STUDIES ON COMPARATIVE EFFICACY OF SOME SYNTHETIC INSECTICIDES, PHYTOPRODUCT AND BIOPESTICIDES AGAINST BRINAL FRUIT AND SHOOT BORER, *Leucinodes orbonalis* Guen. AND HADDA BEETLE, *Epilachna vigintioctopunctata* Fab. IN BRINJAL AT PANTNAGAR

Thesis

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By

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C E R T I F I C A T E

This is to certify that the thesis entitled "**STUDIES ON COMPARATIVE EFFICACY OF SOME SYNTHETIC INSECTICIDES, PHYTOPRODUCT AND BIOPESTICIDES AGAINST BRINAL FRUIT AND SHOOT BORER, *Leucinodes orbonalis* Guen. AND HADDA BEETLE, *Epilachna vigintioctopunctata* Fab. IN BRINJAL AT PANTNAGAR"** submitted in partial fulfillment of the requirements for the degree of Master of Science in Agriculture with major in Entomology of the College of Post-Graduate Studies, G.B. Pant University of Agriculture And Technology, Pantnagar, is a record of *bona-fide* research carried out by **Miss Swati Bahuguna, Id. No. 42531**, under my supervision and no part of the thesis have been submitted for any other degree or diploma.

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(Poonam Srivastava)
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C E R T I F I C A T E

We, the undersigned, members of the advisory committee of **Miss Swati Bahuguna, Id. No. 42531,** a candidate for the degree of Master of Science in Agriculture with major in Entomology, agree that the thesis entitled "**STUDIES ON COMPARATIVE EFFICACY OF SOME SYNTHETIC INSECTICIDES, PHYTOPRODUCT AND BIOPESTICIDES AGAINST BRINJAL FRUIT AND SHOOT BORER, *Leucinodes orbonalis* Guen. AND HADDA BEETLE, *Epilachna vigintioctopunctata* Fab. IN BRINJAL AT PANTNAGAR**" may be submitted in partial fulfillment of the requirements for the degree.

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Introduction

1 INTRODUCTION

Vegetables are the major sources of nutritional security to the consumers and higher economic returns to the farmers. Majority of Indians are vegetarian, with a per capita consumption of 135 gm per day as against the recommended 300 gm per day. Presently, vegetables cultivation occupies 8.98 million hectares area with an annual production of 15.63 million tons. India is the second largest producer of vegetables after China. It is grown in almost all states of India and the total area under cultivation in 2012-2013 was 0.6 million ha and the production during the same period was 5.7 million tonnes which shares the 30.09 per cent of the total production in the world. In our country, in terms of production, West Bengal stands first followed by Orissa, Gujarat and Andhra Pradesh. In terms of percentage share of production in India during 2012-13 West Bengal's share was 26.6 per cent, followed by Orissa at 18.9 per cent and Gujarat at 10.1 per cent **(Source: NHB 2012-2013).** In India West Bengal ranks first in the total production of vegetables and its production during the period 2012-13 was in the tune of more than 23.4 million tones, contributing one-fifth of the country's total vegetables production. Uttar Pradesh, Bihar and Orissa in north India and Tamil Nadu, Maharashtra and Karnataka in south India are the other leading vegetable producing states in the country. It is also major vegetable crop grown in hills as well as plains of Uttarakhand, with the area and production of 89.29 ha and 1006.71 metric tons respectively during the year 2012-2013.

Brinjal is botanically known as *Solanum melongena* L. (2n=24) and belongs to family solanaceae and is commonly called by several names viz., eggplant or aubergine in English; garden egg in French; baigan in Hindi; bandekai in Kannada; vangi in Marathi; vankai in Telugu dilects. India is its center of origin and diversity **(Vavilov, 1931 and Bahaduri, 1951).** It is a popular and principle fruit vegetable grown in India and other parts of tropical and subtropical world but in temperate region, it is grown during warm season. Apart from India, the other major brinjal growing countries are China, Turkey, Japan, Italy, Indonesia, Iraq, Syria, Spain and Philippines.

The immature tender fruits of brinjal are widely used in several culinary foods like cooked vegetable, sliced bhaji, stuffed curry, bharta, chatney and vangibhat. The nutritive value of brinjal fruit is quite high and is well compared with that of tomato. The main composition of edible part of fruits (for 100 g fresh weight) is 92.7 per cent moisture, 1.4 g protein, 4.0 g carbohydrates 1.3 g fibre, 0.3 g minerals, 18 mg calcium, 16 mg magnesium, 47 mg riboflavin, 0.9 mg iron, 44 mg sulphur, 2.4 mg manganese, 124 IU vitamin A, 0.4 mg vitamin B1 and 0.11 mg vitamin B2 etc. It is used in ayurvedic medicines for diabetes, asthma, cholera etc. Its fruits and leaves are known to lower blood cholesterol level. It is amazing to record that eggplant possess the highest nutritive value providing energy of 24 cal, which get easily detoriated by the attack of certain pests.

Constraints to yield several factors are responsible for the low productivity of brinjal in India. These include biotic factors as insect pest and pathogens etc. and abiotic factors include temperature, humidity etc. the losses caused by brinjal pests vary from season to seasons depending upon the environmental factors **(Gangwar and Sachan 1981)**.

Brinjal is attacked by more than 70 diversified insect species and many of them considered as threatening pests **(Subbaratnam and Butani 1982)** of which, the important pests are the shoot and fruit borer, *Leucinodes orbonalis* Guenee. (Lepidoptera: Pyralidae), hadda beetle, *Epilachna vigintioctopunctata* Fabricious. (Coleoptera: Coccinellidae), stem borer, *Euzophera perticella* Ragnot. (Lepidoptera: Phycitidae), leaf roller, *Antoba olivaceae* Walker. (Lepidoptera: Noctuidae), jassids, *Amrasca bigittula bigitulla* Ishida. (Hemiptera: Cicadellidae), leafhopper, *Amrasca devastans* Stal. (Hemiptera: Cicadellidae), whitefly, *Bemicia tabaci* Genn. (Hemiptera: Aleyrodidae) and non-insect pest, red spider mite, *Tetranychus macfurlanei* (Baker. and Pritchard.).

Brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guen. (Lepidoptera: Pyralidae) causes serious crop losses ranging from 15 to 70% in all the brinjal producing areas of the world **(Sandanayake and Edirisinghe, 1992)**. Due to its fast reproductive potential, quick turnover of generations and most common cultivation of brinjal in both wet and dry seasons, this pest poses a serious threat. In early stage of the crop growth, larva of brinjal shoot and fruit borer, *L. orbonalis,* bores into the shoots resulting in droping, withering and drying of the affected shoots. During the reproductive stage, tiny larva bores into the flower buds and fruits, the bored hole are invariably plugged with excreta. The infested fruits become unfit for consumption due to loss of quality and lose their market value. In India, damage levels of pest have been noticed in different regions resulting considerable damage to the fruits. It is generally severe in the July transplanted crop and estimated economic injury level to 6 % infestation **(AVRDC, 2003).**

According to **Alam (1969**) incidence of BSFB in brinjal could cause damage as high as 12-16 percent on shoot and 20-63 percent on fruits and under severe infestation, it causes up to 70 percent yield loss of fruits **(Nair 1986).** The average yield loss caused by this pest has been estimated up to 13.28 to 88.89 percent **(Naresh *et al.*, 1986)** and it has been also reported that there was reduction in vitamin C content to the extent of 68 percent in the infested fruits **(Hemi, 1955).**

Next to brinjal fruit and shoot borer, the hadda beetle *Epilachna vigintioctopunctata* Fab. (Coleoptera: Coccinellidae) is one of the most important destructive pests and causes considerable economic losses to many crops including brinjal **(Bhagat and Munshi, 2004; Islam et al., 2011)** and to a number of solanaceous, cucurbitaceous and leguminous crops extensively found all over India and in other countries **(Anam *et al.*, 2006; Rahaman *et al.*, 2008).** It is highly destructive at both, adult and larval stages, which feed on the epidermal tissues of leaves, flowers, and fruits by scrapping the chlorophyll content and cause a big yield loss **(Ghosh and Senapati 2001).** The affected leaves of the plant become skeletonized, gradually dry and drop down. The larvae confine their attack to the lower surface while adult beetles usually feed on the upper surface.

For the management of brinjal fruit and shoot borer and hadda beetle several management tactics have been formulated and advocated. The conventional method involves the use of chemicals, mechanical control or cultural practices. The cultural practices are either not easily applicable in all the growing areas and are labor intensive. For instance, the crop grown under nets showed fewer incidences of these pests but it was not suitable for every ecology zone. Chemical like Decis and other organic insecticides are used, but their use is very hazardous to human health as the crop is staple and consumed in its original form. Chemical use is also a threat to natural enemies and non-target pests. These problems have highlighted the need for development of new, safer and eco-friendly pest control measures. Naturally occurring plant product and entomopathogens may play an important role to replace or minimize the excessive use of pesticides, as they constitute a rich source of bioactive components (**Natekar *et al.*, 1987)**.

Nowadays many plant products and microbial insecticides are also applied for less environmental hazards and for ecofriendly management of these insect pests in which neem **(Urs, 1987)**, *Bacillus thuringiensis* and *Beauveria bassiana* **(Puranik *et al.*, 2002)** are the most promising insect control agent developed so far and they are found effective against large number of lepidopterans and many other insect pests. Developing resistance to such substances are remote, however there use is limited as they are slow in there action and doesn't give quick result than insecticides. Although, a wide range of insecticides with various spray formulations have been advocated from time to time against these pests. The use of inappropriate pesticides, incorrect timing of application and improper doses have resulted in high pesticides cost with little or no applicable reduction in target population. In general, farmers relied exclusively on the use of insecticides due to their fast action and quick result than any other products.

Hence, judicious use of insecticidal spray at right time of application with right dose is the key for the management of any insect pest. Although, they also detoriates the environment but their use in significant way alongwith use of other tactics gives better result in managing these insect pests.

In views of these considerations, before going for an integrated approach for the management of brinjal fruit and shoot borer and hadda beetle , it is desirable to identify one or two insecticides having effectiveness along with plant product and microbial controlling agents to avoid the development of resistance against both major pest which are relatively safer to the ecosystem. The comparative efficacy of the synthetic insecticides, phytoproduct and biopesticides against brinjal fruit and shoot borer and hadda beetle with following objectives:

1. To study the diversity of insect fauna associated with brinjal ecosystem
2. To study the impact of synthetic insecticides, phytoproduct and biopesticides on the larval population of brinjal fruit and shoot borer
3. To study the impact of synthetic insecticides, phytoproduct and biopesticides on the population of hadda beetle
4. To assess the impact of synthetic insecticides, phytoproduct and biopesticides on the population of beneficial insects in brinjal ecosystem
5. To study the effect of synthetic insecticides, phytoproduct and biopesticides on the yield of brinjal crop

Review of Literature

2 REVIEW OF LITERATURE

The relevant available literature pertaining to the various aspects of the present investigation has been reviewed under the following heads:

2.1 To study the diversity of insect fauna associated with brinjal crop

15 insect pests of brinjal was recorded by **Sachan (1980)** from north eastern hill region of India out of which three were major pests viz., jassid, aphid and including brinjal shoot and fruit borer.

The pest complex of brinjal at MPAU, Maharashtra was reported by **Khaire and Lawande (1986)** and during their study they screened 49 brinjal cultivars for their resistance and found that 8 having < 10 *Myzus persicae* individiuals / plant, 11 having < 50 *A. Biguttula biguttula* individuals, 5 having < 3 shoots/plant damaged by *Leucinodes orbonalis* and 8 as having <6 fruits/plant damaged by *L. orbonalis.*

A study was conducted at Gwaliar (MP) by **(Dhamdhere *et al.,* 1995)** where they recorded 6 hemipteran, 3 lepidopteran, 2 coleopteran and one-mite pests of brinjal.

Suresh *et al.* (1996) conducted a field study to known the pest complex of brinjal in Manipur during 1994 and 95 and they found, that it was infested by aphid (*Aphis gossypii),* jassid *(Amrasca biguttula biguttula),* hadda beetle (*Epilachna vigintiooctopunctata),* leaf roller (*Eublemma olivacea)* and and fruit borer (*Leucinodes orbonalis).*

Thirteen species of insect pest were recorded by **(Bhadauria *et al.,* 1999)** on brinjal in Madhya Pradesh in which, stem borer (*Euzophera perticella),* shoot and fruit borer (*Leucinodes orbonalis),* leaf roller (*Eublemma olivacea), jassid (Amrasca biguttula biguttula)* and aphid (*A. gossypii*) were the most common.

At Barapani, Meghalaya a study was conducted by **(Singh *et al.,* 2002)** regarding the pest complex of brinjal where they reported 27 insect pests and 4 non insect pest which are infesting brinjal crop, of these the jassid (*A. biguttula biguttula*) and shoot and fruit borer (*Leucinodes orbonalis)* are the serious pest of brinjal while aphid (*A. gossypii*), white fly (*Bemisia tabaci)*, hadda beetle (*Epilachna vigintiooctopunctata)*, leaf folder (*Eublemma olivacea)* and flea beetle (*Phyllotreta cruciferae*) as the moderate pests.

Some of the pests associated with brinjal crop were listed by **Kumar *et al.* (2007)** in North India where shoot and fruit borer (*Leucinodes orbonalis*.) and hadda beetle *Epilachna vigintiooctopunctat*a was reported as the major insect pest, while other are jassid (*A. biguttula biguttula)*, whitefly (*Bemisia tabaci),* black hairy caterpillar (*Perica lliaricini*), tobacco caterpillar (*Spodoptera litura*) and green semilooper (*Thysanoplusia orichalacea*).

A field experiment was conducted to study the major insect pests of brinjal crop in Baptala where **(Rajavel *et al.*, 2008)** study revealed that the shoot and fruit borer (*Leucinodes orbonalis* Guen.) damage was serious in their study area and it is the major pest in the locality while the population of hadda beetle (*Epilachna vigintioctopunctata* Fab.), ash weevil, (*Myllocerus* spp Guerin.), mealybug, (*Coccidohystrix insolitus* Green.), aphid, (*Aphis gossypii* Glover.), leafhopper, (*Amrasca devastans* Ishida.) and whitefly, (*Bemisia tabaci* Gennadius.) were also present respectively.

A study of brinjal insect pest complex was conducted at Bangalore where **(Chandrakumar *et al.*, 2008)** recorded that there was three major hemipteran insect pest, aphid *A. gossypii*, leafhopper, (*Amrasca devestans)* whitefly, (*Bemisia tabaci)*, and two major coleopterans, ash weevil, (*Myllocerus spp.)* and hadda beetle (*Epilachna vigintiooctopunctata*) damaging the brinjal crop.

The biodiversity of arthropods in the brinjal fields in Gazipur, Bangladesh was observed by **(Latif *et al.*, 2009)** where twenty species of harmful arthropods under 17 families belonging to 6 different orders were found. However, brinjal shoot and fruit borer (*L. orbonalis)*, hadda beetle, (*E. vigintioctopunctata*), jassid (*Amrasca bigittula bigitulla)*, whitefly, (*Bemisia tabaci)* and aphid, (*A. gossypii)* are found as the most common and the major insect pest of brinjal.

The study on the population of whitefly *(Bemisia tabaci)* on brinjal plants were conducted at the Field Laboratory of the Faculty of Applied Science, Universiti Teknologi MARA by **(Rasdi *et al.*, 2009**) revealed that the total number of whitefly *(Bemisia tabaci)* was found to be most abundant in the middle stratum of the brinjal plants.

Sankari and Thiyagesan (2010) reported 8 species of spider's *Argiop eluzona* (Walckenaer) (Argiopidae), *Cyrtophoracic atrosa* (Doleschall) (Arneidae), C*hryssoargyrodi formis* (Yaginuma) (Theridiidae), *Hipossap antherina* (Thorell) (Lycosidae), *Oxyopes lineatipes* (C.L.Koch) (Oxyopidae), *Oxyopes javanus* (Thorell) (Oxyopidae), *Peucetia viridana* (Thorell) (Oxyopidae) and *Lycosapseudo annulata* (Boescriberg and Strand) (Lycosidae) which are potentially predatory on insect pest of brinjal crop.

2.2 To study the impact of synthetic insecticides, phytoproduct and biopesticides on the larval population of brinjal fruit and shoot borer

Out of 15 insecticides tested against *L. orbonalis* on brinjal crop for two years, **Datar (1983)** found that carbaryl at 0.1 percent application just after establishment of brinjal seedlings and five more times at 15 days interval gave good control of *L. orbonalis*.

All synthetic pyrethoids viz., cypermethrin, deltamethrin, permethrin were highly effective against *L. orbonalis* while carbaryl was moderately effective **Tewari and Moorthy (1983).**

Complete control of the pest under field conditions was achieved by **(Rajendra *et al.*, 1990)** with lambda-cyhalothrin and deltamethrin 200 ppm whereas conventional insecticides (monocrotophos and endosulfan) showed maximum incidence of *L. orbonalis.*

Seven inscticides were evaluated by **Chinniah and Asafali (1999)** including two newer compounds viz., carbosulfan 25 EC and bifenthrin 10 EC and a combination product *viz.*, carbosulfan + quinalphos for the control of brinjal shoot and fruit borer. They revealed that quinalphos 25 EC @ 2 ml per liter and carbosulfan 25 EC (Marshal) @ 2 ml per liter were on par with each other and were significantly superior to all other treatments in terms of least percent shoot damage and average fruit yield per plot. The percent fruit damage was least in the case of combination product (tank mix) namely Marshal + quinalphos @ 1 ml each per l and cypermethrin @ 1 ml/l followed by quinalphos @ 2 ml/l.

Experiments were conducted on the management of brinjal shoot and fruit borer, *L. orbonalis* Guen. by **(Raja *et al.*, 1999)** where the pooled data analysis indicated that the neem products viz., neem oil (4 per cent), neem seed kernel extract (5 per cent) and their combination with endosulfan (0.07 per cent) were effective in reducing the fruit borer damage and on par with insecticides in their efficacy. Moreover, Neem oil (4 per cent), NSKE (5 per cent), endosulfan (0.07 per cent) + neem oil 2 per cent, endosulfan (0.07) + NSKE (5 per cent), endosulfan (0.07 per cent) and carbaryl (0.05 per cent) reduced the fruit borer damage to 10.13, 11.56, 11.37, 11.41, 11.68 and 11.81 per cent respectively as against 36.9 per cent infestation recorded in the untreated control.

The comparative efficacy of different dosages of a new formulation of quinalphos (aqua flow, AF) against *L. orbonalis* on brinjal was studied by **Samanta *et al.* (1999)** who observed that Quinalphos AF @ 500, 750 and 1000 g ai./ha and its mixture with monocrotophos (500 + 360 g ai/ha) gave excellent control of the pests along with a significantly higher crop yield and also found that AF formulation was far superior to the EC formulation at 500 g ai/ha.

Sasikala (1999) reported that among the different treatments, Btk 0.15 percent was found to be effective as it resulted in lower shoot and fruit infestation and higher yield. Next best treatments were release of egg parasitoid *Trichogramma japonicum* (ash) and neem oil (0.1%) + Btk (0.075%). neem oil (0.1%) + carbaryl (2ml/l).

Krishnakumar and Krishnamurthy (1998) at Indian Institute of Horticultural Research (IIHR) conducted an experiment for the control of brinjal shoot and fruit borer *L. orbonalis* and found that NSKE 5 percent was effective in managing the pest.

Mathirajan *et al.* (2000) reported that Lambda-cyhalothrin applied at the rate of 30 g a.i. per hectare was found to be effective against shoot and fruit. The order of efficacy was lambda-cyhalothrin > endosulfan > fenvelarate.

Carbosulfan 25 EC when applied individually at 2 ml/lt as foliar spray was very effective in checking the damage caused by shoot and fruit borer to brinjal. **Srinivasan and Rabindra (2001)** found that the Cypermethrin 25 EC at 0.5 ml/lt or quinalphos 25 EC at 2 ml/lt for 3 round followed by carbosulfan 25 EC at 2 ml/lt for three more rounds was highly effective in checking the pest.

Experiments were conducted in Bijapur, Karnataka, **(Biradar *et al.*, 2001)** to evaluate the efficacy of cypermethrin 3 EC+quinalphos 20 EC against the brinjal shoot and fruit borer, *L. orbonalis*. The treatments consisted of cypermethrin 3 EC+quinalphos 20 EC at 0.25, 0.50, 0.75 and 1.00 ml/litre, cypermethrin 10 EC at 0.50 ml/litre, quinalphos 25 EC at 2.00 ml/litre and an untreated control. The treatments were sprayed twice at 15-day intervals, with the first spray initiated at the peak of *L. orbonalis* incidence. All treatments recorded significantly lower fruit damage and higher fruit yield compared with the untreated control. Cypermethrin 3 EC+quinalphos 20 EC at 1.00 ml/litre recorded the lowest percentage of fruit damage both on a number basis (29.5 and 22.4% after the first and second spray, respectively) and on a weight basis (25.3 and 20.2% after the first and second spray, respectively).

A study of effectiveness of biorational integrated approach in the management of brinjal fruit and shoot borer was conducted by **Chakraborti (2001)** using following components: application of fresh neem cake in nursery @ 3 kg/m^2 at land preparation, fresh neem cake @ 1 kg/plant once in every 30 days after transplanting, foliar application of neem seed kernel extracts @ 7 ml a.i./litre at an interval of 7 days beginning with 30 days after transplanting, root zone application of benzene @ 1 ml a.i./plant once in evey 30 days after transplanting, clipping and destruction of infested plant parts, and single application of carbofuran @ 5 g.a.i/plant on 30 days after transplanting. However Neem components, benzene and destruction of infested plant parts appeared to have produced cumulative effect strongly deterring oviposition and found highly effective showing only 4.92 and 5.32 per cent mean shoot and fruit infestation, respectively. It was markedly superior to conventional chemical method having 20.42 and 25.24 per cent mean shoot and fruit infestation, respectively and suffered only 2 per cent yield loss as compared to 50 per cent and 45 per cent in chemical management and untreated control respectively.

Nine insecticides were evaluated against brinjal shoot and fruit borer, *L. orbonalis* Guen. by **(Jat and Pareek 2001)** and reported that the cypermethrin (0.007%) proved most effective followed by carbaryl (0.20%) and endosulfun (0.07%). However, Nimbecidine (1.51/ha) was found least effective in reducing shoot and fruit infestation followed by Neemgold (1.21/ha) and *Bacillus thruingiensis (B.t.*) alone (0.012%), whereas, *B.t.* + carbaryl (0.012 + 0.10%), *B.t.* + endosulfan (0.012 + 0.035%) and malathion (0.05%) existed in middle order of efficacy. The maximum yield of marketable brinjal fruit and minimum avoidable loss were obtained in cypermethrin followed by carbaryl and endosulfuan, whereas, minimum yield was recorded in the treatment of Nimbecidine.

Field trials were carried out in western Orissa by **(Sontakke *et al.*, 2001)** to evaluate the effectiveness of 4 insecticides against *L. orbonalis* and *Aphis gossypii* on brinjal. They reported that Quinalphos at 0.5% was the most effective compound against *L. orbonalis*, reducing infestation to 4.6% as compared with 25.1% in an untreated variant, followed by 0.02% decamethrin(4.2%) and 0.1% fenvalerate (4.4%). However, Monocrotophos at 0.5% was the most effective compound against *A. gossypii*, reducing infestation to 2.2 aphids/leaf as compared with 22.4 in an untreated variant.

Ghong *et al.* (2002) tested some new ready mix insecticides against brinjal shoot and fruit borer and found that Nurelle D 505, 55 EC (chlorpyriphos 500g + cypermethrin 50 g) at 550ga.i. per hectare was most effective in reducing shoot (4.67%) and fruit infestation (20.81%).

Efficacy of different insecticides, *B. thuringiensis* var. *kurstaki* (Bt), neem and diflubenzuron for the control of shoot and fruit borer, *L. orbonalis* on egg plant was conducted by **(Muralikrishna *et al.*, 2002)** which revealed that shoot infestation by *L. orbonalis* was low due to application of phorate at transplanting followed by foliar spray of Bt + carbaryl in reducing the shoot infestation (9.36%). The fruit infestation on number basis was minimum in phorate application at transplanting followed by a combined application of Bt + endosyuulfan and Bt + carbaryl which recorded 9.71 to 9.93 per cent infestation. Foliar spray of neem and diflubenzuron alone were not effective in reducing the damage of shoot and fruit borer in brinjal.

Evaluation of different *Bacillus thuringiensis (B.t.)* formulations in comparison with neem and chemical insecticides against brinjal shoot and fruit borer, *L.s orbonalis* Guenee was conducted by **(Puranik *et al.*, 2002)** and suggested that five sprays of Dipel 8L @ 0.2 per cent at 10 days interval which resulted in minimum shoot (9.56%) as well as fruit (11.78%) infestation and also proved to be the most effective treatment. It was however, at par with Delfin WG, Halt WP and Biolep WP, all at 0.2 per cent concentrations. This was followed by Biobit HPWP, Spicturin and chemical insecticides viz., cypermethrin and endosulfan, while neem was found to be the least effective treatment.

Six insecticides and their eight combinations were tested by **Dharma and Jang (2003)** for their efficacy against brinjal fruit and shoot borer, *L. orbonalis.* In which Endosulfan + deltamethrin (0.07%, 0.0025%) and endosulfan + fenvalerate (0.07% + 0.005%) were highly effective against fruit borer their were only 13.3% damage as compared to 69.8% in control. The other promising treatments which significantly reduced the fruit damage over the control were in the order: carbaryl + fenvalerate = dichlorvos + fenvalerate (14.9%) > malathion + fenvalerate (16.4%) > fenvalerate + deltamethrin (16.6%) > dichlorvos = carbaryl + deltamethrin = malathion = dichlorvos + deltamethrin = malathion + deltamethrin (18.3%) > endosulfan (20.0%) > carbaryl (21.6%) with mean percentage of damage 14.9, 16.4, 18.3, 20.0, 21.6 and 69.8%, respectively. Carbaryl was least effective, but its combinations with pyrethroids were proved superior over carbaryl alone.

The bio-efficacy of cypermethrin applied at @ 0.003, 0.006 and 0.01%, and fenvalerate applied at @ 0.004, 0.008 and 0.015% concentrations, against brinjal shoot and fruit borer, *L. orbonalls* (Guen.) on brinjal var. 'Pusa Purple Round' along with endosulfan @ 0.07% was tested by **(Duara *et al.*, 2003)**. All insecttcidal treatments gave effective control of shoot and fruit borers and increased yield of fruit over control. However, no significant difference was recorded among the treatments in reducing the shoot damage after 7 day of spraying. Plots treated with cypermethrin 0.006% and fenvalerate 0.015% recorded the 28.25% shoot damage at 7 day after spray.

Ten combinations of insecticides (carbofuran 3G at 0.5 kg a.i./ha, malathion at 0.1%, quinalphos at 0.05% and teepol at 0.4%) and plant extracts neem (*Azadirachta indica*) cake at 20 q/ha, karanj (*Pongamia pinnata*) cake at 20 q/ha, neem oil at 3% and karanj oil at 3%) were evaluated against the brinjal shoot and fruit borer, *L. orbonalis* in Bihar by **Singh (2003)** and reported that the foliar application of quinalphos with basal application of neem cake reduced the incidence of borer and increased the yield of brinjal. The incidence and yield recorded in basal application of neem cake with foliar spray of neem oil was at par with combination of conventional insecticides.

A study was conducted on bioefficacy of neem derivatives (such as neem oil and neem cake extract), along with carbaryl at different concentrations were evaluated by **(Kavitha *et al.*, 2008)** against fourth instar larvae of brinjal pest *L. orbonalis*. All the test solutions manifested larvicidal effect. Larvicidal effect of neem oil was higher than neem cake extract. Larval mortality increased as the concentration of neem derivatives increased and therefore utilization of these neem derivatives can be incorporated as one of the components for sustainable management of *L. orbonalis.*

Nine plant products were evaluated against *L. orbonalis.* Viz., *Azadirachta indica* leaf extract @ 5.0 %, *Calotropis gigantea*. R. Br. leaf extract @ 5.0 %, *Lantana camera* Linn. Leaf extract @ 5.0 %, neem cake extract @ 5.0 %, neem oil @ 2.0 %, Nimbecidine® @ 2 ml /lit, *Pongamia glabra* Linn. leaf extract @ 5.0 %, *Prosopis juliflora* Linn. leaf extract @ 5.0 %, and garlic (*Allium sativum* Linn.) extract @ 5.0 %. The standard check, carbaryl (Sevin 50 WP) @ 0.1% and an untreated check were included. The plant products, neem oil, Nimbecidine, neem cake extract and *C. gigantea* were able to reduce the shoot damage by more than 50%, moreover consistent effect was observed only for neem oil (57.29 %) and Nimbecidine (52.67 %). The plant products were moderately effective compared to the standard check, carbaryl. The plant products were moderately effective against fruit damage too. Among the plant products, neem oil was the best treatment (60.20 %) followed by Nimbecidine (57.42 %). Neem cake extract (51.97 %) and *C. gigantea* (51.34 %) which were also quite effective in reducing fruit damage by more than 50 percent **Murugesan and Murugesh (2008)**.

