BIORATIONAL MANAGEMENT OF MAJOR PESTS IN BRINJAL (*Solanum melongena* L.)

by

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(2012-11-175)

THESIS

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DECLARATION

I, hereby declare that this thesis entitled **"BIORATIONAL MANAGEMENT OF MAJOR PESTS IN BRINJAL (*Solanum melongena* L.)"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Padanakkad,
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CERTIFICATE

Certified that this thesis entitled **"BIORATIONAL MANAGEMENT OF MAJOR PESTS IN BRINJAL (*Solanum melongena* L.)"** is a record of research work done independently by Mr. Gowrish K. R. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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Gowrish, K.R.

Affectionately Dedicated
To
My beloved Parents
"Sri. Ranganath K.C.
Smt. Lakshmi"

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INTRODUCTION

1. INTRODUCTION

Brinjal (*Solanum melongena* L.) is a plant of considerable economic importance in many tropical and subtropical parts of the world. It is one of the widely used vegetable crop by most of the people and is popular in many countries *viz.*, Central South and South East Asia, some parts of Africa and Central America (Gurubban, 1977; Channe *et al.*, 2013). It is a native of India and is grown throughout the country (Choudhary, 1970).

In the world, brinjal occupies an area of 18.53 lakh ha with a production of 484.24 lakh tonnes (FAO, 2012). The production of brinjal is highly concentrated with 90 per cent of output coming from five countries. China occupies first position (58 per cent of world output) followed by India (25 per cent). In India, brinjal occupies an area of 7 lakh ha with a production of 122 lakh tonnes (FAO, 2012). Brinjal is grown throughout the year in almost all parts of the country except in higher altitudes and liked by both poor and rich alike. In Kerala, total vegetable cultivation occupies an area of 40837 ha and brinjal is cultivated in an area of 864 ha. In Kerala, Palakkad stands first in (154.14 ha) area of cultivation followed by Malappuram (101.36 ha), Alappuza (93.21 ha) and Kasargod ranks 12th in (28.89 ha) area of cultivation of brinjal (GOK, 2014).

Brinjal is an important vegetable grown in all the seasons due to its nutritive value, consisting of minerals like iron, phosphorous, calcium and vitamins like A, B and C. Unripe fruits are used primarily as vegetable in the country. It is also used as a raw material in pickle making (Singh *et al.*, 1963; Channe *et al.*, 2013) and has an excellent remedy for those suffering from liver complaints. It is used in Ayurvedic medicine for curing the diabetes. It is also used as a good appetizer.

Brinjal is subjected to attack by number of insect pests right from nursery stage till harvesting (Regupathy *et al.*, 1997). Among the insect pests, the most important and destructive ones are the shoot and fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyraustidae) and epilachna beetle, *Henosepilachna*

(=*Epilachna*) *vigintioctopunctata* (Fab.) (Coleoptera: Coccinellidae). Minor pests like leaf roller, *Antoba olivacea* Wlk. and hairy caterpillar, *Selepa docilis* Butler (Lepidoptera: Noctuidae) are considered the main constraint as it damages the crop throughout the year. Though leaf roller and hairy caterpillar are considered as minor pests, its occurrence is more severe in coastal areas of Kasargod district. The research works on the management of these pests are meagre.

The yield loss due to the major pests is to the extent of 70-92 per cent (Reddy and Srinivasa, 2004; Chakraborti and Kanti, 2011; Jagginavar *et al.*, 2009). Among them, shoot and fruit borer, *L. orbonalis* is the most noxious and destructive pest. The larvae bore within shoots and fruit and feed on the internal tissues (Srinivasan, 2008). This leads to withering of terminal shoots, bore holes can be seen on fruits plugged with excreta, shedding of flower buds and drying of leaves due to boring of petioles (Nair, 1995).

Epilachna beetle, *E. vigintioctopunctata* is a key pest and causes serious damage on the foliage. The larvae and adults scrap the green matter from leaves and resulting in the reduction of flower production there by decrease in the yield (Rajagopal and Trivedi, 1989; Thurkathipana and Mikunthan, 2008).

Leaf roller, *A. olivacea* is one of the minor pest of brinjal, but its occurrence is more severe in coastal areas of Northern Kerala. It folds the tender leaf and feed on the surface tissues of leaves (Kalita *et al.*, 1997).

Hairy caterpillar, *S. docilis* is known as a pest of brinjal and other species of Solanaceae in India. Its attack results in skeletonization and causes considerable damage to brinjal until the plants aged (Rawat, 1967).

For the management of these pests, most farmers depend on synthetic chemical insecticides. Though the present recommendation of insecticidal application controls the insect pests, but they are undesirable because of their high toxicity, high costs, environmental unfriendliness and possible development of resistance among pest species, resurgence of certain pest populations and adverse effect on beneficial organisms such as natural enemies and pollinators. Moreover, many pesticides recommended for management of brinjal pests are banned in Kasargod district of Kerala. Since the district is declared as an organic district, more importance has been given for biological and biorational management of crop pests. The insecticide spinosad 45 SC is less toxic to human being than malathion 50 EC and approved for use in organic agriculture by numerous national and international certification (Thomas *et al.*, 2012).

Hence, there is an impetus for research and development of cost effective ecofriendly alternative for the management of major pests of brinjal. Strategies employing different entomopathogenic microbial preparations, neem based and biorational insecticides are the possible alternative measures for the sustainable management of major pests of brinjal, especially in the present era of organic agriculture.

In this context the present investigation is carried out with the following objectives.

1. Survey of major pests of brinjal in Kasargod district
2. Efficacy testing of microbial preparations, biorational and neem based insecticides against major pests of brinjal
3. Effect and compatibility of spinosad on entomopathogenic fungi using poisoned food technique under *in vitro* condition, and
4. Estimation of residues of spinosad in brinjal fruits.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Brinjal (*Solanum melongena* L.) is an important and indigenous vegetable crop of India. It is often known as the cash crop for the farmers'. It has been extensively cultivated throughout the country due to its demand among the consumers and contributes 9 per cent of the total vegetable production of the country (Sidhu and Dhatt, 2007). The productivity of brinjal depends on the intensity of the attack of pests like borer and leaf feeding insects at different phases of its growth throughout the year. Of these, the most important and destructive ones are the shoot and fruit borer, *Leucinodes orbonalis* (Lepidoptera: Pyraustidae); epilachna beetle, *Henosepilachna* (=*Epilachna*) *vigintioctopunctata* (Coleoptera: Coccinellidae); leaf roller, *Antoba olivacea* (Lepidoptera: Noctuidae) and hairy caterpillar, *Selepa docilis* (Lepidoptera: Noctuidae).

2.1 EFFICACY TESTING OF MICROBIAL PREPARATIONS, BIORATIONAL AND NEEM BASED INSECTICIDES AGAINST MAJOR PESTS OF BRINJAL

2.1.1 Effect of entomopathogenic fungus against major pests of brinjal.

Ghatak *et al.* (2009) reported that there was a significant reduction in fruit damage when *Annona squamosa* (71.98 to 76.94 per cent) was applied followed by *Strychnos nuxvomica* (65.99 to 66.79 per cent) both were used @ 2 ml, 3 ml and 4 ml/L and *Verticillium lecanii* (58.67 to 66.79 per cent) was used @ 1.5 gm, 2 gm and 3 gm/L, while in case of emamectin benzoate used @ 0.22 gm, 0.28 gm and 0.56 gm/L, it was 69.93 to 73.04 per cent. They also reported that the keeping quality of fruit was better in botanicals as compared to treatment with emamectin benzoate.

Ghosh and Senapati (2009) reported that *Beauveria bassiana* (biorin 10^7 conidia/ml @ 1 ml/L) was effective in suppressing dead heart caused by *L. orbonalis.*

Koushik *et al.* (2013) reported that when *Nomuraea rileyi* (Farlow) sprayed at 3.2×10^9 spores/ml gave maximum mortality of shoot and fruit borer after six days of spray. Maximum mortality (93.06 per cent) obtained in first instar larvae, followed by second instar (84.98 per cent), third instar (56 per cent), fourth instar (48.15 per cent) and fifth instar (41.11 per cent). This indicated that early instars are more susceptible than later instars. A combination of *Fusarium semitectum* (3.6×10^{15}) with *N. rileyi* (2×10^8) + spinosad (15 g a.i./ha) and removal and destruction of infected shoots and fruits reduced the shoot and fruit infestation effectively, there by result in maximum marketable fruit yield (136 q/ha).

Three entomopathogens were isolated from *L. orbonalis* larvae, namely *Serratia marcescens*, *Enterobacter* sp. and *Aspergillus ochraceous* in Tamil Nadu (Yasodha *et al.*, 2007). Among them, *A. ochraceous* exhibited maximum mortality of in second instar (56 per cent) at 1×10^7 spores/ ml.

Thurkathipana and Mikunthan (2008) reported that mortality of *E. vigintioctopunctata* was apparent at 18 hours after application of *Beauveria bassiana* at the concentration of 1×10^8 spores/ml, both under the laboratory condition and after 72 hours of application in the field.

Jiji *et al.* (2008) reported that in field condition, wettable powder formulation of *B. bassiana* recorded a mean mortality of 65.27 and 64.36 per cent against *Anadevidia peponis* and *Diphania indica* respectively in vegetables and mean mortality of 76 per cent against epilachna beetle on brinjal plants.

When increased doses of conidial suspension of the green muscardine fungus, *M. anisopliae* were sprayed on different life stages of spotted beetle, the grubs were susceptible to the fungus at a dose of 10^8 and 10^{10} conidia/ml (Rajendran, 2002). High mortality noticed in first (50 and 64.8 per cent) and second (60 and 53.3 per cent) instar grubs, 5 days after application of 10^8 and 10^{10} conodia/ml. High mortality of 65.9, 60.0, 51.5 and 42.8 per cent recorded for 2, 4 and 7 day old adults after 7 days following treatment of the higher dose of conidial suspension. The unhatchability of the eggs following application of the conidial suspension was 20.5, 18.2, 31.9, 31.8 and 37.9 per cent on freshly laid and 1, 2, 3 and 4 day old eggs, respectively.

Santharam *et al.* (1978) reported that *Verticillium lecanii* when sprayed at a concentration of 1.6×10^7 or 4.8×10^7, only the larvae and pupae proved to be susceptible. Death occurred from the third day onwards and the mortality percentage increased with increase in the concentration of fungal spores.

B. bassiana @ 3.0 gm/L of water showed maximum reduction in epilachna beetle (74.91 per cent) population while *M. anisopliae* at same dosage showed 70.71 per cent reduction (Vishwakarma *et al.*, 2011).

2.1.2 Effect of botanical insecticides against major pests of brinjal

According to Mandal *et al.* (2010) neem seed kernel extract (NSKE) @ 5 per cent a.i./ha was found to be the most effective treatment in minimizing the shoot and fruit borer (*L. orbonalis*) population in brinjal which recorded the maximum yield of brinjal.

Pareet and Basavanagoud (2009) reported that basal application of neem cake at 0.5 t/ha + 50 per cent RDF (Recommended Dose of Fertilizer) followed by foliar application of four different indigenous materials *viz.*, NSKE @ 5 per cent, vermiwash 2 per cent, garlic chilli extract 3 per cent, fermented botanical spray 20 per cent were found to be more effective against *L. orbonalis* by reducing shoot infestation (15.46 per cent) and fruit infestation (18.49 per cent) giving maximum marketable fruit yield (122.20 q/ha).

Pavunraj *et al.* (2014) reported that ethyl acetate extract of leaves of *Hyptis suaveolens* Poit. (Lamiaceae) at 1per cent concentration exhibited the maximum antifeedant and insecticidal activity against four lepidopteran pests namely *Helicoverpa armigera* (Hbn.), *Spodoptera litura* (Fab.), *Earias vittella* (Fab.) and *Leucinodes orbonalis* (G.).

According to Mathur *et al.* (2012) newer plant products *i.e.*, oils of iluppai and pungam were on par with standard check endosulfan and were found to be significantly superior than microbial formulations *Beauveria bassiana* and *Verticillium lecanii* and found that there was better efficiency than neem oil in the suppression of *L. orbonalis* infestation. The maximum yield of marketable fruits was obtained using iluppai oil (202.75 q/ha).

According to Kavitha *et al.* (2008) neem oil and neem cake extract had ovicidal effect on the eggs of *L. orbonalis*. Neem oil had higher ovicidal effect than neem cake extract and carbaryl. Egg mortality was found to be less on the older eggs. An increase in the concentration of test solutions resulted in an increase in the rate of mortality of eggs.

The seed extract of *Strychnos nuxvomica* and *Pachyrrhizus erosus* both @ 4.0 ml/L of water reduced 74.13 and 60.18 per cent population of *E. vigintioctopunctata* along with crop yield of 298.18 and 278.81 q/ha respectively (Vishwakarma *et al.*, 2011).

The crude aqueous extracts of leaves from three indigenous plants namely *Ricinus communis, Calotropis procera* and *Datura metel* were used against epilachna beetle. Larvicidal bioassays of the extracts showed the following order of toxicity: *R. communis* (LC_{50}=18.40 per cent) > *C. procera* (LC_{50}=23.70 per cent) > *D. metel* (LC_{50}=29.61 per cent) and the extracts significantly reduced both oviposition and egg-hatch, prolonged larval duration and inhibited pupae formation and adult emergence (Islam *et al.*, 2011).

Ghatak *et al.* (2005) reported that neem spray Aza 3000 EC (5.0 per cent) and neem extract (3.0 per cent) reduced epilachna beetle population by 67.10 and 56.32 per cent, respectively.

Mondal and Ghatak (2009) reported that the seed extracts of *Annona squamosa* at 3 ml/L of water was effective in reducing the population of *E. vigintioctopunctata* on cucumber by 76.37 per cent followed by 64.00 per cent in neemazal at 5 ml/L of water and 57.00 per cent in petroleum ether extracts of rhizome of *Acorus calamus* at 2 ml/L of water.

According to Mane and Kulkarni (2010), neem oil (3 per cent) was the most effective treatment in controlling *E. vigintioctopunctata*, followed by bioneem 0.3 per cent and NSKE 5 per cent.

Sreedevi *et al.* (1993) reported that the plant extracts such as repelin, neemicide, vapenik, neknool and wellgro caused 83.35, 80.05, 76.65, 73.30, and 70 per cent mortality of *E. vigintioctopunctata,* respectively in a greenhouse trial on brinjal.

According to Jayarajan and Babu (1990) nem-75 at 1000 ppm was the best antifeedant for fourth instar grubs, followed by NK-100 and nemidin. However, NK-100 had the greatest antifeedant activity against adults.

Petroleum ether extract of *Calotropia gigantea* leaf (5 per cent) had the maximum ovicidal action of 47.50 per cent against *E. vigintioctopunctata* under laboratory condition (Kanimozhi and Veeravel, 2007). According to Shanumgapriyan and Kingsly (2003) the highest concentration of neem oil, neem cake extract and neem seed kernel extract (each at 0.5, 2.5 and 5.5 per cent), had the maximum ovicidal effect on the *E. vigintioctopunctata.*

Konar *et al.* (2005) reported that biopesticide, azadirachtin (10000 ppm) @ 1 L/ha gave better results in controlling the *E. vigintioctopunctata* on brinjal than *B. bassiana* (10^8 spores/ml) 1 kg/ha.

Saxena and Sharma (2007) reported that 1 per cent petroleum ether leaf extract of *Eucalyptus globulus* caused 100 per cent third instar larval mortality within 10 days. More than 90 per cent mortality was observed with 1 per cent flower extract of *E. globulus* and seed extract of *Nerium indicum* compared to the control (8.33 per cent). Adult emergence was nil with 1 per cent of *E. globulus* leaf and flower extracts, while 91.67 per cent adult emergence occurred in the control.

Extracts of seeds of *Thevetia nerifolia*, root of *Nerium oleander* and leaves of *Lantana camara* and *Ocimum sanctum* each at 1 per cent caused 90 per cent mortality of *E. vigintioctopunctata* in 12-24 h after application (Satpathi and Ghatak, 1990).

Nuaman (1996) reported that neem extract is highly effective against *Selepa docilis*. Jacob and Sheila (1994) reported that the extracts of datura (*Datura alba*) and neem extract showed a high antifeedant activity against *Selepa docilis*.

Cobbinah and Owusu (1988) reported that various concentrations of neem emulsion (neem emulsion, aqueous-methanol extract of defatted neem cake and defatted neem cake applied as a dust) reduced the incidence of the noctuid *Selepa docilis*.

According to Dreyer (1986) aqueous extracts of neem cake and neem kernel powder were equally active in inhibiting the development of 3rd instar larvae of *S. docilis*.

Dreyer (1987) reported that the aqueous extract of 25 or 50 gm pulverized neem seed kernels/L or with 5 or 10 litres neem oil/ha gave good reduction in infestation and damage of *S. docilis*.

2.1.3 Effect of new molecules of insecticides of microbial origin against major pests of brinjal.

Pareet and Basavanagoud (2012) reported that four sprays of emamectin benzoate 5 SG @ 0.2 ml and spinosad 45 EC @ 0.1 ml /L of water were found most effective in reducing shoot infestation (14.6 - 16.9 per cent) and fruit infestation (9.0 - 10.9 per cent). The highest fruit yield was reported in treatment with emamectin benzoate (158.51 q/ha) and spinosad (153.51 q/ha) compared to untreated check (83.93 q/ha). According to Kalawate and Dethe (2012) spinosad (56.25, 72 and 90 g a.i./ha) was most effective against brinjal shoot and fruit borer and also it afforded moderate control of jassid, whitefly and aphid.

Tayde and Simon (2010) reported that spinosad 45 SC @ 0.01 per cent was found most effective against brinjal shoot and fruit borer and showed 9.84 per cent shoot infestation, 6.87 per cent fruit infestation (number basis) and 7.35 per cent (on weight basis) and increased yield of brinjal fruit (239.30 q/ha).

According to Mahesh and Men (2007) the lowest infestation of *L. orbonalis* was observed in plots treated with dipel 8L at 1000 ml/ha. Ghosh and Senapati (2009) reported that *Bacillus thuringiensis* Berliner (biolep 5×10^7 spores/ml @ 1 gm/L) was effective in suppressing dead heart caused by *L. orbonalis.*

Adiroubane and Raghuraman (2008) reported that oxymatrine 1.2 EC (0.2 per cent) and spinosad 45 SC (225 gm/ha), were found to be effective against brinjal shoot and fruit borer, *L. orbonalis*. Oxymatrine was effective at early vegetative stage. The highest percentage reduction of shoot damage was observed in oxymatrine and it was on par with spinosad. Spinosad was effective at fruiting stage. The maximum per cent reduction of fruit damage was recorded in spinosad which is on par with oxymatrine.

Naik *et al.* (2008) reported that profenofos @ 0.1 per cent and spinosad @ 0.015 per cent were most effective in reducing grub population of *E. vigintioctopunctata* besides recording higher brinjal fruit yield.

According to ZhuLiHong *et al.* (2002), *B. thuringiensis* Ba9808 caused feeding inhibition and reduction of pupation percentage in 4^{th} instar larvae and when the adults were fed with Ba9808, their egg production was significantly decreased while dipping the eggs directly into Ba9808 fermented liquid did not affect egg hatching.

Baskaran and Kumar (1980) reported that mixtures of dipel at 0.1 per cent with sublethal doses of carbaryl 0.04 per cent was more effective against leaf roller, *A. olivacea.*

2.1.4 Effect of chemical insecticides against major pests of brinjal.

Yadav and Sharma (2005) reported that malathion 50 EC (0.05 per cent) and *Bacillus thuringiensis* sub sp. *kurstaki* (dipel 8L at 2.5 ml/L of water) are superior to neem products in suppressing the shoot and fruit borer, *L. orbonalis* infestation.

A field evaluation of insecticides revealed that avermectin (vertimec 1.9 EC @ 0.5 ml/L) was the most effective in suppressing dead heart caused by *L. orbonalis*, closely followed by DDVP (0.05 per cent) (nuvan 76 SL @ 2 ml/3L) when compared with the untreated control. The insecticides such as neem formulation (neemactin 0.15 EC @ 2.5 ml/L) and malathion (0.05 per cent) (malathion 50 EC @ 1.0 ml/L), were less effective in suppressing dead heart (Ghosh and Senapati, 2009).

Anil and Sharma (2010) reported that emamectin benzoate (0.002 per cent), endosulfan (0.05 per cent), novaluron (0.01 per cent) and lambda-cyhalothrin (0.004 per cent) were found superior in terms of low shoot infestation. The total number of drooping shoots was minimum (4.17) in plots treated with emamectin benzoate followed by endosulfan (6.83) and novaluron (7.00), as compared to spinosad (9.17), deltamethrin (11.67) and *Bacillus thuringiensis* (13.17). In terms of reduction in fruit infestation, emamectin benzoate (0.002 per cent) was highly effective followed by endosulfan (0.05 per cent), agrospray oil T (0.2 per cent) and spinosad (0.0024 per cent). The cost benefit ratio was highest in agrospray T (0.2 per cent) followed by lambda-cyhalothrin (0.004 per cent), endosulfan (0.05 per cent) and deltamethrin (0.0028 per cent).

Sreenivas *et al.* (2007) found that the new molecule α-endosulfan 35 per cent EC, an isomer of commercial endosulfan 35 per cent EC, was effective at 2.0 ml/L against *L. orbonalis* and to harvest better fruit yields (33.48 t/ha).

Singh *et al.* (2008) reported that minimum infestation of *L. orbonalis* was observed with endosulfan (21.5 per cent) followed by cypermethrin (24.13 per cent) and malathion (25.17 per cent). Total yield of endosulfan treated plants was higher (350 q/ha) and lowest (112.5 q/ha) with control. High profit was obtained from endosulfan (0.07 per cent) followed by cypermethrin (0.05 per cent).

According to Patnaik and Singh (1997) spraying of endosulfan (0.07 per cent) at 30 days after planting (DAP) and fenvalerate (0.02 per cent) at 60 DAP resulted in the lowest fruit damage (33.3 per cent) by *L. orbonalis* as compared with 64.2 - 65.1 per cent damage in the untreated control and had the highest cost: benefit ratio (1:40.3).

Mathur and Jain (2009) reported that cypermethrin 0.007 per cent was the most effective in terms of least shoot as well as fruit infestation by *L. orbonalis*.

According to Malsawmzuali *et al.* (2013) monocrotophos 36 SL @ 2 ml/L reduced mean shoot and fruit infestation of 83.61 per cent and 75.33 per cent respectively against *L. orbonalis*. The maximum pest population was recorded in the second week of July with 2.06 larvae/plant in the case of shoot and 1.20 larvae/plant in the case of fruit infestation. Ghosal *et al.* (2013) reported that rynaxypyr 18.5 SC 40 gm a.i/ha was superior which recorded the lowest shoot and fruit infestation by *L. orbonalis* with 2.65 and 14.07 per cent respectively and highest marketable fruit yield (156.25 q/ha) in brinjal.

According to Singh and Kumar (2011) imidacloprid @ 0.025 kg a.i/ha and fenvalerate @ 0.150 kg a.i./ha were the most effective treatments in reducing the *L. orbonalis* damage on brinjal shoot and fruits and recorded the maximum fruit yield of 290.25 q/ha and 268.5 q/ha respectively.

Misra (2011) found that chlorantraniliprole @ 40 and 50 gm a.i./ha were significantly superior and statistically on par with each other with regard to its efficacy, resulting in 95-97 per cent reduction in shoot damage; 87-90 per cent reduction in fruit damage on number basis and 88-90 per cent reduction in fruit damage on weight basis. At 20-50 gm a.i./ha it was safe to natural enemies.

Spray application of rynaxypyr (20 SC) resulted in lowest shoot damage (1.8 per cent) and fruit damage (8.2 per cent) and highest marketable fruit yield (63.7 q/ac) were obtained (Nayak *et al.*, 2011).

Latif *et al.* (2010) reported that carbosulfan 20 EC and flubendiamide 24 WG showed the highest toxicity against fourth instar larvae of *L. orbonalis* after 24 and 48 h of exposure. In field trials, they reduced more than 80 per cent shoot and fruit infestation in winter and 80 per cent shoot and 70 per cent fruit infestation in summer over control. Carbosulfan protected the highest amount of healthy fruit yield in both cropping seasons.

Quinalphos (ekalux) 25 EC at 0.05 per cent reduced the shoot and fruit borer infestation considerably even at 15 days after spraying and thus provided longer residual protection (Gupta and Kauntey, 2007).

Kumar *et al.* (2010) reported that two to three sprays of the mixture of profenofos (40 per cent) and cypermethrin (4 per cent) @ 0.06 per cent *i.e.*, 1.0 L/ha after 40 days of transplantation at 15 days interval was economically the most viable option for the control of *L. orbonalis* on brinjal.

According to Mehta *et al.* (1998) fenvalerate (0.05 per cent), followed by monocrotophos (0.036 per cent), proved to be the most effective insecticide against *L. orbonalis*. Carbofuran 1.0 kg a.i. /ha, had the lowest shoot infestation percentage (1.77) and lowest cost: benefit ratio (1:1.28).

Deshmukh and Bhamare (2006 a) reported that cartap hydrochloride 50 SP at 0.1 per cent was most effective in reducing shoot infestation (4.20 per cent) and fruit infestation (23.72 per cent on number basis and 25.30 per cent on weight basis) and in increasing brinjal fruit yield (78.73 q/ha).

According to Kumar and Kumar (1996) the LC_{50} of malathion and endosulfan was effective against third instar grubs @ 0.032 and 0.018 per cent respectively and 0.022 and 0.013 per cent to adults of *E. vigintioctopunctata*, respectively.

