Management of Sucking Pests of Brinjal (*Solanum melongena* L.)

ARYA, V. C.

(2012-11-173)

THESIS

Submitted in partial fulfillment of the requirement for the degree of

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY

COLLEGE OF AGRICULTURE

VELLAYANI, THIRUVANANTHAPURAM- 695 522

KERALA, INDIA

2015

DECLARATION

I, hereby declare that this thesis entitled "**Management of sucking pests of brinjal (*Solanum melongena* L.)**" 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 to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

17/12/2015

Vellayani

17-12-2015

Arya,V.C.

(2012 -11- 173)

CERTIFICATE

Certified that this thesis entitled **"Management of sucking pests of brinjal (*Solanum melongena* L.)"** is a record of research work done independently by Ms. Arya, V.C. (2012-11-173) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Vellayani
17-12-2015

Dr. N. Anitha
Major Advisor, Advisory Committee
Professor
Department of Agricultural Entomology
College of Agriculture, Vellayani

CERTIFICATE

We, the undersigned members of the advisory committee of Ms. Arya, V.C. (2012-11-173), a candidate for the degree of **Master of Science in Agriculture** agree that the thesis entitled **"Management of sucking pests of brinjal (*Solanum melongena* L.)"** may be submitted by **Ms. Arya, V.C. (2012-11-173)**, in partial fulfillment of the requirement for the degree.

Dr. N.Anitha
Professor
Dept. of Agrl. Entomology
College of Agriculture, Vellayani
(Chairman)

Dr.K. Sudharma
Professor & Head
Dept. of Agrl. Entomology
College of Agriculture
Vellayani

Dr. Hebsy Bai
Professor (Rtd.)
Dept. of Agrl. Entomology
College of Agriculture
Vellayani.

Dr. Naseema, A.
Professor
Dept. of Plant Pathology
College of Agriculture
Vellayani.

EXTERNAL EXAMINER
(CHANDRIKA MOHAN)
Principal Scientist (Ag. Entomology)
ICAR-CPCRI, RS, Kayamkulam
Kerala - 690533

Dedicated to

My Family

ACKNOWLEDGEMENT

I knelt before the ***infinity****, the* ***Unknown*** *and the* ***Unknowable****, who blessed me to become a part of world of insects as it was always a wonder for me. Without my parents, sister and family members this research would not have been possible for me.*

I could complete my PG programme because of the technical help rendered by my advisory committee members.

I express my sincere gratitude to ***Dr. N. Anitha****, Professor and Chairman of my advisory committee for her valuable guidance throughout the course of this research work and in the preparation of the thesis. This work would not have been possible without her help and support.*

I wish to express my gracious thanks to ***Dr. Sheela, M.S.****, Associate Director and Head, for her suggestions and timely support rendered throughout the course of this research endeavour. I also thank* ***Dr.K.Sudharma****, Professor and Head for the support.*

I express my sincere gratitude to ***Dr. Hebsy Bai****, Professor (Rtd) for her valuable suggestions and criticisms. Her immense knowledge in the field of Agricultural Entomology had contributed a lot to make this work a reality.*

My heartfelt thanks to ***Dr. Naseema A.****,Professor for her valuable suggestions and criticisms throughout this research work.*

I am filled with emotions of gratitude for the sincere support, advice, encouragement and assistance which I got from ***Dr. T. Sajitha Rani****, Associate Professor,Department of Agronomy . Words are not enough to thank you MAM.*

*I am obliged to **Dr. Ambili Paul,** Assisstant professor,for her kind help in availing the farmers field for conducting this work. I also thank all the teaching and non-teaching staff of Department of Agricultural Entomology.*

*I remember with gratitude the ever willing help and motivating advice given by **Dr.Arthur Jacob,** Former Head, Instructional Farm, College of Agricudture,Vellayani*

*I am ineffably thankful to **Nayana K** and **Anju V.S.** with a deep regret on the impossibility of repayment of their services which I received*

I thank Sonia for her timely advice and support whenever I needed . I also thank Jennie, Revoo, Jayalekshmi, Pintu, Nimisha, Safeer, Aneez, Sachana Dhanya, Anushma, Sreejith, Henry, Prasanth, Dipin, Aryamba, Annie, Lokesh and Nimisha V.P. for their helpfulness.

I also remember my juniors, Akhila, Krishnapriya, Divya, Emil,Muralikrishnan, Reeba, Iby, Sukanya, Anju, Sherin, Praveena, Milsha George, Shlipa ,Aswathy, Nithya. I thank my seniors Asha B. Nair, Malini Nilamudeen, Naveeda Shajan and Sivakumar,T. for their blissful presence and assistance throughout the period of my research work.

*I also thank Department of Agriculture, Government of Kerala and Mr. **George K. Mathai,** Assisstant Director of Agriculture,Ettumanoor, Kottayam district, Kerala for granting me leave for completing my thesis work. I also thank my colleagues **Divya Joseph** and **Aswathy C.S** for their support and help*

I also remember my Kunju, Muralimama and Thulasimama whose everwilling help for doing my survey.

Arya, V.C.

CONTENTS

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES

LIST OF ABBREVIATIONS

%	per cent
CD	Critical difference
et al	And others
Fig.	Figure
g	gram
kg	kilogram
mg	milligram
^0C	Degree Celsius
i.e.	That is
viz.,	namely
CRD	Completely Randomized Design
ha^{-1}	per hectare
NS	Non significant
q	quintal

Introduction

1. INTRODUCTION

Brinjal, egg plant or aubergine (*Solanum melongena* L.) occupies a pride of place among the vegetable crops. It is one of the most popular vegetable grown all over the world. Globally, the egg plant is cultivated in an area of 1.72 million hectares with a production of 43.17 million metric tonnes with an average productivity of 25 metric tonnes per hectare (FAOSTAT, 2011). Brinjal is also one of the most important vegetable crops of India, for the production of which the country occupies the second position in the world. The area under brinjal cultivation in the country is estimated to be 0.51 million hectare with a productivity of 16.08 t ha^{-1} (Anjali *et al.*, 2012). Though a summer crop, it is being grown throughout the year under irrigated conditions in most of the states in India. Among the factors affecting the productivity of crops, pests and diseases play a crucial role.

Nayer *et al.* (1995) listed 53 insects attacking brinjal. Among the pests, shoot and fruit borer (*Leucinodes orbonalis* Guen.), whitefly (*Bemisia tabaci* Gennadius), leaf hopper (*Amrasca biguttula biguttula* Ishida) and epilachna beetle (*Henosepilachna viginctioctopunctata* (F.) cause severe damage. Infestation of leaf hopper, whitefly and shoot and fruit borer results in about 70-92 per cent loss in yield of brinjal (Rosaiah, 2001). Of late, the intense attack of sucking pests particularly, aphid, jassid, whitefly, mealy bug and lace wing bug is found to play an important role in the reduction of yield. (Aslam *et al.*, 2004; Swaminathan *et al.*, 2010). The loss caused by sucking pests varies from 10-15 per cent depending on the intensity of infestation (Munde *et al.*, 2011). Apart from the direct damage caused by sucking the cell sap and prohibiting the normal crop growth, several of the sucking pests also act as vectors of virus diseases.

Brinjal is grown extensively in Kerala. However, summer cultivation of brinjal is limited due to severe incidence of sucking pests, especially the leaf hopper (*A. biguttula biguttula*) which affect the yield considerably (Malini *et al.*, 2013). Nowadays homestead vegetable cultivation has gained much popularity in the State. Not only are the crops raised in the garden land but also on terraces. Moreover, terrace-farming is fast becoming a part of people's life in urban and rural areas in the State. Rooftops of houses in most of the districts are devoted to vegetable cultivation, particularly brinjal. The vegetables raised in homesteads too suffer heavily due to the infestation of pests, particularly the sucking pests. Studies related to the pests infesting brinjal in the homesteads including sap feeders are meagre. Hence, there is an urgent need to document the incidence of various pests of brinjal, particularly the sucking pests in homesteads.

Crop protection in agro ecosystem is principally chemical based. The use of noxious chemical pesticides for management of pests have increased remarkably in modern agriculture, causing serious health hazards and environmental problems in developing countries including India. In brinjal too insecticides are used rampantly for pest management. The harvest of brinjal fruits at short intervals paves the way for toxic residues in fruits. Safer crop protection requires combination of optimum use of safer chemicals and non-chemical techniques of pest management. Therefore, newer insecticides with novel mode of action and benign ecotoxicological profiles need to be tested which will enable in strategising cost effective and safer options for pest management.

The present study was envisaged

- to assess the intensity of damage caused by sucking pests in brinjal and
- to identify effective newer insecticides and biopesticides for evolving a suitable management strategy.

Review of literature

2. REVIEW OF LITERATURE

Brinjal is subjected to severe damage by different insect pests leading to significant loss in yield. More than 26 insect pests and a few non insect pest were found infesting brinjal, of which the shoot and fruit borer, whitefly, leaf hopper, and epilachna beetle cause severe damage, necessitating initiation of control measures quite frequently. Synthetic pyrethroids are regularly used for the control of shoot and fruit borer and their indiscriminate use, lead to the resurgence of sucking pests like whitefly, aphid and mite. Information on the sucking pests and their management using novel insecticides, in the recent past, is meagre. The available literature related to the present study has been reviewed under the following heads.

2.1 LEAF HOPPER

Brinjal shoot and fruit borer was the most destructive pest of brinjal that cause more than 90 per cent damage to the crop. Now jassids or leaf hopper became second major pest of brinjal due to the severity of damage to the plants (Das and Islam, 2014).

Amrasca biguttula biguttula (Ishida) was important in the tropics and subtropics because environmental conditions were conducive for growth and development of host and pest (Iqbal *et al.*, 2008). Latif *et al.*, (2009) reported that jassids were the most common and major insect pests of brinjal crop.

Dhawan *et al.*, (1988) reported that *A. biguttula biguttula*, a highly polyphagous pest was found causing damage to cotton. The loss in yield due to this pest has been reported to be 1.19 q ha^{-1} in cotton. Leaf hopper was known to feed on several vegetables like okra, tomato, potato, peppers, cucurbits and field crops (Shrinivasan and Babu, 2001). Among the sucking insect pests jassids were of major importance in mung bean (Khattak *et al.*, 2004). According to Rana and Sheoran (2004) leaf hoppers were the important sucking pests of sunflower in India. Leaf hopper infestation reduces the oil yield in sunflower (Saritha *et al.*, 2008). Ali *et al.* (2012) reported that brinjal is one of the most favourite host plants of *A. biguttula biguttula*.

The extent of jassid damage to number and weight of brinjal could approach 54 percentage (Mahmood *et al.*, 2002).

Jassids caused debilitatory effects in cotton even at early stage of crop growth. In addition to feeding, they disrupted transportation in conducting vessels and apparently introduced a toxin that impairs photosynthesis in proportion to the amount of feeding (Sharma and Chander, 1998). They cause direct and indirect damage to the brinjal plants especially in the early stage (Sharma and Chander, 1998). Samal and Patnaik (2008) reported that the leaf hopper attack not only resulted in the loss of plant vigour, but also spread the mosaic virus diseases affecting fruit yield.

Eggs are laid singly within leaf veins in the parenchymatous layer between the vascular bundles and the epidermis on the upper leaf surface. Average of 15 eggs were laid by a female. Mature leaves were preferred for egg deposition. Incubation and nymphal periods last for 4 to 11 and 7 to 21 days respectively. Longevity of the adults varied from 5 to 8 weeks and there were 10 to 12 overlapping generations in a year. Mating takes place 2 to 16 days after emergence and oviposition begins 2 to 7 days after copulation. Life cycle was completed in 15 to 46 days in the different seasons in cotton (Sadre *et al.*, 2012).

On transformation in to winged adults, jassids live for 5-7 weeks, feeding constantly on the plant cell-sap. There was very little movement of the leaf hopper nymphs between leaves (Mabbett *et al.*, 1984).

Ananthakrishnan (1992) reported that pubescence and tissue hardiness of plant limit insect mobility, thus acting as structural barriers. Jassids were phloem feeders on the midrib area and they oviposit along the midrib, and so the above factors act as inhibitors to better feeding and oviposition. The resistant genotypes had more hairs than the susceptible ones. According to Deole (2008) brinjal cultivars with smooth textured leaves were preferred more by the jassids compared to the cultivars with leaves having leathery texture or leathery texture with spines. Ali *et al.*, (2012) reported that the hair density and length of hair on lamina, midrib, and veins of brinjal had highly significant and negative correlation with the jassid population. The degree of trichomes on the leaves play important role in the plant defence particularly among phytophagous insects. The emergence of *A. biguttula biguttula* was significantly and negatively correlated with the density of trichomes. As the number of primary branches increased the jassid population also increased.

2.2 WHITEFLY

The whitefly is one of the most intractable and worldwide damaging and injurious pest attacking a wide range of important crops, vegetables and ornamentals all over the world. Since late 1980's, the insect has risen from relative obscurity to became one of the primary insect pests of agricultural crops. (Wafaa and Kherb, 2011).

Arthropod biodiversity in the brinjal field showed that whiteflies were the most common and major insect pests of brinjal crop (Latif *et al.,* 2009). It has also been reported that whitefly (*Bemisia tabaci* Gennadius) (Hemiptera: Aleyrodidae) is an important sucking pest of brinjal that caused considerable damage to the brinjal plants (Mandal *et al.*, 2010).

Whitefly became one of the most important sucking pests of world's industrial and food crops like brinjal, cotton, sunflower, melon, tomato etc. Over 500 plant species from Asia, Africa, America, Europe, Russia, Australia and the Pacific Islands confirmed its polyphagous nature (Greathead, 1986). Brinjal plant provided good oviposition site as well as food sources for the pest. High abundances of whiteflies were recorded on brinjal plants just after the plants were transplanted. More pests were found on plants receiving higher amount of nutrients. Good plant growth and high plant quality (vigour) attracted more pests to the plants. Whitefly infestation is influenced by different nutrient contents provided by the host plants that affect its oviposition, longevity, developmental time and mortality rates.

Zaini *et al.* (2013) reported that high number of whitefly were found scattered over the underside of leaves particularly during early growth of the plants. Adults oviposit under surfaces of young leaves and after eclosion, the first instar nymphs (crawlers) moved a short distance over the leaf surface to find a suitable feeding site. Once settled, they continue feeding but remain sessile until they grow to adult stage. At high densities, whiteflies were active pests on several host plants such as brinjal, tomato and chilli.

Jones (2003) studied the feeding behaviour of whiteflies and reported that its direct feeding induced physiological disorders resulted in shedding of immature fruiting parts. Its nymphs produced honeydew, on which black sooty mould grow, reducing the photosynthetic capabilities of plants.

Whiteflies acts as a sole vector of more than 100 plant viruses, which caused diseases to many commercial crops in different parts of the world. Heavy infestation reduced plant vigour and growth and caused chlorosis (Gerling *et al.*, 2001).

2.3. SPIRALLING WHITEFLY

The spiralling whitefly *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae) is an introduced polyphagous pest. It is a native of the Carribean Islands and Central America (Russell,1965). It was first noticed in Kerala on cassava plants at the Central Tuber Crop Research Institute, Thiruvananthapuram (Palaniswami *et al.*,1995).

Waterhouse and Norris (1989) described the biology of spiralling whitefly in brinjal. According to them, the eggs of spiralling whitefly were smooth, elliptical and yellow to tan coloured. They were laid on the under surface of leaves and the incubation period ranged from 9 to 11 days. The first instar larva called 'crawler', was the only immature stage with functional legs and distinct antennae. Crawlers showed a tendency to congregate around the patch of eggs from which they hatched out. The second and third instar nymphs were sedentary with atrophied legs and antennae. The third instar nymph can be distinguished by numerous evenly spaced short glass like rods of wax along the sides of the body. The fourth instar was at first a feeding stage but later ceased feeding and undergo internal tissue organisation and became pupa before moulting into adult. Pupa had a copious amount of white cottony secretion extending upward and outward from dorsum. They were fluffly, waxy or ribbon-like. The adults were similar in appearance but quite larger than many other species of whiteflies. They were white and resemble tiny moths. Both male and female were winged. The total developmental period from egg to adult was 34 to 38 days at 20 to 30^0 C.

The nymphs and adults of spiralling whitefly suck sap with its piercing and sucking mouthparts. Accumulation of honeydew excreted by both nymphs and adults served as a substrate for the dense growth of sooty mould. The mould decreased the photosynthetic activity thereby reducing the vigour of the plants. The copious white waxy flocculent materials secreted by the nymphs were readily spread by wind and create nuisance to man (Waterhouse and Norris,1989).

2.4. BRINJAL MEALY BUGS

The egg plant mealy bug, *Coccidohystrix insolita* (Green) (Pseudococcidae: Hemiptera) is widely distributed in the tropics and subtropics and is an important agricultural pest. Mealy bugs infest the lower leaf surfaces of egg plant. The adult female had very little dorsal wax and secreted a white, waxy ovisac up to six times as long as the body of the female. The immature stages did not secrete a thick layer of mealy wax, the body being shiny yellow-green with sub median grey spots on two abdominal and one thoracic segments.

C. insolita is polyphagous and Ben-Dov (2013) recorded the mealy bug from the families of host plants *viz*., Acanthaceae, Amaranthaceae, Apocynaceae, Araceae, Arecaceae, Aristolochiaceae, Asteraceae, Chenopodiaceae, Cucurbitaceae, Euphorbiaceae, Fabaceae, Malvaceae, Menispermaceae, Moraceae, Poaceae, Rhamnaceae, Rubiaceae, Solanaceae, Sterculiaceae, Tiliaceae, Zygophyllaceae.

Among the mealy bug species, recently, the papaya mealy bug caused damage to brinjal from the early stage of the crop growth to harvest. Both nymphs and adults suck the sap from leaves causing withering and yellowing of leaves and sometimes resulted in sooty mould on the upper surface of the leaves (Janaki *et al.*,2012).

2.5. APHID

Aphis gossypii, Glover (Homoptera: Aphididae) is a cosmopolitan, polyphagous species widely distributed in different habitats worldwide. This pest had a broad range of hosts and found feeding on crops in 88 plant families (Gissella *et al.*, 2006).

Saxena (1998) categorised aphid as one of the important sucking pests of brinjal. Kersting *et al.*, (1999) reported that *A. gossypii* was one of the major destructive pests in tropical and subtropical regions and seen throughout the year reproducing parthenogenetically. *A. gossypii* were phloem-feeding insects which caused direct and indirect damage and transmit viruses (Blackman and Eastop 2000).

In a study conducted at California to find the directional occurrence of pests, Veeravel and Baskaran (1989) observed that the location of the brinjal plot played an important role in pest attack. The plots situated towards north harboured maximum number of aphids during flowering and senescence and southern plots during the pre-flowering stage. Also the population was found to be maximum during flowering stage followed by senescence and pre-flowering stage. Jamwal and Kandoria (1990) observed that the favourable period for population build up of *A. gossypii* on brinjal was from first week of August to fourth week of November.

A. gossypii can survive upto 7000 feet from MSL throughout the year on different host plants (Behura,1963). Blackman and Eastop (1985) reported about 220 host plants of *A.gossypii* belonging to more than 46 families. Takalloozadeh (2010) reported that *A. gossypii* attacked more than 70 host plants in Iran belonging to family Malvaceae, Fabaceae, Solanaceae and Asclepiadaceae.

Aphids suck the cell sap and prohibit the normal crop growth. The infested plants become weak, pale and stunted in growth which consequently resulted in reduced fruit size (Konar *et al.*, 2011). The nymphs were found to pass through four different instars. First instar nymphs were oval in shape, dorsally convex, greenish brown or yellowish-brown in colour with three pairs of legs. Antennae were six segmented, short, filliform and light black in colour. Freshly moulted second instar nymphs were oval in shape and greenish brown to green in colour. Third instar nymphs were spinach in colour and oval in shape. Fourth instar nymphs were emerald green in colour and similar to that of the third instar nymphs. Total nymphal period ranged from 7 to 9 days. As the nymph grows, its colour was changed from greenish brown to willow green, spinach and finally emerald green. The average duration of first, second, third and fourth instar nymphs was (2.04±0.16), (1.68±0.16), (2.00± 0.17) and (1.64±0.13) days, respectively. The longevity of adult ranged from 11-21 days. The female aphid was observed to reproduce for a period of 9 to 22 days. The female had produced 19- 74 individuals. The entire life period of *A. gossypii* was recorded from 18 days to 29 days (Patil and Patel, 2013).