To evaluate the bioefficacy of flubendiamide 480 SC (Fame 480 SC) at three concentrations of 60, 72 and 90 g a.i./ha which were replicated thrice with five other insecticides which are Thiodicarb 75 SP @ 750, g a.i./ha, Quinalphos 20 EC @ 200 g a.i./ha, Carbaryl 50 WP @1000 g a.i./h Malathion 50 EC @ 500 g a.i./ha and Profenophos 50 EC @ 500 g a.i./ha. **(Jagginavar *et al.*, 2009)** reported that the flubendiamide 480 SC @ 90 and 72 g a.i./ha were significantly superior over other treatments and on par with each other in recording less shoot damage (11.43 and 16.21%) at 7 days after first spray. The next best treatments were profenophos 50 EC @ 500 ml a.i./ha (19.43%) and flubendiamide 480 SC @ 60 g a.i./ha (24.37%). Similar trend was recorded at 7 days after second spray in recording less shoot damage. Flubendiamide 480 SC @ 90 g a.i./ha recorded least fruit damage of 0.78 per cent which was on par with flubendiamide 480 SC @ 72 g a.i./ha (1.04%) at 7 days after first spray. Similar trend was observed at 7 days after second spray.

A study on bioefficacy of insecticides was conducted against brinjal shoot and fruit borer, *L. orbonalis* Guenee by **Anil and Sharma (2010)** which showed that in terms of shoot infestation, emamectin benzoate (0.002%), endosulfan (0.05%), novaluron (0.01%) and lambda-cyhalothrin (0.004%) were found superior. The total number of droping shoots was minimum (4.17) in emamectin benzoate followed by endosulfan (6.83) and novaluron (7.00), as compared to spinosad (9.17), deltamethrin (11.67). However, in terms of reduction in fruit infestation, emamectin benzoate (0.002%) was highly effective followed by endosulfan (0.05%), lambda-cyhalothrin (0.2%) and spinosad (0.0024%).

In this study, nine insecticides such as azadirachtin 0.03EC, abamectin 1.8EC, flubendiamide 24WG, chlorpyriphos 20EC, cartap 50SP, carbosulfan 20EC, thiodicarb 75WP, cypermethrin 10EC, and lambdacyhalothrin 2.5EC belonging to different chemical groups were tested against brinjal shoot and fruit borer in field where **Latif *et al.* 2010** reported that carbosulfan and flubendiamide reduced more than 80% shoot and fruit infestation in winter, and 80% shoot and 70% fruit infestation in summer over control. Moreover, Carbosulfan protected the highest amount of healthy fruit yield in both cropping seasons. Flubendiamide also showed the similar efficacy. Cartap and thiodicarb were moderately effective in both the seasons. Efficacy of cypermethrin and abamectin was moderate in winter but low in summer. Lambdacyhalothrin and chlorpyriphos although reduced shoot and fruit infestation of brinjal and protected higher yield as compared to control, their effectiveness was not satisfactory. The performance of azadirachtin against the pest both in the laboratory and in field trials was the poorest while that of carbosulfan and flubendiamide was the best. Thus, it is suggested that carbosulfan and flubendiamide may be used for the control of *L. orbonalis* in brinjal.

A field experiments were carried by **(Bhushan *et al.*, 2011)** to evaluate the efficacy of pest management modules against brinjal shoot and fruit borer (*L. orbonalis*). The result on efficacy of modules revealed that minimum shoot and fruit damage (9.32 and 14.83 per cent, respectively) was observed in module with alternate spraying of Neem (1500 ppm) and Triazophos (35%) plus deltamethrin (1%).

The impact of vegetational diversity through intercrop and the application of antifeedants were assessed for their ability to reduce the infestation of shoot and fruit borer *L. orbonalis* Guen. on brinjal by **Satpathy and Mishra (2011)** where they suggested intercropping with coriander and fennel reduced the fruit damage to 12–15% compared with the plots with brinjal plant monoculture. Total yield of intercropped brinjal plant was significantly higher than the brinjal plant monoculture yield. Moreover, coriander and fennel were found to be equally effective in reducing infestation by *L. orbonalis*. Whereas Neem seed kernel extract (4%) and the neem-based product Neemarin were also found to be more effective in controlling *L. orbonalis* than ash dust and were lower than the untreated control. The fruit infestation level in the neem treatments (either of them) was 15–16% less than the untreated check. The interaction of intercrop and antifeedant showed that coriander-intercropped brinjal plant along with foliar spray of Neemarin[s] significantly reduced fruit damage. In a multiple-choice chamber, orientation of female moths to brinjal plant was significantly reduced in the presence of fennel or coriander. With 38.9 and 37.1 per female, the extent of egg-laying by *L. orbonalis* on eggplant associated with fennel or coriander, respectively, was significantly less than on sole brinjal plant (48.4/female).

Sharma *et al.*, 2012 conducted a field experiment to evaluate the potential of two botanicals viz; ozoneem and neem seed kernel extract (NSKE) and three chemical insecticides viz; imidacloprid, alphamathrin, chlorpyriphos 50% EC + cypermethrin 5% EC against *L. orbonalis*. Where botanicals were tested alone and in combination with cultural practices. On the basis of the pooled means, the results revealed that three sprays of chlorpyriphos + cypermethrin @ 0.01% active substance (a.s.) in 15 days intervals was found to be the most economical, resulting in minimum shoot (2.15%) and fruit (12.95%) infestation respectively, followed by alphamathrin @ 0.01% a.s (active substance) whereas, three sprays of NSKE @ 5 ml/lt. recorded a maximum of shoot (3.91%) and fruit (24.49%) infestation, respectively.

2.3 To study the impact of synthetic insecticides, phytoproduct and biopesticides on the population of hadda beetle

Mishra *et al.*, (1990) concluded that, feeding brinjal leaves treated with 0.025 and 0.05% neem oil to *E. vigintioctopunctata* increased the duration of life stages in the subsequent generation. Neem oil also reduced the weight of treated insects compared with the untreated control.

B. thuringiensis formulations were applied by **(Markandeya *et al.*, 1996)** which revealed that for leaf area protection *B. thuringiensis* formulations were effective and leading to mortality of *E. vigintioctopunctata* infesting brinjal crop.

The effect of biopathogens, *viz.*, *Bacillus thuringiensis* var. *kurstaki* (B.t.) 0.25% suspension, and the white muscardine fungus, *Beauveria bassiana* Vuillemin >(2 x 10^8 conidia/cm^2) was studied on different stages of hadda beetle, *E. vigintioctopunctata* (Fab.) infesting egg plant, *Solanum melongena* Linn. where **Rajendran and Gopalan (1998)** suggested the use of *B.t* as a leaf dip which give a maximum mortality of 68.9% in the first instar grubs and a minimum of 13% in the prepupal stage of hadda beetle. However, the adults were less susceptible to *B.t.* and the percent egg hatchability was respectively 12.2, 11.7, 17.9, 12.9 and 18.7 when freshly laid, 1, 2, 3 and 4-day old eggs were treated with 0.25% *B.t*, whereas direct spraying of the white muscardine fungus killed 58.1% first instar grubs and 35.2% pre-pupal stage grubs. The adults were not susceptible to this fungus, the maximum mortality being 10.3% in the case of newly emerged adults. This fungus caused 54.6% hatchability of one-day old eggs of the hadda beetle.

In West Bengal **(Samanta *et al.*, 1999)** also conducted a field trial to study the comparative efficacy of different dosages of a new formulation of quinalphos (aqua flow, AF) against *E. vigintioctopunctata* on brinjal and suggested Quinalphos AF @ 500, 750 and 1000 g ai./ha and its mixture with monocrotophos (500 + 360 g ai/ha) which gave excellent control of the pests. The AF formulation was far superior to the EC formulation at 500 g ai/ha. Aqua flow formulation of quinalphos was found to be compatible with monocrotophos, zineb and urea and no phytotoxicity was produced when quinalphos AF or its mixtures with other insecticides were applied on brinjal.

The effectiveness of different concentrations of (novaluron) rison 60 EC (0.12, 0.20, 0.24%), (deltamethrin) decis 2.5 EC (0.0125, 0.025, 0.05%) and (carbosulfan) sunsulfan 20 EC (0.08, 0.10 and 0.15%) were tested on the mortality (%) of different larval instars and adult of *Epilachna. vigintioctopunctata*, under the laboratory conditions which were studied by **(Das *et al.*, 2002)** and reported that the insecticides decis showed the highest toxicity which was followed by sunsulfan and rison. The concentration levels of 0.05% decis, 0.15% sunsulfan and 0.24% rison were the most effective against different stages of larvae and adults of *E. vigintioctopunctata*.

The efficacy of neem oil on the mortality, growth and feeding responses of epilachna beetle showed that all the larval instars were susceptible to this oil by **(Anam *et al.,* 2006)** and reported that the LC_{50} values were higher at 3rd instar and it was lowest on 1st instar and also the LT_{50} values of oil increases proportionately with increasing larval age and with decreasing oil concentration. Neem oil significantly prolonged larval and pupal periods and some of the treated larvae never reached to the pupae. Pupal recovery and adult emergence were greatly reduced in treated larvae. In addition, neem oil also reduced the food consumption of this beetle by acting as feeding deterrent.

To evaluate the effect of some chemical insecticides and non-chemical methods against the hadda beetle (Epilachna spp.) on brinjal, a field experiment was conducted at Dhaka, Bangladesh **(Ali *et al.,* 2007)** where they evaluate seven treatments in their study such as, mechanical control (hand collection and destruction of egg masses, larvae and adults), spraying of Cypermethrin 10EC, Chlorpyriphos 20EC, carbaryl 85SP, neem seed kernel extract, mechanical control in combination with neem seed kernel extract and a control. The lowest number of egg masses (0.11/plant), larvae (0.04) and adult (0.13) was observed in carbaryl and this treatment provided more than 90% reduction of egg masses, larvae and adults of epilachna beetle compared to control. Similar results were obtained by using Chlorpyriphos 20EC, Cypermethrin 10EC and mechanical control in combination with application of neem seed kernel extract.

Six isolates of selected entomopathogenic fungi were tested for their efficacy against the eggs, larvae and adults of the ladybird beetle, *E. vigintioctopunctata*, under an ambient environment of 28 ± 20°C, 85 ± 15% RH and 12 h photoperiod by **(Cheekong *et al.,* 2008).** All *B. bassiana* isolates were infective against the eggs, larvae and adults of *E.vigintioctopunctata*. Exposure to a suspension of 1 x 108 conidia ml-1 resulted in 99.2 - 91.5% infection on the eggs, 71.7 - 65.0% on the 1st instar larvae, and 86.7 - 76.7% on the adults seven days after treatment. Infectivity by *Metarhizium anisopliae* was rather weak with the highest infection (54.5%) on the eggs, while the highest against the 1 st instar larvae (58.3%) and that against the adults (40.0%). In general, isolates of B. bassiana inflicted the highest mortality against the eggs, larvae and adults of *E.vigintioctopunctata*. Field experiment showed *B. bassiana* and

Deltamethrin were equally effective and inflicted significantly higher larval mortality (75.0% and 98.0%, respectively) and lesser leaf damage (81.4% and 78.6%, respectively) compared to *M. anisopliae* and the control five days after the last spray.

Murugesan and Murugesh (2008) also evaluated ten plant products against *Epilachna vigintioctopunctata,* which are *Azadirachta indica* (neem) leaf extract (5.0%), *Calotropis gigantea* leaf extract at 5.0%, *Lantana camera* leaf extract at 5.0%, neem cake extract at 5.0%, neem oil at 2.0%, Nimbecidine at 2 ml/litre, *Pongamia pinnata* (pungam) leaf extract at 5.0%, *Prosopis juliflora* leaf extract at 5.0%, *Vitex negundo* leaf extract at 5.0% and *Allium sativum* (garlic) extract at 5.0%. The standard control, carbaryl (Sevin 50 WP) at 0.1% and an untreated control were included. The plant products were able to bring about higher reduction in population of *E. vigintioctopunctata* from 87.86 to 71.97% on the third day after application. However, the efficacy was reduced with the increase in days after application. Higher reduction in the population of *E. vigintioctopunctata* was observed in neem oil and was at par with *C. gigantea*, Nimbecidine and *L. camera*, followed by *P. glabra*, neem cake extract and *V. negundo*. However, the plant products were less effective than carbaryl, but better than the untreated control.

Brinjal plant is attacked by several insect pests including hadda beetle, *Epilachna vigintioctopunctata* Fab. Here the present investigation was carried out under field conditions by **(Pandi *et al.*, 2008)** whose result revealed that neem cake (1000 kg/ha) was found to be very effective in reducing the damage of hadda beetle by 69.79 per cent. As neem cake was less preferred for oviposition which recorded 62.00 eggs/plants, coupled with a minimum feeding area of 6.75 cm^2.

A field experiment was conducted by **(Prasad *et al.*, 2008)** to explore economically viable IPM module for managing one of the most injurious defoliating insect pest, epilachna beetle (*Epilachna vigintioctopunctata* Fab.) infesting brinjal through judicious application of granular insecticides @ 1.0 kg ai/ha incorporated around the root zone of plants at 30 DAT (days after transplanting). The efficacy of the insecticides was in the order: carbofuran > phorate > quinalphos. The interactive impact of crop association and soil application of insecticide @ 1.0 kg ai/ha coupled with need based spray of chlorpyriphos 20 EC @ 1000 ml/ha was significantly effective in suppressing the incidence of the insect pest.

Suresh *et al.* (2008) conducted a field experiment in Tamil Nadu to adopt various eco-friendly measures to control spotted beetle damage in brinjal, where they sugested Farm Yard manure (FYM), Biofertilizers, Poultry manure, Neem cake and Mahua Cake were used as organic sources of nutrients for the management of beetle damage in brinjal. From the study conducted the treatment involving FYM + biofertilizers + neem cake recorded high per cent reduction of beetle infestation over NPK as inorganic form. Next to this was FYM + biofertilizers + mahua cake treatment.

Study was conducted considering the biosafety of the environment and effective management of the pest using mycopathogen, *Beauveria bassiana* was evaluated against *Epilachna. vigintioctopunctata*in Sri Lanka on brinjal crop by **Thurkathipana and Mikunath (2008)** where a pathogenicity tests were conducted in vitro and followed by field evaluation in which concentrations of 1 x 10(9), 10(8), 10(7), 10(6) and 10(5) spores/ml in vitro and in the field, 1 x 10(7) spores/ml of *B. bassiana* was used for evaluation and the result shows that the mortality of *E. vigintioctopunctata* was apparent at 18 hours after application of *B. bassiana* at the concentration of 1 x 10(8) spores/ml under the laboratory condition (30 +/- 2 degrees C, 80 +/- 2% RH) and 72 hours after application in the field.

To find out the impact of plant derived pesticides viz; Neem Azal (*Azadirachta indica)*, Rhizome extracts of Sweet flag (*Acorus calamus)* with petroleum ether as solvent and seed extracts of Custard apple *(Annona squamosa)* with methanol as solvent in controlling epilachna beetle, *Epilachna vigintioctopunctata*, Fabr, a field trial was conducted on ‘Barapata by **(Mondal and Ghatak, 2009)** on variety of cucumber. Both Neem Azal and seed extracts of *Annona squamosa* were used at 4ml, 5ml and 6ml (per Lt. of water) while this was 1ml, 2ml and 3ml (per Lt. of water) in case of petroleum ether extract of rhizome of *Acorus calamus*. Endosulfan 35 EC was used at 1ml, 1.5ml and 2ml (per Lt. of water) to compare the efficacy of plant products. Results of the experiment revealed that Endosulfan 35 EC at $2mL^{-1}$ of water performed very well in reducing population build up of *Epilachna vigintioctopunctata*, Fabr. to the extent of 75.00%, while among the botanical pesticides, this was highest (76.37%) in seed extracts of *Annona squamosa* at $3mL^{-1}$ of water followed by 64.00% in Neem Azal at $5mL^{-1}$ of water and 57.00% in petroleum ether extracts of rhizome of *Acorus calamus* at $2mL^{-1}$ of water.

Present study was conducted to evaluate the efficacy of six insecticides for the management of hadda beetle (*Epilachna vigintioctopunctata)* on ashwagandha in Raichur (Karnataka) with Endosulfan 35EC @ 2 ml/litre, Quinalphos 20 EC @ 2ml/litre, Fenvalerate @ 0.5ml/litre, Chlorpyriphos 20 EC @ 2ml/litre, Dimethoate 30 EC @ 1ml/litre and NSKE 5% by **Chandranath and Katti (2010)** where they reported, that the population of epilachna beetle was in the range of 14.0 to 16.5 beetles per plant before the imposition of treatments causing sufficient foliage damage of 20 per cent in all the plots. After three days of spraying, maximum population of 16.0 beetles per plant was recorded in untreated control. However, there was a reduction in population in all the treatments. Where Dimethoate recorded least number of 6.90 beetles per plant which was at par with all other chemicals except Quinalphos (8.40 beetles/ plant). On the 7th day, the maximum population of 14.90 beetles per plant was recorded in control. The lowest population of 4.30 beetles per plant was recorded in dimethoate which was on par with rest of the chemicals. Maximum yield of 4.6 Q/ha was recorded in dimethoate treated plot, which was on par with all other treatments. Based on the yield obtained, the order of efficacy of the chemicals is as follows: Dimethoate > Fenvelarate > Quinalphos > Chlorpyriphos > Endosulfan > NSKE 5%.

The antifeedant activity of *Azadirachta indica* (L.) A. Juss (neem) leaf extract, seed kernel extract, and seed oil; *Pongamia glabra* Vent seed oil; *Madhuca latifolia* (Roxb.) Macbeth oil and two fungal origin biopesticides, *i.e*., conidia of *Metarhizium anisopliae* (Metchnioff) Sorokin and the enzyme preparation of the fungus, *Myrothecium verrucaria* (Albertini & Schwein) were evaluated by **(Swaminathan *et al.*, 2010)** against the adult of *Epilachna. vigintioctopunctata* under laboratory conditions and reported that, among the botanicals evaluated, *P. glabra* oil showed the maximum anti-feedant activity where no feeding was observed up to 48 hours after treatment. Mortality was noticed 72 hours after treatment and percent mortality was recorded 7 days after treatment at all the concentrations. However Neem oil showed 60 per cent mortality at 5 per cent concentration. The leaf extract and seed kernel extract of *A. indica* had less anti-feedant activity as compared to the oil formulations of *A. indica* and *M. latifolia* (based on the percent leaf area consumed) and also a decrease in feeding was evidenced after treatment with *M.anisopliae* and *M. verrucaria.*

To evaluate efficacy of extracts from plants such as *Pongamia pinnata* L. (Karanja) and *Nicotiana tabacum* L., botanical insecticide such as azadirachtin (1500 ppm), microbial insecticides like *Beauveria bassiana* against *Epilachna. vigintioctopunctata* infesting brinjal crop under field condition were taken, where Cartap hydrochloride 50% SP was used as check. Three sprays at 10-day intervals were made, starting with the initiation of infestation. Total *E. vigintioctopunctata* numbers (both adult and grub) per plant were counted at 4 and 9 days after treatment, where **(Ghosh *et al.*, 2012)** found significant differences in the efficacy of different treatments in reducing the pest population in which *Beauveria bassiana* was found the most effective treatment for the controlling *E. vigintioctopunctata*, followed by b**o**tanical insecticide, azadirachtin and it was observed that botanical insecticide, azadirachtin and extracts of Pongamia at a concentration of 5 % gave satisfactory control, recording more than 50 % mortality. The azadirachtin alone was found very effective against the *E. vigintioctopunctata*, achieving more than 60% mortality at 4 days after spraying.

2.4 To assess the impact of synthetic insecticides, phytoproduct and biopesticides on beneficial insect in brinjal ecosystem

Effect of insecticide on natural enemies is always low or less effective, it is so, because they are active fliers and they mostly fly away at the time of insecticide sprays and therefore use of insecticide is safer to natural enemies.

B. thuringiensis was safe to natural enemies' viz., *Chrysoperla carnea, Coccinella. septumpunctata* and predaceous mite *Amblysiceus perisimilis* (Muma) and it was reported by **Tandon and Nillana (1987**).

Schoonover and Larson (1995) reported that spinosad was found to have short-term toxicity to the mite, *Phytoseiulus perisimilis* (Athias – Henricot), a predator of spider mite but however it was much safer to predator like *E. Formosa* (Gahan), *Orius insidiotus* (Say), *Chrysoperla rufilabris* (B.) and to a convergent lady bird beetle *Hippodamia convergeus*(Guerin.).

Emamectin benzoate is a safe chemical to *C. carnea* and *Coccinellids*, which is reported by **(Dunbar *et al.*, 1998)** in his study where they suggested that this might be due to rapid degradation on the surface of foliage, limiting contact of phytophagous insects as its mode of action is mainly by ingestion, ecologically selective to wide range of beneficial species due to rapid breakdown of the active ingredient by photo-oxidation to non-toxic level on the leaf surface, limiting contact activity to a very short period.

Srinivasan and Sundara Babu (1998) reported that *B. thuringiensis* was harmless to egg parasitoid *Trichogramma* spp. but harmful to the grubs as well as adults of *C. carnea* at higher doses, while Abamectin was relatively safe to *C. carnea.*

The neem extract and neem oil were harmless to the egg and larvae of *Chrysoperla carnea* Steph. and *Coccinella septumpunctata* Thumb and it was reported by **Kaethner (1999).**

The ether extracts of neem seed kernel was suggested by **(Guddewar *et al.,* 1994)** and found safer than synthetic insecticides to *C. septumpunctata*. The order of safety was neem seed kernel extract, endosulfan, quinalphos, malathion and monocrotophos.

The neem based treatments like spraying of neem oil and NSKE were found safer to natural enemies by **Chakraborti (2001)** during their field trials and were on par with untreated check in brinjal ecosystem.

The effect of neem formulations based on azadirachtin content (NeemAzal, Rakshak Gold ICIPE Neem 1% each) was evaluated by **Mann and Dhaliwal (2001)** against beneficial arthropods in cotton agroecosystem where they reported that the parasitization of Bemisia. tabaci by Encarsia spp. in neem-based insecticides was recorded to be minimum (4.1%) in Rakshak Gold @ 2 l/ha which was at par with control (4.5%). However, triazophos recorded very strong detrimental effects with 0.86% parasitization. Number of spiders 15 plants were recorded significantly maximum (5.00) with NeemAzal 1 l/ha than that of control (3.00) to be minimum (3.32) in NeemAzal 2 l/ha. However, triazophos with 0.66 coccinellids/15 plants proved highly toxic. Chrysopids/15 plants were recorded to be minimum (1.40) in Rakshak Gold 2 l/ha which was significantly lower than that of 7.0 in control**.**

Natural enemies like syrphids and spiders in all botanicals treatments were almost equal to untreated control (1.87 spiders and 2.70syrphids/plant) as compared to monocrotophos (0.41 spiders and 1.66 syrphids /5 plants). **(Rosaih, 2001a)** reveal the safety of botanicals to natural enemies compared to synthetic insecticides after 10 days of spray in brinjal.

Among the predatory population in okra ecosystem, spiders, chrysopids, Apanteles sp and coccinellids were most predominant and there was no significant difference in the population of these predators in different plant products. This clearly indicated increased activity of natural enemies in plots treated with botanical insecticides **(Rosaih, 2001b).**

Smitha (2002) reported that neem cake @ 2 q/ha was safer to predatory coccinellid beetles and mites *Polyphagotarsonimus latus* (Banks) in chilli ecosystem which was found next best to untreated check.

Ecofriendly chemicals namely imidacloprid, spinsoad, novaluron and combination treatments, novaluron + spinosad and Bt + spinosad, were used and a study was conducted by **(Sunitha *et al.*, 2004)** which was found to be relatively less toxic to coccinellids when compared to conventional insecticides like dichlorovos.

The activity of insect predatory population (*Chrysoperla* and *Coccinellids*) in emamectin benzoate 5 SG and spinosad 48 SC treated plots was studied by **(Udikeri *et al.*, 2004)** and found to be on par with untreated check indicating safety to these predominant natural enemies in brinjal ecosystem.

The toxicity of spinosad 45 SC (Tracer) and commercial insecticides on natural enemies associated insect pests of pigeonpea was studied by **Mittal and Ujagir (2005).** Treatments were, spinosad 45 g a.i./ha, spinosad 75 g a.i./ha, spinosad 90 g a.i./ha, chlorpyriphos 500 g a.i./ha, quinalphos 500 g a.i./ha and endosulfan 525 g a.i./ha. None of the insecticides affected the natural population of spider during the crop growth. The other natural enemies observed include *Mantis religiosa* (L.), *C. carnea* and *Apantelis sp.*

A study was carried out by **(Jyoti *et al.*, 2008)** to assess the safety of organic amendments in combination with biorationals and microbial pesticides (spinosad 45 SC, emamectin benzoate 5 SG, avermectin 1.9 EC, Btk 5% WP and diafenthiuron 50 WP) on natural enemies associated with insects pests of brinjal. All the organic amendments and biorationals were completely safe to natural enemies (coccinellids, chrysopids & spiders). The tested microbial pesticides including one insect growth regulators did not affect the natural population throughout the crop growth period, but the synthetic insecticide was not safe to the natural enemies in brinjal ecosystem.

Spinosad 45 SC alongwith six chemical insecticides *viz.*, emamectin benzoate 5 WSG, cypermethrin 10 EC quinalphos 25 EC, endosulfan 35 EC, lambda cyhalothrin 5 EC, chlorpyrifos 20 EC was evaluated against natural enemies (*Encarsia, lutea Chrysoperla carnea* and ladybird beetles) on eggplant by **Sharma and Kaushik (2010)** concluded spinosad @ 162.5 ml/h was safe to natural enemies whereas the other chemical insecticides proved toxic to them.

Studies on field evaluation of insecticides, bio-pesticides and neem based insecticides on the population of natural enemies i.e., braconid wasp, coccinellid beetle and predatory spider in brinjal ecosystem was revealed by **(Tiwari *et al.*, 2011)** that the pesticides from the biological origin and neem based were found relatively less harmful to the natural enemies than newer and conventional synthetic organic insecticide imidacloprid and cypermethrin. Spraying of cypermethrin 10 Ec @ 0.016% was found relatively most toxic having higher mortality of coccinellids (57.3, 58.1%); braconid wasp (54.6, 61.7%) and predatory spiders (64.58, 53.09%) during both the years, respectively. Next to cypermethrin application of imidacloprid caused maximum mortality of coccinellids (41.4, 45.3%) braconid wasp (37.86, 50.82%) and predatory spiders (47.1, 41.4%) during both the years, respectively as compared to bio-pesticides and neem based insecticides. However, the toxic effect of the insecticides and bio-pesticides decreased after 7 days of treatment application.

2.5 To study the effect of synthetic insecticides, phytoproduct and biopesticides on the yield of brinjal crop

Lande (1976) from Maharashtra reported that malathion 0.05 per cent spray was the best, which recorded the higher yield of 134.7 q per ha followed by 120.5 kg per ha in carbaryl treatment and the untreated check could record 80.51 q per ha.

Datar (1983) found that carbaryl at 0.1 percent application gave good control of against *L. orbonalis* and the mean yield of 159q per hectare compared to 56.5 q per hectare in the control and 45 q per hactare in treated with monocrotophos at 0.025 percent.

Among the different pyrethroids, **Datar and Ashtaputre (1984)** suggested fenvalerate 0.01 per cent sprayed at 15 days interval after seedling establishment which brought down the infestation and significantly increased the yield upto 214 q per ha compared to 92.6 q per ha in control and they concluded that commercially available pyrethoids were most effective against *Leucinodes. orbonalis* and could give highest yield as compared to endosulfan.

Khaire *et al.* (1986) reported that spraying of cypermethrin at 0.015 per cent starting from flowering and subsequent spray at 10 days interval resulted in the best control of *Leucinodes. orbonalis* and the highest yield of marketable fruits (91.1 q/ha) compared to 13.5 q per ha in control.

Four synthetic pyrethiods and seven other insecticides were evaluated by **Mohan and Prasad (1986)** for the control of *L. orbonalis* and other pest complex on brinjal. All the pyrethiods (deltamethrin, cypermethrin, permethrin and fenvalerate at 0.1 kg a.i/ha) were most effective against *L. orbonalis.* The highest yield was recorded in plots treated with deltamethrin followed by other insecticides.

Cypermethrin (0.25%) dust @ 20 kg per ha was suggested by **(Patil *et al.*, 1996)** and found optimum in reducing shoot and fruit infestation and it also recorded maximum fruit yield (42.86 q/ha) compared to untreated control.

