ECOFRIENDLY PEST MANAGEMENT IN BRINJAL (*Solanum melongena* L.)

By

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2000

DECLARATION

I hereby declare that this thesis entitled "**Ecofriendly pest management in 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 of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

Certified that this thesis entitled "**Ecofriendly pest management in brinjal (*Solanum melongena* L.)**" is a record of research work done independently by Ms. Annie Bernice T. S. 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.

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INTRODUCTION

INTRODUCTION

Vegetable crops comprise a group of complex edible plants with rich sources of essential vitamins, minerals, proteins and dietary fibres which can provide additional calories. Vegetable cultivation has had a chequered history in India and oriental scriptures of pre-christian era mention several kinds of vegetables being grown for nutrition as well as for medicinal purpose. Ancient epics also describe various types of vegetable cultivation and their use and aesthetic value during auspicious ceremonies. The practice of organised vegetable farming commenced during Aryan invasion and later Mughal rulers and traders from Portugal, France and Britain introduced new vegetables to India.

Nearly 60 different kinds of vegetables are being cultivated in India now. Presently, India is the second largest producer of vegetables next to China. Even though India produces 73 million tonnes from cropped area of 5.6 million hectares, it falls short of present requirement of 285 g per capita per day for a balanced diet. A constant and untiring effort is required to enhance the target to 100 million tones so as to supply about 250 g of vegetable per capita per day to the present population of 1 billion. Efforts are being taken in different levels of vegetable production to increase the productivity of vegetables to the ambitious target mentioned earlier. Despite the improvements in vegetable cultivation and marketing scenario, the pest and disease problems still hold an important role in hindering the productivity. Cost effective integrated pest and disease management strategies are one of the future outlooks that can improve present vegetable cultivation to a certain extent.

Among the different types of vegetables, brinjal is an important one being cultivated widely in India and Kerala. Brinjal has got a special place in many of the vegetable delicacies of Kerala. Even though the cultivation of brinjal is not centralized elsewhere in India, it is being cultivated in different locations according to the regional requirements. Brinjal considered to be a very profitable vegetable crop is often affected by a number of pests during different stages of its growth. Pests like shoot and fruit borer, *Leucinodes orbonalis*, Epilachna beetle *Henosepilachna vigintioctopunctata*, brinjal jassid *Amrasca biguttula biguttula*, aphids *Aphis gossypii*, whitefly *Bemisia tabaci* have been recorded to cause considerable damage on brinjal growing areas. According to Nair (1978) brinjal shoot and fruit borer causes 70 per cent loss and about 80 per cent loss is caused by *Epilachna* beetle (Rajagopal and Trivedi, 1989). The natural enemies recorded from these brinjal cultivated areas is very few and their utilization as biological agents in field is also meagre. The present recommendations of insecticidal application can timely kill the insect pest, but it also results in destruction of natural enemies and can also pollute the environment. In this context, the use of indigeniously available cost effective botanical insecticides have got a significant role in the management of pest complex of brinjal.

Even though a number of plants were identified showing insecticidal properties, many more are yet to be identified and their effectiveness needs to be exploited. Plants like Hyptis, *Hyptis suaveolens* and Kiriyath, *Andrographis paniculata* are examples of plants showing insecticidal property which are unexploited.

The present study of "Ecofriendly Pest Management in Brinjal (*Solanum melongena* L.)" was undertaken for fulfilling the above mentioned concepts to a certain extent. Hence, the following programmes were undertaken during 1998-2000 at College of Agriculture, Vellayani to evolve a database of the brinjal farmers belonging to the important brinjal cultivated areas of Thiruvananthapuram district and also to document different pests and natural enemies in these important brinjal cultivated tracts. Study also included the evaluation of the effectiveness of plants like *Hyptis suaveolens*, *Andrographis paniculata*, garlic and neem as an alternative to the present recommended chemical insecticides in the management of pests of brinjal. The results of the studies will help to evolve suitable ecofriendly, cost-effective and sustainable package of practices recommendations against the major pest complex of brinjal. The study comprised of :

1. Population estimation of pests/natural enemies in the three important vegetable cultivated areas of Thiruvananthapuram district.

2. Laboratory studies on deterrency and toxicity of botanicals on major pests of brinjal

3. Pest management trial in brinjal crop in the Instructional farm, College of Agriculture, Vellayani.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Brinjal, *Solanum melongena* Linn. one of the important vegetable crops in Kerala was found to be affected by the sucking, leaf feeding and borer pests at different phases of its growth. Of these the predominant pests being the aphids, *Aphis gossypii*, jassids *Amrasca biguttula biguttula* Ishida, epilachna beetle, *Henosepilachna vigintioctopuntata* Fab. and shoot and fruit borer, *Leucinodes orbonalis* Guen. (Ramakrishna Ayyar, 1963 ; Nair, 1978 and Reghunath *et al.*, 1989).

2.1 SYMPTOMS, DAMAGE AND MANAGEMENT

2.1.1 Brinjal aphids

Aphis gossypii a cosmopolitan polyphagous pest occurring in almost all parts of the world, can survive upto 7000 feet from MSL throughout the year on different host plants (Behura, 1963). Agarwala and Raychaudhari (1985) reported that the principal hosts of these aphids are cotton, okra, potato, tomato, chilli, brinjal, cucurbitaceous crops and papaya. The aphids colonizes in almost all the parts above the ground level viz., leaves, stem, flowers and immature fruits and they infest both seedlings as well as mature crops (Van Emden *et al.*, 1969). According to Nandihalli and Thontadharya (1986), both nymphs and adults of this pest were found to suck the cell sap and secrete honey dew on which black sooty mould developed and retarded the growth of the plant. Aphids can stunt plant growth, deform and discolour leaves and fruits or cause galls on leaves, stems and roots (Hamman, 1985). Alegbego (1986) stated that both nymphs and adults of aphids transmit pepper vein mottle virus. Saxena (1998) categorises this aphid as one of the important sucking pests of brinjal.

The symptoms appear on tender leaves as it feeds sap from it leading to curling of leaves (David and Kumaraswami, 1996). In a study to find the directional occurrence of pests, Veeravel and Baskaran (1989) observed the location of the brinjal plots plays an important role in pest attack. They observed that the plots situated towards north harboured maximum number of aphids during flowering (3450/25plants) and senescence (2580/25plants) and southern plots during the pre-flowering stage (433/25plants).Also the population was found to be maximum (15102/25 plants) during the flowering stage followed by senescence (8015/25 plants) and pre-flowering stage (1739/25 plants). Jamwal and Kandoria (1990) observed that the favourable period for population build up of *A. gossypii* on brinjal is from first week of August to fourth week of November. Prasad and Logiswaran (1997) studied the population build up of *A. gossypii* in relation to weather parameters. According to them, population build up has a positive correlation with maximum temperature and negative correlation with minimum temperature, wind velocity and rainfall.

Garamvolgyi *et al.* (1999) suggested that the protection of egg plants to arthropod pests can be achieved by adopting chemical and biological methods.

Insecticides such as endosulfan, dimethoate, oxydemeton, phosphamidon, chlorpyriphos and malathion have been recommended for the control of brinjal aphids (Anonymous, 1990) . According to Khaire and Naik (1985), monocrotophos 0.5 kg/ha gave 82.5 per cent control of *Myzus persicae*. Monocrotophos at 0.07 per cent not only gave the best control of *Aphis gossypii*, but also the treated plots recorded the highest yield (Rhadke and Aherkar, 1987). Nandihalli and Thontadharya (1986) reported that phorate 2.25 kg a.i./ha and phasalone 0.438 kg a.i./ha were effective in reducing the aphid population. Application of phosphamidon and monocrotophos

during the vegetative phase of the crop and endosulfan and fenvalerate during the fruiting phase reduced the population significantly (Mall *et al.*, 1997).

According to Zeren and Duzguner (1983), the Syrphid predator *Ishiodon aegyptius* is effective against *Aphis gossypii*. Periodical relèase of *Chrysoperla carnea* in 1 : 1 predator prey ratio gave upto 98 per cent control of aphids (Gurbanov, 1982). The coccinellid predator *Harmonia axyridis* is very effective in controlling the population of *Aphis gossypii* and *Myzus persicae*. Biological studies on *Chrysoperla carnea* by Kharizanov and Dimitrov (1972) and on *C. bipunctata* and *C. transversalis* by Shands and Simpson (1972) revealed that these insects could predate more than 600 aphids during their larval and adult phase. Bratu (1998) who conducted field experiments in Romania to assess the effectiveness of *C. septumpunctata* against *Myzus persicae* in pepper reported that levels of effectiveness range between 52.0 and 93.4 per cent, 20 to 25 days after release of the predator at rates of 70,000 to 1,60,000 eggs/ha. According to Verma *et al.* (1983) *Aphis gossypii* is preferred as food by third and fourth instar larvae and adults of *Menochilus sexmaculatus*, although the hosts range of *Menochilus sexmaculatus* include *Myzus persicae, Aphis gossypii, Aphis neeri and Uroleucon carthami.*

Machauer (1968) and Van Emden *et al.* (1969) listed the parasites of this aphid, *Aphis gossypii* and their effectiveness. Stary and Gosh (1975) recorded three parasites viz., *Aphidius matricariae, Toxares shigai* and *Trioxys indicus* from India and Eswaramoorthy *et al.* (1976) recorded *Aphidius platensis* parasitising upto 93.36 per cent of *Myzus persicae* from Tamil Nadu. Tian and Young (1981) collected *Lysiphlebia japonica* and *Trioxys indicus* from *Aphis gossypii*. Burgio *et al.* (1997) reported that the braconid

parasitoid *Aphidius colemani* was partially effective in reducing the population of *Aphis gossypii* on cucumber, but the performance was poor in melon.

Under favourable conditions, the entomophagous fungi were also found to be effective against aphids. Dickson and Laird (1962) observed that the population was kept down by entomophagous fungi in wet spring. Ramaseshiah (1967) identified the fungus *Entomophthora coronata* on *Myzus persicae* in India. Eswaramoorthy and Jayaraj (1977) reported *Verticillium lecanii* as an effective agent in the control of *Myzus persicae.*

Botanical pest control measures ensure durability within the framework of integrated pest management strategies (Saxena, 1998).

The neem formulations were significantly effective in reducing populations of *A. craccivora.* Aphicidal properties of neem products against different plant aphids were described by several workers viz., in *A. gossypii* (Srivastava *et al.*, 1986; Raman *et al.*, 1993; Nimbalkar *et al.*, 1994), in *Myzus persicae* (Nisbet *et al.*, 1996), in *Lipaphis erysimi* (Sharma *et al.*, 1986; Singh *et al.*, 1988), in *Schizaphis graminum.* (Srivastava and Parmar, 1985) and in *Dactynotus carthami* (Devakumar *et al.*, 1988; Patel *et al.*, 1993).

West and Mordue (1992) reported that azadirachtin, the active ingredient of neem derivatives had systemic toxicity against *Rhopalosiphum padi* and *Schizaphis avenae.* Neem oil (5 per cent) exhibited high (92 per cent) aphicidal activity against *Aphis craccivora.* Neem spray recorded 69.5 per cent mortality of *Aphis craccivora* followed by Margocide OK (68.6 per cent) and Margocide CK (67.7 per cent). (Mariappan and Samuel, 1993). Neem oil (3 per cent) was comparable with

endosulfan in reducing *Aphis gossypii* population in cotton (Jayashree, 1984) and *Lipaphis erysimi* population in mustard (Guddewar and Chandra, 1993). Neem oil (5 per cent) reduced the incidence of cowpea mosaic virus in cowpea (Kannan and Doraiswamy, 1993) and potato virus Y infesting chillies (Mariappan and Samuel, 1993) in which *Aphis craccivora* is the vector.

According to Annie Bright (1995), the reduction in aphid population is due to contact toxicity as well as antifeedant effect. The mortality percentage increased gradually with an increase in concentration of the plant extracts. Similar results were reported on *A. craccivora* by Patel and Srivastava (1989).

The crude extract of neem, *Azadirachta indica* A. Juss effected 86.7 per cent kill of *Lipaphis erysimi* after 72 hours of treatment @ 1.5 per cent concentration (Pandey *et al.*, 1987). Likewise a hexane extract obtained from neem seed kernels exhibited higher toxicity against *Lipaphis erysimi* (Singh *et al.*, 1988). Datta (1996) reported that NSKE (0.40 per cent) in combination with dimecron (0.05 per cent) controlled thrips and aphids in cucurbits.

According to Reghunath and Gokulapalan (1996), neem seed oil emulsion and emulsified leaf extract of *Hyptis suaveolens* at 10 per cent concentration were found to be very effective against pea aphids, *Aphis craccivora* and it was on par with malathion 0.05 per cent.

According to the reports of KHDP trials conducted by the Kerala Agricultural University (1996) malathion 0.2 per cent with garlic @ 20 grams per litre was effective against aphids on bittergourd.

Venkateswara Rao and Rosaiah (1993) observed that nicotine sulphate and repelin alone or in combination with carbaryl was effective against jassids, aphids and *Heliothis* sp. on Okra. Significant seed yields were also obtained. Stein *et al.* (1988) reported that the ethanolic and methanolic extracts of *Ocimum sanctum* caused heavy mortality in aphids of cabbage in Thailand. Application of extracts of *Ocimum grattissimum* reduced the rate of oviposition in *Dacus* sp. (Areekul *et al.*, 1989).

Benzene extracts of *Eupatorium odoratum, Clerodendron infortunatum, Thevetia neriifolia* and *Nerium oleander* significantly reduced the population of aphid on Brinjal. (Saradamma, 1989).

Tobacco decoction, four per cent leaf extracts of *T. neriifolia, C. infortunatum* (with soap water), 1.5 per cent fish oil soap emulsion are being recommended against pests of vegetables like amaranthus, bhindi, brinjal, bittergourd and cowpea (Kerala Agricultural University, 1993).

Singh *et al.* (1995) reported that the ethanolic extract of *Jatropa* sp. at one per cent concentration appeared to be toxic to *M. persicae*. ATSO oil emulsion at three per cent concentration provided complete control of cotton aphids (Natarajan *et al.*, 1995).

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* variety *aculeata* gave 52 to 61 per cent mortality of the same on brinjal. Rhizome and leaf extract of blady grass (*Imperata cylindrica* L) was found to be very effective in controlling *Myzus persicae* on pepper. Rhizome extract gave 100 per cent kill at concentration of 0.04g/cm^3 and leaf extract at 0.092g/cm^3 (Salam *et al.*, 1985).

2.1.1.1 Seasonal incidence of natural enemies of pests

Sitaraman (1966) reported the higher incidence of *Xanthogramma scutellare* Fabr. during November to March and April and a lower population during December to February. The maggots and pupae of *Leucopis* sp. were found in small numbers during November and vanished during December. They appeared again in February and were found in appreciable numbers upto April.

Mathew *et al.* (1971) indicated that the population of *A. craccivora* Koch. and its predators were high during September to April at Vellayani. Strong positive correlation were also observed between aphid population and predator groups like coccinellids and syrphids.

Patel *et al.* (1976) and Butani and Bharodia (1984) studied the seasonal abundance of aphids on groundnut and their natural enemies. Positive correlation between groundnut aphid population and population of active stages of their predators were noticed during this period.

Studies on the safflower aphids population and its predator coccinellids by Upadhyay *et al.* (1980) revealed that positive correlation existed between the population of predators and maximum, minimum temperature and sunshine hours while it was negatively correlated with maximum and minimum relative humidity and rainfall.

2.1.2 Whitefly

Reddy *et al.* (1989) observed that cotton whitefly *Bemisia tabaci* multiplied rapidly at a temperature range of 29^0C to 33^0C on cotton and high rainfall suppressed the pest.

Prasad and Logiswaran (1997) observed that the population of whitefly exerted significantly positive correlation with maximum temperature, relative humidity and wind velocity, but negative correlation with minimum temperature and rainfall in winter months. During summer months, significant negative correlation was observed with rainfall, minimum temperature and relative humidity. Positive correlation was noticed with maximum temperature and wind velocity.

Whitefly is managed mechanically by using yellow trap and chemically by using insecticides such as methyl demeton 0.025 per cent, phasolone 0.07 per cent and phasalone 0.07 per cent + neem oil 0.3 per cent (Reghupathy *et al.*, 1997).

Sterk and Mertens (1998) reported that PreFeRal (*Paecilomyces fumosoroseus)* is effective against Aleyrodids in Cucumber and is safe to natural enemies, pollinators and birds. Whitefly, *Trialeurodes vaparariorum* can be controlled by *Trichoderma harzianum* and *Verticillium lecani* as observed by Yohalem *et al.*, (1998).

Feldhege and Schmutterer (1993) observed that parasitoids of the greenhouse whitefly *T. vaporariorum* attacked and parasitised significantly fewer neem treated whiteflies. According to the studies, dipping of greenhouse whitefly puparia on bean leaves in solutions of Margosan-O containing 10 ppm Az A did not harm the parasitoid, *Encarsia formosa* Gah. whereas 20 ppm Az A was slightly harmful.

Dreyer (1983) and Coudriet *et al.* (1985) reported favourable results with foliar applications of 2 per cent neem seed extracts against *Bemisia tabaci* whereas Dreyer (1983) found strong adult repellency and little or no effect on the immature stages. But Coudriet *et al.* (1985) could find the adult repellency and growth regulating effects on immature stages.

In California, the poinsettia Whitefly or 'Superbug' which is a new more potent strain of *Bemisia tabaci* has been controlled by neem products. (National Research Council, 1992)

2.1.3 Leaf Hopper

Leaf hopper *Amrasca biguttula biguttula* (Ishida) is oneof the most serious pests (Sohi *et al.*, 1972) wherever brinjal is cultivated (Prasad and Logiswaran, 1997). It causes yellowing of leaves followed by crinkling and backward curling of leaves leading to bronzing and hopperburn. Plants become stunted and may be killed in severe cases (David and Kumaraswami, 1996). Both nymphs and adults causes damage. Nymph is light green translucent found between the veins of the leaves of the under surface; when disturbed move in a diagonal manner. Adult is green in colour (Reghupathy *et al.*, 1997).

Shukla (1989), Prasad and Logiswaran (1997) are of the view that the population of *Amrasca* showed a significant positive correlations with maximum temperature and a negative correlation with rainfall. An increase of 10^0C in maximum temperature and 1mm rainfall would lead to an increase of 2.10 nymphs and adults per three leaves and a decrease of 1.44 nymphs and adults per three leaves.

Monocrotophos @ 250 ml or dimethoate @ 250 ml/acre are found to control the pest reasonably well (Reghupathy *et al.*, 1997). Root dip treatment with 0.2 per cent Carbofuran 75WP was also reported to be effective against jassids (Mitra and Majumdar, 1977).

2.1.4 Spotted leaf beetle

Epilachna vigintioctopunctata Fabr. is one of the important pests of brinjal, sometimes becoming serious on it. It also breeds on other Solanaceous plants like *Solanum tuberosum* (Rajagopal and Trivedi, 1989), *S.nigrum, S.xanthocarpum, S.torvum, tomato, Datura, Physalis* sp. etc. It appears in the field one week after transplanting (Raghuraman and Veeravel, 1999). The grubs and adults scrape the leaves in a characteristic manner and feed (David and Kumaraswami, 1996). The population of the grubs revealed a positive correlation with maximum temperature, relative humidity and wind velocity, while the correlation was negative with minimum temperature and rainfall.

Spray application of carbaryl 0.1 per cent, methyl parathion 0.025 per cent, malathion 0.1 per cent or fenitrothion 0.05 per cent controls the pest (David and Kumaraswami, 1996). According to Mall *et al.* (1997), the intensity of Epilachna beetle was found to be significantly reduced by application of phosphamidon and monocrotophos during the vegetative phase of the crop. During the fruiting phase of the crop, insecticidal emulsions like endosulfan and fenvalerate was significantly superior to dusts like methyl parathion and cypermethrin.

Folidol was the most effective against this pest, closely followed by DDT (Chowdhuri, 1965). Carbaryl was the most toxic, followed by parathion, malathion,

BHC and DDT (Jayakumari and Nair, 1969). Parathion had a quick knock down effect of grubs and pupae, but later became almost ineffective. It was observed by Hameed and Adlakho (1973) that dimethoate, carbaryl and diazinon gave good control of the grubs and pupae within 10 days. Carbaryl 50 WP (0.5and 0.2 per cent) spray and phorate 10G (18kg and 24 kg/ha) were found to control the infestation at both levels tested (Somchoudhury, 1973).

Bacillus thuringiensis subsp. *kurstaki* 0.25 per cent suspension caused a maximum mortality of 68.9 per cent in the first instar larvae and a minimum of 13 per cent in the prepupal stage. The adults were less susceptible to *B.t.* It was also observed that direct spraying of *Beavueria bassiana* killed 58.1 per cent first instar larvae and 35.2 per cent pre-pupal stage larvae. The adults were not susceptiblle to *B.bassiana* (Rajendran and Gopalan, 1999). *Bacillus thuringiensis* gave complete mortality within 48 hours (Venkataraman *et al.*, 1962).

Aspergillus flavus Link. parasitized and controlled the population in all stages. The spores of the fungus when sprayed on the insects killed them in 3 days. The crude toxin filtrate and the spore of *Aspergillus flavus* have a quick knock down effect. The crude extract killed the insects and was used in dispersal of the fungus in the fields, where it proved to be so effective that it may be used in integrated control (Krishnamoorthy and Shankar Naidu, 1971).

The increase in population of Epilachna beetles is usually checked by parasites and predators. The parasites mainly belong to the order Hymenoptera.

The egg parasite, *Tetrastichus ovulorum* Ferr. (Eulophidae) was recorded on Epilachna from Karnataka (Krishnamurti, 1932; Krishnamurti and Usman, 1954;

Usman *et al.*, 1964). The use of insecticides is inadvisable when the incidence of parasites is high during summer months and able to bring the pest under control. In a survey, seven larval parasites were found, *Pleurotropis foveolatus* Craw., *P. epilachnae* and *Tetrastichus* sp. in a primary role, *Pleurotropis* sp., *Aximopsis* sp., *Eupelmuz urozonas* and *Elasmus* sp. as secondary parasites. The incidence of parasitism recorded was 53.5 to 77.5 per cent (Puttarudriah and Krishnamurti, 1954; Usman *et al.*, 1964).

Pleurotropis foveolatus is a common larval parasite and 15 to 20 have been recorded from one fourth instar parasitized larva. Eighteen generations of this parasite were observed during a year, but there were few during December to January and March to June (Lal, 1946). This parasite had a wide host range and appears to flourish under fairly cold and humid conditions being useful in hilly and other areas (Lal and Gupta, 1947). Efficient parasitisation, especially on third and fourth instar larvae was observed, the per cent of parasitism varying from 35 to 70 per cent in the field (Lal, 1961; Mathur and Srivastava, 1964). Trivedi (1988) reported parasitisation by the eulophid, *Pediobius foveolatus* in Bangalore with up to 9 per cent parasitism of grubs and pupae of epilachna beetle. Kunjamma and Abraham (1973) recorded *Chrysocharis johnsoni* as an important larval parasite on Epilachna.

The reduvid predator , *Rhinocoris fuscipes* Fab. which was recorded on Epilachna and fed on all the stages of the beetle in South India (Cherian and Brahmachari, 1941).

The antifeedant activity was recorded by Venkatarami Reddy *et al.* (1990) in which *A. indica* offered cent per cent protection of leaves and 33.5 per cent per cent mortality of the grubs.