Kumar and Sharma (1994) reported that fenvalerate was highly effective, with LC_{50} of 0.04 and 0.15 ppm against 1st and 3rd instar larvae of *E. vigintioctopunctata*. The minimum effective residual life (90 per cent mortality basis) of fenvalerate when applied at 0.075 kg a.i./ha to brinjal leaves in the field was 7.3 ± 1.3, 6.5 ± 1.5, 5.2 ± 1.3 and 3.5 ± 1.4 days against 1st, 2nd, 3rd and 4th instar larvae respectively.

Ghatak *et al.* (2005) reported that imidacloprid at 0.05 per cent reduced epilachna beetle population by 86.25 per cent.

The carbaryl gave the greatest mortality of *E. vigintioctopunctata* (81.47 per cent) followed by fenvalerate and phosalone (80.36 and 79.31 per cent respectively) in a greenhouse trial on brinjal (Sreedevi *et al.*, 1993). According to Shanumgapriyan and Kingsly (2003) quinalphos 0.025 per cent resulted in 74.33 per cent mortality of *E. vigintioctopunctata* eggs in 24 h.

Dabi *et al.* (1980) reported that food consumption by last-instar larvae of *E. vigintioctopunctata* was inhibited by all six concentrations of fentin acetate (Brestan) treatments as compared with larvae feeding on untreated leaves and more than 70 per cent protection was recorded in the eggplant leaves treated with 0.05 per cent fentin acetate. According to Patnaik *et al.* (2004) foliar spray of thiamethoxam 25 per cent WG @ 50 gm a.i./ha was effective against jassids, *A. biguttula biguttula* and epilachna beetle, *H. vigintioctopunctata*.

Dubey and Awasthi (1992) reported that both malathion and monocrotophos caused shrinkage of the epithelium, disruption of the cell membrane and brush border membrane, shrinkage of nuclei and clumping of chromatin material in reassociated portions of the malpighian tubules of *Mylabris phalerata, E.*

vigintioctopunctata and *Aulacophora calva*. The latter effect resulted in the improper functioning of the malpighian tubules which possibly resulted in the death of the insect due an increased rate of water loss.

Lambda-cyhalothrin (0.004 per cent) and carbaryl (0.20 per cent) were found to be the most potent against hadda beetle, *H. vigintioctopunctata* on bitter gourd and remained effective throughout the observational period *i.e.*, up to 15 days of application with mean reduction of 89.26 and 85.09 and 87.10 and 83.45 per cent in pest population over untreated check (Sheikh and Desh, 2013)

The highest reduction in the *E. vigintioctopunctata* population at all stages of plant growth occurred when cypermethrin was sprayed at 60, 75, 90 and 105 days after transplanting of brinjal (Mandal and Kumar, 2001).

Imidacloprid 0.05 per cent spray was most effective in reducing the leaf infestation of coccinia by *E. vigintioctopunctata* as compared to quinalplos, malathion and dimethoate (Vijayasree *et al.*, 2012).

Chandranath and Katti (2010) reported that dimethoate 30 EC (1 ml/L) recorded the lowest number of *E. vigintioctopunctata* on ashwagandha (*Withania somnifera* cv. Jawahar) per plant (6.90), followed by quinalphos (8.40 beetles per plant). Based on the yield, application of dimethoate was the most effective among the insecticides (4.60 q/ha), followed by fenvelarate (4.40 q/ha) and quinalphos (4.20 q/ha).

Chlorfenvinphos (birlane 35 EC) and monocrotophos (nuvacron 40 WSC) at 0.05 per cent were the most effective and were toxic for 2^{nd} instar larvae of *E. vigintioctopunctata* up to 15 days after treatment (Bhalla *et al.*, 1988).

According to Samanta *et al.* (1999) quinalphos (aqua flow, AF) @ 500, 750 and 1000 gm a.i./ha and its mixture with monocrotophos (500 + 360 gm a.i./ha) gave excellent control of *L. orbonalis* and *E. vigintioctopunctata* on brinjal along with a significantly higher crop yield.

Veeravel and Baskaran (1976) reported that the quinalphos @ 0.037 per cent was most effective insecticides against larvae of *S. docilis.*

2.1.5 Effect of IPM practices against major pests of brinjal.

A study was conducted to test the efficacy of different IPM modules against *L. orbonalis* in *kharif* on variety Aruna. It was found that spinosad + *Metarhizium anisopliae* + chelating agent Fe-EDTA + cartap hydrochloride was found most effective causing minimum shoot infestation (7.47 per cent) and fruit infestation of 23.21 per cent, 21.09 per cent and 23.60 per cent at 3rd, 7th and 11th days respectively after spraying and giving highest yield of 81.82 q/ha (Suradkar *et al.*, 2004).

According to Chakraborti and Kanti (2011) integration of phytosanitation, mechanical control and prophylactic application of NSKE gives a satisfactory impact on the incidence and damage of *L. orbonalis*. A ready mix formulation (triazophos 40 per cent + cypermethrin 4 per cent) and carbofuran also offered good protection against the borer.

Sharma and Sinha (2009) reported that main crop brinjal, border cropped with either baby corn or radish or cluster bean along with two foliar sprays of spinosad @ 75 gm a.i./ha was very effective in minimizing the fruit borer incidence.

Mandal *et al.* (2009) reported that the shoot and fruit damage was reduced in IPM module in which spinosad 45 EC @ 0.4 ml/L spray followed by azadirachtin 0.15 per cent @ 2 ml/L spray along with clipping of infested shoots and removal of infested fruits at each harvesting, resulted in highest yield of marketable fruits (160.24 q/ha).

Removal and destruction of infested twigs/ fallen leaves twice in a week + application of *Bt* @ 0.5 kg/ha showed minimum infestation of shoot (1.23 and 1.13 per cent) and fruit (1.10 and 0.90 per cent) (Tiwari *et al.*, 2009).

Rath and Maity (2005) reported that the integrated pest management (IPM) components such as application of neem cake at 100 kg/acre at transplanting, installation of pheromone traps at 25 per acre at flower bud initiation stage (45 days old crop), mechanical clipping of infested shoots at weekly interval followed by spraying of neem oil (multineem) at 10-12 days interval significantly reduced *L. orbonalis* infestation on brinjal cultivars, Teishpur local and Desi Bada when compared with the non-IPM plots (farmer practice) and it was found that the eco-friendly approach increased the yield of marketable fruits and cost: benefit ratio in the IPM plots over the non-IPM plots.

Brinjal intercropped with coriander and fennel reduced the fruit damage to 12-15 per cent by *L. orbonalis* as compared to egg plant monoculture. The interaction of coriander intercropped eggplant along with foliar spray of antifeedant neemarin® showed that there was significant reduction in fruit damage (Satpathy and Mishra, 2011).

IPM practice such as installation of pheromone trap + shoot clipping + neem based pesticide + removal of damaged fruits during harvesting was found to be the best for the management of brinjal shoot and fruit borer (Mandal *et al.*, 2008). Sahu *et al.* (2004) reported that thiodicarb at 0.75 kg a.i./ha recorded lowest shoot (1.41 per cent) and fruit damage (20.86 per cent) by *L. orbonalis* and also recorded the highest brinjal fruit yield (148.45 q/ha).

Soil application of FYM (12.5 t/ha) + bio fertilizers (2 kg/ha) followed by neem cake (1000 kg/ha) was found consistently effective in reducing the incidence of *E. vigintioctopunctata* and ash weevil under field conditions. FYM + bio fertilizer + neem cake when integrated with two neem oil sprays @ 3 per cent was found significantly effective in reducing the damage due to beetle and weevil (Kavitharaghavan *et al.*, 2007).

Suresh *et al.* (2008) reported that FYM + biofertilizers + neem cake recorded high per cent reduction of *E. vigintioctopunctata* infestation over NPK as inorganic form and also recorded highest fruit yield of 16.65 t/ha.

Prasad *et al.* (2008) reported that brinjal when inter cropped with marigold or french bean reduced the incidence of *E. vigintioctopunctata.*

Ravikumar *et al.* (2008) reported that the application of farm yard manure (12.5 t/ha) + azophos (2 kg/ha) + neem cake (1000 kg/ha) and need-based foliar application of neem oil (3 per cent) were found to be very effective in reducing the incidence of spotted leaf beetle on ashwagandha (*Withania somnifera*).

2.1.6 Effect of natural enemies against major pests of brinjal.

A larval parasitoid, *Eriborus argentiopilosus* (Hymenoptera: Ichneumonidae) of brinjal shoot and fruit borer was identified by Varma *et al.* (2009) and they reported that the extent of parasitization ranged from 2.01 to 24.61 per cent.

Yasodha and Natarajan (2006) reported that twelve hymenopteran parasitoids emerged from field-collected egg and pupae of *L. orbonalis*. Seven of them belonged to superfamily Chalcidoidea (*Antrocephalus mitys*, *Brachymeria lasus*, *Spalangia endius*, *S. irregularis*, *Endius* sp. and *Spalangia* sp.) and five belonged to the superfamily Ichneumonoidea (*Bracon hebetor*, *Trathala flavoorbitalis*, *Chelonus* sp. *Phaneratoma* sp. and *Vaepellinae* sp.). *Trichogramma* sp. was found to parasitize the field-exposed eggs of *L. orbonalis* while all others were pupal parasitoids.

Entomopathogenic nematode *Steinernema carpocapsae* (1, 1.5 and 2 billion/ha) were evaluated against *L. orbonalis* by spraying infective juvenile stages @ 10-12 times, at ten-day intervals, during the brinjal growth cycle, starting at 5-10 per cent flowering stage and it was found that *S.*

carpocapsae caused significant reduction in fruit borer damage and increased yield of brinjal (Visalaksy *et al.*, 2009).

The parasitoids *Tetrastichus ovulorum* (*Oomyzus ovulorum*), *Pediobius foveolatus, Uga menoni* and *Bracon* sp. were observed on various life stages of *E. vigintioctopunctata* (Kaur and Mavi, 2002).

Patnaik and Mohapatra (2004) reported that the egg parasitoid, *Omphale* sp., remained active in brinjal fields parasitizing the eggs of the spotted leaf beetle. Rajendran and Gopalan (1997) reported that the larval parasitoid *Pediobius foveolatus* is a potential biological control agent of *E. vigintioctopunctata.*

Kuruvilla and Jacob (1980) reported that *Paecilomyces farinosus* was shown to infect larvae of leaf roller, *A. olivacea.*

Beevi and Jacob (1982) reported that larvae of *A. olivacea* were not infected by *Fusarium moniliforme* var. *subglutinans* and the pathogen did not harm brinjal plant.

2.1.7 Effect and activity of predatory natural enemies against brinjal pests

Tiwari *et al.* (2011) reported that natural enemies such as coccinellid beetle, *Coccinella septempunctata* and *Cheilomenus sexmaculata*, predatory spider, *Oxiopes* sp. black ant, *Camponotus* sp. and other arthropods appeared in the brinjal ecosystem against shoot and fruit borer, *L. orbonalis,* beetle, *E. vigintioctopunctata* and leaf roller, *Eublema* (*=Antoba*) *olivacea.*

Vijayasree *et al.* (2012) reported that the botanical insecticides *viz.*, azadirachtin, neem oil-garlic emulsion, neem oil, illipe oil and synthetic insecticides *viz.*, imidacloprid, quinalphos, malathion and dimethoate were found safe to the spiders in coccinia.

Sankari and Thiyagesan (2010) reported that eight species of predatory spiders *viz.*, *Argiope luzona*, *Cyrtophora cicatrosa*, *Chrysso argyrodiformis*, *Hipossa pantherina*, *Oxyopes lineatipes*, *Oxyopes javanus*, *Peucetia viridana* and *Lycosa pseudoannulata* were recorded in brinjal and snake-gourd.

According to Sardana *et al.* (2006) significantly higher populations of natural enemies such as coccinellids, predatory spiders and green lace wings were observed in IPM practiced farmers fields. In IPM practiced field predatory spiders were present throughout the season.

The activity of insect predators were maximum (coccinellids: 4.67/5 plants and spiders: 3.75/5 plants) in brinjal intercropped with baby corn along with shoot clipping and foliar application of neemol® @ 5 ml/L (Lakshmi *et al.*, 2011).

2.2 EFFECT AND COMPATIBILITY OF PESTICIDES ON ENTOMOPATHOGENIC FUNGI UNDER *IN VITRO* CONDITION

Concerns of entomopathogenic fungi as alternative pest control agents are increasing even though chemical pesticides have been used as the main control agents for pests and diseases in crop production. The entomopathogenic fungus *M. anisopliae* and *B. bassiana* are the facultative insect pathogens with significant host range and host specifity.

Alizadeh *et al.* (2007) reported that flufenoxuron is not compatible with *B. bassiana* and it caused complete or strong inhibition on its development whereas imidacloprid is compatible with *B. bassiana* and it can be used in integrated pest management. According to Hernandez *et al.* (2012) the application of flufenoxuron with *B. bassiana* revealed a clear synergy and while the combination of azadirachtin and *B. bassiana* had an additive effect.

Rajanikanth *et al.* (2010) found that spinosad is compatible with *B. bassiana* and was found safe to growth, sporulation and spore viability of the fungi. Amutha *et al.* (2010) reported that spinosad 45 SC is slightly toxic to *B. bassiana.*

Silva *et al.* (2013) reported that *M. anisopliae* is compatible with the insecticides like methyl parathion (240 ml/ha), thiamethoxam (31 gm/ha), and lambda-cyhalothrin (6.3 ml/ha) and it can be simultaneously used with this bio-control agent for integrated pest management.

Akbar *et al.* (2012) reported that the spinosad is compatible with *M. anisopliae* and was found safe to conidial germination and growth of the fungi *M. anisopliae.* According to Asi *et al.* (2010) spinosad 45 SC was safe to conidial germination and growth of the fungi *M. anisopliae.*

The insecticide abamectin, deltamethrin, imidacloprid, and spinosad had no detrimental effects on spore germination or mycelial growth of *Lecanicillium attenuatum* (JeongJun and Kyuchin, 2007).

Devi *et al.* (2002) reported that NSKE is not exhibiting mycelial growth and sporulation of *Nomuraea rileyi* while the synthetic insecticide such as monocrotophos and endosulfan completely inhibited the growth and sporulation of *N. rileyi.*

Gonzalez *et al.* (2013) reported that abamectin and imidacloprid were compatible with the entomopathogenic fungus *Lecanicillium lecanii* but dicofol inhibited the conidia germination totally at 10, 100, 200, 500, 1000 and 2000 mg/L concentrations.

The conidial germination of *Lecanicillium lecanii* was 99.3 and 85.7 per cent in pongamia oil and acephate, whereas total inhabitation of conidial germination was observed in chlorothalonil, iprodion+carbendazim, carbendazim and thiophanate methyl (Krishnamoorthy *et al.*, 2007)

According to Terribile and Barros (1991), insecticides *viz.*, diflubenzuron, carbaryl and cyhalothrin had the lowest inhibitory effect on the *N. rileyi*. Ribeiro *et al.* (2012) reported that the aqueous extracts of neem seeds and leaves catigua, depending on the concentration used, and the botanical insecticide Neempro (azadirachtin +3-tigloylazadirachtol), were classified as compatible with the entomopathogen *B. bassiana*.

Damodar *et al.* (2008) reported that indoxacarb and chlorfenapyr were compatible with *B. bassiana* at 10 times less than the recommended dose while chlorfenapyr at recommended dose was compatible with *Paecilomyces fumosoroseus*.

2.3 EFFECT OF PESTICIDE RESIDUES IN BRINJAL

Deshmukh and Bhamare (2006 b) found that cypermethrin 25 EC at 0.006 per cent and spinosad 45 SC at 0.1 per cent were found below the detection limit. Endosulfan 35 EC at 0.05 per cent, monocrotophos 36 WSC at 0.05 per cent and thiodicarb 75 WP at 0.1 per cent had residue deposits of 0.092, 0.061 and 0.178 ppm respectively, all of which were within the prescribed maximum residue level.

According to Romeh and Hendawi (2013) acetamiprid at the recommended dosage is safe and a waiting period of one day is suggested to reduce the risk before consumption of eggplant fruits and processing products.

Punyavathi and Vijayalakshmi (2013) reported that the residue of chloropyrifos, quinalphos, endosulfan, acephate, monocrotophos and carbofuran was found below detectable level in fresh vegetable samples of brinjal.

Chawla *et al.* (2011) reported that persistence of flubendiamide in/on brinjal till 3rd and 7th day after the last spray at 90 (standard dose) and 180 (double dose) gm a.i./ha, respectively. The residues of flubendiamamde were reported as parent compound, and no desiodo metabolite was detected. The initial deposits of 0.17

and 0.42 µg/gm in/on brinjal fruits reached below detectable level of 0.05 µg/gm on the 5th and 10th day at standard and double dose respectively.

Residues of the 0.1 per cent of malathion in brinjal fruits were below detectable levels by the 5th day after spraying (Krishnaia and Bhaskaran, 1988).

Jyot *et al.* (2005) reported that residue of ethion at 375 gm a.i./ha on brinjal were below the maximum residue limit (MRL) after 4 days of application.

According to Rajeswaran *et al.* (2004) the carbosulfan residues were detected only in the first harvest of brinjal fruits with average levels of 0.05, 0.12 and 0.27 µg/gm following its application at 250, 500 and 1000 gm/ha, respectively. The fruit samples from the third harvest did not reveal its presence at the minimum detection limit of 0.002 mg/kg.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The research work entitled "Biorational management of major pests in brinjal (*Solanum melongena* L.)" was conducted with the following objectives.

1. Survey of major pests of brinjal in Kasargod district
2. Efficacy testing of microbial preparations, biorational and neem based insecticides against major pests of brinjal
3. Effect and compatibility of spinosad on entomopathogenic fungi using poisoned food technique under *in vitro* condition, and
4. Estimation of residues of spinosad in brinjal fruits.

The laboratory studies were conducted in the Department of Agricultural Entomology and field experiments in the Instructional Farm of the College of Agriculture, Padannakkad.

3.1 SURVEY OF MAJOR PESTS OF BRINJAL IN KASARGOD DISTRICT

A survey was conducted in major brinjal growing areas of Kasargod district representing three agro climatic regions *viz.,* high land, mid land and low land. The survey covered thirty brinjal cultivating farmers' each from high land, mid land and low land. The details of the survey were recorded as per the proforma given in Appendix 1.

The selected farmers' were interviewed for collecting the details such as farmers' status, farming practices, pests and natural enemies occurring in brinjal. A standard scale was used for assessing the severity of pests of brinjal as shown in Table 1. The predator population in the brinjal field was assessed based on the scale given in Table 2.

Table 1. Criterion for assessing severity of pests of brinjal

Sl. No.	Pest	None	Low	Medium	High
1.	Shoot and fruit borer, *Leucinodes orbonalis*	Nil	≤ 30 per cent (affected branches or fruits)	> 30 - ≤ 60 per cent	60 per cent and above
2.	Epilachna beetle, *Epilachna vigintioctopunctata*	Nil	≤ 3 (number per leaf)	> 3 - ≤ 5 (number per leaf)	> 5 and above
3.	Leaf roller *Antoba olivacea*	Nil	≤ 30 per cent affected leaves	> 30 - ≤ 60 per cent affected leaves	60 per cent affected leaves and above
4.	Hairy caterpillar, *Selepa docilis*	Nil	≤ 30 per cent affected leaves	> 30 - ≤ 60 per cent affected leaves	60 per cent affected leaves and above

(Bernice, 2000)

Table 2. Criterion for assessing the population of natural enemies

Sl. No.	Natural enemies	None	Low	Medium	High
1.	Spiders	Nil	≤ 1/ plant	> 1 - ≤ 5	> 5 and above
2.	Predatory insects	Nil	≤ 1 adult or grub/ plant	> 1 - ≤ 5	> 5 and above

(Bernice, 2000)

3.2 EFFICACY TESTING OF MICROBIAL PREPARATIONS, BIORATIONAL AND NEEM BASED INSECTICIDES AGAINST MAJOR PESTS OF BRINJAL

3.2.1 Maintenance and preservation of entomopathogenic fungus culture

The pure culture of green muscardine fungus *M. anisopliae* and white muscardine fungus *B. bassiana* used in the present study were obtained from National Bureau of Agriculturally Important Insects (NBAII), Bengaluru. The cultures were periodically subcultured to fresh Potato Dextrose Agar (PDA) slants at fortnightly intervals and were stored in refrigerator for regular use.

3.2.1.1 Preparation of culture media (Dhingra and Sindair, 1993)

In the present investigation, potato dextrose agar was used for maintenance of the culture.

Potato dextrose agar medium (PDA)

Potatoes - 200 gm

Dextrose - 20 gm

Agar agar - 20 gm

Water – 1000 ml

Two hundred gram potato was peeled and cut in to pieces and boiled in 500 ml of water until a cooked flavor was obtained. It was then filtered using a muslin cloth in to a clean glass beaker. Dextrose 20 gm and melted agar 20 gm were dissolved in potato extract and made up to one litre and sterilized in autoclave at 15 psi for 20 min. at 121^0C. The PDA media was transferred in to the petriplates inside the laminar air flow hood under aseptic condition. The primary culture was inoculated in to the PDA media in petriplates to obtain fresh cultures for mass multiplication. The petriplates were incubated at 25±1^{0}C in incubator.

The sporulation occurred on 10 to 14 days after inoculation and the culture was seen as green coloured powdery coating on the white mycelia mat (Plate 1. a).

3.2.1.2 Mass multiplication of M. anisopliae (Dhingra and Sindair, 1993)

Mass multiplication of green muscardine fungus *M. anisopliae* was carried out in the laboratory using Potato Dextrose Broth (PDB).

Potato dextrose broth (PDB)

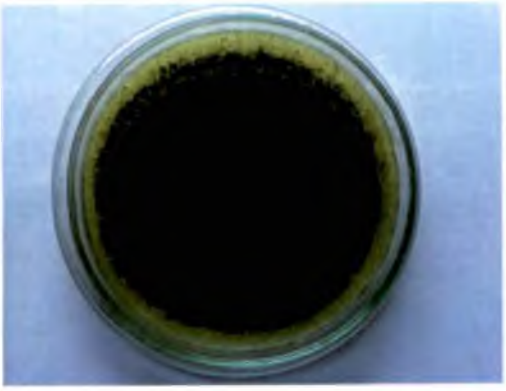
Potatoes - 200 gm

Dextrose - 20 gm

Water – 1000 ml

The procedure for the preparation of PDB is same as that of 3.2.1.1 but without adding agar. Three hundred millilitre of PDB was transferred in to 500 ml glucose bottles and were plugged with cotton and autoclaved at 15 psi for 20 min. at 121^{0}C.

After cooling, a loop full of inoculum from sub-cultured plates of *M. anisopliae* was transferred to the glucose bottles containing PDB. It was then incubated at room temperature (25±1^{0}C) for 14 days. After complete sporulation of *M. anisopliae,* green coloured spores were found on mycelia mat on the surface of the broth (Plate 2. a). The PDB containing the fungal mat were mixed using a mixer grinder and the spore suspension was mixed thoroughly and used for foliar application.



(a) *Metarhizium anisopliae*

(b) *Beauveria bassiana*

Plate 1. Primary culture of entomopathogenic fungus

(a) *Metarhizium anisopliae*

(b) *Beauveria bassiana*

Plate 2. Mass multiplication of entomopathogenic fungus

3.2.1.3 Beauveria bassiana

Maintenance, preservation, sub-culturing, preparation of media and broth are similar as given in 3.2.1.1. The sporulation occurred on 10 to 14 days after inoculation and the culture was seen as white coloured powdery coating on the white mycelia mat (Plate 1. b).

3.2.1.4 Mass multiplication of B. bassiana

Procedure same as given in 3.2.1.2. After the incubation period the fungal spores appeared white in colour on mycelia mat (Plate 2. b). The PDB containing the fungal mat were mixed using a mixer grinder and the spore suspension was mixed and used for foliar application.

3.2.2 Sporulation assay of *M. anisopliae* and *B. bassiana*

Spore counting of *M. anisopliae* and *B. bassiana* was done by using the Neubauer haemocytometer (Plate 3).

The spore suspension of *M. anisopliae* and *B. bassiana* were prepared by serial dilution method and 10^6 dilution was used for counting the spores. The hemocytometer and cover glass were carefully cleaned and dried using non-linting tissue paper. The cover glass was kept over the grid carefully and by using a clean pipette tip, approximately 9 μl (this volume will vary slightly with the brand of hemocytometer) of the spore suspension was placed on the engraved grid and waited for two minutes to allow the conidia to settle at the bottom. The chambers of the hemocytometer were filled slowly and steadily to avoid bubbles in to the chamber and also not to over fill or under fill the counting chamber of the hemocytometer.