Aphid infested plants commonly showed distorted and stunted leaves, reduced fruit set and sometimes showed reduced death vigour, premature die, while plants at the fruiting stage were able to withstand aphid infestation (Shannag *et al.* 2007).

2.6. LACE WING BUGS

The lace wing bug *Urentius hystricellus* (Richt.) (Tingidae: Hemiptera) was first reported on the egg plant, *Solanum melongena,* from different parts of India by Fletcher (1914). Since then, it has been reported from time to time as a specific pest of egg plant (Pillai 1921; Jepson 1924; Patel and Kulkarni 1955). Besides India, it has also been reported from Ghana (Frempong and Buahin 1977) and Thailand (Tigvattn 1990). Recently, Chaudhury *et al*., (2001) recorded its presence on tomato in West Bengal.

Satti and Abdelrahman (2014) reported that tingid bug was one of the important economic pests of egg plant. Nymphs and the adults suck sap from lower surface of leaves causing yellowing of leaves. Affected leaves were covered with exuviae and excreta.

Adults and nymphs inserted the mouth parts into the leaf from either surface. Penetration of the epidermis was mainly intracellular. Feeding damage resulted in externally visible chlorotic areas, caused by the extraction of cell contents within feeding zones which were confined at first to the palisade but later extended to the mesophyll. It was accompanied by laceration of the cell walls and diffusion of an oral secretion of low phytotoxicity. Shrinkage of the leaf was due to collapse of the mesophyll and epithelial cells. The palisade and xylem cells retained their characteristic size and shape until destruction of the other tissues were complete. (Pollard, 1959).

2.7. MITES

Red spider mite emerged as a serious pest of vegetable crops including egg plant, tomato, french bean and cucumber, and other field crops in South Asia, Southeast Asia, Africa, Europe, and Mediterranean countries. Low relative humidity favoured the multiplication of mites and precipitation was the only abiotic factor that restricted mite population (Srinivasan, 2009). He also reported that *Tetranychus urticae* were minute in size, and vary in colour (green, greenish yellow, brown, or orange red) with two dark spots on the body. Eggs were round, white, or cream-colored; egg period was two to four days. There were a larval stage and two nymphal stages. The life cycle was completed in one to two weeks. There were several overlapping generations in a year. The adult lived up to three or four weeks. Spider mites usually extracted the cell contents from the leaves using their long, needle- like mouthparts. This resulted in reduced chlorophyll content in the leaves, leading to the formation of white or yellow speckles on the leaves. In severe infestations, leaves completely desiccated. The mites also produced webbing on the leaf surfaces in severe conditions. Under high population densities, the mites move to the tip of the leaf or top of the plant and congregated using strands of silk to form a ball-like mass.

2.8. MANAGEMENT

2.8.1. Cultural control

Esguerra (1987) suggested pruning of heavily infested plants to minimise the incidence of spiralling whitefly. Sreenivasan (2009) suggested some cultural methods such as avoiding egg plant monocultures and follow crop rotations. Avoiding planting egg plant near cucurbits and cotton fields if thrips and aphids were common in the region. Growing okra as a trap crop along the borders of egg plant field, and focus pesticide spraying on the okra trap crop to manage leaf hoppers. Plant tall border crops like maize, sorghum, or pearl millet to reduce the infestation of whiteflies.

2.8.2. Physical control

Reghupathy *et al.* (1997) suggested the use of yellow trap to manage whiteflies. Srinivasan and Mohanasundaram (1997) recommended a light trap coated with vaseline for trapping adults of *A. dispersus* in home gardens in Tamil Nadu. Reflective plastic or straw mulches reduced the incidence of whiteflies and thrips on egg plant crops (Srinivasan, 2009).

2.8.3. Mechanical Control

Srinivasan (2009) suggested the use of 50–64 mesh nylon net to cover the seedling beds of brinjal if sucking insects were common in the region. He recommended using seedling trays under the net-tunnels or net-houses for seedling production.

2.8.4. Botanicals

Rajan and Nair (1992) reported that 5 per cent neem suspension was effective against aphid population.

Pandey and Srivastava (1983) reported that rhizome extract of *Acorus calamus* gave 50 to 58 per cent mortality of *A. gossypii* and also dried leaf extract of *Lantana camara* var. *aculeata* gave 52 to 61 per cent mortality of the same on brinjal. Coudriet *et al.* (1985) reported that neem seed extract reduced the viability of *B. tabaci* egg by 20 per cent in sweet potato. Growth and development of *B. tabaci* suppressed considerably by neem oil 0.5 per cent and 0.1 per cent in cotton (Natrajan and Sundaramurthy, 1990). According to Reghunath and Gokulapalan (1999) application of the leaf extracts *Andrographis paniculata* + soap solution + well crushed garlic @ 20g l^{-1} and *Hyptis suaveolens* extract + soap solution + Malathion 0.1 per cent were effective for the management of the sucking pests of chillies.

According to Bright, A. (1990), the reduction in aphid population were due to contact toxicity as well as antifeedent effect of botanicals. The mortality percentage increased gradually with an increase in concentration of the plant extracts. NSE (5%) crude extract gave poor control of jassid, whitefly and aphid. Comparatively low yield was recorded in NSE treated plots than other pesticide treatments (Kalawate and Dethe, 2012).

Stein *et al.* (1988) reported that the ethanolic and methanolic extracts of *Ocimum sanctum* caused heavy mortality of aphids. Benzene extracts of *Eupatorium odoratum, Clerodendron infortunatum, Thevetia neriifolia* and

Nerium oleander significantly reduced the population of aphid on brinjal (Saradamma, 1989). Venkateswara and Rosaiah (1993) observed that nicotine sulphate and repelin alone or in combination with carbaryl was effective against jassids and aphids in bhindi.

2.8.5. Biological control

Nene (1973) reported *Paecilomyces farinosus* as a pathogen of adults of *B. tabaci*. Chaudhuri (1976) reported the death of brinjal mealy bug in seven to ten days when inoculated with *Metarhizium anisopliae*. Meade and Byrne (1991) reported mortality of all the three nymphal stages of *B. tabaci* by the fungus *Verticillium lecanii*.

Hall and Burges (1979) reported that spray of entomopathogenic fungus, *V. lecanii* was successfully used to control *A. gossypii*. Whitefly can be controlled by *Trichoderma harzianum* and *V. lecani* as observed by Yohalan *et al.* (1998). Jaichakravarthy (2002) studied the bioefficacy of *V. lecanii* against sucking pests and observed that at 14 days after treatment *V. lecanii* 4 x 10^5 CFU/ml showed appreciable mortality (85.37%) of aphid on brinjal. *Beauveria bassiana* caused 41 per cent mortality of *C. insolita* 10 days after treatment (Vijay and Suresh, 2013).

In India, *Spalgis epius* was the most common predator of mealy bugs *C. insolita*, *Rastrococcus iceryoides* (Green), *Planococcus lilacinus* (Cockerell), and *Planococcus citri* (Risso). The caterpillars were covered with white mealy material (Ayyar, 1929; Puttarudriah & Channabasavanna, 1957). The fringe of long bristles about the sides and front of the body was used in shoveling the waxy covering of the host. The older larvae were considerably larger and markedly resemble syrphid larvae. Pupation takes place in the mealybug colony. (Ayyar, 1929). Their common name, the ape fly, is derived from the appearance of the dorsal view of the pupa which resembles the face of a monkey (Lekagul *et al.*, 1977) which literally means "a butterfly whose pupa resembles a monkey head." *Spalgis epius* (Westwood) (Lepidoptera: Lycaenidae, Miletinae), a hemipterophagous butterfly were found feeding on eggs, nymphs and adults of the mealybug (Pierce *et al.*, 2002).

2.8.6. Chemical control

Chemical control using insecticides was the most efficient method to minimize sucking pest damages to crop production, although such practice is hazardous to water, soil, environment and human health. That may be due to the misuse of chemical insecticides. On the other hand, the increasing incidence of resistance to many conventional insecticides has led to the development of large number of new active compounds such as the neonicotinoides which were introduced as an alternative to the organophosphate, carbamate and pyrethroid insecticides. Recently, neonicotinoides have been the fastest growing class of insecticides in modern crop protection with wide spectrum effect against sucking and certain chewing insect pests (Jeschke and Nauen, 2008).

2.8.6.1. *Conventional Insecticides*

The brinjal mealy bug, *C. insolita*, once a minor pest has assumed status of serious pest in brinjal. Increased efficacy of insecticides on mealy bugs when combined with soaps and oils were reported by Suresh *et al.* (2007). Dimethoate 30EC @ 0.5 ml l^{-1} + NSKE 3% recorded the lowest mean per cent infested plants (14.97). But dimethoate 30EC @ 1ml l^{-1} alone recorded 17.56 per cent infested plants which indicated that NSKE increased the efficacy of dimethoate (Swaminathan *et al.*, 2010).

The insecticides profenophos and methyl parathion were found to be toxic and showed cent per cent mortality of *C. insolita* one day after treatment while fish oil rosin soap and triazophos showed cent per cent mortality in two days after treatment (Vijay and Suresh, 2013).

Dimethoate 30EC @ 0.5 ml l^{-1} + NSKE 3% recorded mealy bug population of 0.78 cm^{-2}. Profenofos 50EC @ 1ml l^{-1} recorded 36.84 per cent plant infestation and 1.86 mealybug cm^{-2}. When Azadirachtin 1EC @ 1ml l^{-1} was combined with half the dose of profenofos, the per cent plant infestation and population were 32.80 and 1.61 respectively (Swaminathan *et al.*, 2010).

Khali *et al.* (1985), Reghunath *et al.*, (1989), Mathur and Jain (2006) reported that carbaryl 0.02 percent resulted in lowest infestation of *A. gossypii.* Neem products and dimethoate were equally effective in reducing the aphid infestation and increasing the yield (Singh *et al.*, 2003; Gupta and Rai, 2006; Ali and Ansari, 2008).

Konar *et al.* (2011) reported that soil application of phorate 10G before transplanting, followed by foliar spray with acephate 75SP at 50 days after transplanting , thiodicarb 75WP at 70 DAT and *Bacillus thuringiensis* var *kurstaki* and seedling treatment with imidacloprid 17.8 SL before transplanting, followed by foliar spray with imidacloprid 17.8 SL at 30 DAT, *Bacillus thuringiensis* var *kurstaki* 5WP at 70 DAT were effective against aphid.

2.8.6.2. ***New Generation Insecticides***

Yazdani *et al.* (2000) during their investigation found that Confidor 200 SL was much effective insecticide against jassid in cotton. Krishnakumar *et al.* (2001) reported that thiamethoxam 25 WG @ 0.4 g l^{-1} gave significantly superior control of leaf hopper. However thiamethoxam @ 0.4 g l^{-1} was on par with imidacloprid seed treatment 12 ml kg^{-1} of seed. Studies conducted by Sharma and Lal (2002) found that thiamethoxam was superior against the leaf hopper. Misra (2002) and Solangi and Lohar (2007) also reported that Confidor was most effective in controlling the jassid population.

Mhaske and Mot (2005) reported that higher doses of thiamethoxam 25 and 50 g ha^{-1} were effective against leaf hopper and whitefly on brinjal. Dhanalakshmi and Mallapur (2008) found that acetamiprid 20 SP at 0.2g l^{-1} was the most effective chemical against leaf hopper. Naik *et al.* (2009) found that thiamethoxam as the efficient chemical against leafhoppers. Nath and Sinha (2010) reported that both neonicotinoides (thiamethoxam and acetamiprid) were effective against leaf hopper. Emamectin benzoate, 6.25 g ai ha^{-1} was proved as the most effective chemical against jassid with low levels of infestation. In summer season, although the magnitude of jassid population was low, emamectin benzoate recorded significantly lower number of jassids in contrast to 20.28 jassids plant^{-1} in untreated control (Kalawate and Dethe, 2012)

Foliar sprays of thiamethoxam 25 WG @ 0.025 per cent recorded 67.55 per cent mean reduction of whitefly population on brinjal (Balaji, 2002). Studies conducted by Sharma and Lal (2002) found that after one day of first spray of thiamethoxam 25 WG, the whitefly population was reduced by 94.06 per cent on brinjal. According to Naik *et al.* (2009) thiamethoxam showed high efficacy against whiteflies. Nath and Sinha (2010) reported that both neonicotinoids (thimethoxam and acetamiprid) were effective against whitefly.

Thiamethoxam showed the highest rates of efficiency against whitefly. It caused reduction in whitefly adult and immature stage populations by 87.5 and 82.4 per cent after three sprays, respectively. Acetamiprid and thiamethoxam caused reduction in adults of *B. tabaci* to the tune of 67.3 and 84.7% respectively. The immature stages of the pest were reduced by 60.1 and 82.1 respectively (AL-Kherb,2011).

Acetamiprid is one of several neonicotinoids that have been introduced in the past decade against *B. tabaci* (Horowitz *et al.*, 1998, Palumbo *et al.*, 2001). Afzal *et al.* (2002) reported that Imicon 25 WP @ 200 g acre^{-1} (imidacloprid) was found to be most effective for whitefly. Emamectin benzoate, 6.25 g a.i. ha^{-1} proved most effective against whitefly with low levels of infestation. In summer it resulted as the best treatments in controlling whiteflies (Kalawate and Dethe, 2012). Thiamethoxam resulted in a maximum mortality of the jassid, followed by acetamiprid. While in case of whitefly, acetamiprid was effective and resulted in a minimum population (Iqbal *et al.*, 2013).

Spiromesifen can be used as a new and valuable tool in whitefly resistance management when combined with neonicotinoid (thiamethoxam and acetamiprid) insecticides. Because *B. tabaci* has developed resistance to organophosphates, pyrethroids, some insect growth regulators and some neonicotinoid insecticides, (Kontsedalov *et al.*, 2008). Spiromesifen is especially active against whiteflies in several cropping systems, including cotton, vegetables, and ornamentals (Nauen *et al.*, 2002;Liu, 2004; Polumbo, 2004). Spiromesifen was superior in reducing the whitefly egg and immature numbers. Spiromesifen is also extremely effective against pyriproxyfen-resistant whiteflies and no cross resistance to any important insecticide and acaricide was found (Nauen *et al.*, 2002). Spiromesifen and buprofezin can be effective foliar alternatives to the neonicotinoid insecticides currently used for controlling whiteflies. A single application of spiromesifen or buprofezin applied early in whitefly population growth can prevent significant losses in fruit quality (Palumbo, 2009). Spiromesifen showed excellent toxicity to the susceptible laboratory and field-collected *B.tabaci* nymphs in 2005 prior to the field use of spiromesifen (Mann *et al.,* 2012).

The efficacy of imidacloprid 70 WS as seed treatment in reducing the population of aphids has been reported by Jarande and Dethe (1994) and Bhargava *et al* (2003). Dhanalakshmi and Mallapur (2008) found that acetamiprid 20 SP at 0.2 g l^{-1} was the most effective insecticide against aphids. In summer emamectin benzoate was the best treatment in controlling aphids (2.95 to 3.55 per leaf) (Kalawate and Dethe, 2012).

Although insecticidal control is one of the common means against sucking pests like jassids, many of the insecticides applied were not effective in the satisfactory control of this pest. Brinjal being a vegetable crop, use of broad-spectrum insecticides will leave considerable toxic residues on the fruits. Beside this, sole dependence on several broad-spectrum insecticides for the control of this pests has led to insecticidal resistance (Natekar *et al.*,1987 and Harish *et al.*, 2011).

Materials and methods

3. MATERIALS AND METHODS

Survey was conducted in Thiruvananthapuram district during 2013-2014 to document the sucking pests of brinjal and to assess the intensity of damage caused. Two field trials were conducted in the Instructional Farm, College of Agriculture, Vellayani to evolve a suitable management strategy using newer insecticides. The details of the materials used and the methods adopted during the course of investigation are described below.

3.1 DOCUMENTATION OF SUCKING PESTS AND ASSESSMENT OF DAMAGE

Four panchayaths namely Kalliyoor, Venganoor, Vattiyoorkavu and Nedumangadu of Thiruvananthapuram district where brinjal was grown extensively in the homesteads were selected to document the sucking pests and assess the damage caused.

3.1.1. Documentation of Sucking Pests

Sixty homesteads where brinjal was grown either in garden land or terrace were selected at random from Kalliyoor, Venganoor, Vattiyoorkavu and Nedumangadu panchayaths of Thiruvananthapuram district and the sucking pests infesting the crop during vegetative and flowering stages were recorded. Other pests infesting brinjal were also noted. The habitats of the pests were also recorded. Density of the various pests was assessed as detailed below.

Pest density	Sucking pests (Number per 5leaves)	Shoot & fruit borer (Number of fruits or shoots damaged)	Leaf feeders (Number per plant)	Leaf miner (Number of leaves damaged)
High	> 50	> 5	> 5	> 5
Moderate	25-50	3-5	3-5	3-5
Low	< 25	< 3	< 2	< 3

3.1.2. Incidence of Natural Enemies

The natural enemies associated with the sucking pests were also recorded. The predators were collected in polythene bags, brought to the laboratory and identified following standard procedures

The brinjal leaves with diseased mealy bugs were removed carefully from the brinjal plants and transferred to polythene covers, brought to the laboratory for isolating the pathogen from the infected mealy bugs. The infected diseased samples were surface sterilized by dipping in 0.1% mercuric chloride ($HgCl_2$) solution for one minute and then washed three times with sterilized distilled water. The excess water was removed using filter paper and then placed into sterilized PDA in petridishes. The plates were incubated at a temperature of 27^0 C and the growth was examined 4-5 days after incubation. The morphological features of the fungus such as spore and mycelial characters were studied by using microscope.

3.1.3. Assessment of Damage

Ten homesteads each where brinjal was grown in the garden land and terrace were identified randomly from the selected sixty homesteads for assessing the extent of damage caused by the sucking pests. Ten plants were selected from each location and the number of pests on five leaves in each plant was counted. The extent of damage caused by each sucking pest was scored. The following scale (0-4) was adopted for leaf hoppers.

Grade	Nature of damage	Level of injury
0	No damage	Healthy green leaf
1	Low damage	Slight yellowing of leaf margin
2	Medium damage	Yellowing and necrosis of leaf
3	High damage	Intensive yellowing of leaf
4	Severe damage	Complete necrosis of leaves

$$\text{Infestation index} = \frac{\text{Sum of all numerical ratings}}{\text{Total number of leaves assessed}} \times \frac{100}{\text{Maximum grade}}$$

(Singh and Rai, 1995)

The other sucking pests namely aphids, mealy bugs and whiteflies were scored based on the following scale.

Grade	Infestation
1	Scattered appearance of few pests on the plant
2	Severe infestation of pests on any one branch of the plant
3	Severe infestation of pests on more than one branch or half portion of the plant
4	Severe infestation of pests on the whole plant

$$\text{Infestation index} = \frac{\text{Sum of all numerical ratings}}{\text{Total number of leaves assessed}} \times \frac{100}{\text{Maximum grade}}$$

(Kataria and Kumar, 2012)

3.2 MANAGEMENT OF SUCKING PESTS

Two field experiments were conducted in the Instructional Farm, Vellayani to evaluate the efficacy of four new generation insecticides and two biopesticides in managing the sucking pests infesting brinjal.

3.2.1. Preparation of the Field

Seedlings of brinjal (Variety - Surya) obtained from the Department of Olericulture, College of Agriculture, Vellayani were used for the trial. The details of the trial were as follows;

Design	RBD
Treatments	8
Replications	3
Plot size	2 x 2 m
Spacing	60 x 60 cm

Treatments of the field trials

Sl. No.	Chemical name	Trade name	Concentration (g ai ha^{-1})	Dosage (g/ ml l^{-1})
1	Spiromesifen	Oberon 22.9 SC	96	0.8
2	Thiamethoxam	Suckgam 25 WG	50	0.4
3	Acetamiprid	Manik 20 SP	10	0.6
4	Dinotefuran	Token 20 SG	30	0.2
5	Oxuron	-	5%	50
6	*Beauveria bassiana*	ITCC 6063	-	20
7	Dimethoate (Insecticide check)	Rogor 30 EC	600	1.65
8	Control (Untreated check)	-	-	-

The crop was raised and maintained as per the package of practices recommendation of KAU (2009) except for the plant protection measures which were given according to the treatments fixed.