A study was conducted on the efficacy of bio-pesticide (*Bacillus thuringiensis* var. kurstaki) against brinjal shoot & fruit borer, *Leucinode sorbonalis* by **(Qureshi *et al.*, 1997)** and the result revealed that *Bacillus thuringiensis* application @ 2 ml/litre significantly reduced fruit damage caused by *L. orbonalis* compared with the untreated control (8.78 vs. 12.34%) and produced higher fruit yield than the control (12.07 vs. 9.98 t/ha).

In a field experiment with brinjal, control of *L. orbonalis* by chemical and biological means was examined by **(Raja *et al.*, 1998)** and found that the most effective control of the pest was achieved with the application of 4 per cent neem (Azadirachta indica L.) oil with the highest fruit yield of 24.48 t per ha. compared to the control which yielded 13.06 t per ha .

In field experiment with brinjal, neem (*A. indica*) based products were comparable or better than endosulfan in controlling shoot borer and **(Srinivasan *et al.*, 1998)** reported the fruit yields in nimbicidine (13.02 t/ha) and neem azal (12.80 t/ha) were higher than in endosulfan, the pest control was most effective in monocrotophos and carbaryl, produced fruit yields of 14.07 and 14.02 t per ha, respectively.

To evaluated four insecticides including two newer compounds viz., carbosulfan 25 EC and bifenthrin 10 EC and a combination product viz., carbosulfan + quinalphos for the control of brinjal shoot and fruit borer, a study was conducted by **Chinniah and Asafali (1999)** and they revealed that quinalphos 25 EC @ 2 ml per l and carbosulfan 25 EC @ 2 ml per l were on par with each other and were significantly superior to all other treatments in terms of least per cent shoot damage and average fruit yield per plot elsewhere of carbosulfan and bifenthrin alone.

Sangappa (1999) conducted an experiment to test the ecofriendly treatments against brinjal shoot and fruit borer *L. orbonalis.* NSKE 5 per cent recorded less fruit damage of 21.06 per cent and highest yield (141.53 q/ha) among the ecofriendly treatments. Whereas, carbaryl recorded 11.78 per cent fruit damage with a yield of 163 q/ha.

Two sprays of cypermethrin +quinolphos 25 EC @ 1.0 ml/l and cypermethrin 10 EC @ 0.5 ml/l at an interval of 15 days were evaluated on a study by **(Biradar *et al.*, 2001)** at Karnataka and found superior in reducing the shoot and fruit borer damage and maximizing the brinjal fruit yield.

Eswara Reddy and Srinivasan (2001a) were of the opinion that pongamia oil 2 percent resulted in lowest fruit borer damage of 11.40 per cent and also recorded highest yield of 39.66 q per ha, it was statistically on par with pongamia oil 1 per cent and Vitex aqucos L. leaf extract (4.5%).

During kharif, endosulfan 0.07 per cent treated plots showed the least fruit damage (10.3%), which was at par with quinalphos 0.05 per cent (11.7%) and carbosulfan 0.05 percent (12.2%) treated plots, the marketable fruit yield was maximum with carbosulfan 0.05 percent (43.9 q/ha) followed by deltamethrin 0.003 per cent (42.8 q/ha). During summer, deltamethrin 0.003 per cent was superior with only 11.1 per cent fruit damage with the highest marketable fruit yield of 52.1 q per ha followed by carbosulfan 0.05 per cent (50.3 q/ha) **(Eswara Reddy and Srinivasa, 2001b).**

Minimum shoot infestation of brinjal was recorded by **(Naitam and Mali, 2001)** in Btk @ 500 g per ha + monocrotophos @ 126 g a.i. per ha (4.17%) followed by cartap hydrochloride @ 2.5 g a.i. per ha + monocrotophos @ 126 g a.i. per ha (5.00%) and Btk alone @ 1 kg per ha (5.83%) which were at par with each other and significantly superior than other treatment.

Patel *et al.* (2001) found that one spray of monocrotophos 0.04 per cent at 9 weeks after transplanting followed by three sprays of spark 0.036 per cent at 11, 13 and 15 weeks after transplanting effectively managed the brinjal fruit borer and gave significantly higher fruit yield (238.3 q/ha).

A treatment schedule consisting of three sprays of chlorpyriphos at the dose of 0.5 to 0.75 kg a.i. per ha per spray was conducted by **Sawant and Dethe, (2001)** where they applied these treatments at an interval of 15 days by initiating the first 5 weeks after transplanting not only lowered the incidence of sucking pests and fruit borer but also recorded more yield of healthy fruit (105 to 176 q/ha) compared to untreated control (66.2 q/ha).

Carbosulfan 25 EC when applied individually at 2.0 ml/l foliar spray was very effective in checking the damage caused by shoot and fruit borer to brinjal. Cypermethrin 25 EC at 0.5 ml /l or quinalphos 25 EC @ 2 ml/l for 3 rounds followed by carbosulfan 25 EC at 2.0 ml /l for three more rounds was highly effective in checking the pest **(Srinivasan and Rabindra, 2001).**

Puranik *et al.* (2002) evaluated the different *B. thuringiensis* (Bt) formulations in comparison with neem and chemical insecticides against brinjal shoot and fruit borer *L. orbonalis* of which five sprays of Dipel SL @ 0.2 per cent at 10 days interval resulted in minimum shoot (9.56%) as well as fruit infestation (11.78%) and maximum yield of marketable fruits (196.96 q/ha) and proved to be the most effective treatment.

Six insecticides and their eight combinations were tested for their efficacy against brinjal fruit and shoot borer, *Leucinodes orbonalis.* In which Endosulfan + deltamethrin (0.07%, 0.0025%) and endosulfan + fenvalerate (0.07% + 0.005%) were highly effective against fruit borer that recorded only 13.3% damage as compared to 69.8% in control. **Dharma and Jang (2003)** recorded that Carbaryl was least effective, but its combinations with pyrethroids were proved superior over carbaryl alone. Dichlorvos + fenvalerate combination gave the highest yield of 263.45 q/ha, whereas carbaryl was least effective giving 225.7 q/ha, respectively. The other treatments were intermediate between the two insecticide regimes. However, all the treatments were superior over the control which produced 113.58 q/ha.

Duara *et al.*, (2003) also evaluate the yield by spraying cypermethrin applied at @ 0.003, 0.006 and 0.01%, fenvalerate applied at @ 0.004, 0.008 and 0.015% concentrations and endosulfan @ 0.07% concentration. However, cypermethrin applied at @ 0.006 and fenvalerate applied at @ 0.015% concentrations was found to be best and also maximum yield (96.91 q ha^{-1}) was reported in cypermethrin 0.006% treated plots, followed by cypermethrin 0.01% (93.83 q ha^{-1}), which was more than endosulfan 0.07% treated plots (68.58 q ha^{-1}).

Ten combination insecticides and plant extract against brinjal shoot and fruit borer *Leucinodes. Orbonalis* were evaluated by **Singh (2003)** and found that the foliar application of quinalphos with basal application of neem cake reduced the incidence of borer and increased the yield of brinjal. The incidence and yield recorded in basal application of neem cake with foliar spray of neem oil was at par with combination of conventional insecticides. From environmental pollution point of view, neem products are safe, alone or in combination with conventional insecticide were advocated.

Spraying of carbaryl 50 WP @ 4 g/l three times at 30, 50 and 70 DAP proved significant by **Shobharani (2003)** and reported superior in recording lowest percent fruit infestation (30.00%) and highest tuber yield of 36.89 q/ha.

A study reported that botanicals imposed three times against shoot borer indicated that nimbecidine @ 5ml/l and NSKE 5% were proved significantly superior in reducing the shoot infestation by **Shobarani and Nandihalli (2004)** and recorded higher tuber yields of 35.82 and 33.38 q/ha, respectively.

Venkatesh *et al.* (2004) studied the influence of application of five organic manures viz., neem cake, pongamia cake, castor cake (all at 1.0 t/ha), farmyard manure and vermicompost (10.0 t/ha) alone and in combination with chemical fertilizer on *L. orbonalis*, whitefly and leafhopper in brinjal. Among the cakes, neem cake was the most effective. Significantly higher yield (40.3 q/ha) was obtained from neem cake treated plots followed by vermicompost and castor cake treated plots.

Prasad Kumar and Devappa (2006) reported that when Proclaim 5 SG was tested against brinjal shoot and fruit borer during 2002-03 and 2003-04. The results indicated that the application of Proclaim 5 SG @ 200 g/ha was found effective in reducing the dead hearts and also fruit damage in brinjal. The total yield was also higher in this treatment.

Three insecticides, i.e. spinosad (0.05%), cypermethrin (0.05%) and malathion (0.05%), were used by **(Singh *et al.*, 2008)** to determine the suitable control measure against the brinjal shoot and fruit borer (*L. orbonalis*) to obtain higher yield and reported the minimum (21.5%) infestation was observed with malathion, followed by cypermethrin (24.13%) and spinosad (25.17%) and the total yield of healthy brinjal fruits was highest (350 q/h) with malathion-treated plants and lowest (112.5 q/h) with the control.

Sharma *et al.* 2012 conducted a field experiment to evaluate the potential of two botanicals viz; ozoneem and neem seed kernel extract (NSKE) and three chemical insecticides viz; imidacloprid, alphamathrin, chlorpyriphos 50% EC + cypermethrin 5% EC against *Leucinodes orbonalis*. Where three sprays of chlorpyriphos + cypermethrin @ 0.01% active substance (a.s.) in 15 days intervals was found to be the most economical, resulting in minimum shoot (2.15%) and fruit (12.95%) infestation respectively, followed by alphamathrin @ 0.01% a.s. with a highest marketable yield of 87.77 q/ha. Whereas the three sprays of NSKE @ 5 ml/lt. recorded a maximum of shoot (3.91%) and fruit (24.49%) infestation, respectively. However, shoot and fruit infestation was brought down and marketable yield increased to some extent, when these treatments were combined with cultural methods. It is therefore, suggested that the combination of chlorpyriphos 50% EC + cypermethrin 5% EC, being the most effective and economically viable insecticide.

Materials & Methods

3 MATERIALS AND METHODS

The experimental methods used and procedures followed during the course of investigation are being described below under the following heads and subheads:

3.1 Experimental site

The experiments were conducted in Pant Ritaraj variety of brinjal at Vegetable Research Centre (VRC), Govind Ballabh Pant University of Agriculture and Technology, Pantnagar- 263145 District Udham Singh Nagar (Uttarakhand) India, during summer season from March to November of 2012.

3.2 General meteorological information

Pantnagar is located in the sub-tropical zone at 29' North latitude 79.30' East longitude and at an altitude of 243.84 m above mean sea level in the “tarai” region of Uttarakhand in Northen India. The location has sub-humid tropical climate and is situated in the foothills of “Shivalik” range of the Himalayas. The meteorological data indicate that the humid climate here is characterized by hot dry summer and cold winter. The temperature rises up to 40^0C in summer, while it falls to 2^0C -10^0C in winter. Approximately, 1400 mm mean rainfall has been recorded and relative humidity fluctuates around 90 ± 5 per cent during rainy season.

3.3 Climate and weather conditions during the experimental period

The maximum and minimum temperatures, relative humidity at I hr (07: 12 am) and at II hr (02:12pm); rainfall and number of bright sunshine hours during the period of experimentation from March to November of 2012 at the University meteorological observatory are presented in Appendix.

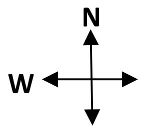
The studied included the following experiments:

1. To study the diversity of insect fauna associated with brinjal
2. Impact of synthetic Insecticides, phytoproduct and biopesticides on the larval population of brinjal fruit and shoot borer

3. Impact of synthetic insecticides, phytoproduct and biopesticides on the population of hadda beetle
4. Effect of synthetic insecticides, phytoproduct and biopesticides on the population of beneficial insect in brinjal ecosystem
5. Effect of synthetic insecticides, phytoproduct and biopesticides on the yield of brinjal crop

3.4 Layout

Field experiments were carried out on Pant Ritaraj variety with thirteen treatments and each was replicated three times. The brinjal (Pant Ritaraj) was sown on middle of March 2012. Each plot (4× $3m^2$) had 60 cm row spacing consisting 5 plants in each row.



R1	R2	R3
T1	T5	T4
T2	T7	T3
T3	T8	T12
T4	T13	T2
T5	T11	T9
T6	T12	T7
T7	T9	T13
T8	T10	T6
T9	T4	T8
T10	T2	T1
T11	T3	T5
T12	T1	T10
T13	T6	T11

Lay of the Experiments

3.5 Observation Procedure

a. Observations on diversity of insect fauna associated with brinjal

Regular surveys were carried out at weekly interval to record and identify the insect fauna including both natural enemies and beneficial insect at various stages (form vegetative to harvesting stage) in brinjal crop.

b. Impact of synthetic Insecticides, phytoproduct and biopesticides on the larval population of brinjal fruit and shoot borer

The experiment was carried out with thirteen treatments of some synthetic insecticides, plant product and biopesticides in randomize block design with three replications. The treatment details are given in the Table 3.1.

All the treatments were imposed by using high volume knapsack sprayer @ 500 litres of spray solution per hactare. The crop received totally three sprays; first spray was given at 60 days after transplanting on 8^{th} of June 2012, the second spray was given sequentially with an interval of 1 month on 9^{th} of July and the third spray was given after 3 months on 28^{th} of October. Number of larvae in infested shoot in each plot one day before spray and 3,7,10 and 14 days after each spraying was recorded on randomly selected 10 plants in each plot.

The observations were recorded for number of larvae infesting shoot and it was done by tagging ten plants randomly in a plot. Efficacy of each treatment was judged on the basis of per cent pest reduction over control.

c. Impact of synthetic insecticides, phytoproduct and biopesticides on the population of hadda beetle

The experiment was carried out with thirteen treatments of synthetic insecticides, plantproduct and biopesticides in randomize block design with three replications. All the treatment were applied thrice at 60 days after transplanting seed and first application was given after 2 months, second after 1month and third application after 3 months.

The total number of adults of hadda beetle was recorded from 10 randomly selected plants per treatments per plot before spraying as pre treatment and post treatment observations were recorded at 3,7,10 and 14 days after each spraying. The relative efficacy of each treatment was assessed on the basis of per cent pest reduction over control.

Table 3.1: Details of treatment in the management of *L. orbonalis* and *E. vigintioctopunctata*

No. of Treatmets	Treatments	Trade name	Dose
T1	Lambda-cyhalothrin (Karate 5 EC)	Karate	0.56 ml/lt
T2	Lambda-cyhalothrin (Karate 5 EC)	Karate	0.69 ml/lt
T3	Lambda-cyhalothrin (Karate 5 EC)	Karate	0.81 ml/lt
T4	Lambda-cyhalothrin (Karate 5 EC)	Karate	1.38 ml/lt
T5	Lambda-cyhalothrin (Karate 5 EC)	Karate	4 ml/lt
T6	Chlorpyriphos (Dursban 20EC)	Dursban	2 ml/lt
T7	Quinalphos (Ekalux25EC)	Ekalux	2 ml/lt
T8	Carbaryl (Sevin 75SP)	Sevin	2 ml/lt
T9	Malathion (Cythion 50EC)	Cythion	2 ml/lt
T10	*Bacillus thiringiensis (*Btk)(Halt 5W.P)	Halt	2gm/lt
T11	*Beavaeria basiana* (Biosoft 5 % WP)	Biosoft	2gm/lt
T12	Neem (Azadrachtan 0.3% EC)	Azadirachtan	2 ml/lt
T13	Untreated (Control)	Water	-

d. Effect of synthetic insecticides, phytoproduct and biopesticides on beneficial insect in brinjal ecosystem

To assess safety of insecticides, plant product and biopesticides against the natural enemies in brinjal ecosystem, the natural enemies count was taken in all treatments. The population count of *Coccinella septumpunctata*, *Chrysoperla carnea,* spider and *Eucanthecona b*ug were recorded on ten randomly selected plants/treatment /plot where pre- spray count of the insect were made a day before spraying and post spray counts were made at 3,7,10 and 14 days after each spraying.

e. Effect of synthetic insecticides, phytoproduct and biopesticides on the yield of brinjal crop

The observations on the yield of brinjal crop were taken with respect to healthy and damaged fruits to compute percentage of infested fruits. Presence of larvae making hole/holes was the criteria for separating damage fruits from healthy ones. The per centage of fruit infestation was calculated according to the following formulae given by **Karmakar *et al*. (2007)**:

$$\text{Per cent fruit infestation} = \frac{\text{Number of larvae infested fruits}}{\text{Larvae infested fruits + Healthy fruits}} \times 100$$

The fruits were harvested from each plot separately and yield per plot on each picking was recorded. Totally four pickings were done. Total yield was calculated by adding yield of each picking. The single plot yield was converted into kilogram per hectare.

• Statistical Analysis

The obtained data from various experiments were subjected to analysis of variance as applicable to randomized block design. The critical difference (CD) at 5% level of significance was calculated.

Results and Discussion

4 RESULTS AND DISCUSSION

This chapter deals with the experimental finding obtained during the course of investigation. The data has been analyzed statically, fully supported by tables and graphs. The results have been presented experiment wise, along with discussion.

4.1 Diversity of insect fauna associated with brinjal

Result of extensive field survey carried out at weekly intervals in brinjal crop at Vegetable Research Centre (VRC), Pantnagar to study the status of harmful and beneficial insect presented in (Table 4.1). Considering the diversity of insect fauna in brinjal, the order Hemiptera occupied largest number of species constituting about 28% of total insect, followed by Lepidoptera 18%, Coleoptera 11%, Diptera 4%, Orthoptera 7%, Hymenoptera 17%, Arachnida 7%, Neuroptera 3% and other 5% (Fig. 4.1).

Twenty-eight species of insects belonging 10 different orders and 20 families were encountered in the Pant Ritaraj variety to know the diversity of brinjal crop. Among these 16 species of insect pest, 8 species of predator and 4 species of insect pollinator were found on brinjal crop.

Out of 16 species of insect pests in brinjal recorded in the present study: brinjal shoot and fruit borer (*Leucinodes orbonalis* Guen.) was observed one of the major pests in brinjal during summer seasons. The infestation of *L. orbonalis* was observed in shoot and fruit where the larvae bored the terminal shoots and fruit therefore, growing points are killed. Withering of terminal shoots and holes plugged with excreta on fruits were noticed due to severe infestation.The peak activity of brinjal shoot and fruit borer was observed during the months of June to November.

The next major pest of brinjal is hadda beetles (*Epilachna vigintioctopunctata* Fab.). Both grub and adults of hadda beetles caused damage by feeding on the upper surface of leaves. They eat up regular areas of the leaf tissue, leaving parallel bands of uneaten tissues between, thus, present a lace-like appearance and the infested leaves turn brown, dry up and fall off, and the plants were completely skeletonized and it was observed active throughout the experiment with peak activity during the months of June-July and October- November.

Kumar *et al*. (2007) reported shoot and fruit borer (*Leucinodes orbonalis*.) and hadda beetles (*Epilachna vigintiooctopunctata)* as the major insect pest in their study, while other minor pests are jassid (*A. biguttula biguttula)*, whitefly (*Bemisia tabaci)*, black hairy caterpillar (*Pericallia ricini*), tobacco caterpillar (*Spodoptera litura*) and green semilooper (*Thysanoplusia orichalacea*).

Similarly, **Rajavel *et al.* (2008)** also reported that the shoot and fruit borer (*Leucinodes orbonalis* Guen.) and hadda beetles (*Epilachna vigintioctopunctata* Fab.) damage caused in their study area.

Stem borer (*Euzophera perticella* Ragnot) was observed feeding exclusively in the main stem and have never been obsererved to bore into the fruits. The attack of the borer was seen in the month of June-October. As a result of their attack in the field, stray plants were observed withered and finally dried up.

The incidence of leaf roller (*Antoba olivaceae* Walker) was observed in the month of October-November. The larvae used to feed on leaf, first by folding the leaf with silken threads and there by scrapping leaf tissue from inside of the rolled leaf.

Small sized jassids (*Amrasca bigittula bigitulla* Ishida) occurred in large numbers throughout the experiment with peak activity during the months of June-July and September- October. Both nymph and adult feeds on leaflets and as a result of feeding leaflets become cup shaped with yellow edges and tips.

Yellowish green leaf hoppers (*Amrasca devastans* Stal.) were noticed in large numbers during the months of June-October. Both nymph and adults were of same shape but nymph did not have wings. Nymph run sideways when disturbed. As a result of feeding leaves become cup shaped with yellow margins.

Bhadauria *et al*. (1999) also found that jassid *(Amrasca biguttula biguttula),* leaf roller (*Eublemma olivacea),* aphid (*A. gossypii*) and stem borer (*Euzophera perticella),* were the most common insect *spp.* attacking brinjal.

Suresh *et al*. (1996) also reported that brinjal also was infested by jassid *(Amrasca biguttula biguttula),* fruit and shoot borer (*Leucinodes orbonalis,* hadda beetles (*Epilachna vigintiooctopunctata)*, leaf roller (*Eublemma olivacea)* and aphid (*Aphis gossypii).*

The caterpillars of green semilooper (*Thysanoplusia oricalcea* Fabricius) were recorded primarily on leaves and caused irregular holes. Young caterpillars utilized leaf lamina as their food by making small holes, but older caterpillars feed on the tissue between the veins and skelotinising the leaves giving them a ragged appearance during September-October.

Leaf feeder (*Helicoverpa armigera* Hubner) was also observed active on brinjal in the month of October. It is a polyphagous pest and caterpillar feed on foliage and defoliation in early stages were noticed as the clinical symptoms of the attack of this pest.

The nymphs and adults of whitefly (*Bemicia tabaci* Gennadius) were observed in the months of June- September. Both nymphs and adults suck the sap from the undersurface of leaves. Severe infestation results in premature defoliation, development of sooty mould. Yellowish colour on leaves was noticed as the clinical symptom of the attack of white fly.

Singh *et al*. (2002) were found 27 insect pests and 4 non insect pest infesting brinjal crop, of which jassid (*A. biguttula biguttula*), white fly (*Bemisia tabaci)*, leaf folder (*Eublemma olivacea),* aphid (*A. gossypii*) and flea beetles (*Phyllotreta cruciferae*) were important pests.

Chandrakumar *et al*. (2008) also reported that there were three major hemipteran insect pests viz., leafhopper, (*Amrasca devestans)* whitefly, (*Bemisia tabaci)* andaphid (*A. gossypii)* infesting brinjal crop.

Green bug (*Nezara viridula* Burmeister) was observed active on brinjal throughout the experiment with peak activity during the months of July and October. Both nymph and adult were found sucking cell sap from the leaves, which gradually wilt and dry up.

Both nymphs and adults of tur pod bug (*Clavigralla gibbosa* Spinola) were found active on brinjal throughout the season with peak activity during the months of July and September. Both nymphs and adults were found sucking cell sap from leaves, stem and flower buds as a result the infested plant part shows appears yellow patches and later on shrivel up.

Treehoppers (*Sictocephala baralis* Casher) were observedin the months of September and November. The nymphs were green in colour while adults are black andwere found sucking cell sap from leaves, stem and flower buds as a result the infested plant part show yellow patches and later on shrivel up.

Adult of pumpkin beetles (*Raphidopalpa cruciferae* Lucas) was mainly responsible for the damage of the plant above ground, attacking on the leaves, flowers and fruits and observed during the month of June and August. Young plants were defoliated and deflowered sooner than older ones.

The above findings were supported by **Dhamdhere *et al*. (1995)** who reported 6 hemipteran, 3 lepidopteran, 2 coleopteran and one-mite pests of brinjal.

Adult of thrips (*Thrips palmi* Lindeman.) showed its incidence during the month of June-September on flower buds and flowers resulting their premature fall without forming any fruits. They are brownish black in colour and in their severe infestation, plants did not produce any flowers. High population of thrips resulted in discolour and distorted flowers.

Nymph and adults of short horn grasshopper (*Hieroglyphus banian* Fabricius) were found feeding on brinjal leaf, causing defoliation and observed in the month of August-October.

Fruit flies (*Bactocera spp.* Coquillet) damage is caused by maggots and was observed in the month of August-September. Adults makes punctures for egg laying which attract fermenting microorganism whereas the maggot destroy the pulp making it foul smelling and discolored.

Out of 4 species of insect visitors, the most common pollinator on the brinjal crop are honeybee *Apis dorsata* Fabricius and non-apis bee *Amegilla zonata* Rayment which were observed to visit on the flowers of brinjal crop in the months of June-September.

The next pollinator is Carpenter bee *Xylocopa iridipennis* Lepeletier and *Xylocopa aestuans* Linnaeus were observed in the months of June- August, visiting on brinjal crop.

While out of 8 species of predators on brinjal insect-pests, ichneumonid wasp *Charops sp.* Ashmead, eucantheconid bug (*Eucanthecona furcelleta* Aubrey) was

Table 4.1: Diversity of Insect fauna associated with brinjal at Vegetable Research Centre, Pantnagar (2012)

Sl.No.	Scientific Name	Common Name	Order: family	Damaging stage	Period of incidence	Status
1.	*Leucinodes orbonalis* Guenee.	Brinjal shoot and fruit borer	Lepidoptera:Pyralidae	Caterpillar	June- November	Major
2.	*Euzophera perticella* Ragnot	Stem borer	Lepidoptera: Pyralidae	Caterpillar	June-October	Minor
3.	*Thysanoplusia oricalcea* Fabricius	Green semilooper	Lepidoptera :Noctuidae	Caterpillar	September-October	Minor
4.	*Antoba olivaceae* Walker	Leaf roller	Lepidoptera :Noctuidae	Caterpillar	October-November	Minor
5.	*Helicoverpa armigera* Hubner	Leaf feeder	Lepidoptera:Noctuidae	Caterpillar	October	Minor
6.	*Amrasca bigittula bigitulla* Isihda.	Jassid	Hemiptera:Cicadellidae	Nymph and Adult	June- October	Major
7.	*Amrasca devastans* Stal	Leaf hopper	Hemiptera: Cicadellidae	Nymph and Adult	June - October	Major
8.	*Sictocephala baralis* Casher	Tree hopper	Hemiptera:Membricidae	Nymph and Adult	September-November	Minor
9.	*Bemicia tabaci* Gennadius	Whitefly	Hemiptera: Aleyrodidae	Nymph and Adult	June- September	Minor
10.	*Nezara viridula* Burmeister	Green bug	Hemiptera: Pentatomidae	Nymph and Adult	July-November	Minor
11.	*Clavigralla gibbosa* Spinola	Tur pod bug	Hemiptera:Coreidae	Nymph and Adult	July-September	Minor
12.	*Epilachna vigintioctopunctata* Fabricius	Brinjal hadda beetle	Coleoptera: Coccinellidae	Adult and Grub	June-November	Major
13.	*Raphidopalpa cruciferae* Lucas.	Pumkin Beetle	Coleoptera: Chrysomelidae	Adult and Grub	June-August	Minor
14.	*Hieroglyphus banian* Fabricius	Short horn grasshopper	Orthoptera:Acrididae	Nymph and Adult	August-October	Minor
15.	*Thrips palmi* Lindeman	Thrips	Thysanoptera: Thripidae	Nymph and Adult	September-November	Minor
16.	*Bactocera spp.*Coquillet	Fruitflies	Diptera: Tephritidae	Adult and Maggot	August-September	Minor

POLLINATORS							
1.	*Apis. dorsatas* Fabricius	Honey bee	Hymenoptera: Apidae			June-September	Minor
2.	*Amegilla zonata* Rayment	Non-Apis bee	Hymenoptera: Apidae				
3.	*Xylocopa iridipennis* Lepeletier	Carpenter bee	Hymenoptera: Xylocopidae			June- August	Minor
4.	*Xylocopa aestuans* Linnaeus						
PREDATORS							
1.	*Eucanthecona furcelleta* Aubrey	Eucantheconid bug	Hemiptera	Pentatomidae	Adult and grub of hadda beetle	October-November	Minor
2.	*Chrysoperla. Carnea* Stephens	Green lace wing	Neuroptera	Chrysopidae	Thrips and Lepidopteran larvae	June- July	Minor
3.	*Coccinella septunpunctata* Linnaeus	Lady bird beetle	Coleoptera	Coccinellidae	Jassids and Thrips	June-November	Minor
4.	*Charops sp.* Ashmead	Ichneumonid wasp	Hymenoptera:	Ichneumonidae	Eggs of Lepidopteran	June-September	Minor
5.	*Ceriagrion fallax* Ris	Damselflies	Odonata	Coenagriidae	Lepidopteran larvae	June-September	Minor
6.	*Anax sp. Eichkoff*	Dragonfly		Aeshnidae			
7	*Meta menardi* Latreille	Spider	Arachnida	Metidae	Thrips and Small flies	June-November	Minor
8.	*Agelenopsis sp.* Giebel			Agelenidae			

Epilachna vigintioctopuntata

Thysanoplusia oricalcea

Nezara viridula

Hieroglyphus banian

Clavigralla gibbosa

Diversity of Insect fauna associated with brinjal at Vegetable Research Centre, Pantnagar

Antoba olivaceae

Amrasca devastans

Leucinodes orbonalis

Coccinellid beetle

Sictocephala baralis

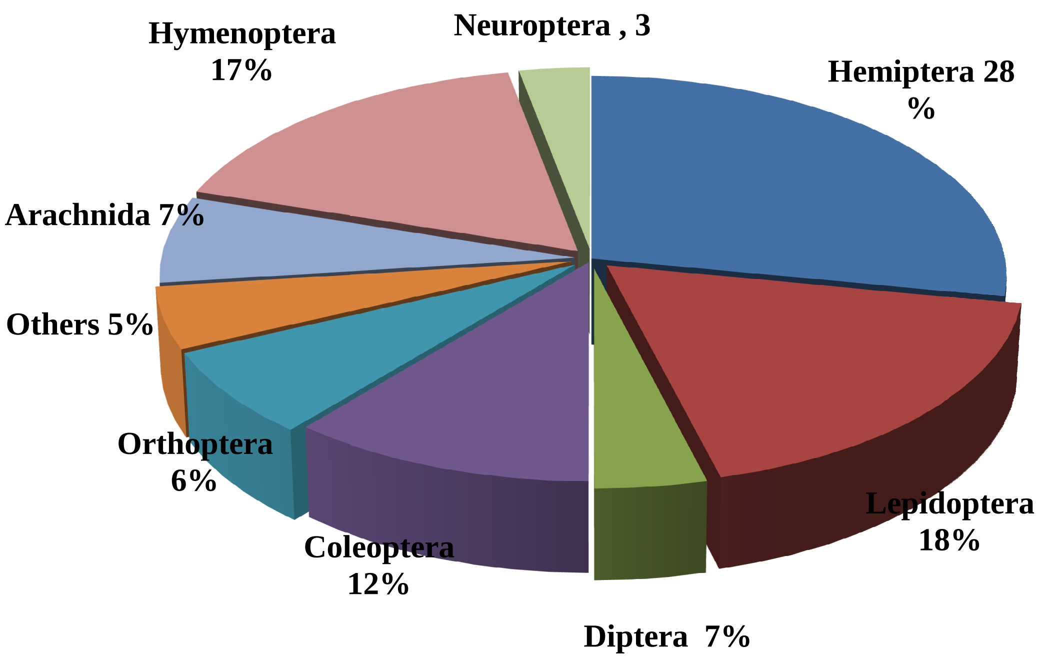


Fig. 1: Diversity of Insect Fauna Associated With Brinjal in Vegetable Research Centre at Pantnagar

observed predating on adult and grub of hadda beetles and also on lepidopteran larvae in the months of October- November. Green lacewing (*Chrysoperla carnea* Stephens) was observed predating on thrips and lepidopteran larvae in the months of June- July. Ladybird beetles (*Coccinellid septunpunctata* Linnaeus) were found predating on jassids and thrips throughout the experiment with peak activity in the month of June-July and September-November. Damselflies *(Ceriagrion fallax* Ris*)* and dragonflies (*Anax sp. Eichkoff*) were also frequently observed predating on lepidopteran larvae in the month of June-September.