When neem based pesticides were applied for the control of Epilachna, the natural enemies observed by Nandakumar and Saradamma (1996) include *Tetrastichus* sp., *Chrysocharis johnsoni, Tetragnatha* sp., *Oxyopes* sp. and orb-web spiders.

Trials conducted by KHDP (Kerala Agricultural University, 1996) indicated that Neem Seed Oil 2.5 or 5.0 per cent with garlic @ 20 g/l effectively controlled epilachna beetle, jassid, aphid and mite on bittergourd.

Saradamma (1989) found that two per cent benzene extract of neem leaves reduced populations of Epilachna, *A. gossypii* on brinjal and epilachna beetle of bittergourd and was on par with carbaryl 0.2 per cent. However, Venkatarami Reddy *et al.* (1990) opined that one per cent petroleum ether extract of neem leaves controlled epilachna beetle on brinjal.

Methanol extracts of Neem Seed Kernel showed antifeedant activity against *Epilachna varivestis* Muls. both in the laboratory and on potted plants (Ascher, 1980).

When brinjal leaves treated with 0.025 and 0.05 per cent Neem Seed Oil were fed to *Epilachna sparsus* Hbst. adults by Mishra *et al.* (1990), the pre-oviposition period was 21 per cent longer than the insects fed on untreated leaves. Oviposition period was shorter than normal and eggs were smaller in size.

Jeyarajan and Sundara Babu (1990) found that azadirachtin rich neem fractions were good antifeedants against adults and fourth instar grubs of epilachna beetle on brinjal.

Neem seed extract applied as soil drench and foliar sprays reduced the population of epilachna grubs (Kerala Agricultural University, 1985).

Chandla and Misra (1977) reported repellent and antifeedant effects of neem cake 10 per cent against grubs and adults of *Epilachna ocellata*.

Rajendran (1999) have stated that treating susceptible egg plants with the steam distillate extract of wild *S. aethiopicum* decreased the settling of both adults and third instar grubs of Epilachna. The steam distillate extract also reduced egg hatchability from 84 per cent in the untreated control to 62 per cent in the 4000 ppm treatment. Larvae fed with leaves treated with 4000 ppm of steam distillate extract experienced 50 per cent mortality. Adults reared on a diet containing the extract had decreased growth and reduction in body weight compared to the control ranging from 59.1 per cent at 1000 ppm to 86.4 per cent in 4000 ppm distillate.

Saradamma (1989) observed that extracts of *E.odoratum, C.infortunatum, T.neriifolia* and *N.oleander* reduced the population of vegetable pests like Epilachna.

Gupta and Dogra (1993) reported that fumigation or topical application of *Acorus calamus* oil to pre-pupae and pupae of *Epilachna* interfered with adult eclosion, induced morphological abnormalities and death due to anorexia within 6 days of ecdysis.

Exposure of adult females of *Epilachna varivestis* to food treated with extract of *A.europacum* resulted in reduced fecundity upto 92 per cent. All the eggs laid were found to be sterile. (Schmutterer and Kleffner, 1988).

Rao *et al.* (1992) and Janardhan *et al.* (1992) reported that petroleum ether extracts of leaves of *Bougainvillea spectabilis* at 0.5 per cent concentration gave cent per cent protection against Epilachna.

The seed extract of *Gynandropsis gynandra* was found to be the most toxic to epilachna beetle followed by rhizome extract of *Acorus calamus* and shade dried stem extract of *Cyperus rotandus* (Chandel *et al.*, 1987).

Tobacco decoction, four per cent leaf extracts of *T.neriifolia, C.infortunatum* (with soap water), 1.5 per cent fish oil soap emulsion are recommended against pests of brinjal (Kerala Agricultural University, 1993).

In field experiments, Lily and Saradamma (1994) and Lily (1995) demonstrated that acetone and water extracts of *C.infortunatum* was comparable to carbaryl in controlling epilachna beetle on bittergourd.

Hebsy Bai (1996) reported that seed extracts of *T.neriifolia* was an effective antifeedant leading to larval starvation in epilachna beetle.

Rao *et al.* (1990) reported the antifeedant potency of petroleum ether and aqueous extracts of leaves of *Annona squamosa* and *Argemone mexicana, Ricinus communis* against second instar grubs of Epilachna. Petroleum ether extracts of the rhizomes of *Acorus calamus* 0.5 and 0.1 per cent gave full protection to the leaves of

eggplant against the grubs and adults of epilachna (Tewari and Krishnamoorthy, 1985).

Water extracts of *Mentha arvensis* showed significant antifeedant action against grubs of *Epilachna vigintioctopuntata* (KAU Annual Report, 1981).

2.1.5 Shoot and Fruit Borer

Among the various pests which infest brinjal, the shoot and fruit borer, *Leucinodes orbonalis* Guen. is the most destructive and ubiquitous pest (Dhamdhere and Sharma, 1991). The losses caused by this pest ranges from 28 to 85 per cent fruits (Ahmad,1974; Nighut and Taley, 1979). Its infestation is the main constraint in brinjal production not only in the Indian sub continent, but also in South Africa, Congo and Malaysia (Patil, 1990). Dhankar *et al.* (1977) recorded 63 per cent yield losses. In India, the occurrence of this pest on eggplant was first reported by Hampson (1896). Besides egg plant, the pest have been reported feeding on potato, tomato (Hargreaves, 1937), Cape gooseberry (Pillai, 1922), green pea pods (Hussai, 1925) and mango shoots (Hutson, 1930).

Prasad and Logiswaran (1997) reported that the incidence of shoot damage by *Leucinodes* revealed a positive correlation with maximum temperature, relative humidity and a negative correlation with minimum temperature. Tripathy *et al.* (1998) reported that the peak shoot infestation was recorded during November and peak fruit infestation during December. They have also observed that the September planted crop had the greatest shoot damage (4.53 per cent) followed by February planted crop (4.48 per cent) and shoot damage was least on the June planted crop.

Maximum fruit damage was recorded on the October planted crop (38.2 per cent) followed by November planted crop (36.6 prer cent).

In an experiment to find the effect of NPK fertilisers on the incidence of shoot and fruit borer by Patnaik *et al.* (1998) in Orissa, it was found that the incidence of the borer was 35.4 to 44.4 per cent in plots applied with 125 per cent and 150 per cent of the recommended dose of fertilisers (i.e.) (N: P2O5: K2O @ 125: 80: 100 Kg/ha), while plots receiving no fertilisers showed minimum fruit infestation (26.1 to 27.6 per cent).

According to Sharma *et al.* (1998), out of 8 cultivars of brinjal evaluated for their response to *L. orbonalis*, none of the cultivars were absolutely tolerant. Hence, proper managent of the pest should be ensured.

According to Banerjee and Basu (1955), mechanical and chemical methods could prevent the incidence of *Leucinodes orbonalis* and DDT 0.1 per cent suspension sprayed at fortnightly intervals reduced the incidence to 19 per cent as against 64.4 per cent in control. Wesley (1956) reported that mechanical removal and destruction of affected shoots and fruits of brinjal and dumping them in boiling water as a very effective and cheap method of control.

Srinivasan and Gowder (1959) observed that six fortnightly applications of lindane, dieldrin or DDT 0.1 per cent or endrin 0.02 per cent reduced the percentage of fruits attacked to 11.6, 15.8, 24 and 30 respectively as against 54 in the untreated plot.

Jotwani and Sarup (1963) tested carbaryl, DDT, Gamma BHC, carbaryl, endrin, parathion and found that mixture of DDT and gamma BHC were

effective against the fruit borer. Leela David (1963) reported that among the sprays of thiometon 0.01 per cent, methyl demeton and carbaryl 0.1 per cent and dusts of heptachlor 3 per cent, carbaryl proved to be the best and it was followed by methyl demeton and thiometon. The insecticides were applied three times at intervals of 2 to 3 weeks. The yield in plots treated with carbaryl was doubled than that of control.

Peswani and Lal (1964) studied the toxicity of different insecticides to the first instar larvae of *Leucinodes orbonalis* and found that malathion, thiometon, diazinon, fenitrothion, chlordane and dichlorvos were more toxic than lindane. Lal and Ahmed (1965) found that endrin 0.02 per cent spray gave a fair control of the fruit and shoot borer. Trials conducted by David (1966) with eleven chemical sprays and a dust for the control of *Leucinodes orbonalis* showed that 0.1 per cent sprays of trichlorphon and carbaryl applied three times beginning when the transplanted crop was six weeks old gave the best fruit production and greatest economic return.

Sardar Singh and Guram (1967) observed that the percentage of affected fruits got reduced from 61.4 per cent for control to 33.3 to 26.2 per cent by insecticides endrin and diazion 0.4 per cent and a mixture of parathion 0.04 per cent and DDT 0.1 per cent applied at intervals of 10 to 15 days.

The relative efficiency of twelve insecticides to newly hatched larvae of *Leucinodes orbonalis* was assessed by Theotia and Sinha (1971). As judged from the LC_{50} values, Malathion was the most effective and it was followed by thiometon, diazion, fenitrothion, chlordane, dichlorvos, gamma BHC, heptachlor, isobenzene, endrin, carbaryl and dieldrin.

Kabir and Rahman (1971) observed that sprays of wettable powder phosmet 0.1 per cent applied to run off level gave the best control of *Leucinodes*.

Deshmukh and Udean (1972) recommended the application of endosulfan 0.05 per cent 2 to 3 times at fortnightly intervals for the control of the pest. Joshi and Sharma (1973) found that the percentage of the fruits infested by the larvae of *Leucinodes orbonalis* was 4.77 as compared with 11.07 and yield was 169.44 quintals per hectare when treated with three sprays of carbaryl 0.25 per cent.

Purohit and Khatri (1973) observed that application of phosphamidon, formothion, dimethoate and parathion each at 135, endosulfan at 225, endrin at 90 and monocrotophos at 135 g/ha reduced the percentage of damaged fruits (in counts made after) 7,14 and 21 days to 11.53, 17.60, 19.14, 21.2, 22.28, 23.3 and 26.10 respectively compared with 36.83 per cent for no treatment.

Pranabroy *et al.* (1973) found that parathion 0.04 per cent sprayed six times at 15 days interval commencing from a week after transplanting was effective in reducing the infestation level of the fruit borer and also in increasing the yield.

In field plot tests conducted to study the effectiveness of 0.05 per cent sprays of four insecticides, Srivastava and Singh (1974) observed that treatment with phosphamidon produced the highest yield (44.11 quintals) and the highest net economic return.

Uthamaswamy *et al.* (1975) found that chlorfenvinphos, sevidol or carbaryl 0.1 per cent, endosulfan 0.01 per cent, dicrotophos 0.5 per cent, carbopenthion 0.06 per cent, chlorpyriphos 0.1 per cent are on par in reducing the incidence of fruit borer, as revealed by weight and number.

Field trials conducted by Ayanna *et al.* (1976) showed that monocrotophos and quinalphos at 0.05 and 0.25 per cent kg a.i./ha were effective in controlling the shoot and fruit borer. Butani and Varma (1976) reported that sprays of dichlorvos or endosulfan 0.05 per cent gave efficient control of the fruit borer. Krishnaiah and Jagan Mohan (1976) observed from field trials that the borer infestation of the fruit was effectively lowered by carbaryl spray at 0.1 per cent concentration corresponding to 1 kg a.i./ha. They also found that there was a significant difference in the efficacy of carbaryl doses at 1 and 2 kg a.i./ha. The application of systemics viz., dimethoate,cyclotrane, phorate and carbaryl showed that cyclotrane could be effective against fruit borer (Kumaresan and Baskaran, 1976). Christudas *et al.* (1976) found that DDT and carbaryl were effective for the control of the pest. Field trials conducted by Nair and Nair (1976) to evaluate the effectiveness of various insecticides and found that carbaryl 0.1 per cent was the best treatment followed by sprays of endosulfan or phosphamidon at 15 days intervals from 25 days after transplanting controlled the fruit borer, the latter being more effective as shown by the enhanced yields.

Of the seven insecticides applied six times at 14 days intervals, trichlorphon at 0.05 per cent gave the best control on fruits (Nawale and Sonone,1977). Veeravel and Bhaskaran (1995) found that phoxim 0.037 per cent controlled the larvae of *Leucinodes orbonalis* on shoots and quinalphos 0.05 per cent on fruits. Gowda *et al.* (1977) observed that three sprayings of phenthoate 0.06 per cent at intervals of 15 days beginning 20 days after transplanting reduced the average incidence of *Leucinodes orbonalis* to 28.62 to 45.5 per cent as compared with 57.10 - 58.91 per cent for no treatment.

Mote (1978) found that granules of phorate or aldicarb applied at the rate of 1 kg toxicant per hectare 15 days after transplanting followed by three fortnightly application of carbaryl 0.02 per cent or quinalphos 0.05 per cent gave effective control of the fruit borer and gave considerable increase in the yield although disulfoton granules followed by sprays of phenthoate 0.05 per cent gave the greatest population reduction of *L.orbonalis.*

The synthetic pyrethroids fenvalerate and permethrin recorded significantly low fruit borer infestation of 5.19 amd 7.8 per cent based on fruit number while infestation in other treatments ranged from 31.54 to 43.98 per cent and these were on par with the untreated check. Fenvalerate and permethrin recorded significantly higher yield of 103.13 and 102.87 quintals of marketable produce per hectare. All the other treatments with yields ranging from 38.27 to 75.47 quintals were statistically on par with the untreated check. (Jagan Mohan *et al.*, 1980).

According to Sudharma (1981) three to four rounds of sprayings with synthetic pyrethroids like cypernethrin will have to be recomended for protecting the fruits from the pest infestation.

Efficacy of nine insectides viz., thiodicarb, endosulfan, phosphamidon, monocrotophos, quinalphos, dimethoate, methyl demeton, cypermethrin and phasalone was assessed against the brinjal shoot and fruit borer. On the basis of infestation and yield of borer free fruits, thiodicarb 0.15 per cent and monocrotophos 0.04 per cent were most effective. The former treatment was most economical and gave an additional income of Rs. 3061 per ha. (Dhamdhere and Sharma, 1991).

In another experiment, per cent fruit infestation by weight and number remained significantly lower in fenvalerate and cypermethrin while other treatments viz., carbofuran at earthing + 5 sprays with malathion, monocrotophos and deltamethrin were not significantly different from control indicating failure of the insecticides in controlling the pests. (Mishra, 1993).

Krishnamoorthy and Mani (1998) recorded a new parasitoid *Diadegma apostata* from the fruit borer.*Trichogramma chilonis*, egg parasitoid released at fortnightly intervals significantly reduced pest damage and produced furit yield 20 to 30 t. compared with the control yield of 13.06 t (Raja *et al.*, 1997).

Field trials by Adhikary (1985) showed that crude methanol extracts of neem seed was more efficient than mevinphos and deltamethrin against *Plutella xylostella*. Neem seed extract applied as soil drench and foliar spray reduced population of epilachna grubs, while the shoot borer was not controlled. (Kerala Agricultural University, 1985). Petroleum ether extract of neem at a dilution of 1 : 100 gave good control of L.orbonalis (Krishnamurthy Rao, 1983).

Mohan (1988) observed that root dipping of brinjal seedlings with NSO three per cent followed by NSKE five per cent spray controlled fruit borer.

Petroleum ether extract of neem at a dilution of 1 : 100 gave good control of *L. orbonalis* (Krishnamurthy Rao, 1983). Asari and Nair (1972) carried out field trials to evaluate the effectiveness of nine deterrents in protecting brinjal from insect pests. They found that deterrents were not effective in controlling *L. orbonalis*.

The most effective control of the pest was achieved with the application of 4 per cent neem oil producing the highest fruit yield of 24.48 t/ha (Raja *et al.*, 1998).

In a field experiment in Tamilnadu with brinjal, neem based products were comparable or better than endosulfan in controlling fruit borer. Fruit yields with Nimbecidine (13.02 t/ha) and Neemazal (12.80 t/ha) were higher than endosulfan (Srinivasan and Babu, 1997).

Gupta *et al.* (1999) reported that intercropping with fennel significantly reduced the infestation by *Leucinodes*.

Rhizomes of garlic, *Allium sativum* L. posses antifeedant property against a number of insects (Pandey *et al.*, 1987). *Allium sativum* caused 85 per cent mortality against lepidopteran larvae as against *Melia azedarach* which caused mortality upto 91.7 per cent when applied at the rate of 100 g/l as observed by Nasseh and Furassy (1992).

MATERIALS AND METHODS

Methodology adopted for recording observations of pests and natural enemies in brinjal.

Sl. No.	Pest	Method of observation
1.	*Epilachna vigintioctopunctata*	a) Number of grubs on three leaves at random per plant b) Number of grubs parasitised out of 5 per plant c) Number of pupae parasitised out of 5 per plant
2.	Jassid *Amrasca biguttula biguttula*	Number of adults in three leaves at random per plant
3.	Budworm *Scrobipalpa blapsigona*	Number of buds infested out of ten per field.
4.	Aphid *Aphis gossypii*	a) Number of adults in three leaves at random per plant. b) Number of predatory insects in three leaves at random per plant. c) Number of spiders per plant
5.	Whitefly *Bemiscia tabaci*	Number of adults in the leaves at random per plant
6.	Shoot and fruit borer *Leucinodes orbonalis*	a) Percentage of infested shoots out of whole number of shoots available per plant b) Percentage of damaged fruits in standing crop.

Criteria for assessing level of damage of pests of brinjal is given in Table below.

Criteria for assessing number of pests of brinjal

Sl. No.	Pest	None	Low	Medium	High
1.	Epilachna	Nil	≤ 3 (per leaf)	> 3 - ≤ 5	> 5
2.	Aphid	Nil	≤ 5 adults (per leaf)	> 5 - ≤ 10	> 10
3.	Jassid	Nil	≤ 5 adults (per leaf)	> 5 - ≤ 10	> 10
4.	Whitefly	Nil	≤ 5 adults (per leaf)	> 5 - ≤ 10	> 10
5.	Leucinodes	Nil	≤ 30 per cent (branches or fruits)	> 30 - ≤ 60 per cent	60 per cent

instead of seedlings for the experiment. Two fruits : one treated and one untreated were kept side by side and twenty numbers of first instar larvae were released on the treated fruits and the whole setup was covered with the metal cage. This served as one replication. Number of insects settled on the treated and untreated seedlings (fruits in case of Leucinodes) were recorded after two and twenty four hours. Percentage deterrency was worked out using the formula A - B /A x 100 where A - Total number of insects released and B - number of insects congregated on the treated plant (fruit). In case of Leucinodes observation was taken only at the end of 24 hours.

3.2.4 Estimation of mortality

3.2.4.1 Aphids

Mortality was estimated by dry film technique. One ml of the extracts were transferred to the petridish and it was rotated horizontally so that a dry film of the solvents got deposited uniformly on the inner surface of the petridish and it was air dried for five minutes. Twenty numbers of fourth instar nymphs were collected from the culture and released into this treated petridish. The nymphs were fed with fresh brinjal leaves. Number of dead as well as the deformed adults at the end of 24 hours was taken as a measure of mortality. Two such replications were maintained for each treatment.

3.2.4.2 Epilachna

Third instar grubs of uniform size were collected from the mass culture maintained in the laboratory. The extracts were directly sprayed on the test insects taken in clean petridishes using an atomiser. One ml of the extract

sprayed in one dish containing ten insects formed one replication. Two such replication were maintained for each treatment. Grubs sprayed with water served as control. The sprayed grubs were kept exposed under a fan for the spray fluid to evaporate. The grubs were then transferred to petridishes with fresh food material. Number of dead as well as the deformed adults at the end of 24 hours was taken as a measure of mortality. Two such replications were maintained for each treatment.

3.2.4.3 Leucinodes

A fresh brinjal fruit was dipped in the respective solutions and air dried for five minutes. Twenty numbers of first instar larvae obtained from the culture were released on the treated fruit. Number of dead larvae that have failed to develop pinholes at the end of third day after the release as well as the rest of the larvae even after gaining entry inside the fruit, number of larvae that have failed to emerge as adult i.e., number of larvae dead was taken as a measure of mortality. Two replications were maintained for each treatment.

3.3 Pest management trial in brinjal at the Instructional Farm, College of Agriculture, Vellayani

The trial was conducted in the Instructional Farm in College of Agriculture, Vellayani.

3.3.1 *Raising the nursery*

The nursery was raised in pots during November, 1999. Pots were filled to three fourth with potting mixture (2 : 1 : 1 of sand : soil : cattle

manure). Seeds of 'Surya' variety brinjal were sown at the rate of 50 per plot. Pots were watered regularly. One month old seedlings were transplanted to the main field.

3.3.2 Preparation of main field

The effective treatments of the lab experiment were tried in the field. A randomized block design was adopted with three replications including control. The plot size was approximately 9 m^2. About twenty plants were maintained per plot. The seedlings were planted with the spacing of 70 x 60 cm . All cultural operations suggested in the 'Package of Practices' of the Kerala Agricultural University (1996) for raising brinjal were followed excluding the plant protection measures.

Observations were taken on the middle six plants excluding the border rows. Observations on population of the pests were taken from three leaves selected randomly from the top, middle and bottom portions of the plant and for extent of damage from ten leaves selected randomly. For Leucinodes, number of branches (fruits) affected out of total number of branches (fruits) were recorded. The sprayings were done twice during the crop period i.e., on the 40^{th} and 75^{th} days after transplanting. Observations were taken on number of pests and level of damage at one week, two weeks, four weeks and five weeks after first spraying and one week, two weeks, three weeks, four weeks and five weeks after second spraying

The treatments were as detailed below :

T_1 - Malathion 0.1 per cent

T_2 - Malathion 0.1 per cent + garlic @ 20 g/l of spray solution

T_3 - Garlic @ 20 g/l of spray solution

T_4 - Neem oil emulsion 2.5 per cent

T_5 – Neem oil emulsion 2.5 per cent + garlic @ 20 g/l of spray solution

T_6 – Leaf extract of *Hyptis suaveolens* mixed with soap solution + garlic @ 20 g/l of spray solution

T_7 – Neem oil emulsion 2.5 per cent + Leaf extract of *Hyptis suaveolens* mixed with soap solution

T_8 – Neem oil emulsion 2.5 per cent plus Leaf extract of *Hyptis suaveolens* mixed with soap solution + garlic @ 20 g/l of spray solution

T_9 – Neem oil emulsion 2.5 per cent + garlic @ 20 g/l of spray solution plus Leaf extract of *Hyptis suaveolens* mixed with soap solution

T_{10} – *Control*

For the first spraying, spray solution was used @ 100 l/acre and for the second spraying, @ 200 l/acre.

3.4 Yield data

The harvesting of fruits was done at weekly intervals and the total weight of the fruits obtained from the six observation plants from each plot was recorded.

3.5 Statistical analysis

Data generated from the survey, lab and field experiments were subjected to statistical analysis by applying analysis of variance technique for the survey, lab experiment and yield data and analysis of co-variance technique for the field experiment. All the data of the field experiment were subjected to $\sqrt{x+1}$ transformation.

RESULTS

RESULTS

4.1 Population estimation of pests/natural enemies

4.1.1 The values indicated in Table 1 explain the farmer's status and farming practice followed by brinjal cultivators in the different locations where survey was conducted.

Age

The survey revealed that majority of farmers (56 per cent) involved in agriculture are of the age group 41 to 50 years. Farmers in the age group of 31 to 40 are only 29 per cent. 15 per cent of farmers are in the age group of above 50 years.