3.2.2. Pest Count after Treatment Application

Five plants were selected randomly from each plot excluding the border plants and labelled. Twenty leaves were selected from each observational plant (seven from top, seven from middle and six from bottom). The number of both nymphs and adults of pests in twenty leaves were counted and expressed as number of pests per plant. Pest count after treatment application was taken on the 3rd, 5th, 7th, 9th and 15th day after spraying.

3.2.3. Damage Score.

Damage score was done as in 3.1.1.

3.2.4. Incidence of Other Pests.

Incidence of other pests was also recorded.

3.2.5. Biometric Observations

The following biometric characters of the labelled plants were taken at monthly intervals.

3.2.5.1. Height of the Plant

Plant height was taken from base to the terminal portion of the branch. The mean plant height was expressed in cm.

3.2.5.2. Number of Branches

The number of primary branches was taken at monthly intervals.

3.2.5.3. Number of Leaves

The number of fully opened leaves were taken at monthly intervals and expressed as total number of leaves per plant.

3.2.6. Yield

The number and weight of fruits were recorded after each harvest. Weight of fruits per plot was converted to per hectare basis and expressed as yield per hectare. Benefit cost ratio was also calculated.

3.3. STATISTICAL ANALYSIS

Data of each experiment were analysed, applying suitable methods of analysis (Panse and Sukhatme, 1967).

Results

4. RESULTS

The results of the studies conducted on the sucking pests infesting brinjal in homesteads and the damage caused and the field experiments on the efficacy of new generation insecticides and biopesticides in managing the sucking pests are depicted in Tables 1 to 16.

4.1. DOCUMENTATION OF SUCKING PESTS AND ASSESSMENT OF DAMAGE

4.1.1. Sucking Pests Infesting Brinjal

Seven sucking pests namely the leaf hopper (*Amrasca biguttula biguttula* Ishida, Family: Cicadellidae), aphid (*Aphis gossypii* Glover, Family: Aphididae), mealy bug (*Coccidohystrix insolita* Gr., Family: Pseudococcidae), whiteflies (*Bemisia tabaci* Gennadius , *Aleurodicus dispersus* Russell, Family: Aleyrodidae), lace wing bug (*Urentius hystricellus* Richt., Family: Tingidae) and mite (*Tetranychus* sp., Family: Tetranychidae) were recorded from brinjal grown in homesteads of Thiruvananthapuram district. The occurrence of the pests was observed in garden land and terraces both during the vegetative and flowering stages. Among the pests, the leaf hopper, aphid, whiteflies and mealy bug were seen both during the vegetative and flowering stages of the brinjal grown in garden land as well as on terrace. The spiralling whitefly was prevalent during the flowering stage in garden land and terrace. Lace wing bug was recorded exclusively from the brinjal raised on terrace both in the vegetative and flowering stages. Mites were seen during the flowering stage on brinjal grown in terrace.

Considering the habitat of the various sucking pests, leaf hopper, aphid and spiralling whitefly were found on the upper leaves. *B. tabaci* was recorded

Table 1. Sucking pests of brinjal in the homesteads of Thiruvananthapuram district

Sl. No.	Common name	Scientific name	Family	Garden Land		Terrace		Habitat	Pest density
				Veg. stage	Fl. stage	Veg. stag e	Fl. stage		
1	Leaf hopper	*Amrasca biguttula biguttula* (Ishida)	Cicadellidae	+	+	+	+	Upper leaves	High
2	Aphid	*Aphis gossypii* Glover	Aphididae	+	+	+	+	Upper leaves	High
3	Whitefly	*Bemisia tabaci* (Gennadius)	Aleyrodidae	+	+	+	+	Upper and middle leaves	High
4	Brinjal mealy bug	*Coccidohystrix insolita* Gr.	Pseudococcidae	+	+	+	+	Upper, middle and lower leaves	High
5	Spiralling whitefly	*Aleurodicus dispersus* Russell.	Aleyrodidae	-	+	_	+	Upper leaves.	Low
6	Lace wing bug	*Urentius hystricellus* (Richt.)	Tingidae	_	_	+	+	Upper, middle and lower leaves	Moderate
7	Mite	*Tetranychus* sp.	Tetranychidae	-	-	-	+	Middle and lower leaves	Low

Veg.stage - Vegetative stage
Fl.stage - Flowering stage

\+ - Presence
\- - Absence

High - > 50 pests/5leave
Moderate - 25-50 pests/5 leaves
Low - < 25 pests/ 5 leaves

from upper and middle leaves. The mealy bug was seen on upper, middle and lower leaves while the mite was observed on middle and lower leaves.

Among the sucking pests recorded, leaf hopper, aphid, whiteflies and mealy bug which occurred in high densities (>50 pests per 5 leaves) were the major ones infesting brinjal. The incidence of lace wing bug was moderate (25-50 pests per 5 leaves). The spiralling whitefly and mite occurred in low densities (<25 pests per 5 leaves) (Table 1)

4.1.1.1. Nature of Damage

The type of damage caused by the sucking pests recorded from brinjal grown in the homesteads is described herewith.

Amrasca biguttula biguttula

The green coloured adults and greenish yellow nymphs were found in between the veins and suck sap from the leaves. Injury is caused by the toxic material of the insect's saliva which is injected into the leaf during feeding. Marginal chlorosis, bronzing (browning), puckering (development of crinkles, curls and folds), and drying of leaves are the characteristic symptoms associated with the infestation of the pest. The severely attacked plants become stunted and fail to grow (Plate 1).

Aphis gossypii

Occurrence of aphids can be identified by the presence of ants that feed on honey dew. As a result of the infestation by the aphids, leaves curl and crinkle and the plants become weak (Plate 2).

Bemisia tabaci

Adults have two pairs of pure white wings. Both adults and nymphs of whitefly feed on leaves by sucking cell sap. They excrete honey dew which results in the development of sooty mould. Chlorotic spots were seen on the leaves which later coalesce forming irregular yellowing of leaves (Plate 3).

Adult

Nymph

Symptom

Plate 1. ***Amrasca biguttula biguttula***

Infested plant

Plate 2. ***Aphis gossypii***

Bemisia tabaci

Aleurodicus dispersus

Plate 3. Whitefly

Coccidohystrix insolita

The mealy bugs infest leaves and tender shoots. These were seen aggregating near the veins and veinlets. Leaves turn yellow and crinkle resulting in the drying of leaves (Plate 4).

Urentius hystricellus

Lace wing bug is a small bug whose body covered with spines and the wings show a distinct lace-like appearance. Both adults and nymphs were found in groups on the underside of leaves. They suck sap from the leaves causing whitish to yellowish mottled patches on the leaves. In case of serious infestation, the leaves turn yellow and drop off. Attacked leaves are speckled with black shiny spots, which are the faeces of the bugs (Plate 5).

***Tetranychus* sp.**

The adults and nymphs were seen on the underside of the leaf. White speckling was seen on the attacked leaves, leading to yellowish bleaching (Plate 6.)

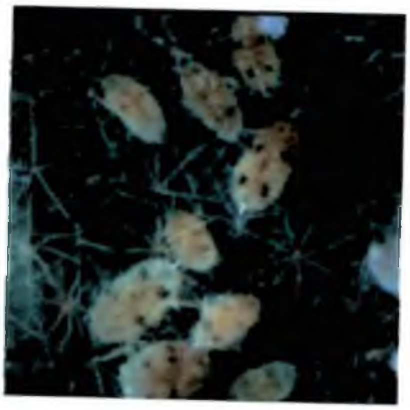
4.1.2. Borers and Leaf Feeders

The shoot and fruit borer, *Leucinodes orbonalis* Guen (Lepidoptera: Pyralidae) and leaf feeders were the other pests observed infesting brinjal (Table 2). The leaf feeders included the epilachna beetle *Henosepilachna viginctioctopunctata* (F.) (Coleoptera: Coccinellidae), leaf folder *Antoba olevaceae* Wlk. (Lepidoptera: Noctuidae), leaf eating caterpillar *Spodoptera litura* (F.) (Lepidoptera: Noctuidae), hairy caterpillar *Spilosoma obliqua* (Walker) (Lepidoptera : Arctidae), leaf webber *Psara bipunctalis* F. (Lepidoptera : Pyralidae) and an unidentified leaf miner.

The shoot and fruit borer, epilachna beetle, leaf folder, leaf eating caterpillar and hairy caterpillar were seen in both the garden land and terrace during the vegetative and the flowering stages. The leaf miner was recorded from

Female

Male

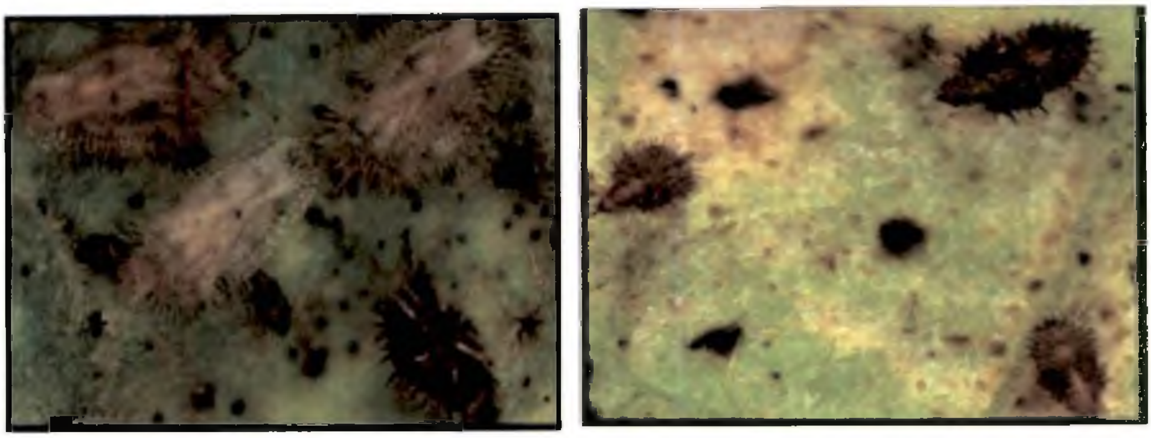


Crawlers

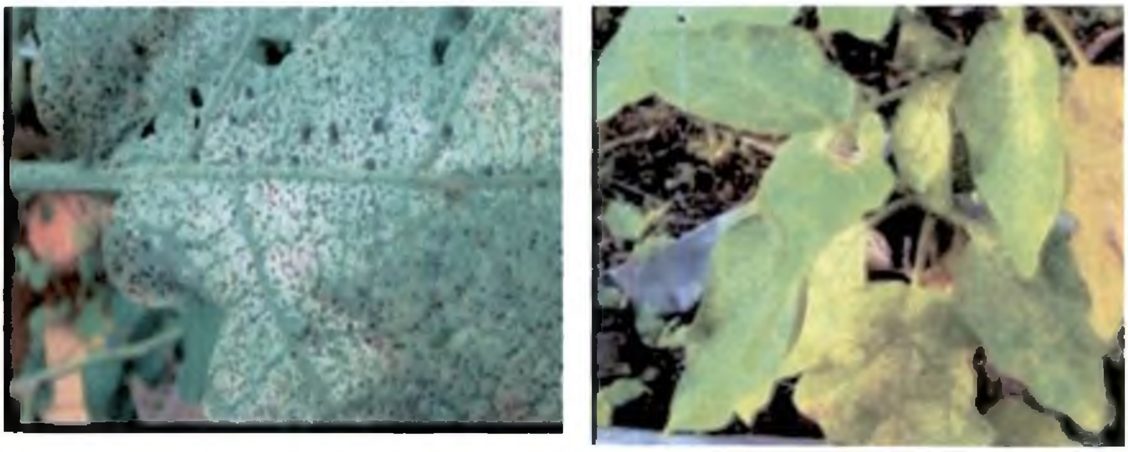
Infested plant

Infested leaf

Plate 4. *Coccidohystrix insolita*

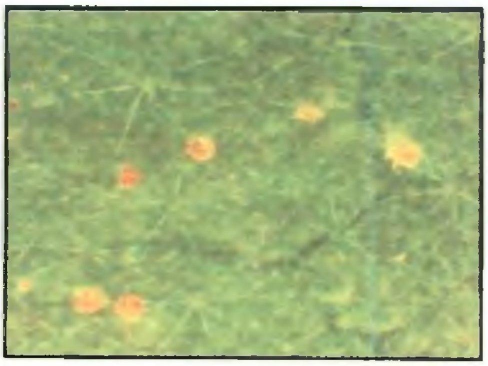


Adults and nymphs



Symptoms

Plate 5. *Urentius hystricellus*



Adults and nymphs

Plate 6. *Tetranychus* sp.

Table 2. Borers and leaf feeders of brinjal in homesteads of Thiruvananthapuram district

Sl. No.	Common name	Scientific name	Order	Family	Garden Land		Terrace		Habitat	Pest density
					Veg. stage	Fl. stage	Veg. stage	Fl. stage		
1	Shoot and fruit borer	*Leucinodes orbonalis Guen.*	Lepidoptera	Pyralidae	+	+	+	+	Shoot and fruit	High
2	Epilachna beetle	*Henosepilachna viginctioctopunctata* (F.)	Coleoptera	Coccinellidae	+	+	+	+	Leaves	Moderate
3	Leaf folder	*Antoba olevaceae* Wlk.	Lepidoptera	Noctuidae	+	+	+	+	Upper leaves	Low
4	Leaf webber	*Psara bipunctalis* F.	Lepidoptera	Pyralidae	-	+	-	-	Upper leaves	Moderate
5	Leaf miner	Unidentified			+	+	-	-	Upper, middle and lower leaves	Moderate
6	Leaf caterpillar	*Spodoptera litura* (F.)	Lepidoptera	Noctuidae	+	+	+	+	Upper and middle leaves	Moderate
7	Hairy caterpillar	*Spilosoma obliqua* (Walker)	Lepidoptera	Arctidae	+	+	+	+	Middle leaves	Low

Veg.stage - Vegetative stage
Fl.stage - Flowering stage

+ - Presence
- - Absence

For shoot & fruit borer
High - > 5 fruits or shoots damaged
Moderate - 3-5 fruits or shoots damaged
Low - < 3 fruits or shoots damaged

For leaf miner
High - > 5 leaves damaged
Moderate - 3-5 leaves damaged
Low - < 3 leaves damaged

For leaf feeder
High - >5 pests
Moderate - 3-5 pests
Low - < 3pests

brinjal raised in garden land during vegetative and flowering stages. Leaf webbers were seen during flowering stage in garden land.

Shoot and fruit borers occurred in high density while the occurrence of leaf feeders was moderate.

4.1.2.1. Nature of Damage

The type of damage caused by the shoot and fruit borer and leaf feeders recorded from brinjal growing in homesteads is described herewith.

Leucinodes orbonalis

The damaged shoot droop, wither and dry up. The infested fruits present a deformed appearance and show holes on them plugged with excreta (Plate 7).

Henosepilachna viginctioctopunctata

Both adults and grubs damaged brinjal leaves by scraping the surface tissues. The damaged leaves dry up (Plate 8).

Antoba olevaceae

The larva fold the tender leaf and feed on the surface tissues of leaves from within. The folded leaves dry up due to the loss of surface tissues (Plate 9).

Psara bipunctalis

The caterpillar webs together the leaves and feed gregariously from within. The leaves were totally eaten up leaving only the veins and webbings (Plate 10).

Leaf miner

The larvae tunnel the leaf lamina, eating chlorophyll rich mesophyll cells. Unlike mining of serpentine leaf miner, this particular mining was discontinuous (Plate 11).

Symptoms

Plate 7. ***Leucinodes orbonalis***

Adult

Nymph

Symptom

Plate 8. *Henosepilachna viginctioctopunctata*

Adult

Larva

Symptom

Plate 9. *Antoba olevaceae*

4.1.3. Natural Enemies.

The natural enemies recorded included the lycaenid butterfly *Spalgis* sp., larvae of which predates on mealy bugs (Plate 12). A pathogen, *Fusarium* sp. was also isolated from the mealy bug and Koch's postulates was proved. On microscopic observation, the conidial characters were found to be multiseptate and sickle shaped (Plate 13).

4.1.4. Incidenceof Pests in Homesteads of Thiruvananthapuram District

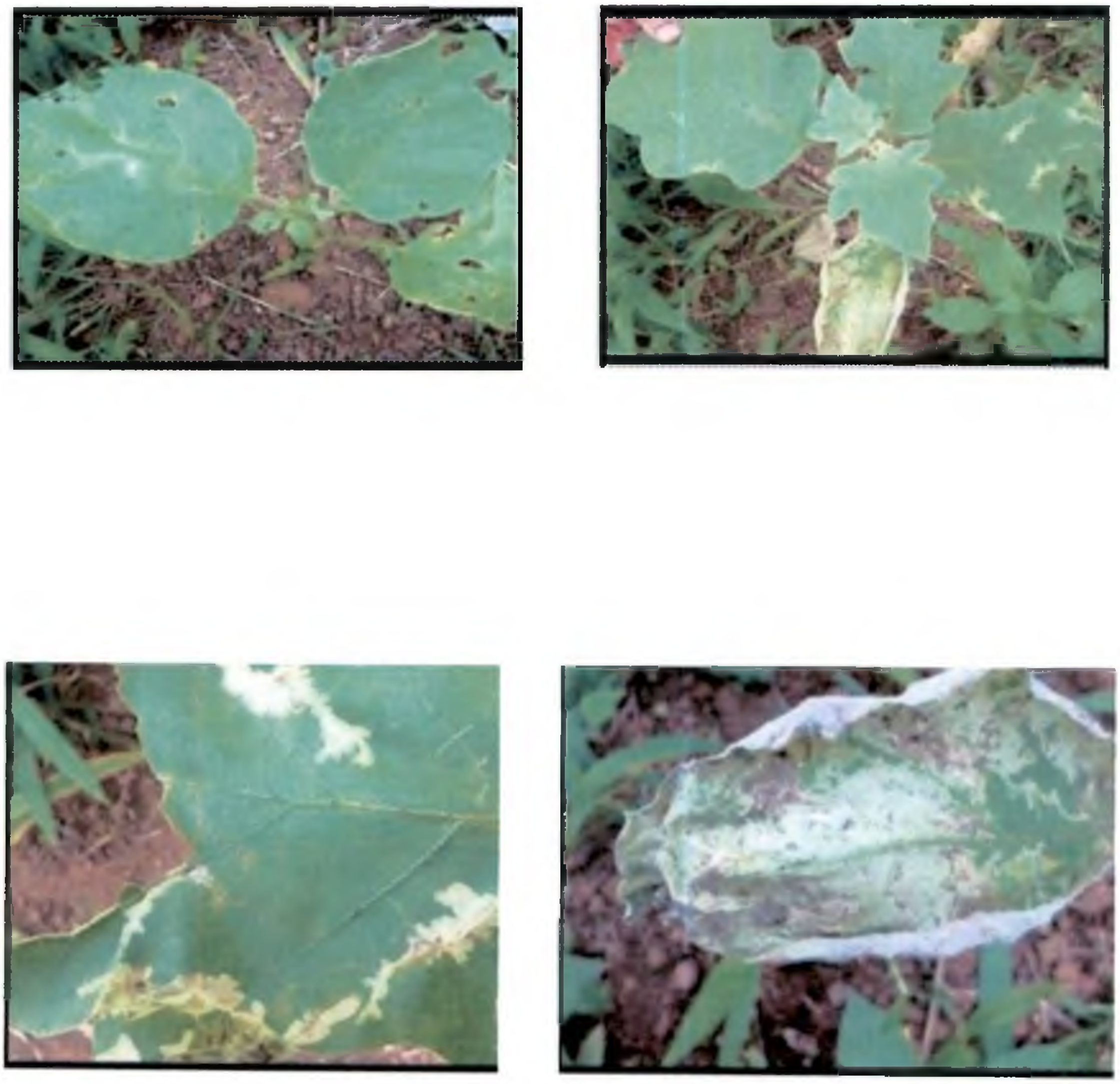
Sucking pests were found infesting brinjal grown in both land and terrace in all the locations surveyed during vegetative and flowering stages (Table 3). Infestation of shoot and fruit borer in brinjal raised in garden land was recorded from 20 per cent locations during vegetative stage and 65 per cent locations in the flowering stage while its infestation on brinjal raised in terraces was recorded from 45 per cent locations during vegetative stage and 80 per cent locations during flowering stage. Sixty per cent of the locations where brinjal was grown in garden land were found infested with leaf feeders during vegetative stage. During flowering stage, the infestation was recorded from 65 per cent locations. In terrace cultivation, 75 per cent locations were found infested with leaf feeders during vegetative stage while during flowering stage it was recorded from 90 per cent locations.