Spiders (*Meta menardi* Latreille) and *(Agelenopsis sp.* Giebel) were found predating on thrips and small flies and observed throughout the experiment.

Out of 16 insect pests attacking brinjal, the maximum number of ten species belonged to foliage feeder, one species was found to feed on shoot and fruit (fruit and shoot borer) and one found to feed on flower (thrips) and stem.

From Table 4.1 it is also evident that the brinjal fruit and shoot borer and hadda beetles showed prolonged activity i.e., 20 days after transplanting right from May till November (5 months) in appreciable population and therefore, appeared as the major pests of brinjal in the present study.

4.2 Impact of synthetic insecticides, phytoproduct and biopesticides on the larval population of brinjal fruit and shoot borer

The efficacy of lambdacyhalothrin at 0.56ml/lt (T1), lambdacyhalothrin at 0.69ml/lt (T2), lambdacyhalothrin at 0.81ml/lt (T3), lambdacyhalothrin at 1.38 ml/lt (T4), lambdacyhalothrin at 4ml/lt (T5), chlorpyriphos at 2ml/lt (T6), quinalphos at 2ml/lt (T7), carbaryl at 2ml/lt (T8), malathion at 2ml/lt (T9), *B.t* (Halt) at 2ml/lt (T10), *B.b* (Biosoft) at 2ml/lt (T11), neem at 2ml/lt (T12) and untreated control (T13) were evaluated against brinjal fruit and shoot borer and the average number of larvae/shoot/10plants/plot and per cent reduction in larval population over control are summarized in table 4.2 and 4.3 and fig 4.2. All the treatments were applied three times; the first application was done on 8thof June after 60 days of transplanting, second application on 9th of July and third application on 28th of October.

4.2.1 Effect of various treatments on the larval population of brinjal fruit and shoots borer

The data presented in table 4.2 revealed that protection wise all the treatments were found significantly superior over untreated control.

After 3 days of Ist application, treatment T5 proved most effective recording lowest number of 8.66 larvae/shoot/10plants/plot followed by, treatment T2, T6 and T10 with 9.33, 9.66 and 10.00 larvae/shoot/10plants/plot respectively which were observed statistically on par with each other. However, T12 and T13 were found less effective with highest number of 11.00 and 14.00 larvae/shoot/10plants/plot respectively. The average number of brinjal fruit and shoot borer larvae was significantly lower (P>0.05) in treatment T5, T2, T6 and T10 compared with T12 and T13.

Similarly, after 7 days, significantly lowest larval population was recorded in the treatment T5, T4, T2 and T10 which ranged from 10.66 to 12.33 larvae/shoot/10plants/plot and being statistically on par with each other. Whereas, the least effective treatment in reducing larval population was observed in the treatment T12, T11, T7 and T3 with 14.00, 13.66, 13.33 and 13.00 larvae/shoot/10plants/plot respectively. The treatment T5, T4, T2, T10 were significantly superior (P<0.05) from the treatment T1, T3, T7, T11 and T12 in reducing larval population.

At 10 days after 1st application, the treatment T5, T2, T1 and T4 treated plots exhibited 12.33-14.00 larvae/shoot/10plants/plot which were significantly lower from the treatment T3, T6, T7, T8, T9, T10, T11 and T12 with 14.66-16.00 larvae/shoot/10plants/plot. However, untreated plot (T13) exhibited highest number of 20.33larvae/shoot/10plants/plot. The average larval population was significantly lower (P> 0.05) in treatment T5, T2, T1 and T4 as compared to T3, T6, T7, T8, T9, T10, T11 and T12.

The effect of various treatments after 14 days of 1stapplication showed that T5 was still effective in reducing larval population with 14.33 larvae/shoot/10plants/plot followed by the treatment T2 (15.66), T1 (16.33) and T4 (16.33). Treatment T12 was recorded least effective in reducing larval population with 20.00 larvae/ shoot/10plants/plot. However, untreated check recorded significantly highest number 24.00 larvae/ shoot/10plants/plot over others. The average number of larvae/shoot/

10plants/plot were significantly lower (P>0.05) in the treatment T5, T2, T1 and T4 as compared to T3, T6, T7, T8, T9, T10, T11 and T12.

Following second application, treatments T5, T1, T2, T4 and T6 treated brinjal plant had less than 8.66 larvae/shoot/10plants/plot after 3 days of spraying over 16.00 larvae/shoot/10plants/plot in untreated check. The treatments T3, T7, T8, T11 and T12 were also found effective in reducing larval population and recorded less than 10.33 larvae/shoot/10plants/plot. All the treatments were significantly lower (P>0.05) as compared to untreated check.

At 7 and 10 days of 2nd application, treatments T5 and T1 recorded significantly lowest number of larvae/shoot/10plants/plot (varied from 8.33-11.00) compared to treatments T2, T4, T6 and T8 (varied from 10.00-12.33 larvae/shoot/10plants/plot).

Observations after 14 days of 2nd application indicated that the number of larvae/shoot/10plants/plot was increased in all treatments but pattern was almost similar to earlier observations. The lowest number of larvae/shoot/10plants/plot was recorded in T5 and T1 treated plots with 13.00 and 13.33larvae/shoot/10plants/plot over 26.33larvae/shoot/10plants/plot in untreated check. The number of larvae/shoot/ 10plants/plot was significantly lower (P>0.05) in T5, T1, T2, T4 and T8 than T3, T6, T7, T9 and T10.

A low population of borer was observed at the time of third application. Significantly lowest number of larvae/shoot/10plants/plot were recorded in all the treatment as compared with untreated check.

The observations after 3 days of 3rd application showed that significantly lowest number of larvae/shoot/10plants/plot was recorded in the treatment T1, T2, T4, T5 and T8 treated plots which varied from 7.00- 8.66 larvae/shoot/10plants/plot which were found statistically on par with each other. However, treatment T6, T7, T9, T11 and T12 treated plots recorded 10.66, 11.00, 11.33 and 12.00 larvae/shoot/10plants/plot respectively. Significantly highest number of larval population of brinjal fruit and shoot borer was recorded in the untreated check with 18.66larvae/shoot/10plants/plot.

After 7 days, the lowest larval population was recorded in treatment T1 with 9.00 larvae/shoot/10plants/plot which slightly differs by T4 and T3 with 9.33 and 9.66 larvae/shoot/10plants/plot and were found statistically on par with each other. Whereas,

Table 4.2: Effect of various treatments on the larval population infesting brinjal shoots

Treatment	Dose (ml/lt)	Pre - spray	Average numbers of larvae/shoot/10plants/plot											
			Days after Ist application				Days after IInd application				Days after IIIrd application			
			3	**7**	**10**	**14**	**3**	**7**	**10**	**14**	**3**	**7**	**10**	**14**
T1 Lambda-cyhalothrin	0.56	8.66 (17.11)	10.33 (18.73)*	12.66 (20.82)	14.33 (22.21)	16.33 (23.80)	7.33 (15.70)	9.00 (17.44)	11.00 (19.35)	13.33 (21.39)	7.00 (15.31)	9.00 (17.44)	11.33 (19.65)	14.00 (21.94)
T2 Lambda-cyhalothrin	0.69	8.33 (17.75)	9.33 (17.75)	11.33 (19.64)	13.33 (21.39)	15.66 (23.28)	8.66 (17.07)	10.66 (19.03)	12.33 (20.53)	14.33 (22.22)	7.66 (16.02)	10.33 (18.73)	12.66 (20.82)	15.00 (22.77)
T3 Lambda-cyhalothrin	0.81	9.33 (16.73)	10.33 (18.72)	13.00 (21.12)	14.66 (22.49)	16.66 (24.08)	9.66 (18.10)	11.33 (19.66)	13.33 (21.41)	16.00 (23.57)	7.33 (15.70)	9.66 (18.10)	13.33 (21.39)	15.66 (23.30)
T4 Lambda-cyhalothrin	1.38	8.66 (17.07)	10.00 (18.38)	11.33 (19.61)	14.00 (21.96)	16.33 (23.82)	8.33 (16.73)	10.00 (18.42)	12.00 (20.25)	14.00 (21.96)	7.00 (15.31)	9.33 (17.78)	11.66 (19.96)	14.66 (22.49)
T5 Lambda-cyhalothrin	4	8.33 (16.77)	8.66 (17.11)	10.66 (19.05)	12.33 (20.55)	14.33 (22.24)	7.00 (15.31)	8.33 (16.77)	10.66 (19.05)	13.00 (21.12)	8.00 (16.40)	9.33 (17.75)	11.66 (19.94)	14.33 (22.23)
T6 Chlorpyriphos	2	9.66 (16.58)	9.66 (17.93)	12.00 (20.11)	14.66 (22.43)	16.66 (24.02)	8.66 (17.11)	10.66 (19.05)	12.66 (20.84)	15.00 (22.77)	11.00 (19.35)	13.00 (21.12)	15.33 (23.04)	18.00 (25.09)
T7 Quinalphos	2	9.00 (7.44)	10.33 (18.72)	13.33 (21.39)	15.66 (23.30)	18.00 (25.09)	10.33 (18.74)	12.33 (20.55)	14.33 (22.24)	16.33 (23.83)	11.33 (19.66)	13.33 (21.41)	15.66 (23.30)	18.33 (25.35)
T8 Carbaryl	2	8.33 (16.75)	10.66 (19.04)	13.00 (21.12)	15.66 (23.30)	18.00 (25.08)	9.33 (17.75)	10.66 (19.03)	12.33 (20.54)	14.33 (22.23)	8.66 (17.11)	11.00 (19.35)	13.33 (21.41)	15.66 (23.31)
T9 Malathion	2	8.00 (16.34)	10.33 (18.68)	12.66 (20.82)	15.33 (23.02)	18.33 (25.31)	8.66 (17.09)	11.00 (19.35)	14.66 (22.51)	15.66 (23.30)	11.33 (19.64)	13.66 (21.68)	16.00 (23.55)	18.66 (25.57)
T10 *Bacillus thiringiensis* (Halt 5W.P)	2	8.00 (16.40)	10.00 (18.42)	12.33 (20.54)	14.66 (22.49)	17.00 (24.33)	8.66 (17.07)	10.66 (19.03)	13.33 (21.40)	14.66 (22.51)	10.66 (19.03)	13.00 (21.12)	15.33 (23.05)	18.66 (25.59)
T11 *Beavaeria basiana* (Biosoft 5 W.P)	2	8.00 (16.29)	10.66 (19.00)	13.66 (21.66)	16.00 (23.55)	18.66 (25.57)	10.00 (18.42)	12.66 (20.84)	12.33 (20.55)	17.33 (24.60)	12.00 (20.25)	14.33 (22.24)	16.66 (24.09)	20.00 (26.56)
T12 Neem	2	8.00 (16.40)	11.00 (19.35)	14.00 (21.97)	16.66 (24.09)	20.00 (26.56)	9.66 (18.10)	12.00 (20.25)	14.33 (22.24)	17.00 (24.34)	10.66 (19.05)	13.33 (21.41)	16.66 (24.09)	20.33 (26.79)
T13 Control	_	11.00 (19.35)	14.33 (22.22)	17.00 (24.33)	20.33 (26.78)	24.66 (29.75)	16.00 (23.55)	19.33 (26.07)	23.33 (28.86)	26.33 (30.86)	18.66 (25.57)	22.66 (28.41)	26.66 (31.07)	30.66 (33.62)
CV	_	7.68	6.87	5.64	5.33	4.85	6.42	4.85	3.33	3.50	5.74	4.54	4.50	3.83
SEM±	_	0.70	0.76	0.77	0.87	0.91	0.66	0.60	0.50	0.60	0.64	0.62	0.73	0.72
CD at 5%	_	2.01 (0.72)	2.17 (0.74)	1.99 (0.68)	2.05 (0.70)	2.03 (0.69)	1.92 (0.65)	1.60 (0.55)	1.21 (0.41)	1.38 (0.47)	1.77 (0.60)	1.57 (0.53)	1.72 (0.59)	1.61 (0.55)

*data present on parenthesis are square root transformed value

significantly highest number of larvae was recorded in T6, T7, T9, T10 and T11 which ranged from 13.00- 14.33 larvae/shoot/10plants/plot.

The treatment T1, T4, T5 and T2 were observed still effective after 10 days and had less than 12.66 larvae/shoot/10plants/plot and were found statistically on par with each other. However, significantly highest number of larval population was recorded in T11 and T12 with 16.66 larvae/shoot/10plants/plot.

The observation after 14 days of 3rd application showed that treatment T1, T2, T4 and T5 were recorded minimum number of larvae (less than 15.00 larvae/ shoot/10plants/plot) and were found statistically on par with each other. The treatment T6 (18.00), T7 (18.33), T9 (18.66) and T10 (20.33) recorded comparatively higher number of larvae/shoot/10plants/plot but they were significantly lower ($P>0.05$) as compared to untreated check (30.66).

4.2.2 Impact of various treatments on the per cent reduction of larval population of brinjal fruit and shoots borer

The Impact of various treatments on the per cent reduction of larval population was presented in table 4.3.

Data computed after 3 days of 1st application showed that significantly highest reduction in larval population was recorded in the treatment T5 with 39.33 per cent followed by treatment T2, T6 and T10 with 34.00, 32.50 and 30.00 per cent respectively. Although, these treatments were found statistically on par with each other. However, significantly lowest per cent reduction was recorded in the treatment T12 in larval population (23.16). The per cent reduction in larval population was significantly higher ($P< 0.05$) in treatment T5, T2, T6 and T10 than T12.

After 7 days treatment T5 was recorded significantly highest per cent reduction (36.96) in larval population followed by the treatment T4, T2, T6 and T10 with 33.18, 32.80 and 29.96 per cent reduction in larval population respectively and being statistically on par with each other. Whereas, T12, T11, T7 and T3 were recorded with significantly lowest 17.10, 19.83, 20.93 and 23.36 per cent reduction in larval population respectively.

The observation recorded after 10 days showed that significantly highest per cent reduction of 38.70 was recorded in the treatment T5 followed by the treatment T2 with 33.46 per cent reduction. However, significantly lowest reduction was recorded in T7, T8, T11 and T12 with 22.13, 22.72, 21.33 and 17.43 percent respectively.

Similarly, 14 days of 1st application the highest per cent reduction in larval population was recorded in the treatment T5 with 37.50 followed by T2 with 35.96. Whereas, T3, T6, T7, T8, T9, T10, T11 and T12 was recorded with significantly lowest per cent reduction 29.00, 27.83, 26.66, 27.06, 25.83, 31.03, 24.13 and 18.50 respectively. The per cent reduction in larval population was significantly higher ($P< 0.05$) in treatment T5, T4, T3 and T2 than the other.

Following second application, it was observed that per cent reduction in larval population was increase in all treatments but pattern was similar to first application. Significantly highest per cent reduction after 3 days of application was recorded in T5 with 55.56 followed by T1, with 53.70. Treatment T4, T2 and T6 recorded 48.13, 45.56 and 45.56 per cent reduction and were statistically on par with each other. Although, significantly lowest per cent reduction in larval population was recorded in T3, T7, T8, T11 and T12 with 38.86, 35.16, 41.13, 36.66 and 39.23 respectively.

The observation recorded after 7 days of 2nd application showed that the per cent reduction of larvae over control was significantly higher in the treatment T5 with 56.70 followed by T1with 53.10 per cent. While, the lowest reduction in larval population was recorded in T11 with, 34.06 per cent. The percent reduction was significantly higher ($P<0.05$) in T5 and T1 as compared with T2, T3, T4, T6, T8, T9 and T10.

Similarly at 10 days significantly highest reduction in larval population with 54.20 was recorded in the treatment T5 followed by T1 with 52.80 per cent. The treatment T4 and T2 were found statistically on par with each other with 48.30 and 46.50 per cent reduction respectively. However, the least effective treatment was T9 with significantly lowest reduction 32.86 per cent.

After 14 days of 2nd application it was observed that the highest per cent reduction in larval population (50.56) was recorded in the treatment T5 and it was followed by T1 (49.33) per cent which indicate the effectiveness of T5 and T1 till 14 days. The treatment T4 and T2 recorded 46.66 and 45.06 per cent reduction found to be statistically on par with each other. Whereas, significantly lowest per cent reduction was recorded in T11 with 33.96 per cent.

The observations during 3rd application on per cent reduction in larval population gradually increased in all treatment over control but pattern was slightly differ than the Ist application. Significantly highest per cent (62.00) of reduction was recorded in T1, T3 and T4 followed by treatment T2 and T5 with 58.90 and 58.93 per cent reduction which were found statistically on par with each other. Whereas, T11 was recorded with significantly lowest per cent reduction with 35.46 as it was least effective in reducing the larval population. The percent reduction in 3 days were significantly higher ($P<0.05$) in the treatment T1, T2, T3, T4 and T5 than other.

The observation recorded after 7 days of 3rd application showed that significantly highest per cent reduction in larval population was recorded in T1 (60.23) followed by T3, T4 and T5 with 56.96, 58.73 and 58.36 per cent reduction. These treatments were found statistically on par with each other. However, significantly lowest per cent reduction in larval population was recorded in T11 with 36.56 per cent.

Similarly, at 10 days of 3rd application significantly highest per cent reduction in larval population was recorded in T1 with 57.36 followed by T4 with 56.13 per cent reduction which were found statistically on par with each other respectively. Whereas, T11 and T12 was recorded with significantly lowest per cent of 32.43 reduction in larval population.

After 14 days the highest per cent reduction in larval population was recorded in T5 (54.50) and it was followed by T1 (53.10), T4 (52.00) and T2 (50.90) which were found statistically on par with each other respectively. However, significantly lowest per cent reduction 34.70 was recorded in T12. The per cent in treatment T1, T5, T4 and T2 were significantly higher ($P<0.05$) as compared to T3, T6, T7, T8, T9, T10, T11 and T12.

The data on the bioefficacy of different insecticides against brinjal shoot and fruit borer proved that Lambda-cyhalothrin 5 EC at 4, 0.56, 1.38, 0.69 and 0.81 ml/lt (T5, T1, T4, T2 and T3) was consistently most effective by recording significantly higher reduction of shoot and fruit infestation at 3 days, 7 days, 10 days and 14 days after each application in which lambda-cyhalothrin at 4ml/lt dose proved excellent against *L. orbonalis.* Next in order of effectiveness was Carbaryl 50 WP at 2 ml/lt (T8) and Chlorpyriphos 20 EC at 2ml/lt (T6) followed by Quinalphos 25 EC (T7) and Btk 5% WP (T10) and at last neem 0.03% (T12).

During the investigation, lambda-cyhalothrin excelled well over all other synthetic insecticides tested in reducing shoot and fruit infestation.

The superiority of lambda-cyhalothrin may be because it has quick down effect. The present findings are in line with **Rajendra *et al*. (1990)** who reported the complete control of *L. orbonalis* achieved with lambda-cyhalothrin and deltamethrin sprayed at in brinjal crop.

However, the superiority of the lambda-cyhalothrin was in accordance with **Mathirajan *et al.* (2000)** who observed that Lambda-cyhalothrin applied at the rate of 30 g a.i. per hectare was found to be effective against brinjal shoot and fruit borer. The order of efficacy was lambda-cyhalothrin>endosulfan>fenvelarate.

Similarly, to the present finding, **Anil and Sharma (2010)** reported that bioefficacy of insecticides when conducted against brinjal shoot and fruit borer, *L. orbonalis* Guen. showed that in terms of shoot and fruit infestation, emamectin benzoate (0.002%), endosulfan (0.05%), novaluron (0.01%) and lambda-cyhalothrin (0.004%) were found superior. However, in terms of reduction in fruit infestation, emamectin benzoate (0.002%) was highly effective followed by endosulfan (0.05%), lambda-cyhalothrin (0.2%) and spinosad (0.0024%). All synthetic pyrethoids were highly effective against *L. orbonalis* while carbaryl was moderately effective. **Tewari and Moorthy (1983).**

The present finding is contradictory to the findings of **Ghong *et al*. (2002)** who reported that the new ready mix insecticides Nurelle D 505, 55 EC (chlorpyriphos 500g + cypermethrin 50 g) at 550 g a.i. per hectare was most effective in reducing shoot (4.67%) and fruit infestation (20.81%). The deviation probably being due to alone use of chlorpyriphos treatment. **Sharma *et al*. 2012** also reported that the chlorpyriphos 50% EC + cypermethrin 5% EC was found effective against *L. orbonalis*, resulting in minimum shoot (2.15%) and fruit (12.95%) infestation respectively, followed by alphamathrin @ 0.01% a.s(active substance) whereas, three sprays of NSKE @ 5 ml/lt. recorded a maximum of shoot (3.91%) and fruit (24.49%) infestation, respectively.

The above findings is in partial agreement with the findings of **Muralikrishna *et al.* (2002)** who reported that *B. thuringiensis* var. *kurstaki* (Bt), neem and diflubenzuron is used for the control of shoot and fruit borer, *L. orbonalis* on brinjal

Table 4.3: Efficacy of various treatments on the percent reduction of larval population of brinjal fruit and shoot borer

Treatment	Dose (ml/lt)	Per cent reduction in larval population over control											
		Days after I[st] application				Days after II[nd] application				Days after III[rd] application			
		3	7	10	14	3	7	10	14	3	7	10	14
T1 Lambda-cyhalothrin	0.56	27.83	25.46	29.43	33.33	53.70	53.10	52.80	49.33	62.60	60.00	57.36	54.50
		(31.76)	(30.18)	(32.71)	(35.08)	(47.13)	(46.79)	(46.60)	(44.61)	(52.28)	(50.91)	(49.24)	(47.54)
T2 Lambda-cyhalothrin	0.69	34.03	32.80	33.46	35.96	45.53	44.50	46.50	45.06	58.90	54.00	52.46	50.90
		(35.15)	(34.63)	(35.07)	(36.72)	(42.37)	(41.78)	(42.93)	(42.11)	(50.16)	(47.50)	(46.41)	(45.51)
T3 Lambda-cyhalothrin	0.81	28.13	23.36	27.66	29.00	38.86	41.10	32.63	39.16	62. 60	57.00	47.30	48.86
		(32.01)	(28.84)	(31.64)	(34.30)	(38.49)	(39.85)	(34.22)	(38.74)	(52.56)	(49.02)	(43.39)	(44.34)
T4 Lambda-cyhalothrin	1.38	29.86	33.13	30.56	33.60	48.13	48.20	48.36	46.66	62. 60	58.40	56.13	52.00
		(32.68)	(34.82)	(33.39)	(35.41)	(43.92)	(43.96)	(44.06)	(43.08)	(52.28)	(50.03)	(48.52)	(46.15)
T5 Lambda-cyhalothrin	4	39.33	36.96	38.70	37.50	55.56	56.70	54.20	50.56	58.93	58.36	55.86	53.10
		(38.82)	(37.41)	(38.40)	(37.65)	(48.25)	(48.86)	(47.41)	(45.32)	(50.32)	(49.87)	(48.41)	(46.78)
T6 Chlorpyriphos	2	32.50	29.96	29.96	27.83	45.56	44.70	45.56	43.00	40.86	42.60	37.33	41.23
		(34.06)	(32.68)	(31.50)	(34.88)	(42.44)	(41.95)	(42.45)	(40.97)	(39.71)	(40.74)	(37.64)	(39.94)
T7 Quinalphos	2	26.96	20.93	22.13	26.66	35.16	36.06	36.10	37.76	39.03	41.00	39.00	40.13
		(30.18)	(26.22)	(27.46)	(31.01)	(36.35)	(36.90)	(36.90)	(37.90)	(38.65)	(39.80)	(38.62)	(39.30)
T8 Carbaryl	2	25.56	23.36	22.70	27.06	41.13	44.80	47.13	45.53	53.00	51.03	49.80	48.80
		(30.35)	(28.84)	(28.30)	(31.34)	(39.74)	(41.99)	(43.35)	(42.43)	(46.74)	(45.60)	(44.88)	(44.31)
T9 Malathion	2	27.76	25.10	24.43	25.83	45.93	43.13	32.86	40.53	38.50	42.33	39.53	39.16
		(31.34)	(29.62)	(29.40)	(30.51)	(42.66)	(41.05)	(34.37)	(39.53)	(38.21)	(40.57)	(38.84)	(38.70)
T10 *Bacillus*	2	30.03	27.20	28.33	31.03	45.90	44.80	46.96	44.00	42.96	42.53	40.13	39.00
thiringiensis		(33.14)	(31.28)	(31.21)	(33.83)	(42.63)	(41.99)	(43.25)	(41.53)	(40.94)	(40.69)	(39.27)	(38.63)
(Halt 5W.P)	2	25.86	19.83	21.30	24.13	36.66	34.06	34.70	33.96	35.50	36.60	32.40	35.80
T11 *Beavaeria basiana*		(30.37)	(26.34)	(27.48)	(29.27)	(37.11)	(35.62)	(36.08)	(35.62)	(36.51)	(37.19)	(34.11)	(36.07)
(Biosoft 5 W.P)	2	23.16	17.10	17.43	18.50	39.23	37.93	36.10	35.30	42.56	40.73	32.40	34.70
T12 Neem		(28.76)	(24.08)	(24.32)	(25.27)	(38.75)	(38.01)	(36.90)	(36.43)	(40.71)	(39.61)	(34.11)	(36.78)
	_	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T13 Control		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	_	20.29	18.82	16.29	13.50	10.52	7.83	12.48	5.92	8.83	5.43	9.30	5.84
CV	_	5.38	4.55	4.13	3.82	3.98	2.98	4.26	2.20	3.56	2.20	3.38	2.24
SEM±	_	10.22	8.90	7.83	8.82	6.82	3.82	7.90	3.74	6.17	3.74	6.11	3.81
CD at 5%		(3.50)	(3.05)	(2.68)	(2.37)	(2.33)	(1.73)	(2.70)	(1.28)	(2.11)	(1.28)	(2.09)	(1.30)

*data present on parenthesis are angular transformed value.

Egg

Grub

Adult

Pupa

Egg

larvae

Adult

Pupa

Life cycle of *Epilachna vigintioctopuntata* and *Leucinodes orbonalis*

which revealed that shoot infestation by *L. orbonalis* was low due to application of phorate at transplanting followed by foliar spray of Bt + carbaryl in reducing the shoot infestation (9.36%). The fruit infestation on number basis was minimum in phorate application at transplanting followed by a combined application of Bt + endosulfan and Bt +carbaryl which recorded 9.71 to 9.93 per cent infestation. Foliar spray of neem and diflubenzuron alone were not effective in reducing the damage of shoot and fruit borer in brinjal.