Number of spores were counted under (40 X objective) the compound microscope. The spores were counted in four (I, II, III and IV) corner large squares (0.1 mm^3) on hemocytometer. The spores were counted on top and left

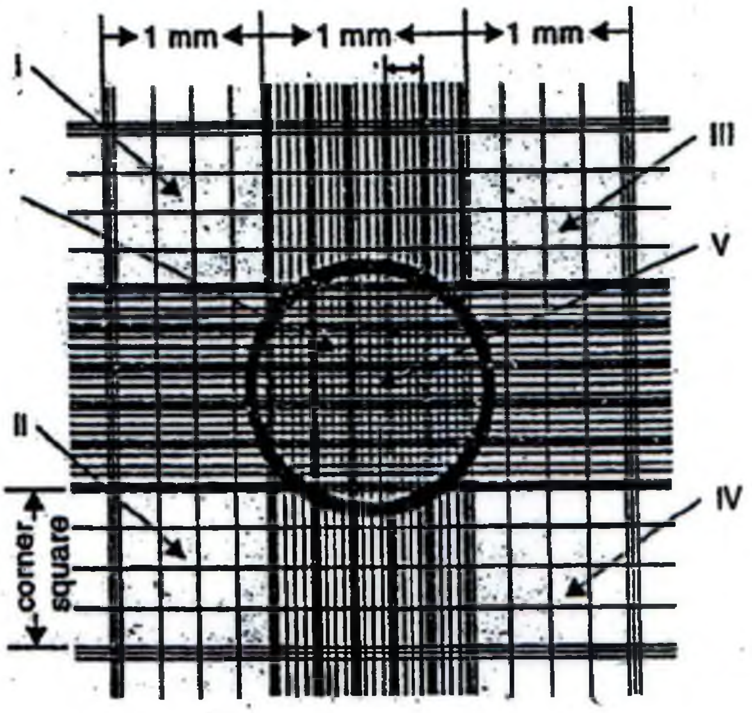


Plate 3. Neubauer haemocytometer

touching middle line of the perimeter of each square and the spores were not counted touching the middle line at bottom and right sides.

The total spores counted in the four corner squares of hemocytometer were calculated using the formula,

$$\textbf{Spores/ml} = (n) \times 10^4 \times \textbf{dilution factor}$$

Where n = the average cell count per square of the four corner squares counted.

3.2.3 Preparation of talc formulation of *M. anisopliae* and *B. bassiana*

M. anisopliae and *B. bassiana* were mass multiplied in PDB. The PDB containing the fungal mat were mixed using a mixer grinder. This spore suspension was mixed thoroughly with one kilogram sterilized talc powder and kept overnight for drying (Plate 4) and this was used for application in the field.

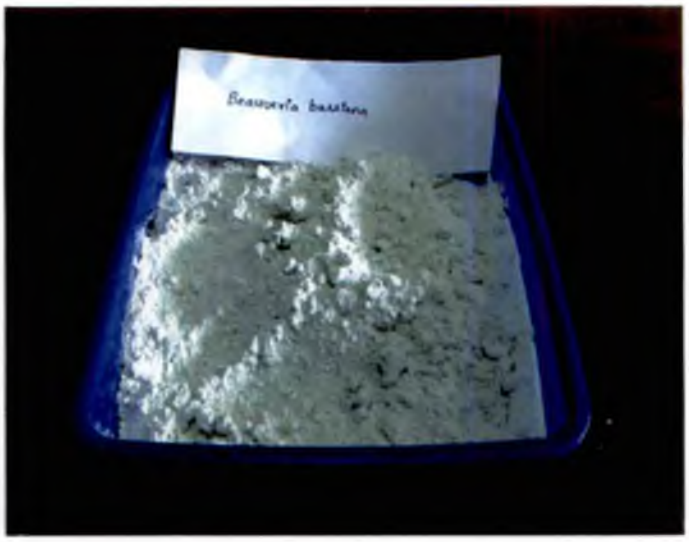
3.2.4 Pest management trial in brinjal at the Instructional Farm, College of Agriculture, Padanakkad.

A field experiment was conducted on brinjal variety '*Surya*' in the field of Instructional Farm, College of Agriculture, Padanakkad.

3.2.4.1 Raising the nursery

A nursery was prepared in a raised nursery bed of size 2 × 3 m, during February 2013 for summer crop and June 2013 for *kharif* crop. All the practices for brinjal nursery preparation were followed as per package of practices recommendation by KAU, 2011 except chemical spray. Seeds of brinjal variety '*Surya*' were sown and the nursery was irrigated daily. One month old seedlings were used for transplanting in the main field.

(a) *Metarhizium anisopliae*



(b) *Beauveria bassiana*

Plate 4. Talc formulation of entomopathogenic fungus

3.2.4.2 Preparation of main field

The main field was prepared in 10 cent area (Plate 5). The field experiment was laid out in randomized block design (RBD) with three replication. The plot size was 8 m^2. About 18 plants were maintained per plot. The seedlings were planted with a spacing of 70 × 60 cm. All cultural operations given in the package of practices of the KAU, 2011 were followed for raising the brinjal crop except plant protection measures.

Observations were taken from five randomly selected plants excluding the border plants.

The damage of shoot and fruit borer, *L. orbonalis* was recorded with total number of attacked shoots and fruits out of total number of shoots and fruits.

Observation on damage of epilachna beetle, *E. vigintioctopunctata,* with total number of attacked leaves out of total number of leaves and number of grubs and adults on upper three leaves, middle three leaves and lower three leaves were recorded.

Observation on damage of leaf roller, *A. olivacea,* with total number of attacked leaves out of total number of leaves were recorded.

Observation on damage of hairy caterpillar, *S. docilis,* with total number of attacked leaves out of total number of leaves were recorded.

Total population of natural enemies *viz.,* predatory coccinellids and spiders per plant were recorded.

The treatments are detailed below

T_1: *Metarhizium anisopliae* (talc formulation @ 5 gm/L of water).

T_2: *Metarhizium anisopliae* (potato dextrose broth @10^7 spores/ml).

Plate 5. Experimental plot

T_3: *Beauveria bassiana* (talc formulation @ 5 gm/L of water).

T_4: *Beauveria bassiana* (potato dextrose broth @10^7 spores/ml).

T_5: *Bt* formulation @ 1 ml/L of water

T_6: Spinosad 45 SC @ 0.4 ml/L of water

T_7: Neem based insecticide (Azadirachtin 1% @ 2 ml/L of water)

T_8: Malathion 50 EC @ 2 ml/L of water – standard check.

T_9: Absolute control.

The required dose of biorational insecticides in the treatments were dissolved in one litre of water and were used for spraying in the respective treatments and water was used as a spray solution in all the control treatments.

Spray application of treatments were done once in 15 days after transplanting, as soon as the pests population was noticed in the field and thus four sprays were given.

3.2.5 Yield data

The harvesting of fruits was done at weekly interval and the total weight of the fruits from five plants from each plot were recorded. The total weight of the fruits obtained from each plot was also recorded.

3.2.6 Statistical analysis

Data obtained from the survey, lab and field experiments were subjected to statistical analysis by applying analysis of variance (ANOVA). The data of the field experiment were subjected to $\sqrt{x+1}$ transformation wherever necessary.

3.3 LABORATORY STUDIES ON EFFECT AND COMPATIBILITY OF SPINOSAD ON ENTOMOPATHOGENIC FUNGUS USING POISONED FOOD TECHNIQUE

3.3.1 *In vitro* evaluation of spinosad on entomopathogenic fungi using poisoned food technique

Commercial formulation, spinosad 45 SC (Tracer®) was evaluated *in vitro* against *M. anisopliae* and *B. bassiana,* by poisoned food technique (Nene and Thapliyal, 1993). Three concentrations of the stock solution of spinosad *viz.,* 40 µl, 80 µl and 120 µl were prepared in sterilized distilled water. To obtain the desired concentration of spinosad in the media, the required amount of stock solution were added in 50 ml sterilized distilled water (to get the double strength) and then mixed with 50 ml melted double strength PDA to get desired concentration. Twenty millilitre of the poisoned media was poured in to sterilized petriplate (nine centimeter diameter) under aseptic conditions in laminar air flow chamber and allowed to solidify.

Each plate was inoculated in the centre with three millimeter diameter disc cut from the periphery of actively growing one week old test cultures of *M. anisopliae* and *B. bassiana* individually under aseptic conditions and incubated at 28 ± 1^0C in an incubator.

Untreated PDA plates inoculated with *M. anisopliae* and *B. bassiana* served as checks. Radial growth of the test isolates were recorded after 24 hr and 48 hr of incubation. Per cent inhibition of growth over control was calculated using the formula (Vincent, 1927)

$$I = \frac{C - T}{C} \times 100$$

Where,

I = per cent inhibition.

C = growth of micro organism in untreated medium.

T = growth of micro organism in treated medium.

3.3.2 Sporulation assay of *M. anisopliae* and *B. bassiana*

After *in vitro* evaluation of spinosad on entomopathogenic fungi, *M. anisopliae* and *B. bassiana* by poisoned food technique, sporulation assay were carried out using Martins rose Bengal agar media. The media was prepared using five gram peptone, 10 gm dextrose, 20 gm agar, one gram KH_2PO_4, 0.5 gm $MgSO_4.H_2O$, 30 mg Rose Bengal and one litre distilled water. All the ingredients except agar were dissolved in 500 ml distilled water; 20 gm agar was dissolved in another 500 ml distilled water by boiling. These were then mixed thoroughly and Rose Bengal dye was added. It was then poured in to two 500 ml conical flasks and plugged with cotton and kept for sterilization in autoclave at 121 ^{0}C for 20 minutes.

The spore suspension of entomopathogenic fungi was prepared by serial dilution method (10^6 dilution was used of the study) using *M. anisopliae* and *B. bassiana* growth on poisoned food technique. One millilitre spore suspension of *M. anisopliae* and *B. bassiana* were poured in a sterilized petriplate. Thereafter, 20 ml of the melted Rose Bengal agar medium was poured in to petriplate containing spore suspension. It was done under aseptic condition in laminar air flow chamber and allowed to solidify and incubated at 28 ± 1^0C in an incubator. Number of colonies of the test isolates were recorded after 14 days of incubation.

3.3.3 Spore germination inhibition studies

The spore germination inhibition studies were conducted following the method by Peterson (1941). The spore suspension of *M. anisopliae* and *B. bassiana* were prepared by serial dilution method. Required concentration of spinosad was prepared using sterile distilled water and 0.1 ml of the solution was placed at the centre of a clean and sterilized cavity glass slide and allowed to dry at room temperature (30-35 ^{0}C). Spore suspension of 0.1 ml prepared in PDB was placed on the same spot where spinosad suspension was placed.

It was then placed in moist chamber. The moist chamber was prepared using wet blotting paper placed in petriplate. This was carried out in aseptic condition in a laminar air flow chamber. The moist chamber along with slides were incubated at 28±1 ^{0}C in an incubator. Observations on the number of spores germinated were recorded 12 hr after incubation under the compound microscope (40 X objective).

Four replications were maintained for each concentration. From each replication, five microscopic fields were observed following the method by Yashoda (1998), for converting average number of spores germinated per microscopic field.

Per cent spore germination inhibition was calculated using the formula developed by Verma and Singh (1987):

$$I = \frac{C - T}{C} X\ 100$$

Where,

I = per cent inhibition

C = number of spores germinated in control.

T = number of spores germinated in treatment.

3.4 ESTIMATION OF RESIDUE OF SPINOSAD IN BRINJAL FRUIT

Estimation of residue of spinosad in brinjal fruit (AOAC, 2007) was done in the pesticide residue laboratory under the "All India Co-ordinated Research Project" (AICRP) on Pesticide Residue, College of Agriculture, Vellayani.

The analytical sample was prepared from the total amount of brinjal fruits obtained from the spinosad sprayed plot and two kilogram of the fruits were taken from each plot as a sample for residue estimation of spinosad and for checking compliance with maximum residue limits (MRL). Two kilograms of brinjal fruits obtained from the spinosad sprayed plot was blended using blender. From this, 25 gm of the sample was taken for the analysis. Fifty milliliter of acetonitrile (CH_3CN) were added to the sample and homogenized at 4000 rpm and 10 gm of NaCl was added under insolent agitation and centrifuged at 2000 to 2500 rpm for four minutes.

Sixteen millilitre of the supernatant was collected and six grams of sodium sulfate (Na_2So_4) was added. It was mixed thoroughly and 12 ml of supernatant were transferred to 15 ml tube, containing 0.2 gm Primary Secondary Amine (PSA) + 1.2 gm Magnesium sulfate ($MgSO_4$) and it was vortex for 30 sec and centrifuged for 3 min at 2500 rpm. Five millilitre of supernatant was collected in turbovap tube and acetonitrile was evaporated in turbovap at 45 ^{0}C and the residue was reconstituted in to 2 ml methanol and sent to liquid chromatography-mass spectrometry (LC-MS) to record the reading.

The residue of spinosad was calculated using the formula:

$$\textbf{Pesticide residue (in ppm)} = \frac{\textbf{Area of sample} \times \textbf{concentration of standards} \times \textbf{dilution factor}}{\textbf{Area of standards}}$$

The residue of spinosad at harvest was expressed in mg/kg.

RESULTS

4. RESULTS

Studies were und er taken to investigate the severity of major pests of brinjal in Kasargod district. Field experiments were carried out to asses various microbial preparations, biorational and neem based insecticides against major pests of brinjal and laboratory experiments were carried out to asses effect and compatibility of spinosad on entomopathogenic fungi and estimation of residue of spinosad in brinja fruits. The results of the studies are presented in this chapter.

4.1 SURVEY OF MAJOR PESTS OF BRINJAL IN KASARGOD DISTRICT

4.1.1 Incidence of pests of brinjal in the three agro climatic regions of Kasargod district

The incidence of important pests of brinjal observed by the farmers' in their field in the three agro climatic regions of Kasargod district are given in Table 3.

Brinjal fruit and shoot borer, *L. orbonalis* and epilachna beetle, *E. vigintioctopunctata* incidence were the major problem in low land area in 96.7 per cent of the farmers' field surveyed and problem was moderate in 3.3 per cent of the farmers' field. Leaf roller, *A. olivacea* incidence was severe in 66.7 per cent of the farmers' field and moderate with 33.3 per cent of them. Hairy caterpillar, *S. docilis* incidence was severe in 16.7 per cent of the farmers' field and moderate with 40 per cent of them and mild in 43.3 per cent field.

Shoot and fruit borer, *L. orbonalis* and epilachna beetle, *E. vigintioctopunctata* was also major problem with severe infestation in mid land areas of all most all the farmers' field. Leaf roller, *A. olivacea* incidence was severe with 53.3 per cent of the farmers' field, moderate with 43.3 per cent of them and mild with 3.3 per cent field. .The hairy caterpillar, *S. docilis* incidence

Table 3. Incidence of pests observed by the farmers' in their brinjal field in the three agro climatic regions of Kasargod district

Sl. No.	Pests	Low land (30 farmers')						Mid land (30 farmers')						High land (30 farmers')					
		Mild		Moderate		Severe		Mild		Moderate		Severe		Mild		Moderate		Severe	
		NOF	%	NOF	%	NOF	%	NOF	%	NOF	%	NOF	%	NOF	%	NOF	%	NOF	%
1.	Shoot and fruit borer, *Leucinodes orbonalis*	00	00.00	01	03.33	29	96.66	00	00.00	00	00.00	30	100.00	04	13.33	03	10.00	23	76.66
2.	Epilachna beetle, *Epilachna vigintioctopunctata*	00	00.00	01	03.33	29	96.66	00	00.00	00	00.00	30	100.00	03	10.00	14	46.66	13	43.33
3.	Leaf roller, *Antoba olivacea*	00	00.00	10	33.33	20	66.66	01	03.33	13	43.33	16	53.33	00	00.00	05	16.66	25	83.33
4.	Hairy caterpillar, *Selepa docilis*	13	43.33	12	40.00	05	16.66	06	20.00	23	76.66	01	03.33	09	30.00	21	70.00	00	00.00

NOF- Number of Farmers

was severe with 3.3 per cent of the farmers' fields, moderate with 76.7 per cent of them and mild in 20 per cent of them.

Shoot and fruit borer, was the major problem in high land area infesting 76.7 per cent of the farmers' field, moderate in 10 per cent of them and problem was mild with 13.3 per cent of the farmers' field. Epilachna beetle, *E. vigintioctopunctata* incidence was severe with 43.3 per cent of farmers' field, moderate with 46.7 per cent of them and the incidence was mild in 10 per cent of them. The leaf roller, *A. olivacea* was severe in 83.3 per cent of the farmers' field and moderate in 16.7 per cent of them. The infestation of the hairy caterpillar, *S. docilis* was moderate in 70 per cent of the farmers' field and mild in 30 per cent of them.

4.1.2 Stage of crop affected by the pests

Brinjal shoot and fruit borer, epilachna beetle, leaf roller, hairy caterpillar were present in all the stages of the crop in the farmers' field surveyed (Table 4). The incidence of the fruit and shoot borer was present at two and three months after transplanting in all most all the farmers' field surveyed in low and mid land, where as it was 93.3 per cent in the high land area. The incidence of the fruit and shoot borer was present at one month after transplanting with 6.7 per cent of the farmers' field in high land area.

The incidence of epilachna beetle, *E. vigintioctopunctata* was found at one month after transplanting in all most all the farmers' field in low and mid land area, whereas in high land area, it was found in 90 per cent of the farmers' field but the incidence was found two to three months after transplanting in 10 per cent of the farmers' field in high land area. Leaf roller was present at two and three months after transplanting in all most all the farmers' field in low and mid land area whereas, it was 93.3 per cent in high land areas. The incidence of leaf roller was found one month after transplanting in 6.7 per cent of the farmers' field in high land area.

Table 4. Incidence of pests observed by the farmers' in their brinjal field at the different stages of the crop in the three agro climatic regions of Kasargod district

Sl. No.	Pests	Low land (30 farmers')				Mid land (30 farmers')				High land (30 farmers')			
		1MAT		2 and 3MAT		1MAT		2 and 3MAT		1MAT		2 and 3MAT	
		NOF	%	NOF	%	NOF	%	NOF	%	NOF	%	NOF	%
1.	Shoot and fruit borer, *Leucinodes orbonalis*	00	00.00	30	100.00	00	00.00	30	100.00	02	6.66	28	93.33
2.	Epilachna beetle, *Epilachna vigintioctopunctata*	30	100.00	00	00.00	30	100.00	00	00.00	27	90.00	03	10.00
3.	Leaf roller *Antoba olivacea*	00	00.00	30	100.00	00	00.00	30	100.00	02	6.66	28	93.33
4.	Hairy caterpillar, *Selepa docilis*	05	16.66	25	83.33	00	00.00	30	100.00	03	10.00	27	90.00

MAT- Month after transplanting NOF- Number of farmers

Hairy caterpillar, *S. docilis* incidence were seen at two and three months after transplanting with 83.3, 100 and 90 per cent of the farmers' field in low, mid and high land area respectively. The incidence of hairy caterpillar was present at one month after transplanting with 16.7 and 10 per cent of the farmers' field in low and high land area respectively.

4.1.3 Population of natural enemies of pests of brinjal in farmers' field.

The results presented in Table 5 showed that the farmers' surveyed in the low land area have not observed any population of natural enemies in their field one month after transplanting. However, in the mid land area, 6.7 and 16.7 per cent of farmers' noticed the presence of lady beetles and rove beetles respectively one month after transplanting.

There was an increase in the number of natural enemies when the crop was at two and three months after transplanting. The population of the coccinellids were high in 93.3, 66.7 and 96.7 per cent of the farmers' field at two months after transplanting in low, mid and high land area respectively. It was opinied by 6.7, 26.7 and 3.3 per cent of the farmers' that there was presence of natural enemies at three months after transplanting in low, mid and high land area respectively.

The population of rove beetles was observed by 50, 16.7 and 33.3 per cent of farmers' in low land, mid and high land respectively at two months after transplanting, whereas it was opinied by 30, 66.7 and 63.3 per cent of the farmers' in low, mid and high land area respectively at three months after transplanting. The population of rove beetles was observed by 30, 66.7 and 63.3 per cent of farmers' at three months after transplanting in low, mid and high land area respectively.

The population of spiders was seen after two months of transplanting. It was opinied by 46.7, 30 and 40 per cent of farmers' in low, mid and high land area

Table 5. Population of natural enemies of pest observed by the farmers' in their brinjal field in the three agro climatic regions of Kasargod district

Sl. No.	Category	Low land (30 farmers')						Mid land (30 farmers')						High land (30 farmers')					
		1MAT		2MAT		3MAT		1MAT		2MAT		3MAT		1MAT		2MAT		3MAT	
		NOF	%	NOF	%	NOF	%	NOF	%	NOF	%	NOF	%	NOF	%	NOF	%	NOF	%
1.	Coccinellids	00	00.00	28	93.33	02	6.66	02	6.66	20	66.66	08	26.66	00	00.00	29	96.66	01	03.33
2.	Rove beetles	00	00.00	15	50.00	15	30.00	05	16.66	05	16.66	20	66.66	01	03.33	10	33.33	19	63.33
3.	Spiders	00	00.00	14	46.66	16	53.33	01	03.33	09	30.00	20	66.66	01	03.33	12	40.00	17	56.66

MAT- Month after transplanting NOF- Number of farmers respectively. However, in low, mid and high land area, 53.3, 66.7 and 56.7 per cent of the farmers' respectively noticed the presence of spiders population was high at three months after transplantation respectively.

4.2. EVALUATION OF MICROBIAL PREPARATIONS, BIORATIONAL AND NEEM BASED INSECTICIDES AGAINST MAJOR PESTS OF BRINJAL

Two field experiments were carried out in brinjal crop at the Instructional Farm, College of Agriculture, Padanakkad, to evaluate the efficacy of microbial preparations, biorational and neem based insecticides against major pests of brinjal *viz.,* shoot and fruit borer, *L. orbonalis*; epilachna beetle, *E. vigintioctopunctata*; leaf roller, *A. olivacea* and hairy caterpillar, *S. docilis* during summer (February to May, 2013) and *kharif* (June to October, 2013) season.

4.2.1 Efficacy of microbial preparations, biorational and neem based insecticides against *L. orbonalis* infesting on shoot of brinjal during summer (February to May, 2013) and *kharif* (June to October, 2013) season

The mean per cent infestation of *L. orbonalis* showed that there was significant difference among the treatments (Table 6; Plate 6).

From the results on fifteen days of observation after first application of treatments during summer season revealed that, the T_6 (spinosad 45 SC) showed significantly lowest shoot infestation (6.82 per cent), while the T_9 (control) recorded the highest shoot infestation (26.70 per cent). The treatment T_6 was on par with T_8 (malathion 50 EC) and T_5 (*Bt* formulation) with 8.84 and 9.90 per cent of shoot infestations respectively. The treatments T_5, T_7 (azadirachtin 1%), T_3 (*B. bassiana* talc formulation) and T_4 (*B. bassiana* PDB) were on par each other with shoot infestation of 9.90, 11.92, 12.42 and 12.82 per cent respectively. Shoot infestation in T_5 (9.90 per cent) was significantly different from T_2 (*M. anisopliae* PDB) (15.87 per cent) and T_1 (*M. anisopliae* talc formulation) (17.92 per cent).

Plate 6. Shoot infested by *L. orbonalis*

Table 6. Mean per cent of shoot infestation at different intervals after application of treatments against *L. orbonalis* during summer and *kharif* season

Treatments	Per cent shoot infestation							
	Summer season				*kharif* season			
	15 DAFS	15 DASS	15 DATS	15 DAFRS	15 DAFS	15 DASS	15 DATS	15 DAFRS
T_1	17.92	20.48	24.55	27.66	19.95	23.04	23.76 (4.97)	25.72 (5.16)
T_2	15.87	19.23	23.71	25.35	18.66	20.26	21.95 (4.79)	23.62 (4.96)
T_3	12.42	16.38	19.32	22.47	17.66	19.65	20.75 (4.66)	21.77 (4.77)
T_4	12.82	14.01	17.16	20.31	16.27	17.71	19.45 (4.52)	20.27 (4.61)
T_5	9.90	10.66	11.86	11.58	13.96	13.47	13.35 (3.78)	12.62 (3.69)
T_6	6.82	5.88	4.50	3.77	8.26	6.81	2.93 (1.98)	1.97 (1.72)
T_7	11.92	12.59	13.36	15.07	13.96	13.32	15.14 (4.01)	15.74 (4.09)
T_8	8.84	8.03	7.64	6.55	10.35	10.27	9.96 (3.31)	9.71 (3.27)
T_9	26.70	35.44 (s)	49.72 (s)	57.70 (s)	29.56	39.83 (s)	44.17 (6.72)	45.69 (6.83)
CD at 0.05%	4.79	2.41	3.60	1.55	5.92	2.66	0.98	1.01

Figures in parenthesis denote $\sqrt{x+1}$ transformed values, (s) - Highly significant

DAFS- Days after first spray; DASS- Days after second spray; DATS- Days after third spray; DAFRS- Days after fourth spray.

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B.bassiana* (potato dextrose broth @10^7 spores/ml);T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

The treatment T_7 (11.92 per cent) was significantly different from T_1 (17.92 per cent). The per cent shoot infestation during *kharif* season showed that the per cent shoot infestation ranged from 8.26 per cent in T_6 to 29.56 per cent in T_9. In summer, treatment T_6 recorded significantly lowest shoot infestation, which was on par with T_8 (10.35 per cent), T_7 (13.96 per cent) and T_5 (13.96 per cent). The respective shoot infestation per cent in the treatments T_1, T_2, T_3 and T_4 with 19.95, 18.66, 17.66 and 16.27 and were all on par with each other. However, T_7 and T_5 were significantly different from T_1 (19.95 per cent).

Fifteen days after second application of treatments during summer season, the results showed that the per cent infestation of shoot ranged from 5.88 per cent in T_6 to 35.44 per cent in T_9. Treatment T_6 was on par with T_8 giving 8.03 per cent shoot infestation. Treatment T_5 and T_7 were on par with 10.66 and 12.59 per cent shoot infestation respectively. The T_4 (14.01 per cent) was on par with T_3 (16.38 per cent). The treatment T_2 and T_1 were on par each other with 19.23 and 20.48 per cent shoot infestation respectively. Whereas the treatment T_5 (10.66 per cent) was significantly different from T_4, T_3, T_2 and T_1 with 14.01, 16.38, 19.23 and 20.48 per cent shoot infestation respectively. However, T_7 (12.59 per cent) was significantly different from T_3, T_2 and T_1 with 16.38, 19.23 and 20.48 per cent shoot infestation respectively. The results obtained during *kharif* season revealed that there was a significantly lowest shoot infestation in T_6 (6.81 per cent) followed by T_8 (10.27 per cent), T_7 (13.32 per cent) and T_5 (13.47 per cent), whereas highest per cent shoot infestation was found in T_9 (39.83 per cent) followed by T_1 (23.04 per cent). Treatments T_2, T_3 and T_4 were on par with each other with 20.26, 19.65 and 17.71 per cent shoot infestation respectively. Treatment T_5 (13.47 per cent) was on par with T_7 (13.32 per cent). However, T_5 (13.47 per cent) and T_7 (13.32 per cent) were significantly different from T_4 (17.71 per cent), T_3 (19.65 per cent), T_2 (20.26 per cent) and T_1 (23.04 per cent).