Adult

Larva

Symptom

Plate 10. ***Psara bipunctalis***



Symptom

Plate 11. Leaf miner

Adult

Larva

Pupa

Plate 12. *Spalgis* sp.

Healthy mealy bug

Infected mealy bug

Isolated pathogen

Fusarium sp.

Plate 13. *Fusarium* sp.

Table 3. Incidence of pests on brinjal in the homesteads of Thiruvananthapuram district

Pest	Land (%)		Terrace (%)	
	Vegetative stage	Flowering Stage	Vegetative Stage	Flowering Stage
Sucking pests	100	100	100	100
Shoot & fruit borer	20	65	45	80
Leaf feeders	60	65	75	90

Table 4. Incidence of major sucking pests on brinjal in the homesteads of Thiruvananthapuram district

Pests	Garden Land (%)		Terrace (%)	
	Vegetative Stage	Flowering Stage	Vegetative Stage	Flowering Stage
Amrasca biguttula biguttula	100	100	100	100
Aphis gossypii	95	75	95	95
Bemisia tabaci	85	75	95	95
Coccidohystrix insolita	95	90	85	90

4.1.4.1. Incidence of Sucking Pests

The incidence of the major sucking pests of brinjal in homesteads of Thiruvananthapuram district *viz.*, *A. biguttula biguttula*, *A. gossypii*, *B. tabaci* and *C. insolita* is given in Table 4. The data showed that *A. biguttula biguttula* was found on brinjal grown both in garden land and terrace in all the locations surveyed during vegetative and flowering stages. *A. gossypii* was found in 95 per cent locations surveyed during vegetative stage and flowering stage in terrace whereas in garden land 95 per cent locations showed the incidence of *A. gossypii* during vegetative stage. However, its incidence was observed from 75 per cent locations during flowering stage. *B. tabaci* was found in 85 per cent locations surveyed during vegetative stage in garden land and 75 per cent locations surveyed during flowering stage. In terrace, it was recorded from 95 per cent locations surveyed during vegetative and flowering stages.

4.1.5. Population of Sucking Pests in Homesteads of Thiruvananthapuram District

The data on population of sucking pests on brinjal in homesteads of Thiruvananthapuram district (Table 5) revealed that the population of leaf hopper (92.17 per five leaves) was significantly higher during vegetative stage. This was followed by mealy bugs, whiteflies and aphids which were on par, the mean number of pests being 60.68, 60.37 and 54.46 per five leaves during vegetative stage in garden land.

A similar trend was observed during the flowering stage in garden land. The population of leaf hopper was found to be significantly higher (151.29 per five leaves). It was followed by mealy bugs, aphids and whiteflies, the mean number of pests being 71.74, 68.22 and 57.00 per five leaves.

The population of whiteflies (84.64 per five leaves), leaf hoppers (82.99 per five leaves) and aphids (61.46 per five leaves) were found to be statistically on

Table 5. Population of sucking pests of brinjal in the homesteads of Thiruvananthapuram district

Pests	Mean number of pests in 5 leaves/plant			
	Garden land		Terrace	
	Vegetative stage	Flowering stage	Vegetative stage	Flowering stage
Amrasca biguttula biguttula	92.17 (9.57)	151.29 (12.30)	82.99 (9.11)	119.24 (10.92)
Aphis gossypii	54.46 (7.38)	68.22 (8.26)	61.46 (7.84)	123.43 (11.11)
Bemisia tabaci	60.37 (7.77)	57.00 (7.55)	84.64 (9.20)	96.82 (9.84)
Coccidohystrix insolita	60.68 (7.79)	71.74 (8.47)	50.97 (7.14)	91.01 (9.54)
C.D(0.05)	(1.77)	(3.27)	(2.01)	(2.02)

Values given in parenthesis are angular transformed value

Table 6. Extent of damage caused by sucking pests in homesteads of Thiruvananthapuram district

Pests	Infestation index (%)			
	Garden land		Terrace	
	Vegetative stage	Flowering stage	Vegetati ve stage	Flowering stage
Amrasca biguttula biguttula	40.17	58.88	35.35	53.08
Aphis gossypii	34.46	36.14	41.45	50.50
Bemisia tabaci	30.11	31.22	36.00	40.24
Coccidohystrix insolita	46.23	49.28	34.16	43.97
C.D.(0.05)	8.750	12.194	NS	NS

par during vegetative stage in terrace cultivation. The population of mealy bug was 50.97 per five leaves.

The population of aphids (123.43 per five leaves), leaf hoppers (119.24 per five leaves), whiteflies (96.82 per five leaves) and mealy bugs (91.01 per five leaves) were statistically on par during the flowering stage of brinjal grown in terrace.

4.1.6. Extent of Damage by Sucking Pests in Homesteads

Among the sucking pests surveyed, the damage caused by leaf hoppers and mealy bugs were higher in garden land whereas in terrace there is no significant diifference (Table 6).

During vegetative stage, high damage was caused by mealy bugs (46.23 per cent) and it was on par with that of leaf hoppers (40.17 per cent). Damage caused by aphids (34.46 per cent) was on par with leaf hoppers and it was on par with that caused by whiteflies (30.11 per cent) also.

Regarding the damage caused by various sucking pests in garden land during flowering stage, higher damage was caused by leaf hoppers with 58.88 per cent and was on par with that of mealy bugs (49.28 per cent). This was followed by aphids (36.14 per cent) which were on par with whiteflies (31.22 per cent).

Comparatively, lower damage was seen in the terrace. During vegetative stage higher damage was caused by aphids (41.45 per cent). Whiteflies followed next with 36 per cent damage. This was followed by leaf hopper (35.35 per cent) and mealy bugs with 34.16 per cent damage.

In the flowering stage, leaf hoppers caused higher damage with 53.08 per cent and it was followed by aphids with 50.50 per cent damage. Mealy bugs with 43.97 per cent damage followed next and lowest damage was caused by whiteflies with 40.24 per cent.

4.2. FIELD TRIAL

The results of the two field trials on the management of sucking pests of brinjal using insecticides and biopesticides are presented in Tables 7 to 15.

4.2.1. First Crop

The major sucking pest observed during the first crop was the leaf hopper (*A. biguttula biguttula*).

4.2.1.1. Effect of New Generation Insecticides and Biopesticides on A. biguttula biguttula

First spraying

Observations recorded after first spray indicated that all the treatments except *B. bassiana* reduced the population of the leaf hopper significantly (Table 7).

The pre-treatment population ranges from 53 to 88. Considering the relative efficacy of various treatments on the third day after spraying, thiamethoxam 50 g ai ha^{-1} recorded least number of hoppers (2.20 per plant) and it was on par with spiromesifen 96 g ai ha^{-1} with a population of 2.88 per plant. This was followed by dinotefuran 30 g ai ha^{-1} and acetamiprid 10 g ai ha^{-1}. Acetamiprid 10 g ai ha^{-1} was on par with dimethoate 600 g ai ha^{-1}. The number of pests recorded in the treatments was 12.39, 18.62 and 28.37 per plant respectively.

On fifth day after spraying thiamethoxam 50 g ai ha^{-1} and spiromesifen 96 g ai ha^{-1} were superior in reducing the pest population, the number of pest recorded per plant being 0.58. This was followed by dinotefuran 30 g ai ha^{-1} (2.88 per plant) which was on par with *B. bassiana* 20 g l^{-1} (4.76 per plant). Dimethoate 600 g ai ha^{-1} (9.17 per plant), acetamiprid 10 g ai ha^{-1} (9.56 per plant) and oxuron 5ml l^{-1} (20.90 per plant) also reduced the population of the pest when compared to the untreated check (35.48 per plant).

Table 7. Population of *Amrasca biguttula biguttula* in plots treated with new generation insecticides and biopesticides (After first spray)

Treatments	Number per plant			
	3rd DAS	5th DAS	7th DAS	9th DAS
Spiromesifen 22.9 SC @ 96 g ai ha^{-1}	2.88 (1.97)	0.58 (1.26)	0.66 (1.29)	0.51 (1.23)
Thiamethoxam 25 WG @ 50 g ai ha^{-1}	2.20 (1.79)	0.58 (1.26)	0.69 (1.30)	0.42 (1.19)
Acetamiprid 20 SP @10 g ai ha^{-1}	18.62 (4.43)	9.56 (3.25)	3.97 (2.23)	1.19 (1.48)
Dinotefuran 20 SG 30 g ai ha^{-1}	12.39 (3.66)	2.88 (1.97)	0.56 (1.25)	0.30 (1.14)
Oxuron @ 5ml l^{-1}	39.44 (6.36)	20.90 (4.68)	12.70 (3.70)	0.77 (1.33)
Beauveria bassiana 20 g l^{-1}	35.60 (6.05)	4.76 (2.40)	18.3 (4.39)	9.05 (3.17)
Dimethoate (Check) 30 EC@ 600 g ai ha^{-1}	28.37 (5.42)	9.17 (3.19)	3.00 (2.00)	0.64 (1.28)
Control (Untreated check)	48.42 (7.03)	35.48 (6.04)	10.15 (3.34)	10.00 (3.32)
C.D (0.05)	(1.357)	(1.098)	(0.757)	(0.424)

DAS – Day after spraying

Values given in parenthesis are angular transformed value.

On the seventh day after spraying, dinotefuran 30 g ai ha^{-1}, spiromesifen 96 g ai ha^{-1} and thiamethoxam 50 g ai ha^{-1} reduced the pest population significantly, the number of pest per plant recorded in the treatments being 0.56, 0.66 and 0.69 respectively as against 10.15 per plant in the control plot. The three treatments being on par in their effect. Significant reduction in the number of pest was also observed in the insecticide check dimethoate 600 g ai ha^{-1} (3.00 per plant). This treatment was followed by acetamiprid 10 g ai ha^{-1} (3.97 per plant). Oxuron 5ml l^{-1} and *B. bassiana* 20 g l^{-1} recorded 12.70 and 18.30 hoppers per plant respectively.

Observations recorded on ninth day after spraying indicated that the population of the pests was significantly reduced by all the treatments except *B.bassiana*. All the treatments except *B. bassiana* 20 g l^{-1} (9.05 per plant) were statistically on par. The treatment follows the order, dinotefuran 30 g ai ha^{-1} (0.3 per plant), thiamethoxam 50 g ai ha^{-1} (0.42 per plant), spiromesifen 96 g ai ha^{-1} (0.51 per plant), dimethoate 600 g ai ha^{-1} (0.64 per plant), oxuron 5ml l^{-1} (0.77 per plant) and acetamiprid 10 g ai ha^{-1} (1.19 per plant).

Second spraying

A similar trend in the efficacy of the treatments was noticed after the second spray too (Table 8).

On the third day after spraying significant reduction in population was recorded in spiromesifen 96 g ai ha^{-1} (0.23 per plant). This was closely followed by thiamethoxam 50 g ai ha^{-1} (0.39 per plant) and dinotefuran 30 g ai ha^{-1} (0.46 per plant). The three treatments were on par in their effect. Dimethoate 600 g ai ha^{-1} with a population of 0.61 per plant and was on par with oxuron 5ml l^{-1} (0.66 per plant), *B. bassiana* 20 g l^{-1} (0.82 per plant), and acetamiprid 10 g ai ha^{-1} (0.84 per plant).

Table 8. Population of *Amrasca biguttula biguttula* in plots treated with new generation insecticides and biopesticides. (After second spray)

Treatments	Number per plant				
	3rd DAS	5th DAS	7th DAS	9th DAS	15th DAS
Spiromesifen 22.9 SC @ 96 g ai ha^{-1}	0.23 (1.11)	0.16 (1.08)	0.34 (1.16)	0.18 (1.09)	0.25 (1.12)
Thiamethoxam 25 WG @ 50 g ai ha^{-1}	0.39 (1.18)	0.29 (1.14)	0.14 (1.07)	0.14 (1.07)	0.21 (1.10)
Acetamiprid 20 SP @10 g ai ha^{-1}	0.84 (1.36)	0.34 (1.16)	1.25 (1.50)	0.34 (1.16)	0.32 (1.15)
Dinotefuran 20 SG 30 g ai ha^{-1}	0.46 (1.21)	0.32 (1.15)	0.30 (1.14)	0.61 (1.27)	0.21 (1.10)
Oxuron @ 5ml l^{-1}	0.66 (1.29)	1.31 (1.52)	1.13 (1.46)	0.71 (1.31)	0.32 (1.15)
Beauveria bassiana 20 g l^{-1}	0.82 (1.35)	0.39 (1.18)	1.01 (1.42)	1.16 (1.47)	0.53 (1.24)
Dimethoate (Check) 30 EC@ 600 g ai ha^{-1}	0.61 (1.27)	0.34 (1.16)	0.66 (1.29)	0.48 (1.22)	0.39 (1.18)
Control (Untreated check)	0.98 (1.41)	1.40 (1.55)	1.99 (1.73)	1.99 (1.73)	0.71 (1.31)
C.D. (0.05)	(0.17)	(0.30)	(0.22)	(0.24)	(0.16)

Values given in parenthesis are angular transformed value.

On the fifth day after spraying spiromesifen 96 g ai ha^{-1} with the least number of pest (0.16 per plant) was the best treatment. It was followed by thiamethoxam 50 g ai ha^{-1} (0.29 pests per plant), dinotefuran 30 g ai ha^{-1} (0.32 pests per plant), acetamiprid 10 g ai ha^{-1} (0.34 pests per plant), dimethoate 600 g ai ha^{-1} (0.34 pests per plant) and *B. bassiana* 20g l^{-1} (0.39 pests per plant). These treatments were statistically on par.

Thiamethoxam 50 g ai ha^{-1}, dinotefuran 30 g ai ha^{-1} and spiromesifen 96 g ai ha^{-1} proved superior in reducing the pest population, the number of pest recorded were 0.14, 0.30 and 0.34 per plant respectively on the seventh day after spraying. Dimethoate 600 g ai ha^{-1} (0.66 per plant), *B. bassiana* 20 g l^{-1} (1.01 per plant), oxuron 5ml l^{-1} (1.13 per plant) and acetamiprid 10 g ai ha^{-1} (1.25 per plant) were on par and differed significantly from the control plot (1.99 per plant)

A significant reduction in the number of pests was seen in all the treated plots on the ninth day after spraying, compared to the control plot (1.99 per plant). Thiamethoxam 50 g ai ha^{-1} recorded lowest number of pests (0.14 per plant) and was on par with spiromesifen 96 g ai ha^{-1}, acetamiprid 10 g ai ha^{-1} and dimethoate 600 g ai ha^{-1}. The number of pests recorded was 0.18, 0.34 and 0.48 per plant respectively. Dinotefuran 30 g ai ha^{-1}, oxuron 5 ml l^{-1} and *B. bassiana* 20g l^{-1} treated plots recorded a population of 0.61, 0.71 and 1.16 pests per plant respectively.

Thiamethoxam 50 g ai ha^{-1} and dinotefuran 30 g ai ha^{-1} sprayed plots recorded significantly lower number of pests (0.21 per plant) on the fifteenth day after spraying and were on par with spiromesifen 96 g ai ha^{-1} with 0.25 pests per plant. Acetamiprid 10 g ai ha^{-1}, oxuron 5ml l^{-1} and *B. bassiana* 20 g l^{-1} treated plots showed 0.32, 0.32 and 0.53 pests per plant and were superior to control plot with 1.31 pests per plant.

4.2.1.2. Effect on Damage

The damage caused by the leaf hoppers were scored and the percentage infestation was worked out. All the treatments showed low infestation than the control plot (Table 9).

After the first spraying lowest damage was shown by thiamethoxam 50 g ai ha^{-1} (37.35 per cent). This was on par with dinotefuran 30 g ai ha^{-1} with 41.12 per cent infestation. Spiromesifen 96 g ai ha^{-1} followed the above treatments with 42.13 per cent infestation and it was on par with dimethoate 600 g ai ha^{-1} (44.04 per cent infestation) and acetamiprid 10 g ai ha^{-1} (45 per cent infestation). Oxuron 5 ml l^{-1} and *B. bassiana* 20 g l^{-1} showed 50.76 per cent infestation and was superior to the control plot (56.83 per cent infestation).

After the second spraying too, thiamethoxam 50 g ai ha^{-1} showed least damage of 38.24 per cent infestation. It was on par with spiromesifen 96 g ai ha^{-1} (41.13 per cent infestation) and dimethoate 600 g ai ha^{-1} (43.07 per cent infestation). Dinotefuran 30 g ai ha^{-1} follows with 44.04 per cent infestation. Acetamiprid 10 g ai ha^{-1} (46.91 per cent infestation) was on par with *B. bassiana* 20g l^{-1} (47.88 per cent infestation) and oxuron 5 ml l^{-1} with 51.77 per cent infestation. All the treatments were superior to the control plot with 60.26 per cent infestation.

4.2.1.3. Effect on Plant Characters

Plant characters recorded at monthly intervals were statistically analysed and given in Table 10.

4.2.1.3.1. Plant Height

The data on the height of the plant recorded at monthly intervals during the first crop revealed that the different treatments did not cause significant variation in the plant height. The height of the plant ranged from 71 cm to 110 cm

Table 9. Extent of infestation by *Amrasca biguttula biguttula* on brinjal treated with new generation insecticides and biopesticides

Treatments	1 month after 1^{st} spraying (%)	1 month after 2^{nd} spraying (%)
Spiromesifen 22.9 SC @ 96 g ai ha^{-1}	42.13	41.13
Thiamethoxam 25 WG @ 50 g ai ha^{-1}	37.35	38.24
Acetamiprid 20 SP @10 g ai ha^{-1}	45.00	46.91
Dinotefuran 20 SG 30 g ai ha^{-1}	41.12	44.04
Oxuron @ 5ml l^{-1}	50.76	51.77
Beauveria bassiana 20 g l^{-1}	50.76	47.88
Dimethoate (Check) 30 EC@ 600 g ai ha^{-1}	44.04	43.07
Control (Untreated check)	56.83	60.26
C.D. (0.05)	4.666	6.970

4.2.1.3.2. Number of Branches

The perusal of the data revealed that there was no significant variation in the number of branches due to different treatments imposed. After second spraying thiamethoxam 50 g ai ha^{-1} recorded maximum branches (6.87 per plant) and it was on par with dinotefuran 30 g ai ha^{-1} (6.33 per plant) and spiromesifen 96 g ai ha^{-1} (6.07 per plant). This was followed by *B. bassiana* 20g l^{-1} (5.47 per plant) and acetamiprid 10 g ai ha^{-1} (5.40 per plant). Dimethoate 600 g ai ha^{-1} (5.33 per plant) was on par with oxuron 5ml l^{-1} (5.13 per plant).

4.2.1.3.3. Number of Leaves

The perusal of the data revealed that there was significant variation in number of leaves due to different treatments .

Regarding the number of leaves taken after first spray, maximum number of leaves was recorded from acetamiprid 10 g ai ha^{-1} (139.13 leaves per plant) and it was on par with thiamethoxam 50 g ai ha^{-1} (130.13 leaves per plant) and spiromesifen 96 g ai ha^{-1} (127.80 leaves per plant).