Nature of Land

About 58 per cent of the farmers practice brinjal cultivation in their homesteads, while only 42 percent of them carry it out in gardenland.

Education

Regarding education, about 51 per cent of the brinjal cultivators have completed their middle school, 30 per cent of them high school and 16 per cent of them were left with just primary school. Only 3 per cent of the farmers have had their pre-degree and other higher education.

Ownership of Land

About 85 per cent of the brinjal cultivators carry out their brinjal cultivation in their own land with just 15 per cent of them in the leased land.

Table 1 Farmer's status and farming practices prevalent in the brinjal cultivated tracts of Thiruvananthapuram district

Sl. No.	Category	Frequency	Percentage
a)	**Age group**		
	21 – 30	0	0
	31 – 40	29	29
	41 – 50	56	56
	>50	15	15
	Total	100	100
b)	**Nature of land**		
	Wet land	0	0
	Garden land	42	42
	Homestead	58	58
	Total	100	100
c)	**Education**		
	1. Primary school (1-5th standard)	16	16
	2. Middle school (5-8th standard)	51	51
	3. High school (8-10th standard)	30	30
	4. Pre-degree & Higher education	3	3
	Total	100	100
d)	**Ownership of land**		
	Own	85	85
	Leased	15	15
	Total	100	100
e)	**Size of holding**		
	≤ 1-2 cents	45	45
	≥ 2-5 cents	19	19
	≥ 5-10 cents	23	23
	≥ 10 cents	13	13
	Total	100	100
f)	**Variety cultivated**		
	Local variety	97	97
	KAU variety	3	3
	Total	100	100
g)	**Season of cultivation**		
	September, October (sowing)	31	31
	Throughout the year	7	7
	April, May (sowing)	62	62
	Total	100	100

Sl. No.	Category	Frequency	Percentage
h)	**Duration of the crop**		
	<6 months	21	21
	6-12 months	33	33
	1-2 years	37	37
	>2 years	9	9
	Total	100	100
i)	**Manure**		
	Organic	53	53
	Organic + Chemical fertilizers	47	47
	Total	100	100
j)	**Farming practices**		
	Labour alone	2	2
	Farmers + Labourers	49	49
	Farmer alone	49	49
	Total	100	100
k)	**Insecticide application**		
	Prophylatic	57	57
	Curative	43	43
	Total	100	100
l)	**Source of information**		
	Department (KHDP)	40	40
	University	0	0
	Dealers	17	17
	Media	19	19
	Own	24	24
	Total	100	100
m)	**Fruit quality**		
	Low	24	24
	Medium	46	46
	High	30	30
	Total	100	100
n)	**Yield**		
	< 6 kg	41	41
	> 6-15 kg	21	21
	> 15-30	18	18
	> 30-60	15	15
	> 60	5	5
	Total	100	100

Size of holding

Regarding farm size, brinjal is cultivated by 45 per cent of farmers in area of less than two cents, 23 per cent of them in five to ten cents, 19 per cent in two to five cents. Only 13 per cent of the farmers carry out brinjal cultivation extensively in area of more than ten cents.

Variety cultivated

About 97 per cent of the farmers use the local variety called Nadan, while only 3 per cent of the farmers use the Kerala Agricultural University variety called Haritha.

Season of cultivation

About 62 per cent of the farmers take up brinjal sowing in April, May with 3 per cent of them taking up their sowing in September, October. 7 per cent of the farmers take up their sowing in any part of the year.

Duration of the crop

37 per cent of the farmers maintain the crop in the field for one to two years and 33 per cent of them for six to twelve months. The crop is retained for a period of less than six months by 21 per cent of the farmers with 9 per cent of them maintaining the crop for a period of more than two years.

Manure

Organic manure alone is used by 53 per cent of the farmers while 47 per cent of them uses both organic and chemical fertilizers.

Farming practice

The farming practice was carried by farmer alone in 49 per cent of the farmers. An equal percentage of them carry out the farming operations with the help of labourers. Only a negligiable percentage (2 per cent) of them carry out farming operations with labour alone.

Insecticide application

57 per cent of the farmers carry out prophylatic application of treatments to save their crop while it is curative with 43 per cent of them.

Source of Information

About 40 per cent of the farmers depend upon KHDP for getting valuable information and innovative practices with 19 and 17 per cent of them depending upon the media and dealers respectively for their information. About 24 per cent of them carry out the operations by themselves, i.e., their own experience.

Fruit quality

The fruit quality was only medium with 30 to 60 per cent damage with 46 per cent of the farmers. It is high with less than 30 per cent damage and low with more than 60 per cent damage with 30 and 24 per cent of the farmers respectively.

Yield

About 41 per cent of the farmers obtain an yield of less than 6 kg per week per cent ; 21 per cent, more than 6 to 15 kg fruits per week per cent; 18 per cent more than 15 to 30 kg and 15 per cent with more than 30 to 60 kg fruits per week per cent. Only about 5 per cent of the farmers obtain an yield of more than 60 kg fruits per week per cent.

4.1.2 Percentage incidence of pests of brinjal in farmers' field

Leucinodes orbonalis was the major problem with 59 per cent of the farmers (Table 2) and the problem was moderate with 35 per cent of the farmers. *Epilachna vigintioctopunctata* incidence was severe with 45 per cent of the farmers, moderate with 33 per cent of them and the incidence was mild in 22 per cent of them. *Aphis gossypii* was the problem in 38 per cent of the farmers' field; moderate in 36 per cent of them and mild in 26 per cent of the cases. *Bemisia tabaci* was severe in only 12 per cent of the farmers' field, moderate in 27 per cent of them while it was only a mild incidence in 61 per cent of them. Incidence of hairy caterpillars, bud worms and other pests were only mild in 22 per cent of the farmers' field and moderate in 10 per cent of them.

Regarding disease, bacterial wilt was severe in 2 per cent of the farmers' field and moderate in 15 per cent of them. However, the attack was widespread though mild in 60 per cent of the farmers' field. The incidence of little leaf was mild in 39 per cent of the cases, but moderate in 11 per cent of them. However, it was a serious problem with 2 per cent of them. About 3 per cent of the farmers had the incidence of other diseases like leaf spot.

Table 2 Percentage incidence of pests in brinjal in farmers' field

Pests	Mild	Moderate	Severe
1. Epilachna	22	33	45
2. Leucinodes	6	35	59
3. Jassids	61	29	10
4. Aphids	26	36	38
5. Whiteflies	61	27	12
6. Others	22	10	0
Diseases			
1. Bacterial wilt	60	15	2
2. Little leaf	39	11	2
3. Others	3	0	0

4.1.3 Percentage of incidence of natural enemies of pests of brinjal in farmers' field

The incidence of the natural enemies was almost nil at one month after transplanting (Table 3). However, the incidence of coccinellids and syrphids were low in 18 and 17 per cent of the plots respectively.

According to the cultivators, there was an increase in the incidence of natural enemies of the pest when the crop is at three months after transplanting. The incidence of the staphylinids was high in 10 per cent of the farmers' field, moderate in 13 per cent of them while the incidence was only low in 9 per cent and absent in 68 per cent of them. The incidence of the coccinellids was also high in 8 per cent of the cases, medium in 38 per cent cases and low in 31 per cent of the farmers' field. However, the coccinellids were absent in 23 per cent of the farmers' field. The incidence of syrphids though was absent in 75 per cent of the cases, was low in 20 per cent and medium in 5 per cent of them. The condition was 42 per cent, 38 per cent and 20 per cent respectively in case of Eulophids. Spiders were absent in 61 per cent of the cases. However, the incidence was low and medium in 30 and 9 per cent of the farmers' field respectively.

The incidence of natural enemies was maximum when the crop is at four-month stage after transplanting. The predominant natural enemy observed was staphylinids, the incidence being high in 28 per cent of the farmers' field, medium in 11 per cent and low in 5 per cent. The incidence of coccinellids was a little less than the stage before with the incidence being

Table 3 Percentage incidence of natural enemies of pest of brinjal in farmers' field

Natural enemy	Absent	Low	Medium	High
1 MAT				
Coccinellids	81	18	1	0
Staphylinids	100	0	0	0
Syrphids	80	17	3	0
Eulophids	93	7	0	0
Spiders	100	0	0	0
3 MAT				
Coccinellids	23	31	38	8
Staphylinids	68	9	13	10
Syrphids	75	20	5	0
Eulophids	42	38	20	0
Spiders	61	30	9	0
4 MAT				
Coccinellids	41	29	23	7
Staphylinids	56	5	11	28
Syrphids	95	3	2	0
Eulophids	79	17	4	0
Spiders	26	40	24	0

1 MAT – First month after transplanting
3 MAT – Third months after transplanting
4 MAT – Fourth months after transplanting

high in only 7 per cent of the cultivator's field surveyed, medium and low in 23 per cent and 29 per cent of them respectively. Syrphids though was absent in 95 per cent of the field surveyed, the incidence was low and medium in 3 and 2 percent cases respectively. Eulophids was also absent in 79 per cent of the field surveyed but the incidence was mild in 17 per cent cases. The spiders were absent in 64 per cent cases, low in 40 per cent of them and medium in 24 per cent of the cases.

4.1.4 Stages of crop affected by the pest

Leucinodes, epilachna, jassids, aphids and whiteflies were present in all stages of the crop in 34, 20, 25, 28 and 31 per cent of the farmers' field surveyed (Table 4). The incidence of the fruit and shoot borer was present at three and four months after transplanting in 94 per cent of the field surveyed, 6 per cent in whiteflies, 4 per cent in Epilachna and 3 per cent in the case of jassids and aphids. In about 39 per cent of the farmers' field, Epilachna was present in one and three months after transplanting. The condition was 27 per cent regarding aphids and whiteflies. In about 36 per cent of the farmers' fields, the jassids were present at one month after transplanting.

4.1.5 Control measures of pests as practiced by the farmers

Botanical pesticides (Table 5) using neem oil, Leaf extract of hyptis, garlic etc. gave good control for 10 farmers, while it was fair for 19 per cent of them. Insecticides gave satisfactory control for 15 of them while a combination of botanicals and chemicals proved to be good for 12 of them.

Table 4 Incidence of pests in the different stages of the crop

Pests	Months after transplanting					
	1	3	1 & 3	4	3 & 4	1,3 & 4
Epilachna	9	28	39		4	20
Leucinodes	-	12	10		44	34
Jassids	36	11	25		3	25
Aphids	26	16	27		3	28
Whiteflies	28	8	27		6	31
Others	7	10	2	11	-	-
Disease						
Bacterial wilt	25	10	38		4	-
Little leaf	21	16	15		-	-
Other			3			

Table 5 Control measures for pest as practiced by farmers

	Poor	Satisfactory	Fair	Good
Botanical		5	19	10
Chemicals	3	15	4	
Botanicals + Chemicals			3	12
Physical and Chemical		5	2	1
Physical and Botanical			1	4
Mechanical and Chemical		2	2	1
Mechanical and Botanical			1	4
Physical, Chemical and Botanical			1	2
Mechanical, Chemical and Botanical			1	2

4.2 Lab studies on deterrency and toxicity on major pests of brinjal

Deterrent effects of different treatments was assessed in terms of percentage of insects deterring from treated plant surface.

4.2.1 Lab studies on deterrency to aphids

4.2.1.1 Percentage deterrency to aphids after 2 hours

From table 6, it can be seen that the deterrent effect of malathion 0.1 per cent with (T_2) or without garlic (T_1) recorded high level of deterrency (27.46 and 27.17 per cent). The deterrency observed in plants treated with neem oil + garlic (T_7) was 20 per cent. It was found that the garlic (T_4), *Andrographis paniculata* + garlic (T_5), Neem oil emuslion (T_6), *Hyptis suaveolens* + garlic (T_9), combination of *A. paniculata* + garlic plus neem oil (T_{10}), neem oil + *H. suaveolens* (T_{11}), combination of neem oil plus *H. suaveolens* + garlic (T_{12}), combination of neem oil + garlic plus *H. suaveolens* (T_{13}) and combination of *A. paniculata* plus neem oil + garlic with 12.39, 12.39, 10.00, 13.50,15.50,16.83,11.46 and 10.00 percentage deterrency respectively were on par with each other. The percentage deterrency was less with *A. paniculata* i.e., T_3 (7.30) and in T8 i.e., *H. suaveolens* (8.44). No deterrency was observed in control.

4.2.1.2 Percentage deterrency to aphids after 24 hours

The perusal of Table 6 shows the percentage deterrency after 24 hours ranged from a maximum of 60 per cent in plants sprayed with neem oil emulsion (T_6) to a minimum of 12.39 in control (T_{15}). Neem oil emulsion (T_6) was on par with malathion 0.1 per cent (55.03 per cent). Besides the

Table 6 Detterent effect shown by important pests of brinjal to the different treatments (in %)

Treatments	Aphids		Epilachna		Leucinodes
	2 hrs	24 hrs	2 hrs	24 hrs	
T_1	27.17 (31.40)	55.03 (47.86)	29.50 (32.89)	75.17 (60.09)	85.35 (67.47)
T_2	27.46 (31.60)	47.50 (43.55)	40.00 (39.22)	80.00 (63.41)	97.44 (80.77)
T_3	7.30 (15.67)	32.47 (34.73)	44.97 (42.10)	70.50 (57.08)	39.78 (39.09)
T_4	10.00 (18.43)	34.92 (36.21)	34.92 (36.21)	65.08 (53.76)	89.99 (71.54)
T_5	12.39 (20.60)	35.00 (36.26)	50.00 (44.10)	80.00 (63.41)	75.17 (60.09)
T_6	12.39 (20.60)	60.00 (50.75)	55.03 (47.86)	80.00 (63.41)	99.99 (90.00)
T_7	20.00 (26.55)	44.97 (42.10)	60.00 (50.75)	80.00 (63.41)	99.99 (90.00)
T_8	8.44 (16.88)	37.48 (37.74)	24.83 (29.88)	60.00 (50.75)	85.35 (67.47)
T_9	10.00 (18.43)	39.95 (39.18)	40.00 (39.22)	80.00 (63.41)	89.99 (71.54)
T_{10}	13.50 (21.54)	40.00 (39.21)	50.00 (44.10)	70.50 (57.08)	99.99 (90.00)
T_{11}	15.50 (23.17)	42.49 (40.66)	50.00 (44.10)	85.36 (67.47)	99.99 (90.00)
T_{12}	16.83 (24.21)	42.49 (40.66)	40.00 (39.22)	80.00 (63.41)	99.99 (90.00)
T_{13}	11.46 (19.78)	44.99 (42.11)	29.50 (32.89)	70.50 (57.08)	99.99 (90.00)
T_{14}	10.00 (18.43)	40.00 (39.21)	40.00 (39.22)	80.00 (63.41)	99.99 (90.00)
T_{15}	0 (0)	12.39 (20.60)	0 (0)	5.27 (13.28)	24.83 (29.87)
CD	7.0083	5.4895	11.4525	14.20	10.2951

Figures in parenthesis denote transformed values

$\sqrt{x+1}$ transformation

percentage deterrency of malathion 0.1 per cent + garlic (T_2) was 47.50. The percentage deterrency recorded with neem oil + garlic (T_7), *Hyptis suaveolens* (T_8), *H. suaveolens* + garlic (T_9), combination of *A. paniculata* + garlic plus neem oil (T_{10}), neem oil + *H. suaveolens* (T_{11}), combination of neem oil plus *H. suaveolens* + garlic (T_{12}), combination of neem oil + garlic plus *H. suaveolens* (T_{13}) and combination of *A. paniculata* and neem oil + garlic (T_{14}) was 44.97, 37.48, 39.95, 40.00, 42.49, 42.49, 44.99 and 40.00 respectively. T_2, T_7, T_{11}, T_{12} and T_{13} were on par. Also, T_3, T_4, T_5, T_8, T_9, T_{10} and T_{14} were on par.

4.2.2 Lab studies on deterrency to Epilachna

4.2.2.1 Percentage deterrency to Epilachna after 2 hours

A close perusal of Table 6 showed that plants sprayed neem oil + garlic (T_7) deterred the most (60 per cent) while control showed no deterrency. It was found that plants sprayed with neem oil (T_6), A. *paniculata* + garlic (T_8), combination of *A. paniculata* + garlic plus neem oil (T_{10}), neem oil + *H. suaveolens* (T_{11}) and *A. paniculata* (T_{13}) with percentage deterrency of 55.02 in T_6, 50.00 each in T_8, T_{10} and T_{11} and 44.97 in T_3 were on par with each other.

4.2.2.2 Percentage deterrency to Epilachna after 24 hours

Table 6 showed that the percentage deterrency of Epilachna after 24 hours ranged from 85.35 in neem oil + *H. suaveolens* (T_{11}) to 5.27 in control (T_{15}). Malathion 0.1 per cent + garlic (T_7), *H. suaveolens* + garlic (T_9), combination of neem oil plus *H. suaveolens* + garlic (T_{12}) and combination of *A. paniculata* plus neem oil + garlic (T_{14}) with 80 per cent deterrency were on par with T_{11}.

4.2.3 Lab studies on deterrency to Leucinodes

4.2.3.1 Percentage deterrency to Leucinodes

Highest deterrency of 99.99 per cent (Table 6) was recorded with neem oil emulsion (T_6), neem oil + garlic (T_7), combination of *A. paniculata* + garlic plus neem oil (T_{10}), neem oil + *H. suaveolens* (T_{11}), combination of neem oil plus *H. suaveolens* + garlic (T_{12}), combination of neem oil + garlic plus *H. suaveolens* (T_{13}) and combination of *A. paniculata* plus neem oil + garlic (T_{14}). It was found that T_2, T_6, T_7, T_{10}, T_{11}, T_{12}, T_{13} and T_{14} were on par with each other. The percentage deterrency was 24.83 percent in control (T_{15}).

4.2.4 Lab studies of toxicity

4.2.4.1 Percentage mortality of aphids

Table 7 showed malathion 0.1 per cent + garlic (T_2) recorded the maximum mortality percentage of 92.69 while the control recorded the least (12.39). Combination of neem oil + garlic plus *H. suaveolens* (T_{13}) with the percentage mortality of 89.99 was on par with T_2. The percentage mortality was 82.57 with malathion 0.1 per cent (T_1) and neem oil emulsion (T_6). Further. T_{11} (70.12) was on par with T_{12} (70.00). The percentage mortality was only 32.47 per cent in combination of *A. paniculata* + garlic plus neem oil emulsion.

4.2.4.2 Percentage mortality of Epilachna

The percentage mortality of Epilachna (Table 7) ranked the highest in malathion 0.1 per cent (T_1) and with garlic (T_2) being 99.99 per cent. There was no mortality in control (T_{15}) and *A. paniculata* (T_3). The percentage

Table 7 Percentage mortality of major pests of brinjal under different treatments

Treatment	Aphids	Epilachna	Leucinodes
T_1	82.57 (65.30)	99.99 (90.00)	35.00
T_2	92.70 (74.29)	99.99 (90.00)	40.00
T_3	32.48 (34.73)	0 (0)	0
T_4	52.50 (46.42)	44.97 (42.10)	0
T_5	35.00 (36.26)	29.50 (32.89)	16.66
T_6	82.57 (65.30)	60.00 (50.75)	100.00
T_7	75.17 (60.09)	60.00 (50.75)	100.00
T_8	52.50 (46.42)	30.00 (33.20)	75.00
T_9	52.50 (46.42)	40.00 (39.22)	50.00
T_{10}	32.48 (34.73)	29.50 (32.86)	100.00
T_{11}	70.12 (56.84)	88.75 (32.86)	100.00
T_{12}	70.00 (56.77)	50.00 (44.98)	100.00
T_{13}	89.99 (71.54)	70.50 (57.08)	100.00
T_{14}	40.00 (39.21)	24.83 (29.88)	100.00
T_{15}	12.39 (20.60)	0 (0)	0
CD	5.5654	18.38	

Figures in parenthesis denote transformed values

$\sqrt{x+1}$ transformation

mortality was 88.74 per cent in combination of neem oil + *H. suaveolens*. T_4 (44.99), T_6 and T_7 (60.00), T_9 (40.00) and T_{12} (50.00) were on par with each other.

4.2.4.3 Percentage mortality of *L. orbonalis*

Table 7. showed the percentage mortality was 100 per cent (Plate 2) in all the treatments containing neem oil. There were no pin holes on the treated fruits. The percentage mortality was 75 per cent in *H. suaveolens* alone (T_8) and 50 per cent in *H. suaveolens* + garlic (T_9). No mortality was observed in T_3, T_4 and T_{15} (Plate 3). It was 35 and 40 per cent in Malathion alone (T_1) and with garlic (T_2) respectively.

4.3 Pest management trial in brinjal at the Instructional Farm, College of Agriculture, Vellayani

4.3.1 Mean count of jassid at different intervals after application of different treatments

The result has been expressed as the mean count of jassids per leaf with respect to precount.

The mean count of jassid 24 hrs after spraying of different treatment (Table 8) was found not significant. However, one week after application of treatments, there was a significant increase in the mean count of jassids with the control recording the maximum of 0.37. The plot treated with combination of neem oil + garlic plus *H. suaveolens* (T_9) recorded the minimum mean count of 0.02. Combination of neem oil plus *H. suaveolens* +

Table 8 Mean population of jassids at different intervals after spraying (no./leaf)

Intervals	Treatments										CD
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	
Pre count	0.08 (1.04)	0.29 (1.14)	0.46 (1.21)	0.14 (1.07)	0.08 (1.04)	0.19 (1.09)	0.28 (1.13)	0.25 (1.12)	0.39 (1.18)	0.23 (1.11)	NS
24 hours after I application of treatments	-	-	-	-	-	-	-	-	-	-	NS
1 week after I application of treatments	0.06 (1.03)	0.06 (1.03)	0.19 (1.09)	0.08 (1.04)	0.08 (1.04)	0.14 (1.07)	0.04 (1.02)	0.04 (1.02)	0.02 (1.01)	0.37 (1.17)	0.0336
2 week after I application of treatments	0.25 (1.12)	0.21 (1.10)	0.51 (1.23)	0.42 (1.19)	0.37 (1.17)	0.46 (1.21)	0.39 (1.18)	0.32 (1.15)	0.21 (1.10)	0.59 (1.26)	0.0873
4 weeks after I application of treatments	0.46 (1.20)	0.32 (1.15)	0.63 (1.28)	0.41 (1.18)	0.40 (1.18)	0.65 (1.28)	0.29 (1.13)	0.34 (1.15)	0.16 (1.07)	0.77 (1.33)	0.0581
5 weeks after I application of treatments	1.36 (1.53)	1.10 (1.45)	1.43 (1.55)	0.78 (1.33)	0.61 (1.26)	1.23 (1.49)	0.76 (1.32)	0.70 (1.30)	0.66 (1.28)	1.64 (1.62)	0.0570
24 hours after II application of treatments	-	-	-	-	-	-	-	-	-	-	NS
1 weeks after II application of treatments	0.06 (1.02)	0.05 (1.02)	0.52 (1.23)	0.12 (1.05)	0.08 (1.03)	0.14 (1.06)	0.04 (1.01)	0.03 (1.01)	0.03 (1.01)	1.74 (1.65)	0.0258
2 weeks after II application of treatments	0.18 (1.08)	0.20 (1.09)	0.51 (1.22)	0.25 (1.12)	0.22 (1.10)	0.18 (1.08)	0.12 (1.06)	0.12 (1.06)	0.11 (1.06)	1.76 (1.66)	0.0233
3 weeks after II application of treatments	0.42 (1.19)	0.40 (1.18)	0.63 (1.27)	0.34 (1.16)	0.36 (1.16)	0.60 (1.26)	0.25 (1.11)	0.22 (1.10)	0.18 (1.08)	1.83 (1.68)	0.0265
4 weeks after II application of treatments	0.72 (1.31)	0.57 (1.25)	0.98 (1.40)	0.59 (1.26)	0.56 (1.24)	0.57 (1.25)	0.49 (1.22)	0.36 (1.16)	0.34 (1.15)	1.86 (1.69)	0.0437
5 weeks after II application of treatments	0.87 (1.36)	0.74 (1.31)	1.30 (1.51)	0.66 (1.28)	0.70 (1.30)	0.93 (1.39)	0.77 (1.33)	0.75 (1.32)	0.58 (1.25)	2.00 (1.73)	0.0463

Figures in parenthesis denote transformed values $\sqrt{x+1}$ transformation

garlic (T_8) and neem oil + *H. suaveolens* (T_7) recorded mean count of 0.04 while malathion 0.1 per cent alone (T_1) and with garlic (T_2) recorded 0.06. The plot treated with garlic alone (T_3) showed mean count of 0.19. T_1, T_2, T_4, T_5, T_7, T_8 and T_9 were on par with each other.