A similar trend in the shoot infestation by *L. orbonalis* was observed on fifteen days after third application of the treatments during summer and *kharif* season. T_6 recorded significantly lowest shoot infestation (4.50 per cent) which was on par with T_8 (7.64 per cent) while, T_9 recorded significantly highest shoot infestation (49.72 per cent). It was found that T_5 and T_7 are on par with each other with 11.86 and 13.36 per cent shoot infestation, respectively. T_4 and T_3 are on par with each other with 17.16 and 19.32 per cent shoot infestation respectively. Treatments T_2 and T_1 were on par with each other with 23.71 and 24.55 per cent shoot infestation respectively. The same trend was observed in T_6 on fifteen days after third application of treatments during *kharif* season, which recorded the lowest (2.93 per cent) shoot infestation, whereas the highest per cent of shoot infestation was recorded in T_9 (44.17 per cent). Treatment T_6 (2.93 per cent) was followed by T_8 and T_5 with 9.96 and 13.35 per cent shoot infestation respectively. Treatments T_1, T_2, T_3, T_4 and T_7 were on par with each other with 23.76, 21.95, 20.75, 19.45 and 15.14 per cent shoot infestation respectively. However, T_5 (13.35 per cent) was significantly different from T_2 (21.95 per cent) and T_1 (23.76 per cent).

Observation on fifteen days after fourth application of treatments during summer season revealed that same trend was observed with T_6 recording minimum mean shoot infestation of 3.77 per cent followed by T_8 and T_5 recording 6.55 and 11.58 per cent shoot infestation respectively. Treatment T_9 recorded significantly maximum mean per cent of shoot infestation (57.70 per cent). During *kharif* 2013 season also the lowest per cent shoot infestation was recorded in T_6 (1.97 per cent) and highest in T_9 (45.69 per cent). T_6 was followed by T_8 and T_5 with 9.71 and 12.62 per cent shoot infestation respectively. The T_1, T_2, T_3 and T_4 were on par with each other with 25.72, 23.62, 21.77 and 20.27 per cent shoot infestation respectively. However, T_5 (12.62 per cent) was significantly different from T_3 (21.77 per cent), T_2 (23.62 per cent) and T_1 (25.72 per cent).

Efficacy of microbial preparations, biorational and neem based insecticides against *L. orbonalis* infesting on fruits of brinjal during summer and *kharif* season.

The results on the per cent fruit infestation on number basis (Table 7) showed a significant difference among the treatments in checking the *L. orbonalis* infestation on fruits.

The data on per cent fruit infestation on number basis revealed that the infestation level ranged from 11.58 to 40.59 per cent on different treatments on fifteen days after first application of treatments during summer season. Treatment T_6 recorded the lowest fruit infestation of 11.58 per cent while the infestation was highest in T_9 (40.59 per cent). T_6 was on par with T_8 (16.47 per cent). Treatments T_7, T_3, T_4, T_1 and T_2 were on par with each other with 24.42, 25.94, 28.60, 29.91 and 30.15 per cent fruit infestation respectively. Treatment T_5 (19.58 per cent) was significantly different from T_4, T_1 and T_2 with 28.60, 29.91 and 30.15 per cent fruit infestation respectively.

Fifteen days after first application of treatments during *kharif* season revealed that the per cent fruit damage ranged from 20.13 per cent in T_6 to 53.33 per cent in T_9. Treatment T_6 (20.13 per cent) was on par with T_8, T_7 and T_5 with 25.26, 29.20 and 30.35 per cent fruit infestation respectively. Treatment T_9 (53.33 per cent) was on par with T_2 (42.85 per cent) and T_1 (41.11 per cent). Treatments T_2, T_1, T_4, T_3 and T_5 were on par with each other with 42.85, 41.11, 35.55, 33.96 and 30.35 per cent of fruit infestation respectively. However, T_7 (29.20 per cent) was significantly different from T_2 (42.85 per cent).

On comparing the fruit infestation over fifteen days after second application of treatments during summer season, T_6 showed significantly lowest fruit infestation (10.34 per cent) which was on par with T_8 (15.75 per cent), while T_9 showed significantly higher fruit infestation of 58.66 per cent. Treatment T_9

Table 7. Mean per cent of fruit infestation at different intervals after application of treatments against *L. orbonalis* during summer and *kharif* season

Treatments	Per cent fruit infestation							
	Summer season				*Kharif* season			
	15 DAFS	15 DASS	15 DATS	15 DAFRS	15 DAFS	15 DASS	15 DATS	15 DAFRS
T_1	29.91 (5.56)	43.32 (6.65)	56.62 (7.59)	66.62 (8.22)	41.11	54.16	62.22	69.06 (8.37)
T_2	30.15 (5.58)	44.99 (6.78)	54.24 (7.43)	62.56 (7.97)	42.85	50.00	54.29	60.63 (7.85)
T_3	25.94 (5.19)	33.33 (5.85)	37.09 (6.17)	52.46 (7.31)	33.96	37.73	42.34	47.31 (6.95)
T_4	28.60 (5.44)	39.58 (6.37)	47.16 (6.93)	51.18 (7.22)	35.55	42.37	46.15	54.92 (7.47)
T_5	19.58 (4.53)	23.35 (4.93)	24.89 (5.08)	26.23 (5.21)	30.35	29.47	29.10	28.17 (5.40)
T_6	11.58 (3.54)	10.34 (3.36)	8.77 (3.12)	4.60 (2.36)	20.13	16.15	13.09	8.03 (3.00)
T_7	24.42 (5.04)	28.87 (5.46)	33.54 (5.87)	38.20 (6.26)	29.20	33.27	36.51	40.42 (6.43)
T_8	16.47 (4.18)	15.75 (4.09)	13.07 (3.75)	12.92 (3.73)	25.26	18.10	15.95	11.84 (3.58)
T_9	40.59 (6.44)	58.66 (7.72)	73.42 (8.62)	86.21 (9.33)	53.33	73.14 (s)	82.73	85.38 (9.29)
CD at 0.05%	0.72	1.20	1.16	1.34	13.08	7.07	10.66	1.38

Figures in parenthesis denote $\sqrt{x+1}$ transformed values (s) - Highly significant

DAFS- Days after first spray; DASS- Days after second spray; DATS- Days after third spray; DAFRS- Days after fourth spray.

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B.bassiana* (potato dextrose broth @10^7 spores/ml);T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

(58.66 per cent) was on par with T_2 and T_1 with 44.99 and 43.32 per cent of fruit infestation respectively. Treatments T_3, T_4, T_1 and T_2 were on par with each other with 33.33, 39.58, 43.32 and 44.99 per cent fruit infestation respectively. T_5 (23.35 per cent) was on par with T_3, T_7 and T_8 with 33.33, 28.87 and 15.75 per cent fruit infestation respectively. Treatment T_5 (23.35 per cent) was significantly different from T_4, T_1 and T_2 with 39.58, 43.32 and 44.99 per cent fruit infestation respectively. However, treatment T_7 (28.87 per cent) was significantly different from T_2 with 44.99 per cent fruit infestation. The results during *kharif* season revealed that significantly lowest per cent of fruit infestation (16.15 per cent) was recorded in T_6, where as higher per cent of fruit infestation (73.14 per cent) was recorded in T_9. T_6 was on par with T_8 (18.10 per cent). The T_7 (33.27 per cent) was on par with T_5 with 29.47 per cent fruit infestation. Treatment T_3 (37.73 per cent) was on par with T_4 and T_7 with 42.37 and 33.27 per cent fruit infestation respectively. However, T_5 (29.4 per cent) was significantly different from T_3 (37.73 per cent), T_4 (42.37 per cent), T_2 (50 per cent) and T_1 (54.16 per cent).

Fifteen days after third application of treatments during summer season, it was observed that there was a decrease in the incidence of *L. orbonalis* on fruits in T_6 with 8.77 per cent fruit infestation which was on par with T_8 (13.07 per cent). Here again the same trend was observed with T_9 which recorded maximum fruit infestation (73.42 per cent) which was on par with T_1 (56.62 per cent). Treatments *viz.*, T_1, T_2 and T_4 were on par with each other with 56.62, 54.24 and 47.16 per cent fruit infestation respectively. Treatments *viz.*, T_7, T_3 and T_4 were on par with each other with 33.54, 37.09 and 47.16 per cent fruit infestation respectively. T_3 (37.09 per cent) was on par with T_7 and T_5 with 33.54 and 24.89 per cent fruit infestation respectively. T_5 (24.89 per cent) was significantly different from T_4, T_2 and T_1 with 47.16, 54.24 and 56.62 per cent fruit infestation respectively. However, treatment T_7 was significantly different from T_2 and T_1 with 33.54, 54.24 and 56.62 per cent fruit infestation respectively. The same trend was observed during *kharif* season with T_6 recording as lowest as 13.09 per cent of fruit infestation while it was highest (82.73 per cent) in T_9. T_6 (13.09 per cent) was on par with T_8 (15.95 per cent). T_7 (36.51 per cent) was on par with T_5 (29.10 per cent). Treatments T_4, T_3 and T_7 were on par with each other with 46.15, 42.34 and 36.51 per cent fruit infestation respectively. However, T_5 (29.10 per cent) was significantly different from T_3 (42.34 per cent), T_4 (46.15 per cent), T_2 (54.29 per cent) and T_1 (62.22 per cent).

Observation recorded fifteen days after fourth application of treatments during summer season revealed that the per cent fruit infestation by *L. orbonalis* ranged from minimum of 4.60 per cent (T_6) to maximum of 86.21 per cent (T_9). Treatment T_6 (4.60 per cent) was followed by T_8 and T_5 with 12.92 and 26.23 per cent fruit infestation respectively. T_9 (86.21 per cent) was on par with T_1 with (66.62 per cent). Treatments T_1, T_2, T_3 and T_4 were on par with each other with 66.62, 62.56, 52.46 and 51.18 per cent fruit infestation respectively. T_7 was on par with T_5 with 38.20 and 26.23 per cent fruit infestation respectively. T_5 (26.23 per cent) was significantly different from T_4, T_3, T_2 and T_1 with 51.18, 52.46, 62.56 and 66.62 per cent fruit infestation respectively. However, T_7 was significantly different from T_2 and T_1 with 38.20, 62.56 and 66.62 per cent fruit infestation respectively. Results on *kharif* season revealed that significantly lowest (8.03 percent) per cent fruit infestation was recorded in T_6 and highest (85.38 per cent) per cent fruit infestation was recorded in T_9. T_6 was on par with T_8 (11.84 per cent). The treatments T_4, T_2 and T_1 were on par with each other with 54.92, 60.63 and 69.06 per cent of fruit infestation respectively. However, T_5 (28.17 per cent) was significantly different from T_3 (47.31 per cent), T_4 (54.92 per cent), T_2 (60.63 per cent) and T_1 (69.06 per cent).

4.2.2 Efficacy of microbial preparations, biorational and neem based insecticides against *E. vigintioctopunctata* infesting on leaves of brinjal during summer (February to May) and *kharif* (June to October) season

The results on field experiment conducted to test the efficacy of microbial preparations, biorational and neem based insecticides against *E.*

vigintioctopunctata infesting on leaves of brinjal during summer and *kharif* season are furnished in Table 8.

Mean per cent of leaf infestation by *E. vigintioctopunctata* on fifteen days after first application of treatments during summer season revealed that the T_8 (26.07 per cent) recorded significantly lowest leaf infestation. However, this was on par with T_7 (27.40 per cent) and T_6 (28.70 per cent), while it was highest in T_9 (42 per cent). T_9 was on par with T_4 (37.98 per cent). Treatments *viz.*, T_1, T_2, T_5 and T_3 were on par with each other with leaf infestation of 32.72, 33.39, 35.67 and 35.73 per cent respectively. Treatment T_7 (27.40 per cent) was significantly different from T_1, T_2, T_5, T_3 and T_4 with 32.72, 33.39, 35.67, 35.73 and 37.98 per cent leaf infestation respectively. However, T_6 (28.70 per cent) was significantly different from T_5, T_3 and T_4 with 35.67, 35.73 and 37.98 per cent leaf infestation respectively. The same trend was followed in *kharif* season, whereas there was a significantly lowest (21.33 per cent) per cent of leaf infestation in T_8 whereas highest (47.60 per cent) per cent of leaf infestation in T_9. T_8 (21.33 per cent) was on par with T_7 (26.82 per cent). T_3, T_5, T_2, T_1 and T_6 were on par with each other with 37.23, 36.78, 35.35, 32.13 and 31.24 per cent of leaf infestation respectively. However, T_7 (26.82 per cent) was significantly different from T_2 (35.35 per cent), T_5 (36.78 per cent), T_3 (37.23 per cent) and T_4 (38.92 per cent).

On comparing the per cent leaf infestation over fifteen days after second application of treatments during summer season, the results revealed that a minimum 26.29 per cent leaf infestation was found in T_7 which was on par with T_8 (20.76 per cent). Maximum per cent leaf infestation of 52.04 per cent was found in T_9 which was on par with T_4 (49.35 per cent). T_3, T_5 and T_2 were on par with each other with 42.58, 41.69 and 37.29 per cent leaf infestation respectively. T_1 (35.30 per cent) was on par with T_6 (30.81 per cent). However, T_7 (26.29 per cent) was significantly different from T_1, T_2, T_5, T_3 and T_4 with 35.30, 37.29, 41.69, 42.58 and 49.35 per cent leaf infestation respectively. During *kharif* season, the per cent leaf infestation ranged from 18.03 per cent in T_8 to 61.68 per

Table 8. Mean per cent of leaf infestation at different intervals after application of treatments against *E. vigintioctopunctata* during summer and *Kharif* season

Treatments	Per cent leaf infestation							
	Summer season				*Kharif* season			
	15 DAFS	15 DASS	15 DATS	15 DAFRS	15 DAFS	15 DASS	15 DATS	15 DAFRS
T_1	32.72	35.30	37.69	39.16	32.13	34.12	38.52	40.73
T_2	33.39	37.29	41.12	44.58	35.35	36.81	39.37	41.73
T_3	35.73	42.58	48.83	52.91	37.23	40.68	49.07	51.17
T_4	37.98	49.35	51.09	57.46	38.92	43.21	50.14	54.44
T_5	35.67	41.69	45.32	48.50	36.78	39.81	44.54	46.89
T_6	28.70	30.81	32.44	34.25	31.24	28.24	23.79	21.80
T_7	27.40	26.29	25.73	24.69	26.82	23.93	18.92	16.50
T_8	26.07	20.76	18.50	14.43	21.33	18.03	13.05	12.43
T_9	42.00 (s)	52.04 (s)	70.59 (s)	80.34 (s)	47.60	61.68 (s)	78.28 (s)	88.80 (s)
CD at 0.05%	4.80	6.75	5.01	6.84	6.26	1.58	2.54	5.97

(s) – Highly significant

DAFS- Days after first spray; DASS- Days after second spray; DATS- Days after third spray; DAFRS- Days after fourth spray.

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

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cent in T_9. T_8 (18.03 per cent) was followed by T_7 and T_6 with 23.93 and 28.24 per cent leaf infestation respectively. T_3 (40.68 per cent) was on par with T_5 (39.81 per cent). However, T_7 (23.93 per cent) was significantly different from T_6, T_1, T_2, T_5, T_3 and T_4 with 28.24, 34.12, 36.81, 39.81, 40.68 and 43.21 per cent leaf infestation respectively.

Data on fifteen days after third application of treatments during summer season, the results revealed that among the biorational insecticides leaf infestation observed in T_7 (25.73 per cent) while by T_8 (standard check) recorded (18.50 per cent) being the lowest. However, highest per cent leaf infestation (70.59 per cent) was recorded in T_9. T_4 (51.09 per cent) was on par with T_3 (48.83 per cent). T_2 and T_1 were on par with each other with 41.12 and 37.69 per cent leaf infestation respectively. T_5 (45.32 per cent) was on par with T_3 and T_2 with 48.83 and 41.12 per cent leaf infestation respectively. Treatment T_7 (25.73 per cent) was significantly different from T_6, T_1, T_2, T_5, T_3 and T_4 with 32.44, 37.69, 41.12, 45.32, 48.83 and 51.09 per cent leaf infestation respectively. The same trend was observed during *kharif* season. Minimum (13.05 per cent) leaf infestation was recorded in T_8 while it was maximum (78.28 per cent) in T_9. Treatment T_8 was followed by T_7 (18.92 per cent). T_2 was on par with T_1 with 39.37 and 38.52 per cent leaf infestation respectively. However, treatment T_7 was significantly different from T_6, T_1, T_2, T_5, T_3 and T_4 with 23.79, 38.52, 39.37, 44.54, 49.07 and 50.14 per cent leaf infestation respectively.

A similar trend was observed on T_7 at fifteen days after fourth application of treatments during summer season. The per cent of leaf infestation ranged from 24.69 per cent in T_7 to 80.34 per cent in T_9. However, treatment T_8 (14.43 per cent) being standard check recorded minimum leaf infestation. There was a significant different between T_6 (32.25 per cent) and T_7 (24.69 per cent). Treatment T_3 (52.91 per cent) was on par with T_4 and T_5 with 57.46 and 48.50 per cent of leaf infestation respectively. Treatment T_1 (39.16 per cent) was on par with T_2 (44.58 per cent) and T_6 (34.25 per cent). Observation recorded during *kharif* season revealed that significantly lowest per cent of leaf infestation (12.43 per cent) was recorded in T_8 which was on par with T_7 (16.50 per cent) whereas highest per cent of leaf infestation (88.80 per cent) was observed in T_9. Treatment T_3 (51.17 per cent) was on par with T_4 (54.44 per cent) and T_5 (46.89 per cent). However, treatment T_7 (16.50 per cent) was significantly different from T_1 (40.73 per cent), T_2 (41.73 per cent), T_5 (46.89 per cent), T_3 (51.17 per cent) and T_4 (54.44 per cent). The results obtained during summer and *kharif* season revealed that the T_7 (azadirachtin 1%) was best among biorational insecticides in reducing the leaf infestation.

Efficacy of microbial preparations, biorational and neem based insecticides against mean count of epilachna grubs on upper, middle and lower leaves of brinjal during summer and *kharif* season

The effect of microbial preparations, biorational and neem based insecticides against mean count of epilachna grubs (Plate 7) on upper, middle and lower three leaves of brinjal during summer (February to May) season were presented in Table 9. The results revealed that there was significant difference among the treatments.

Mean count of epilachna grubs on fifteen days after first application of treatments (Table 9.1) revealed that there was a significant reduction in the mean count of (0.88) grubs in T_8. Treatment T_9 recorded the maximum mean count of (3.33) grubs per plant. Treatments T_7 and T_1 recorded the minimum mean count of 1.43 and 1.20 grubs per plant respectively. However, they were on par with T_8. Treatments T_6 (2.57 grubs) and T_4 (2.93 grubs) were on par with T_9 (3.33 grubs). The population of grubs on different position of leaves on brinjal plants revealed that, there was a higher mean count of (2.76) grubs in upper leaves. However, it was on par with middle (2.31 grubs) and lower (1.13 grubs) leaves.

Plate 7. Epilachna grubs, *E. vigintioctopunctata* infesting on brinjal leaf

Table 9. Mean number of epilachna grubs, *E. vigintioctopunctata* on upper, middle and lower three leaves at different intervals after application of treatment during summer season

Table 9.1. Mean number of epilachna grubs on upper, middle and lower three leaves at fifteen days after first spray

Treatment	Upper	Middle	Lower	Treatment mean
T_1	1.83 (1.68)	1.58 (1.60)	0.34 (1.16)	1.20 (1.48)
T_2	2.39 (1.84)	2.08 (1.75)	1.19 (1.48)	1.87 (1.69)
T_3	2.66 (1.91)	2.28 (1.81)	1.19 (1.48)	2.01 (1.73)
T_4	4.19 (2.27)	3.06 (2.01)	1.74 (1.65)	2.93 (1.98)
T_5	2.99 (1.99)	2.78 (1.94)	1.70 (1.64)	2.47 (1.86)
T_6	3.71 (2.17)	2.72 (1.93)	1.45 (1.56)	2.57 (1.88)
T_7	2.06 (1.75)	1.66 (1.63)	0.68 (1.29)	1.43 (1.56)
T_8	1.02 (1.42)	1.29 (1.51)	0.39 (1.18)	0.88 (1.37)
T_9	4.79 (2.40)	3.71 (2.17)	1.78 (1.66)	3.33 (2.08)
Position mean	2.76 (1.94)	2.31 (1.82)	1.13 (1.46)	

CD for treatment- 0.65
CD for position- 1.14
CD for interaction- NS

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

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

Minimum mean count of grubs were recorded (1.09) in T_8 on fifteen days after second application of treatments (Table 9.2) and the maximum mean count (4.19 grubs) in T_9. Mean count of 1.67 and 2.36 grubs were recorded in T_1 and T_7 respectively, which was on par with T_8 (1.09 grubs). Hence, treatment T_7 (azadiractin 1%) was being less toxic and a derivative of naturally occurring insecticide and T_1 (*M. anisopliae* talc formulation) being a microbial origin, there can be recommended in the field. Treatments T_6 and T_5 with 4.07 and 3.99 grubs per plant respectively, were on par with T_9 (4.19 grubs). Population of grubs on different position of leaves on plant showed that the maximum mean count of grubs were recorded in upper leaves (4.29 grubs), which was on par with middle and lower leaves with mean count of 3.24 and 1.37 grubs respectively.

There was a gradual reduction (Table 9.3) in the mean count of grubs than the previous observations in T_8 with lowest mean count of 1.28 grubs per plant recorded on fifteen days after third application of treatments. However, treatment T_8 was on par with T_1 (2.40 grubs) and T_7 (2.81 grubs). Highest mean count of 5.27 grub was recorded in T_9. However, highest mean count of 5.86 grubs were recorded in upper leaves based on position of grubs population on leaves of brinjal plant, which was on par with mean count of 3.46 grubs on middle leaves, while lowest (1.55) mean count of grubs on lower leaves. Observations recorded on fifteen days after fourth application of the treatments (Table 9.4) revealed that the T_8 (8.4 grubs) was on par with T_1 (1.39 grubs) and T_7 (1.71 grubs). Based on the position of leaves on the plants, the epilachna grubs populations were maximum on upper leaf followed by middle leaves with mean count of 4.60 and 3.69 grubs respectively. Minimum mean count of 0.67 grubs were recorded in lower leaves.

During *kharif* season (Table 10.1) the mean number of grubs ranged from 0.95 in T_8 to 4.76 in T_9 during fifteen days after first application of treatments. The T_8 was on par with T_1 (1.26 grubs) and T_7 (2.02 grubs). Treatment T_9 was on par with T_6 (3.77 grubs) and T_4 (3.26 grubs). Mean count of epilachna grubs on different positions of leaves on brinjal plant revealed that maximum (4.27) grubs

Table 9.2. Mean number of epilachna grubs on upper, middle and lower three leaves at fifteen days after second spray

Treatment	Upper	Middle	Lower	Treatment mean
T_1	1.97 (1.72)	2.09 (1.76)	1.02 (1.42)	1.67 (1.63)
T_2	5.31 (2.51)	2.68 (1.91)	1.06 (1.43)	2.82 (1.95)
T_3	4.45 (2.33)	2.37 (1.83)	1.52 (1.58)	2.68 (1.92)
T_4	4.79 (2.40)	4.65 (2.37)	1.66 (1.63)	3.57 (2.13)
T_5	7.04 (2.83)	3.45 (2.10)	2.04 (1.75)	3.99 (2.23)
T_6	6.35 (2.71)	5.04 (2.45)	1.52 (1.58)	4.07 (2.25)
T_7	3.78 (2.18)	2.45 (1.85)	1.13 (1.46)	2.36 (1.83)
T_8	1.19 (1.48)	1.44 (1.56)	0.68 (1.29)	1.09 (1.44)
T_9	5.31 (2.51)	6.04 (2.65)	1.79 (1.67)	4.19 (2.27)
Position mean	4.29 (2.30)	3.24 (2.05)	1.37 (1.53)	

CD for treatment- 0.79
CD for position- 1.36
CD for interaction- 0.45

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

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

Table 9.3. Mean number of epilachna grubs on upper, middle and lower three leaves at fifteen days after third spray

Treatment	Upper	Middle	Lower	Treatment mean
T_1	4.02 (2.24)	2.45 (1.85)	1.06 (1.43)	2.40 (1.84)
T_2	5.91 (2.62)	3.50 (2.12)	1.44 (1.56)	3.42 (2.10)
T_3	5.39 (2.52)	3.39 (2.09)	1.44 (1.56)	3.25 (2.06)
T_4	6.49 (2.73)	4.52 (2.35)	1.81 (1.67)	4.08 (2.25)
T_5	8.96 (3.15)	4.10 (2.25)	1.78 (1.66)	4.57 (2.36)
T_6	7.80 (2.96)	4.62 (2.37)	2.44 (1.85)	4.75 (2.39)
T_7	5.58 (2.56)	2.44 (1.85)	1.06 (1.43)	2.81 (1.95)
T_8	1.71 (1.64)	1.44 (1.56)	0.74 (1.32)	1.28 (1.51)
T_9	8.69 (3.11)	5.45 (2.54)	2.45 (1.85)	5.27 (2.50)
Position mean	5.86 (2.62)	3.46 (2.11)	1.55 (1.59)	

CD for treatment- 0.84
CD for position- 1.45
CD for interaction- NS

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

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

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Table 9.4. Mean number of epilachna grubs on upper, middle and lower three leaves at fifteen days after fourth spray

Treatment	Upper	Middle	Lower	Treatment mean
T_1	1.88 (1.69)	2.08 (1.75)	0.39 (1.18)	1.39 (1.54)
T_2	3.82 (2.19)	3.14 (2.03)	0.68 (1.29)	2.40 (1.84)
T_3	5.96 (2.63)	3.45 (2.11)	0.34 (1.16)	2.88 (1.97)
T_4	7.72 (2.95)	4.39 (2.32)	0.74 (1.32)	3.83 (2.19)
T_5	3.87 (2.20)	4.24 (2.28)	0.74 (1.32)	2.76 (1.93)
T_6	7.36 (2.89)	4.73 (2.39)	0.96 (1.40)	3.97 (2.22)
T_7	2.09 (1.76)	3.09 (2.02)	0.34 (1.16)	1.71 (1.64)
T_8	2.14 (1.77)	1.52 (1.58)	0.29 (1.13)	1.25 (1.50)
T_9	9.11 (3.18)	7.86 (2.97)	1.71 (1.64)	5.77 (2.60)
Position mean	4.60 (2.36)	3.69 (2.16)	0.67 (1.29)	

CD for treatment- 1.19
CD for position- 2.06
CD for interaction- NS

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

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

were recorded in upper leaves and was on par with middle (2.99 grubs) and lower (0.86 grubs) leaves.