Different treatments proved to be significantly different in number leaves after second spray. Acetamiprid 10 g ai ha^{-1} (190.87 leaves per plant) recorded maximum number of leaves and it was on par with spiromesifen 96 g ai ha^{-1} (180.33 leaves per plant) and thiamethoxam 50 g ai ha^{-1} (176.40 leaves per plant). All other treatments *viz.,* dinotefuran 30 g ai ha^{-1} (165.20 leaves per plant), dimethoate 600 g ai ha^{-1} (156.93 leaves per plant), oxuron 5ml l^{-1} (153.20 per leaves per plant) and *B. bassiana* 20 g l^{-1} (151.67 leaves per plant) were on par with control plot (149.13 leaves per plant).

Table 10. Biometric characters of brinjal plants treated with new generation insecticides and biopesticides against *Amrasca biguttula biguttula*

Treatments	1 month after 1st spraying			1 month after 2n spraying		
	Plant height (cm)	Number of branches	Number of leaves	Plant height (cm)	Number of branches	Number of leaves
Spiromesifen 22.9 SC @ 96 g ai ha^{-1}	72.87	3.80	127.80	95 .00	6.07	180.33
Thiamethoxam 25 WG @ 50 g ai ha^{-1}	71.27	4.20	130.20	110.00	6.87	176.40
Acetamiprid 20 SP @10 g ai ha^{-1}	77.60	2.27	139.13	105.73	5.40	190.87
Dinotefuran 20 SG 30 g ai ha^{-1}	83.47	3.20	116.67	108.20	6.33	165.20
Oxuron @ 5ml l^{-1}	75.67	2.47	115.20	105.80	5.13	153.20
Beauveria bassiana 20 g l^{-}	80.67	3.13	111.20	106.87	5.47	151.67
Dimethoate (Check) 30 EC@ 600 g ai ha^{-1}	71.80	2.53	117.80	100.13	5.33	156.93
Control (Untreated check)	77.00	3.00	107.67	103.93	5.40	149.13
C.D. (0.05)	NS	NS	18.619	NS	0.99	20.860

4.2.1.4. Yield

Effect of new generation insecticides and biopesticides on number and weight of fruits are given in Table 11. Considering the number of fruits none of the treatments proved to be significantly different during first crop.

Certain treatments showed significant difference in weight of fruits. Spiromesifen 96 g ai ha^{-1} treated plot gave highest yield (10.36 kg per plot). This was followed by thiamethoxam 50 g ai ha^{-1} (9.56 kg per plot) and dinotefuran 30 g ai ha^{-1} (8.95 kg per plot). These treatments were statistically on par. The treatments oxuron 5ml l^{-1} (8.39 kg per plot), *B. bassiana* 20g l^{-1} (8.29 kg per plot), dimethoate 600 g ai ha^{-1} (7.49 kg per plot) and acetamiprid 10 g ai ha^{-1} (7.38 kg per plot) were superior to the control plot with 4.54 kg per plot.

Spiromesifen 96 g ai ha^{-1} gave a B.C. ratio 1.76 as against control which gave 1.15. The next best treatment was thiamethoxam 50 g ai ha^{-1} which gave 1.62. Benefit cost ratio of dinotefuran 30 g ai ha^{-1}, oxuron 5ml l^{-1}, *B. bassiana* 20 g l^{-1}, dimethoate 600 g ai ha^{-1} and acetamiprid 10 g ai ha^{-1} were 1.51, 1.40, 1.40, 1.27 and 1.25 respectively.

4.2.2. Second Crop

Whitefly (*B. tabaci*) was the major sucking pest observed during the second crop. A similar trend in the efficacy of the treatments was noticed after the spraying (Table 12). All the treatments reduced the population of the pest significantly when compared to the untreated check.

Table 11. Yield of brinjal in plots treated with new generation insecticides and biopesticides

Treatments	Number of fruits/ plot	Weight of fruits		B:C ratio
		kg plot^{-1}	t ha^{-1}	
Spiromesifen 22.9 SC @ 96 g ai ha^{-1}	127.67	10.36	25.90	1.76
Thiamethoxam 25 WG @ 50 g ai ha^{-1}	131.67	9.56	23.90	1.62
Acetamiprid 20 SP @10 g ai ha^{-1}	120.33	7.38	18.40	1.25
Dinotefuran 20 SG 30 g ai ha^{-1}	122.00	8.95	22.30	1.51
Oxuron @ 5ml l^{-1}	75.00	8.39	20.90	1.40
Beauveria bassiana 20 g l^{-1}	96.67	8.29	20.70	1.40
Dimethoate (Check) 30 EC@ 600 g ai ha^{-1}	120.67	7.49	18.70	1.27
Control (Untreated check)	72.00	4.54	11.30	1.15
C.D. (0.05)	NS	1.859	-	-

4.2.2.1. Effect New Generation Insecticides And Biopesticides on Population of Bemisia tabaci

Third day after treatment application, lowest population of the pest was recorded in the plot sprayed with thiamethoxam 50 g ai ha^{-1} (17.49 pests per plant). It was followed by spiromesifen 96 g ai ha^{-1} (18.71 pests per plant), dinotefuran 30 g ai ha^{-1} (19.88 pests per plant) and acetamiprid 10 g ai ha^{-1} (21.94 pests per plant).. These treatments were on par with thiamethoxam 50 g ai ha^{-1} . Oxuron 5ml l^{-1} too reduced the pest population (30.69 pests per plant).

On the fifth day after spraying, the lowest number of pest was recorded in spiromesifen 96 g ai ha^{-1} (4.19 pests per plant) treatment which was superior to all other treatments. While thiamethoxam 50 g ai ha^{-1} (12.03 pests per plant) and dinotefuran 30 g ai ha^{-1} (12.99 pests per plant) were statistically on par, dimethoate 600 g ai ha^{-1} (19.98 pests per plant) and *B. bassiana* 20g l^{-1} (22.91 pests per plant) were on par with acetamiprid 10 g ai ha^{-1} (24.40 pests per plant). Number of pests seen in oxuron 5ml l^{-1} treated plot was 26.77 per plant as against 33.46 pests per plant in the control plot.

Compared to the control plot (45.65 pests per plant), reduction in the number of pests was seen in all the treated plots on the seventh day after treatment. Significantly lower number of pests was seen in spiromesifen 96 g ai ha^{-1} sprayed plots (1.37 pests per plant). The number of pests seen in thiamethoxam 50 g ai ha^{-1} and dinotefuran 30 g ai ha^{-1} treated plots were 4.24 and 4.38 pests per plant respectively and the treatments were on par. Dimethoate 600 g ai ha^{-1} (7.64 pests per plant) and acetamiprid 10 g ai ha^{-1} (12.54 pests per plant) too recorded lower populations while *B. bassiana* 20 g l^{-1} (24.70 pests per plant) and oxuron 5ml l^{-1} (28.16 pests per plant) were on par.

Table 12. Population of *Bemisia tabaci* in plots treated with new generation insecticides and biopesticides. (Second crop)

Treatments	Number / plant				
	3rd DAS	5th DAS	7th DAS	9th DAS	15th DAS
Spiromesifen 22.9 SC @ 96 g ai ha^{-1}	18.71 (4.44)	4.19 (2.28)	1.37 (1.54)	2.09 (1.76)	0.28 (1.13)
Thiamethoxam 25 WG @ 50 g ai ha^{-1}	17.49 (4.30)	12.03 (3.61)	4.24 (2.29)	5.40 (2.53)	0.80 (1.34)
Acetamiprid 20 SP @ 10 g ai ha^{-1}	21.94 (4.79)	24.40 (5.04)	12.54 (3.68)	12.91 (3.73)	4.34 (2.31)
Dinotefuran 20 SG @ 30 g ai ha^{-1}	19.88 (4.57)	12.99 (3.74)	4.38 (2.32)	1.22 (1.49)	0.59 (1.26)
Oxuron @ 5 ml l^{-1}	30.69 (5.63)	26.77 (5.27)	28.16 (5.40)	29.14 (5.49)	21.3 (4.72)
Beauveria bassiana @ 20 g l^{-1}	38.81 (6.31)	22.91 (4.89)	24.7 (5.07)	25.94 (5.19)	21.60 (4.75)
Dimethoate (Check) 30 EC@ g ai ha^{-1}	20.34 (4.62)	19.98 (4.58)	7.64 (2.94)	2.46 (1.86)	7.47 (2.91)
Control (Untreated check)	42.56 (6.60)	33.46 (5.87)	45.65 (6.83)	46.61 (6.90)	43.40 (6.66)
C.D. (0.05)	(0.348)	(0.596)	(0.385)	(0.639)	(0.709)

Values given in parenthesis are angular transformed value.

Ninth day after spraying, dinotefuran 30 g ai ha^{-1} (1.22 pests per plant) recorded lower number of pests and it was on par with spiromesifen 96 g ai ha^{-1} (2.09 pests per plant) and dimethoate 600 g ai ha^{-1} (2.46 pests per plant). The population of the pest was substantially low in the plots sprayed with thiamethoxam 50 g ai ha^{-1} (5.40 pests per plant) and acetamiprid 10 g ai ha^{-1} (12.91 pests per plant). *B. bassiana* 20g l^{-1} too registered lower population of the pest (25.94 pests per plant) and was on par with oxuron 5ml l^{-1} (29.14 pests per plant). All the treatments reduced the population of the whitefly significantly when compared to the control plot (46.61 pests per plot).

On the fifteenth day too significantly lower number of pests was seen in spiromesifen 96 g ai ha^{-1} (0.28 pests per plant). It was on par with dinotefuran 30 g ai ha^{-1} (0.59 pests per plant) and thiamethoxam 50 g ai ha^{-1} (0.80 pests per plant). Acetamiprid 10 g ai ha^{-1} (4.34 pests per plant) was on par with dimethoate 600 g ai ha^{-1} (7.47 pests per plant). Oxuron 5ml l^{-1} (21.30 pests per plant) and *B. bassiana* 20g l^{-1} (21.60 pests per plant) were on par in their efficacy and differed significantly from the control plot (43.40 pests per plot).

4.2.2.2. Effect of New Generation Insecticides And Biopesticides on Damage

All the treatments showed lower infestation than the control plot (Table 13).

Spiromesifen 96 g ai ha^{-1} treated plot showed least damage (40.19 per cent infestation) after the treatment. This was followed by thiamethoxam 50 g ai ha^{-1} with 43.08 per cent infestation. Dinotefuran 30 g ai ha^{-1} with 47.86 per cent infestation was on par with dimethoate 600 g ai ha^{-1} and acetamiprid 10 g ai ha^{-1}, the percentage infestation were 48.83 and 48.84 respectively. Oxuron 5ml l^{-1} gave 51.75 per cent infestation while *B. bassiana* 20 g l^{-1} gave 57.74 per cent infestation which was better than the control plot with 61.14 per cent infestation.

Table 13. Extent of infestation by *Bemisia tabaci* on brinjal treated with new generation insecticides and biopesticides.

Treatments	1 month after spraying
Spiromesifen 22.9 SC @ 96 g ai ha^{-1}	40.19
Thiamethoxam 25 WG @ 50 g ai ha^{-1}	43.08
Acetamiprid 20 SP @ 10 g ai ha^{-1}	48.84
Dinotefuran 20 SG @ 30 g ai ha^{-1}	47.86
Oxuron 5 ml l^{-1}	51.75
Beauveria bassiana 20 g l^{-1}	57.74
Dimethoate (Check) 30 EC @ 600 g ai ha^{-1}	48.83
Control (Untreated check)	61.14
C.D. (0.05)	2.858

4.2.2.3. Effect on Plant Characters

Plant characters recorded at monthly intervals were statistically analysed and given in Tables 14.

4.2.2.3.1. Plant Height

The data on height of the plant recorded one month after spraying revealed that the different treatments did not cause significant variation in plant height. The height of the plant ranged from 66 cm to 80 cm.

4.2.2.3.2. Number of Branches

The perusal of the data revealed that there was no significant variation in the number of branches due to different treatments imposed when recorded one month after spraying.

4.2.2.3.3. Number of Leaves

After spraying none of the treatments proved to be significantly different. The number of leaves produced ranges from 104 to 116.

4.2.2.4. Yield

Effect of different treatments on number and weight of fruits are given in Table 15.

Dinotefuran 30 g ai ha^{-1} recorded highest number of fruits (112.33 fruits per plot) and it was on par with spiromesifen 96 g ai ha^{-1} (110.33 fruits per plot) and thiamethoxam 50 g ai ha^{-1} (108.33 fruits per plot). This was followed by acetamiprid 10 g ai ha^{-1} (82.67 fruits per plot) and was on par with dimethoate 600 g ai ha^{-1} (82.00 fruits per plot) and oxuron 5ml l^{-1} (75.67 fruits per plot).

Spiromesifen 96 g ai ha^{-1} gave highest yield of 10.95 kg per plot. It was on par in its efficacy with thiamethoxam 50 g ai ha^{-1} with 9.42kg per plot. All

Table 14 Biometric characters of brinjal plants treated with new generation insecticides and biopesticides against *Bemisia tabaci.*

Treatments	One month after spraying		
	Plant height (cm)	Number of branches	Number of leaves
Spiromesifen 22.9 SC @ 96 g ai ha^{-1}	71.60	3.00	116.40
Thiamethoxam 25 WG @ 50 g ai ha^{-1}	80.33	3.13	109.47
Acetamiprid 20 SP @ 10 g ai ha^{-1}	75.00	3.33	114.00
Dinotefuran 20 SG @ 30 g ai ha^{-1}	78.33	3.00	114.40
Oxuron @ 5 ml l^{-1}	73.53	2.80	108.13
Beauveria bassiana @ 20 g l^{-1}	77.73	2.60	104.27
Dimethoate (Check) 30 EC @ 600 g ai ha^{-1}	71.27	2.93	112.67
Control (Untreated check)	66.33	2.86	107.13
C.D.(0.05)	NS	NS	NS

other treatments recorded better yield than the control plot having an yield of 4.47 kg per plot. The treatment follows the order dinotefuran 30 g ai ha^{-1} (8.27 kg per plot), acetamiprid 10 g ai ha^{-1} (7.81 kg per plot), dimethoate 600 g ai ha^{-1} (7.61 kg per plot), *B. bassiana* 20g l^{-1} (6.71 kg per plot) and oxuron 5ml l^{-1} (6.65 kg per plot).

Spiromesifen 96 g ai ha^{-1} gave a B C ratio of 1.86 against control which gave 1.59. Thiamethoxam 50 g ai ha^{-1} and dinotefuran 30 g ai ha^{-1} gave 1.59 and 1.40. Benefit cost ratio of acetamiprid 10 g ai ha^{-1}, dimethoate 600 g ai ha^{-1}, *B. bassiana* 20g l^{-1} and oxuron 5ml l^{-1} were 1.32, 1.29, 1.14 and 1.12 respectively.

Table 15. Yield of brinjal in plots treated with new generation insecticides and biopesticides.

Treatments	Number of fruits ($plot^{-1}$)	Weight of fruits		B:C ratio
		kg $plot^{-1}$	t ha^{-1}	
Spiromesifen 22.9 SC @ 96 g ai ha^{-1}	110.33	10.95	27.37	1.86
Thiamethoxam 25 WG @ 50 g ai ha^{-1}	108.33	9.42	23.55	1.59
Acetamiprid 20 SP @ 10 g ai ha^{-1}	82.67	7.81	19.52	1.32
Dinotefuran 20 SG @ 30 g ai ha^{-1}	112.33	8.27	20.67	1.40
Oxuron @ 5 ml l^{-1}	75.67	6.65	16.62	1.12
Beauveria bassiana @ 20 g l^{-1}	46.67	6.71	16.77	1.14
Dimethoate 30 EC (Check) @ 600 g ai ha^{-1}	82.00	7.61	19.02	1.29
Control (Untreated check)	41.67	4.47	11.17	1.13
C.D. (0.05)	22.905	1.630	-	

Discussion

5. DISCUSSION

Brinjal, *Solanum melongena* L. is grown throughout the country and is described as poor man's vegetable since it is popular among the small scale farmers and low income consumers. Though a summer crop, it is being grown throughout the year under irrigated conditions. It is subjected to attack by a number of insect pests from the nursery stage till harvesting (Reghupathy *et al.*, 1997). Apart from the shoot and fruit borer, sucking pests such as aphid (*Aphis gossypii* Glover), leaf hopper (*Amrasca biguttula biguttula* Ishida), whitefly (*Bemisia tabaci* Gennadius), mealy bug (*Coccidohystrix insolita* Green) and lace wing bug (*Urentius hystricellus* Richt.) have assumed the status of serious pests in brinjal (Swaminathan *et al.*, 2010). Besides causing direct damage by sucking the cell sap and prohibiting the normal crop growth, they also act as vectors for virus diseases. In view of shorter interval in the picking of brinjal fruits, there are always chances of toxic residues in fruits if insecticides are used for pest management. Cost effective crop production requires combination of optimum use of chemicals and non-chemical techniques of pest management. The present study aims to evaluate the efficiency of newer insecticides, biopesticides and bioagents for the management of sucking pests infesting brinjal.

The present research work was aimed to document the incidence of sucking pests of brinjal grown in homesteads and to evolve a suitable management strategy using newer and safer insecticides and biopesticides. The results of the experiment are discussed hereunder.

5.1. PEST INCIDENCE

Survey conducted in 60 homesteads distributed in four panchayaths of Thiruvananthapuram district revealed the predominance of sucking pests in the homesteads.

The sucking pests observed infesting brinjal raised in the homesteads of Thiruvananthapuram district were the leafhopper (*A. biguttula biguttula),* aphid (*A. gossypii),* whitefly (*B. tabaci*), spiralling whitefly (*A. dyspersus),* lace wing bug (*U. hystricellus*), mealy bug (*C. insolita*) and mites (*Tetranychus* sp.). The shoot and fruit borer, the leaf feeders *viz.*, epilachna beetle, leaf folder, leaf webber, leaf miner, leaf caterpillar and hairy caterpillar were also observed attacking brinjal in the homesteads. The predominance of *A. gossypii*, *A. biguttula biguttula*, *H. viginctioctopunctata* and shoot and fruit borer *L.* ' *orbonalis* in brinjal were reported by Reghunath *et al.*, (1989). Sudhakar *et al.*, (1998) observed that brinjal suffered mainly from the attack of the shoot and fruit borer, whitefly and jassids. Bernice (2000) found that sucking pest (aphid), leaf feeder (epilachna beetle) and shoot and fruit borer were the dominant pests of brinjal in Thiruvananthapuram district of Kerala.

The predator, *Spalgis* sp. and the pathogen *Fusarium* sp. were the natural enemies recorded from the mealy bug. The lycaenid butterfly was seen predating on the larval stages of the mealy bug. The entomopathogen was isolated from the mealy bug. The infection of *Fusarium* sp. on the brinjal mealy bug *C. insolita* was reported earlier by Gopinathan *et al.*(1982). He observed 100 per cent mortality of the pest consequent to infection by the fungus.

The sucking pests were observed in all the locations surveyed. The shoot and fruit borer was seen in 42.5 per cent locations in garden land and 62.5 per cent locations in terrace. Leaf feeders were seen in 62.5 per cent locations in garden land and 83.5 locations in terrace (Fig. 1). The study clearly indicated the predominance of the sucking pests in the homesteads of Thiruvananthapuram district. The results of the study was in conformity with the findings of Suresh *et al.* (2007) who had observed that the sucking pests of major importance in brinjal were whitefly, jassid and aphid.