In accordance with the present finding, **Jat and Pareek (2001)** reported that the treatment of cypermethrin (0.007%) proved most effective followed by carbaryl (0.20%) and endosulfun (0.07%). However, Nimbecidine (1.51/ha) was found least effective in reducing shoot and fruit infestation followed by Neemgold (1.21/ha) and *Bacillus thruingiensis B.t.* (Halt) alone (0.012%), whereas, *B.t.* + carbaryl (0.012 + 0.10%), *B.t.* + endosulfan (0.012 + 0.035%) and malathion (0.05%) existed in middle order of efficacy.

4.3 To study the impact of synthetic insecticides, phytoproduct and biopesticides on the population of hadda beetles

The efficacy of lambdacyhalothrin at 0.56ml/lt (T1), lambdacyhalothrin at 0.69m/lt (T2), lambdacyhalothrin at 0.81ml/lt (T3), lambdacyhalothrin at 1.38 ml/lt (T4), lambdacyhalothrin at 4ml/lt (T5), chlorpyriphos at 2ml/lt (T6), quinalphos at 2ml/lt (T7), carbaryl at 2ml/lt (T8), malathion at 2ml/lt (T9), *B.t* (Halt) at 2ml/lt (T10), *B.b*(Biosoft) at 2ml/lt (T11) and neem at 2ml/lt (T12) and untreated control (T13) were evaluated against hadda beetles and average number of beetles/10plants/plot and per cent reduction in the beetles were summarized in the Table 4.4 and 4.5 and fig 4.2.

4.3.1 Effect of various treatments on the population of hadda beetles infesting brinjal leaves

The observation recorded after 3 days of 1st application showed that the lowest number of hadda beetles was recorded in T6 with 6.66 beetles/10plants/plot followed by the treatment T1, T2 and T8 with 7.00, 7.33 and 7.66 beetles/10plants/plot respectively. Whereas, T11 and T3 was least effective in reducing the number of hadda beetles with 8.66 beetles/10plants. The treatment T3 and T11 were significantly higher ($P<0.05$) as compared to rest of the other treatments.

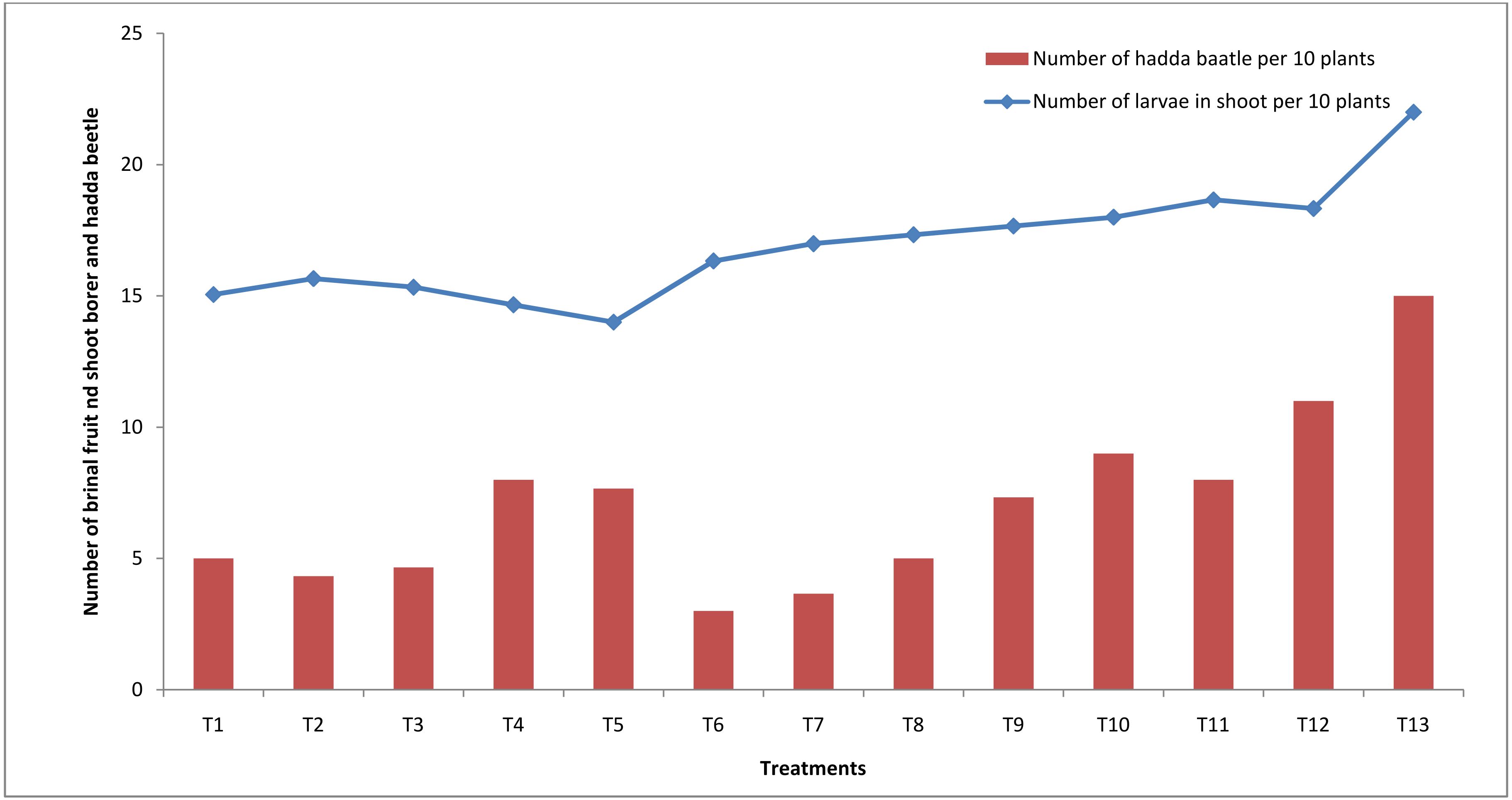


Fig 4.2 Effect of various treatment on the population of brinjal fruit and shoot borer and hadda beetle

After 7 days of 1st application lowest number of hadda beetles was recorded in the treatment T6 and T9, T4, T5, T7, T8, T10 and T12 varied from 4.00-4.66 beetles/10 plants/plot were found to be statistically on par with each other. Whereas, significantly highest number varied from 5.00-6.33beetles/10plants/plot were recorded in T1, T2, T11 and T3 over T13 with 13.42 beetles/10plants/plot.

At 10 days the observation showed that treatment T9, T8, T4, T6, T7, T12, T2 and T10 treated plots recorded lowest population which ranged from 1.33-2.66 beetles/10plants/plot and being statistically on par with each other. However, T1, T4 and T11 range from 3.00-3.66 beetles/10plants/plot was recorded less effective in reducing the number of hadda beetles. Treatment T8, T4, T6, T7, T12, T2 and T10 were significantly lower ($P>0.05$) compared to T1, T4 and T11. Highest population was recorded in T13 with 7.33 beetles/10plants/plot.

The number of hadda beetles observed after 14 days of 1st application showed that the lowest number of 0.33 and 0.66 beetles/10plants/plot was recorded in T6 and T10 followed by the treatment T2, T7, T12 and T11 with 1.00 to 1.33 beetles/10plants/plot which were found statistically on par with each other respectively. Whereas, T3 and T13 with 3.00 and 5.33 beetles/10plants/plot was recorded significantly highest number of beetles. The number of hadda beetles were significantly lowest ($P>0.05$) in T6, T10, T2, T7, T12 and T11 compared to T3, T13, T4, T5, T8 and T9.

It was observed from the table 4.4 that population of beetles gradually decreased during second application. After 3 days treatment T6, T2 and T4 recorded with significantly lower number (2.33 -3.00 beetles/10plants/plot) found statistically on par with each other. However, the highest number of 3.66 to 4.33 beetles/10plants/plot were recorded in treatment T1, T3, T5, T7, T8, T9, T10, T11 and T12 respectively. Untreated check recorded significantly highest number 6.7 beetles/10plants/plot over all the treatments.

At 7 days the observation recorded indicates that all treatment were effective in reducing the number of beetles and had less than 2.66 beetles/10plants/plot over untreated check with 5.33 beetles/10plants/plot.

Table 4.4: Effect of various treatments on the population of hadda beetle

Treatment	Dose (ml/lt)	Pre - spray	Average numbers of hadda beetle/10 plants/plot											
			Days after Ist application				Days after IInd application				Days after IIIrd application			
			3	7	10	14	3	7	10	14	3	7	10	14
T1 Lambda-cyhalothrin	0.56	9.00	7.00	5.00	3.66	1.66	4.33	2.00	1.00	1.00	4.33	2.00	1.33	0.66
		(3.00)	(2.64)	(2.23)	(1.92)	(1.29)	(3.21)	(3.56)	(3.78)	(4.04)	(2.09)	(1.40)	(1.16)	(0.75)
T2 Lambda-cyhalothrin	0.69	10.00	7.66	5.66	2.66	1.33	3.00	1.00	1.66	2.33	3.33	1.66	1.33	0.33
		(3.16)	(2.77)	(2.38)	(1.64)	(1.16)	(3.05)	(3.36)	(3.65)	(3.95)	(1.83)	(1.29)	(1.16)	(0.49)
T3 Lambda-cyhalothrin	0.81	10.66	8.66	6.33	3.33	3.00	4.00	2.33	1.00	1.33	2.66	1.66	1.66	1.33
		(3.27)	(2.95)	(2.52)	(1.83)	(1.73)	(3.21)	(3.61)	(3.83)	(4.08)	(1.62)	(1.29)	(1.29)	(1.02)
T4 Lambda-cyhalothrin	1.38	9.00	7.00	4.66	2.66	2.00	3.00	1.66	1.00	1.33	4.33	2.00	1.33	0.66
		(3.00)	(2.65)	(2.16)	(1.62)	(1.23)	(3.16)	(3.36)	(3.74)	(4.04)	(2.09)	(1.43)	(1.16)	(0.75)
T5 Lambda-cyhalothrin	4	9.33	7.00	4.66	3.00	1.66	3.66	2.33	1.00	1.33	3.00	1.66	1.00	1.00
		(3.04)	(2.64)	(2.15)	(1.73)	(1.29)	(2.95)	(3.27)	(3.51)	(4.07)	(1.73)	(1.29)	(0.89)	(1.02)
T6 Chlorpyriphos	2	11.00	6.66	4.00	2.00	0.33	2.33	1.66	1.00	0.33	2.66	1.66	0.66	0.33
		(3.32)	(2.59)	(2.00)	(1.43)	(0.49)	(3.08)	(3.44)	(3.81)	(3.79)	(1.64)	(1.29)	(0.75)	(0.49)
T7 Quinalphos	2	10.00	7.66	4.33	2.00	1.00	4.00	2.33	0.66	0.66	3.66	1.66	0.66	0.66
		(3.16)	(2.77)	(2.09)	(1.43)	(0.89)	(3.21)	(3.65)	(3.96)	(4.24)	(1.92)	(1.29)	(0.75)	(0.75)
T8 Carbaryl	2	9.00	7.33	4.33	1.66	1.66	4.00	2.33	2.00	1.66	4.33	1.33	1.00	0.33
		(3.00)	(2.71)	(2.08)	(1.26)	(1.26)	(3.27)	(3.61)	(3.96)	(4.24)	(2.09)	(1.16)	(0.89)	(0.49)
T9 Malathion	2	9.66	7.00	4.00	1.33	1.66	4.00	2.33	1.66	1.00	4.00	1.33	1.00	1.00
		(3.11)	(2.65)	(2.00)	(1.16)	(1.29)	(3.21)	(3.56)	(3.91)	(4.28)	(2.00)	(1.16)	(0.89)	(0.89)
T10 *Bacillus thiringiensis*	2	9.66	7.00	4.66	2.33	0.66	4.33	2.00	1.66	1.66	5.33	3.33	2.66	1.66
(Halt 5W.P)		(3.10)	(2.64)	(2.16)	(1.53)	(0.62)	(3.16)	(3.51)	(3.83)	(4.12)	(2.31)	(1.83)	(1.64)	(1.29)
T11 *Beavaeria basiana*	2	11.00	8.66	5.66	3.00	1.33	3.66	2.66	2.00	1.33	4.00	3.66	2.66	1.66
(Biosoft 5 W.P)		(3.30)	(2.81)	(2.33)	(1.67)	(1.16)	(3.26)	(3.69)	(4.00)	(4.32)	(2.00)	(1.92)	(1.64)	(1.29)
T12 Neem	2	10.00	7.33	4.33	1.66	1.00	4.33	2.00	1.00	2.66	4.66	3.33	2.66	1.33
		(3.16)	(2.71)	(2.07)	(1.29)	(0.89)	(3.32)	(3.74)	(4.08)	(4.47)	(2.16)	(1.83)	(1.64)	(1.16)
T13 Control	_	11.00	13.00	12.00	7.33	5.33	6.66	5.33	4.66	3.66	8.00	7.33	6.00	4.66
		(3.32)	(3.61)	(3.46)	(2.70)	(2.30)	(3.78)	(4.12)	(4.51)	(4.96)	(2.83)	(2.71)	(2.45)	(2.16)
CV	_	7.41	8.46	13.42	17.88	40.38	6.61	5.38	5.03	4.55	9.99	14.37	31.74	45.11
SEM±	_	0.85	0.75	0.82	0.57	0.60	0.60	0.49	0.53	0.58	0.46	0.35	0.43	0.39
CD at 5%	_	0.98	0.93	0.51	0.49	0.81	0.72	0.98	0.71	0.96	0.83	0.75	0.67	0.73
		(0.53)	(0.43)	(0.67)	(0.36)	(0.48)	(0.52)	(0.41)	(0.43)	(0.40)	(0.31)	(0.22)	(0.23)	(0.25)

*data present on parenthesis are square root transformed value.

A low population of beetles was observed after 10 and 14 days of 2nd application which ranging from 0.66-2.00 beetles/10plants/plot in all treatment over 4.66 beetles/10plants/plot in untreated check.

After 3 days of 3rd application showed that the lowest number of beetles was recorded in T2, T3, T5, T6 and T7 range from 2.66-3.33 beetles/10plants/plot found to be statistically on par with each other. However, significantly highest number range from 4.00-5.33 beetles/10plants/plot were recorded in T1, T4, T8 and up to T12, which is least effective in reducing number of hadda beetles. Significantly highest number of hadda beetles/10plants/plot was recorded with the untreated check of 8.00 numbers over all the treatments.

At 7 days the observation recorded indicate that the treatment T1, T2, T3, T5, T6, T7, T8 and T9 was varied from 1.33-2.00beetles/10plants/plot. Whereas, the treatment T11, T12 and T13 was recorded with significantly highest number 3.66, 3.33 and 7.33 beetles/10plants/plot, which was least effective in reducing number of hadda beetles. The number of hadda beetles was significantly lower ($P>0.05$) in T1, T2, T3, T5, T6, T7, T8 and T9 than T11, T12 and T13.

A low population of beetles was observed after 10 and 14 days of 3rd application which ranging from 0.66-2.66 beetles/10plants/plot in all treatment over 6.00 beetles/10plants/plot in untreated check.

4.3.2 Efficacy of various treatments on per cent reduction of hadda beetles population

Result present in the table 4.5 revealed that after 3 of 1st application the highest per cent reduction was recorded in the treatment T6 with 48.73 per cent followed by the treatment T1, T2, T7, T9, T10, T11 and T3 treated plots varied from 46.36-41.03 per cent reduction and found statistically on par with each other. Whereas, significantly lowest per cent reduction in hadda beetle population was recorded in the treatment T11 with 33.06 per cent.

At 7 days, the per cent reduction of hadda beetle population was highest in the treatment T6 with 66.06 per cent followed by the treatment T1, T2, T7, T8 and T10 ranging from 65.50-61.30 per cent reduction in beetle population. Whereas, the lowest per cent reduction was recorded in T11 with 40.43 per cent. The treatment T1, T2, T7, T8 and T10 was recorded significantly higher ($P<0.05$) over all the treatment.

After 10 days of 1st application, the observation recorded showed that the highest reduction of beetles population was observed 80.43 per cent in the treatment T9. The treatment T6, T7, T10 and T11 recorded 71.96, 67.20, 76.43 and 76.73 per cent reduction in beetle population respectively. Whereas, T1 was recorded with 47.63 per cent which significantly lowest per cent reduction in the population is of hadda beetles. The per cent reduction in hadda beetle population was significantly higher ($P<0.05$) in T9, T6, T7, T10 and T11 than T1, T2 T3, T4, T5, T8.

The observation recorded after 14 days of 1st application showed that the highest reduction in beetles population was observed 75.46 per cent in the treatment T6 followed by the treatment T7, T1, T8 and T11 with 72.80, 68.80, 67.13 and 66.90 per cent reduction respectively. However, significantly lowest per cent of reduction (20.00) was recorded in the treatment T3.

Following 2nd application after 3 days, treatment T6 was observed with 65.30 which is significantly highest per cent reduction in beetles population. The treatment T2and T4 treated plots recorded 52.76 and 51.40 per cent of reduction in the beetle population. Whereas, the lowest per cent reduction 33.33 and 34.73 in beetles population was recorded in the treatment T10 and T11.

At 7 and 10 days of the application it was observed that significantly highest per cent reduction in beetles population 68.90 and 65.00 was recorded in the treatment T6 and T7. The treatment T3, T4, T5, T8, T9, T10 and T11 treated plants recorded 51.33 to 62.23 per cent reduction in the beetle population. While, the lowest per cent reduction was observed in the treatment T2 and T11 with 41.76 and 31.66 respectively.

After 14 days of 2nd application the observation showed that the treatment T6was recorded with significantly highest per cent reduction with 63.90. The treatment T7, T1, T8, T9 and T10 treated plots were recorded in the range 52.77 and 41.66 per cent reduction in beetles population. However, the treatment T2 and T12 was recorded with lowest reduction 25.00 and 21.00 per cent respectively.

At 3 days of 3rd application it was found that the highest per cent reduction 65.23 and 65.80 was recorded in the treatment T3 and T6 followed by the treatment T5 and T2 with 61.53 and 57.93 per cent reduction in beetles population respectively. The lowest per cent reduction was recorded in the treatment T1, T4, T7, T9, T10, T11 and T12 treated plots with 45.76, 45.33, 54.23, 44.80, 48.50, 32.73, 49.03 and 41.60 respectively.

The observation recorded after 7 days of 3^{rd} application showed that the treatment T8 and T9 were recorded with significantly highest per cent reduction in beetles population with 81.54. The treatment T1, T2, T3, T4, T5, T6 and T7 treated plots were recorded in the range 73.20-77.37 per cent reduction. Whereas, the treatment T11 was recorded with significantly lowest per cent of reduction 49.40. The percent reduction was significantly higher ($P<0.05$) in T8, T9, T1, T2, T3, T4, T5, T6 and T7 compared to T10, T11 and T12.

After 10 days the observation recorded showed that the treatment T6 and T7 was recorded with the similar highest per cent reduction 77.50 followed by T8 and T9 with 76.46 and 76.33 per cent reduction respectively and being statistically on par with each other. The lowest per cent reduction in beetles population 46.59 was observed in the treatment T11 and T12.

The observation after 14 days of 3^{rd} application indicate that significantly highest 78.33 per cent reduction was recorded in the treatment T2 and T6. Whereas, the lowest per cent of reduction 31.66 was recorded uniformly in the treatment T10 and T11.

The average number of hadda beetles indicated that chlorpyriphos (T6) was most effective in reducing the population of beetle followed by quinalphos (T7), malathion (T9) and *B.t.* (Halt) (T10) whereas, the least effective treatment in reducing the population of beetle are lambdacyhalothrin (T1-T5) and the untreated check (T13).

The above findings were in similar with the findings of **Samanta *et al*. (1999)** whoreported that thecomparative efficacy of different dosages of a new formulation of quinalphos (aqua flow, AF) against *E. vigintioctopunctata* on brinjal and suggested that Quinalphos AF @ 500, 750 and 1000 g ai./ha gave excellent control of the pests and also there is no phytotoxicity was produced when quinalphos (AF) were applied on brinjal.

Table 4.5: Efficacy of various treatments on the percent reduction of hadda beetle population

Treatment	Dose (ml/lt)	Percent reduction in beetle population over control											
		Days after Ist application				Days after IInd application				Days after IIIrd application			
		3	**7**	**10**	**14**	**3**	**7**	**10**	**14**	**3**	**7**	**10**	**14**
T1 Lambda-cyhalothrin	0.56	46.36	65.50	47.63	68.80	34.70	63.33	53.33	50.77	45.76	73.20	60.80	63.33
		(42.91)*	(54.26)	(43.63)	(56.14)	(36.08)	(53.06)	(46.14)	(46.05)	(42.56)	(59.23)	(50.84)	(53.06)
T2 Lambda-cyhalothrin	0.69	45.96	63.10	52.36	67.13	51.40	41.76	41.66	25.00	57.93	77.37	61.57	78.33
		(42.59)	(52.67)	(46.36)	(55.36)	(46.13)	(38.88)	(42.28)	(19.99)	(49.61)	(61.82)	(51.18)	(62.28)
T3 Lambda-cyhalothrin	0.81	41.03	50.00	61.63	20.00	37.50	55.56	53.00	22.23	65.23	77.37	71.57	43.33
		(39.83)	(44.99)	(51.99)	(16.92)	(37.20)	(48.25)	(46.92)	(18.25)	(54.26)	(61.82)	(68.11)	(58.02)
T4 Lambda-cyhalothrin	1.38	33.06	62.53	64.56	21.66	52.76	67.76	53.33	27.77	45.33	72.61	76.33	63.33
		(35.01)	(52.53)	(53.54)	(23.07)	(46.74)	(55.80)	(46.14)	(26.75)	(42.29)	(58.45)	(61.47)	(51.14)
T5 Lambda-cyhalothrin	4	40.60	52.36	59.00	39.03	44.43	55.56	53.66	22.23	61.53	77.37	50.47	46.00
		(39.53)	(46.36)	(50.29)	(33.28)	(41.74)	(48.25)	(48.06)	(18.25)	(51.89)	(61.82)	(40.37)	(39.99)
T6 Chlorpyriphos	2	48.73	66.06	71.96	75.46	65.30	68.90	53.33	63.90	65.80	77.37	77.50	78.33
		(44.27)	(54.49)	(58.10)	(60.36)	(53.91)	(56.31)	(43.06)	(53.25)	(54.40)	(61.82)	(63.10)	(62.28)
T7 Quinalphos	2	46.56	61.30	67.20	72.80	38.90	56.66	65.00	52.77	54.23	77.37	77.50	53.33
		(43.01)	(51.54)	(55.24)	(69.51)	(38.04)	(49.22)	(54.22)	(46.75)	(47.43)	(61.82)	(63.10)	(42.28)
T8 Carbaryl	2	43.16	61.30	54.23	67.13	40.26	56.66	41.66	47.23	44.80	81.54	76.46	51.66
		(41.02)	(51.63)	(47.91)	(55.36)	(39.33)	(49.22)	(31.14)	(38.25)	(41.89)	(64.91)	(61.99)	(41.14)
T9 Malathion	2	45.70	57.13	80.43	26.66	37.50	55.56	50.00	50.77	48.50	81.54	76.33	46.66
		(42.47)	(49.22)	(64.35)	(21.14)	(37.20)	(48.25)	(48.06)	(46.75)	(44.07)	(64.91)	(61.47)	(38.06)
T10 *Bacillus thiringiensis*	2	45.30	63.10	76.43	45.23	33.33	62.23	50.00	41.66	32.73	54.16	55.70	31.66
(Halt 5W.P)		(42.08)	(52.67)	(61.83)	(37.59)	(34.78)	(52.47)	(48.06)	(34.99)	(34.74)	(47.41)	(48.28)	(33.06)
T11 *Beavaeria basiana*	2	33.06	40.43	76.73	66.90	43.03	50.00	31.66	22.77	49.03	49.43	46.59	31.66
(Biosoft 5 W.P)		(35.01)	(35.09)	(61.47)	(55.67)	(40.90)	(44.99)	(31.14)	(46.75)	(44.47)	(44.69)	(38.68)	(33.06)
T12 Neem	2	43.80	63.06	71.96	45.23	34.73	62.23	51.33	21.00	41.60	54.16	46.59	43.33
		(41.42)	(52.77)	(58.10)	(37.59)	(35.62)	(52.47)	(36.14)	(19.99)	(40.15)	(47.41)	(38.68)	(58.06)
T13 Control	_	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
		(.00)	(.00)	(.00)	(.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
CV	_	15.99	14.23	15.97	57.26	24.57	28.75	68.38	71.30	13.08	12.34	51.65	76.50
SEM±	_	5.80	6.33	7.34	16.12	8.57	11.09	20.37	16.93	5.37	5.86	17.36	20.60
CD at 5%	_	10.19	11.22	13.51	22.00	15.53	17.26	21.32	25.01	9.29	11.24	18.86	23.93
		(3.49)	(3.84)	(4.63)	(13.02)	(5.32)	(7.62)	(15.70)	(13.51)	(3.18)	(3.85)	(13.65)	(16.42)

*data present on parenthesis are angular transformed value.

Ali *et al*. (2007) reported that the spraying of Chlorpyriphos 20EC and Carbaryl 85SP gives the lowest number of egg masses (0.11/plant), larvae (0.04) and adult (0.13) in Carbaryl and this treatment provided more than 90% reduction of egg masses, larvae and adults of *Epilachna* beetles compared to control. Similar results were obtained by spraying Chlorpyriphos 20EC and it is similar to the above findings.

The above findings are in partial agreement with the findings of **Chandranath and Katti (2010)** who reported that the population of epilachna beetles was in the range of 14.0 to 16.5 beetles per plant before the imposition of treatments causing sufficient foliage damage of 20 per cent in all the plots. After three days of spraying, maximum population of 16.0 beetles per plant was recorded in untreated control. However, there was a reduction in population in all the treatments. Where, Quinalphos recorded (8.40 beetles/ plant). On the 7th day, the maximum population of 14.90 beetles per plant was recorded in control and the lowest population of 4.30 beetles per plant was recorded in Quinalphos, which was on par with rest of the chemicals.

Markandeya *et al*. (1996) reported that the *B. thuringiensis* formulations when applied for leaf area protection provideseffective control and leads to mortality of *E. vigintioctopunctata* infesting brinjal crop but, the present finding is contradictory, as the spray of *B. thuringiensis* was least effective in comparison to other treatments but also being on par with some other treatments. The deviation probably being on the higher dose they used.

4.4 To assess the impact of synthetic insecticides, phytoproduct and biopesticides on beneficial insect in brinjal ecosystem

The effect of various treatments on the populations of various natural enemies viz., *coccinellid* beetles, green lacewing bug *Chrysoperla carnea*, spiders and *Eucanthecona* bug are summarized on the table 4.6 to 4.9 and fig. 4.3.

4.4.1 Effect of various treatments on the population of *coccinellid* beetles in brinjal ecosystem

A perusal of the data present in the table 4.6 indicate that after 3 days of 1st application the population of *coccinellid* beetles gradually decreased (less than 1.66-1.00 *coccinellid* /10plants/plot) in all treatment except in untreated check (5.00

coccinellid /10plants/plot) which showed that all treatment had some harmful effect on the *coccinellid* beetles.

However, after 7 days of 1st application the population of *coccinellid* beetles were slightly increased in all treatment but lower than untreated check. The lowest number of beetles was recorded in the treatment T3, T4, T5 and T6 (less than 3.33 *coccinellid* /10plants/plot) which showed that these treatments were highly toxic for natural enemies. The number of *coccinellid* beetles in the treatment T3, T4, T5 and T6 were significantly lower ($P>0.05$) than rest of the treatments.

Similarly, after 10 days of 1st application the lowest population of *coccinellid* beetles was recorded on the treatment T2, T3, T4, T5 and T7 (less than 2.33 *coccinellid* /10plants/plot) over 6.66 *coccinellid/*10plants/plot in the untreated check indicating not safety of these treatments.

The observations recorded after 14 days of 1st application showed that the population of *coccinellid* beetles gradually decreased in all treatment but significantly highest population in untreated check 2.33 *coccinellid/*10plants/plot indicating not safety of these treatments. The population of beetle was significantly higher ($P<0.05$) in untreated check than rest of all the treatment.

Following 2nd application after 3 days, the populations of *coccinellid* beetles was still lower in all treatments except T12 with 2.33 *coccinellid/*10plants/plot and untreated check with 5.66 *coccinellid/*10plants/plot indicating no safety of these treatments over control.

After 7 days, the highest populations of *coccinellid* beetles was recorded lowest in the treatment T13 (untreated check) with 6.00 *coccinellid/*10plants/plot followed by 4.66 *coccinellid/*10plants/plot in the treatment T11 and T12 indicating safety of these treatments. Other treatment showed low population of beetles which ranged from 1.00-3.66 *coccinellid/*10plants/plot.