Minimum mean count of grubs were observed (1.71 grubs) in T_8 and the maximum (5.34 grubs) was observed in T_9 during fifteen days after second application of treatments (Table 10.2). Treatment T_8 was on par with T_1, T_7 and T_2 with 2.15, 2.32 and 2.55 grubs respectively. The position of leaves on plant showed that the maximum grubs were recorded in upper leaves (4.35), which was on par with middle and lower leaves with 3.87 and 1.23 grubs respectively.

There was a gradual increase in the mean count of grubs (Table 10.3) than the previous observations during fifteen days after third application of treatments. The lowest mean count of 1.75 grubs was recorded in T_8 and the T_8 was on par with T_1 and T_7 with 2.24 and 2.90 grubs respectively. The highest mean count of 5.13 grubs was observed in upper leaves which was on par with middle (4.55 grubs) and lower leaves (1.79 grubs).

During the observations recorded on fifteen days after fourth application of treatments, the results revealed that the mean count of epilachna grubs ranged from 2.21 in T_8 to 7.09 in T_9 (Table 10.4). Treatment T_9 (7.09 grubs) was on par with T_1 and T_7 with 2.60 and 2.97 grubs respectively. Based on the position of leaves on plant, epilachna grub populations were maximum on upper leaves (4.93 grubs). However, they were on par with middle (4.78) and lower (1.89) leaves.

Table 10. Mean number of epilachna grubs, *E. vigintioctopunctata* on upper, middle and lower three leaves at different intervals after application of treatments during *kharif* season

Table 10.1. Mean number of epilachna grubs on upper, middle and lower three leaves at fifteen days after first spray

Treatment	Upper	Middle	Lower	Treatment mean
T_1	2.37 (1.83)	1.38 (1.54)	0.29 (1.13)	1.26 (1.50)
T_2	3.83 (2.19)	2.24 (1.80)	0.68 (1.29)	2.11 (1.76)
T_3	4.77 (2.40)	3.70 (2.16)	0.96 (1.40)	2.96 (1.99)
T_4	5.00 (2.45)	4.35 (2.31)	1.03 (1.42)	3.26 (2.06)
T_5	4.46 (2.33)	3.47 (2.11)	0.85 (1.36)	2.75 (1.93)
T_6	6.03 (2.65)	4.75 (2.39)	1.27 (1.50)	3.77 (2.18)
T_7	4.02 (2.24)	1.83 (1.68)	0.68 (1.29)	2.02 (1.74)
T_8	2.09 (1.76)	0.68 (1.29)	0.29 (1.13)	0.95 (1.39)
T_9	6.84 (2.80)	6.11 (2.66)	2.00 (1.73)	4.76 (2.40)
Position mean	4.27 (2.29)	2.99 (1.99)	0.86 (1.36)	

CD for treatment- 1.21
CD for position- 2.10
CD for interaction- NS

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

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

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Table 10.2. Mean number of epilachna grubs on upper, middle and lower three leaves at fifteen days after second spray

Treatment	Upper	Middle	Lower	Treatment mean
T_1	3.37 (2.09)	2.75 (1.93)	0.68 (1.29)	2.15 (1.77)
T_2	3.58 (2.14)	3.45 (2.11)	0.97 (1.40)	2.55 (1.88)
T_3	4.26 (2.29)	4.43 (2.33)	1.38 (1.54)	3.22 (2.05)
T_4	4.81 (2.41)	4.90 (2.43)	1.45 (1.56)	3.56 (2.13)
T_5	3.92 (2.21)	3.90 (2.21)	1.03 (1.42)	2.81 (1.95)
T_6	5.67 (2.58)	5.54 (2.55)	1.64 (1.62)	4.09 (2.25)
T_7	3.67 (2.16)	2.71 (1.92)	0.91 (1.38)	2.32 (1.82)
T_8	3.11 (2.02)	1.78 (1.66)	0.54 (1.24)	1.71 (1.64)
T_9	7.39 (2.89)	6.22 (2.68)	2.88 (1.97)	5.34 (2.51)
Position mean	4.35 (2.31)	3.87 (2.20)	1.23 (1.49)	

CD for treatment- 1.07
CD for position- 1.86
CD for interaction- NS

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

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

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Table 10.3. Mean number of epilachna grubs on upper, middle and lower three leaves at fifteen days after third spray

Treatment	Upper	Middle	Lower	Treatment mean
T_1	3.44 (2.10)	3.08 (2.02)	0.62 (1.27)	2.24 (1.80)
T_2	4.69 (2.38)	3.94 (2.22)	1.49 (1.58)	3.25 (2.06)
T_3	5.57 (2.56)	5.13 (2.47)	1.95 (1.71)	4.07 (2.25)
T_4	6.46 (2.73)	5.06 (2.46)	2.37 (1.83)	4.49 (2.34)
T_5	5.10 (2.47)	4.83 (2.41)	2.07 (1.75)	3.90 (2.21)
T_6	7.01 (2.83)	6.39 (2.71)	3.09 (2.02)	5.37 (2.52)
T_7	4.20 (2.28)	3.87 (2.20)	1.06 (1.43)	2.90 (1.97)
T_8	2.61 (1.90)	2.15 (1.77)	0.68 (1.29)	1.75 (1.65)
T_9	8.04 (3.00)	7.40 (2.89)	3.53 (2.12)	6.17 (2.67)
Position mean	5.13 (2.47)	4.55 (2.35)	1.79 (1.67)	

CD for treatment- 1.10
CD for position- 1.91
CD for interaction- NS

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

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

Table 10.4. Mean number of epilachna grubs on upper, middle and lower three leaves at fifteen days after fourth spray

Treatment	Upper	Middle	Lower	Treatment mean
T_1	3.24 (2.05)	3.38 (2.09)	1.38 (1.54)	2.60 (1.89)
T_2	4.02 (2.24)	4.64 (2.37)	1.70 (1.64)	3.35 (2.08)
T_3	4.69 (2.38)	4.51 (2.34)	1.82 (1.68)	3.57 (2.13)
T_4	5.74 (2.59)	5.60 (2.56)	1.76 (1.66)	4.18 (2.27)
T_5	4.48 (2.34)	5.02 (2.45)	1.61 (1.61)	3.56 (2.13)
T_6	7.87 (2.97)	6.05 (2.65)	2.06 (1.75)	5.06 (2.46)
T_7	3.36 (2.09)	4.14 (2.26)	1.64 (1.62)	2.97 (1.99)
T_8	3.10 (2.02)	2.30 (1.81)	1.36 (1.53)	2.21 (1.79)
T_9	9.30 (3.20)	8.40 (3.06)	4.10 (2.25)	7.09 (2.84)
Position mean	4.93 (2.43)	4.78 (2.40)	1.89 (1.70)	

CD for treatment- 1.04
CD for position- 1.81
CD for interaction- NS

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

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

Efficacy of microbial preparations, biorational and neem based insecticides against mean count of epilachna beetles on upper, middle and lower leaves of brinjal during summer and *kharif* season

In the field experiment conducted during summer season, the efficacy of microbial preparations, biorational and neem based insecticides were evaluated against the adults (Plate 8) of *E. vigintioctopunctata* in brinjal and the results are presented in (Table 11).

The mean count of epilachna adults on fifteen days after first application of treatments (Table 11.1) revealed that there was a significant reduction in the mean count of (0.33) adults as seen in T_8. T_9 recorded the maximum mean count of (1.93) adults. T_1 (0.55 adults) and T_7 (0.65 adults) were on par with T_8. T_6 and T_4 with 1.38 and 1.45 adults respectively, were on par with T_9 (1.93 adults). Population of adults on different position of leaves on brinjal plant revealed that, even though higher count was recorded in upper leaves (1.65 adult), it was on par with middle (1.10 adult) and lower (0.29 adult) leaves.

Minimum adults were recorded (0.52 adults) in T_8 on fifteen days after second application of treatments (Table 11.2) and the maximum 2.17 adults recorded in T_9. Treatments T_1 (0.65 adults) and T_7 (1.01 adults) were on par with T_8 (0.52 adults). The population of adults on different position of leaves on plant showed that the maximum adults were recorded in upper leaves (1.81). However, it was on par with middle and lower leaves with 1.56 and 0.59 adults respectively.

There was a slight reduction in the mean count of adults than the previous observations in T_8 during fifteen days after third application of treatments with 0.68 adults (Table 11.3). However, treatment T_8 was on par with T_1 (0.90 adults) and T_7 (1.04 adults). As far as the population of adults on different position of leaves are concerned same trend was seen as in previous observations.

Plate 8. Epilachna adult, *E. vigintioctopunctata* infesting on brinjal leaf

Table 11. Mean number of epilachna adults, *E. vigintioctopunctata* on upper, middle and lower three leaves at different intervals after application of treatment during summer season

Table 11.1. Mean number of epilachna adults on upper, middle and lower three leaves at fifteen days after first spray

Treatment	Upper	Middle	Lower	Treatment mean
T_1	1.13 (1.46)	0.62 (1.27)	0.00 (1.00)	0.55 (1.24)
T_2	1.38 (1.54)	1.06 (1.43)	0.29 (1.13)	0.88 (1.37)
T_3	1.06 (1.43)	1.13 (1.46)	0.29 (1.13)	0.80 (1.34)
T_4	2.59 (1.89)	1.79 (1.67)	0.29 (1.13)	1.45 (1.56)
T_5	1.71 (1.64)	1.13 (1.46)	0.29 (1.13)	1.00 (1.41)
T_6	1.84 (1.68)	1.79 (1.67)	0.62 (1.27)	1.38 (1.54)
T_7	1.13 (1.46)	0.59 (1.26)	0.29 (1.13)	0.65 (1.28)
T_8	0.68 (1.29)	0.34 (1.16)	0.00 (1.00)	0.33 (1.15)
T_9	3.93 (2.22)	1.70 (1.64)	0.62 (1.27)	1.93 (1.71)
Position mean	1.65 (1.62)	1.10 (1.44)	0.29 (1.13)	

CD for treatment- 0.54
CD for position- 0.93
CD for interaction- NS

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

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

Table 11.2. Mean number of epilachna adults on upper, middle and lower three leaves at fifteen days after second spray

Treatment	Upper	Middle	Lower	Treatment mean
T_1	0.74 (1.32)	0.97 (1.40)	0.29 (1.13)	0.65 (1.28)
T_2	2.44 (1.85)	1.38 (1.54)	0.29 (1.13)	1.28 (1.51)
T_3	1.71 (1.64)	1.57 (1.60)	0.62 (1.27)	1.28 (1.51)
T_4	2.71 (1.92)	2.02 (1.73)	0.68 (1.29)	1.73 (1.65)
T_5	2.07 (1.75)	2.06 (1.75)	0.62 (1.27)	1.54 (1.59)
T_6	2.86 (1.96)	1.70 (1.64)	0.62 (1.27)	1.65 (1.62)
T_7	1.25 (1.50)	1.19 (1.48)	0.62 (1.27)	1.01 (1.42)
T_8	0.54 (1.24)	0.68 (1.29)	0.34 (1.16)	0.52 (1.23)
T_9	2.55 (1.88)	2.77 (1.94)	1.31 (1.52)	2.17 (1.78)
Position mean	1.81 (1.67)	1.56 (1.60)	0.59 (1.26)	

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

CD for treatment- 0.65
CD for position- 1.13
CD for interaction- NS

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

Table 11.3. Mean number of epilachna adults on upper, middle and lower three leaves at fifteen days after third spray

Treatment	Upper	Middle	Lower	Treatment mean
T_1	1.44 (1.56)	1.06 (1.43)	0.29 (1.13)	0.90 (1.38)
T_2	2.32 (1.82)	1.50 (1.58)	0.29 (1.13)	1.29 (1.51)
T_3	2.06 (1.75)	1.52 (1.58)	0.29 (1.13)	1.22 (1.49)
T_4	3.12 (2.03)	2.07 (1.75)	0.62 (1.27)	1.84 (1.68)
T_5	2.05 (1.74)	2.06 (1.75)	0.77 (1.33)	1.59 (1.61)
T_6	2.65 (1.91)	2.32 (1.82)	0.29 (1.13)	1.63 (1.62)
T_7	1.58 (1.60)	1.38 (1.54)	0.29 (1.13)	1.04 (1.43)
T_8	0.74 (1.32)	1.06 (1.43)	0.29 (1.13)	0.68 (1.29)
T_9	2.77 (1.94)	2.90 (1.97)	1.06 (1.43)	2.18 (1.78)
Position mean	2.04 (1.74)	1.73 (1.65)	0.46 (1.20)	

CD for treatment- 0.59
CD for position- 1.03
CD for interaction- NS

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

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

A similar trend were seen from the observation (Table 11.4) recorded on fifteen days after fourth application of treatments. T_8 recorded lowest (0.43) adults while T_9 recorded highest (2.28) adults. However, T_8 was on par with T_1 (0.67 adults) and T_7 (0.89 adults). T_4 and T_6 recorded 1.58 and 1.50 adults respectively, and they were on par with T_9. Based on the position of leaves on plant, epilachna adult populations were maximum on upper leaves (2.07 adults) and middle leaves (1.31 adults). Minimum 0.32 adults were recorded in lower leaves and they were on par with each other.

The results of the experiment conducted during *kharif* season were presented in Table 12.

Number of adults ranged from 0.33 in T_8 to 2.55 in T_9 during the observations on fifteen days after first application of treatments (Table 12.1). T_8 was on par with T_1 (0.55 adults) and T_7 (0.74 adults). T_9 was on par with T_6 and T_4 with 1.88 and 1.57 adults respectively. Mean count of epilachna adults on different positions of leaves on brinjal revealed that the maximum (1.67 adults) adults were recorded in upper leaves was on par with middle (1.42 adults) and (0.58 adults) lower leaves.

Minimum mean count adults were observed (0.45 adults) in T_8 during fifteen days after second application of treatments (Table 12.2). Maximum mean count of (2.88) adults per plant was observed in T_9. T_8 was on par with T_1 (0.56 adults) and T_7 (0.90 adults). The position of leaves on plant in the incidence of adults showed that the maximum adults were recorded in upper leaves (2.32 adults), which was on par with middle (1.49 adults) and lower (0.78 adults) leaves.

There was a gradual reduction in the mean count of adults per plant during fifteen days after third application of treatments (Table 12.3) than the previous observations. The lowest number of adults were observed in T_8 (0.77 adults) and highest mean count of adults was observed in T_9 (3.26 adults). Treatment T_8

Table 11.4. Mean number of epilachna adults on upper, middle and lower three leaves at fifteen days after fourth spray

Treatment	Upper	Middle	Lower	Treatment mean
T_1	1.50 (1.58)	0.68 (1.29)	0.00 (1.00)	0.67 (1.29)
T_2	1.73 (1.65)	1.52 (1.58)	0.34 (1.16)	1.15 (1.46)
T_3	1.78 (1.66)	1.25 (1.50)	0.29 (1.13)	1.06 (1.43)
T_4	2.72 (1.93)	2.06 (1.75)	0.29 (1.13)	1.58 (1.60)
T_5	2.05 (1.74)	1.65 (1.62)	0.29 (1.13)	1.26 (1.50)
T_6	2.64 (1.90)	1.44 (1.56)	0.62 (1.27)	1.50 (1.58)
T_7	1.51 (1.58)	0.96 (1.40)	0.29 (1.13)	0.89 (1.37)
T_8	1.13 (1.46)	0.29 (1.13)	0.00 (1.00)	0.43 (1.19)
T_9	3.99 (2.23)	2.32 (1.82)	0.91 (1.38)	2.28 (1.81)
Position mean	2.07 (1.75)	1.31 (1.52)	0.32 (1.14)	

CD for treatment- 0.55
CD for position- 0.95
CD for interaction- NS

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

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

Table 12. Mean number of epilachna adults, *E. vigintioctopunctata* on upper, middle and lower three leaves at different intervals after application of treatments during *kharif* season

Table 12.1. Mean number of epilachna adults on upper, middle and lower three leaves at fifteen days after first spray

Treatment	Upper	Middle	Lower	Treatment mean
T_1	0.68 (1.29)	0.68 (1.29)	0.219 (1.13)	0.55 (1.24)
T_2	1.27 (1.50)	1.19 (1.48)	0.39 (1.18)	0.93 (1.39)
T_3	2.00 (1.73)	1.70 (1.64)	0.68 (1.29)	1.43 (1.55)
T_4	2.09 (1.76)	1.99 (1.72)	0.74 (1.32)	1.57 (1.60)
T_5	1.78 (1.66)	1.38 (1.54)	0.62 (1.27)	1.23 (1.49)
T_6	2.62 (1.90)	2.19 (1.78)	0.97 (1.40)	1.88 (1.69)
T_7	0.91 (1.38)	1.06 (1.43)	0.29 (1.13)	0.74 (1.31)
T_8	0.68 (1.29)	0.34 (1.16)	0.00 (1.00)	0.33 (1.15)
T_9	3.69 (2.16)	2.69 (1.92)	1.44 (1.56)	2.55 (1.88)
Position mean	1.67 (1.63)	1.42 (1.55)	0.58 (1.25)	

CD for treatment- 0.73
CD for position- 1.27
CD for interaction- NS

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

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

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Table 12.2. Mean number of epilachna adults on upper, middle and lower three leaves at fifteen days after second spray

Treatment	Upper	Middle	Lower	Treatment mean
T_1	0.74 (1.32)	0.68 (1.29)	0.29 (1.13)	0.56 (1.25)
T_2	2.57 (1.89)	1.52 (1.58)	0.62 (1.27)	1.51 (1.58)
T_3	2.90 (1.97)	1.78 (1.66)	0.29 (1.13)	1.54 (1.59)
T_4	2.93 (1.98)	1.71 (1.64)	0.62 (1.27)	1.67 (1.63)
T_5	2.97 (1.99)	1.76 (1.66)	1.70 (1.64)	2.12 (1.76)
T_6	3.57 (2.13)	2.44 (1.85)	1.13 (1.46)	2.30 (1.81)
T_7	1.38 (1.54)	0.74 (1.32)	0.62 (1.27)	0.90 (1.38)
T_8	0.68 (1.29)	0.34 (1.16)	0.34 (1.16)	0.45 (1.20)
T_9	4.10 (2.25)	3.02 (2.00)	1.70 (1.64)	2.88 (1.97)
Position mean	2.32 (1.82)	1.49 (1.57)	0.78 (1.33)	

CD for treatment- 0.67
CD for position- 1.17
CD for interaction- NS

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

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

Table 12.3. Mean number of epilachna adults on upper, middle and lower three leaves at fifteen days after third spray

Treatment	Upper	Middle	Lower	Treatment mean
T_1	1.58 (1.60)	0.96 (1.40)	0.00 (1.00)	0.78 (1.33)
T_2	2.00 (1.73)	1.78 (1.66)	1.06 (1.43)	1.60 (1.61)
T_3	3.17 (2.04)	2.27 (1.80)	1.06 (1.43)	2.10 (1.76)
T_4	2.96 (1.99)	2.37 (1.83)	0.68 (1.29)	1.91 (1.70)
T_5	2.45 (1.85)	2.00 (1.73)	1.38 (1.54)	1.93 (1.71)
T_6	3.37 (2.09)	2.73 (1.93)	1.38 (1.54)	2.44 (1.85)
T_7	1.71 (1.64)	1.70 (1.64)	1.06 (1.43)	1.48 (1.57)
T_8	1.44 (1.56)	0.68 (1.29)	0.29 (1.13)	0.77 (1.33)
T_9	5.39 (2.52)	3.09 (2.02)	1.70 (1.64)	3.26 (2.06)
Position mean	2.59 (1.89)	1.90 (1.70)	0.92 (1.38)	

CD for treatment- 0.69
CD for position- 1.20
CD for interaction- NS

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

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

was on par with T_1 (0.78 adults) and T_7 (1.48 adults). Highest number of (2.59) adults were observed in upper leaves. However, there was no significant difference on number of adults to that of position of leaves on plant.

Mean count of epilachna adults ranged from 0.93 in T_8 to 3.52 in T_9 when observation recorded on fifteen days after fourth application of treatments (Table 12.4). Treatment T_8 was on par with T_1 (1.23 adults) and T_7 (1.57 adults).

4.2.3 Efficacy of microbial preparations, biorational and neem based insecticides against *A. olivacea* on brinjal during summer and *kharif* season

Extent of damage caused by *A. olivacea* (Plate 9) was expressed as mean per cent of leaf infestation per plant and were presented in Table 13.

Observations recorded on fifteen days after first application of treatments during summer season revealed that the infestation was minimum in T_5 (7.07 per cent), while it was maximum in T_9 (12.60 per cent). Treatment T_5 was on par with T_8 and T_7 with 7.15 and 8.01 per cent leaf infestation respectively. However, other treatments were on par with each other except that T_6 (8.87 per cent) being significantly different from T_4 (11.29 per cent). Observation recorded during *kharif* season showed that the minimum (4.06) per cent leaf infestation were recorded in T_8. Treatment T_8 was on par with T_5 (4.08 per cent), T_6 (4.93 per cent) and T_7 (5.00 per cent). Microbial preparations were on par with each other. However, treatments T_6 (4.93 per cent) and T_7 (5.00 per cent) were significantly different from T_3, T_1, T_4 and T_2 with 7.21, 7.28, 7.84 and 7.90 per cent leaf infestation respectively.

After fifteen days of second application of treatments during summer season, the same trend was observed with minimum leaf infestation in T_5 (5.06 per cent), which was on par with T_8 and T_6 with 6.00 and 7.05 per cent leaf infestation respectively. However, treatments T_2, T_3, T_1 and T_4 were on par with

Table 12.4. Mean number of epilachna adults on upper, middle and lower three leaves at fifteen days after fourth spray

Treatment	Upper	Middle	Lower	Treatment mean
T_1	2.00 (1.73)	1.61 (1.61)	0.29 (1.13)	1.23 (1.49)
T_2	2.64 (1.91)	3.09 (2.02)	0.68 (1.29)	2.04 (1.74)
T_3	3.71 (2.17)	3.65 (2.15)	0.96 (1.40)	2.64 (1.91)
T_4	4.02 (2.24)	3.37 (2.09)	1.21 (1.48)	2.76 (1.94)
T_5	3.16 (2.04)	3.22 (2.05)	0.68 (1.29)	2.23 (1.79)
T_6	4.85 (2.41)	4.03 (2.24)	1.73 (1.65)	3.43 (2.10)
T_7	2.30 (1.81)	2.38 (1.84)	0.34 (1.16)	1.57 (1.60)
T_8	2.02 (1.73)	0.68 (1.29)	0.29 (1.13)	0.93 (1.39)
T_9	5.13 (2.47)	4.11 (2.26)	1.70 (1.64)	3.52 (2.12)
Position mean	3.24 (2.06)	2.82 (1.95)	0.84 (1.35)	

CD for treatment- 0.86
CD for position- 1.49
CD for interaction- NS

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

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

Plate 9. Leaf roller, *A. olivacea* larva infesting on brinjal leaf

Table 13. Mean per cent of leaves infestation at different intervals after application of treatments against *A. olivacea* during summer and *kharif* season

Treatment	Per cent leaf infestation							
	Summer season				*Kharif* season			
	15 DAFS	15 DASS	15 DATS	15 DAFRS	15 DAFS	15 DASS	15 DATS	15 DAFRS
T_1	10.06	12.63	13.01	14.57	7.28	8.21	10.91	12.12
T_2	10.57	11.72	12.39	13.98	7.90	9.37	14.10	16.12
T_3	10.04	12.19	15.05	17.23	7.21	8.13	10.13	11.26
T_4	11.29	13.55	15.96	17.33	7.84	9.15	12.36	14.57
T_5	7.07	5.06	3.92	2.39	4.08	3.24	2.08	1.81
T_6	8.87	7.05	6.13	5.18	4.93	4.55	4.57	4.29
T_7	8.01	8.51	7.76	7.08	5.00	5.11	5.26	6.27
T_8	7.15	6.00	4.04	3.32	4.06	3.28	3.08	2.79
T_9	12.60	16.43	21.02	25.37	10.97	13.96	16.13	20.01
CD at 0.05%	1.75	2.18	1.12	1.33	1.38	0.76	0.88	1.58

DAFS- Days after first spray; DASS- Days after second spray; DATS- Days after third spray; DAFRS- Days after fourth spray.