The sucking pests predominantly seen in the homesteads of Thiruvananthapuram districts were the leaf hopper, aphid, whitefly and mealy bug. Leaf hoppers were seen in all the locations surveyed in garden land and terrace. Aphids were recorded from 85 per cent locations in garden land and 95 per cent locations in terrace. Whitefly was present in 80 per cent locations in

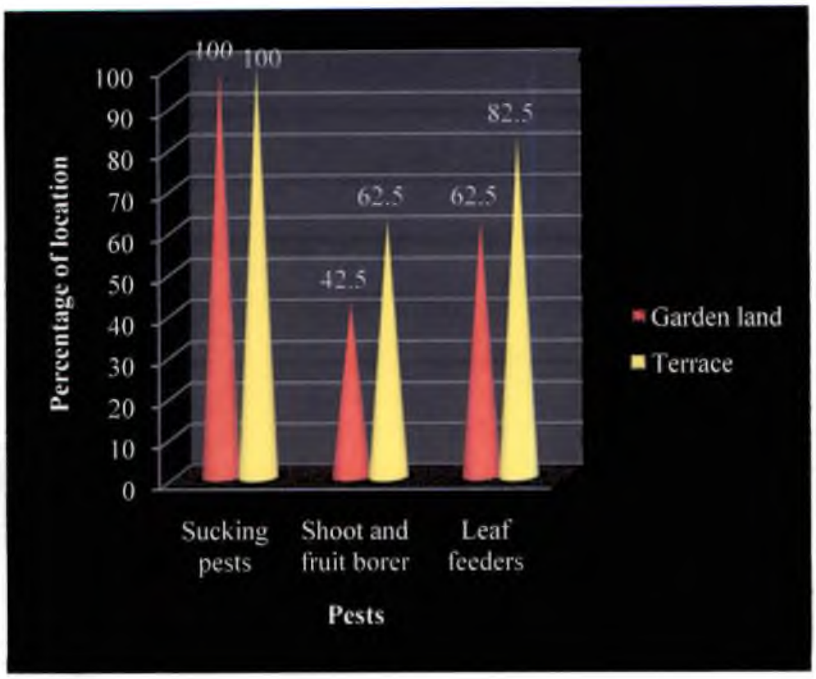


Fig.1. Incidence of pests in homesteads of Thiruvananthapuram district

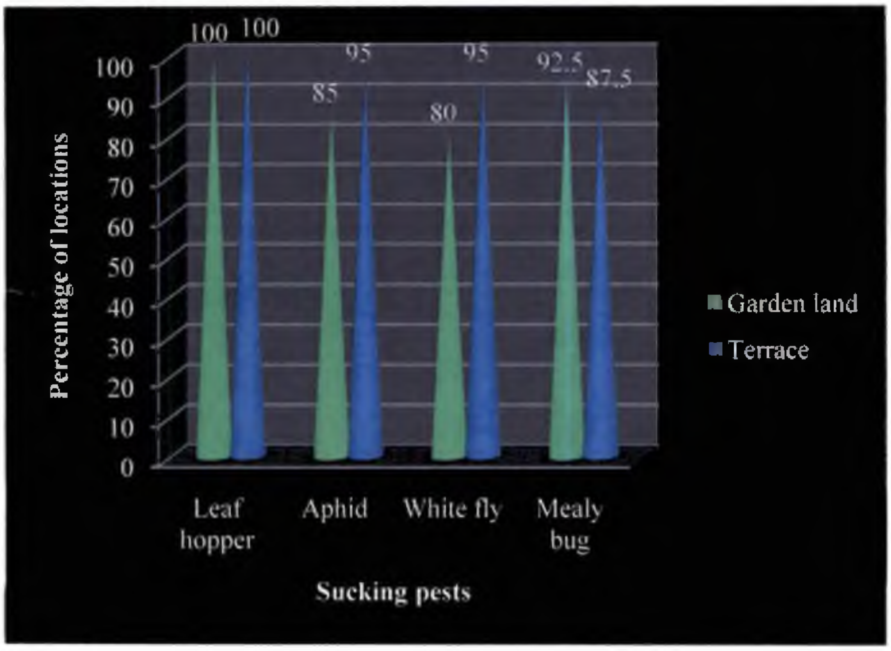


Fig. 2. Incidence of major sucking pests in homesteads of Thiruvananthapuram district

garden land and 95 per cent locations on terrace. Mealy bugs were seen in 92.5 per cent locations in garden land and 87.5 per cent locations in terrace (Fig. 2). The results are in conformity with the study conducted by Latif *et al.* (2009). They reported that the arthropod biodiversity in the brinjal field showed that jassid and whitefly were the most common and major insect pests of brinjal crop.

In garden land and terrace, leaf hoppers were the predominant sucking pests with a mean population of 10.94 and 10.02 per five leaves respectively. In terrace, whiteflies were seen in higher number after leafhopper (9.52). This was followed by aphids (9.48) and mealy bugs (8.34). In garden land, mealy bugs were in second position in population (8.13). This was followed by aphids (7.82) and whiteflies (7.66) (Fig.3). The perusal of the data showed that leaf hoppers were the predominant sucking pests in brinjal and it was observed earlier by Malini *et al.* (2013). They reported that during summer season, cultivation of brinjal is limited in Kerala due to severe incidence of sucking insects especially jassids or leaf hoppers which affect the yield considerably. Jassids caused debilitatory effects even at early stage of crop growth. In addition, it disrupts transportation in conducting vessels and apparently introduces a toxin that impairs photosynthesis in proportion to the amount of feeding. They reported leaf hopper as a very serious pest of brinjal. Kataria and Kumar (2012) reported that the sap sucking pests like aphids, whiteflies and mealy bugs as serious pest in India. Bisane *et al.* (2010) reported that in brinjal, mealy bug incidence was to the extent of 3.8 and 9 mealy bugs/5 cm twig, respectively.

5.2. MANAGEMENT

New generation insecticides and biopesticides were evaluated in the field for determining their efficacy against the sucking pests of brinjal. During the first crop leaf hopper was the major sucking pest observed.

After the first spray least population was recorded from the spiromesifen 96 g ai ha^{-1} treated plot (1.16 pests per plant). Thiamethoxam 50 g ai ha^{-1} treated

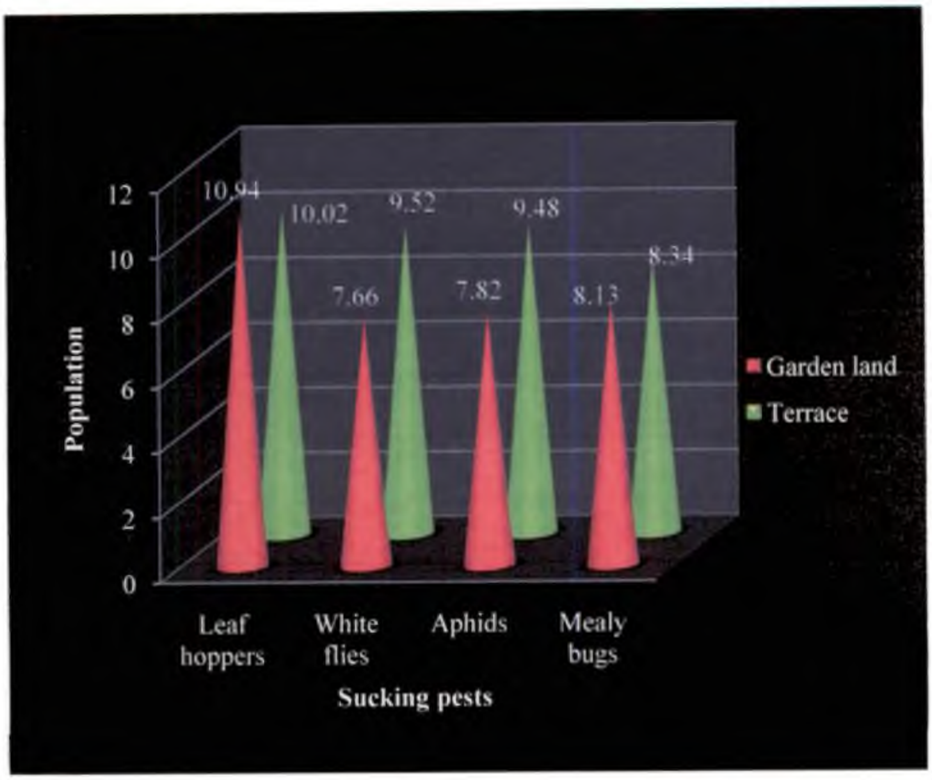


Fig. 3. Population mean of sucking pests of brinjal in homesteads of Thiruvananthapuram district

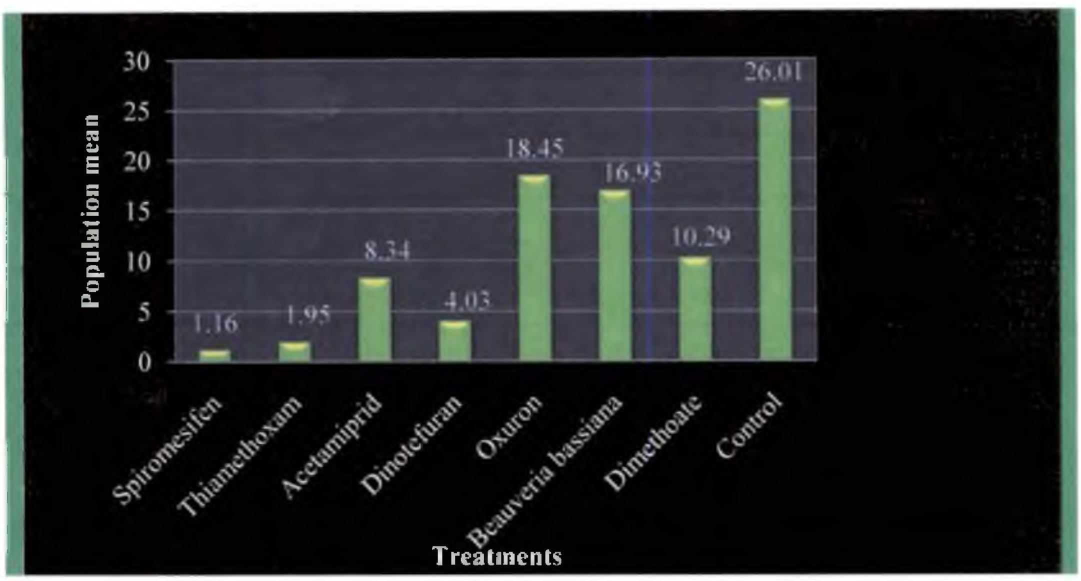


Fig.4. Population mean of *Amrasca biguttula biguttula* in plots treated with new generation insecticides and biopesticides (After first spray)

plot recorded 1.95 pests per plant against 26.01 pests per plant in control plot. There was a sudden reduction in the hopper population after fifth day of spraying in plots treated with *B. bassiana* (Table 4) may be due to the non-persistence of the pathogen coupled with the further entry of hoppers from adjacent plots. (Fig.4).

Population mean of *A.biguttula biguttula* after second spray also showed that spiromesifen 96 g ai ha^{-1} and thiamethoxam 50 g ai ha^{-1} were the best treatment with a population of 0.23 pests per plant (Fig. 5). Percentage reduction of *A. biguttula biguttula* over control revealed that spiromesifen 96 g ai ha^{-1} gave maximum percentage reduction of 94.91 whereas thiamethoxam 50 g ai ha^{-1}shows 94.02 percentage reduction (Fig. 6).

Krishnakumar *et al.*,(2001) reported that thiamethoxam 25WG @ 0.4 g l^{-1} gave significantly superior control of leaf hopper. Studies conducted by Sharma and Lal (2002) showed that thiamethoxam was superior to other treatments against the leaf hopper. Mhaske and Mot (2005) reported that thiamethoxam 25 and 50WG was effective against leaf hopper on brinjal. According to Naik *et al.* (2009) thiamethoxam showed high efficacy against leaf hopper. Nath and Sinha (2010) reported both thiamethoxam and acetamiprid were effective against leaf hopper. Acetamiprid was intermediate in its response to the jassids-mortality with significant difference from all the other treatments. Thiamethoxam resulted in a maximum mortality of the pest, followed by acetamiprid (Iqbal *et al.* 2013).

In the second crop whitefly (*B. tabaci*) was the major pest observed. Observation on the mean population of *B. tabaci* revealed that spiromesifen 96 g ai ha^{-1} treated plot recorded least population mean of 5.33 per plant followed by thiamethoxam 50 g ai ha^{-1} (7.99 per plant) (Fig.7). Spiromesifen 96 g ai ha^{-1} showed 87.40 percentage reduction and thiamethoxam 50 g ai ha^{-1} gave 81.12 percentage reduction reduction (Fig. 8).

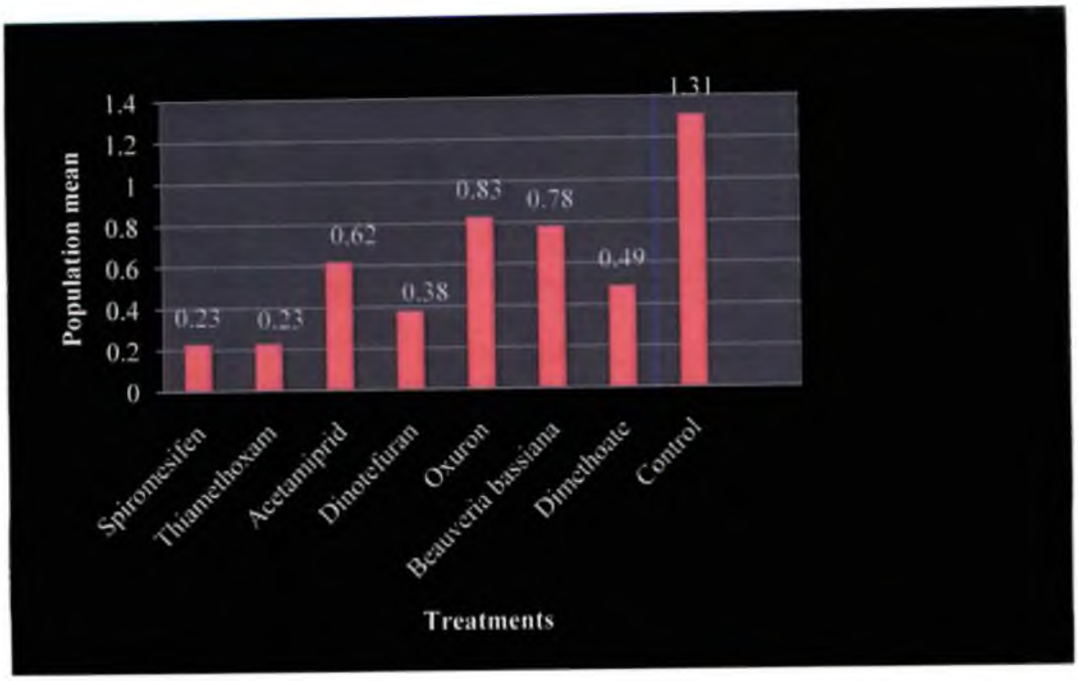


Fig. 5. Population mean of *Amrasca biguttula biguttula* in plots treated with new generation insecticides and biopesticides (After second spray)

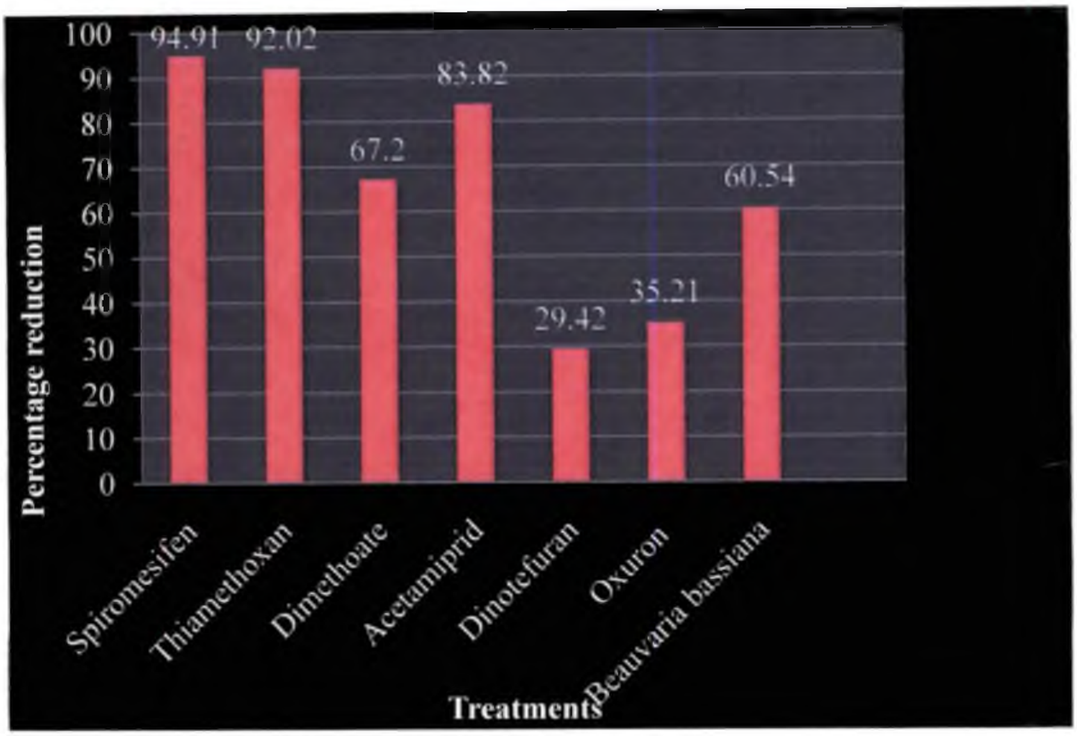


Fig. 6. Percentage reduction of *Amrasca biguttula biguttula* over control

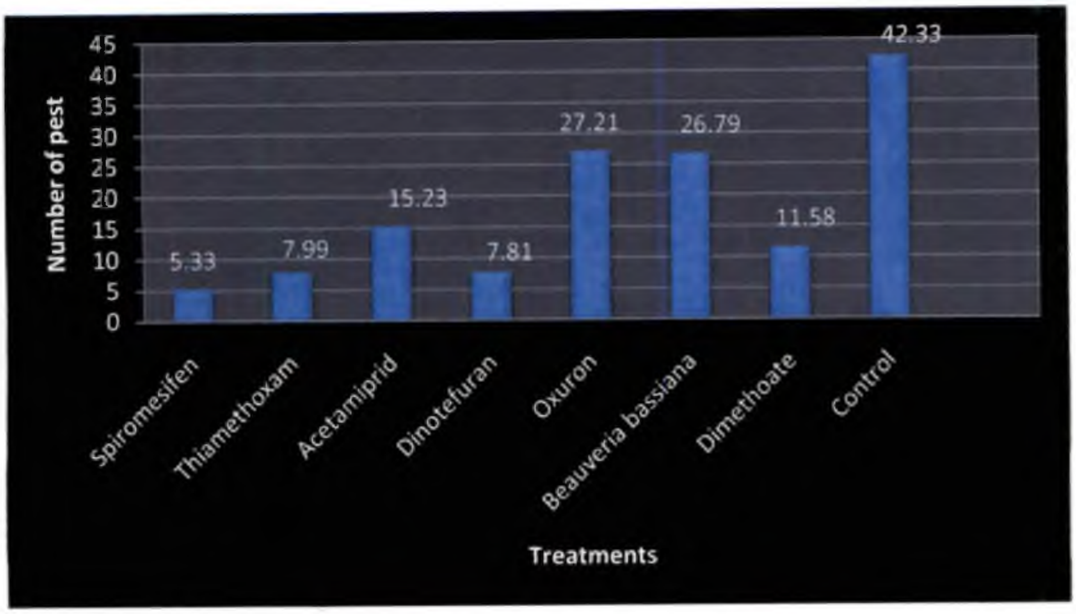


Fig. 7. Population mean of *Bemisia tabaci* in plots treated with new generation insecticides and biopesticides (Second crop)

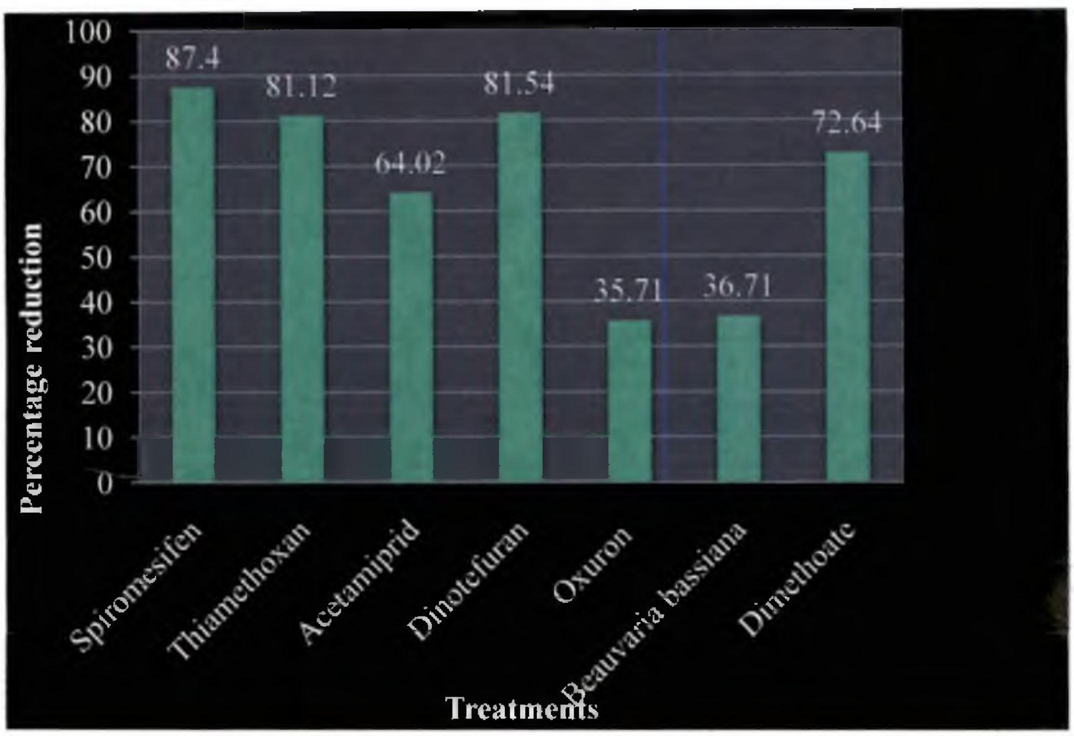


Fig.8. Percentage reduction of *Bemisia tabaci* over control after spraying

Thiamethoxam has been reported to be effective against whitefly in brinjal. Foliar sprays of Thiamethoxam 25 WG @ 0.025% recorded 67.55 per cent mean reduction of whitefly population in brinjal (Balaji, 2002). Studies conducted by Sharma and Lal (2002) showed that after one day of first spray of thiamethoxam 25 WG, the whitefly population was reduced by 94.06% in brinjal. Naik *et al.* (2009) found that thiamethoxam shows high efficacy against whiteflies. Nath and Sinha (2010) reported that neonicotinoids like thimethoxam and acetamiprid were effective against whitefly.