The observation recorded after 10 days indicate that the population of *coccinellid* beetles was gradually increased in all treatments where as untreated check recorded significantly highest number of 9.00 *coccinellid/*10plants/plot and the treatment T2, T4, T5, T6, T7, T8, T9, T10, T11 and T12 were varied from 4.33-6.66 *coccinellid/* 10plants/plot indicating reduction in the toxicity of these treatments. However, the lowest numbers of *coccinellid* beetles was recorded in T1 and T3 with 3.00 and 3.66 *coccinellid/*10plants/plot indicating no safety of these treatment till 10 days of application. Significantly lower (P>0.05) number of *coccinellid* beetles was recorded in T1 and T3 as compared to T13, T2, T4, T5, T6, T7, T8, T9, T10, T11 and T12.

At 14 days, the observation recorded showed that the populations of *coccinellid* beetles were gradually decreased in all the treatment including untreated check due to absence of pest population in the field.

However, after 3 days of 3rd application the lowest population of *coccinellid* beetles was recorded in the treatment T1, T2, T3, T4, T5 and T8 (less than 1.66*Coccinellid /*10plants/plot) showed that the treatments were found harmful against *coccinellid* beetles. Whereas the highest population of *coccinellid beetles* was recorded in untreated check with 6.33*Coccinellid/*10plants/plot.

The observation recorded after 7 days indicate that the populations of *coccinellid* beetles was gradually increased in all the treatment but significantly highest in T13 with 8.00 *coccinellid /*10plants/plot. Whereas, the treatment T1, T2, T4, T5 and T11 treated plots were recorded less than 3.66 *coccinellid/*10plants/plot indicating high toxicity of these treatments or no pest population for the buildup of *coccinellid* beetles in the treated plots. The treatment T1, T2, T4, T5 and T11 was significantly lower (P>0.05) compared to T13, T3, T6, T7, T8, T9, T10 and T12.

At 3rd application the observation recorded after 10 days showed that the lowest population of *coccinellid* beetles was recorded in the treatment T1, T2, T3, T4, T5, T7, T8, T9 and T10 treated plots with less than 1.33 *coccinellid/*10plants/plot. Whereas the treatment T13 was recorded with 4.66 *coccinellid/*10plants/plot.

After 14 days of 3rd application the populations of *coccinellid* beetles were gradually decreased in all the treatment including untreated check.

The population of *coccinellid* beetles indicated that phytoproduct neem (T12) and microbial insecticides *B.t.* (Halt) and *B.b*(Biosoft) (T10 and T11) along with some synthetic insecticides, mlathion 50 EC (T9), Dursban 20 EC and Ekalux 25 EC (T6 and T7) spray were bit safe to the *coccinellid* beetles (*Coccinellid septumpunctata)* but significantly lower in compared to untreated check indicating complete safety of the treatment.

Table 4.6: Effect of various treatments on the population of *Coccinellid* beetle in brinjal ecosystem

Treatment	Dose (ml/lt)	Pre - spray	Average numbers of *Coccinellid* beetle/10 plants/plot											
			Days after I[st] application				Days after II[nd] application				Days after III[rd] application			
			3	7	10	14	3	7	10	14	3	7	10	14
T1 Lambda-cyhalothrin	0.56	4.00 (2.11)	1.66 (1.46)*	4.66 (2.26)	2.66 (1.64)	0.33 (0.87)	0.33 (0.87)	1.00 (0.89)	3.00 (1.87)	0.00 (0.00)	.33 (.87)	2.33 (1.67)	0.33 (0.87)	0.00 (0.70)
T2 Lambda-cyhalothrin	0.69	4.33 (2.18)	1.00 (1.17)	4.00 (2.11)	2.33 (1.48)	0.33 (0.87)	0.66 (1.05)	1.66 (1.29)	4.33 (2.18)	0.33 (0.87)	1.33 (1.34)	3.33 (1.95)	0.33 (0.87)	0.33 (0.87)
T3 Lambda-cyhalothrin	0.81	5.33 (2.40)	1.00 (1.17)	3.00 (1.85)	1.00 (0.89)	0.33 (0.87)	0.00 (0.70)	1.00 (0.89)	3.66 (2.02)	0.33 (0.87)	1.66 (1.38)	4.00 (2.09)	0.66 (1.05)	0.33 (0.87)
T4 Lambda-cyhalothrin	1.38	4.66 (2.27)	1.00 (1.17)	3.33 (1.93)	1.33 (0.99)	0.0 (0.00)	0.66 (1.05)	1.33 (1.16)	4.33 (2.19)	0.00 (0.70)	1.66 (1.46)	3.66 (2.03)	0.33 (0.87)	0.00 (0.70)
T5 Lambda-cyhalothrin	4	5.00 (2.33)	1.66 (1.05)	3.66 (2.02)	1.33 (1.16)	0.66 (1.05)	0.33 (0.87)	2.00 (1.40)	5.00 (2.33)	0.00 (0.70)	1.33 (1.28)	3.66 2.03)	0.33 (0.87)	0.33 (0.87)
T6 Chlorpyriphos	2	4.66 (2.25)	1.33 (1.28)	3.66 (2.48)	3.33 (1.83)	0.0 (0.00)	0.33 (0.87)	2.33 (1.53)	5.00 (2.33)	0.33 (0.87)	2.66 (1.77)	4.66 (2.27)	1.66 (1.46)	0.33 (0.87)
T7 Quinalphos	2	6.33 (2.60)	0.33 (.87)	5.33 (2.40)	2.66 (1.64)	1.00 (0.89)	1.00 (1.17)	3.00 (1.73)	5.33 (2.41)	0.33 (0.87)	2.33 (1.65)	4.33 (2.18)	1.33 (1.34)	0.33 (0.87)
T8 Carbaryl	2	5.00 (2.33)	0.66 (1.05)	4.66 (2.25)	1.66 (1.13)	0.66 (1.05)	0.33 (0.87)	2.66 (1.64)	5.66 (2.48)	0.33 (0.87)	1.66 (1.46)	4.00 (2.11)	1.33 (1.34)	0.33 (0.87)
T9 Malathion	2	5.00 (2.35)	1.33 (1.34)	6.00 (2.54)	3.33 (1.81)	0.33 (.87)	1.33 (1.34)	3.66 (1.92)	6.00 (2.54)	0.33 (0.87)	3.33 (1.95)	5.00 (2.33)	1.33 (1.34)	0.66 (1.05)
T10 *Bacillus thiringiensis* (Halt 5W.P)	2	5.33 (2.41)	0.66 (1.05)	5.66 (2.48)	3.00 (1.73)	1.00 (0.89)	1.00 (1.22)	3.00 (1.73)	6.00 (2.54)	0.33 (0.87)	3.66 (2.03)	5.66 (2.48)	1.33 (1.34)	0.33 (0.87)
T11 *Beavaeria basiana* (Biosoft 5 W.P)	2	5.00 (2.34)	1.00 (1.17)	6.00 (2.54)	3.33 (1.83)	0.66 (1.05)	1.00 (1.17)	4.66 (2.16)	6.66 (2.60)	0.66 (1.05)	3.00 (1.85)	3.66 (2.03)	1.66 (1.46)	0.66 (1.05)
T12 Neem	2	4.66 (2.26)	1.00 (1.17)	6.66 (2.67)	4.33 (2.09)	1.00 (0.89)	2.33 (1.67)	4.66 (2.16)	6.66 (2.60)	0.66 (1.05)	3.00 (1.82)	5.33 (2.41)	2.00 (1.55)	0.66 (1.05)
T13 Control	_	6.66 (2.67)	5.00 (2.34)	8.33 (2.96)	6.66 (2.57)	2.3 (1.67)	5.66 (2.48)	6.00 (2.45)	9.00 (3.07)	1.66 (1.46)	6.33 (2.60)	8.00 (2.90)	4.66 (2.26)	2.33 (1.67)
CV	_	9.67	27.85	9.63	25.23	29.29	24.44	21.39	8.87	28.86	19.85	8.68	16.87	28.29
SEM±	_	0.61	0.45	0.60	0.60	0.41	0.37	0.52	0.58	0.30	0.57	0.48	0.33	0.31
CD at 5%	_	0.38 (0.13)	0.96 (0.20)	0.98 (0.13)	0.78 (0.23)	0.48 (0.15)	0.48 (0.16)	0.57 (0.19)	0.93 (0.12)	0.45 (0.15)	0.89 (0.18)	0.92 (0.11)	0.73 (0.12)	0.45 (0.15)

*data present on parenthesis are square root transformed value

The above findings are in conformity with those of **Kaethner (1999),** reported neem extract and neem oil was harmless to the egg and larvae of *Coccinellid septumpunctata* Thumb.

Similarly, **Chakraborti (2001)** reported that the neem based treatments like spraying of neem oil and NSKE were found safer to natural enemies during their field trials and were on par with untreated check in brinjal ecosystem.

Smitha (2002), reported that neem cake were safe to *Coccinellid* predatory beetles in chilli ecosystem. Further, **Rosaih (2001b)** reported that botanicals in general and NSKE in particular were safe to the predator's viz., *Coccinellid*, *Chrysoperla*, spiders, apsantele in brinjal and okra ecosystem. The above findings support the present work

Similarly, the results are in line with **Tandon and Nilana (1987)** who reported that *B. thuringiensis* was safe to natural enemies viz., *C. septumpunctata*.

Rosaih (2001a) reported that synthetic insecticides were not safe to natural enemies, which is in agreement with the present findings.

4.4.2 Effect of various treatments on the population of green lacewing bug *Chrysoperla* in brinjal ecosystem

The data computed in the table 4.7 revealed that after 3 days of 1st application the population of *Chrysoperla* gradually decreased in all treatment (less than 1.33 *Chrysoperla/*10plant/plot*)* except the untreated check 3.33 *Chrysoperla/*10plant/plot indicating not safety of the treatment over control.

However, after 7 days of 1st application the population of *Chrysoperla* was increased in all treatments but lower than untreated check. Whereas, the treatment T1, T2, T3, T4, T5 and T7 were recorded with the lowest number (less than 3.33 *Chrysoperla/*10plant/plots) indicating toxicity of these treatment.

At 10 days the observation recorded indicate that the populations of *Chrysoperla* was recorded significantly lowest in the treatment T1 with 1.66 *Chrysoperla/*10plant/plots showed that treatment is highly toxic for the *Chrysoperla.* Whereas, the rest of all treatments T2-12 were recorded in the range 3.66-6.33 *Chrysoperla/*10plant/plot indicating safety of these treatments. However, the highest population of 8.33 was recorded in untreated check. Significant higher (P<0.05) number of *Chrysoperla* was recorded in treatment T13 as compared to rest of all the treatments.

The population of *Chrysoperla* gradually decreased in all treatments after 14 days of 1st application. Where, the untreated check recorded highest population 3.33 *Chrysoperla/*10plant/plot in comparison to rest of all the treatment.

Following 2nd application after 3 days the population of *Chrysoperla* was still lower in all treatment but T13 (untreated check) recorded 4.66 *Chrysoperla/* 10plant/plots which is the highest population over rest of all the treatments indicating complete safety of the treatment.

However, after 7 days the population of Chrysoperla gradually increased in all treatment but lower than untreated check. The lowest population of *Chrysoperla* was recorded in T1, T2, T3, T4, T5 and T6 (less than 5.66 *Chrysoperla/*10plant/plots) indicating not safety of these treatment.

After 10 days the population of *Chrysoperla* was recorded lowest in the treatment T1, T2, T3, T4 and T5 (less than 3.00 *Chrysoperla/*10plant/plots. Whereas, the treatment T6, T7, T8, T9, T10, T11 and T12 were varied from 3.33-5.33 *Chrysoperla/*10plant/plot which is found statistically on par with each other and also with untreated check of 6.33*Chrysoperla/*10plant/plots indicating safety of these treatments. The treatment T1, T2, T3, T4 and T5 was significantly lower (P>0.05) than T6, T7, T8, T9, T10, T11 and T12.

The observation recorded after 14 days showed that the population of *Chrysoperla* gradually decreased in all treatment.

There was no population of *Chrysoperla* present in the field during third application.

In agreement with the above findings, **Kaethner (1999)** also reported that the neem extracts and neem oil were harmless to the egg and larvae of *Chrysoperla carnea* Steph.

Tandon and Nillana (1987) also reported that the *B. thuringiensis* was safe to natural enemies' viz., *Chrysoperla carnea.*

Table 4.7: Effect of various treatments on the population of *Chrysoperla* in brinjal ecosystem.

Treatment	Dose (ml/lt)	Pre - spray	Average numbers of *Chrysoperla*/10 plants							
			Days after I[st] application				Days after II[nd] application			
			3	**7**	**10**	**14**	**3**	**7**	**10**	**14**
T1 Lambda-cyhalothrin	0.56	4.00	0.66	2.66	1.66	0.33	0.33	4.33	2.33	1.00
		(2.12)*	(0.75)	(1.77)	(1.27)	(0.49)	(0.49)	(2.19)	(1.67)	(1.46)
T2 Lambda-cyhalothrin	0.69	3.66	1.00	2.33	3.66	0.33	1.00.	4.00	2.66	1.00
		(2.03)	(0.89)	(1.67)	(2.03)	(0.49)	(0.89)	(2.11)	(1.77)	(1.17)
T3 Lambda-cyhalothrin	0.81	3.66	0.66	3.00	5.00	0.33	0.66	4.00	2.33	1.00
		(2.01)	(0.75)	(1.82)	(2.32)	(0.49)	(0.75)	(2.09)	(1.64)	(1.17)
T4 Lambda-cyhalothrin	1.38	4.66	1.33	3.66	5.00	0.00	0.33	4.00	2.00	1.00
		(2.27)	(1.02)	(2.01)	(2.33)	(0.22)	(0.49)	(2.12)	(1.55)	(1.17)
T5 Lambda-cyhalothrin	4	4.33	1.00	2.66	5.00	0.33	0.33	4.66	3.00	1.00
		(2.19)	(0.89)	(1.76)	(2.33)	(0.49)	(0.49)	(2.27)	(1.85)	(1.05)
T6 Chlorpyriphos	2	3.66	1.00	4.00	6.00	1.33 (1.16)	1.66	5.00	3.33	1.33
		(2.01)	(.89)	(2.12)	(2.54)	1.00	(1.29)	(2.33)	(1.95)	(1.28)
T7 Quinalphos	2	4.00	1.66	3.33	5.00	(0.89)	1.00	5.66	3.66	0.33
		(2.11)	(1.29)	(1.95)	(2.34)	1.33	(0.89)	(2.48)	(2.01)	(0.87)
T8 Carbaryl	2	5.00	1.66	4.00	6.00	(1.16)	1.33	6.33	4.33	0.66
		(2.33)	(1.29	(2.12)	(2.54)	2.33	(1.16)	(2.61)	(2.18)	(1.05)
T9 Malathion	2	4.00	2.33	4.66	6.00	(1.50)	2.00	7.00	5.00	1.00
		(2.11)	(1.53)	(2.27)	(2.54)	2.66 (1.64)	(1.40)	(2.73)	(2.33)	(1.17)
T10 *Bacillus thiringiensis*	2	3.33 (1.95)	1.33	4.33	6.33	2.33 (1.53)	2.66	6.33	5.00	1.33
(Halt 5W.P)		4.33	(1.16)	(2.19)	(2.61)	2.00 (1.40)	(1.64)	(2.61)	(2.34)	(1.34)
T11 *Beavaeria basiana*	2	(2.19)	2.66	4.66	6.33	3.33	2.33	6.33	4.33	1.66
(Biosoft 5 W.P)		3.66	(1.64)	(2.26)	(2.60)	1.83)	(1.53)	(2.60)	(2.19)	(1.46)
T12 Neem	2	(2.03)	2.00	4.00	6.33		3.33	6.66	5.33	1.33
		4.33	(1.40)	(2.11)	(2.60)	21.83	(1.83)	(2.67)	(2.41)	(1.34)
T13 Control	_	(2.19)	3.33	6.00	8.33	0.41	4.66	8.66	6.33	5.00
			(1.83)	(2.54)	(2.97)	0.63 (0.28)	(2.16)	(3.02)	(2.61)	(2.34)
		10.42								
CV	_	0.52	17.64	9.83	6.47		14.18	6.87	9.39	17.85
SEM±	_	0.37	0.46	0.44	0.43		0.40	0.45	0.42	0.38
CD at 5%	_	(0.12)	0.75	0.82	0.93		0.61	1.38	0.96	0.58
			(0.25)	(0.11)	(0.92)		(0.22)	(0.97)	(0.11)	(0.20)

*data present on parenthesis are square root transformed value.

Rosaih (2001b) reported that NSKE in particular were safe to *Chrysopids* in brinjal and okra ecosystem.

The safety of *B. thuringiensis* and synthetic pyrethiroids by **Srinivasan and Sundara Babu (1998) and Udikeri *et al*. (2004)** have been reported by above workers which agree with the present findings.

Schoonover and Larson (1995) reported that spinosad was found to have short-term toxicity to the mite, *Phytoseiulus perisimilis* (Athias – Henricot), a predator of spiders mite but however it was much safer to predator like *E. Formosa* (Gahan), *Oriusins idiotus* (Say), *Chrysoperla rufilabris* (B.).

Rosaih (2001a) reported that synthetic insecticides were not safe to natural enemies, which is in agreement with the present findings.

4.4.3 Effect of various treatments on the population of spiders in brinjal ecosystem

The impact of various applications on population of spiders was presented on the table 4.8.

The result revealed that after 3 days of 1st application the population of spiders gradually decreased (less than 1.66 spiders/10plants/plot) in all treatment except in untreated check (4.00 spiders/10plants/plot) which showed that all the treatment had some toxic effect on the spiders population.

However, after 7 days of 1st application the population of spiders was increased in all treatment but significantly highest population of spiders was recorded in untreated check. The lowest population of spiders was recorded in T1, T2, T3, T4, T5, T6, T7 and T8 (less than 3.33 spiders/10plants/plot) indicating not safety of these treatments.

At 10 days the observation recorded indicate that lowest population of spiders was observed in the treatment T1 and T7 with 2.00 and 3.00 spiders/10plants/plot respectively indicating harmful effect of the treatment. Whereas, the treatment T2, T3, T4, T5, T6, T8, T9, T10, T11, T12 and T13 varied from 3.33- 5.66 spiders/10plants/plot found statistically on par with each other and indicating safety of these treatments. The number of spiders was significantly lower ($P>0.05$) in T1 and T7 than T2, T3, T4, T5, T6, T8, T9, T10, T11, T12 and T13.

After 14 days the population of spiders gradually decreased in all treatment except the untreated check with 6.33 spiders/10plants/plot. The lowest population of spiders were observed in T1, T2 and T5 (less than 1.33 spiders/10plants/plot) indicating not safety of the treatment.

Following after 3 days of 2nd application the population of spiders was still lower (less than 1.33 spiders/10plants/plot) in all treatment except untreated check (4.66 spiders/10plants/plot).

After 7 days the population of spiders gradually increased in similar pattern in all treatment. The highest population of 11.00 spiders/10plants/plot was recorded in untreated check. The lowest treatment T1, T2 and T4 recorded less than 5.66 spiders/10plants/plot. Whereas, the treatment T3, T5, T6, T7, T8, T9, T10, T11 and T12 range from 6.33-7.33spiders/10plants/plot found statistically on par with each indicating loss in the toxicity effect on the spiders population. Significantly lowest ($P>0.05$) population of spiders was recorded in T1, T2 and T4 over T3, T5, T6, T7, T8, T9, T10, T11 and T12.

At 10 days the lowest population (less than 4.33 spiders/10plants/plot) was recorded in the treatment T1, T2, T4, T5 and T11 indicating no safety of the treatment. Whereas, untreated check recorded significantly highest number of spiders/10plants/plot (8.00).

The observation recorded after 14 days indicate that the population of spiders gradually decreased in all treatment including the untreated check 4.66 spiders/10plants/plot.

After 3 days of 3rd application the population of spiders was still lower in all treatments less than 1.66 spiders/10plants/plot.

However, after 7 days the population of spiders was increased in all treatment but significantly the highest population was recorded in untreated check 7.33 spiders/10plants/plot. However, the lowest population of spiders was recorded in the treatment T1, T2, T5 and T6 (less than 4.00 spiders/10plants/plot) indicating not safety of the treatment.

At10 days the population of spiders was recorded lowest in the treatment T1, T2, T3, T4 and T5 (less than 1.33 spiders/10plants/plot) which showed harmful effect

Table 4.8: Effect of various treatments on the population of Spider in brinjal ecosystem

Treatment	Dose (ml/lt)	Pre - spray	Average numbers of spider/10 plants											
			Days after Ist application				Days after IInd application				Days after IIIrd application			
			3	**7**	**10**	**14**	**3**	**7**	**10**	**14**	**3**	**7**	**10**	**14**
T1 Lambda-cyhalothrin	0.56	4.66 (2.27)	1.33 (0.99)*	3.00 (1.85)	2.00 (1.85)	0.33 (0.87)	0.33 (0.49)	4.33 (2.19)	2.33 (1.67)	1.00 (0.78)	0.33 (.87)	3.66 (2.03)	1.33 (1.16)	0.33 (0.87)
T2 Lambda-cyhalothrin	0.69	5.00 (2.34)	1.66 (1.29)	3.66 (2.03)	3.33 (1.93)	1.33 (1.34)	1.66 (1.29)	5.66 (2.48)	4.33 (2.18)	1.66 (1.25)	0.00 (.70)	3.00 (1.87)	0.33 (0.49)	0.33 (0.87)
T3 Lambda-cyhalothrin	0.81	4.33 (2.18)	1.33 (0.99)	2.66 (1.73)	4.00 (2.11)	1.66 (1.38)	1.66 (1.29)	6.33 (2.61)	4.66 (2.27)	1.00 (0.78)	0 .33 (0.87)	4.33 (2.19)	1.66 (1.29)	0.66 (1.05)
T4 Lambda-cyhalothrin	1.38	5.00 (2.33)	1.66 (1.13)	3.33 (1.93)	3.66 (2.03)	1.66 (1.46)	1.66 (1.13)	5.66 (2.46)	4.00 (2.11)	1.00 (0.78)	0.66 (1.05)	4.33 (2.19)	1.66 (1.29)	0.33 (0.87)
T5 Lambda-cyhalothrin	4	5.33 (2.41)	0.66 (0.75)	3.00 (1.87)	3.66 (2.02)	1.33 (1.28)	1.33 (1.16)	6.00 (2.54)	4.00 (2.12)	1.00 (0.78)	0.33 (0.87)	3.33 (1.95)	1.00 (0.89)	0.33 (0.87)
T6 Chlorpyriphos	2	6.00 (2.54)	1.66 (1.13)	3.33 (1.94)	3.33 (1.93)	2.66 (1.77)	2.33 (1.53)	7.00 (2.73)	5.00 (2.33)	1.00 (0.78)	0.33 (0.87)	4.00 (2.11)	2.00 (1.40)	1.66 (1.46)
T7 Quinalphos	2	5.33 (2.40)	1.66 (1.29)	4.66 (2.27)	3.00 (1.85)	2.33 (1.65)	2.33 (1.53)	6.66 (2.67)	5.33 (2.41)	0.66 (0.76)	0.66 (1.05)	4.66 (2.27)	2.00 (1.43)	1.33 (1.34)
T8 Carbaryl	2	4.66 (2.27)	1.00 (0.89)	3.33 (1.95)	4.66 (2.25)	1.66 (1.46)	2.66 (1.64)	7.00 (2.72)	5.00 (2.33)	1.00 (0.78)	0.66 (1.05)	4.66 (2.27)	2.33 (1.53)	1.33 (1.34)
T9 Malathion	2	5.33 (2.41)	2.33 (1.48)	5.00 (2.33)	4.33 (2.19)	3.33 (1.95)	2.33 (1.50)	7.00 (2.73)	5.33 (2.40)	2.00 (1.96)	1.00 (1.22)	5.66 (2.48)	2.66 (1.64)	1.33 (1.34)
T10 *Bacillus thiringiensis* (Halt 5W.P)	2	6.33 (2.61)	3.33 (1.83)	4.66 (2.27)	4.00 (2.11)	3.66 (2.03)	3.33 (1.83)	7.00 (2.73)	5.33 (2.41)	1.66 (1.25)	1.00 (1.17)	4.33 (2.18)	2.33 (1.50)	1.33 (1.34)
T11 *Beavaeria basiana* (Biosoft 5 W.P)	2	6.33 (2.61)	2.33 (1.53)	5.00 (2.34)	4.00 (2.11)	3.00 (1.85)	2.33 (1.53)	6.33 (2.60)	4.33 (2.19)	1.66 (1.25)	1.00 (1.17)	5.33 (2.41)	3.00 (1.73)	1.66 (1.46)
T12 Neem	2	6.66 (2.67)	3.00 (1.73)	5.33 (2.41)	4.66 (2.27)	3.00 (1.82)	3.00 (1.73)	7.33 (2.79)	5.66 (2.46)	2.33 (1.24)	1.33 (1.34)	5.33 (2.41)	3.66 (1.92)	2.00 (1.55)
T13 Control	_	6.33 (2.61)	4.00 (2.00)	6.66 (2.67)	5.66 (2.48)	6.33 (2.60)	4.66 (2.15)	11.00 (3.38)	8.00 (2.91)	4.66 (3.51)	1.66 (1.46)	7.33 (2.79)	4.66 (2.16)	4.66 (2.26)
CV	_	6.57	31.37	10.74	12.69	19.85	24.59	7.36	8.76	25.03	28.30	6.41	22.28	26.87
SEM±	_	0.43	0.66	0.50	0.62	0.57	0.52	0.60	0.53	0.55	0.36	0.36	0.43	0.33
CD at 5%	_	0.27 (0.92)	0.91 (0.31)	0.98 (0.13)	0.83 (0.15)	0.96 (0.18)	1.35 (0.20)	1.21 (0.11)	1.63 (0.11)	0.73 (0.17)	0.50 (0.17)	0.85 (0.83)	0.91 (0.18)	0.83 (0.12)

*data present on parenthesis are square root transformed value

of these treatments. Whereas, significantly highest population of spiders was recorded in untreated check 4.66 spiders/10plants/plot.

The observation recorded after 14 days showed that the population of spiders gradually decreased in all treatment except the untreated check4.66 spiders/10plants/plot which showed that the treatment T13 without any spray good for the buildup of spiders population.

It is clear from the result that untreated check was the safest treatment followed by phytoproduct and biopesticides which were also safe to the spiders population but significantly lower as compared to untreated check.

The findings are in accordance with **Rosaih (2001a)** who also reported that NSKE in particular were safe to spiders in brinjal ecosystem.

The above findings are in accordance with the findings of **Tiwari *et al*. (2011)** who reportedthat the pesticides from the biological origin and neem based were found relatively less harmful to the natural enemies than newer and conventional synthetic insecticide.

Mann and Dhaliwal (2001) who reported that the number of spiders 15 plants were recorded significantly maximum (5.00) with Neem Azal 1 l/ha than that of control (3.00) to be minimum (3.32) in Neem Azal 2 l/ha. in cotton agroecosystem .

Jyoti *et al*. 2008 who also reported that the spray of microbial pesticides (Btk 5% WP) were safe on spiders associated with insects pests of brinjal.

Rosaih (2001a) reported that synthetic insecticides were not safe to natural enemies, which is in agreement with the present findings.

4.4.4 Effect of various treatments on the population of *Eucanthecona* bug in brinjal ecosystem

Data computed after 3 days application showed that the population of *Eucanthecona* bug gradually decreased (less than 2.66*Eucanthecona* bug/10plants/plot) in all treatment except in untreated check (5.00 *Eucanthecona* bug/10plants/plot) present in Table 4.9.