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

each other with 11.72, 12.19, 12.63 and 13.55 per cent leaf infestation respectively. Treatment T_7 (8.51 per cent) was on par with T_8 and T_6 with 6.00 and 7.05 per cent leaf infestation respectively. Mean per cent leaf infestation ranged from 3.24 in T_5 to 13.96 in T_9 on fifteen days after second application of treatments during *kharif* season. Treatment T_5 was on par with T_8 (3.28 per cent). The treatments T_7 and T_6 were on par with each other with 5.11 and 4.55 per cent leaf infestation respectively. The treatments T_2 and T_4 were on par with each other with 9.37 and 9.15 per cent leaf infestation respectively. However, treatments T_6 (4.55 per cent) and T_7 (5.11 per cent) were significantly different from T_3, T_1, T_4 and T_2 with 8.13, 8.21, 9.15 and 9.37 per cent leaf infestation respectively.

There was a gradual decrease in the per cent leaf infestation in biorational and neem based insecticide treated plots on fifteen days after third application of treatments during summer season, than the previous observations. Treatment T_5 exhibited 3.92 per cent leaf infestation where as it was highest (21.02 per cent) in T_9. The T_5 (3.92 per cent) was on par with T_8 (4.04 per cent). Treatment T_4 was on par with T_3 with 15.96 and 15.05 per cent leaf infestation respectively. Treatment T_6 (6.13 per cent) was significantly different from T_7 (7.76 per cent), T_2 (12.39 per cent), T_1 (13.01 per cent), T_3 (15.05 per cent) and T_4 (15.96 per cent). However, treatment T_7 was significantly different from the microbial preparation. Observations during *kharif* season revealed that a minimum per cent leaf infestation (2.08 per cent) was observed in T_5, whereas the leaf infestation was maximum in T_9 (16.13 per cent). Treatment T_5 was followed by T_8 (3.08 per cent) and T_6 (4.57 per cent). Treatment T_1 (10.91 per cent) was on par with T_3 (10.13 per cent). However, treatments T_6 (4.57 per cent) and T_7 (5.26 per cent) were significantly different from T_3, T_1, T_4 and T_2 with 10.13, 10.91, 12.36 and 14.10 per cent leaf infestation respectively.

The per cent leaf infestation ranged from 2.39 per cent in T_5 to 25.37 per cent in T_9 on fifteen days after fourth application of treatments during summer season. The T_5 (2.39 per cent) was on par with T_8 (3.32 per cent). Treatment T_4 was on par with T_3 with 17.33 and 17.23 per cent leaf infestation respectively. Treatment T_1 was on par with T_2 with 14.57 and 13.98 per cent leaf infestation respectively, whereas treatment T_6 was significantly different from T_7, T_2, T_1, T_3 and T_4 with 7.08, 13.98, 14.57, 17.23 and 17.33 per cent leaf infestation respectively. However, treatment T_7 was significantly different from the microbial preparation. The same trend was observed on fifteen days after fourth application of treatments during *kharif* season with T_5 recording minimum (1.81) per cent leaf infestation, whereas maximum per cent leaf infestation was observed in T_9 (20.01 per cent). Treatment T_5 was on par with T_8 (2.79 per cent). However, treatment T_6 was significantly different from T_7, T_3, T_1, T_4 and T_2 with 6.27, 11.26, 12.12, 14.57 and 16.12 per cent leaf infestation respectively.

4.2.4 Efficacy of microbial preparations, biorational and neem based insecticides against *S. docilis* on brinjal during summer and *kharif* season

The results of the experiment were furnished in Table 14.

Lesser per cent leaf infestation by *S. docilis* (Plate 10) was found on fifteen days after first application of treatments during summer season in biorational and neem based insecticide treated plots compared to microbial preparations and untreated control. T_8 (standard check) recorded minimum leaf infestation (5.06 per cent) which was on par with T_7 (6.06 per cent), where as treatment T_9 recorded significantly maximum leaf infestation (11.83 per cent). Treatments *viz.*, T_6, T_5, T_3, T_4, T_1 and T_2 were on par with each other with 7.08, 7.17, 7.26, 7.89, 8.37 and 8.42 per cent leaf infestation respectively. However, treatment T_7 (6.06 per cent) was significantly different from T_4, T_1 and T_2 with 7.89, 8.37 and 8.42 per cent leaf infestation respectively.

During *kharif* season, the results revealed that there was a significant reduction in the per cent leaf infestation in T_8 (4.04 per cent) whereas there was a increase in the per cent leaf infestation in T_9 (11.95 per cent). The treatment T_8

Plate 10. Hairy caterpillar, *S. docilis* larva infesting on brinjal leaf

Table 14. Mean per cent of leaves infestation at different intervals after application of treatments against *S. docilis* during summer and *kharif* season

Treatment	Per cent leaf infestation							
	Summer season				*Kharif* season			
	15 DAFS	15 DASS	15 DATS	15 DAFRS	15 DAFS	15 DASS	15 DATS	15 DAFRS
T_1	8.37	9.05	9.98	10.21	7.93	9.32	12.35	14.01
T_2	8.42	9.19	10.37	11.95	8.10	10.07	13.46	15.69
T_3	7.26	7.71	8.00	8.14	7.04	8.14	9.51	11.97
T_4	7.89	8.04	8.25	9.38	7.55	9.37	12.09	13.99
T_5	7.17	5.06	4.12	2.07	5.71	3.96	2.47	0.74
T_6	7.08	6.24	5.24	4.13	5.48	4.18	2.82	1.09
T_7	6.06	4.04	2.97	1.47	4.55	3.46	2.25	0.50
T_8	5.06	3.00	1.68	0.91	4.04	3.13	2.01	0.37
T_9	11.83	13.63	15.28	18.06	11.95	14.98	16.83	18.89
CD at 0.05%	1.69	2.29	1.36	0.93	1.64	0.97	0.53	1.11

DAFS- Days after first spray; DASS- Days after second spray; DATS- Days after third spray; DAFRS- Days after fourth spray.

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

was on par with T_7 (4.55 per cent) and T_6 (5.48 per cent). The T_2, T_1, T_4 and T_3 were on par with each other with 8.10, 7.93, 7.55 and 7.04 per cent leaf infestation respectively. However, treatment T_7 (4.55 per cent) was significantly different from T_3, T_4, T_1 and T_2 with 7.04, 7.55, 7.98 and 8.10 per cent leaf infestation respectively.

Observations recorded fifteen days after second application of treatments during summer season revealed that there was a reduction in leaf infestation in T_8 (3.00 per cent), which was on par with T_7 and T_5 with 4.04 and 5.06 per cent leaf infestation respectively. There was an increase per cent leaf infestation in T_9 (13.63 per cent). Treatments T_2, T_1, T_4 and T_3 were on par with each other with 9.19, 9.05, 8.04 and 7.71 per cent leaf infestation respectively. Treatments T_6, T_5 and T_7 were on par with each other with 6.24, 5.06 and 4.04 per cent leaf infestation respectively. However, treatments T_7 and T_5 were significantly different from T_3, T_4, T_1 and T_2 with 7.71, 8.04, 9.05 and 9.19 per cent leaf infestation respectively. The results during *kharif* season showed that the lowest (3.13) per cent leaf infestation was recorded in T_8 and highest (14.98 per cent) in T_9. Treatment T_8 was on par with T_7 (3.46 per cent) and T_5 (3.96 per cent). Treatments T_2, T_4 and T_1 were on par with each other with 10.07, 9.37 and 9.32 per cent leaf infestation respectively. However, treatment T_7 (3.46 per cent) was significantly different from T_3, T_1, T_4 and T_2 with 8.14, 9.32, 9.37 and 10.07 per cent leaf infestation respectively.

The per cent leaf infestation on fifteen days after third application of treatments during summer season revealed that the minimum per cent leaf infestation were found in T_8 (1.68 per cent) and maximum in T_9 (15.28 per cent). The T_8 was on par with T_7 (2.97 per cent). Treatment T_2 (10.37 per cent) was on par with T_1 (9.98 per cent). Treatment T_4 was on par with T_3 with 8.25 and 8 per cent leaf infestation respectively. However, treatment T_6 (5.24 per cent) was on par with T_5 (4.12 per cent). The results during *kharif* season showed that lowest per cent (2.01 per cent) leaf infestation was observed in T_8, whereas, highest per cent (16.83 per cent) leaf infestation was observed in T_9. T_8 was on par with T_7 (2.25 per cent) and T_5 (2.47 per cent). Treatment T_1 (12.35 per cent) was on par with T_4 (12.09 per cent). However, T_7 (2.25 per cent) was significantly different from T_6, T_3, T_4, T_1 and T_2 with 2.82, 9.51, 12.09, 12.35 and 13.46 per cent leaf infestation respectively.

There was a slight reduction in the per cent leaf infestation as revealed from the observations taken fifteen days after fourth application of treatments during summer season. The lowest per cent leaf infestation (0.91 per cent) were recorded in T_8 which was on par with T_7 (1.47 per cent) followed by T_5 (2.07 per cent) whereas T_9 recorded highest (18.06) per cent leaf infestation. Treatments T_1 and T_4 were on par with each other with 10.21 and 9.38 per cent leaf infestation respectively. However, T_7 (1.47 per cent) was significantly different from treatments T_6 (4.13 per cent), T_3 (8.14 per cent), T_4 (9.38 per cent), T_1 (10.21 per cent) and T_2 (11.95 per cent). The results during *kharif* season showed that significantly lowest per cent leaf infestation was observed in T_8 (0.37 per cent) and highest per cent leaf infestation in T_9 (18.89 per cent). Treatment T_8 was on par with T_7, T_5 and T_6 with 0.50, 0.74 and 1.09 per cent leaf infestation respectively. However, T_7 (0.50 per cent) was significantly different from treatments T_3, T_4, T_1 and T_2 with 11.97, 13.99, 14.01 and 45.69 per cent leaf infestation respectively.

4.2.5 Effect of microbial preparations, biorational and neem based insecticides against the population of coccinellids on brinjal ecosystem during summer and *kharif* season

The activity of coccinellids on the brinjal ecosystem based on mean number of coccinellids per plant is presented in Table 15.

There was a significant variation in the activity of coccinellids in terms of number from fifteen days after first application of treatments during summer season. The minimum (0.78) coccinellids per plant was observed in T_8, which

Table 15. Mean number of coccinellids at different intervals after application of treatments during summer and *kharif* season

Treatment	Mean number of coccinellids							
	Summer season				*Kharif* season			
	15 DAFS	15 DASS	15 DATS	15 DAFRS	15 DAFS	15 DASS	15 DATS	15 DAFRS
T_1	1.06 (1.43)	1.79 (1.67)	1.79 (1.67)	1.58 (1.60)	1.20 (1.48)	1.00 (1.41)	1.46 (1.57)	1.39 (1.54)
T_2	1.19 (1.48)	1.99 (1.73)	1.99 (1.73)	0.91 (1.38)	1.00 (1.41)	1.00 (1.41)	1.26 (1.50)	1.99 (1.73)
T_3	2.13 (1.76)	0.94 (1.39)	2.59 (1.89)	1.99 (1.73)	1.00 (1.41)	1.39 (1.54)	1.52 (1.58)	2.20 (1.78)
T_4	1.08 (1.44)	1.58 (1.60)	2.79 (1.94)	1.79 (1.67)	1.00 (1.41)	1.38 (1.54)	1.53 (1.59)	1.79 (1.67)
T_5	1.99 (1.73)	0.99 (1.41)	0.99 (1.41)	1.99 (1.73)	1.39 (1.54)	1.60 (1.61)	1.00 (1.41)	1.39 (1.54)
T_6	1.39 (1.54)	1.58 (1.60)	1.58 (1.60)	1.19 (1.48)	1.20 (1.48)	1.46 (1.56)	1.59 (1.61)	1.79 (1.67)
T_7	1.00 (1.41)	0.93 (1.39)	0.86 (1.36)	0.93 (1.39)	1.19 (1.48)	1.00 (1.41)	1.19 (1.48)	1.39 (1.54)
T_8	0.78 (1.33)	0.71 (1.30)	0.00 (1.00)	0.62 (1.27)	1.33 (1.52)	1.06 (1.43)	1.06 (1.43)	1.19 (1.48)
T_9	2.26 (1.80)	2.78 (1.94)	2.99 (1.99)	3.19 (2.04)	1.79 (1.67)	2.19 (1.78)	2.79 (1.94)	3.06 (2.01)
CD at 0.05%	0.19	0.22	0.12	0.29	0.08	0.11	0.09	0.09

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

DAFS- Days after first spray; DASS- Days after second spray; DATS- Days after third spray; DAFRS- Days after fourth spray.

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

was on par with T_7, T_1, T_4 and T_2 with 1.00, 1.06, 1.08 and 1.19 coccinellids per plant respectively while maximum (2.26) coccinellids per plant was observed in T_9. However, treatment T_9 was on par with T_3 (2.13) and T_5 (1.99). Mean count of coccinellids during *kharif* season revealed that there was lowest population of (1.00 per plant) coccinellids were was recorded in T_4 which was on par with treatments T_3, T_2, T_7, T_6 and T_1 with 1.00, 1.00, 1.19, 1.20 and 1.20 coccinellids per plant respectively. Highest population of 1.79 coccinellids per plant was present in T_9 followed by T_5 (1.39).

The activity of coccinellids in brinjal ecosystem on fifteen days after second application of treatments during summer season revealed that significantly lowest (0.71) coccinellids per plant was recorded in T_8 and the highest (2.78) coccinellids per plant recorded in T_9. Treatment T_9 was on par with T_2 (1.99). However, treatment T_8 was on par with T_7 (0.93), T_3 (0.94) and T_5 (0.99 coccinellids per plant). There was steady increase in the predator population during *kharif* season. Lowest coccinellids per plant (1.00) was recorded in T_7, which was on par with T_2 and T_1 with 1.00 coccinellids per plant in both treatments.Highest coccinellids per plant was observed in T_9 (2.19) followed by T_5 (1.60). The T_6, T_3 and T_4 were on par with each other with 1.46, 1.39 and 1.38 coccinellids per plant respectively.

There was a complete reduction in the population of coccinellids in T_8 on fifteen days after the third application of treatments during summer season and the population remained the highest in T_9 (2.99), which was on par with T_4 and T_3 with 2.79 and 2.59 coccinellids per plant respectively. Treatments T_2, T_1 and T_6 were on par with each other with 1.99, 1.79 and 1.58 coccinellids per plant respectively. Treatment T_5 (0.99) was on par with T_7 (0.86). However, T_7 and T_5 were significantly different from other microbial treatments. During *kharif* season, the minimum (1.00) coccinellids per plants was recorded in T_5, which was on par with T_8, T_7 and T_1 with 1.06, 1.19 and 1.46 coccinellids per plant respectively. Treatments T_6, T_4, T_3 and T_1 were on par with each other with 1.59, 1.53, 1.52 and 1.46 coccinellids per plant respectively.

There was a slight increase in the predator populations on fifteen days after fourth application of treatments during summer season. The lowest coccinellids were recorded in T_8 (0.62). The population continued to be the highest in T_9 (3.19) followed by T_5 (1.99). Treatments T_2, T_7 and T_6 were on par with T_8 (0.62) with 0.91, 0.93 and 1.19 coccinellids per plant respectively. The treatments T_5, T_3, T_4, T_1 and T_6 were on par with each other with 1.99, 1.99, 1.79, 1.58 and 1.19 coccinellids per plant respectively. However, treatment T_7 (0.93) and T_2 (0.91) were significantly different from T_5 and T_3 with 1.99 and 1.99 coccinellids per plant respectively. The minimum of 1.19 coccinellids per plant were recorded in T_8 as seen from observation on fifteen days after fourth application of treatments during *kharif* season. Treatment T_9 recorded maximum (3.06) coccinellids per plant. Treatment T_5 recorded 1.39 coccinellids per plant and was on par with T_7 and T_1 with 1.39 coccinellids per plant in both treatments.

4.2.6 Effect of microbial preparations, biorational and neem based insecticides on populations of predatory spider in brinjal ecosystem during summer and *kharif* season

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

The mean count of predatory spiders on fifteen days after first application of treatments during summer season revealed that there was a significant difference between the spider populations in difference treatments. The treatment T_8 recorded significantly lowest (0.29) spiders per plant, while highest (2.06) predatory spiders per plant was recorded in T_9. T_8 was on par with T_7 (1.00). T_9 (0.29) was on par with T_4 and T_2 with 1.93 and 1.66 predatory spiders per plant respectively. Treatments T_1, T_5, T_6, T_3 and T_7 were on par with each other with 1.39, 1.39, 1.26, 1.12 and 1.00 spiders per plant respectively. However, T_7 (1.00) was significantly different from T_4 (1.93) and T_2 (1.66), while T_6 (1.26) was significantly different from T_4 (1.93).

Table 16. Mean number of spiders at different intervals after application of treatments during summer and *kharif* season

Treatment	Mean number of spiders							
	Summer season				*Kharif* season			
	15 DAFS	15 DASS	15 DATS	15 DAFRS	15 DAFS	15 DASS	15 DATS	15 DAFRS
T_1	1.39 (1.54)	1.39 (1.54)	2.79 (1.94)	1.99 (1.73)	1.19 (1.48)	1.00 (1.41)	2.06 (1.75)	1.86 (1.69)
T_2	1.66 (1.63)	1.99 (1.73)	1.79 (1.67)	1.40 (1.54)	1.00 (1.41)	1.66 (1.63)	1.26 (1.50)	1.46 (1.57)
T_3	1.12 (1.45)	2.06 (1.75)	2.00 (1.73)	1.26 (1.50)	0.91 (1.38)	1.46 (1.57)	1.59 (1.61)	2.19 (1.78)
T_4	1.93 (1.71)	1.98 (1.72)	1.38 (1.54)	1.98 (1.72)	1.58 (1.60)	1.39 (1.54)	1.79 (1.67)	1.79 (1.67)
T_5	1.39 (1.54)	0.96 (1.40)	1.99 (1.73)	1.79 (1.67)	1.25 (1.50)	1.00 (1.41)	1.52 (1.58)	1.59 (1.61)
T_6	1.26 (1.50)	1.19 (1.48)	1.19 (1.48)	1.39 (1.54)	1.39 (1.54)	1.19 (1.48)	1.39 (1.54)	2.26 (1.80)
T_7	1.00 (1.41)	0.29 (1.13)	1.00 (1.41)	1.19 (1.48)	1.39 (1.54)	1.58 (1.60)	1.19 (1.48)	1.00 (1.41)
T_8	0.29 (1.13)	0.00 (1.00)	0.62 (1.27)	1.00 (1.41)	0.29 (1.13)	0.00 (1.00)	1.66 (1.63)	1.19 (1.48)
T_9	2.06 (1.75)	2.19 (1.78)	2.79 (1.94)	2.98 (1.99)	1.93 (1.71)	2.19 (1.78)	2.66 (1.91)	3.26 (2.06)
CD at 0.05%	0.15	0.21	0.17	0.15	0.27	0.12	0.12	0.08

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

DAFS- Days after first spray; DASS- Days after second spray; DATS- Days after third spray; DAFRS- Days after fourth spray.

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

During *kharif* season, same trend was continued with T_8 recording the minimum (0.29) spiders. T_8 was on par with T_3 (0.91). The treatment T_9 was on par with T_4, T_6, T_7, T_5 and T_1 with 1.58, 1.39, 1.39, 1.25 and 1.19 spiders per plant respectively.

The observation on fifteen days after second application of treatments during summer season showed that there was a complete reduction in the activity of predatory spiders in T_8 (standard check) and the population remained the highest in the T_9 with 2.19 spiders per plant, which was on par with T_3, T_2 and T_4 with 2.06, 1.99 and 1.98 spiders per plant respectively. The treatment T_8 was on par with T_7 with 0.29 spiders per plant, while the T_1 (1.39) was on par with T_6 (1.19). However, T_7 (0.29) is significantly different from all other treatments except T_8 (0.00). T_5 (0.96) and T_6 (1.19) were significantly different from T_2 (1.99), T_4 (1.98) and T_1 (1.39). Same trend was observed during *kharif* season. T_2, T_7, T_3 and T_4 were on par with each other with 1.66, 1.58, 1.46 and 1.39 spiders per plant respectively. However, T_8 (standard check) had no spiders at all.

Minimum 0.62 spiders per plant were observed in T_8 from the observation on fifteen days after the third application of treatments during summer season. T_9 and T_1 recorded maximum 2.79 spiders per plant. However, T_3 (2.00) was on par with T_5 (1.99). T_4 (1.38) was on par with T_6 (1.19). T_7 (1.00) recorded very few spiders per plant than other treatments. Observation during *kharif* season revealed that the lowest (1.19) spiders per plant was recorded in T_7. The T_7 was on par with T_2, T_6 and T_5 with 1.26, 1.39 and 1.52 spiders per plant respectively. Highest predatory spiders was recorded in T_9 (2.66) closely followed by T_1 with 2.06 spiders per plant.

During fifteen days after fourth spray, T_8 (1.00) recorded lowest spider per plant, while there was maximum activity of spiders in T_9 (2.98). However, T_5 (1.79) recorded more number of spiders than T_8 (1.00). There was a gradual reduction in the population of spiders in T_7 with significantly lowest (1.00) spiders per plant on fifteen days after fourth application of treatments during *kharif* season. T_7 was on par with T_8 with 1.19 spiders per plant, whereas highest spiders per plant were recorded in T_9 (3.26) which were followed by T_6 with 2.26 spiders per plant.

4.2.7 Yield of brinjal crop during summer and *kharif* season

The results on yield obtained from the experiment were furnished in Table 17.

The average yield ranged from 18957.49 kg per ha in T_6 to 8644.16 kg per ha in T_9. Yield was high in T_6 (spinosad 45 SC) followed by T_8 (15281.19 kg per ha) and T_7 (13688.17 kg per ha). Yield obtained from T_7 was on par with T_5 (13681.83 kg per ha).

Yield from the plots treated with microbial preparations was low compared to the biorational and neem based insecticides. T_1 recorded a yield of 12836.13 kg per ha which was on par with T_3, T_2 and T_4 with a yield of 12566.40, 12249.07 and 12101.51 kg per ha respectively. Yield obtained during *kharif* season (Table 16) ranged from 20088.79 kg per ha in T_6 to 8736.18 kg per ha in T_9. Highest yield was recorded in T_6 (spinosad 45 SC) followed by T_8 with 16715.53 kg per ha.

Yield obtained from T_7, T_5, T_1, T_3 and T_2 were on par with each other. However, T_4 recorded lowest yield during both season among treatments. In both season, T_6 recorded highest yield as compared to other treatments.

Table 17. Yield obtained due to the application of different treatments during summer and *kharif* season

Treatments	Yield of brinjal					
	Summer season			*Kharif* season		
	Per plant (gm)	Per plot (Kg)	Per ha (Kg)	Per plant (gm)	Per plot (Kg)	Per ha (Kg)
T_1	539.33	9.708	12836.13	575.80	10.364	13704.04
T_2	514.66	9.264	12249.07	557.46	10.034	13267.71
T_3	528.00	9.504	12566.40	567.86	10.221	13515.23
T_4	508.46	9.152	12101.51	528.40	9.510	12575.92
T_5	574.86	10.347	13681.83	596.93	10.740	14207.01
T_6	796.53	14.337	18957.49	844.06	15.193	20088.79
T_7	575.13	10.352	13688.17	623.40	11.221	14836.92
T_8	642.06	11.557	15281.19	702.33	12.642	16715.53
T_9	363.20	6.537	8644.16	367.06	6.607	8736.18
CD at 0.05 %	26.57	0.47	632.55	40.86	0.73	972.67

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

4.2.8 Economics of brinjal crop during summer and *kharif* season.

The results of the economics of brinjal yield obtained from field experiment during summer and *kharif* season (Table 18) revealed that the application of T_6 gave Rs. 2.52 in return for every one rupee invested against T_9 (control) which gave only Rs. 1.27. Application of biorational insecticides *viz.*, *Bt* formulation (T_5) and neem based insecticides azadirachtin 1% (T_7) gave Rs. 1.99 and Rs. 1.94 for every one rupee invested. Benefit: cost ratio of microbial preparation *viz.*, *M. anisopliae* talc formulation, *B. bassiana* talc formulation, *M. anisopliae* liquid formulation and *B. bassiana* liquid formulation were 1.88, 1.84, 1.77 and 1.75 rupees respectively.

The economics of brinjal yield obtained from field experiment during *kharif* season are furnished in Table 18.

The results revealed that application of spinosad 45 SC (T_6) gave Rs. 2.67 in return for every one rupee investment against untreated control (T_9) gave only 1.29. Application of malathion 50 EC (T_8), azadirachtin 1% (T_7), *Bt* formulation (T_5) gave 2.43, 2.10 and 2.06 for every one rupee invested respectively. Benefit: cost ratio of microbial preparation *viz., M. anisopliae* talc formulation (T_1), *B. bassiana* talc formulation (T_3), *M. anisopliae* liquid formulation (T_2) and *B. bassiana* liquid formulation (T_4) were 2.01, 1.98, 1.92 and 1.82 rupee respectively.

4.3 EFFECT AND COMPATIBILITY OF SPINOSAD 45 SC ON ENTOMOPATHOGENIC FUNGI USING POISONED FOOD TECHNIQUE UNDER *IN VITRO* CONDITION.