Two weeks after first application of treatments the mean count ranged from maximum of 0.59 in control (T_{10}) to minimum of 0.21 in each of T_4 i.e., malathion 0.1 per cent + garlic. The garlic (T_3) treated plot recorded 0.51. T_1, T_2, T_5, T_7, T_8 and T_9 were found to be on par with each other. Also T_3, T_6 and T_{10} were on par.

Four weeks after first application of treatments, maximum mean count was recorded in the control plot (0.77) and minimum mean count of 0.16 in plot sprayed with combination of neem oil + garlic plus *H. suaveolens* (T_9). Neem oil + *H. suaveolens* i.e., T_7 with mean count of 0.29 was on par with T_9. Also T_4, T_5, T_2 and T_8 were on par. T_3 was on pr with T_6.

Five weeks after first application of treatments, the same trend was observed with T_{10} recording maximum mean count (1.64) and T_9 recording minimum mean count (0.66). T_4, T_5, T_7, T_8 and T_9 were on par with each other. T_3 recorded 1.43 but was not on par with control.

As before, the mean count of jassids 24 hrs after second application of treatments was not significant. The population was less in all the treated plots. The control (T_{10}) recorded the maximum population of 4.74 and plot treated with combination of neem oil + garlic plus *H. suaveolens* (T_9) and combination of neem oil plus *H. suaveolens* + garlic (T_8) the least (0.03), T_1, T_2, T_5, T_7, T_8 and T_9 were on par with each other.

Observations recorded two weeks after second application of treatments showed that the mean count of jassids ranged from maximum of 1.76 in T_{10} to minimum of 0.11 in T_9. There was no significant difference between T_9 (0.11), T_8 and T_9 each with 0.12. Besides T_1, T_2 and T_6 were on par with each other.

The number of insects ranged from 1.83 in T_{10} to 0.18 in T_9 when the observations were recorded three weeks after second application of treatments. The mean count of jassids was 0.63 in plots treated with garlic (T_3) and 0.60 in plots treated with *H. suaveolens* + garlic (T_6). T_9 and T_8 showed no significant difference among themselves. Also, T_1 and T_2 doesn't differ significantly.

Four weeks after second application of treatments, it was observed that there was an increase in the jassid population than the preceding week. Here again the same trend was observed with T_{10} recording maximum mean count (1.86) and T_9 the minimum (0.34). T_8 with 0.36 was on par with T_9. T_3 (0.98) recorded a population only a little less than control but was not on par with it. T_2, T_4, T_5 and T_6 were found to be on par.

The maximum mean count of jassids recorded 2.00 in control plot five weeks after second application of treatments. The mean count was 0.58 in T_9 followed by 0.66 in T_4. T_3 recorded a population of 1.30. There was no significant difference between T_9 and T_4 as well as T_2, T_5, T_7 and T_8. Also, T_1 was on par with T_6.

4.3.2 Mean number of leaves damaged by jassids at different intervals after application of treatments

Extent of damage done by jassids was expressed as the mean number of leaves damaged by pest.

Observations recorded one week after first application of treatments revealed (Table 9) that the damage was the maximum in control plot (T_{10}) with 0.15 leaves damaged per plant while it was minimum in plot treated with neem oil (T_4) with only 0.003 leaves damaged per plant. The plots treated with combination of neem oil plus *H. suaveolens* + garlic (T_8) and combination of neem oil + garlic plus *H. suaveolens* (T_9) recorded a mean count of 0.003 and 0.02 respectively. There was no significant difference among the different treatments, though all treatments differ significantly from the control.

After two weeks, the same trend was observed with the control (T_{10}) recording maximum mean number of damaged leaves (0.22) and T_9 recording the minimum (0.01). T_9 was followed by T_7 (0.11). T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 were on par. Also, T_1 was on par with T_{10}.

There was a gradual increase in the mean number of damaged leaves than the previous observations. The control plot exhibited 0.55 damaged leaves per plant whereas it was only 0.05 in plot treated with combination of neem oil plus *H. suaveolens* + garlic. T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 exhibited no significant difference among themselves. Also T_1 was on par with T_{10}.

Table 9 Mean number of damaged leaves per plant due to jassids at different intervals after application of treatments

Intervals	Treatments										CD
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	
Pre count	0 (1)	0.05 (1.0256)	0.10 (1.0510)	0.05 (1.0256)	0 (1)	0 (1)	0.21 (1.1005)	0.10 (1.0513)	0.32 (1.1498)	0 (1)	NS
1 week after I application of treatments	0.04 (1.0212)	0.05 (1.0240)	0.11 (1.0522)	0.003 (0.9983)	0.04 (1.0212)	0.04 (1.0212)	0.01 (1.0065)	0.003 (1.0019)	0.02 (1.0119)	0.15 (1.0726)	0.0715
2 week after I application of treatments	0.17 (1.0799)	0.11 (1.0524)	0.16 (1.0759)	0.11 (1.0524)	0.06 (1.0286)	0.11 (1.0542)	0.04 (1.0213)	0.05 (1.0248)	0.01 (0.9920)	0.22 (1.1053)	0.0842
4 weeks after I application of treatments	0.38 (1.1763)	0.33 (1.1529)	0.27 (1.1261)	0.27 (1.1257)	0.16 (1.0763)	0.15 (1.0760)	0.11 (1.0521)	0.05 (1.0258)	0.05 (1.0275)	0.55 (1.2452)	0.1260
5 weeks after I application of treatments	0.79 (1.3367)	0.77 (1.3323)	0.94 (1.3923)	0.72 (1.3118)	0.67 (1.2940)	0.94 (1.3946)	0.64 (1.2805)	0.55 (1.2445)	0.57 (1.2525)	1.06 (1.4361)	0.1082
1 weeks after II application of treatments	0.55 (1.2470)	0.55 (1.2463)	0.60 (1.2668)	0.49 (1.2225)	0.44 (1.2020)	0.72 (1.3109)	0.55 (1.2442)	0.38 (1.1767)	0.43 (1.1978)	1.16 (1.4712)	0.0828
2 weeks after II application of treatments	0.89 (1.3741)	0.77 (1.3316)	0.99 (1.4119)	0.72 (1.3103)	0.72 (1.3107)	0.94 (1.3946)	0.71 (1.3085)	0.66 (1.2883)	0.71 (1.3074)	1.70 (1.6438)	0.0717
3 weeks after II application of treatments	1.15 (1.4668)	1.05 (1.4307)	1.61 (1.6151)	0.94 (1.3933)	0.92 (1.3874)	1.19 (1.4807)	0.94 (1.3932)	0.83 (1.3520)	0.89 (1.3760)	2.21 (1.7916)	0.1422
4 weeks after II application of treatments	1.58 (1.6076)	1.34 (1.5284)	1.88 (1.6974)	1.15 (1.4655)	1.13 (1.4611)	1.66 (1.6299)	1.08 (1.4417)	1.09 (1.4470)	0.84 (1.3572)	2.72 (1.9293)	0.1640)
5 weeks after II application of treatments	1.92 (1.7093)	1.79 (1.6706)	2.46 (1.8606)	1.68 (1.6369)	1.66 (1.6300)	1.86 (1.6927)	1.32 (1.5220)	1.30 (1.5182)	1.02 (1.4215)	3.05 (2.0116)	0.1692

Figures in parenthesis denote transformed values $\sqrt{x+1}$ transformation

The mean number of damaged leaves ranged from maximum of 1.06 in T_{10} to 0.55 in T_8, 0.57 in T_9 and 0.64 in T_7. T_1, T_2, T_4, T_5, T_7, T_8 and T_9 were on par. Also T_3, T_6 and T_{10} were on par.

There was a slight reduction in the number of damaged leaves one week after second application of treatments. The number of damaged leaves ranged from 1.16 in T_{10} to 0.38 in T_8 and 0.43 in T_9. T_1, T_2, T_4, T_5, T_7, T_8 and T_9 were on par. Also T_3 and T_6 were on par.

Two weeks after second application of treatments the same trend was observed with control recording maximum of 1.70. T_8 (0.66) was followed by T_9 and T_7. T_2, T_4, T_5, T_7, T_8 and T_9 showed no significant difference among themselves. As well as T_1, T_3 and T_6 doesn't differ significantly.

During three weeks after second application of treatments, the mean number of damaged leaves ranged from 2.21 in control to 0.83 in T_8 followed by T_9 with mean count of 0.89. T_1, T_2, T_4, T_5, T_6, T_7, T_8 and T_9 were on par with each other.

The mean number of damaged leaves was the highest in control (2.72) when the observations were recorded four weeks after second application of treatments whereas the plots sprayed with combinations of neem oil + garlic plus *H. suaveolens* (T_9) recorded the least mean count of 0.84. T_7 and T_8 recorded mean count of 1.08 and 1.09 respectively. T_4, T_5, T_7, T_8 and T_9 were on par with each other.

The mean count of damaged leaves ranged from a maximum of 3.05 in T_{10} to 1.02 in T_9. On par with T_9 was T_8 (1.30) and T_7 (1.32). Also T_1, T_2, T_4, T_5 and T_6 were on par with each other.

4.3.3 Mean count of whiteflies after application of different treatments at different intervals

There was a reduction in the mean number of whiteflies (Table 10) twenty four hrs after first application of treatments in all the plots except control. In control the mean number of whiteflies was 1.45 which was the maximum while the plot sprayed with malathion 0.1 per cent + garlic (T_2) was completely free of pest. T_2 was followed by T_1 i.e., malathion 0.1 per cent with mean count of 0.05. T_1 and T_2 as well as combination of *H. suaveolens* + garlic (T_6), combination of neem oil + *H. suaveolens* (T_7) and combination of neem oil + garlic plus *H. suaveolens* (T_9) doesn't differ significantly.

One week after first application of treatments, the mean number of whiteflies ranged from maximum of 2.15 in T_{10} to 0.17 in T_2 and 0.18 in T_1. T_1 and T_2 as well as T_6 and T_7 were found to be on par with each other. Also, T_4, T_5, T_8 and T9 doesn't differ significantly. The population in garlic treated plot (T_3) was 1.42.

Two weeks after first application of treatments, the mean count was the highest in control plot (1.99) while it was 0.80, 0.89 and 0.91 in T_8, T_9 and T_4 respectively. The mean count was 1.42 in T_3. T_4, T_5, T_6, T_8 and T_9 were found to be on par with each other.

Observations recorded four weeks after first application of treatments revealed an increase in the population than the previous observation with 2.28 in T_{10} to 0.56 and 0.59 in T_9 and T_8 respectively. Here again T_3 recorded a higher mean count of 1.64. T_8 and T_9 were on par. Also T_4, T_5 and T_7 were on par with each other.

Table 10 Mean population of whiteflies per leaf at different intervals after application of treatments

Intervals	Treatments										CD
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	
Pre count	2.14 (1.7730)	1.16 (1.4685)	1.54 (1.5952)	1.79 (1.6696)	1.73 (1.6523)	1.67 (1.6348)	1.91 (1.7052)	1.61 (1.6148)	1.88 (1.6970)	1.37 (1.5388)	NS
24 hours after I application of treatments	0.05 (1.0231)	0.00 (1.0011)	0.62 (1.2728)	0.61 (1.2697)	0.55 (1.2458)	0.24 (1.1145)	0.40 (1.1837)	0.14 (1.0678)	0.14 (1.0704)	1.45 (1.5663)	0.0632
1 week after I application of treatments	0.18 (1.0858)	0.17 (1.0823)	1.42 (1.5561)	0.84 (1.3569)	0.84 (1.3572)	1.18 (1.4755)	1.11 (1.4556)	0.76 (1.3258)	0.76 (1.3275)	2.15 (1.7764)	0.1374
2 weeks after I application of treatments	1.32 (1.5227)	1.18 (1.4763)	1.42 (1.5571)	0.91 (1.3807)	0.89 (1.3747)	0.93 (1.3914)	1.04 (1.4300)	0.80 (1.3418)	0.89 (1.3746)	1.99 (1.7305)	0.0616
4 weeks after I application of treatments	1.50 (1.5799)	1.28 (1.5094)	1.64 (1.6254)	0.98 (1.4062)	1.03 (1.4262)	1.41 (1.5539)	0.98 (1.4082)	0.59 (1.2638)	0.56 (1.2497)	2.28 (1.8118)	0.0610
5 weeks after I application of treatments	2.42 (1.8484)	2.32 (1.8217)	2.53 (1.8786)	1.55 (1.5963)	1.54 (1.5932)	1.77 (1.6633)	1.20 (1.4838)	1.18 (1.4756)	1.03 (1.4268)	3.63 (2.1515)	0.0572
24 hours after II application of treatments	-	-	-	-	-	-	-	-	-	-	NS
1 week after II application of treatments	0.66 (1.2897)	0.58 (1.2577)	1.31 (1.5191)	0.61 (1.2694)	0.56 (1.2512)	1.06 (1.4363)	0.54 (1.2405)	0.49 (1.2208)	0.47 (1.2115)	5.44 (2.5373)	0.0503
2 weeks after II application of treatments	1.14 (1.4638)	0.53 (1.2370)	2.00 (1.4485)	0.43 (1.1944)	0.39 (1.1811)	0.54 (1.2430)	0.42 (1.1934)	0.30 (1.1403)	0.31 (1.1441)	5.72 (2.5933)	0.0547
3 weeks after II application of treatments	1.42 (1.5549)	1.39 (1.5452)	1.31 (1.5187)	0.86 (1.3649)	0.79 (1.3389)	1.19 (1.4793)	0.76 (1.3278)	0.55 (1.2434)	0.10 (1.2153)	6.79 (2.7920)	0.0779
4 weeks after II application of treatments	1.78 (1.6672)	1.59 (1.6098)	2.30 (1.8178)	1.63 (1.6220)	1.53 (1.5912)	1.94 (1.7155)	1.49 (1.5782)	1.46 (1.5684)	1.16 (1.4700)	7.07 (2.8419)	0.0622
5 weeks after II application of treatments	2.42 (1.8505)	2.31 (1.8200)	2.39 (1.8425)	2.11 (1.7650)	1.98 (1.7267)	1.77 (1.6651)	1.48 (1.5752)	1.39 (1.5460)	1.21 (1.4853)	7.29 (2.8807)	0.0764

Figures in parenthesis denote transformed values $\sqrt{x+1}$ transformation

An increasing trend in the mean number of whiteflies continued during five weeks after first application of treatments also. The maximum mean count was in T_{10} (3.63) and the minimum mean count in T_9 with 1.03 followed by T_8 with 0.49. The mean count was higher in T_3 (2.53) and T_1 (2.42). T_7, T_8 and T_9 as well as T_1, T_2 and T_3 were on par. Also T_4 was on par with T_5.

There was a sudden decrease in the whitefly population at 24 hrs after second application of treatments and it was not significant.

A general increase in the whitefly population was observed one week after second application of treatments. The mean count ranged from 5.44 in control (T_{10}) to 0.47 in plot treated with combination of neem oil + garlic plus *H. suaveolens* (T_9). It was 0.49 and 0.54 in T_8 and T_7 respectively. T_2, T_5, T_7, T_8 and T_9 were on par with each other. Also T_1 was on par with T_4.

Two weeks after second application of treatments, the control was found to harbour more pests with the maximum mean count of 5.72. It was the least in T_8 followed by T_9 and subsequently by T_5. T_1 and T_3 were left with the mean count of 1.14 and 2.00 respectively. T_4, T_5, T_7, T_8 and T_9 were on par with each other. Also T_2 and T_6 were on par.

The maximum mean count in control was 6.79 (T_{10}) and the minimum mean count was 0.10 in T_9 closely followed by 0.55 in T_8. T_8 and T_9 were found to be on par. T_1 (1.42) and T_2 (1.39) recorded more number of pest than T_3 (1.31). T_4, T_5 and T_7 were on par with each other.

There was an increasing trend in the mean count of whiteflies four weeks after second application of treatments with the control recording the

maximum mean count of 7.07 and plot treated with combination of neem oil + garlic plus *H. suaveolens* (T_9) recording the minimum mean count of 1.16. It was 1.46, 1.49 and 1.53 in T_8, T_7 and T_5 respectively.

The maximum mean count of whiteflies five weeks after second application of treatments was at the control plot (7.29) and minimum at T_9 (1.21) followed by T_8 (1.39) and T_7 (1.48). The mean count was 1.31, 2.39 and 2.42 in T_2, T_3 and T_1 respectively. T_8 was on par with T_9 and T_4 with T_5. Besides T_1, T_2 and T_3 were on par.

4.3.4 Mean number of leaves damaged by whiteflies at different intervals after application of various treatments

The results were expressed as the mean number of damaged leaves per plant.

One week (Table 11) after first application of treatments, maximum mean count of damaged leaves was found in control (1.27) and minimum mean count was in plot treated with malathion 0.1 per cent + garlic i.e., T_2 (0.38) followed by malathion 0.1 per cent alone (T_1). Malathion 0.1 per cent alone (T_1), malathion 0.1 per cent + garlic (T_2), neem oil emulsion alone (T_4) and with garlic (T_5), neem oil + *H. suaveolens* (T_7), combination of neem oil plus *H. suaveolens* + garlic (T_8) and combination of neem oil + garlic plus *H. suaveolens* (T_9) were found to be on par.

After two weeks the mean number of damaged leaves ranged from 1.56 in control to 0.38 in T_9 followed by 0.49 in T_8. T_3 and T_6 recorded a higher mean count of 1.20 and 0.99 respectively. T_8 was on par with T_9. Further T_2, T_4 and T_5 were on par.

Table 11 Mean number of damaged leaves per plant due to whiteflies at different intervals after application of treatments

Intervals	Treatments										CD
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	
Pre count	4.29 (2.2998)	4.27 (2.2963)	4.32 (2.3307)	4.34 (2.3101)	4.26 (2.2927)	4.48 (2.3421)	4.57 (2.3611)	4.48 (2.3401)	4.40 (2.3244)	4.35 (2.3129)	NS
1 week after I application of treatments	0.38 (1.1756)	0.38 (1.1742)	1.14 (1.4540)	0.55 (1.2452)	0.49 (1.2228)	0.66 (1.2900)	0.50 (1.2248)	0.40 (1.1851)	0.27 (1.1280)	1.27 (1.5069)	0.0840
2 weeks after I application of treatments	0.77 (1.3317)	0.72 (1.3101)	1.22 (1.4895)	0.66 (1.2885)	0.55 (1.2462)	0.99 (1.4119)	0.77 (1.3308)	0.49 (1.2219)	0.38 (1.1758)	1.56 (1.6009)	0.0684
4 weeks after I application of treatments	1.17 (1.4726)	1.00 (1.4128)	1.38 (1.5431)	1.00 (1.4128)	0.78 (1.3342)	1.54 (1.5930)	0.88 (1.3733)	0.60 (1.2654)	0.49 (1.2230)	3.16 (2.0408)	0.0856
5 weeks after I application of treatments	2.72 (1.9284)	2.38 (1.8399)	3.00 (1.9999)	1.66 (1.6326)	1.56 (1.5996)	1.60 (1.6133)	1.53 (1.5915)	1.11 (1.4519)	1.00 (1.4129)	4.33 (2.3087)	0.0863
1 week after II application of treatments	2.46 (1.8593)	2.24 (1.8002)	2.86 (1.9650)	1.57 (1.6020)	1.44 (1.5624)	1.45 (1.5669)	1.31 (1.5191)	0.91 (1.3841)	0.99 (1.4137)	4.93 (2.4348)	0.0754
2 weeks after II application of treatments	2.65 (1.9100)	2.62 (1.9017)	3.48 (2.1170)	2.00 (1.7320)	1.84 (1.6851)	2.21 (1.7911)	1.81 (1.6779)	1.15 (1.4693)	1.33 (1.5253)	5.33 (2.5162)	0.0646
3 weeks after II application of treatments	3.18 (2.0445)	2.85 (1.9628)	3.94 (2.2235)	2.33 (1.8238)	2.17 (1.7797)	2.54 (1.8805)	2.02 (1.7390)	1.48 (1.5759)	1.48 (1.5740)	5.75 (2.5984)	0.0472
4 weeks after II application of treatments	3.61 (2.1466)	3.28 (2.0683)	4.58 (2.3634)	2.82 (1.9546)	2.66 (1.9143)	3.27 (2.0668)	2.50 (1.8710)	1.94 (1.7142)	1.95 (1.7165)	6.38 (2.7170)	0.0375
5 weeks after II application of treatments	4.00 (2.2372)	3.69 (2.1662)	4.93 (2.4356)	3.09 (2.0233)	3.08 (2.0199)	3.71 (2.1698)	2.81 (1.9525)	2.27 (1.8084)	2.27 (1.8080)	7.00 (2.8285)	0.0230

Figures in parenthesis denote transformed values $\sqrt{x+1}$ transformation

Four weeks after first application of treatments the same trend was observed with the count ranging from 3.16 to 0.49 in T_{10} and T_9 respectively. T_8 was on par with T_9.

The trend remained the same when the observations were taken five weeks after first application of treatments. Mean number ranged from 4.33 (T_{10}) to 1.00(T_9), 1.11(T_8) and 1.53 (T_7). T_3, T_1 and T_2 recorded 3.00, 2.72 and 2.38 damaged leaves per plant. T_8 and T_9 as well as T_4, T_5, T_6 and T_7 were on par with each other.

There was a slight reduction in the mean number of damaged leaves as revealed from the observations taken one week after first application of treatments. The maximum mean count of 4.93 and minimum mean count of 0.91 and 0.99 were recorded in T_{10}, T_8 and T_9 respectively. T_8 and T_9 doesn't differ significantly. The mean number of damaged leaves was more in T_3 being 2.86. T_4, T_5 and T_6 were found to be on par.

The trend was the same at two, three and four weeks after second application of treatments. The maximum mean count at control recorded 5.33, 5.75 and 6.38 respectively. The mean count at T_8 and T_9 were 1.15, 1.57, 1.94 and 1.33, 1.57 and 1.95 respectively. T_8 and T_9 doesn't differ significantly in all cases

Five weeks after second application of treatments the maximum mean number of damaged leaves was found in control (7.00) and minimum mean count in T_9 (2.27) followed by T_8. The plot treated with garlic (T_3) recorded higher mean count of 4.93. T_7, T_8 and T_9 were on par. Also T_1, T_2, T_4 and T_5 were found to be on par with each other.