However, after 7 days, the population of *Eucanthecona* was still lower in all treatment except T13 (5.33 *Eucanthecona* bug/10plants/plot). Whereas, the lowest

Table 4.9: Effect of various treatments on the population of *Eucanthecona* bug in brinjal ecosystem

Treatments	Dose (ml/lt)	Pre - spray	Average number of *Eucanthecona bug*/10 plants/plot			
			Days after application			
			3	7	10	14
T1 Lambda-cyhalothrin	0.56	4.33 (2.19)*	1.66 (1.29)	1.66 (1.29)	1.00 (0.89)	0.33 (0.49)
T2 Lambda-cyhalothrin	0.69	5.00 (2.33)	2.66 (1.64)	2.33 (1.53)	0.66 (0.75)	0.33 (0.49)
T3 Lambda-cyhalothrin	0.81	3.00 (1.85)	2.33 (1.50)	1.66 (1.29)	1.00 (0.89)	0.33 (0.49)
T4 Lambda-cyhalothrin	1.38	5.66 (2.48)	1.33 (1.02)	1.66 (1.13)	0.66 (0.75)	0.00 (0.22)
T5 Lambda-cyhalothrin	4	5.00 (2.33)	1.33 (1.16)	1.33 (1.16)	1.00 (0.89)	0.33 (0.49)
T6 Chlorpyriphos	2	4.33 (2.18)	2.00 (1.23)	1.66 (1.26)	1.66 (1.29)	1.33 (1.16)
T7 Quinalphos	2	3.66 (2.02)	2.66 (1.59)	2.33 (1.53)	1.66 (1.29)	1.00 (0.89)
T8 Carbaryl	2	3.66 (2.01)	2.66 (1.64)	3.33 (1.83)	1.33 (1.16)	1.33 (1.16)
T9 Malathion	2	4.00 (2.11)	2.66 (1.56)	2.33 (1.53)	3.00 (1.73)	1.33 (1.50)
T10 *Bacillus thiringiensis* (Halt 5W.P)	2	3.33 (1.95)	4.00 (2.00)	2.66 (1.64)	3.33 (1.81)	2.66 (1.64)
T11 *Beavaeria basiana* (Biosoft 5 W.P)	2	4.00 (2.09)	2.66 (1.64)	3.00 (1.73)	2.66 (1.64)	2.33 (1.53)
T12 Neem	2	4.66 (2.25)	3.66 (1.92)	3.33 (1.83)	3.33 (1.83)	2.00 (1.40)
T13 Control	_	7.33 (2.79)	5.00 (2.23)	5.33 (2.31)	3.66 (1.92)	3.33 1.83)
CV	_	12.72	28.37	18.72	30.52	36.83
SEM±	_	0.67	0.65	0.42	0.46	0.41
CD at 5%	_	0.47 (0.16)	0.75 (0.25)	0.48 (0.16)	0.66 (0.22)	0.63 (0.21)

*data present on parenthesis are square root transformed value.

Coccinellid beetles

Meta menardi

Eucanthecona furcelleta predating on hadda beetle and larvae of semilooper

Eucanthecona furcelleta predating on grub of hadda beetle

Ceriagrion fallax

Agelenopsis sp

Chrysoperla carnea

Natural enemies present on brinjal ecosystem

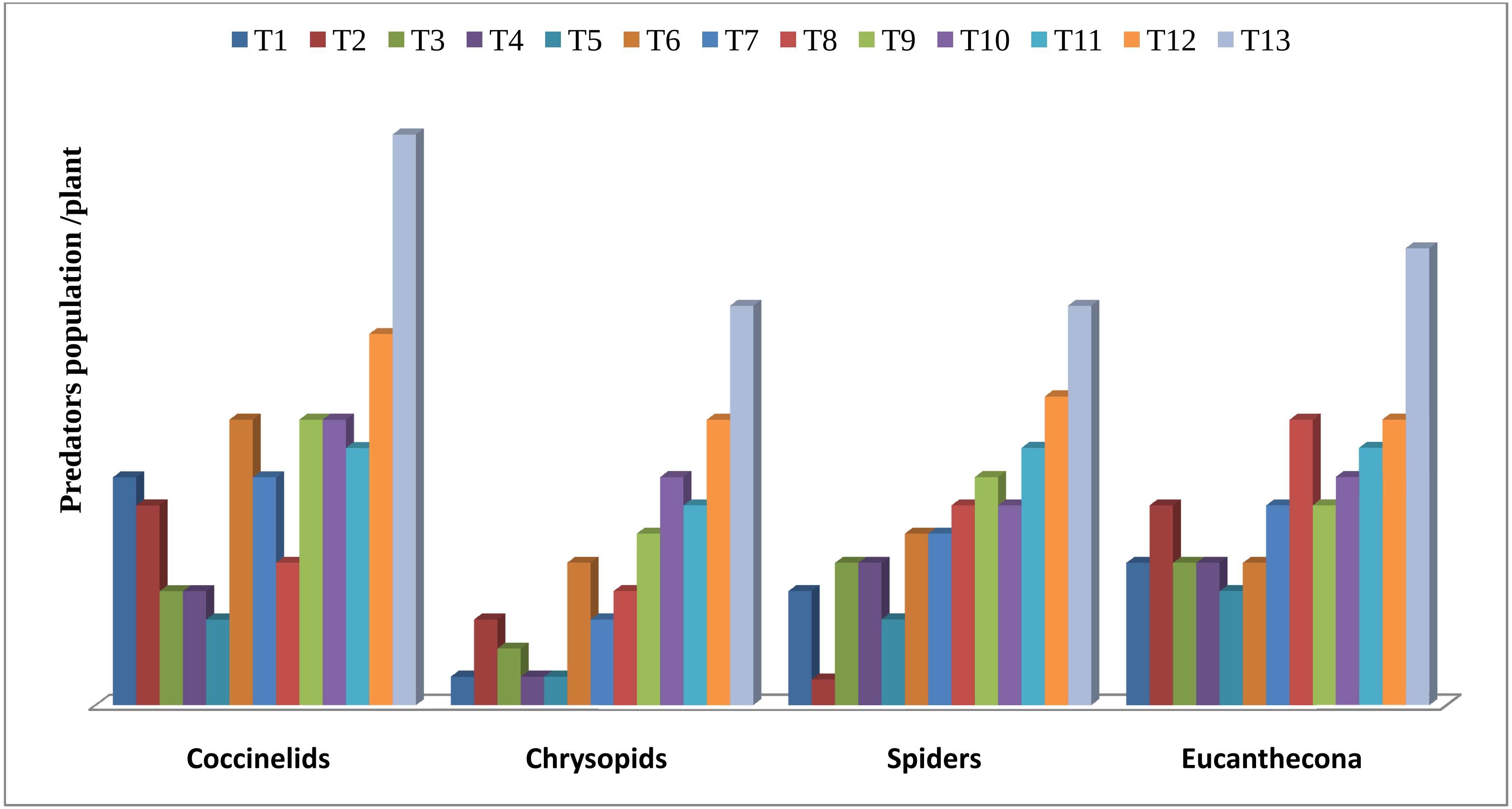


Fig. 4.3: Effect of various treatments on beneficial insect in brinjal ecosystems

population was recorded in T1, T2, T3, T4, T5, T6, T7 and T9 (less than 2.33 *Eucanthecona* bug/10plants/plot) which shows the harmful effect of the treatment. Significantly lowest (P>0.05) number was recorded in T1, T2, T3, T4, T5, T6, T7 and T9 than T13.

At 10 and 14 days the population of *Eucanthecona* bug was still lower in all treatment except untreated check (3.66 *Eucanthecona/*10plants/plot). Whereas, the lowest population of *Eucanthecona* bug was observed in T1, T2, T3, T4, T5, T6, T7 and T8 with less than 1.33 *Eucanthecona* bug/10plants/plot indicating not safety of these treatments.

There is lack of literature on *Eucanthecona* bug regarding to the effects of these above treatments. However, the maximum numbers of *Eucanthecona* bug/10plants/plot were recorded in untreated check followed by neem (T12) treated plots. Next best treatment is *B.t.* (Halt) and *B.b*(Biosoft) (T10 and T11). These are followed by Malathion and Quinalphos at 2 ml/lt (T9 and T7).

Whereas the lowest number of *Eucanthecona* bug/10plants/plot were recorded in Lambda-cyhalothrin at 4ml/lt (T5).

4.5 To study the effect of synthetic insecticides, phytoproduct and biopesticides on the yield of brinjal crop

The data on per cent fruits damage and yield of crop are presented in table 4.10 and fig. 4.4. The percentage of damage fruits showed significant difference among the treatments, being the minimum in the treatment T5 with 28.00 to maximum in the treatment T13 (untreated control) with 88.33 percent.

The T5 was recorded significantly superior in terms of lowest fruit damage (28.00 per cent) and higher yield 204.16 kg/ha followed by treatment T4 and T2 with 32.51 and 35.30 per cent damage fruit with 197.22 and 190.27 kg/ha yield. Whereas, the treatment T3 and T1 were found statistically on par with each other with 38.70 per cent fruit damage and yield 170.83 kg/ha.

However, the maximum per cent of fruits damage was recorded in the treatment T13, T11, T10 and T12 with 88.33, 87.00, 83.66 and 79.33 per cent respectively. Similarly, these treatments were obtained significantly lower yield 101.72, 100.38, 113.88 and 122.22 kg/ha respectively. The per cent fruit damage and yield were significantly higher ($P<0.05$) in T5, T4, T2, T1 and T3 than T6, T7, T8, T9, T10, T11, T12 and T13.

Though many of the treated plots had statistically significant difference in fruit yield as compared to untreated control, there was gain in yield over the untreated control in all insecticides treated plots except in the treatment T11.

The actual gain in fruit yield over control was maximum (103.44 kg/ha) in the treatment T5 which was increased with 102.70 per cent. This gain in yield was followed by T4 (96.50 kg/ha) which was increased 95.80 per cent and T2 (89.55 kg/ ha) which amounted to 88.91 per cent increase, respectively.

The gain in 25.66 kg/ha in the treatment T9 and 27.05 kg/ha T8 amounted to 26.86 and 25.48 per cent increase, respectively.

There was negligible gain (66.66 kg/ha) in the treatment T11 amounting to 0.66 per cent increase over control.

Among different insecticides applied against brinjal shoot and fruit borer lambda cyhalothrin, remained effective throughout the observations period by recording lowest per cent shoot and fruit infestation with higher yield. This may be because lambdacyhalothrin exhibits more toxic effect to eggs and neonate larvae, which is the most susceptible stage of this pest.

Lambda-cyhalothrin a pyrethroid group proved excellent at 4ml/lt (T5) dose against *L. orbonalis.* The superiority of lambda-cyhalothrin may be due to the fact that it has quick down effect.

The present findings are in line with **Mathirajan *et al*. (2000),** who reported the superiority of L- cyhalothrin in controlling brinjal shoot and fruit borer and recorded highest yield with maximum marketable fruit yield (204.16 kg/ha). **Latif et al, 2010** reported that Lambda-cyhalothrin and chlorpyriphos although reduced shoot and fruit infestation of brinjal and protected higher yield as compared to control. Among the different pyrethroids, **Datar and Ashtaputre (1984)** reported that commercially available pyrethoids were most effective against *L. orbonalis* and could give highest yield as compared to endosulfan.

Table.4.10: Effect of various treatments on the yield of the brinjal crop

Treatments	Dose (ml/lt)	Percent damaged Fruits/ 10 plants	Yield of healthy fruits /plot (kg/ha)	Gain over control (kg/ha)	Percent increase over control
T1. Lambda-cyhalothrin	0.56	38.70 (31.56)*	170.83	70.11	69.60
T2. Lambda-cyhalothrin	0.69	35.30 (26.94)	190.27	89.55	88.90
T3. Lambda-cyhalothrin	0.81	38.70 (31.56)	170.83	70.11	69.60
T4. Lambda-cyhalothrin	1.38	32.51 (28.42)	197.22	96.50	95.80
T5. Lambda-cyhalothrin	4	28.00 (19.38)	204.16	103.44	102.70
T6. Chlorpyriphos	2	57.21 (41.94)	163.88	63.16	62.70
T7. Quinalphos	2	79.33 (64.37)	122.22	21.50	21.34
T8. Carbaryl	2	75.66 (67.39)	127.77	26.50	26.30
T9. Malathion	2	77.36 (69.82)	126.38	25.66	25.47
T10.*Bacillus thiringiensis* (Halt 5W.P)	2	83.66 (72.51)	113.88	13.16	13.06
T11.*Beavaeriabasiana* (Biosoft 5 W.P)	2	87.00 (79.77)	100.38	0.66	0.65
T12. Neem	2	79.33 (64.37)	122.22	21.50	21.34
T13. Control	_	88.33 (78.86)	101.72	_	_
	_		12.40	_	_
CV	_	5.73	14.45	_	_
SEM±	_	.83	34.87	_	_
CD at 5%		11.07	(25.36)		
		(0.90)			

*data present on parenthesis are angular transformed value.

Similarly, the above findings is in conformity with the findings of **Mohan and Prasad (1986)** who indicated that all the pyrethiods were most effective against *L. orbonalis* and give the highest yield.

Next best treatments in recording marketable fruit yield were chloropyriphos (163.68 kg/ha), carbaryl (127.77 kg/ha) and malathion (126.38 kg/ha) and the present findings are in line with **Sawant and Dethe, (2001)** who reported that sprays of chlorpyriphos at the dose of 0.5 to 0.75 kg a.i. per ha per spray at an interval of 15 days lowered the incidence of fruit borer and recorded more yield of healthy fruit (105 to 176 q/ha) compared to untreated control (66.2 q/ha).

Besides, **Lande (1976)** who reported that malathion 0.05 per cent spray was the best, which recorded the higher yield of 134.7 q per ha followed by 120.5 kg per ha in carbaryl treatment and the untreated check could record 80.51 q per ha.

The above findings is in accordance with the findings of **Singh *et al*. (2008)** who reported three insecticides, i.e. spinosad (0.05%), cypermethrin (0.05%) and malathion (0.05%), against the brinjal shoot and fruit borer (L. orbonalis) to obtain higher yield and reported the minimum (21.5%) infestation was observed with malathion, followed by cypermethrin (24.13%) and spinosad (25.17%) and the total yield of healthy brinjal fruits was highest (350 q/h) with malathion-treated plants and lowest (112.5 q/h) with the control.

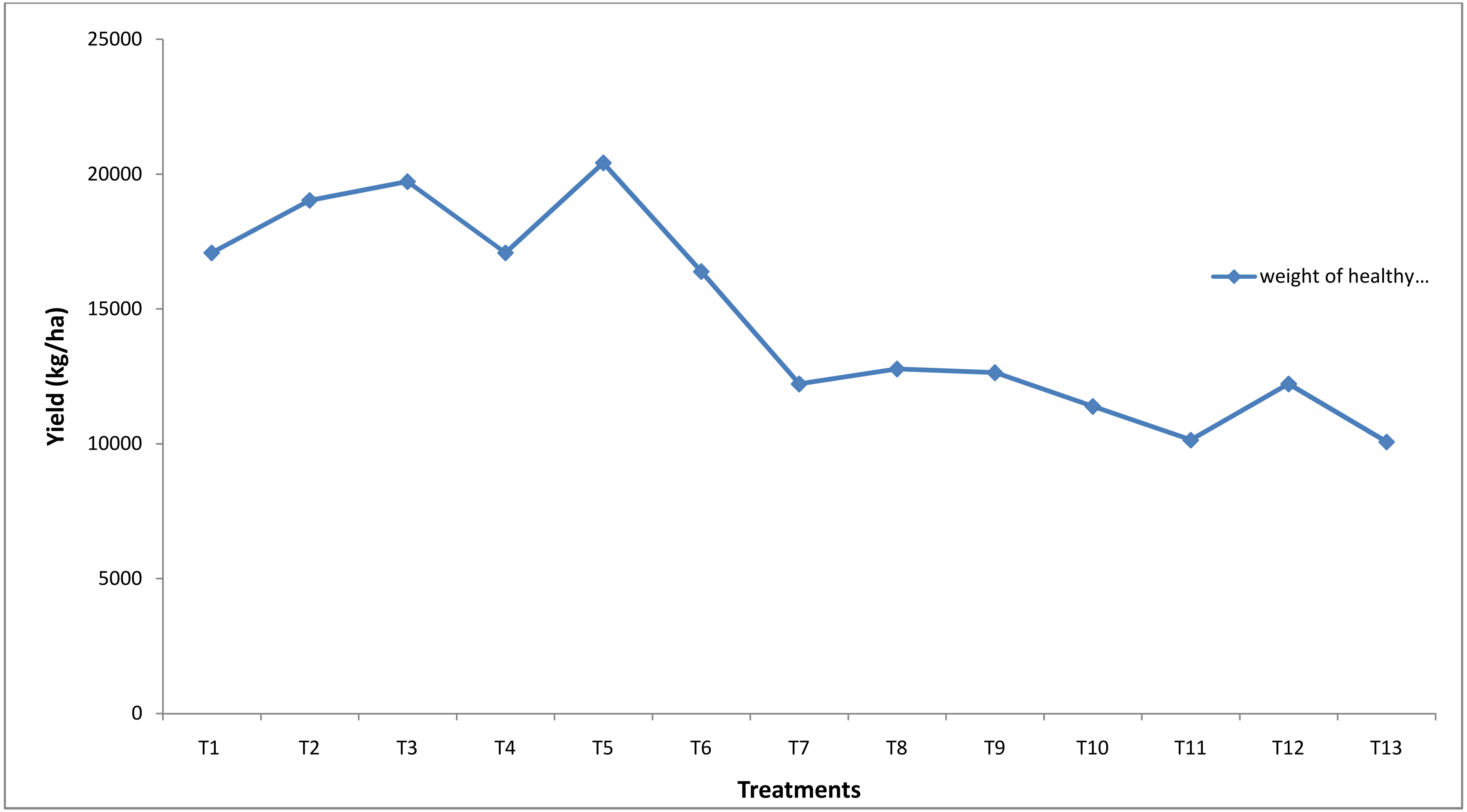


Fig. 4.4: weight of healthy fruits (yield in kg/ha)

*The sequence of treatments is as its is given in the table

Summary and Conclusion

5 SUMMARY

The thesis incorporates the result of the study on insect fauna of brinjal and the evaluation of comparative efficacy of some synthetic insecticides, phytoproduct and biopesticides against the larval population of brinjal shoot and fruit borer *Leucinodes orbonalis* and adult population of hadda beetle *Epilachna vigintioctopunctata* and effect of these treatment on the beneficial insects along the yield of brinjal, conducted at Vegetable Research Centre (VRC), G. B. Pant University of Agriculture and Technology, Pantnagar (U. S. Nagar), Uttarakhand during summer season, 2012.

The results obtained during the course of investigations are summarized below:

- A total of 28 species of insect belonging 10 different orders and 16 families were found in the brinjal crop where regular surveys were carried out at weekly interval to record and identify the insect fauna including both natural enemies and beneficial insect at various stages (form vegetative to harvesting stage) of brinjal. These were: brinjal shoot and fruit borer (*Leucinodes orbonalis* Guen.), leaf feeder (*Helicoverpa armigera*. Hubner), green semilooper (*Thysanoplusia oricalcea*. Fabricius), stem borer (*Euzophera perticella* Ragnot), leaf roller (*Antoba olivaceae* Walker), hadda beetle (*Epilachna vigintioctopunctata* Fab.), pumkin beetle (*Raphidopalpa cruciferae* Lucas.), whitefly (*Bemicia tabaci* Genn.), jassids (*Amrasca bigittula bigitulla* Ishida.), leafhopper (*Amrasca devastans* Stal.), green bug (*Nezara viridula* Burmeister), tur pod bug (*Clavigralla gibbosa*. Spinola), tree hopper (*Sictocephala baralis* Casher.), thrips (*Thrips palmi* Lindeman), short horn grasshopper (*Hieroglyphus banian* Fabricius.) and fruit flies (*Bactocera spp.*), honeybee (*Apis dorsata* Fabricius), non-apis bee (*Amegilla zonata* Rayment), ichneumonid wasp (*Charops sp.* Ashmead), carpenter bee (*Xylocopa iridipennis* Lepeletier) and (*Xylocopa aestuans* Linnaeus), eucantheconid bug (*Eucanthecona furcelleta* Aubrey*)*, green lacewing (*Chrysoperla.carnea* Stephens), ladybird beetles (*Coccinella septunpunctata* Linnaeus), damselflies *(Ceriagrion fallax* Ris*)* and dragonflies (*Anax. sp. Eichkoff*) and spiders (*Meta menardi* Latreille) and *(Agelenopsis sp.* Giebel*).* Of these the brinjal shoot and fruit borer (*L. orbonalis)* and hadda beetle (*E. vigintioctopunctata*), have been reported as the most prevalent species as evidenced by their activity period at Vegetable Research Centre, Pantnagar and therefore, appeared to be the major pests of brinjal followed by, stem borer, leaf roller, thrips, green bug, whitefly etc, the minor pests.

- Among the various pest complex of brinjal the order Hemiptera occupied largest number of species constituting about 28% of total insect followed by Lepidoptera 18%, Coleoptera 11%, Diptera 4%, Orthoptera 7%, Hymenoptera 17%, Arachnida 7%, Neuroptera 3% and other 5%
- Among the 16 pests attacking brinjal, the maximum number of ten species belonged to foliage feeder, one species was found to feed on shoot and fruit (fruit and shoot borer), one on flowers (thrips) and one on stem (stem borer).
- The brinjal shoot and fruit borer and hadda beetle showed prolonged activity right from June to November.
- The larval population of brinjal fruit and shoot borer were observed by recording the number of larvae in infested shoot and fruit in each plot one day before spray and 3,7,10 and 14 days after each spraying and observations were recorded on randomly selected 10 plants in each plot. The experiment was carried out with thirteen treatments of synthetic insecticides, plant product and biopesticides where the larval population of brinjal fruit and shoot borer gradually increased after each application in all the treatments. However, low population of larvae was recorded in all treatments as compared to untreated check.
- All synthetic pyrethriod insecticide treatments reduced the shoot and fruit damaged in comparison to other treatment. The lambdacyhalothrin at 4ml/lt (T5) with 14.33 larvae/shoot/10plants/plot after 3rd application was found to be most effective in reducing larval population as it recorded with lowest number of larvae, which is significantly lower in respect to all other treatments followed by the treatment lambdacyhalothrin at 0.56, 1.38, 0.69 and 0.81 ml/lt (T1) 14.00, (T4) 14.66, (T2) 15.00 and (T3) 15.66 larvae/shoot/10plants/plot which were recorded statistically on par with each other.

- The highest number of larvae population was recorded in the treatment *B.t.* (Halt), *B.b*(Biosoft) and neem at 2ml/l with 18.66, 20.00 and 20.33 larvae/shoot/10plants/plot which is significantly least effective in reducing the larval population after untreated check.
- The relative efficacy of each treatment was assessed on the basis of per cent pest reduction over control where the per cent reduction of larval population over control was recorded and observed to be highest in lambdacyhalothrin at 4ml/lt (T5) which is significantly highest (54.50) percent in reducing larval population in 14 days after 3rd application followed by the lambdacyhalothrin at 0.56, 1.38, 0.69 and 0.81 ml/lt (T1-T3) 53.10, 52.00, 50.90 and 48.86 per cent respectively which were found statistically on par with each other.
- The lowest percent reduction of larval population over control was recorded in *B.t.* (Halt), *B.b*(Biosoft) and neem at 2ml/l (T10, T11 and T12) with 39.00, 35.80 and 34.70 per cent respectively per cent, which is significantly least effective in reducing larval population.
- The number of adults of hadda beetle was recorded from 10 randomly selected plants per treatments per plot, before spraying as pre treatment and post treatment observations were recorded at 3,7,10 and 14 days after each spraying. The population of hadda beetle was recorded lowest after 3rd application in chlorpyriphos, quinalphos, carbaryl at 2ml/lt, lambdacyhalothrin at 1.38, 0.69 and 0.56 ml/lt (T6, T7, T8, T4, T2 and T1) from 0.33-0.66 beetles/10plants/plot which was found most effective in reducing the population of hadda beetle. Whereas, *B.t.* (Halt), *B.b*(Biosoft), neem and malathion at 2ml/l, lambdacyhalothrin at 0.81 and 4ml/lt (T10, T11, T12, T3, T9, and T5) varied from 1.00-1.66 beetles/10plants/plot were recorded with significantly highest number of hadda beetle indicating the least effect of treatment on the population of hadda beetle.
- The relative efficacy of each treatment was assessed on the basis of per cent pest reduction over control where the percent reduction of hadda beetle population was recorded highest in chlorpyriphos, quinalphos, carbaryl at 2ml/lt, lambdacyhalothrin at 1.38, 0.69 and 0.56 ml/lt (T6, T7, T8, T4, T2 and T1) range from 78.33-53.33 per cent. However, the lowest percent of reduction

was recorded in *B.t.* (Halt), *B.b*(Biosoft), neem and malathion at 2ml/l, lambdacyhalothrin at 0.81 and 4ml/lt (T10, T11, T12, T3, T9, and T5) varied from 51.66-31.66 per cent.

- To assess safety of insecticides, plant product and biopesticides against the natural enemies in brinjal ecosystem, the natural enemies *(Coccinella septumpunctata*, *Chrysoperla carnea,* spider and *Eucanthecona* bug) count was taken in all treatments where pre-spray count of the insect were made a day before spraying and post spray counts were made at 3,7, 10 and 14 days after each spraying. The highest population of natural enemies was found in untreated check (T13), indicating complete safety in control for all natural enemies followed by neem, *B.t.* (Halt) and *B.b*(Biosoft) at 2ml/lt which indicates partial safety of the treatments.
- The highest yield of brinjal was recorded in treatment lambdacyhalothrin at 4ml/lt (T5) with 204.16 kg/ha followed by lambdacyhalothrin at 1.38, 0.69, 0.81 and 0.56 ml/lt (T4, T2, T3 and T1) with 197.22, 190.27 and 170.83 kg/ha which were found statistically on par with each other beside, *B.b*(Biosoft) at 2ml/lt (T11) was recorded with lowest yield 100.38 kg/ha.
- The percent of fruit damage was recorded for the relative efficacy of each treatment, where lambdacyhalothrin at 4 ml/lt (T5) was recorded with lowest per cent (28.00) followed by lambdacyhalothrin at 1.38, 0.69, 0.81 and 0.56 ml/lt (T4, T2, T3 and T1) with 32.51, 35.30 and 38.70 per cent. However, *B.b*(Biosoft) at 2ml/lt (T11) was recorded with highest percent of 87.00 fruit damage after untreated check (T13).

On the basis of the result summarized above, it can be concluded that brinjal crop has a rich biodiversity of insect fauna including insect pest and beneficial insects which affect the population of brinjal pests. The efficacy of various treatments conclude that the population of brinjal shoot and fruit borer can be managed by the application of lambdacyhalothrin at 4, 1.38, 0.81, 0.69 and 0.56 ml/lt (T5-T1) as compare to other treatments, as this group of insecticide effects quickly on the insect pests.

It is also conclude that the population of hadda beetle can be manage by the application of chlorpyriphos (T6) and quinalphos (T7) at 2ml/lt which show remarkable affect on decreasing the population of hadda beetle as compare to neem (T12), *B.t.* (Halt) (T10) and *B.b*(Biosoft) (T11) at 2ml/lt as they were moderately slow in their mode of action.

The effect of various treatment on natural enemies population conclude that the untreated check (T13) was the most safest treatment applied as it was recorded with highest population of natural enemies beside, neem (T12), *B.t.* (Halt) (T10) and *B.b*(Biosoft) (T11) at 2ml/lt were also little bit safe treatments as they are less harmful in compare to insecticidal treatment.

The above summarized result on the yield of brinjal conclude that the lambdacyhalothrin at 4 ml/lt (T5) was most affective in the reduction of brinjal shoot and fruit borer perhaps with highest yield.

This study would be helpful to develop an integrated approach for controlling the insect pest attacking brinjal crop and enhancing the activity of natural enemies to obtained maximum yield.

Literature Cited

LITERATURE CITED

Anonymous, 2004a, Vegetables Horticultural Information Service, Monthly Bulletin, Director of Horticulture, Lalbaugh, Bangalore, p. 51-93.

Anonymous, 2004b, Horticultural Crops Statistics of Karnataka State at a Glance, Statistical Wing, Director of Horticulture, Lalbaugh, Bangalore, p. 117

Anandkumar, V., 2002. Survey and management of brinjal pests with special reference to biology of *Leucinodes orbonalis* (Guen.). M. Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad.

Alam, M. Z. 1969. Insect Pest of Vegetables and Their Control In East Pakistan. The Agriculture Information Service, Department Of Agriculture;3, R.K Mission Road, Dacca-3, East Pakistan, p.146.

Ali, M. M.; Latif, M. A.; Rahman, S. M. M. and Ali, M. Y. 2008. Effect of some chemicals and non-chemical methods on epilachna beetle of brinjal and their impact on spider and lady bird beetle. Indian *Journal of Agricultural Research* **4(08)**:92-96

AVRDC. 2003. *Development of an IPM strategy for eggplant fruit and shoot borer in South Asia. Technical bulletin.* **28**: 1-23

Bajpai, N., K. Swami., Hemant, Kumar. and Gupta, Ashok. 2005. In Development of IPM modules for brinjal shoot and fruit borer, *Leucinodes orbonalis* Guene. National conference on Applied entomology: current status, challenges and opportunities.

Bhadauria, N. K. S.; Bhadauria, N. S.; Jakhmola, S. S. 1999. Insect pest complex of brinjal *Solanum melongena* in north-west Madhya Pradesh. *Advances in Plant Sciences.* **12(2):**607-608

Bhaskaran, P. And Kumar, A., 1980. Further studies on Dipel and insecticides combinations against the insect pests of brinjal. *Pesticides*, 14 : 9-16.

Bheemanna, M., Patil, B. V., Hanchinal, S. G., Hosamani, A. C. And Kengegowda, N., 2005. Bio-efficacy of emamectin benzoate (Proclaim) 5% SG against cotton bollworm complex. Pestology, 26 : 31-34.