The results on compatibility of spinosad 45 SC on microbial preparations are presented in Table 19 to 22.

Table 18. Economics of brinjal crop during summer and *Kharif* season

Treatments	Economics of brinjal								
	Normal cost excluding insecticides (Rs./ha)	Expense for insecticides (Rs./ha)	Total expenses (Rs./ha)	Summer season			*Kharif* season		
				Gross income (Rs./ha)	Net income (Rs./ha)	B : C ratio	Gross income (Rs./ha)	Net income (Rs./ha)	B : C ratio
T_1	67555.00	420.00	67975.00	128361.30	60386.33	1.88	137040.40	69065.40	2.01
T_2	67555.00	1400.00	68955.00	122490.70	53535.67	1.77	132677.10	63722.07	1.92
T_3	67555.00	420.00	67975.00	125664.00	57689.00	1.84	135152.30	67177.27	1.98
T_4	67555.00	1400.00	68955.00	121015.10	52060.07	1.75	125759.20	56804.20	1.82
T_5	67555.00	1200.00	68755.00	136818.30	68063.27	1.99	142070.10	73315.13	2.06
T_6	67555.00	7488.00	75043.00	189574.90	114531.90	2.52	200887.90	125844.90	2.67
T_7	67555.00	2822.00	70377.00	136881.70	66504.73	1.94	148369.20	77992.20	2.10
T_8	67555.00	1152.00	68707.00	152811.90	84104.87	2.22	167155.30	98448.33	2.43
T_9	67555.00	0.00	67555.00	86441.60	18886.60	1.27	87361.870	19806.87	1.29

T_1: *M. anisopliae* (talc formulation @ 5 gm/L of water); T_2: *M. anisopliae* (potato dextrose broth @10^7 spores/ml); T_3: *B. bassiana* (talc formulation @ 5 gm/L of water); T_4: *B. bassiana* (potato dextrose broth @10^7 spores/ml); T_5: *Bt* formulation @ 1 ml/L of water; T_6: Spinosad 45 SC @ 0.4 ml/L of water; T_7: Azadirachtin 1% @ 2 ml/L of water; T_8: Malathion 50 EC @ 2 ml/L of water; T_9: Absolute control.

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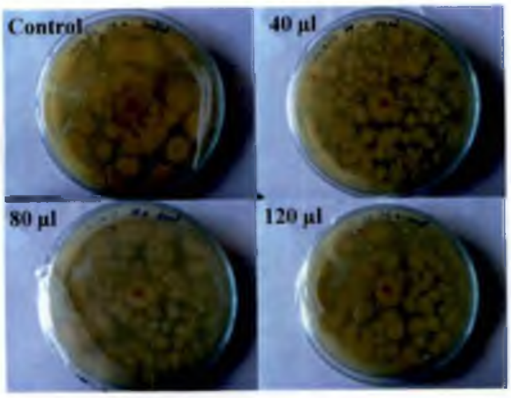
4.3.1 *In vitro* evaluation of spinosad 45 SC by poisoned food technique

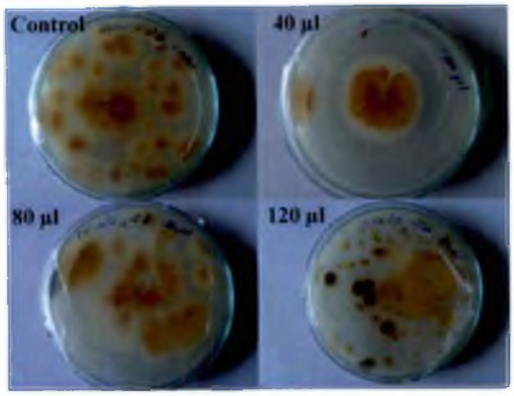
The results of the *in vitro* evaluation of spinosad 45 SC on entomopathogenic fungi *M. anisopliae* by poisoned food technique (Table 19; Plate 11) revealed that the highest per cent inhibition (26.75 per cent) of colony diameter of *M. anisopliae* was found in samples treated with 120 µl concentration of spinosad 45 SC at 14 days after inoculation, where as the lowest (5.23) per cent inhibition was found in samples treated with 40 µl of spinosad 45 EC (*i.e.*, the concentration which is used in the field experiment against pests of brinjal). The spinosad 45 SC at the concentration of 80 µl recorded 10.44 per cent inhibition of colony diameter of *M. anisopliae.*

The results obtained from the *in vitro* evaluation of spinosad 45 SC on entomopathogenic fungi *B. bassiana* by poisoned food technique (Table 20; Plate 11) revealed that the highest (47.76) per cent of inhibition of colony diameter of *B. bassiana* was found in sample treated with 120 µl concentration of spinosad 45 SC at 14 days after inoculation. The lowest (23.22) per cent inhibition of colony diameter was found in samples treated with 40 µl concentration at 14 days after inoculation and it was on par with 80 µl concentration with 29.62 per cent inhibition.

4.3.2 *In vitro* evaluation of spinosad 45 SC on entomopathogenic fungi by sporulation inhibition study

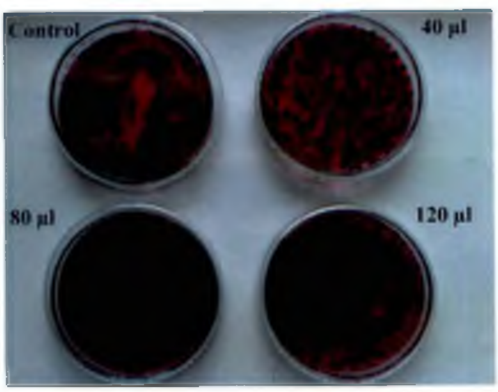
The results obtained from the sporulation inhibition (Table 21; Plate 12) revealed that all the tested concentration of spinosad 45 SC gave 100 per cent inhibition of sporulation on *B. bassiana* but in the case of *M. anisopliae,* maximum (17.86 per cent) inhibition of sporulation was found in the 120 µl concentration and lowest (3.76 per cent) inhibition of sporulation was recorded in samples with 40 µl concentration. At 80 µl concentration, there was 10.69 per cent sporulation inhibition of *M. anisopliae* was recorded.

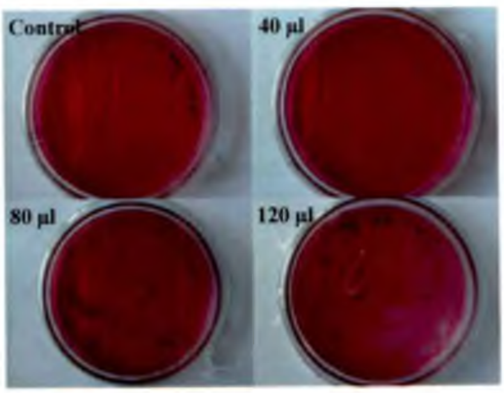




Metarhizium anisopliae *Beauveria bassiana*

Plate 11. *In vitro* efficacy of spinosad 45 SC on entomopathogenic fungus using poisoned food technique in PDA media





Metarhizium anisopliae *Beauveria bassiana*

Plate 12. *In vitro* evaluation of spinosad 45 SC on entomopathogenic fungus for sporeulation assay in Rose Bengal Agar media

Table 19. Effect and compatibility of spinosad on *M. anisopliae* using poisoned food technique under *in vitro* condition

Treatments	Inhibition of colony diameter of *M. anisopliae* (cm)*			Per cent inhibition of colony diameter of *M. anisopliae* *		
	10 DAI	12 DAI	14 DAI	10 DAI	12 DAI	14 DAI
T_1 : Spinosad 45 SC @ 40 µl	3.35	3.47	4.07	4.24	4.73	5.23
T_2 : Spinosad 45 SC @ 80 µl	3.27	3.32	3.85	6.41	8.86	10.44
T_3 : Spinosad 45 SC @ 120 µl	2.65	2.72	3.15	24.22	25.20	26.75
T_4 : Control	3.50	3.65	4.30	-	-	-
SE @0.05 %	0.13	0.14	0.13	1.03	1.79	0.81
CD @0.05 %	0.04	0.04	0.04	3.31	5.79	2.61

*Mean of four replications DAI- Days After Inoculation

Table 20. Effect and compatibility of spinosad on *B. bassiana* using poisoned food technique under *in vitro* condition

Treatments	Inhibition of colony diameter of *B. bassiana* (cm)*			Per cent inhibition of colony diameter of *B. bassiana* *		
	10 DAI	12 DAI	14 DAI	10 DAI	12 DAI	14 DAI
T_1 : Spinosad 45 SC @ 40 µl	2.00	2.55	2.95	8.82	20.20	23.22
T_2 : Spinosad 45 SC @ 80 µl	1.82	2.35	2.70	16.79	26.36	29.62
T_3 : Spinosad 45 SC @ 120 µl	1.67	1.72	2.00	23.65	46.03	47.76
T_4 : Control	2.20	3.20	3.85	-	-	-
SE @0.05 %	0.15	0.14	0.25	2.39	1.82	2.72
CD @0.05 %	0.04	0.04	0.08	7.65	5.82	8.71

*Mean of four replications DAI- Days After Inoculation

Table 21. Effect and compatibility of spinosad on entomopathogenic fungi using sporulation inhibition study under *in vitro* condition

Treatments	Mean count of colony *		Inhibition of sporulation (%)*	
	M. anisopliae	*B. bassiana*	*M. anisopliae*	*B. bassiana*
T_1 : Spinosad 45 SC @ 40 µl	312.50	0.00	3.76	100.00
T_2 : Spinosad 45 SC @ 80 µl	290.00	0.00	10.69	100.00
T_3 : Spinosad 45 SC @ 120 µl	266.75	0.00	17.86	100.00
T_4 : Control	324.75	0.00	-	-
SE @0.05 %	3.83	-	0.36	-
CD @0.05 %	1.24	-	1.16	-

*Mean of four replications

Table 22. Effect and compatibility of spinosad on entomopathogenic fungi using spore germination inhibition study under *in vitro* condition

Treatments	Inhibition of spore germination (%)*	
	M. anisopliae	*B. bassiana*
T_1 : Spinosad 45 SC @ 40 µl	26.82	100.00
T_2 : Spinosad 45 SC @ 80 µl	44.65	100.00
T_3 : Spinosad 45 SC @ 120 µl	82.73	100.00
SE @0.05 %	0.81	-
CD @0.05 %	2.49	-

*Mean of four replications

4.3.3 *In vitro* evaluation of spinosad 45 SC on entomopathogenic fungi by spore germination inhibition study

The results (Table 22) of the *in vitro* evaluation of spinosad 45 SC by spore germination inhibition study revealed that all the test concentration of spinosad 45 SC gave 100 per cent inhibition to the germination of *B. bassiana* spores whereas in the case of *M. anisopliae* the maximum (82.73 per cent) spore germination inhibition was found in 120 µl concentration and minimum (26.82 per cent) spore germination was inhibited in 40 µl concentration. The 80 µl concentration inhibited 44.65 per cent spore germination.

4.4 RESIDUE OF SPINOSAD 45 SC ON BRINJAL FRUITS

The results of residue estimation of spinosad on brinjal fruits were presented in Table 23.

Table 23. Residue of spinosad in brinjal fruits

Components of Spinosad	**Residue of spinosad (mg/kg)**			**Cumulative mean (mg/kg)**
	R_1	**R_2**	**R_3**	
Spinosyn A	0.091	0.092	0.129	0.104
Spinosyn D	0.029	0.016	0.032	0.025

Residue estimation of spinosad on brinjal fruits revealed that the mean content of residue of major component of spinosad *i.e., spinosyn* A recorded the residue of 0.104 mg/kg of fruits where as the minor component of spinosad *i.e., spinosyn* D shows the residue of 0.025 mg/kg of fruits.

DISCUSSION

5. DISCUSSION

The results of the thesis "Biorational management of major pests of brinjal (*Solanum melongena* L.)" are discussed in this chapter.

5.1 SURVEY OF MAJOR PESTS OF BRINJAL IN KASARGOD DISTRICT.

The survey revealed that the incidence of pests like *L. orbonalis, E. vigintioctopunctata* and *A. olivacea* are severe on brinjal in low, mid and high land area of Kasargod district, while infestation of *S. docilis* was moderate in mid land and high land area. However, severe infestation of *S. docilis* was noticed in low land, compared to mid and high land area (Table 3; Fig. 1). This is mainly because of the succulent nature of leaves due to continuous irrigation of crop in sandy areas. The farmers usually irrigate two times a day so as to keep the plant without wilting.

From the survey, it was seen that the pest attack starts right from nursery and continues till harvest (Table 4; Fig. 2). The present finding is in agreement with earlier work by Regupathy *et al.* (1997), who reported that the incidence of pests of brinjal starts from nursery and continues till harvest.

The activities of natural enemies such as predatory coccinellids, rove beetles and spiders were very high in the field after two months of transplanting. At this stage, the plant is in its maximum flowering and this coincides with the activity of soft bodied insects like aphids, mealy bugs, white flies etc. The predatory coccinellids have much like towards soft bodied insects (Table 5; Fig. 3). This might be the reason for high activity of natural enemies at two months after transplanting.

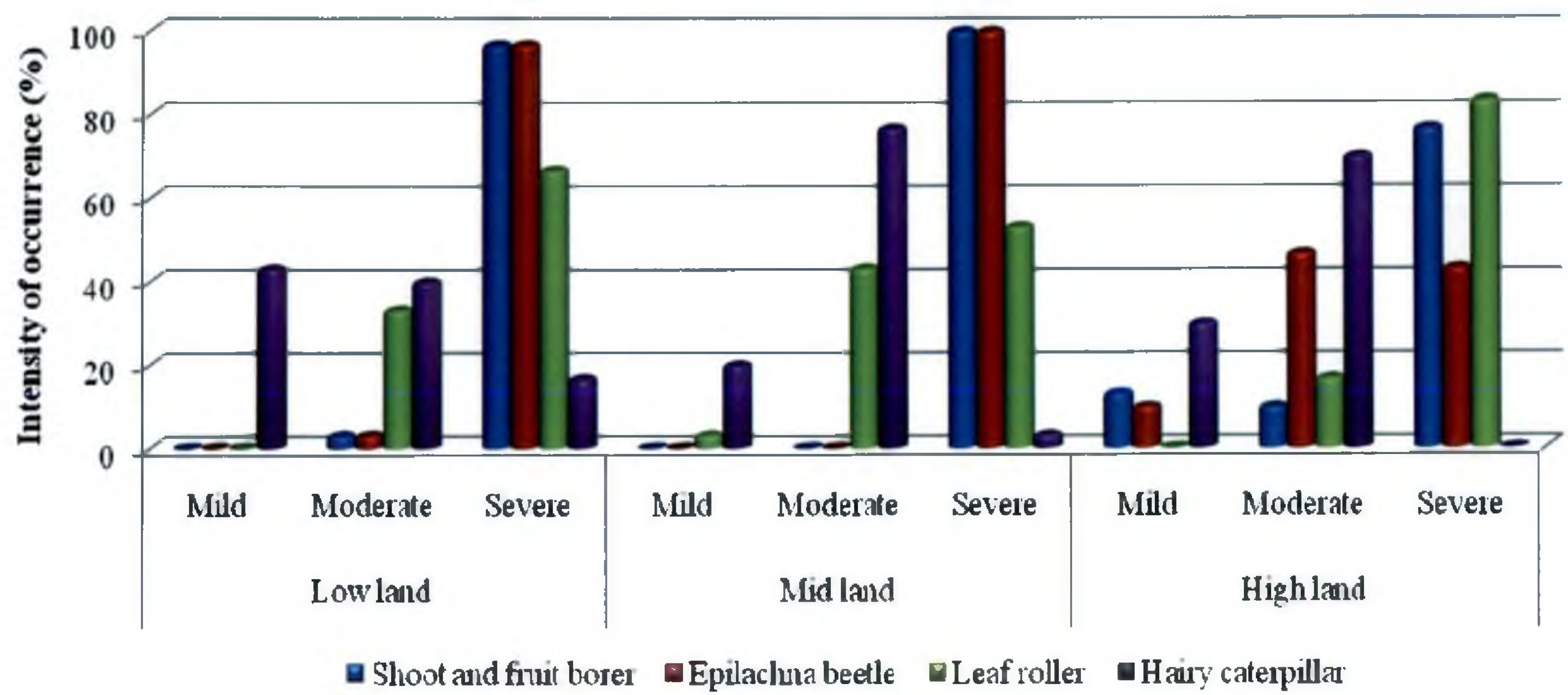


Fig. 1. Incidence of pests observed by the farmers' in their brinjal field in the three agro climatic regions of Kasargod district

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Fig. 2. Incidence of pests observed by the farmers' in their brinjal field at the different stages of the crop in the three agro climatic regions of Kasargod district

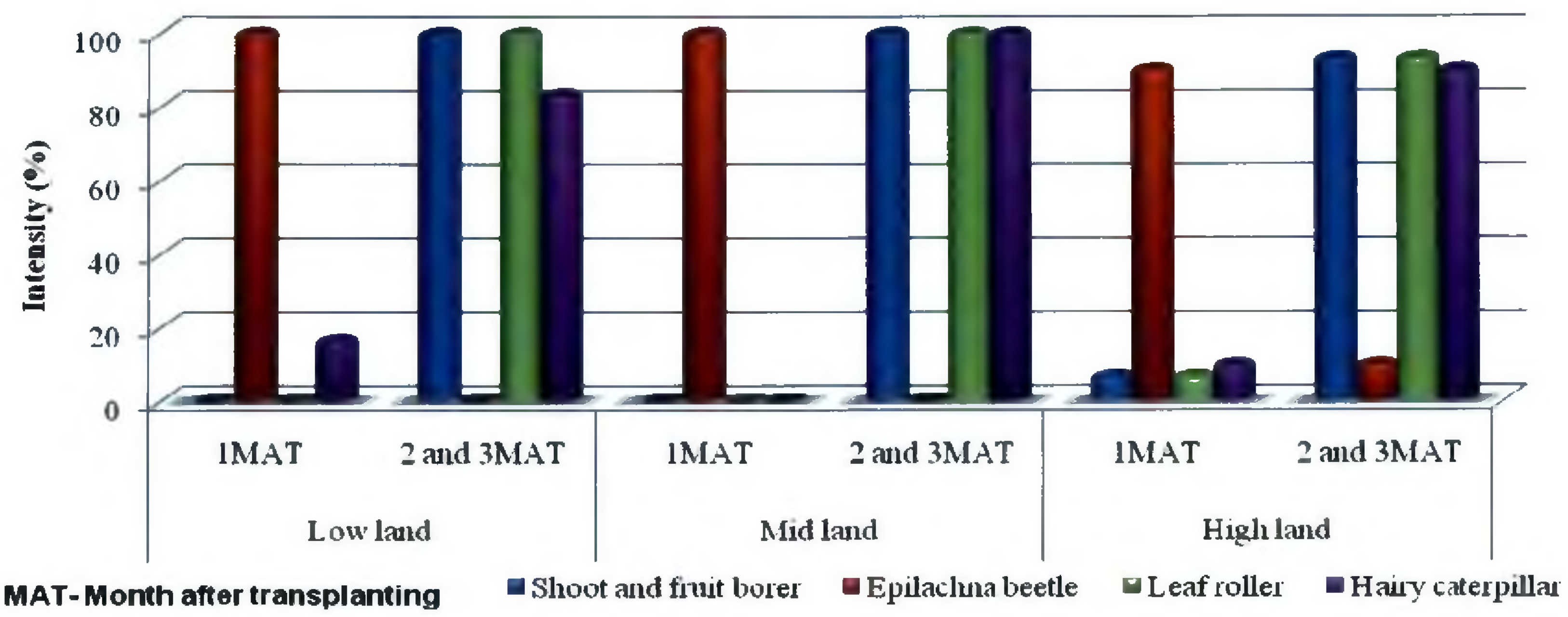

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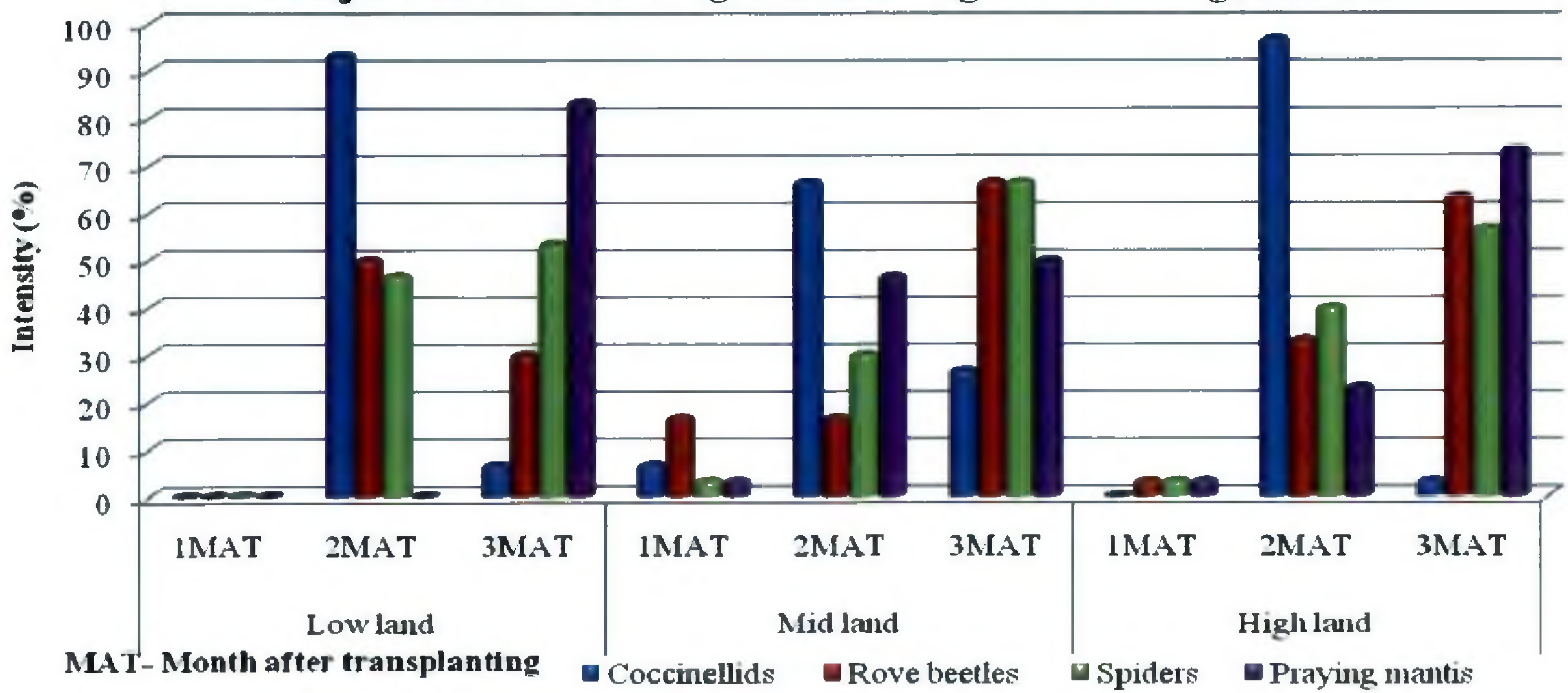
Fig. 3. Population of natural enemies of pest observed by the farmers' in their brinjal field in the three agro climatic regions of Kasargod district



5.2. EVALUATION OF MICROBIAL PREPARATIONS, BIORATIONAL AND NEEM BASED INSECTICIDES AGAINST MAJOR PESTS OF BRINJAL.

5.2.1 Efficacy of microbial preparations, biorational and neem based insecticides against *L. orbonalis* infesting on shoot and fruits of brinjal during summer and *kharif* season.

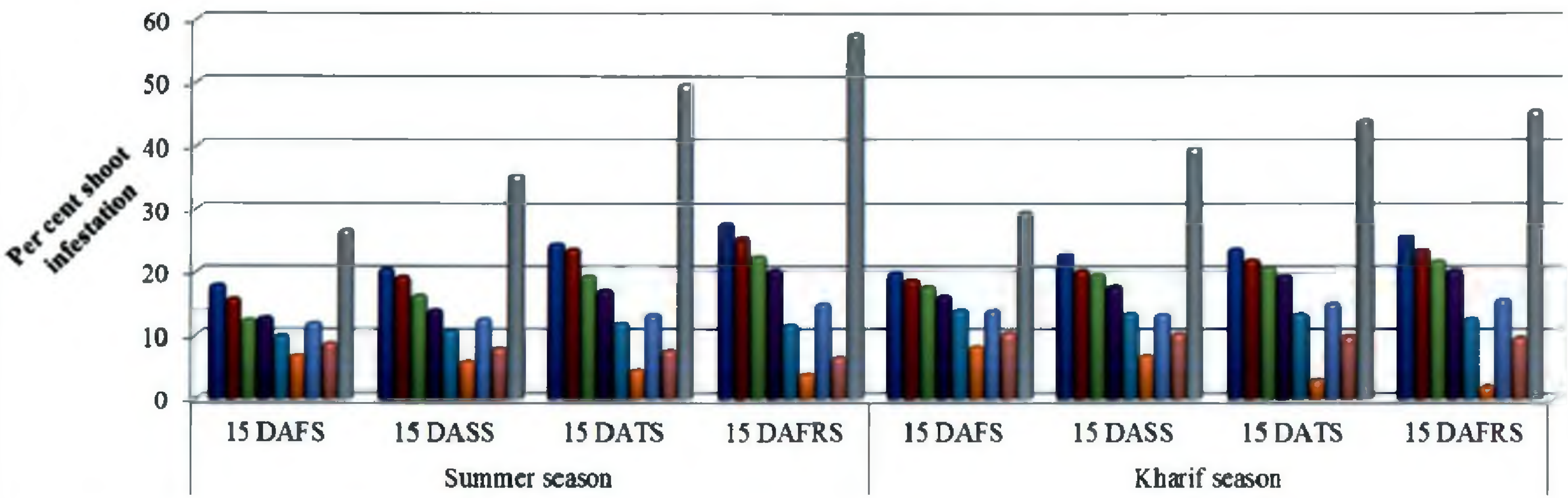
From the experiment, it was observed that the mean per cent of shoot infestation was minimum in the T_6 (spinosad 45 SC) in both summer and *kharif* season (Table 6; Fig. 4). This is in confirmantion with the findings of Pareet and Basavangoud (2012) where they reported that spinosad 45 EC was most effective against *L. orbonalis* in reducing per cent shoot infestation.