4.3.5 Mean count of Leucinodes larvae at different intervals under different treatments

The result was expressed as mean number of Leucinodes larvae per branch.

Though there was incidence of Leucinodes (Table 12) before application of treatments, after application of treatments there was a sudden reduction in the population of Leucinodes. The control plot recorded the maximum mean count of 2.14 and plot treated with combination of neem oil + garlic plus *H. suaveolens* (T_9), the minimum mean count of 0.92 followed by 0.99 in plot treated with combination of neem oil plus *H. suaveolens* (T_7) as revealed from observation taken five weeks after first application of treatments. It was found that T_4, T_5, T_6, T_7, T_8 and T_9 were on par.

The mean count of Leucinodes in the control increased from 2.48 at one week after second application of treatments to 3.14 and further increased to 3.66 at second and third week after second application of treatments. The minimum mean count at one, two and third week after second application of treatments was recorded in T_9 (0.64), T_7 (0.65) and 0.11 each at T_8 and T_9 respectively. The mean count was 1.05 each at T_5 and T_7 and 1.15 in T_8 as revealed from the observations taken one week after second application of treatments. T_1, T_2, T_3, T_7, T_8 and T_9 were found to be on par. Two weeks after second application of treatments T_1, T_2, T_4, T_5, T_6, T_7, T_8 and T_9 were on par. The mean count of T_8 and T_9 was 0.71 and 0.11 respectively at two and three weeks after application of treatments. T_4, T_5, T_6, T_7, T_8 and T_9 were found to be on par at three weeks after second application of treatments.

Table 12 Mean count of Leucinodes per branch at different intervals after application of treatments

Intervals	Treatments										CD
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	
Pre count	2.85 (1.9634)	2.80 (1.9504)	2.95 (1.9883)	2.43 (1.8527)	2.53 (1.8795)	2.21 (1.7906)	2.46 (1.8595)	2.43 (1.8527)	2.40 (1.8437)	2.46 (1.8615)	NS
1 week after I application of treatments	-	-	-	-	-	-	-	-	-	-	NS
2 weeks after I application of treatments	-	-	-	-	-	-	-	-	-	-	NS
4 weeks after I application of treatments	-	-	-	-	-	-	-	-	-	-	NS
5 weeks after I application of treatments	1.58 (1.6060)	1.45 (1.5661)	1.98 (1.7264)	1.21 (1.4856)	1.10 (1.4491)	1.29 (1.5139)	0.99 (1.4096)	1.04 (1.4278)	0.92 (1.3849)	2.14 (1.7721)	0.1680
1 week after II application of treatments	1.40 (1.5482)	1.33 (1.5269)	1.66 (1.6308)	1.21 (1.4873)	1.05 (1.4308)	1.53 (1.5916)	1.05 (1.4313)	1.15 (1.4661)	0.64 (1.2864)	2.48 (1.8662)	0.1563
2 weeks after II application of treatments	0.96 (1.3994)	0.90 (1.3780)	1.52 (1.5869)	0.76 (1.3283)	0.71 (1.3097)	0.86 (1.3655)	0.65 (1.2868)	0.71 (1.3068)	0.71 (1.3071)	3.14 (2.0361)	0.1467
3 weeks after II application of treatments	0.31 (1.1471)	0.38 (1.1732)	0.87 (1.3672)	0.16 (1.0786)	0.21 (1.1027)	0.28 (1.1332)	0.16 (1.0784)	0.11 (1.0531)	0.11 (1.0536)	3.66 (2.1586)	0.1101
4 weeks after II application of treatments	0.87 (1.3662)	0.86 (1.3644)	2.07 (1.7525)	1.00 (1.4169)	0.89 (1.3736)	1.35 (1.5340)	0.94 (1.3939)	0.84 (1.3555)	0.61 (1.2709)	3.99 (2.2343)	0.1119
5 weeks after II application of treatments	1.62 (1.6204)	1.48 (1.5742)	2.30 (1.8163)	1.53 (1.5895)	1.39 (1.5456)	1.09 (1.4455)	0.74 (1.3188)	0.69 (1.2998)	0.59 (1.2603)	5.18 (2.4866)	0.1326

Figures in parenthesis denote transformed values $\sqrt{x+1}$ transformation

Four weeks after second application of treatments, the mean count ranged from the maximum of 3.99 in T_{10} to 0.61 and 0.84 in T_9 and T_8 respectively. T_1, T_2, T_5, T_8 and T_9 were on par. Besides T_4 was on par with T_7.

The population as revealed from the observations taken five weeks after second application of treatments recorded the maximum mean count of 5.18 in control (T_{10}) and minimum mean count of 0.59 in plot treated with combination of neem oil + garlic plus *H. suaveolens* (T_9) followed by 0.69 and 0.74 in T_8 and T_7 respectively. T_3 was left with population of 1.85. T_7, T_8 and T_9 were on par. Besides T_1, T_2, T_4 and T_5 were found to be on par.

4.3.6 Extent of damage by Leucinodes at different intervals after application of various treatments

Damage by Leucinodes was expressed in terms of percentage of affected branches after first application of treatments and percentage of affected fruits after second application of treatments.

One week after first application of treatments (Table 13) it was found that there was a general reduction in the extent of damage by Leucinodes. However, the control plot recorded the highest damage of 29.03 per cent while it was the lowest in plots treated with combination of *H. suaveolens* + garlic (T_6) being 18.98. There was no significant difference among the treatments Malathion 0.1 per cent + garlic (T_2), Garlic (T_3), neem oil emulsion + garlic (T_5), combination of *H. suaveolens* + garlic (T_6), Neem oil emulsion + *H. suaveolens* (T_7), combination of neem oil plus *H. suaveolens* + garlic (T_8) and combination of neem oil + garlic plus *H. suaveolens* (T_9) exhibiting percentage damages of 21.32, 21.56, 19.85, 18.98, 21.42, 21.43 and 19.20 respectively.

Table 13 Extent of damage due to Leucinodes at different intervals after application of treatments (in percentage)

Intervals	Treatments										CD
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	
Pre count	26.39 (5.2342)	27.99 (5.3841)	30.01 (5.5763)	24.57 (5.0563)	24.66 (5.0683)	23.05 (4.9041)	26.64 (5.2576)	24.97 (5.0965)	25.85 (5.1816)	23.61 (4.9608)	NS
1 week after I application of treatments	23.48 (4.9476)	21.32 (4.7241)	21.56 (4.7494)	22.40 (4.8371)	19.85 (4.5661)	18.98 (4.4696)	21.42 (4.7347)	21.43 (4.7359	19.20 (4.4947)	29.03 (5.4802)	0.3449
2 weeks after I application of treatments	21.98 (4.7937)	21.32 (4.5675)	21.96 (4.7915)	20.42 (4.6290)	20.00 (4.5826)	19.08 (4.4811)	21.30 (4.7227)	19.68 (4.5479)	18.15 (4.3760)	29.75 (5.5455)	0.0336
4 weeks after I application of treatments	21.98 (4.6211)	20.65 (4.6527)	24.01 (5.0010)	18.37 (4.4030)	20.76 (4.6646)	18.52 (4.4188)	21.95 (4.7909)	18.23 (4.3851)	17.03 (4.2463)	29.93 (5.5613)	0.2620
5 weeks after I application of treatments	28.00 (5.3848)	25.36 (5.1346)	28.92 (5.4704)	24.16 (5.0158)	21.49 (4.7428)	24.93 (5.0920)	26.47 (5.2410)	23.36 (4.9359)	20.67 (4.6552)	36.35 (6.1114)	0.2523
1 week after II application of treatments	21.54 (4.7480)	21.34 (4.7261)	35.89 (6.0734)	21.39 (4.7317)	19.87 (4.5684)	25.25 (5.1237)	21.62 (4.7561)	18.74 (4.4434)	11.72 (3.5672)	41.06 (6.4856)	0.2918
2 weeks after II application of treatments	10.61 (3.4079)	11.67 (3.5602)	27.76 (5.3628)	9.27 (3.2052)	8.63 (3.1804)	24.49 (5.0486)	18.11 (4.3721)	17.90 (4.3473)	15.06 (4.0080)	46.72 (6.9079)	0.3132
3 weeks after II application of treatments	14.11 (3.8879)	15.16 (4.0198)	16.62 (4.1983)	14.83 (3.9789)	14.66 (3.9574)	18.13 (4.3743)	15.70 (4.0863)	14.30 (3.9120)	11.90 (3.5922)	50.59 (7.1828)	0.2375
4 weeks after II application of treatments	28.10 (5.3946)	31.15 (5.6704)	33.61 (5.8830)	31.25 (5.6790)	29.56 (5.5284)	36.94 (6.1593)	17.60 (4.3129)	23.88 (4.9883)	15.26 (4.0331)	59.55 (7.7814)	0.3300
5 weeks after II application of treatments	36.40 (6.1154)	35.96 (6.0796)	41.34 (6.5073)	32.28 (5.7688)	29.49 (5.5217)	35.85 (6.0708)	26.01 (5.1973)	23.68 (4.9678)	21.39 (4.7319)	60.75 (7.8580)	0.2235

Figures in parenthesis denote transformed values $\sqrt{x+1}$ transformation

Two weeks after first application of treatments, the percentage damage ranged form 29.75 in control to 18.15 in plot treated with combination of neem oil + garlic and *H. suaveolens* (T_9). Closely following T_9 was *H. suaveolens* + garlic T_6 with 19.08 per cent damage. T_2, T_4, T_5, T_6, T_8 and T_9 were on par. Also T_1, T_3 and T_7 were on par.

The observations recorded four and five weeks after first application of treatments revealed a maximum damage percentage of 29.93 and 36.35 respectively in control whereas the minimum damage percentage in T_9 was 17.03 and 20.67 respectively. The percentage damage was 18.23 in T_8 four weeks after first application of treatments and it was found that T_4, T_6, T_8 and T_9 were on par. Also T_1, T_2 and T_5 did not differ significantly. At five weeks after first spray T_5 and T_9 as well as T_2, T_4, T_6 and T_8 was found to be on par.

There was a reduction in percentage damage of Leucinodes one week after second application of treatments. The percentage damage remained 11.72 in T_9 (Plate 6 a and 6 b) followed by 18.74 in T_8 (Plate 5 a and 5 b). Damage of percentage in T_3 was higher (35.89) but was not on par with control. T_9 was significantly different from others. T_1, T_2, T_4, T_5 and T_7 were on par with each other.

Percentage damage ranged from maximum of 46.72 in control while it was the minimum in T_5 (8.63) followed by 9.27 in T_4. T_1 and T_2 recorded 10.61 and 11.67 percentage damage respectively. T_1, T_4 and T_5 as well as T_7 and T_8 were on par.

Three weeks after second application of treatments the percentage damage was lowest in T_9 (11.90) followed by T_1 (14.11), T_8 (14.30) and T_4 (14.83). T_{10}

recorded the highest damage of 50.59. T_9 remained significantly different. T_1, T_2, T_4, T_5 and T_8 were found to be on par. Also T_3 and T_7 were on par.

Four weeks after second application of treatments, again it is the control plot which exhibited maximum damage (59.55) while the minimum damage was in plot sprayed with combination of neem oil + garlic plus *H. suaveolens* (15.26). It was found to be on par with neem oil + *H. suaveolens* (Plate 4 a and 4 b). Further T_1, T_2 and T_4 were on par.

Five weeks after second application of treatments, the percentage damage remained the highest than ever before. T_{10} recorded maximum percentage damage of 60.70 (Plates 7 a and 7 b) while T_9 and T_8 recorded 21.39 and 23.68 respectively. T_4 remained significantly different from others. T_2, T_3 and T_6 were on par with each other.

4.3.7 Population build up of aphids after application of different treatments

The aphid population is expressed as mean number of aphid per leaf. There was a slight incidence of aphid, 0.44 in T_1, 0.22 in T_4, 0.33 in T_5 and 0.02 in T_{10} when the observation were recorded before application of treatments. The aphid population completely disappeared in all the treated plots after first application of treatments. However, there was incidence of aphid in control (0.84). There was a slow increase in aphid population till four weeks after first application of treatments (1.13) in control. The population decreased to 0.81 at five weeks after first application of treatments, decreased gradually and disappeared.

4.3.8 Population build up of Epilachna after application of different treatments

The Epilachna population is expressed as the number of Epilachna grubs per leaf.

Regarding Epilachna, through the number of grubs per leaf remained non-significant being only 0.11 per leaf in T_2, 1.00 in T_5 and 0.66 in T_9, many egg masses was found to be distributed evenly in the field before first application of treatments. However, the population in all the treated plots disappeared after application of treatments as against a slow increase in control plot. At five weeks after first application of treatments, the population was 0.22 in T_5, 0.11 in T_7, T_8 and T_9. T_{10} recorded the highest population of 3.66. One week after second application of treatments, the population decreased to 0.11 in T_5 and 0.88 in T_{10}. Two weeks after second application of treatments, it was 0.22 in T_6 and 0.99 in T_{10}. In all the other plots, there was no incidence of Epilachna. However, the incidence was not observed afterwards.

4.3.9 Population buildup of natural enemies

4.3.9.1 Mean number of rove beetles per plant after application of different treatments

Mean number of rove beetles per plant is presented in Table 14.

Rove beetle (Staphylinidae : Coleoptera) appeared in the field four weeks after first application of treatments. The incidence of rove beetle was very high in plot treated with Malathion 0.1 per cent (T_1), neem oil emulsion (T_4), neem oil + garlic (T_5), combination of neem oil plus *H. suaveolens* +

Table 14 Mean number of rove beetles observed per plant after application of different treatments

Treatments	4 weeks after I application of treatments	5 weeks after I application of treatments	1 week after II application of treatments	2 weeks after II application of treatments	3 weeks after II application of treatments	4 weeks after II application of treatments	5 weeks after II application of treatments
T_1	0.33	0.66	0.66	2.66	2.66	3.66	4.66
T_2	0.66	0.66	3.00	3.66	3.00	4.00	5.33
T_3	0.00	0.33	3.00	3.66	4.00	2.66	3.33
T_4	0.33	0.66	1.66	6.66	3.66	9.00	7.66
T_5	0.33	0.66	1.33	3.66	4.00	4.66	5.00
T_6	0.00	0.33	1.33	6.33	5.33	3.66	4.33
T_7	0.00	0.66	4.66	3.66	3.33	4.00	5.33
T_8	0.33	0.66	3.33	3.33	3.33	5.33	5.66
T_9	0.33	0.66	1.00	2.33	3.33	8.33	9.00
T_{10}	0.00	1.33	3.33	6.00	7.33	10.00	12.00
CD	NS	NS	1.1314	1.2287	1.3313	1.1971	0.9756

garlic (T_8) and combination of neem oil + garlic plus *H. suaveolens* with 0.33 beetles per plot.

There was a gradual increase in the number of rove beetles at fifth week after first application of treatments and it recorded the highest population in T_{10} (1.33). T_1, T_2, T_4, T_5, T_7, T_8 and T_9 were left with the population of 0.66.

There was a sudden increase in the population one week after second application of treatments. The population was the highest in neem oil + *H. suaveolens* with 4.66. On par with this are plots treated with combination of neem oil plus *H. suaveolens* + garlic and control. T_2 and T_3 were on par with each other.

Two weeks after second application of treatments, the population showed a increase than the previous week with highest population in plot treated with neem oil (6.66). Not much less than this is *H. suaveolens* + neem treated plot (6.33) and control (6.00). The population three weeks after second application of treatments ranged from 7.33 in control to 2.66 in Malathion 0.1 per cent. T_3, T_4, T_5, T_7, T_8 and T_9 were found to be on par with each other.

Four weeks after second application of treatments, the population continued to be the highest in control (10.00) followed by T_4 (9.00). It was the least in T_1 and T_5 being 4.00. The control plot continued to be the highest reservoir of natural enemies at five weeks after second application of treatments (12.00) and the population was the least in T_6 (4.33).

4.3.9.2 Mean count of coccinellids at different intervals after application of different treatments

The mean number of coccinellids per plant is presented in Table 15.

The coccinellids were present in the field from four weeks after first application of treatments. About 1.66 coccinellids per plant was present in the plots treated with Malathion 0.1 pre count + garlic, neem oil emulsion and combination of neem oil + garlic and *H. suaveolens*. In all other plots, it was not significant.

Five weeks after first application of treatments, the plot sprayed with neem oil recorded the highest population of 2.33 per plant followed by plot sprayed with garlic (T_3) and combination of neem oil plus *H. suaveolens* + garlic (T_8) with the population being 2.00. There was no significant difference among other treatments.

It was observed that there was a slight reduction in the population one week after second application of treatments and the population remained the highest in the control plot (1.33). In all other plots, it was not significant. Similarly, at two weeks after application of treatments, the population was the highest in T_{10} and T_3 (1.33). There was no significant population in all other plots.

There was a steady increase in the predator population three weeks after the second application of treatments. The population continued to be the highest in T_{10} (2.00) followed by 1.66 in T_5, T_7, T_8 and T_9. T_1, T_2, T_4, T_5, T_6, T_7, T_8 and T_9 were on par with T_{10}.

Table 15 Mean number of coccinellids observed per plant after application of different treatments

Treatments	4 weeks after I application of treatments	5 weeks after I application of treatments	1 week after II application of treatments	2 weeks after II application of treatments	3 weeks after II application of treatments	4 weeks after II application of treatments	5 weeks after II application of treatments
T_1	1.33	1.00	0.66	0.66	1.33	1.33	2.33
T_2	1.66	1.33	0.66	1.00	1.33	2.00	2.66
T_3	1.00	2.00	1.00	1.33	1.00	1.66	1.66
T_4	1.66	2.33	1.00	0.66	1.33	2.00	2.33
T_5	0.66	1.33	1.00	1.00	1.66	2.33	2.33
T_6	1.00	1.33	1.00	1.00	1.33	3.00	2.33
T_7	1.00	1.33	0.66	0.66	1.66	3.33	3.66
T_8	1.33	2.00	0.66	1.00	1.66	2.66	3.33
T_9	1.66	1.33	0.66	0.66	1.66	3.33	3.66
T_{10}	1.00	1.33	1.33	1.33	2.00	2.00	3.33
CD	1.5966	1.3678	1.0819	1.0407	0.8236	1.9650	0.9756

After four and five weeks after second application of treatments, the population was the highest in T_7 and T_8 being 3.33 and 3.66 respectively. At four weeks after second application of treatments T_8 and T_{10} recorded 3.33. T_7, T_8, T_9 and T_{10} doesn't differ significantly. Also T_1, T_2, T_4, T_5 and T_6 were on par with each other.

4.3.9.3 Population of spiders at different intervals after application of different treatments

The mean number of spiders per plant is presented in Table 16.

Spiders, though they were present in the field right from two weeks after first application of treatments, the population was not significant till five weeks after first application of treatments. At one week after second application of treatments, the population was 3.3 in garlic treated plot (T_3) and control (T_{10}). It was 3.00 in plot treated with neem oil + *H. suaveolens* (T_7). T_{10}, T_3 and T_7 were on par.

Two weeks after second application of treatments, the population was the highest in plot treated with neem oil (T_4) being 4.00. In all other plots, the population was comparatively less. Again, at three weeks after second Four weeks after second application 4.46 and 3.66 respectively. In remained the highest in T_5 (2.66). It was closely followed by T_2, T_6, T_8, T_9 and T_{10}. At five weeks after second application of treatments, it was 2.66 in T_5 and T_6 and 2.33 in T_2, T_4 and T_{10}.

Table 16 Mean number of spiders observed per plant after application of different treatments

Treatments	2 weeks after I application of treatments	4 weeks after I application of treatments	5 weeks after I application of treatments	1 week after II application of treatments	2 weeks after II application of treatments	3 weeks after II application of treatments	4 weeks after II application of treatments	5 weeks after II application of treatments
T_1	0.33	0.66	0.33	0.66	1.33	1.66	1.00	1.33
T_2	0.00	0.00	0.33	0.66	0.33	1.00	2.33	2.33
T_3	0.33	0.33	0.33	3.33	0.33	1.00	1.66	1.66
T_4	0.33	0.66	0.00	0.66	4.00	4.66	2.00	2.33
T_5	0.00	0.33	0.33	1.00	1.66	2.00	2.66	2.66
T_6	0.00	1.00	0.33	0.33	1.00	2.33	2.33	2.66
T_7	0.33	1.66	0.00	3.00	1.66	2.00	1.33	1.66
T_8	0.33	1.33	0.33	1.00	1.00	2.00	2.33	2.00
T_9	0.00	0.66	0.66	1.66	0.66	2.33	2.33	2.00
T_{10}	0.33	1.33	0.66	3.33	2.33	3.66	2.33	2.33
CD	NS	NS	NS	1.4606	1.2551	1.2062	1.1971	1.5193

Among the parasites, *C. johnsoni* and *T. ovulorum* parasitising the grub and pupae of Epilachna was observed. However, the incidence was very low and was not significant.

4.3.10 Correlation between the weather parameters and the incidence of pests and natural enemies

The occurrence of maximum and minimum temperature, relative humidity, total rainfall, wind speed was studied from 1st December, 1999 to 25th March, 2000 and correlation worked out (Table 17).

The relative humidity of 7.22 hours had a significant negative correlation with aphid population. However, the aphid population had a significant positive correlation with maximum temperature and wind speed at 14.22 hours. Significant negative correlation was observed between whitefly population and relative humidity at 7.22 hours and significant positive correlation was observed between whitefly population with maximum temperature and wind speed at 14.22 hours. *Leucinodes orbonalis* had a significant negative correlation with RH at 7.22 hours and significant positive correlation with maximum temperature.

Regarding natural enemies, Staphylinids exhibited a significant negative relation with RH at 7.22 hours and significant positive correlation with RH at 14.22 hour, maximum temperature, wind speed at 14.22 hours and also with aphid, and *Leucinodes* population. Coccinellids exhibited significant negative correlation between RH at 7.22 hours and significant positive correlation with aphid population. Significant negative correlation was observed between RH at 7.22 hours and spiders and significant positive correlation with maximum temperature, wind speed at 14.22 hours and presence of aphids.

Table 17 Correlation between weather parameters, incidence of pests and natural enemies

	Aphid	Epilachna	Leucinodes	Rove beetle	Coccinellids	Spiders
RH - 7.22 hours	-0.8905**	-0.9311**	-0.8416**	-0.8479**	-0.8932**	-0.8609**
RH – 14.22 hours	0.2018	0.2571	0.3727	0.0643	0.2202	0.4728
Maximum temperature	0.7356*	0.8938**	0.7568*	0.8695**	0.9548**	0.7099*
Minimum temperature	0.6001	0.6548*	0.6671*	0.4164	0.6089	0.6821*
Wind speed – 7.22 hours	-0.5634	-0.3409	-0.4471	-0.5685	-0.3085	-0.4106
Wind speed – 14.22 hours	0.7000*	0.7308*	0.3988	0.6896*	0.5900	0.7148*
Rain fall	-0.2688	-0.3246	-0.3620	-0.1784	-0.2958	-0.1443
Aphid				0.8907**	0.7944**	0.8328**
Epilachna				0.8518**	0.9426**	0.8810**
Leucinodes				0.6568*	0.8918**	0.6488*

** Significant at 1 per cent level
* Significant at 5 per cent level

4.3.11 Yield

The yield per hectare is given in Table 18.