Efficiency of spiromesifen against whitefly has been reported earlier. Spiromesifen was superior in reducing the whitefly egg and immature stages and effective against pyriproxyfen-resistant whiteflies and no cross resistance to any important insecticide found (Nauen *et al.*, 2002). It can be used as a new and valuable tool in whitefly resistance management when combined with neonicotinoid (thiamethoxam and acetamiprid) insecticides. Because *B. tabaci* has developed resistance to organophosphates, pyrethroids, some insect growth regulators and some neonicotinoid insecticides, the unique mode of action of spiromesifen played an important role in resistance management programmes (Kontsedalov *et al.*,2008). Spiromesifen can be effective foliar alternatives to the neonicotinoid insecticides currently used for controlling whiteflies (Palumbo, 2009).

AL-Kherb (2011) reported the efficiency of thiamethoxam in cucumber and tomato. It caused reduction in whitefly adult and immature stage populations by 87.5 and 82.4% after three sprays, respectively.

The results of the study thus indicated that the leaf hopper ***A. biguttula biguttula*** and whiteflies *B.tabaci* were the predominant sucking pests infesting brinjal. The new generation insecticides *viz.*, spiromesifen 96 g ai ha^{-1} and thiamethoxam 50 g ai ha^{-1} can be used as alternatives to the highly toxic conventional insecticides against the leaf hopper and whitefly.

Summary

6. SUMMARY

Brinjal (*Solanum melongena* L.) is one of the most important vegetable crops of India. The main factor that limits cultivation of brinjal is the occurrence of pests and diseases. Sucking pests, leaf feeders and borers infest the crop at different phases of its growth. At least two to three sprayings are required against these pests. The indiscriminate use of insecticides may result in the development of resistance in insects to insecticides and resurgence of sucking pests. The present investigation was undertaken to document the incidence of sucking pests of brinjal grown in homesteads of Thiruvananthapuram district and to evolve a suitable management strategy using newer and safer insecticides and biopesticides. The salient findings of the investigations on the management of sucking pests of brinjal are summarized below:

Survey conducted in 60 homesteads of vegetable growing tracts of Thiruvananthapuram district revealed the incidence of seven sucking pests namely leaf hopper *Amrasca biguttula biguttula* (Ishida), aphid *Aphis gossypii* Glover, whitefly *Bemisia tabaci* Gennadius, spiralling whitefly *Aleurodicus dispersus*, brinjal mealy bug *Coccidohystrix insolita* Green, lace wing bug *Urentius hystricellus* (Richt) and mite *Tetranychus* sp. on brinjal grown in garden land and terrace.

The occurrence of the pests was observed in garden land and terraces during the vegetative and flowering stages. Among the pests, the leaf hopper, aphid, whiteflies and mealy bug were seen both during the vegetative and flowering stages of the vegetable grown in garden land as well as terrace.

Among the sucking pests recorded, leaf hopper, aphid, whiteflies and mealy bug which occurred in high densities (>50 pests per 5 leaves) were the major ones infesting brinjal. The incidence of lace wing bug was moderate (25-50 pests per 5 leaves). The spiralling whitefly and mite occurred in low densities (<25 pests per 5 leaves).

The shoot and fruit borer, *Leucinodes orbonalis* Guen (Lepidoptera: Pyralidae), epilachna beetle *Henosepilachna viginctioctopunctata* (F.) (Coleoptera: Coccinellidae), leaf folder *Antoba olevaceae* Wlk. (Lepidoptera: Noctuidae), leaf eating caterpillar *Spodoptera litura* (F.) (Lepidoptera: Noctuidae), hairy caterpillar *Spilosoma obliqua* (Walker) (Lepidoptera : Noctuidae), leaf webber *Psara bipunctalis* F. (Lepidoptera : Pyralidae) and an unidentified leaf miner were also observed during the survey.

Sucking pests were the dominant group in the homesteads of Thiruvananthapuram district. Leaf hoppers were seen in all the locations surveyed in garden land and terrace, while aphids were recorded from 85 per cent locations in garden land and 95 per cent locations in terrace. Whitefly was present in 80 and 95 per cent locations in garden land and terrace respectively. Mealy bugs were seen in 92.5 per cent locations in garden land and 87.5 per cent locations in terrace.

In garden land and terrace, leaf hoppers were the predominant sucking pests with a mean population of 10.94 and 10.02 per five leaves respectively. On the terrace, whiteflies were seen in higher number after leafhopper (9.52). This was followed by aphids (9.48) and mealy bugs (8.34). In garden land, mealy bugs were in second position in population (8.13). This was followed by aphids (7.82) and whiteflies (7.66).

The infestation of the leaf hopper was recorded from all the locations surveyed. Aphid, whitefly (*B. tabacii)* and mealy bug were present in 90.00, 87.50 and 90.00 per cent homesteads, respectively. The damage caused by the pests ranged from 35.35 to 58.88 (leaf hopper), 30.11 to 40.24 (*B. tabacii*), 34.46 to 50.50 (aphid) and 34.16 to 49.28 (mealy bug) per cent. A predator *viz*., *Spalgis epius* (Westwood) and a pathogen *Fusarium* sp. were isolated from the mealy bug, *C. insolita.*

The two field trials conducted to evaluate the efficacy of the new generation insecticides *viz*., spiromesifen 96 g ai ha^{-1}, thiamethoxam 50 g ai ha^{-1}, acetamiprid

10 g ai ha^{-1}, dinotefuran 30 g ai ha^{-1}, dimethoate 600 g ai ha^{-1} and biopesticides *viz.*, oxuron 5 ml l^{-1} and *Beauveria bassiana* 20 g l^{-1} revealed that the new generation insecticides reduced the population of sucking pests significantly.

During the first crop, leaf hopper was the major sucking pest observed. After the first spray least population of *A.biguttula biguttula* was recorded from the spiromesifen 96 g ai ha^{-1} treated plot (1.16 pests per plant). Thiamethoxam 50 g ai ha^{-1} treated plot recorded 1.95 pests per plant as against 26.01 pests per plant in control plot. Population of *A.biguttula biguttula* after second spray showed that spiromesifen 96 g ai ha^{-1} and thiamethoxam 50 g ai ha^{-1} treated plot recorded 0.23 pests per plant whereas 1.31pests per plant was observerd in control plot. Percentage reduction of *A. biguttula biguttula* after first spray showed that spiromesifen 96 g ai ha^{-1} gave maximum percentage reduction of 94.91 whereas thiamethoxam 50 g ai ha^{-1} gave 92.02 percentage reduction.

During the second crop *B. tabaci* was the major pest observed. Spiromesifen 96 g ai ha^{-1} treated plot recorded least population of *B. tabaci* (2.23 per plant) followed by thiamethoxam 50 g ai ha^{-1} (2.81 per plant). Maximum reduction of population of *B. tabaci* (87.40 percentage) was shown by spiromesifen 96 g ai ha^{-1}. Dinotefuran 30 g ai ha^{-1} gave 81.54 per cent reduction and thiamethoxam 50 g ai ha^{-1} gave 81.12 per cent reduction. Among the different treatments applied against *Bemisia tabaci*, spiromesifen 96 g ai ha^{-1} and thiamethoxam 50 g ai ha^{-1} were found to be the promising treatments.

The results of the study thus revealed that the leaf hopper *A. biguttula biguttula* , aphid *A. gossypii*, whitefly *B.tabaci* and mealy bug *C. insolita* were the predominant sucking pests infesting brinjal in the homesteads. The new generation insecticides *viz.*, spiromesifen 96 g ai ha^{-1} and thiamethoxam 50 g ai ha^{-1} can be used as alternatives to the highly toxic conventional insecticides against the sucking pests, particularly the leaf hopper and whitefly.

References

7. REFERENCES

Afzal, M., Ahmad, T. and Bashir, M. H.2002. Relative toxicity of different insecticides against whitefly, *Bemisia tabaci* (Genn.) and black thrips, *Caliothrips indicus* on NM-92mungbean, *Vigna radiata* (L.). *Pak. J. Agri. Sci.* 39(3): 224-225.

Ali, H. and Ansari, M.S. 2008. Efficacy of insecticides against *Lipaphis erysimi* on mustard crop. *J. Ent. Res.*32(1): 45-47.

Ali, M., Ashfaq, M., Akram, W., Sahi, S. T. and Ali, A.2012. The physio-morphic characters of the brinjal (*Solanum melongena* L.) plant and their relationship with the jassid (*Amrasca biguttula biguttula* (Ishida)) population fluctuation. *Pakistan J. Agric. Sci.* 49 (1): 67-71.

AL-Kherb,W.A. 2011. Field efficacy of some neonicotinoid insecticides on whitefly *Bemisia tabaci* (Homoptera: Aleyrodidae) and its natural enemies in cucumber and tomato Plants in Al-qassim Region, KSA. *J. Entomol*. 8(5): 429-439.

Ananthakrishnan, T.N. 1992. *Dimensions of Insect Plan Interactions*. Oxford and IBH Publishing Co. Ltd., New Delhi. 184p.

Anjali, M.,Singh, N.P. , Mahesh, M. and Swaroop,S.2012. Seasonal incidence and effect of abiotic factors on population dynamics of major insect pests on brinjal crop. *J. Environ. Res. Develop.*7(1A): 431-435.

Aslam, M., Razaq, M., Shah, S. A. and Ahmad, F. 2004. Comparative efficacy of different insecticides against sucking pests of cotton. *J. Res. Sci.* 15: 53-58.

Ayyar, T.V.R. 1929. Notes on some Indian Lepidoptera with abnormal habits. *J. Bombay Nat. History Soc.* 33: 668-675.

Balaji, K. 2002. Efficacy of some new insecticides against pest complex of brinjal (*Solanum melongena* Linn.) M.Sc. (Ag.) Thesis Acharya N. G. Ranga Agric. Univ, Hyderabad.

Behura, B.K. 1963. Aphids of India. Proceedings of the First Seminar School of Zoology, Shimla, India 1961: 25-78

Ben-Dov Y (2013) ScaleNet. *Coccidohystrix insolita*. Accessed 16 December 2013.URL: http://www.sel.barc.usda.gov/catalogs/Pseudoco/ Coccidohystrixinsolita.htm#Coccidohystrixinsolita

Bernice, A. T. S. 2000. Ecofriendly pest management in brinjal (*Solanum melongena*) MSc. thesis. Kerala Agricultural University. Thrissur, 86p.

Bhargava, K.K., Bhatnagar, A. and Sharma, H.C. 2003. Bio-efficacy of imidacloprid and betacyfluthrin for the management of insect pests of brinjal. *Indian J. Pl. Prot.* 21(2): 111-113.

Bisane,K.D.,Khande,D.M. and Aherkar,S.K.2010.Occurence of mealybugs in Vidarbha region of Maharashtra. *Indian. J. Entomol.* 72(3):202-204.

Blackman R.I., Eastop V.F. (1985): Aphids on the World's Crop: An Identification Guide. John Wiley and Sons. London.

Blackman, R.I. and Eastop, V.F. 2000. Aphids on the World's Crops: an Identification and Information Guide. 2nd ed. Wiley, London, United Kingdom, 476 pp.

Bright, A. 1990. Bioefficacy of nimbecidine 0.03 per cent EC and TNAU Neem 0.03 per cent EC in comparison with chemical insecticides. M.Sc. (Ag.) thesis, Tamil Nadu Agricultural University, Coimbatore.

Chaudhuri, S. 1976. *Metarhizium anisopliae* (Metch) Sorokin on brinjal mealy bug and its use in biological control of the pest. *Curr. Sci.* 45:34

Chaudhury, N., Deb, D.C. and Senapati, S.K. 2001. Assessment of loss in yield caused by pest complex of tomato under tarai region of West Bengal. *Research on Crops.* 2:71-79.

Coudriet, D.L., Prabhakar, N. and Meyerdrik, D. E. 1985. Sweet potato whitefly (Homoptera:Aleyrodidae) effects of neem seed extract on oviposition and immature stages. *Environ. Entomol.* 14: 776-779

Das, G. and Islam, T. 2014. Relative efficacy of some newer insecticides on the mortality of jassid and whitefly in brinjal. *Int. J. Res. Biol. Sci.* 4(3): 89-93

Deole, S. 2008. Screening of brinjal cultivars against jassid, *Amrasca biguttula biguttula* based on the leaf texture of the plant. *J. Applied Zoological Res.*19 (2): 139-140.

Dhanalakshmi, D. N. and Mallapur, C.P. 2008. Evaluation of promising molecules against sucking pests of okra. *Ann. Plant Prot. Sci.* 16(1): 29-32.

Dhawan, A.K., Sidhu, A. S. and Simwat, G. S. 1988. Assessment of avoidable loss in cotton (*Gossypium hirsutum* and *Gossypium arboreum*) due to sucking pests and bollworms. *Indian. J. Agric. Sci.* 58 : 290-299.

Esguerra, N.M. 1987. The spiralling whitefly *Aleyrodicus dispersus* Russell. *Entmol. Bull.* 1:1.

FAOSTAT. 2011. FAOSTAT On-line. Rome: United Nations Food and Agriculture Organization. http://faostat.fao.org/default.aspx.

Fletcher, T.B. 1914. Some south Indian insects and other animals of importance. Madras, India: Superintendent Government Press. 565 pp.

Frempong, E. and Buahin G.K.A. 1977. Studies on the insect pests of eggplant *Solanum melongena* L. in Ghana. *Bulletin de-1 Institut Fondamental d'Afrique Norie-Serie* . 39:627-641.

Gerling,D., Alomar, O. and Arno, J. 2001. Biologiacal control of *Bemisia tabaci* using predators and parasitoids. *Crop Prot.* 20: 779-799.

Gissella, M. Vasquez D., Orr B. and Baker, J.R. 2006. Efficiency assessment of *Aphidius colemani* (Hymenoptera: Braconidae) for suppression of *Aphis gossypii* (Homoptera: Aphididae) in greenhouse grown chrysanthemum. *J. Eco. Entomol.* 99 (4): 1104–1111.

Gopinathan, P.B.,Beevi, N.S. and Nair, M.R.G.K. 1982. Occurence of *Fusarium equisetti* (corda) Sacci as a fungal pathogen of brinjal mealy bug *Coccidohystrix insolita* (Green). *Entomon* 7:120.

Greathead, A.H. 1986 Host plants. In: Cock, (ed.), *Bemisia tabaci*, A Literature Survey on the Cotton Whitefly with an Annotated Bibliography, pp: 17–26. CAB International UK.

Gupta, M.P. and Rai, H.S. 2006. Integrated management of mustard aphid, *Lipaphis erysimi* Kalt. *Ann. Pl. Protec. Sci.*14: 76-79.

Hall, R.A. and Burges, H.D. 1979. Control of glasshouse aphdis with the fungus *Verticillium lecanii*. *Ann. Appl. Biol.* 93: 236-246.

Harish, D.K., Agasimani, A.K., Imamsaheb, S.J., Satish, P.S. 2011. Growth and yield parameters in brinjal as influenced by organic nutrient management and plant protection conditions. *Res. J. Agric. Sci.* 2(2): 221-225.

Horowitz, A.R., Mendelson, Z., Weintraub, P.G. and Ishaaya, I. 1998. Comparative toxicity of foliar and systemic applications of acetamiprid and imidacloprid against the cotton whitefly, *Bemisia tabaci* (Hemiptera:Aleyrodidae). *Bull. Entomol. Res.* 88(4): 437-442.

Iqbal,J., Hasan,M., Ashfaq,M.,Sah,S.T.and Ali,A.2008. Screening of okra genotypes against jassid, *Amrasca biguttula biguttula* (Ishida) (Homoptera: Cicadellidae). *Pak. J. Agri. Sci.* 45(4):448-451.

Iqbal,J., Nadeem,M., Assi,M.S., Fiaz,M.M. and Hassan,M.W.U. 2013. Comparative efficacy of some insecticides against sucking insect pests on mungbean, *Vigna radiata* (L.). *Journal of Research.* 29(1):31-37.

Jaichakravarthy, G. 2002. Bioefficacy of fungal bioagent *Verticillium lecanii* (Zimm) against some sucking pests. M.Sc. (Ag) thesis, Mahatma Phlue Krishi Vidhyapeeth, Rahuri, 97p.

Jamwal, R. and Kandoria, J. L. 1990. Appearance and build up of *Aphis gossypii* Glover on chilli, brinjal and okra in Punjab. *J. Aphidology* 4: 49-52.

Janaki,I., Suresh,S. and Karuppuchamy, P.2012. Efficacy and economics of biopesticides for the management of papaya mealybug, Paracoccus marginatus (Williams and Granara de Willink) in brinjal (Solanum melongena L.). *J Biopest.* 5(1): 87-90

Jarande, N.T. and Dethe, M.D. 1994. Effective control of brinjal sucking pests by imidacloprid. *Pl. Prot.Bull.*46(2-3): 43-44.

Jepson,M.1924. Pests of brinjal. Report of Director, Agriculture, Ceylon. pp132-147.

Jeschke,P. and Nauen, R. 2008. Neonicotinoids-from zero to hero in insecticide chemistry. *Pest. Manage. Sci.* 64: 1084-1098.

Jones, D.R. 2003 Plant viruses transmitted by whiteflies. European *J. Plant Pathol.* 109: 195–219.

Kalawate, A. and Dethe, M.D. (2012) Bioefficacy study of biorational insecticides on brinjal. *J Biopesticides* 5 (1): 75-80.

Kataria, R. and Kumar, D. 2012. Occurence and infestation level of sucking pests: aphids on various host plants in Agricultural Fields of Vadodara, Gujarat (India). *Int. J. Sci. Res. Publ.* 2(7): 1-6

Kerala Agricultural University2009. ***Package of Practices Recommendations: Crops*** 14th edition. Kerala Agricultural University, Thrissur- 360p.

