 2005. Studies on the biological characteristics and control of *Diaphania perspectalis* Walker. J. Shanghai Jiaotong University Agric. Sci., 23(1): 52 – 56.

* Originals not seen

APPENDIX

APPENDIX – I

Population of insect pollinators before application of treatments

Treatments	*A. ceranaindica*	*Anderna* sp.	*Trigona* sp.
Neem oil 2%	5.25	4.08	3.5
Malathion 0.2%	4.83	4	3.58
Acephate 0.05%	5.08	3.83	3.58
Dimethoate 0.05%	4.92	4	3.58
Carbaryl 0.1%	5.08	4	3.58
Lambda cyhalothrin 0.01%	4.92	4.33	3.75
Fenvalerate 0.02%	5	4.08	3.67
Imidacloprid 0.002%	4.92	4.75	3.67
Control	5.33	4.58	3.75

APPENDIX – II

Population of insect pests before application of treatments

Treatments	*Aulacophora* sp.		*D. indica*		*A. peponis*	
	I	II	I	II	I	II
Neem oil 2%	3.92	5	4	3.08	2.33	2.08
Malathion 0.2%	4.5	4.67	3.92	3	2.5	1.92
Acephate 0.05%	4.5	5	4	3	2.17	2.17
Dimethoate 0.05%	4.08	4.5	4	3	2.42	2
Carbaryl 0.1%	4.33	4.42	3.92	2.83	2.42	2.25
Lambda cyhalothrin 0.01%	4.33	4.42	4	3.08	2.58	1.75
Fenvalerate 0.02%	4.25	4.58	4.08	2.9	2.5	1.83
Imidacloprid 0.002%	4.5	4.75	4	3	2.58	1.75
Control	4.58	5.08	4.08	3.42	2.58	2.42

APPENDIX – III

Population of natural enemies before application of treatments

Treatments	Spiders		Coccinellid beetles	
	First spray	Second spray	First spray	Second spray
Neem oil 2%	2.5	3.58	2.83	3.83
Malathion 0.2%	2.92	3.75	2.75	4
Acephate 0.05%	2.83	3.5	2.75	4.25
Dimethoate 0.05%	2.58	3.08	2.83	4
Carbaryl 0.1%	3	3.17	2.92	3.67
Lambda cyhalothrin 0.01%	2.75	3.5	2.75	3.58
Fenvalerate 0.02%	3.08	3.58	2.92	3.58
Imidacloprid 0.002%	3.17	3.58	3.08	4.25
Control	2.83	3.17	3	3.42

INSECT COMMUNITY ANALYSIS IN CUCURBITACEOUS VEGETABLES AND IMPACT OF INSECTICIDES ON INSECT POLLINATORS

JANGAIAH . V

Abstract of the
thesis submitted in partial fulfillment of the requirement
for the degree of

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University, Thrissur

2007

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM - 695 522

ABSTRACT

A study was undertaken to document the various insects associated with cucurbitaceous vegetables in ten locations of Kalliyoor panchayat of Thiruvananthapuram district from March 2006 to February 2007. A field trial was also carried out to assess the impact of insecticides on the insect pollinators, natural enemies and pests.

The total number of different species of insects recorded on the cucurbitaceous vegetables was found to be 47. Of these, the important groups of insects observed were Hymenoptera (28 per cent), Coleoptera (21 per cent), Lepidoptera (19 per cent), Hemiptera (17 per cent), Diptera (11 per cent) followed by Orthoptera and Thysanoptera (2 per cent each). Besides the insects, two species of spiders (Araneae) and one species of mite (Acariformes) were observed in three cucurbits.

Bees were the predominant insect pollinators identified. Among the four species recorded, *Apis cerana indica* Fab. was the most abundant in oriental pickling melon and snake gourd. *Trigona* sp. was abundant in bitter gourd. *Apis mellifera* L. least visited the cucurbit flowers. Among the three cucurbitaceous vegetables, the highest insect pollinators activity was recorded in oriental pickling melon followed by bitter gourd and snake gourd. The peak period of activity of the pollinators was noted to be during 1000 hr to 1100 hr and 1500 hr to 1600 hr. Maximum foraging activity of different insect pollinators was recorded during the seventh week after sowing in bitter gourd and snake gourd and sixth week after sowing in oriental pickling melon. The population of insect pollinators was more in summer than rainy season. The higher activity of insect pollinators was observed under pesticide free condition in the Instructional farm when compared to farmer's field where insecticides were frequently applied.

The dominant insect pests recorded were *Bactrocera cucurbitae* Coq. and *Aulacophora* spp. followed by *Aphis* spp., *Henosepilachna* sp., *Liriomyza trifoli* Burgess, *Diaphania indica* Saunders, *Anadevidia peponis* Fb. and thirteen other pests. The highest fruit fly infestation was observed in bitter gourd (38.66 per cent) followed by snake gourd and oriental pickling melon. Pumpkin beetles caused up to 28.99 per cent damage in

oriental pickling melon and 22.44 per cent in snake gourd. No infestation was observed in bittergourd. Two species of spiders(*Oxyopes javanus* Thorell and *Lycosa pseudoannulata* Boes et st.), three coccinellid beetles (*Menochilus sexmaculatus* Fab., *Synharmonia octomaculata* Fab. and *Micraspis crocea* Mulsant) and two parasitoids (*Apanteles* sp. and *Chrysocharis johnsonii* Walker) were the major natural enemies recorded.

Foliar application of neem oil 2.0 per cent, imidacloprid 0.002 per cent and malathion 0.2 per cent proved to be safer to pollinators than other chemical insecticides. Imidacloprid 0.002 per cent and malathion 0.2 per cent significantly reduced pest infestation. Neem oil 2.0 per cent and imidacloprid 0.002 per cent were also safer to the natural enemies. The highest yield was recorded in imidacloprid 0.002 per cent treatment followed by malathion 0.2 per cent and carbaryl 0.1 per cent treated plot.

Evidently, selective use of insecticides like imidacloprid 0.002 per cent and malathion 0.2 per cent could effectively check pest infestation without harming the pollinators and natural enemies in cucurbitaceous vegetable ecosystem.