The average yield per hectare ranged from 11686.33 kg in control to 23710.77 kg in the plots treated with a combination of neem oil + garlic plus *H. suaveolens* (T_9). The yield was the highest in T_9. Followed by these were the plots treated with the combinations of neem oil plus emulsion of *H. suaveolens* + garlic (T_8) with 22829.8 kg which on par with T_9.

The yield from the plot treated with neem oil + *H. suaveolens* was 21952.81 kg. T_2 (17758.27 kg) was on par with T_6 (17805.89 kg). The garlic treated plot (T_3) gave only 15032.03 kg. The yield from all the treated plots differ significantly from the control.

4.3.12 Economics

The close perusal of Tables 19 revealed combination of neem oil + garlic plus *H. suaveolens* (T_9) gave Rs. 2.28 in return for every one rupee invested as against control which gave only 1.14. Combination of neem oil plus *H. suaveolens* + garlic (T_8) and neem oil + *H. suaveolens* (T_7) gave Rs. 2.20 and Rs. 2.11 for every one rupee invested. Benefit : cost ratio of T_5, T_4, T_2, T_6 and T_1 were 1.94, 1.81, 1.72, 1.72 and 1.53 respectively. BC ratio was only 1.44 with T_3.

Table 18 Yield obtained due to the application of different treatments (kg ha^{-1})

Treatments	Harvest				Total	Mean
	I	II	III	IV		
T_1	222.22	6480.28	4825.49	4297.70	15825.69	3991.67
T_2	261.91	7670.78	4960.41	4865.17	17758.27	4412.33
T_3	607.15	6412.82	3833.41	4178.65	11532.03	3791.67
T_4	238.10	7670.78	4892.95	5952.50	18754.33	4729.00
T_5	182.54	8464.45	5222.32	6281.87	20151.18	5082.67
T_6	349.21	7670.78	4365.16	5420.74	17805.89	4491.00
T_7	460.32	9785.91	5158.83	6547.75	21952.81	5535.00
T_8	369.05	9127.16	3587.43	6746.16	22829.80	5762.00
T_9	460.32	10777.99	5396.93	7075.53	23710.77	5985.33
T_{10}	238.1	5885.03	2698.46	3039.74	11686.33	2995.67

CD – 292.5942

Table 19 Economics

Treatments	Normal cost excluding insecticides (Rs. ha^{-1})	Expense for insecticides (Rs. ha^{-1})	Total expenses (Rs. ha^{-1})	Gross income (Rs. ha^{-1})	Net income (Rs. ha^{-1})	B : C ratio
T_1	61387.47	435.00	61822.47	94954.14	33131.67	1.53
T_2	61387.47	552.00	6193.47	106549.62	44610.15	1.72
T_3	61387.47	900.00	62287.47	90192.18	27904.71	1.44
T_4	61387.47	780.00	62167.47	912525.98	50358.51	1.81
T_5	61387.47	786.60	62174.07	120907.08	5873.01	1.94
T_6	61387.47	600.00	61987.47	106835.34	44847.87	1.72
T_7	61387.47	744.00	62131.47	931716.86	69585.39	2.11
T_8	61387.47	855.60	62243.07	936978.80	74735.73	2.20
T_9	61387.47	750.00	62137.47	142264.62	80127.15	2.28
T_{10}	61387.47	0	61387.47	70117.98	8730.51	1.14

DISCUSSION

DISCUSSION

Brinjal is an important vegetable crop which is widely cultivated throughout Kerala. The crop is vulnerable to attack by various types of insect pests. Injudicious use of many persistent insecticides lead to various well documented side effects and hence it is desirable to evaluate alternate methods for the pest management practices. The present research work was aimed to study the population dynamics of the pests and their natural enemies in the important brinjal growing tracts of Thiruvananthapuram district and to evolve suitable ecofriendly pest management practices which help to reduce the toxic hazards due to persistent insecticides and conserve the natural enemies in the ecosystem.

5.1.1 Population estimation of pests/natural enemies

The results of the experiments are discussed here under. Survey was conducted in the three different locations of Thiruvananthapuram district to study the socio-economic conditions of the brinjal cultivators as well as about the incidence of pests, diseases and natural enemies. The survey covered the age, nature of land, education, ownership of land, size of holding, varieties cultivated, seasons of cultivation, duration of crop, farming practices and management strategies and yield. Majority of farmers used local varieties which were either their own or purchased from other farmers. This was due to the lack of awareness about the varieties released by Kerala Agricultural. University and non-availability of quality seeds in time. Similar observation was made by Nandakumar (1999) in bitter gourd. It was found that majority

Fig. 1 Percentage incidence of pests in brinjal in farmers field

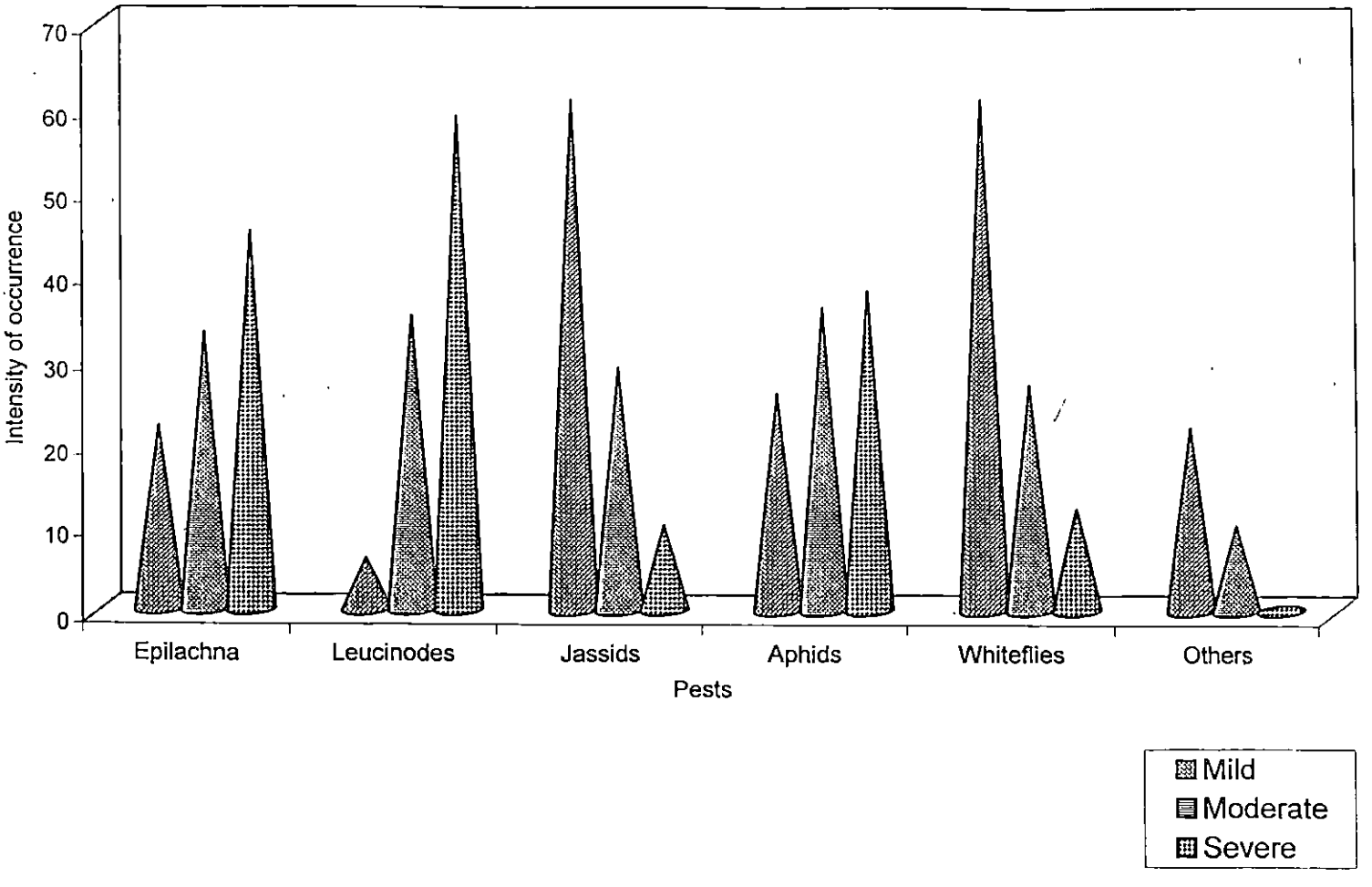


Fig. 2 Incidence of natural enemies of pests of brinjal in farmer's field

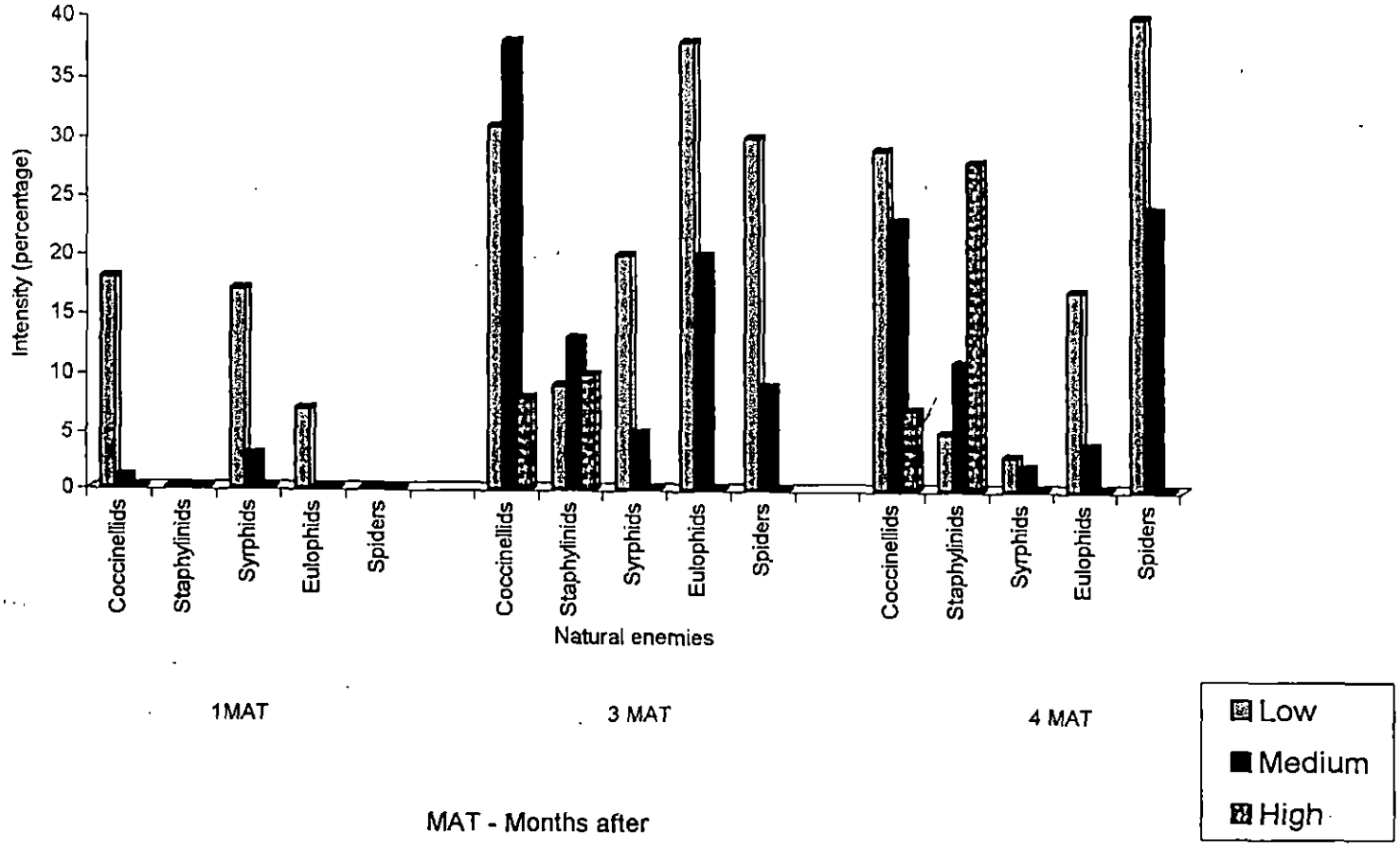
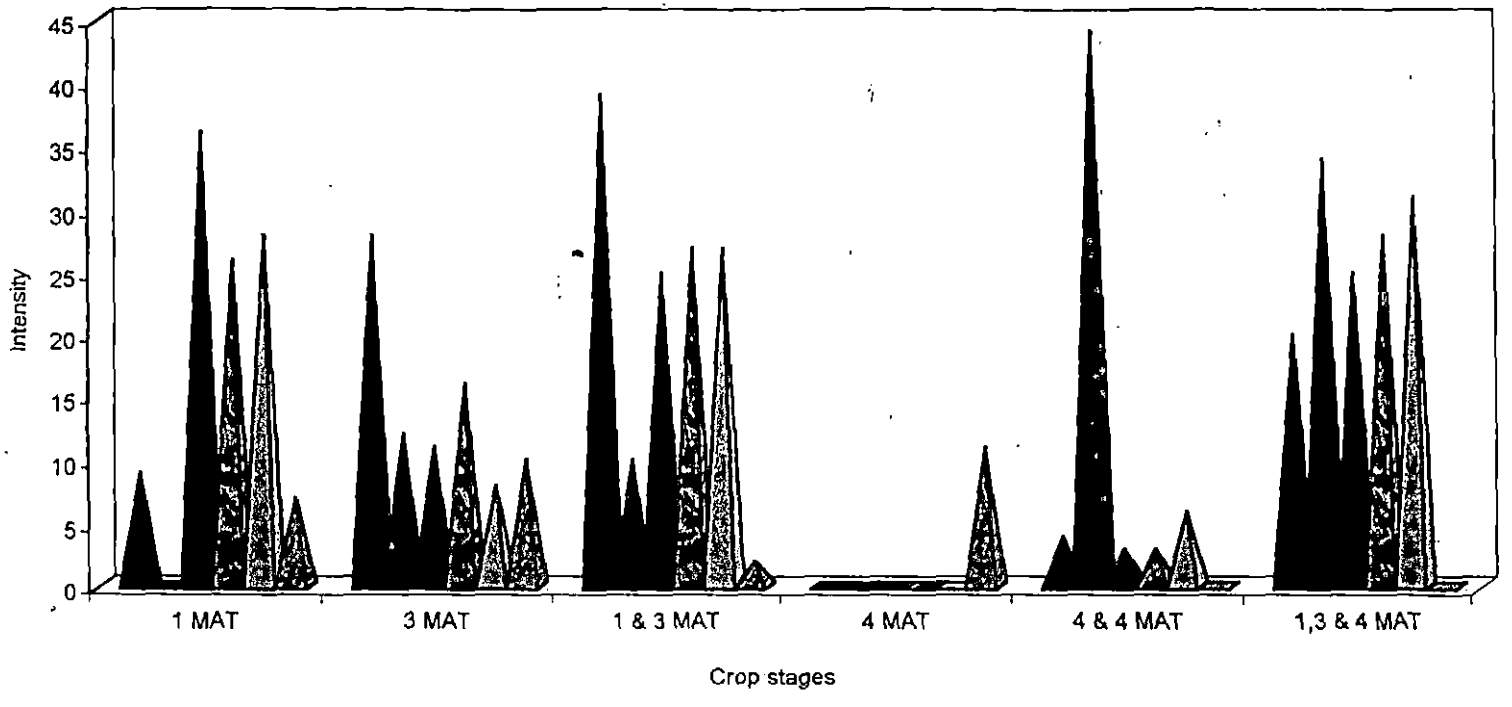


Fig. 3 Stages of crop affected by pest



MAT - Months after

of the farmers carried out prophylatic spraying to save the crop. Binno Bonny (1991) opined that experience in vegetable cultivation had a significant positive association with the extent of adoption of improved vegetable cultivation practices. This wide variation in cultural and plant protection measures was observed in the KHDP survey 1994-95 (Kerala Agricultural University, 1996). The percentage of incidence of pests like *Leucinodes orbonalis*, *Epilachna vigintioctopunctata* and *Aphis gossypii* are high compared to others and also *Bemisia tabaci* (Table 2, Fig. 1). Nandakumar (1999) reported that the natural enemies were in general low due to the indiscriminate use of pesticide sprayed by farmers. Similar results were observed in the present investigation also (Table 3 and Fig. 2). The incidence of natural enemies has got positive correlation with the incidence of pests. This is in line with the reports of David and Kumaraswami (1996) who observed the incidence of the pests of brinjal from nursery to harvest.

The plant protection measures of the farmers included collection and destruction of damaged plant parts and use of chemical pesticides and botanicals (Table 5). Similar observations were made by Nandakumar (1999) in bittergourd farmers of Thiruvananthapuram District. The use of insecticides was the most important pest control tactic. The organophosphorus pesticides was the most widely used one.

5.2.1 Lab studies on deterrency on major pests of brinjal

5.2.1.1 Percentage deterrency to aphids

The percentage deterrency to aphids 2 hrs after application revealed that (Table 6) the treatment with malathion was the most efficient. The insects

were found to be moving away from the treated plants. This may be due to the presence of inhibitory stimulus or absence of gustatory stimulus of the plants sprayed with insecticides which may prevent the insect from sustained feeding or oviposition. The treatments like neem oil emulsion and garlic is also sharing similar effects. After 24 hrs, neem oil emulsion has been shown to possess maximum deterrent activity. Isman *et al.* (1990), Schmutterer (1990) viewed similar activity in the case of neem oil emulsion. Rice *et al.* (1985) observed its feeding and oviposition deterrence. The presence of 0.3 per cent Azadirachtin (A,B,C,H,I isomers), 1.4 per cent salannin, 0.5 per cent nimbin etc. (Gahukar, 1998) might be responsible for the deterrent effect of neem oil. On par with this treatment was malathion 0.1 per cent. However it was noted that neem oil in combination with garlic had pronounced deterrency.

5.2.1.2 Percentage deterrency to Epilachna

Neem oil alone and activated with garlic has been shown to possess the highest deterrent effect against Epilachna (Table 6). However, this effect has been found to be on par with leaf extract of *A. paniculata* either alone or with garlic, neem oil emulsion with hyptis and combination of *A. paniculata* + garlic and neem oil emulsion. However all the treatments have been found to be on par with each other when the insects were observed for deterrency after 24 hours. All the treatments were highly significant than the control.

5.2.1.3 Percentage deterrency to Leucinodes

In case of Leucinodes, the treatments, malathion 0.1 per cent + garlic, neem oil emulsion alone or in combination with garlic and all the

combinations with *A. paniculata* or *H. suaveolens* were found to be on par with each other (Table 6). Neem oil has been highly effective against *L. orbonalis*. This is in accordance with the findings of Srinath (1990). The deterrency of *A. paniculata* may be due to the alkaloid andrographoid present in it.

5.2.2 Lab studies on mortality on major pests of brinjal

5.2.2.1 Percentage mortality of aphids

The treatment Malathion 0.1 per cent + garlic (Table 7) showed the highest mortality against aphids. This is in accordance with the findings of Nandakumar (1999) that Malathion was highly toxic within 24 hours. Moreover, the compatibility of Malathion with garlic may be responsible for this pronounced mortality. It is interesting to know that the presence of diallyl disulphide and triallyl trisulphide in garlic by itself possess insecticidal activity (David and Kumaraswami, 1996 ; Parmar and Devakumar, 1993). On par with malathion + garlic is the combination of neem oil + garlic plus *H. suaveolens*. Moreover, malathion 0.1 per cent and neem oil emulsion had been seemed to possess same mortality percentage. The efficiency of malathion in controlling aphids had already been reported by Reghupathy *et al.*, (1997) and Santhosh Kumar (1999). Besides, leaf extract of *H. suaveolens* had been shown to posess some aphidicidal property. This may be due to the presence of alkaloid in it. This is in line with the finding of Regunath and Gokulapalan (1996) who reported that *H. suaveolens* was on par with malathion 0.05 per cent against pea aphid. Also the aphidicidal property of neem products against *A. gossypii* had already been reported by Srivastava *et al.* (1986), Raman *et al.* (1993) and Nimbalkar *et al.* (1994).

5.2.2.2 Percentage mortality of Epilachna

In the case of mortality studies of Epilachna, the maximum mortality was exhibited by the Malathion treatments. The high toxicity of Malathion may be the reason behind this mortality. On par with it is combination of neem oil + *H. suaveolens*. A lesser percentage of morality had been exhibited by garlic, neem oil emulsion with or without garlic (Table 7) leaf extract of *H. suaveolens* and garlic and combination of neem oil plus *H. suaveolens* + garlic. No mortality was observed with leaf extract of *A. paniculata* and it was found to be on par with control. In addition only a least percentage of mortality had been exhibited in all the treatments involving *A. paniculata*. It may be due to the antagonistic effect of *A. paniculata* with other extracts against epilachna. It may also be due to the non-toxic effect of the leaf extracts of *A. paniculata* as the effect had been the same with aphids also. Hence, *A. paniculata* may be seemed to possess only deterrant action. Hermawan *et al.* (1993) had reported about the antifeedant effect of *A. paniculata* against *P. xylostella*.

5.2.2.3 Percentage mortality of Leucinodes

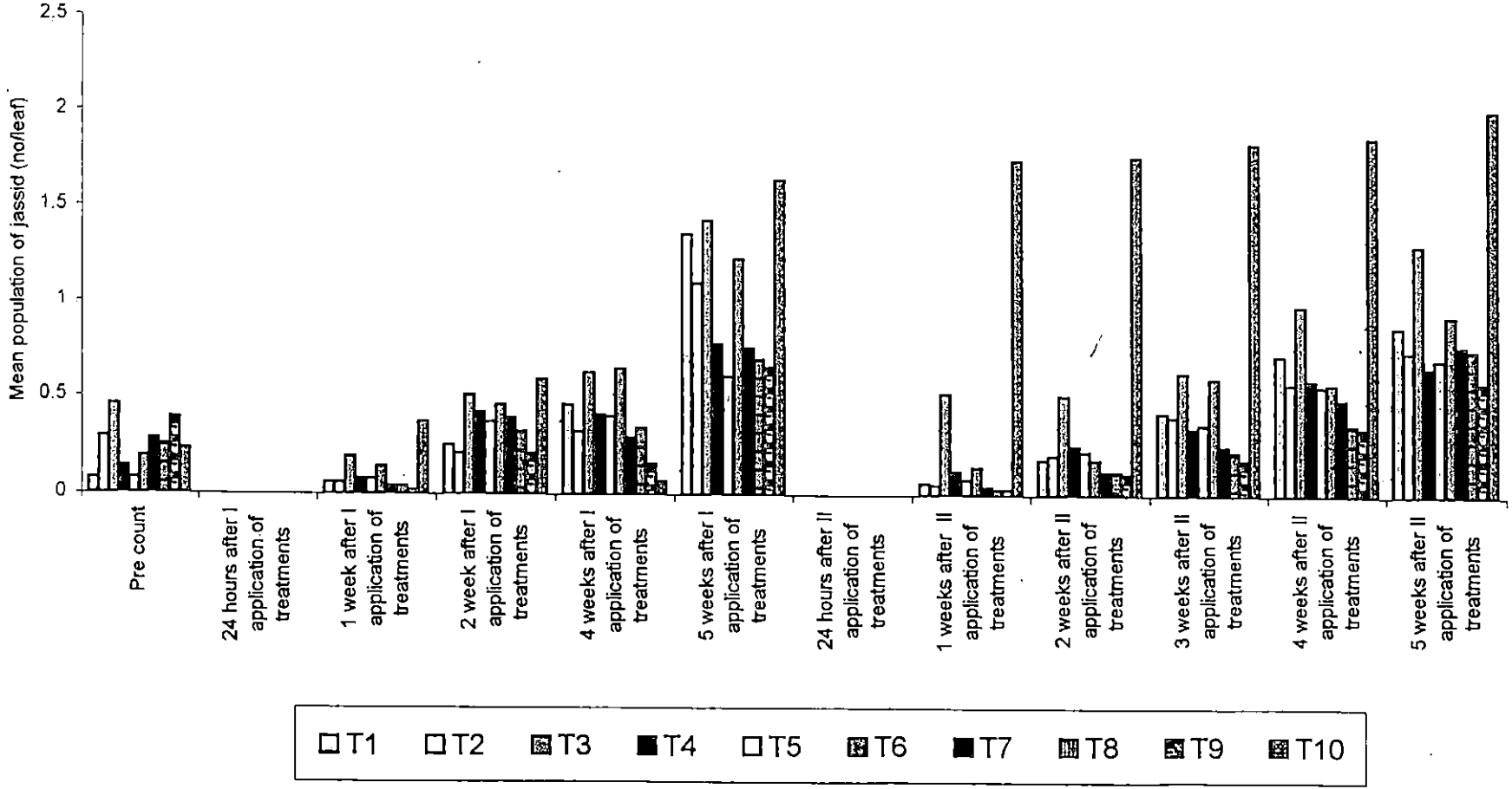
In assessing the mortality of Leucinodes (Table 7) all the treatments involving neem oil exhibited cent per cent mortality. The insects were found to be dead when preliminary observation was taken three days after the application of the treatments. The variation in the toxicity of these plant products to different insects may be due to the presence of different detoxification mechanism present in various insects (Ajay Kumar, 2000).