Kersting U., Sator S., and Uygun N., 1999, Effect of temperature on development, rate of fecundity of apterous *Aphis gossypii* Glover (Homoptera :

Aphidae) reared on *Gossypium hirsutum* L., *J. Applied Entomol.* 123(1): 23-27.

Khali, S.S., Bardos, J. and Landa, Z. 1985.Effectiveness of *Verticillium lecanii* to reduce population of aphids under glasshouse and field conditions. *Agric. Ecosystem and Envirn.* 12(2):151-156.

Khattak, M. K., Ali, S., Chishti, J. I., Saljiki, A. M. and Hussain, A. S. 2004. Efficacy of certain insecticides against some sucking insect pest of mungbean (*Vigna radiate* L.). *Pak.Entomol.*26(1):75-80.

Konar, A., Paul, S. and More, K.A. 2011. Efficacy of different insecticidal treatment schedules against aphid and whitefly on brinjal. *The J. Plant Prot. Sci.* 3(2) : 43-52).

Kontsedalov,S., Gottlieb,Y., Ishaaya,I., Nauen,R., Horowitzc,R. and Ghanima, M.2008. Toxicity of spiromesifen to the developmental stages of *Bemisia tabaci* biotype B. Online. Wiley Interscience.

Krishnakumar, N. K., Krishna Moorthy, P. N. and Reddy, R. 2001. Imidacloprid and thiamethoxam for the control of okra leaf hopper, *Amrasca biguttula biguttula* (Ishida). *Pest Manag. Horticultural Ecosystem.* 7(2): 117-123.

Latif, M. A., Rahman, M. M., Islam, M.R. and Niruddin, M.M. 2009. Survey of arthropod biodiversity in the brinjal field. *J. Entomol.*6(1):28-34.

Lekagul, B., Askins, K., Nabhitabhata, J. and Samruadkit, A.1977. Field Guide to the Butterflies of Thailand. Association for the Conservation of Wildlife, Bangkok.

Liu, T.X. 2004. Toxicity and efficacy of spiromesifen, a tetronic acid insecticide, against sweetpotato whitefly (Homoptera: Aleyrodidae) on melons and collards. *Crop Prot.* 23:505–513.

Mabbett, T.H., Nachapong, M., Monglakul, K. and Mekdaeng, J. 1984. Distribution of *Amrasca devastans* and *Ayyaria chactophora* in relation to pest scouting techniques on cotton for Thailand. *Trop. Pest Manag.* 30:133-141.

Mahmood, T. Hussain, S.I., Khokhar, K.M., Jeelani, G.and Mukhtar, A . 2002. Populations dynamics of leaf hopper (*Amrasca biguttula biguttula*) on brinjal and effects of abiotic factors on it. *Asian J. Plant Sci.* 1(2): 107-108.

Malini, C. D., Prasanna, K.P. and Gopalakrishnan, T. R. 2013. Screening brinjal genotypes for resistance to jassid (*Amrasca biguttula biguttula* [Ishida]). *J. Trop. Agric.* 51 (1-2): 42-50

Mandal, S., Singh, N.J., Konar, A. 2010. Efficacy of synthetic and botanical insecticide against whitefly *(Bemicia tabaci)* and shoot and fruit borer *(Leucinodes orbonalis)* on brinjal *(Solanum melongena* L.). *J. Crop Weed.* 6(1): 49-51.

Mann, R. S., Schuster, D. J.,Cordero, R. and Toapanta, M.2012 Baseline toxicity of spiromesifen to biotype B of *Bemisia tabaci* in Florida. *Florida Entomologist.*95(1):95-98.

Mathur, A. and Jain, N. 2006. Control of shoot and fruit borer of brinjal, *Leucinodes orbonalis* in the field. *Entomon.*, 31(2): 141-144.

Meade, D.L. and Byrne, D. N. 1991. The use of *Verticillium lecanii* against subimaginal instars of *Bemisia tabaci. J. Invertebr. Pathol.* 57: 296-298.

Mhaske and Mot, U. N. 2005. Studies on evaluation of new insecticides against brinjal pest complex. *J. Maharashtra agric. univ.* 30(3): 303-306.

Misra, H. P. 2002. Field evaluation of some newer insecticides against aphids (*Aphis gossypii*) and jassid (*Amrasca biguttula biguttula*) on okra. *Indian J. Ent.*64(1): 80-84.

Munde, A. D., Latpate, C. B., Shinde, S. T and Badgujar, A. G. 2011. Integrated management of aphids and jassids infesting brinjal. *J. Entomol. Res.*, 35 (1): 43-49.

Naik, V. C. B., Rao, P. A., Krishnayya, P. V. and Chalam, M. S. V. 2009. Seasonal incidence and management of *Bemisia tabaci* (Gennadius) and *Amarasca bittula biguttula* (Ishida) of brinjal. *Ann. Plant Prot. Sci.* 17(1): 9-13.

Natarajan, K. and Sundaramurthy, V. T. 1990. Effect of neemoil on cotton whitefly (*Bemisia tabaci*). *Indian J. Agric. Sci.* 60:290-291

Natekar, M.G., Samarjit, R. and Agnihotri, N.P .1987. Bioefficacy of synthetic pyrethroids and their residues in brinjal fruit. *Pestology.* 11:18-22.

Nath, V. and Sinha, S. R. 2010. Comparative efficacy of neonicotinoides and insecticide mixtures against sucking pests of okra.

Nauen, R., Bretschneider, T., Bruck, E., Elbert, A., Reckmann, U.,Wachendorff, U.,Tiemann, R. 2002 *The BCPC Conference: Pests and Diseases. Proceedings of the International Conference,* (18–21 Nov. 2002.Brighton, U.K.) BSN 2060: A novel compound for whitefly and spider mite control, pp 39–44, British Crop Protection Council, Farnham, U.K.

Nayer, K.K., T.N. Anantha krishnan and B.V. David, 1995. General andApplied Entomology. 11 edn. Tata McGraw- Hill pub. Co. Ltd. 4/12, New Delhi-110002, pp: 557.

Nene, Y. L. 1973. Note on a fungus parasite of *Bemisia tabaci* Genn., a vector of several plant viruses. *Indian J. Agric. Sci.* 43: 514-516.

Palaniswami, M. S., Pillai, K. S., Nair, R. R. and Mohandas, C. 1995. A new cassava pest in India. *Cassava Newsl.* 19:6-7.

Palumbo, J. C. 2009. Spray timing of spiromesifen and buprofezin for managing *Bemisia* whiteflies in cantaloupes. Online. Plant Health Progress doi:10.1094/PHP-2009-0407-01-RS.

Palumbo, J. C., Horowitz, A. R., and Prabhaker, N. 2001.Insecticidal control and resistance management for *Bemisia tabaci*. *Crop Prot.* 20: 739-765.

Pandey,V. K. and Srivastava, A. 1983. Efficacy of certain plant extracts against brinjal aphid *Aphis gossypii* Glover. *Indian J. Entomol.* 45(3): 313-314.

Panse,V.G. and Sukhatme,P.V.1967.*Statistical Method for Agricultural Workers.*Second edition. Indian Council of Agricultural Research. New Delhi,381p.

Patel, K.C. and Kulkarni, H.L. 1955. Bionomics of *Urentius echinus*. *J. Bombay Nat. History Soc* .53:86-96.

Patil, S. J. and Patel, B.R.2013. Biology of aphid, *Aphis gossypii* (Hemiptera: Aphididae) Glover infesting isabol crop. *Med. Plant Res.* .3(7): 52-56.

Peirce, N.E., Braby, M.F., Heath, A., Lohman, D.J., Mathew, J. R. D.B. and Travassos, M.A. 2002. The ecologyand evolution of ant association in the Lycaenidae (Lepidoptera). *Ann. Rev. Entomol.* 47: 733-771.

Pillai, R.N. 1921. Short notes on insect pests of Travancore. Travancore Department of Agriculture, Trivendrum. 53 pp.

Pollard, D. G. 1959. Feeding habits of the lace-bug *Urentius aegyptiacus* Bergevin (HEMIPTERA: TINGIDAE). *Ann. Appl. Biol.* 47: 778–782.

Polumbo, J.C. 2004. Comparative efficacy of Oberon (spiromesifen) against *Bemisia* whiteflies in spring cantaloupes. 2004 Vegetable Report, University of Arizona, College of Agriculture and Life Science pp 466.

Puttarudriah, M. and Channabasavanna, G.P. 1957. Notes on some predators of mealybugs (Coccidae, Hemiptera). *The Mysore Agric. J.* 32(1): 4-19.

Rajan, A. P.A. and Nair, M.R.G.K. 1992. On the control of brinjal pests using deterrents. *Agric.Res. J. Kerala*. 10(2): 133-135.

Rana, J.S. and Sheoran, R.K. 2004. Evaluation of sunflower *Helianthus annuus* L. hybrids against insect pests in semi-arid tropics. *J. Oilseeds Res.* 21 (2) : 374-375.

Reghunath, P. and Gokulapalan, C. 1999. IPDM in chillies- experiences in participatory approaches. In: Kesavan, P.K. (ed.), *Proceedings of National Seminar HORTINDIA '99*, 8-9 January 1999 Cochin, pp.280-282.

Reghunath, P., Nandakumar, C. and Mohandas,N. 1989. Insecticidal control of the insect pest complex of brinjal *Solanum melongena* L. *Indian J. Ent.* 51(3): 242-245.

Reghupathy, A., Palanisamy, S., Chandramohan, N. and Gunathilakaraj, K. 1997. *A Guide on Crop Pests.* Sooriya Desktop Publishers, Coimbatore, p.290.

Rosaiah, B. 2001. Evaluation of different botanicals against the pest complex of brinjal. *Pestology*. 25(4): 14-16.

Russell, L.M. 1965. A new species of *Aleurodicus douglas* and two close relatives. *Florida Entomologist*.48:47-55.

Sadre, M., Fakhri, A. and Jamal, K. 2012. Management of *Bemisia tabaci, Amrasca biguttula biguttula* and *Helicoverpa armigera* on field grown cotton using different ecofriendly insecticides. *Indian. J. Agric. Biol. Res.*2 (3): 522-529.

Samal, T. and Patnaik, H.P. 2008 Field efficacy of insecticides against *Amrasca bigttula biguttula* (Ishida) incidence on egg plant. *Ann. Pl. Protec. Sci.*, 16 (1): 115-118.

Saradamma, K. 1989. Biological activity of different plant extracts with particular reference to their insecticidal, hormonal and antifeeding action. Ph.D thesis, Kerala Agricultural University, Thrissur.

Saritha, R., Reddy, K.D. and Basappa, H. 2008. Screening of sunflower varieties for resistance against sucking pests. *Indian J. Plant Prot.* 36 (1) : 144-147.

Satti,A.A. and Abdelrahman, A.H.2014. Insecticidal effects of three solanaceous plants against *Urentius hystricellus* (Richter) (Hemiptera: Tingidae). *Int. J. Agric. Innovations Res.* 3 (4):964-967.

Saxena, R. C. 1998. Green revolutions without blues : botanicals for pest management. Proceedings of International Conference on Ecological Agriculture : Towards Sustainable Development, Chandigarh, India.

Shannag, H.K., Al-Qudah,J.M., Makhadmeh, I.M. and Freihat,N.M.2007. Differences in growth and yield responses to *Aphis gossypii* Glover between different okra varieties. *Plant Protect. Sci.* 43(3): 109–116.

Sharma, K. and Chander, S.1998. Spatial distribution of jassid *Amrasca biguttula biguttula* (Ishida) on cotton. *Indian J. Ent.* 60(4): 326-328.

Sharma, S. and Lal, O. P. 2002. Bio efficacy of thiamethoxam in comparison to recommended insecticides against leafhopper and whitefly of brinjal (*Solanum melongena* L.). *J. Entomol. Res.* 26(3): 257-262.

Shrinivasan, G. and Babu, P.C.S. 2001 Field evaluation of neem products against whitefly, *Bemisia tabaci* Gennadius on brinjal. *Ann. Pl. Pro. Sci.* 9: 19-21.

Singh, B. and Rai, S. 1995. Resistance of cotton jassid *Amrasca biguttula biguttula* (Ishida) in okra. National Symposium on Recent Developments in Vegetable Improvement, Raipur. 28-29.

Singh, S., Kumar, S. and Ahmad, N. (2003) Synthesis and validation of IPM module for mustard crop under Haryana agroclimatic condition. *Ann. Pl. Protec. Sci.* 11: 373-376.

Solangi, B. K. and Lohar, M. K. 2007. Effect of some insecticides on the population of insect pest and predators on okra. *Asian J. Plant Sci.* 6(6): 920-926.

Srinivasan R. 2009. Insect and mite pests on eggplant: a field guide for indentification and management. AVRDC – The World Vegetable Center, Shanhua, Taiwan. AVRDC Publication No. 09-729. 64 p.

Srinivasan, G. and Mohanasundaram, M. 1997. A novel method to trap the spiralling whitefly, *Aleyrodicus dispersus* Russell adults in the homegardens. *Insect Environ.*3:18.

Stein, U., Sayampol, B., Klingarf, F., Bestmann, H. J.,Vostrovosky, O. and Classen, B. 1988. Aphicidal action of ethanol extracts of holy basil *Ocimum sanctum*. *Entomologia generalis.*13(3-4): 229-237.

Sudhakar,K.,Punnaiah,K.C. and Krishnayya,P.V.1998.Efficacy of certain selected insecticides on the sucking pest complex of brinjal (*Solanum melongena* L.). *Indian J. Entomol.* 60(3):241-244.

Suresh, K., Rajendran, R. and Rani, B.U. 2007. Ecofriendly approach for managing major sucking pests of brinjal. *J. Entomol.Res.*31(1):19-22.

Swaminathan, V. R., Sanguttuvan, T and Gajendran, G. 2010. Combined efficacy of neem and insecticides against brinjal mealy bug, *Coccidohystrix insolita* (Green). *Madras Agric. J.*, 97 (7): 273-274.

Takalloozadeh, H.M. 2010. Effects of host plants and various temperatures on population growth parameters of *Aphis gossypii* Glover (Hom: Aphididae). *Middle East J. Sci. Res.* 6(1):25-30.

Tigvattn, A. S. 1990. Studies on the bionics and local distribution of some lace bugs in Thailand. III . *Urentius echinus* Distant (Hemiptera: Tingidae). *Keen Kaset Khon Kaen Agric. J.* 18:251-260.

Veeraval, R. and Baskaran, P. 1989. Prey predator interaction between aphids and coccinellids in egg plants (Abstr.). In: Vedalia International Symposium UC. Reverside,California, USA, p.192.

Venkateswara, R. S. and Rosaiah, B. 1993. Evaluation of botanical insecticides alone and in combination with carbaryl against insect pest complex of okra. In : *Neem and environment.* (Ed. Singh, R. P., Chari, M. S., Rahja, A. K. and Kraus, W.) 1: 493- 503.

Vijay,S. and Suresh.S .2013. Bioefficacy of certain insecticides and *Beauveria bassiana* against coccids in flower crops. *J. Biopest.* 6(2):96-100.

Wafaa, A. and Kherb, A.2011. Field efficacy of some neonicotinoid insecticideson whitefly *Bemisia tabaci* (Homoptera:Aleyrodidae) and its natural enemies in cucumber and tomato plants in Al-qassim Region, KSA. *J. Entomol.* 8(5):429-439

Waterhouse, D.F. and Norris, K.R. 1989. Spiralling whitefly *Aleurodicus dispersus,* Biological Control Pacific Prospects – Supplement I. ACIAR Monograph No. 12, 125 p.

Yazdani, M. S., Sohail, A., Razzaq, M and Khan, H. A. 2000. Comparative efficacy of some insecticides against cotton jassids , *Amrasca devastans* Dist. and effecting non-target insects in cotton. *Int. J. Agric. Biol.* 2(1): 19-20.

Yohalem, D., Brodsgaard, H. F. and Enkegaard, A. 1998. Interaction of *Verticillium lecanii* (Mycotal) and *Trichoderma harzianum* (Trichodex) for control of whiteflies and grey mould on tomatoes: a preliminary report. *15th Danish Plant Protection Conference. Pests and Diseases, Tjele, Denmark.*

Zaini, M.R., Rawi, C.S.M. and Hassan,A.2013. Effect of nutrient and pre-infested brinjal, *Solanum melongena* by whitefly and aphid on population dynamics of whitefly, *Bemisia tabaci*. *Agriculture, Forestry and Fisheries*. 2(1): 1-10

Abstract

Management of Sucking Pests of Brinjal

(*Solanum melongena* L.)

ARYA, V. C.

(2012-11-173)

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

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY

COLLEGE OF AGRICULTURE

VELLAYANI, THIRUVANANTHAPURAM- 695 522

KERALA, INDIA

2015

ABSTRACT

An investigation on "Management of sucking pests of brinjal (*Solanum melongena* L.)" was carried out at College of Agriculture, Vellayani during 2013-2014. The objectives were to assess the intensity of damage caused by sucking pests in brinjal and evolve a suitable management strategy using newer insecticides.

Survey conducted in 60 homesteads of vegetable growing tracts of Thiruvananthapuram district revealed the incidence of seven sucking pests namely leaf hopper, *Amrasca biguttula biguttula* (Ishida), aphid, *Aphis gossypii* Glover, whitefly, *Bemisia tabaci* Gennadius, spiralling whitefly, *Aleurodicus dispersus*, brinjal mealy bug, *Coccidohystrix insolita* Green, lace wing bug, *Urentius hystricellus* (Richt) and mite, *Tetranychus* sp. on brinjal grown in garden land and terrace. The leaf hopper, aphid, whiteflies and mealy bug were the major sucking pests infesting brinjal in the garden land and terrace during the vegetative and flowering stages. The infestation of the leaf hopper was recorded from all the locations surveyed and aphid, whitefly (*B. tabacii)* and mealy bug in 89.17, 86.67 and 85 per cent homesteads respectively. The damage caused by the pests ranged from 35.35 to 58.88, 30.11 to 40.24, 34.46 to 50.50 and 34.16 to 49.28 per cent by leaf hopper, *B. tabacii,* aphid and mealy bug respectively. A predator *viz*., *Spalgis epius* (Westwood) and a pathogen *Fusarium* sp. were isolated from the mealy bug, *C. insolita.*

Two field trials conducted to evaluate the efficacy of the new generation insecticides *viz*., spiromesifen 96 g ai ha^{-1}, thiamethoxam 50 g ai ha^{-1}, acetamiprid 10 g ai ha^{-1}, dinotefuran 30 g ai ha^{-1}, dimethoate 600 g ai ha^{-1} and biopesticides *viz*., oxuron 5ml l^{-1} and *Beauveria bassiana* 20 g l^{-1} revealed that the new generation insecticides reduced the population of sucking pests significantly. Thiamethoxam 50 g ai ha^{-1} resulted in significant reduction in the population of leaf hopper (1.10 $plant^{-1}$) and was on par with spiromesifen 96 g ai ha^{-1} (1.12 $plant^{-1}$) in the first crop. Spiromesifen treated plot recorded highest yield of 10.36

kg $plot^{-1}$ and it was on par with thiamethoxam (9.56 kg $plot^{-1}$). Spiromesifen 96 g ai ha^{-1} reduced the population of whitefly (1.13 $plant^{-1}$) and it was on par with thiamethoxam 50 g ai ha^{-1} (1.34 $plant^{-1}$) in the second crop. Highest yield was also recorded from spiromesifen 96 g ai ha^{-1} treated plot (10.95 kg $plot^{-1}$) followed by thiamethoxam 50 g ai ha^{-1} (9.42 kg $plot^{-1}$).

The results of the study thus indicated that the leaf hopper *A. biguttula biguttula* and whitefly *B.tabaci* were the predominant sucking pests infesting brinjal in the homesteads of Thiruvananthapuram district. The new generation insecticides *viz.*, spiromesifen 96 g ai ha^{-1} and thiamethoxam 50 g ai ha^{-1} can be used as alternatives to the highly toxic conventional insecticides against the sucking pests, leaf hopper and whitefly.