Biradar, A. P.; Teggelli, Rs. G.; Patil, D. R.; Balikai, R. A. 2001. Evaluation of cypermethrin 3 EC+ quinalphos 20 EC(=23 EC) against brinjal shoot and fruit borer. *Karnataka Journal of Agricultural Sciences.* **14(2)**: 369-372

Chakraborti, S., 1999. An integrated approach for management of brinjal shoot and fruit borer. Vegetable Science, 26 (2) : 57-59.

Chakraborti, S. 2001. A biorational approach for the management of brinjal fruit and shoot borer, *Leucinodes orbonalis* Guen. *Journal of Entomological Research.* **25(1)**:73-76

Chandranath, H. T. and Katti, Pramod. 2010. Management of epilachna beetle on ashwagandha . *Karnataka Journal of AgricultureScience.* **23(1)**:171

Chandrakumar, H. L., Kumar, Ashok; Kumar, N. G., Chakaravarthy. A. K. and Putta, Raju. T. B. 2008. Seasonal occurrence of major insect pests and their natural enemies on brinjal. *Current Biotica*., **2(1):**63-7.

Chatterjee, M. And Subhrajyoti, 2004. Bioefficacy of some insecticides against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guen.) and effect of novalueron on natural enemies of brinjal pest. *Pestology*, 28 (10): 52-57.

Chen, N. C. 1997. Cultivation and seed production of egg plant, in training Workshop On Vegetable Cultivation And Seed Production Technology, Shanhua, Asian Vegetable Research And Development Centre (AVRDC), Taiwan.

Choudhary, B., 1970. Vegetables. National Book Trust, India, pp. 25-50.

Dadmal, S. M., Nemade, S.B. And Akhare, M.D. 2004. Field screening of brinjal cultivar for ressistance to *Leucinodes orbonalis* (Guen.) *Pest Management in Horticulture Ecosystem,* **10(2):**145-150.

Das, G., Islam, K.S. and Saha, K.C., 2002. Effectiveness of Three Chemical Insecticides in Controlling Epilachna Beetle, *Epilachna dodecastigma* Muls. . *Journal of Biological Sciences, 2: 679-681.*

Dhamdhere, S., Dhamdhere, S. V. And Mathur, R. 1995. Occurrence and succession of pest of brinjal, solanum melongena linn. at Gwalior (Madhya pradesh), *Indian journal of entomological research,* 19:71-77.

Duara, B.; Deka, S. C.; Baruah, L. H. and Barman, N. 2003. Bio-efficacy of Synthetic Pyrethroids against Brinjal Shoot and Fruit borer, *Leucinodes orbonalis* (Guen.) *Pesticide Research Journal.* **15(2)**:155-156

Ehrlich and ehrlich.1981. *Extinction: The causes and consequences of disappearance of species. Random house, New York.*

Eswara Reddy, S. G. And Srinivasa, 2004. Management of shoot and fruit borer, *Leucinodes orbonalis* (Guen.) in brinjal using botanicals/oils. Pestology, 28: 50-52.

Eswara Reddy, S. G. and Srinivasa, N., 2001. Efficacy of botanicals against brinjal shoot and fruit borer *Leucinodes orbonalis* Guen. Proceedings of National Symposium on Integrated Pest Management (IPM) in Horticultural crops: New Molecules Biopesticides and Environment, Bangalore 17-19, pp. 11-13.

Goud , K.B. and Jyoti , D.P. (2008). Safety of organic amendments and microbial pesticides to natural enemies in brinjal ecosystem. *Annuals of Plant Protection Sciences*, **16 (1)**:111-114.

Ghatak SS and Mondal S 2008. Feasibility of using plant products and biopesticides against epilachna beetle, *Epilachna vigintioctopunctata* Fab. infecting brinjal. *Indian J. Entomol*. 70(3): 278-27

Ghosh, Sunil K. and Chakraborty, Gautam. 2012. Integrated field management of *Epilachna vigintioctopunctata* (Fabr.) on potato using botanical and microbial pesticides. *Journal of biopesticide*. **5(1):** 151-154

Guddewar, M. B., Sukhla, A., Chandra, R., Pandey, S. And Saini, M. L., 1994. Tabenaemontana coranaria B. Apocynacae, a potential source of botanical **s**insecticides. Plant Protection Bulletin, 46 : 1-5.

Hemi, M. A Sharma, 1995. Effect of borer attack on the vitamin 'c' content of brinjal. *Pakistan journal of health,* **4**:223-224.

Islam, Kamrul, Islam, M., Saiful and Ferdousi, Zennat. 2011. Control of *Epilachna vigintioctopunctata* Fab. (Coleoptera: Coccinellidae) using some indigenous plant extracts. Journal of Life and Earth Science, 6: 75-80.

Jat, K. L. and Pareek, B. L. 2001. Field Evaluation of Ecofriendly Insecticides against Brinjal Shoot and Fruit Borer, *Leucinodes orbonalis* Guen. *Indian Journal of Plant Protection.* **29(2):**53-56

Jagginavar, S. B.; Sunitha, N. D. and Biradar, A. P. 2009. Bioefficacy of flubendiamide 480 SC against brinjal fruit and shoot borer, *Leucinodes orbonalis* Guen. *Karnataka Journal of Agriculture Science.* **22(3)** : (712-713)

Jyoti, D. P. and Goud, B. K. 2008. Safety of organic amendments and microbial pesticide to natural enemies in brinjal ecosystem**.** *Annals of Plant Protection Sciences.* 16(1):111-114.

Kaethner, M., 1999. No side effect of neem extracts on the aphidophagous predators, *Chrysoperla carnea* Steph. and *Coccinella septumunctata*. Anzeigerfus schadling Skunds Flanzeneschutz unweltschutz, 64 : 97-99.

Kavitha, V. S.; Revathi, N.; Kingsley, S. 2008. Bioefficacy of neem derivatives against IV instar larvae of *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae). *Journal of Applied Zoological Researches*. 19 (2): 183-185

Khaire,V. A. and Lawande, K. E. 1986. Screening of promising germplasm of brinjal against shoot and fruit borer. *Current Research Reporter, MPAU.*, 2(1):112-115.

Krishna Moorthy, P. N., Krishna Kumar, N. K.And Edward Raj A, M., 2001. Neem and pongamia cakes in the management of vegetable pests. In : Proceedings of the Second National Symposium on Integrated Pest Management (IPM) in Horticulture Crops : New molecules, biopesticides and environment, Bangalore, 17-19 October, 2001, pp. 74-75.

Krishnamoorthy, P. N. asnd Krishnakumar, N. K., 2001. Annual Report of 2000-01. Indian Institute of Horticulture Research, Bangalore, p. 551.

Kumar, P.A. et al. 1998. Genetic Engineering of Eggplant *Solanum melongena*. *Ag. Biotech. News and Information.*, 10:329-339

Kumar, R.; Sharma, G.; Ramaurthy, V.V. and Kumar, N. 2007. Major lepidopterous insect pests of vegetables in north india. *Indian J. Ent.*, 69(2): 189-195.

Latif, M. A.; Rahman, M. M.; Islam, M. R. and Nuruddin, M. M. 2009. Survey of arthropod biodiversity in the brinjal field. *Journal of entomology*., 6(1):28-34

M, Ana.; Masum, Ahmad. and Haque, M.A. 2006. Efficacy of Neem Oil on the Biology and Food Consumption of Epilachna Beetle, *Epilachna dodecastigma* (Wied). *Journal of Agriculture & Rural Development.* **4(1)**

Mann, G. S. and Dhaliwal, G. S. 2001. Impact of neem-based insecticides on beneficial arthropods in cotton ecosystem. *Annals of Plant Protection Sciences.* **9(2)**:225-229

Mathirajan, V. G.; Natarajan, K.; Kuttalam, S.; Chandrasekaran, S. and Regupathy, A. 2000. Efficacy of lambda cyhalothrin (karate®) 5 EC against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guen.). *Pesticide Research Journal* . **12(1)**: 117-119

Mathura Rai. 2006. Focus to be on vertical expansion. Survey of Indian agriculture. pp.158-163.

Mishra, B. K.; Mishra, P. R.; Patnaik, N. C. 1999. Effect of neem oil on the growth and development of epilachna beetle, *Epilachna sparsa* (Hbst.). *Orissa Journal of Agricultural Research.* 2 (3-4): 169-172

Murali Krishna, T., Lal, O. P., Srivastava, Y. N. S. And Handa, S. K., 2002. Field efficacy of different insecticides, Bacillus thuringiensis var. Kurstaki (Bt), neem and diflubenzuron for the control of shoot and fruit borer, *Leucinodes orbonalis* on egg. *Journal of Entomological Research*, 26 : 43-49.

Murugesan, N. and Murugesh, T. 2008. Efficacy of some plant products against spotted leaf beetle (*Hadda* beetle), *Epilachna vigintiooctopunctata* (F.) in Brinjal. *Journal of Biopesticides.* **1(1)**: 67-69

Murugesan, N. and Murugesh, T. 2008. Efficacy of some plant products against spotted leaf beetle (Hadda beetle) *Epilachna vigintiooctopunctata* (F.) in brinjal. *Journal of Biopesticides,* 1 (1): 67-69

Murugesan, N. and Murugesh, T. 2009. Efficacy of some plant products against brinjal shoot and fruit borer *Leucinodes orbonalis* . *Journal of Biopesticides.* 2(1): 60-63.s

Naik, V.C. B.; Rao, P. A.; Krishnayya, P.V. and Chalam, M.S.V. 2009. Seasonal incidence and management of *Bemisia tabaci* Genndius and *Amrasca biguttula biguttula* Ishida of brinjal. *Ann. Pl. protection. Sci.*, 17(1): 9-13

Nair, M.R.G.K. 1986. Insects and mites of crops in India ICAR. pp.151-152

Naresh, J.S., Malik, V.S., Balan, J.S. And Khokar, K.S. 1986. A new record *Trathala s*p. A larval endoparasite attacking brinjal fruit borer, *Leucinodes orbonalis* Guenee. *Bull. Ent.*, 27(1):74

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

NHB, 2013. www. india_productions.aspx.htm

Nonita, M., Bijaya, P. and Singh, T.K. 2007. Effect of abiotic and biotic factors on the abundance of *Aphis gossypii* infesting brinjal. *Indian.J.Ent.,* **69(2**):149-153

Pareet, D. Jyoti. 2006. Biorational approaches for the management of brinjal shoot and fruit borer. M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad, Karnataka, India.

Patnaik, H. P. And Singh, K. M., 1997. Efficacy of Bacillus thuringiensis Berliner and convention insecticides against brinjal shoot and fruit under different spraying schedules. *Orissa Journal of Horticulture*, 25 : 18-21

Prasad Kumar and Devappa, V., 2006. Bioefficacy of emamectin benzoate 5% SG (Proclaim) against brinjal shoot and fruit borer. *Pestology*, 30 : 17-19.

Prasad, U. K.; Rabindra Prasad; Devendra Prasad, 2008. Integrated management of epilachna beetle (*Henosepilachna vigintioctopuncta* Fabricious) infesting brinjal.*Journal of Research, Birsa Agricultural University.*20(1): 77-82.

Puranik, T. R.; Hadapad, A. B.; Salunkhe, G. N. and Pokharakar, D. S. 2002. Management of shoot and fruit borer, *Leucinodes orbonalis* Guenee through *Bacillus thuringiensis* formulations on brinjal. *Journal of Entomological Research*. **26(3)**: 229-232

Rajavel, D.S., Elanchezhyan, K. and Murali Baskaran, R.K. 2008. Field screening of brinjal on major insect pests. *Journal of Biopesticides.*1, 113-120.

Rajagopal, D and Trivedi, T. P. 1989. Status, bioecology and management of Epilachna beetle, *Epilachna vigintioctopunctata* (Fab.) (Coleoptera: Coccinellidae) on potato in India: A review. *Tropical Pest Management.*35(4)

Raja, J., Rajendran, B. And Pappiah, C. M., 1998. Management of egg plant shoot and fruit borer Leucinodes orbonalis G. In : Proceedings of Second International Symposium on Pest Management in Horticulture Crops, Bangalore, pp. 84-93.

Rajendran, B. and Gopalan, M. 1999. Effect of biopathogens (*Bacillus thuringiensis* Berliner and *Beauveria bassiana* Vuillemin) on different stages of egg plant spotted beetle, *Epilachna vigintioctopunctata* (Fab.) (Coleoptera: Coccinellidae) . *Journal of Entomological Research*. **23(1)**: 9-14

Raja, J.; Rajendran, B. and Pappiah, C. M. 1999. Management of brinjal shoot and fruit borer *Leucinodes orbonalis* Guen. *Indian Society of Vegetable Science.* **26(2)**

Rajneesh, H. 2006. Management of shoot borer *Leucinodes orbonalis* Guen on potato crop. M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad, Karnataka, India

Rosaih, R., 2001a, Evaluation of different botanicals against the pest complex of brinjal. Pestology, 25 : 14-16.

Samanta, A.; Roy, P.; Das, A. K.; Majumdar, D.; Somchoudhury, A. K. 1999 Bio-efficacy of a new formulation of quinalphos against insect pests of brinjal. *Journal of Interacademicia.* **3(1)** ;49-52

Sankari, A. and. Thiyagesan, K. 2010. Population and predatory potency of spiders in brinjal and snake gourd. *Journal of Biopesticides.*028 - 032

Sangappa, N., 1999, Management of brinjal shoot and fruit borer Leucinodes orbonalis G. M. Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad.

Satpathy, S. and Mishra, D.S. 2011. Use of intercrops and antifeedants for management of eggplant shoot and fruit borer *Leucinodes orbonalis* (Lepidoptera: Pyralidae). *International Journal of Tropical Insect Science.* 31(2) :52-58

Schmutter, L., 1990. Evaluation of the insecticidal properties of the common Indian neem *Azadirachta indica*. Bulletin of Entomological Society, Egyptian Economic Series, 13 : 39-47.

Schoonover, J. R. and Larson, L. L., 1995. Laboratory activity of spinosad on non-target beneficial arthoropods, 1994. Arthropod Management tests, 20 : 357. **Singh, P. K. 2003.** Control of brinjal shoot and fruit borer, *Leuonodes orbonalis* with combination of insecticides and plant extracts. *Indian Journal of Entomology*. **65 (2)**: 155-159 .

Sharma, P.C. and Anil. 2010. Bioefficacy of insecticides against *Leucinodes orbonalis* on brinjal. *Journal of Environmental Biology*.399-402

Sharma, S.S. and Kaushik, H.D. 2010. Effect of Spinosad (a bioinsecticide) and other insecticides against pest complex and natural enemies on eggplant (*Solanum melongena* L.) *Journal of Entomological Research*. **34 (1)** : 39-44

Sharma, Deepak. Kumar.; Hasseb, Masarat. and Qamar, Munhata 2012. Comparative potential of different botanicals and synthetic insecticides and there economics against leucinodes orbonalis in egg plant**.** *Indian Journal of plant protection research*. **52 (1).**

Shobharani, M. And Nandihalli, B. S., 2004. Seasonal incidence and management of potato shoot borer Leucinodes orbonalis G. In : Proceedings of National Seminar for Sustainable Agriculture, p. 504.

Sontakke, B. K.; Dash, A. N.; Mohapatra, H. 1990. Bio-efficacy of insecticides against brinjal pests in western Orissa. *Indian Journal of Plant Protection*. 18 (1) :101-103

Sinha S.R., Sharma R.K. 2010. Effect of Insecticides on Insect Pests of Brinjal. *Annals of Plant Protection Sciences. 82-85*

Singh, P. K. 2000. Effect of neem products on incidence of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. *Journal of Applied Zoological Researches* 11 (1): 23-24

Singh, P. K., 2003. Control of brinjal shoot and fruit borer Leucinodes orbonalis with combination of insecticides and plant extracts. Indian Journal of Entomology, 65 (2) : 155-159.

Singh, S., Krishnakumar, S. And Katyal, S. L., 1963. Fruit culture in India. Indian Council of Agricultural Research, New Delhi, p. 412.

Singhal, V., 2003. Brinjal area production and productivity. Indian Agriculture, pp. 262-263.

Som, M. G. and Moity, T. K., 1988. Vegetable crops of India. In Advances in Horticultural Crops, Ed. Nose, T. K. and Som, M. G., Nayak Prakash, Culcutta, India, p. 293.

Sontakke, B.K., Dash, A.N., Mahapatra, H. 1990. Bioefficacy of insecticides against brinjal pests in western Orissa. *Indian J. Pl. Protec*., 18: 101-103.

Sreenivasa Murthy, D., Edward Raja, M. and Shivana, 2001. Economic assessment of neem cake to manage fruit borer in brinjal. In : Proceedings of Second National Symposium on Integrated Pest Management (IPM) in Horticulture Crops : New molecules, Biopesticides and Environment, Bangalore, 17-19 October, 2001, p. 13.

Srinivasan, G. and Sundara Babu, P. C., 1998. Management of brinjal shoot and fruit borer, *Leucinodes orbonalis* (Lepidoptera : Pyralidae) using neem products and insecticides. In : Proceedings of National Symposium on Integrated Pest Management (IPM) in Horticultural crops : Bangalore 1998.

Subbaratnam, G.V. and Butani, D.K. 1982. Chemical control of insect pest complex of brinjal. *Entomon***, 8(1**):97-100.

Sunitha, P. G., Ramachandra Rao, P., Arjuna Rao and Rajashekhar, 2004. Toxicity of ecofriendly chemicals to coccinellid predators on okra. Journal of Biological Control, 1 : 207-208.

Suresh,M.; Bijaya, P; Prasad, B. and Singh, T. K. 1996. Seasonal incidence of insect pests on brinjal and a note on the biology of *Leuonodes orbonalis in Manipur.* Uttar Pradesh J. Zoology., **16(3):**151-155.

Suresh, K.; Rajendran, R. and Rani, B. Usha. 2008. Eco-friendly measures to manage spotted beetle (*Epilachna vigintioctopunctata* Fab) in brinjal. *Indian Journal of Agricultural Research.* **42(2)**: 136-139

Swaminathan, R.; Manjoo, Suman. and Hussain, T. 2010. Anti-feedant activity of some biopesticides on *Epilachna vigintioctopunctata* (F.) (Coleoptera: Coccinellidae). *Journal of Biopesticides.* **3(1)**:77-80

Tandon, J. S. And Nillana, N. C., 1987. Biological control of Asiatic corn borer (*Ostrinia furnacalis*) and earworm (*Helicoverpa armigera*). Journal of Agricultural Food and Nutrition, 9 : 33-48.

Thurkathipana, N. and Mikunthan, G. 2008. Eco-friendly management of hadda beetle using *Beauveria bassiana* in Brinjal. *Applied Biological Science.* **73(3)**:597-602

Tiwari, Ghanan.; Prasad, C. S. and Nath, Lok. 2011. Effect of insecticides, bio-pesticides and botanicals on the population of natural enemies in brinjal ecosystem. *An International Journal of Plant Research.* **24(2):**40-44

Udikeri, S. S., Patil, S. B., Rachappa V. and Khadi, B. M., 2004. Emamectin benzoate 5 SG : A safe and promising bio-rational against cotton bollworm, 7 : 78-81.

Urs, K. C. D., 1987. Prospects of Indigenous plant products as future alternatives to conventional pesticides. In : Proceedings of Symposium on Alternative Insecticides, p. 202.

Vishal Mittal and Ram Ujagir, 2005. Toxicity of spinosad 45 SC to natural enemies associated with insect pests of pigeonpea at panthnagar. Journal of Biological Control, 19 : 73-76.

Yin, R. G., 1993. Bionomics of Leucinodes orbonalis Guen. and its control. Entomological Knowledge, 30 : 91-92.

Yusof Ibrahim; Tan, Gek Kiang and Cheong, Chee Kong, 2008. Laboratory and field evaluation of selected isolates of *Metarhizium anisopliae* and *Beauveria bassiana* against the leaf beetle *Epilachna indica* Mulsant. *Agro-search.* 13

Appendices

APPENDIX I

Meteorological parameters during experimental period (2012) at Pantnagar

Weekly weather data

STATION NAME : PANTNAGAR **LONGITUDE** : 79 deg. 30' E

LATITUDE : 29 deg. N **ALTITUDE** : 243.84 m. AMSL

Month	Metro Week No.	Date	Temperature (^oC)		Relative Humidity (%)		Rainfall (mm)
			Max.	Min.	0712 am	1412 pm	
Mar	**1**	**05-11**	27.4	11.8	88	45	000.6
Mar	**2**	**12-18**	27.5	11.0	90	40	003.2
Mar	**3**	**19-25**	30.4	13.5	88	39	000.0
Mar-Apr	**4**	**26-01**	32.9	15.5	88	38	000.0
Apr	**5**	**02-08**	35.7	18.7	77	31	000.0
Apr	**6**	**09-15**	32.1	17.7	83	49	007.4
Apr	**7**	**16-22**	35.0	18.2	72	30	000.0
Apr	**8**	**23-29**	36.4	19.4	60	22	000.0
Apr-May	**9**	**30-06**	36.6	18.6	47	23	000.0
May	**10**	**07-13**	37.9	22.4	59	27	000.0
May	**11**	**14-20**	38.9	21.5	66	27	000.0
May	**12**	**21-27**	40.9	20.9	62	18	000.0
May-Jun	**13**	**28-03**	41.5	24.3	57	25	000.0
Jun	**14**	**04-10**	40.3	24.1	61	25	000.0
Jun	**15**	**11-17**	42.4	25.1	54	23	000.0
Jun	**16**	**18-24**	38.7	27.8	65	41	021.2
Jun-Jul	**17**	**25-01**	38.1	26.9	72	36	000.0
Jul	**18**	**02-08**	32.8	26.3	83	71	018.2
Jul	**19**	**09-15**	33.5	26.0	86	61	054.4
Jul	**20**	**16-22**	34.9	26.9	85	61	012.2
Jul	**21**	**23-29**	31.7	25.8	88	75	143.2
Jul-Aug	**22**	**30-05**	31.0	25.2	90	75	238.6
Aug	**23**	**06-12**	32.8	26.0	90	70	056.6
Aug	**24**	**13-19**	33.2	26.0	87	70	015.6
Aug	**25**	**20-26**	31.0	24.8	91	78	110.0
Aug-Sep	**26**	**27-02**	32.0	25.8	90	69	055.6
Sep	**27**	**03-10**	32.8	24.1	92	65	052.8
Sep	**28**	**11-18**	33.5	25.1	88	63	013.9
Sep	**29**	**19-30**	34.9	27.8	85	54	000.0
Sep-Oct	**30**	**30-06**	26.0	26.9	78	51	000.0
Oct	**31**	**07-15**	26.9	26.3	73	42	000.0
Oct	**32**	**16-23**	25.8	25.8	69	41	000.0
Oct	**33**	**24-31**	25.2	22.4	67	32	000.0
Oct-Nov	**34**	**01-07**	26.0	21.5	57	28	000.0
Nov	**35**	**08-15**	27.5	19.4	53	22	000.0
Nov	**36**	**16-23**	20.4	18.6	40	20	000.0

VITA

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Advisor : Dr Poonam Srivastava

ABSTRACT

Twenty-eight species of insects belonging 10 different orders and 20 families were encountered to know the diversity of insect fauna associated with brinjal crop. Among the various insect pest of brinjal, the brinjal shoot and fruit borer (*L. orbonalis)* and hadda beetle (*E. vigintioctopunctata),* have been recorded as the most prevalent species as evidenced by their activity period at Vegetable Research Centre, Pantnagar

The relative efficacy of each treatment was assessed on the basis of per cent pest reduction over control where the per cent reduction of larval population over control was recorded and observed to be highest in lambdacyhalothrin at 4 ml/lt with 54.50 percent which is highest percent in reduction of larval population after 3rd application followed by the lambdacyhalothrin at 0.56, 1.38, 0.69 and 0.81 ml/lt with 53.10, 52.00, 50.90 and 48.86 per cent over *B. t.* (Halt), *B. b.* (Biosoft) and neem at 2ml/l with 39.00, 35.80 and 34.70 per cent respectively.

The percent reduction of hadda beetle population was recorded highest in chlorpyriphos, quinalphos, carbaryl at 2ml/lt, lambdacyhalothrin at 1.38, 0.69 and 0.56 ml/lt range from 78.33-53.33 per cent. However, the lowest percent of reduction was recorded in the treatment *B. t.* (Halt), *B. b.* (Biosoft), neem and malathion at 2ml/l, lambdacyhalothrin at 0.81 and 4ml/lt 51.66-31.66 per cent.

The safety of the treatments for the natural enemies viz., *Coccinella septumpunctata*, *Chrysoperla carnea*, spider and *Eucanthecona* bug were observed and the results revealed that the highest population of natural enemies was found in untreated check (T13), as it was the complete safest treatment for all natural enemies followed by neem, *B. t.* (Halt) and *B. b.*(Biosoft) at 2ml/lt indicating partial safety of the treatment whereas, lambdacyhalothrin at 0.56, 0.69, 0.81, 1.38 and 4ml/lt, chlorpyriphos, quinalphos, carbaryl and malathion were recorded with lowest number of natural enemies indicating no safety of the treatments.

The highest yield of brinjal was recorded in lambdacyhalothrin at 4 ml/lt (204.16 kg/ha) with per cent damage of (28.00) followed by lambdacyhalothrin at 1.38, 0.69, 0.81 and 0.56 ml/lt with 197.22, 190.27 and 170.83 kg/ha and a per cent damage of (32.51, 35.30 and 38.70) respectively. Whereas, *B. b.* (Biosoft) at 2ml/lt was recorded with lowest yield100.38 kg/ha and a per cent damage of (87.00).

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शोध ग्रन्थ शीर्षक : **"पंतनगर में बैंगन पर ल्युसीनोइड आरबोनेलिस एवं एपिलिकना विजिनटियोक्ओपन्टाटा पर कृत्रिम कीटनाशक, पादप उत्पाद एवं जीवरसायन का तुलनात्मक प्रभाव"**

सलाहकार : डा0 पूनम श्रीवास्तव

सारांश

प्रस्तुत शोधकार्य पंतनगर में बैंगन पर ल्युसीनोइड आरबोनेलिस एवं एपिलिकना विजिनटियोक्ओपन्टाटा पर कृत्रिम कीटनाशक, पादप उत्पाद एवं जीवरसायन का तुलनात्मक प्रभाव गोविन्द बल्लभ पंत कृषि एवं प्रौद्योगिकी विश्वविद्यालय पंतनगर में 2012 में किया गया है।

बैंगन पर पाये जाने वाले 28 कीट प्रजातियॉ, 10 विभिन्न गण एवं 20 विभिन्न परिवारों से सम्बन्ध रखती है। हानिकारक कीटो ल्युसीनोइड आरबोनेलिस तथा एपिलिकना विजिनटियोक्ओपन्टाटा प्रमुख महत्व के थे तथा अन्य कम हानिकारक थे। ल्युसीनोइड आरबोनेलिस की अधिकतम प्रतिशत कमी 54.50, लैम्डासाइलोहार्थिन @ 4 मि.ली. में मापी गयी तथा न्यूनतम प्रतिशत कमी 39.00, 35.80 एवं 34.70, बैसलिस थीरूजैनेसिस (होल्ट), बेवेरिया ब्रेसियाना (बायोसोफ्ट) एवं नीम @ 2 मि.ली. में दर्ज की गयी ।

बैसलिस थीरूजैनेसिस (होल्ट), बेवेरिया ब्रेसियाना (बायोसोफ्ट), नीम एवं मेलाथियोन @ 2 मि.ली., लेम्डासाईलोहर्थिन @ 0.81, एवं 4 मि.ली. में हडडा बीटल की न्यूनतम प्रतिशत कमी 51.66–31.66, मापी गयी है। हडडा बीटल की अधिकतम प्रतिशत कमी 78.33– 53.33, क्लोरोपाइरीफॉस, क्यूनलफॉस, कारबोरिल @ 2 मि.ली./ली, लैम्डासाइलोहेर्थिन @ 1.38, 0.69 एवं 0.56 में दर्ज की गई है।

प्राकृतिक शत्रु काक्सीनेला सपटमपन्कटाटा, क्राइसोपरला कार्निया, स्पाइडर एवं यूकेनथीकोना वग की सर्वाधिक संख्या अनुपचारित उपचार में पायी गई है। नीम, बैसलिस थीरूजैनेसिस (होल्ट), बेवेरिया ब्रेसियाना (बायोसोफ्ट) @ 2 मि.ली./ली उपचार में प्राकृतिक शत्रु की आंशिक सुरक्षा पायी हैं ।

बैंगन की सर्वाधिक उपज (204.16किग्रा/हे0), लैम्डासाइलोहर्थिन @ 4 मि.ली/ली पाया गया जिसमें 28 प्रतिशत फल क्षति दर्ज की गयी है। बेवेरिया ब्रेसियाना (बायोसोफ्ट) @ 2 मि.ली/ली में बैंगन की उपज 100.38 किग्रा/हे0 पायी गयी जिसमें फलक्षति 87.00 प्रतिशत है।

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