5.3 Pest management trial in brinjal crop at the Instructional Farm, College of Agriculture, Vellayani

5.3.1 Population of jassids at different intervals after application of different treatments

In all the treatments (Table 8 and Fig. 4) it has been found that the mean count of jassids was the highest in the control. Immediately after spraying the population was not significant which indicates that all the treatments could reduce the pest population. However, at one week after first application of treatment, the population build up had been significant which indicates the reduced effect of these treatments on pest population. The mean count of jassids had been the minimum in combination of neem oil +garlic plus *H. suaveolens* at all observations. Moreover, the treatments, combination of neem oil plus *H. suaveolens* + garlic had been found to be on par with it at all observations except four weeks after first application of treatments. Also, combination of neem oil + garlic plus *H. suaveolens* had been found to be on par with neem oil + *H. suaveolens* at all observations except three, four and five weeks after second application of treatments. Neem oil alone or with garlic had been on par with combination of neem oil + garlic plus *H. suaveolens* at all observations except four weeks after first application of treatments and two, three and four weeks after application of treatments. These suggest that neem oil could effectively control jassids. These finding corroborate with the findings of Asari and Nair (1972) who reported that neem seed kernel suspension significantly protected brinjal against leafhopper. Also, this has been well established by the trials conducted by KHDP in the

Fig. 4 Mean population of jassids at different invervals after application of treatments (no./leaf)

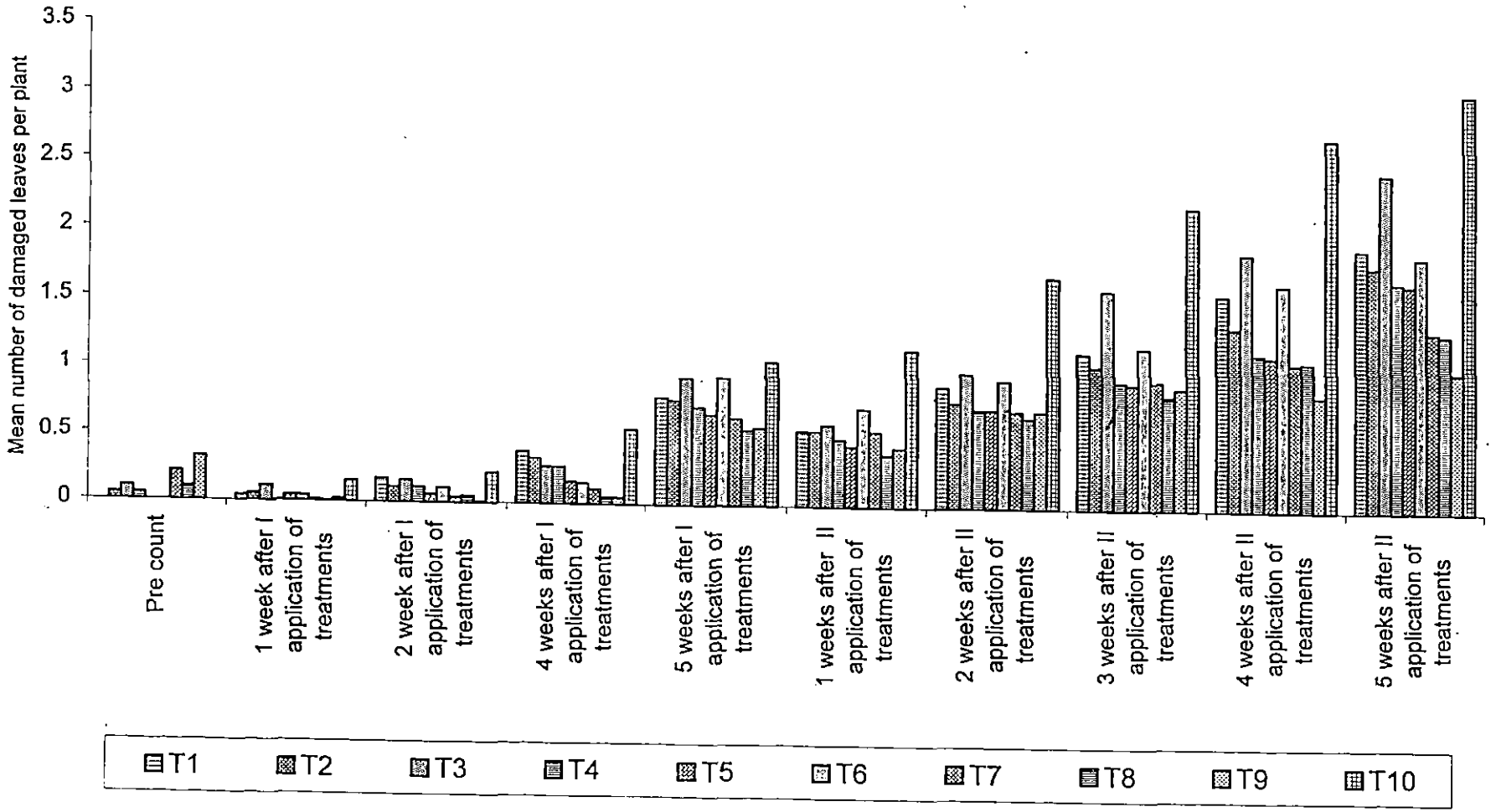


farmers' field which indicates that NSO 2.50 or 5.00 per cent with garlic effectively reduced jassids in bittergourd. Besides, the alkaloid present in *H. suaveolens* may be responsible for its control of jassids. However, not much literature is available in this regard. According to Gahukar (1998) neem oil shows synergised effect when it is mixed with plant derived oils or biopesticides. Similar synergistic effect may be the reason for the enhanced effect of combination of neem oil plus *H. suaveolens* + garlic and combination of neem oil + garlic plus *H. suaveolens* over other treatments. Also, the soap solution added during the preparation of these treatment solutions enhanced the toxicity of plant extracts (Srinath, 1990). Moreover, Malathion 0.1 per cent alone or with garlic had been found to be on par with combination of neem oil plus *H. suaveolens* + garlic and combination of neem oil + garlic plus *H. suaveolens* at one and two weeks after second spraying. In all other observations, the population build up is more than neem oil containing combinations. Nandakumar (1999) has found that Malathion is highly toxic within 24 hours. This is by the low persistent effects of Malathion which answers for the lesser population buildup immediately after spraying and the population rising afterwards. This is in agreement with Santhoshkumar (1999) who stated that malathion 0.2 per cent as less effective than neem seed oil emulsion and *H. suaveolens* in controlling aphids. The KHDP trials of Kerala Agricultural University (1996) revealed that Malathion 0.2 per cent with garlic was effective against jassids on bittergourd.

5.3.2 Extent of damage due to jassids at different intervals after application of treatments

Here again (Table 9 and Fig. 5), the plots treated with the combination of neem oil + garlic plus *H. suaveolens*, combination of neem oil plus *H. suaveolens* + garlic and neem oil + *H. suaveolens* was found to be with minimum number of damaged leaves at all observations. The treatments neem oil alone or with garlic was found to be on par with neem oil + *H. suaveolens*, combination of neem oil plus *H. suaveolens* + garlic and combination of neem oil + garlic plus *H. suaveolens* in all the observations except at five weeks after second application of treatments. It might be the combined or synergistic effect of neem oil with *H. suaveolens* offering protection for long period of time. It is in accordance with the finding of Srinath (1990) who stated that the toxicity of neem remained in brinjal field reducing the damage by pest throughout the season. Malathion 0.1 per cent + garlic treated plot remained on par with combination of neem oil + *H. suaveolens*, combination of neem oil plus *H. suaveolens* + garlic and combination of neem oil + garlic plus *H. suaveolens* in all observation except fourth and fifth week after second application of treatments. Malathion 0.1 per cent treated plot was on par with combination of neem oil + *H. suaveolens*, combination of neem oil plus *H. suaveolens* + garlic and combination of neem oil + garlic plus *H. suaveolens* except two weeks after first application of treatments and fourth and fifth week after second application of treatments. This may be probably because of the low persistence of Malathion 0.1 per cent in offering protection coupled with the poor growth of the plants. The garlic alone treated plants

Fig. 5 Mean number of leaves damaged due to jassids in different intervals after application of treatments



was found to exhibit more number of damaged leaves. The addition of garlic with Malathion or neem oil had no beneficial effect in controlling the pest.

5.3.3 Mean count of whiteflies after application of different treatments at different intervals

The mean count of whiteflies was found to be the least (Table 10 and Fig. 6) in plots treated with Malathion 0.1 per cent alone or with garlic during first and second week after first application of treatment. In all other observations, the mean count of white flies was found to be the least in all the plots treated with neem either alone or in combination with *H. suaveolens* and garlic. Singh *et al.* (1996) observed that malathion 0.1 per cent was very effective against *Bemisia tabaci*. Similar result was obtained in the present investigation at first and second week after treatment applications. The population build up of the whiteflies at two weeks after application of treatments may be due to the low residual toxicity of malathion as observed by Mathew and Nair (1969). Reghupathy *et al.* (1997) reported the efficiency of neem oil (0.3 per cent) against whitefly. Besides, Coudriet *et al.* (1985) could find the adult repellency and growth regulating effects of neem products on the immature stages. Not much literature pertaining to the effect of *H. suaveolens* on white flies is available.

5.3.4 Extent of damage by whiteflies at different intervals after application of various treatments

The mean number of leaves damaged was found to be minimum (Table 11 and Fig. 7) in plot treated with combination of neem oil + garlic plus

Fig 6 Mean population of whiteflies at different intervals after application of treatments (no./leaf)

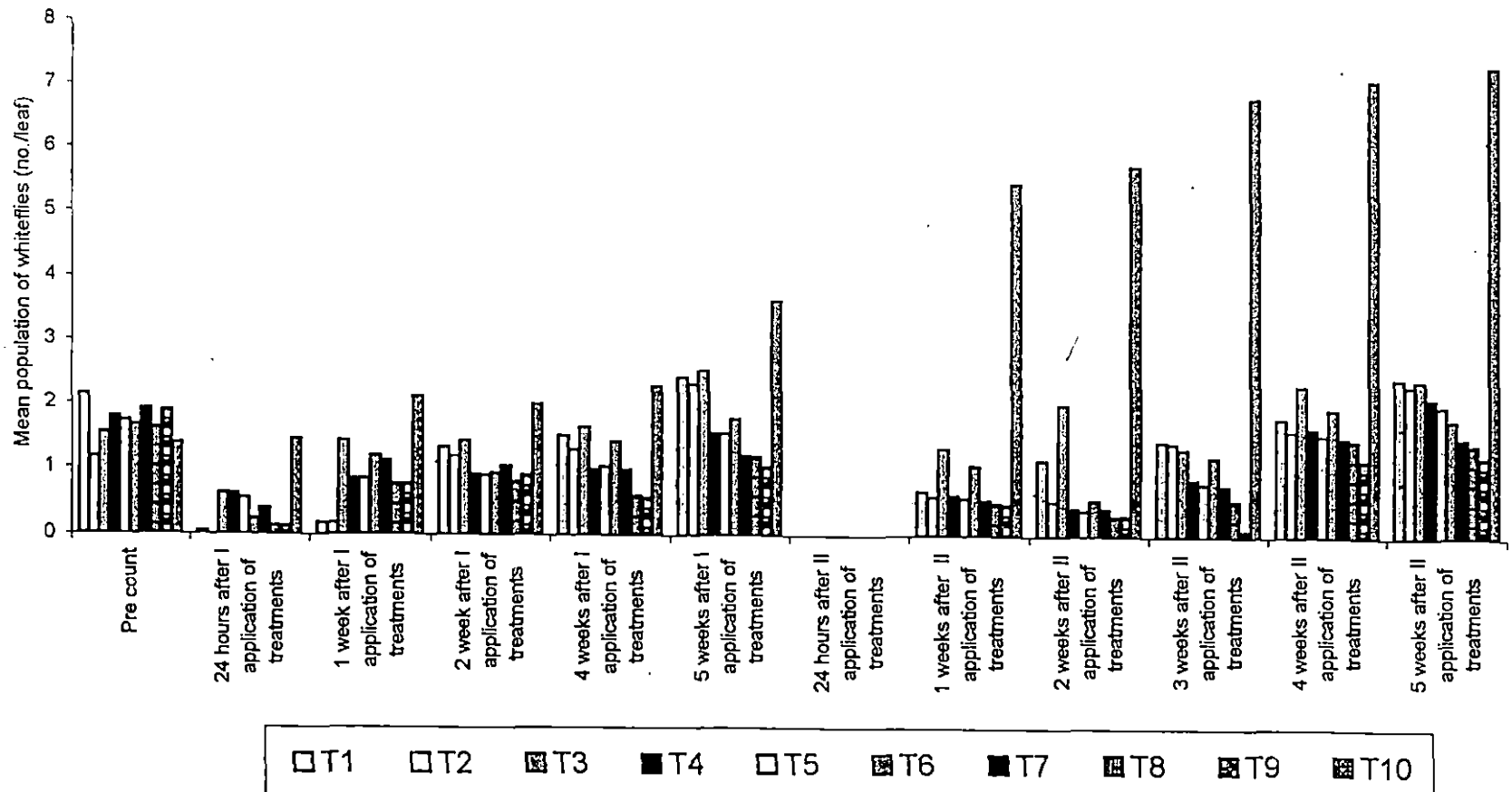
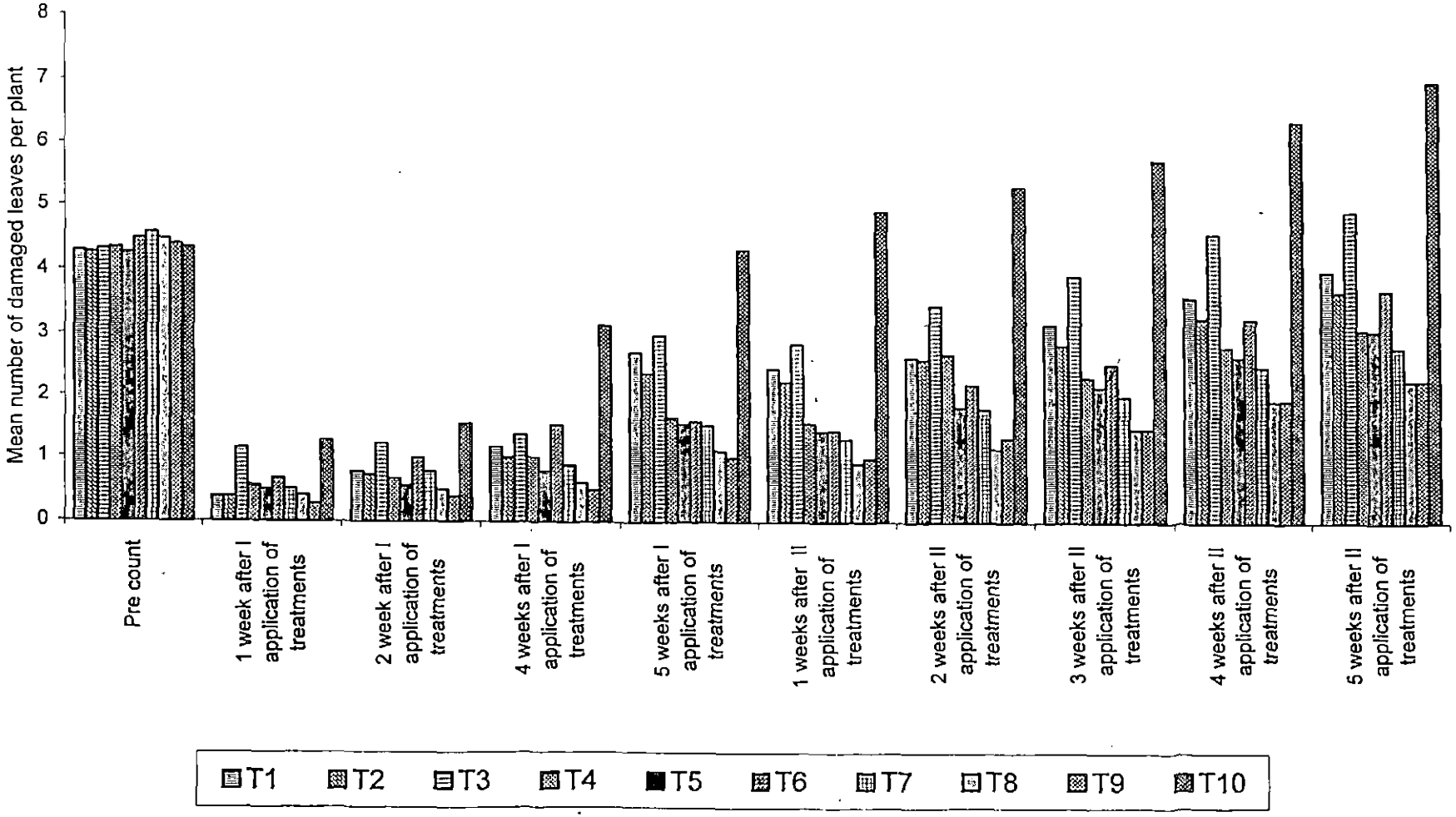


Fig. 7 Extent of damage due to whiteflies at different intervals after application of treatments (mean number of damaged leaves per plant)

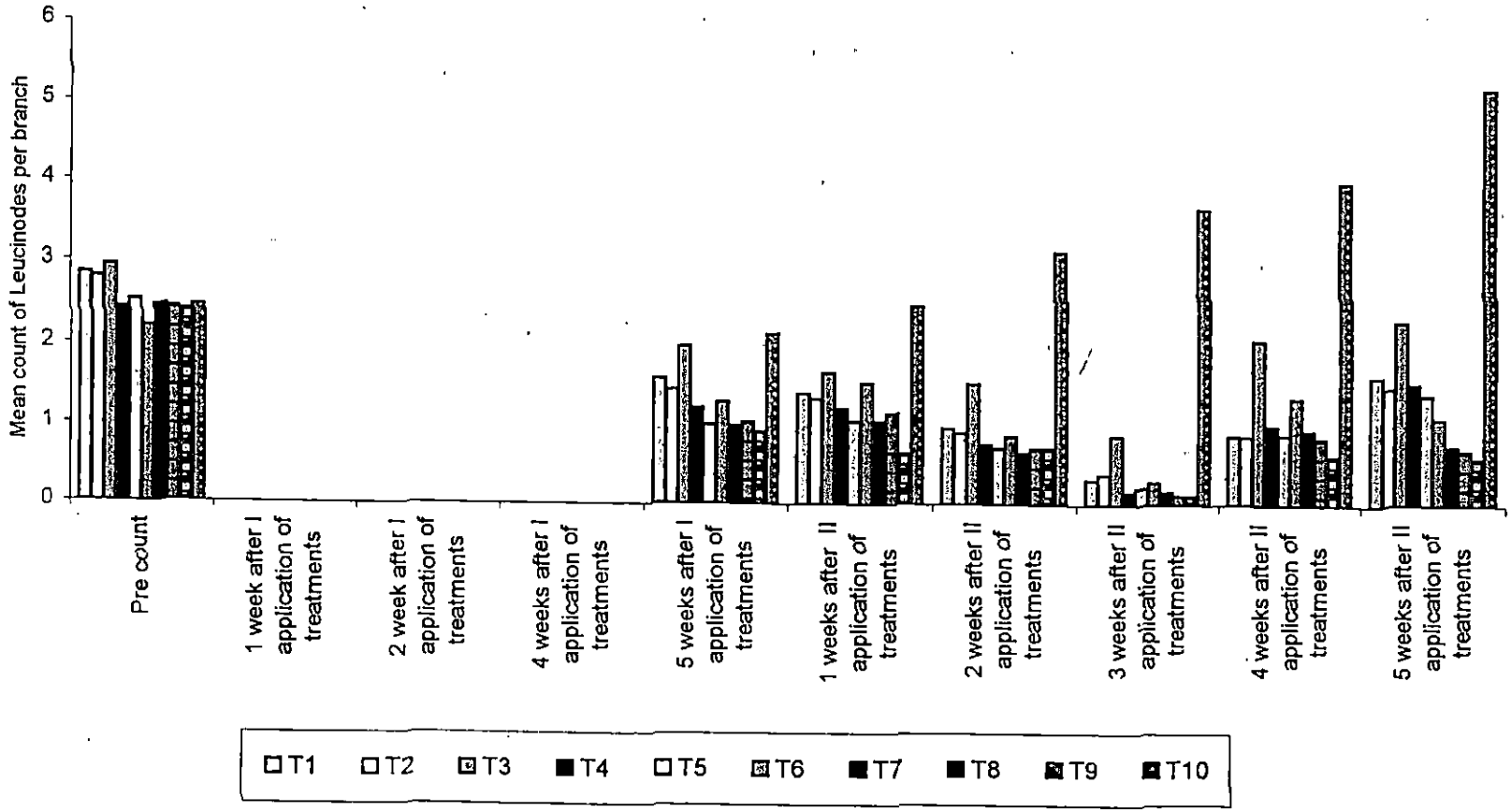


H. suaveolens. On par with this are plots treated with neem oil either alone or in combination with *H. suaveolens* and garlic. The lesser number of whiteflies in these plots may be responsible for the lesser number of leaves damaged.

5.3.5 Mean number of Leucinodes per branch after application of different treatment at different intervals

The mean number of Leucinodes per branch (Table 12 and Fig. 8) declined abruptly after first application of treatments and remained non significant till four weeks after first application of treatments expect for the control plot. This may be due to the prevention of the young caterpillars which were found infesting the young stems of the brinjal plants from further infestation. The incidence of the pest was noticed again only at fifth week after first application of treatment. Here again the plot sprayed with combination of neem oil + garlic plus *H. suaveolens*, combination of neem oil plus *H. suaveolens* + garlic and combination of *H. suaveolens* + neem recorded the least number of *L. orbonalis* at all observations. Neem oil alone and with garlic were found to be on par with it except at four and five weeks after second application of treatments. The effect of the spraying shouldn't be concluded from the observation recorded seven and fourteen days after application of treatments. This is because the larvae which had entered the fruit at the time of spraying would remain unaffected and emerge as adults. Similar findings were also made by Sudharma (1981). Though the minimum mean count was in plot sprayed with combination of neem oil + garlic plus *H. suaveolens*, all the treatments involving neem oil were found to be on par with it which indicates the greater efficiency of neem oil in reducing the borer

Fig. 8 Mean count of Leucinodes per branch at differnt intervals after application of treatments

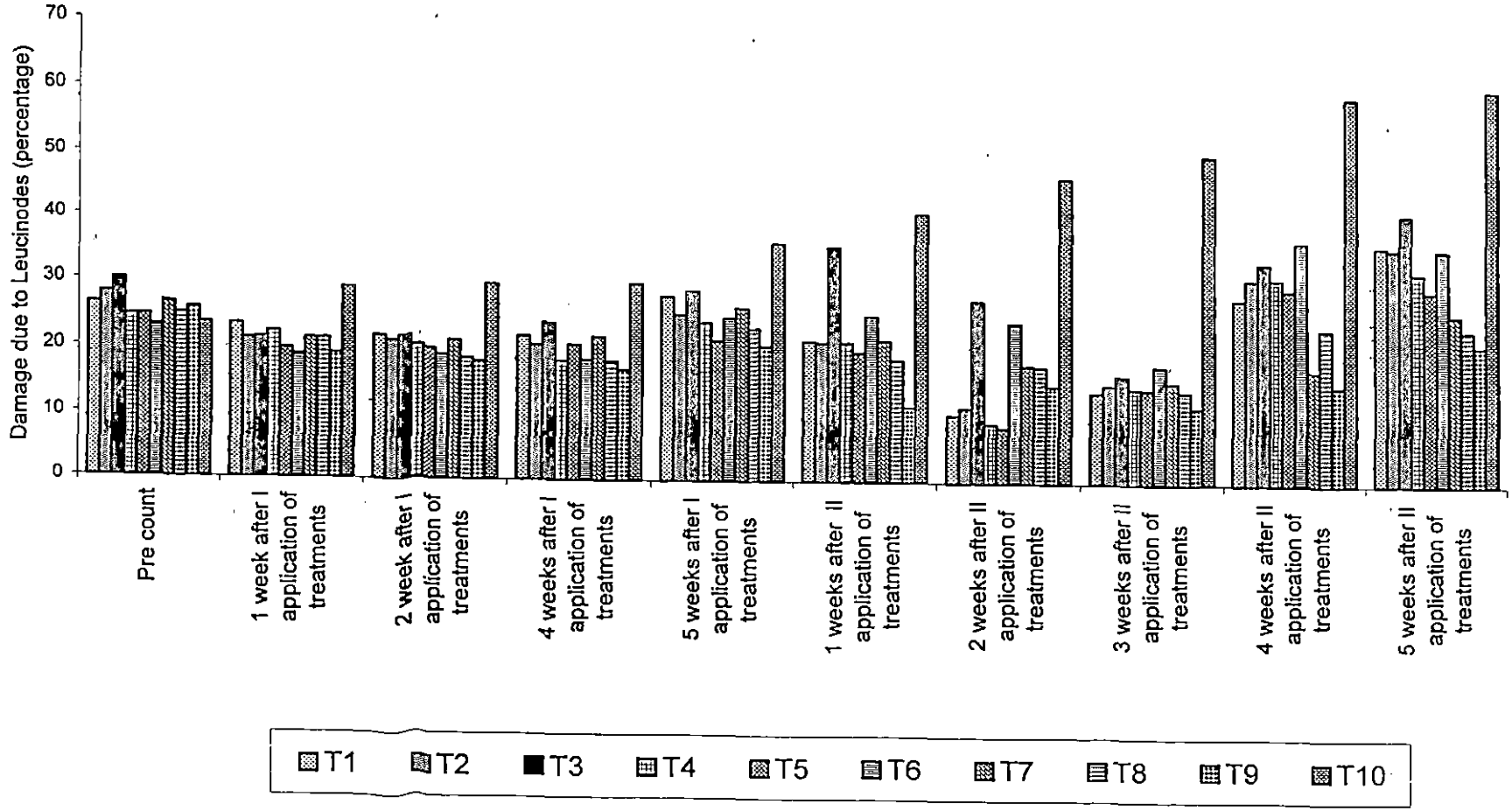


incidence. Though malathion 0.1 per cent alone and with garlic were on par with treatments involving neem oil and *H. suaveolens* alone or with garlic at four weeks after second application of treatments, it was not the same after five weeks. Malathion because of lesser persistence of three to four days cannot afford protection for long period. At the end of five weeks it was found that all the treatments involving neem oil and *H. suaveolens* alone or with garlic offered protection for a long time. The synergistic effect of neem oil with *H. suaveolens* may be responsible for the better control of the pest for a long time. Also according to Srinivasan and Babu (1997) control of Leucinodes was comparable or better with neem based products than endosulfan. Similar trend was also observed by Raja *et al.* (1997) that the most effective control of the Leucinodes was achieved with the application of four per cent neem. According to Kumar (1996), Az was not effective upto 7 days after spraying, but after 15 days the bioinsecticide proved to be most efficient. This may be due to the accumulation of the compound. According to Reghunath and Gokulapalan (1996), extracts of *H. suaveolens* was on par with malathion against pea aphid. Garlic alone was least effective in controlling Leucinodes. This is in line with Dubey *et al.* (1991) who reported the lesser efficiency of garlic in controlling *Heliothis armigera* and it seemed to possess poor antifeedant property while neem oil 0.5 per cent was very effective. The present finding agreed well with all the observations.

5.3.6 *Extent of damage by Leucinodes at different intervals after* application of various treatments

The percentage damage by *Leucinodes orbonalis* (Table 13 and Fig. 9) was found to be the least in plot sprayed with combination of neem oil + garlic

Fig. 9 Extent of damage due to Leucinodes at different intervals after application of treatments (in percentage)



plus *H. suaveolens* at two, four and five weeks after first application of treatments and one, three, four and five weeks after second application of treatments. Combination of *H. suaveolens* + garlic recorded the minimum percentage of damage during the first week after first application of treatments and one, three, four and five weeks after second application of treatments. Combination of neem oil + garlic recorded the minimum percentage of damage at two weeks after second application of treatments. Though all the treatments were found to be better than the control, extent of damage was higher in garlic treated plot. The Malathion treated plots recorded a higher percentage of damage at four and five weeks after first as well as second application of treatments. The present observation corroborate with the observation of Mandal *et al.* (1995) that malathion was not effective against Leucinodes and malathion treated plots recorded a similar damage percentage as that of control. Similar trends was also reported by Mishra (1993). They also observed that the efficacy of all the agrochemicals were reduced at 15 days after spraying as compared to that of 7 days after the treatment. Dubey *et al.* (1991) observed that garlic was least effective against *Heliothis armigera* in chickpea whereas neem oil 0.5 per cent gave maximum protection against the pest. The synergistic effect of neem oil with *H. suaveolens* may be responsible for the lesser percentage of damage in the plots treated with them.

5.3.7 Mean number of natural enemies per plant after application of different treatments

The rove beetles (Table 14) appeared in the field four weeks after first spraying when the population of the jassids, whiteflies and aphids was higher. The mean number of the predator increased with the increase in number of the pest at five weeks after first application of treatments. The predator population was found to be more in plots treated with neem oil + *H. suaveolens* and also in plots treated with combination of neem oil plus *H. suaveolens* + garlic at one week after second application of treatments. Similarly, at two weeks after second application of treatment, the predator population was the highest in plot treated with neem oil alone and also in combination with *H. suaveolens*. This indicated that the botanicals were relatively safe to natural enemies. Besides, higher predator population in control plot suggested the positive correlation between the pest and natural enemies.

The results of 4.3.9.2 indicated that plant extracts were safe to coccinellids. This agreed with the findings reported by Srinath (1990) and Patel and Yadav (1993). The coccinellids observed include *Coccinella transversalis*, *Menochilus sexmaculatus*, *Coccinella septempunctata* and *Micraspis discolor*.

The result given in 4.3.9.3 gave an idea about mean number of spiders per plant after application of different treatments. The mean number of spiders per plant was higher in control and also in plots treated with neem oil either alone or in combination with garlic plus *H. suaveolens*. Ajay Kumar (2000) observed that the plant products were safe to spiders in rice ecosystem

The population was comparatively lesser in plot treated with malathion either alone or with garlic. This indicated that these treatments are comparatively unsafe to natural enemies. These observations were in agreement with the reports of Satpathy *et al.* (1968) and Thomas and Phadke (1991). The present finding corroborates well with these findings.

5.3.8 Correlation between the weather parameters and the incidence of pests and natural enemies

There was a significant positive correlation (Table 17) between the jassid population and the maximum temperature. Similar correlation was obtained by Prasad and Logiswaran (1997) in Brinjal. Whitefly population was correlated negatively with relative humidity and positively with maximum temperature and wind speed. In line with this findings is the report by Prasad and Logiswaran (1997). The correlation between *L.orbonalis* was negative with relative humidity and positive with maximum temperature. However, Prasad and Logiswaran (1997) observed a positive correlation with relative humidity. Regarding natural enemies, Staphylinids, Coccinellids and Spiders exhibited significant positive correlation with the incidence of jassids. However, Nandakumar (1999) observed a negative correlation of spiders with jassid population. The positive correlation between pests and their natural enemies indicated that peaks of pest abundance matched peaks of their natural enemy numbers. Once the prey numbers reduced the population of natural enemies also declined. Similar observation were also made by Nandakumar (1999) and Veeravel and Baskaran (1989).

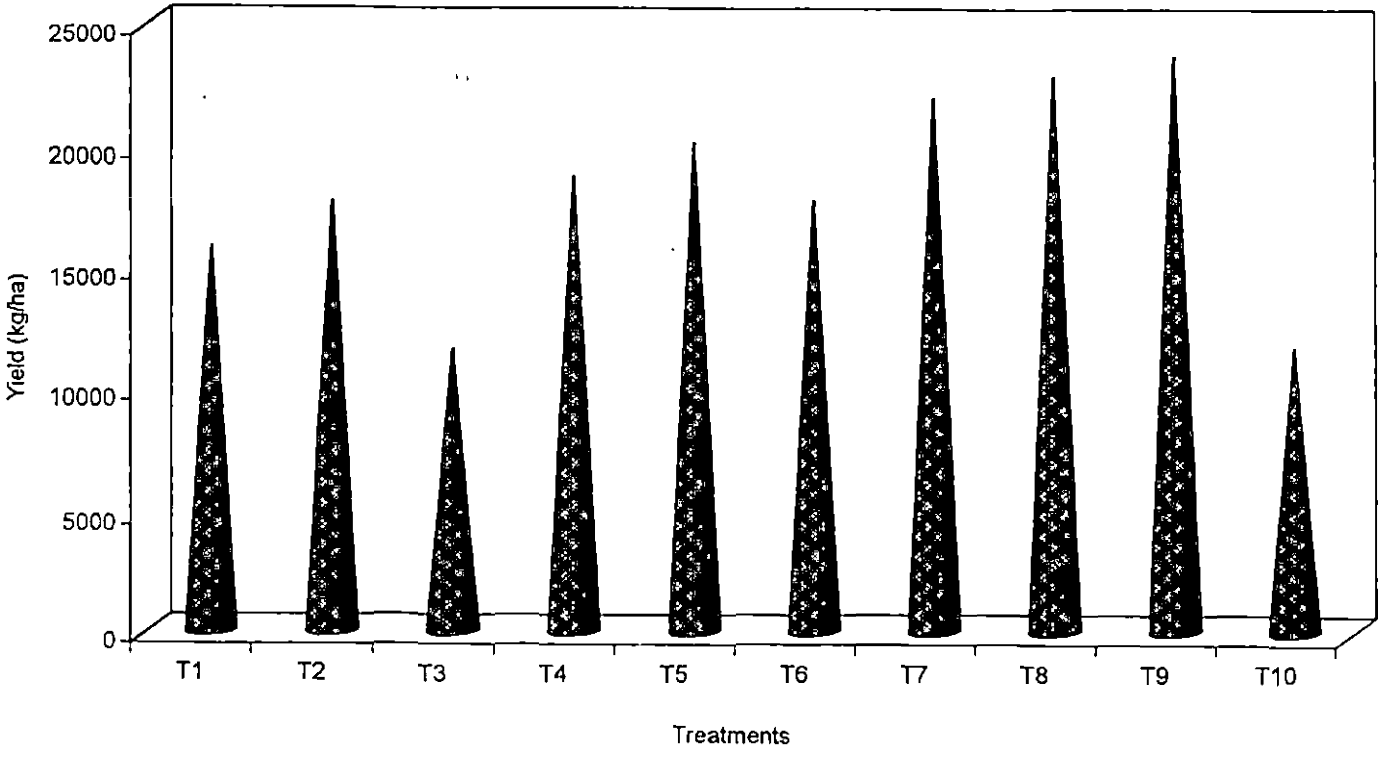
5.3.9 Yield

The yield was maximum (Table 18 and Fig. 10) in plot sprayed with combination of neem oil + garlic plus *H. suaveolens* followed by combination of neem oil plus *H. suaveolens* alone and with garlic. This may be due to the better protection offered by these products against the pests for a longer period. Srinath (1990) opined that plant extracts can produce more yield due to the multichemical principles which reduce the feeding and normal activities of the pest. He also observed that *A. indica* could produce comparitively high yield. Similar observations were made by Dubey *et al.* (1991) in chickpea. The present findings are in line with the findings.

5.3.10 Economics

Combination of neem oil + garlic plus *H. suaveolens* gave higher return of Rs.2.28 for every one rupee invested. On par with it are combination of neem oil plus *H. suaveolens* + garlic and combination of neem oil plus *H. suaveolens*. The higher yield in these plots account for the higher benefit cost ratio from these plots.

Fig. 10 Yield


25000
20000
15000
10000
5000
0
Yield (kg/ha)
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
Treatments

SUMMARY

SUMMARY

The present study entitled "Ecofriendly pest management in Brinjal (*Solanum melongena* L.)" was conducted during May 1999 to March 2000. This work was undertaken in the Instructional Farm, College of Agriculture, Vellayani. The main objectives were to study the population dynamics of pests and their natural enemies and to evolve suitable ecofriendly pest management practices which would help to reduce the toxic hazards due to insecticides and conserve the natural enemies.

The following experiments were carried out

1. Population estimation of pests and natural enemies.
2. Laboratory studies on the deterrency and toxicity on the major pests of brinjal
3. Pest management trial in brinjal in the Instructional Farm, College of Agriculture, Vellayani.

The survey brought into light the major pests of brinjal and their natural enemies in important brinjal growing tracts of Thiruvananthapuram district. The important pests included Aphids (*Aphis gossypii*), Epilachna beetle (*Henosepilachna vigintioctopuntata*) and shoot and fruit borer (*Leucinodes orbonalis*) and the important natural enemies included coccinellids, staphylinids, syrphids and spiders. These pests were present in the field during different growth stages of the crop.

Laboratory experiment was conducted to assess the deterrency and toxicity of the different treatments on aphids, epilachna and leucinodes which were identified as the major pests of brinjal from the farmers' field. The results obtained from the laboratory experiment were as follows.

1. Malathion alone or with garlic proved to be the most deterrent to aphids two hours after application of treatments.
2. Neem oil emulsion was found to exert maximum deterrency on aphids 24 hours after application of treatments.
3. The plants sprayed with neem oil + garlic deterred epilachna the most two hours after application of treatments.
4. The treatments with *Andrographis paniculata* was found to have a little deterrent effect on aphids and epilachna. However it didn't have toxic effect on any of them.
5. Combination of neem oil + *Hyptis suaveolens* was found to exert maximum deterrency on epilachna 24 hours after application of treatments.
6. All the combinations containing neem oil were found to deter Leucinodes.
7. Malathion + garlic was found to be more toxic to aphids than the other treatments.
8. Malathion alone or in combination with garlic exerted maximum toxicity on epilachna.

Only the effective treatments of the laboratory experiment were carried out in the field. The effective treatments as identified from the lab experiment are :

1. Malathion alone
2. Malathion + garlic
3. Garlic
4. Neem oil emulsion
5. Neem oil emulsion + garlic

6. Leaf extract of *Hyptis suaveolens*
7. Combination of neem oil + *Hyptis suaveolens*
8. Combination of neem oil plus *Hyptis suaveolens* + garlic
9. Combination of neem oil + garlic plus *Hyptis suaveolens*

The field experiment was carried out in the Instructional Farm, College of Agriculture, Vellayani. The important findings of the field experiment are summarized hereunder.

Malathion activated with garlic was found to exert good control over jassids and whiteflies. However, the effect was only for a short period of time and in long run it was ineffective.

Emulsion of *Hyptis suaveolens* when used alone was not very effective. Neem oil alone or with garlic was found to contain the pests. However, the effect was much pronounced and prolonged when neem oil activated with garlic was used in combination with *Hyptis suaveolens*. This combination was also found to offer protection for the brinjal plants for a longer period of time. Also, neem oil used in combination with *Hyptis suaveolens* alone or with garlic was found to give good control of the pest. The treatment with garlic alone did not give satisfactory results.

The natural enemies included coccinellids, staphylinids and spiders. The botanicals were found to be safe for natural enemies.

The yield was found to be the maximum in plots treated with combination of neem oil + garlic plus *Hyptis suaveolens*. This combination gave promising result with higher net income and benefit cost ratio.

The results of the present pest management trial indicated the possibility of reducing the use of chemical pesticides by using botanicals.

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*Original not seen

APPENDICES

APPENDIX – I
PROFORMA

1. Name and address of the farmer :
   Age :
   Education :
2. Whether the crop is raised as Wetland/Gardenland/Cultivation :
   a) Own :
   b) Leased :
   c) If leased, rate of rend paid :
4. Variety grown :
5. Season of cultivation :
6. How long is the crop maintained in the field :

CROP MANAGEMENT PRACTICE

7. Type of manures applied : Organic (alone) / Organic + chemical fertilizers
8. Whether the recommended practice followed : Yes / No.
9. a) Farming practice are carried by :

b) If by farmer himself, whether family labourer engaged :

PEST MANAGEMENT

10 (i) Pests	Intensity of damage			Stage of plant infested			Season of occurrence
	Mild	Moderate	Severe	1 MAT	3 MAT	1, 3 and 4 MAT	
a. Epilachna							
b. Leucinodes							
c. Jassids							
d. Aphids							
e. Whiteflies							
f. Hairy Caterpillar							
g) Mite							
(ii) Diseases							
a. Bacterial wilt							
b. Little leaf							
c) Others							

11. Natural enemies

Natural enemies	1 MAT	3 MAT	4 MAT
Coccinellids			
Rove beetles			
Syrphids			
C. johnsoni			
T. ovulorum			
Spiders			

12. Control measure adopted

1) Pesticide applied (name and dosage)			Frequ-ency of applic-ation	Equip-ment used	Other control meas-ures	Level of control			
Chemical	Botanical	Others				Poor	Satisf-actory	Fair	Good

13. a) Is he aware of any resistant variety :
    b) If so, details of that variety :
14. Whether the insecticide is applied as prophylactic (or) curative :
15. Whether insecticide and fungicide are applied together :
16. a) Whether 2 insecticides are applied in combination :
    b) If then, details :
17. a) Sources of information of Plant production :
    b) If not dependent on agencies, reasons :
18. Whether they are in need of advice for handling problem :
19) Yield obtained
20. Fruit quality : Low/medium/high

APPENDIX - II

Period	Time	RH (%)	Maximum (^{0}C)	Minimum (^{0}C)	Wind speed (km/ha)	Rf (mm)
Nov.28-Dec. 4	7.22	95.14	-	23.38	0	6.42
	14.22	74.28	29.10	-	5.14	0
Dec.5-Dec. 11	7.22	94.57	-	21.557	0	0
	14.22	64.42	31.81	-	5.71	-
Dec.12-18	7.22	94.42	-	22.90	0	0
	14.22	67.00	30.02	-	4.857	-
Dec.19-25	7.22	93.28	-	20.80	0	0.05
	14.22	60.00	30.62	-	5.714	-
Dec.26-Jan.1	7.22	93.42	-	20.57	0	0
	14.22	60.00	30.84	-	7.14	-
Jan.2-8	7.22	94.71	-	22.45	0	1.40
	14.22	60.70	31.17	-	5.74	-
Jan-9-15	7.22	94.71	-	22.67	0	1.22
	14.22	66.14	30.60	-	5.14	-
Jan-16-22	7.22	95.71	-	21.57	0.57	0
	14.22	61.00	30.82	-	6	-
Jan-23-29	7.22	95.71	-	20.40	0	0
	14.22	58.28	31.02	-	5.71	-
Jan.30-Feb.5	7.22	94.14	-	21.82	0	10.057
	14.22	59.57	30.84	-	6.857	-
Feb.6-12	7.22	92.57	-	23.17	0	4.342
	14.22	65.85	30.95	-	6	-
Feb.13-19	7.22	92.28	-	22.24	0	0
	14.22	61.28	30.81	-	6.28	-
Feb.20-26	7.22	90.57	-	22.857	0	0
	14.22	66.285	31.085	-	6	-
Feb.27-March 4	7.22	91.42	-	23.114	0	0
	14.22	61.714	31.30	-	6.285	-
March 5-11	7.22	88.14	-	23.62	0	0.875
	14.22	65.85	31.80	-	7.14	-
March 12-18	7.22	89.42	-	23.574	0	0.485
	14.22	63.57	31.785	-	6.285	-
March 19-25	7.22	87.28	-	23.04	0	0
	14.22	64.14	32.22	-	6.285	-

ECOFRIENDLY PEST MANAGEMENT IN BRINJAL (*Solanum melongena* L.)

By

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ABSTRACT OF THE THESIS
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ABSTRACT

A survey was conducted in the important brinjal growing tracts of Thiruvananthapuram district to study the population dynamics of the pests and their natural enemies in the brinjal ecosystem. Laboratory experiment and field experiments were conducted in the College of Agriculture, Vellayani to assess the deterrency and toxicity of the different treatments on aphids, epilachna and Leucinodes which were identified as important pests of brinjal from the survey and the effective treatments as identified from the laboratory experiment were carried out in the field.

Malathion alone or with garlic was found to be toxic to aphids, Epilachna and Leucinodes. The treatments with neem oil and *Hyptis suaveolens* either alone and in combination were found to have deterrent and toxic effects on aphids, Epilachna and Leucinodes in the laboratory experiment. However, the effect was much pronounced when neem oil activated with garlic was used in combination with *Hyptis suaveolens*.

In the field, though malathion was found to contain the pests, the effect was not persistent for a long time and hence was not effective in the long run. The combination of neem oil + garlic plus *Hyptis suaveolens* was found to offer protection for the pest for a long period of time. On par with it were combination of neem oil plus *Hyptis suaveolens* + garlic and combination of

neem oil + *H. suaveolens*. The botanicals were also found to be safe for the natural enemies like coccinellids, staphylinids and spiders. This treatment was also found superior to other treatments in terms of net income and benefit cost ratio and the lower unit cost of the treatment with high yield was precisely the reason for its superiority.