The mean per cent fruit infestation was also very less in plots sprayed with spinosad 45 SC (Table 7; Fig. 5) during summer and *kharif* season as compared to T_8 (standard check-malathion 50 EC). This is in line with the report of Adiroubane and Raghuraman (2008) who observed that spinosad 45 SC was found to be effective against *L. orbonalis* at fruiting stage and maximum per cent reduction of fruit damage was observed on plots treated with spinosad 45 SC in brinjal.

From the earlier reports and from present investigation, it was evident that the spinosad 45 SC was most effective in reducing the per cent infestation of shoot and fruits in brinjal. Moreover, the insecticide spinosad 45 SC is less toxic to human being than malathion 50 EC and approved for use in organic agriculture by numerous national and international certification (Thomas *et al.*, 2012).

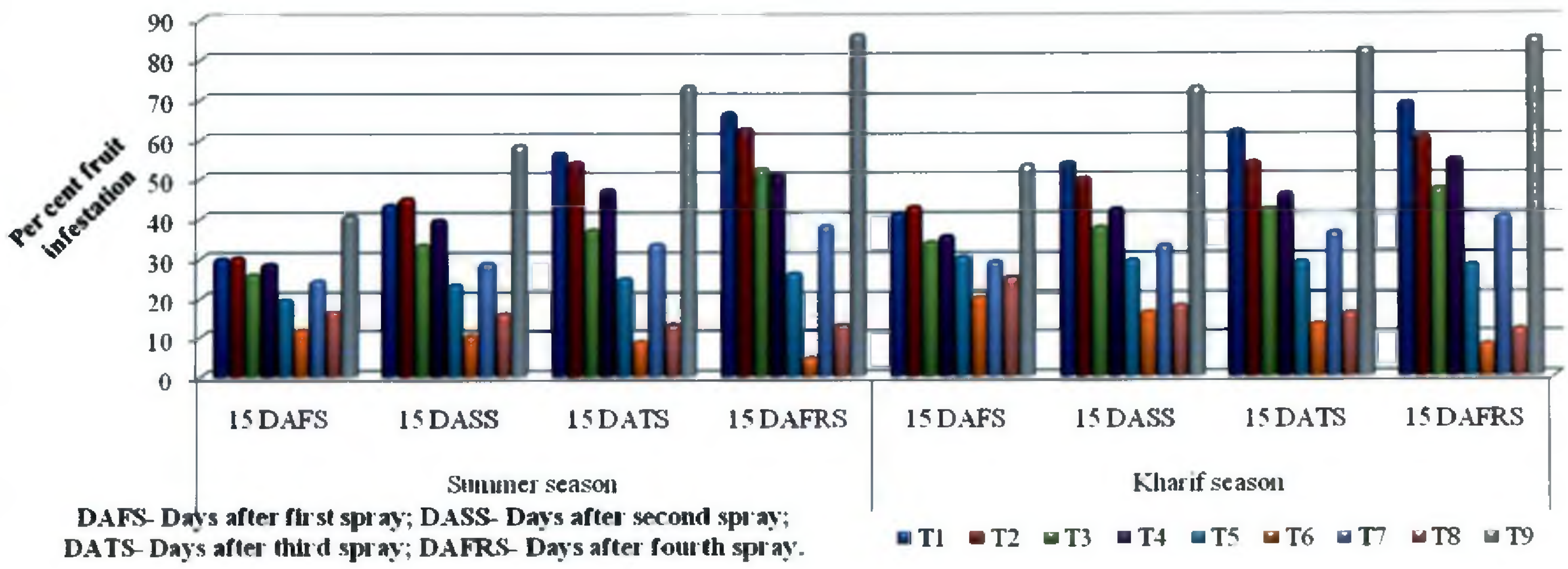
Mark *et al.* (2011) reported that spinosad 45 SC increases the mortality of larval stages than adults. This is highly advantageous in managing lepidopteran insects where, the larva is damaging stage in all the cases except fruit

Fig. 4. Mean per cent of shoot infestation at different intervals after application of treatments against *L. orbonalis* during summer and *kharif* season



DAFS- Days after first spray; DASS- Days after second spray; DATS- Days after third spray; DAFRS- Days after fourth spray.

Fig. 5. Mean per cent of fruit infestation at different intervals after application of treatments against *L. orbonalis* during summer and *kharif* season



DAFS- Days after first spray; DASS- Days after second spray; DATS- Days after third spray; DAFRS- Days after fourth spray.

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sucking moths. Hence, present study reconfirms the earlier findings that the spinosad 45 SC is highly effective in managing *L. orbonalis* larvae.

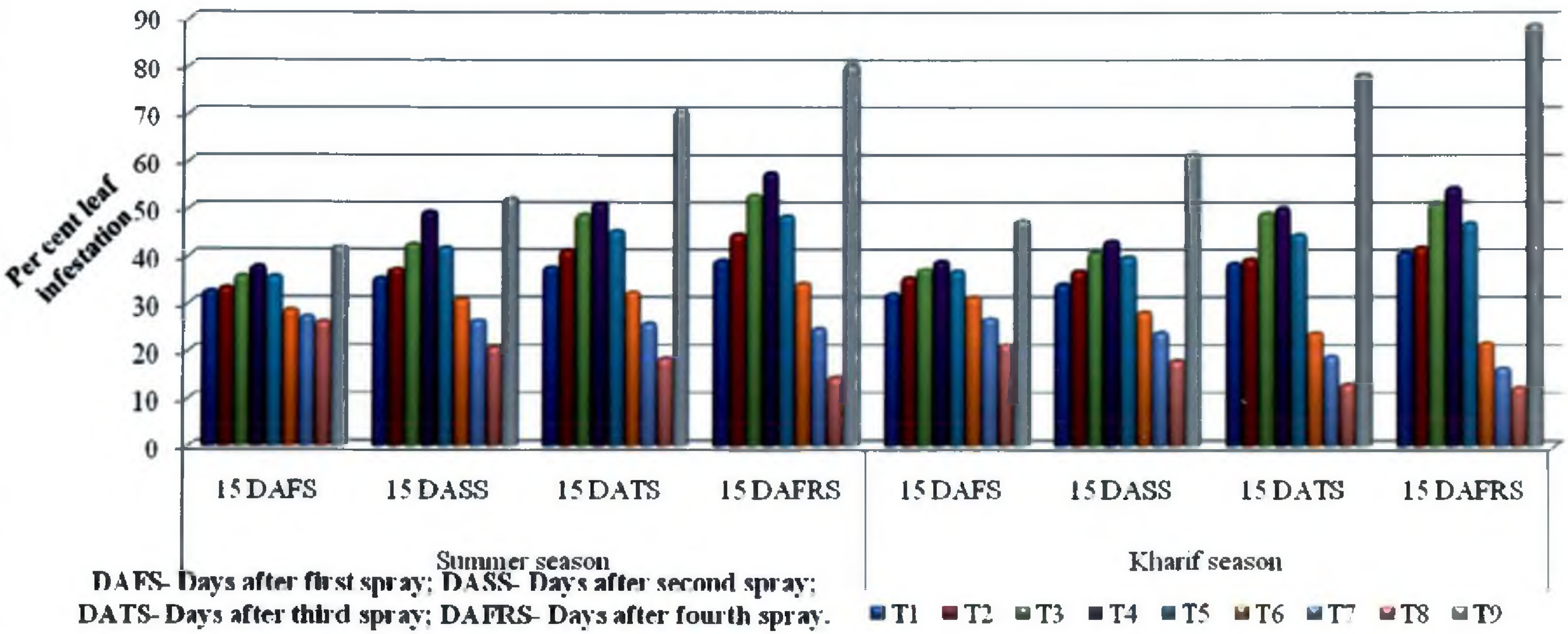
The spinosad 45 SC is an insecticide derived from microbes (*Saccharopolyspora spinosa*) and falls under moderately toxic (blue label) category. Kasargod being declared as organic district, the usage of highly toxic insecticides are banned. Since spinosad 45 SC is moderately toxic chemical and it is derived from microbes, the residual toxicity will be very less. Hence, this can be very well recommended in vegetables especially brinjal, where the time taken from harvest to consumption is very less.

5.2.2 Efficacy of microbial preparations, biorational and neem based insecticides against *E. vigintioctopunctata* infesting on leaves of brinjal during summer and *kharif* season.

The mean per cent of leaf infestation by *E. vigintioctopunctata* during summer and *kharif* season (Table 8; Fig. 6) revealed that the minimum per cent of leaf infestation was found in plots treated with T_7 (azadirachtin 1%). This shows the antifeedant activity of azadirachtin to beetles. Similar results were reported by earlier workers Konar *et al.* (2005) and Mane and Kulkarni (2010) that azadirachtin (1000 ppm) and neem oil (3 per cent) gave better results in controlling *E. vigintioctopunctata* than microbial insecticides. In the present study, T_8 (standard check-malathion 50 EC) was also found to be effective. Since it is synthetic insecticide, the azadirachtin 1% being the insecticide of botanical origin, the same may be recommended as it reduces residue in the vegetable and has got less human risk.

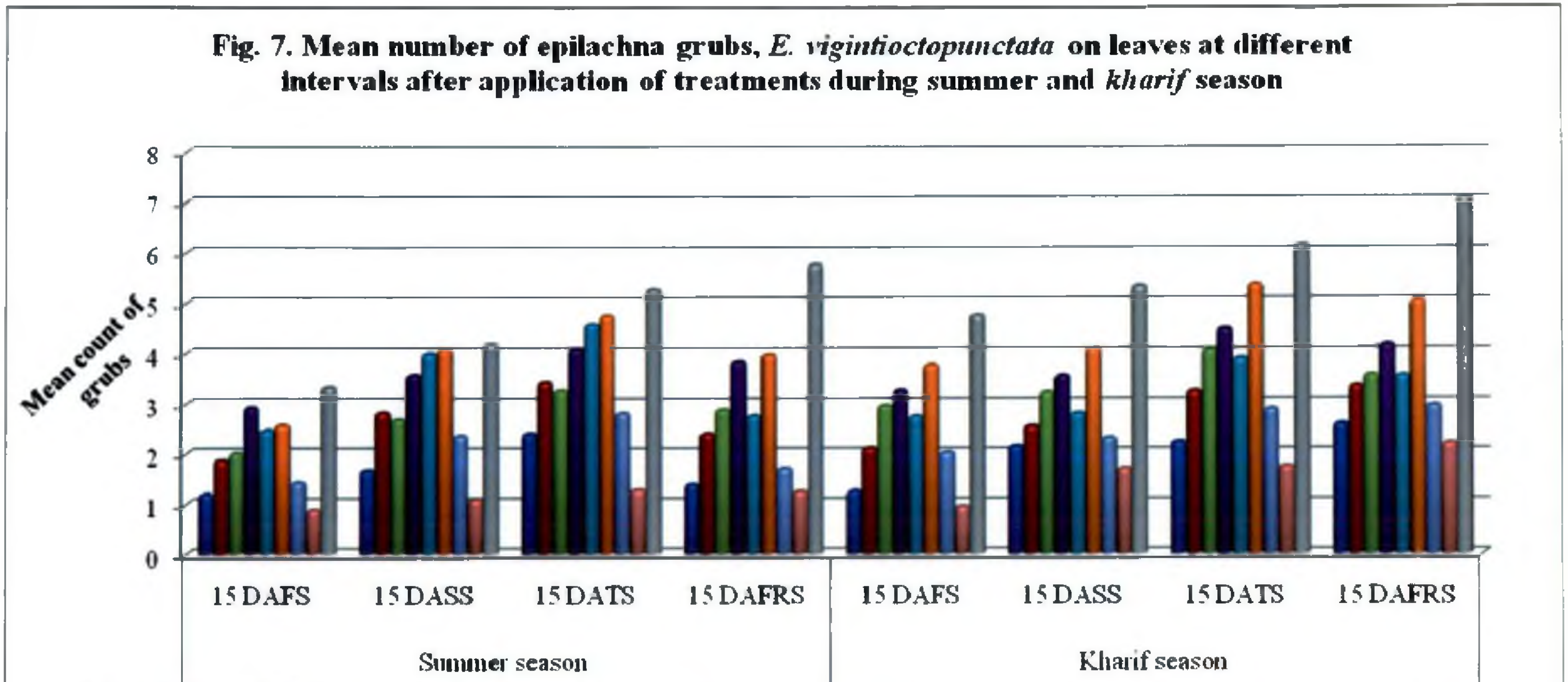
The mean count of epilachna grubs were minimum in plots treated with *M. anisopliae* talc formulation (Table 9 and 10; Fig. 7). The *M. anisopliae* is highly effective against grubs than adults. This corroborates earlier report by Rajendran (2002) that high mortality of *E. vigintioctopunctata* grubs were observed when *M. anisopliae* applied @ 10^8 and 10^{10} conodia/ml. However, *M. anisopliae* (T_1) talc

Fig. 6. Mean per cent of leaf infestation at different intervals after application of treatments against *E. vigintioctopunctata* during summer and *kharif* season



DAFS- Days after first spray; DASS- Days after second spray;
DATS- Days after third spray; DAFRS- Days after fourth spray.

112



DAFS- Days after first spray; DASS- Days after second spray;
DATS- Days after third spray; DAFRS- Days after fourth spray.

113

formulation was on par with T_7 (azadirachtin 1%) in reducing the epilachna grubs. This is in line with the earlier report by Jayarajan and Babu (1990), that nem-75 and azadirachtin 1000 ppm was found to be better antifeedant for fourth instar grubs of epilachna beetles.

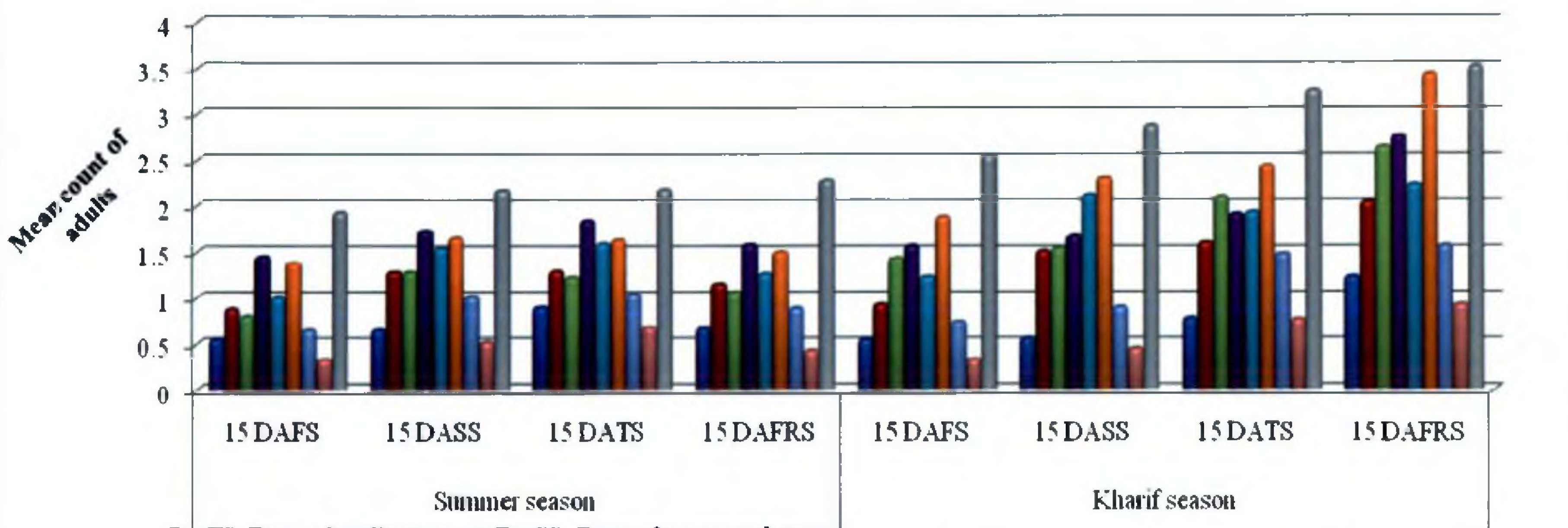
The mean count of epilachna adults (Table 11 and 12; Fig. 8) was minimum in T_1 (*M. anisopliae* talc formulation) during summer and *kharif* seasons and it was found that the mean count of epilachna adults was highest in the control. Moreover, the treatment T_1 was found to be on par with T_7 (azadirachtin 1%). These finding corroborate with the findings of Rajendran (2002) that *M. anisopliae* at 10^8 and 10^{10} conodia/ml gave highest mortality of epilachna adults on seven days after application of the treatments. Vishwakarma *et al.* (2011) also reported that *M. anisopliae* used at 3.0 gm/L of water showed 70.71 per cent reduction in epilachna beetle population. However, high mortality of adults were recorded in the present study where *M. anisopliae* talc formulation was used at 5 gm/L of water.

From the results, it is evident that *M. anisopliae* talc formulation is effective in reducing grubs and adults, while per cent of leaf infestation was found to be low when azadirachtin 1% was applied. This is because that azadirachtin 1% is acting mainly as an antifeedent and a growth disrupter.

5.2.3 Efficacy of microbial preparations, biorational and neem based insecticides against *A. olivacea* on brinjal during summer and *kharif* season

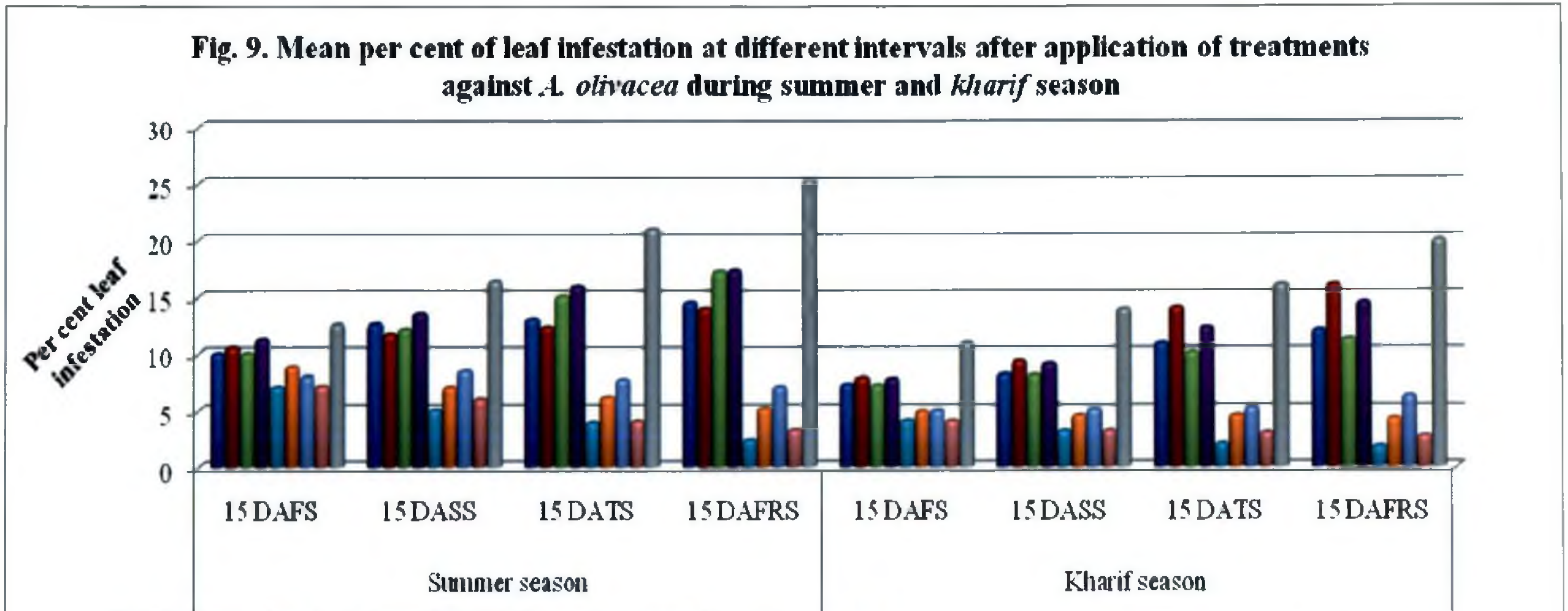
Results presented in Table 13; Fig. 9 showed that the *Bt* formulation (T_5) was highly effective against *A. olivacea*. The *Bt* formulation paralyzes the digestive tract of the insect and as a results the insect stop feeding and starve to death. From the present study it was found that the *Bt* formulation was effective in reducing the young larval instars. However, older larval instars were less affected by *Bt* formulation. When the larva attains second instar, it starts folding the leaves and the *Bt* formulation insecticide could not reach the folded leaves.

Fig. 8. Mean number of epilachna adults, *E. vigintioctopunctata* on upper, middle and lower three leaves at different intervals after application of treatments during summer and *kharif* season



DAFS- Days after first spray; DASS- Days after second spray; DATS- Days after third spray; DAFRS- Days after fourth spray.

115



DAFS- Days after first spray; DASS- Days after second spray; DATS- Days after third spray; DAFRS- Days after fourth spray.

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This might be the reason for inefficiency of *Bt* in controlling older instars. The present findings corroborate earlier report by Baskaran and Kumar (1980) that a mixture of dipel at 0.1 per cent with sublethal doses of carbaryl (0.04 per cent) were found to be most effective in controlling *A. olivacea*.

5.2.4 Efficacy of microbial preparations, biorational and neem based insecticides against *S. docilis* on brinjal during summer and *kharif* season

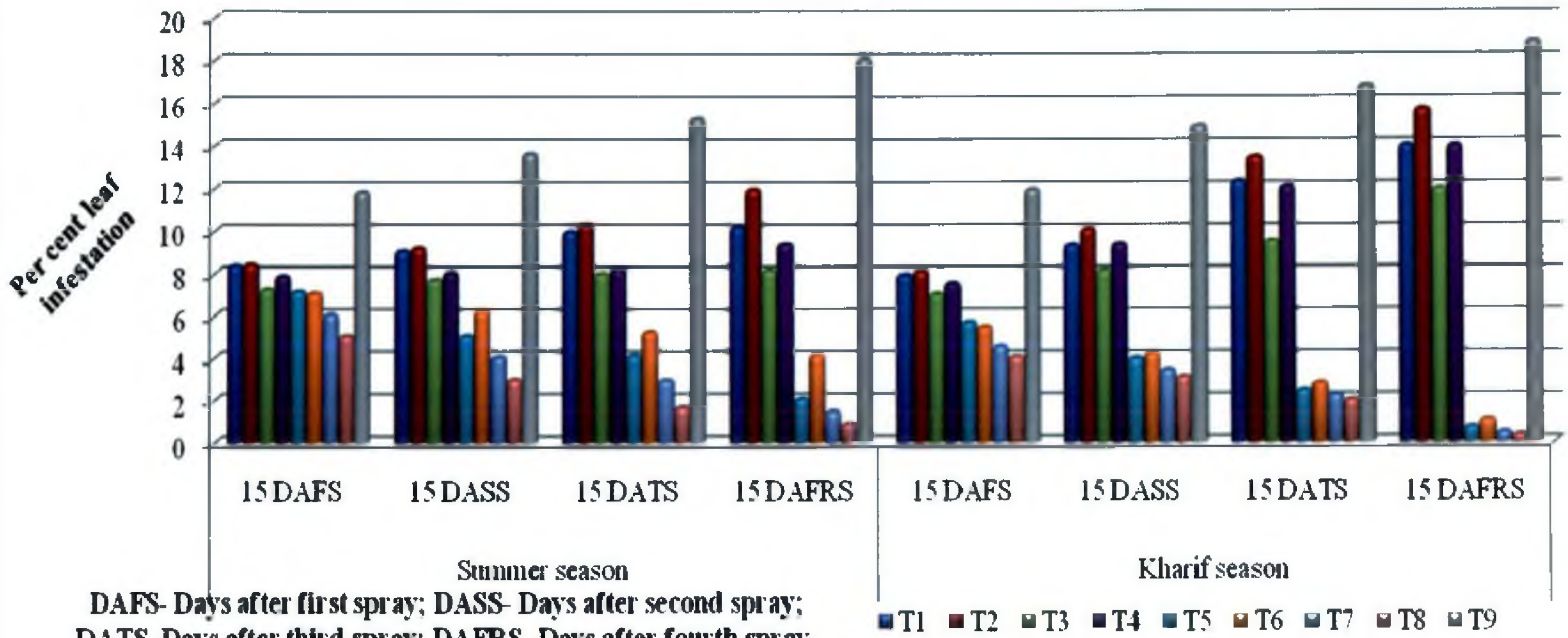
The experiment on the efficacy testing of microbial and biorational insecticides (Table 14; Fig. 10) showed that the standard check malathion 50 EC, performed better in reducing the leaf infestation. However, azadirachtin 1% was equally effective in reducing the per cent infestation of leaf. Eventhough malathion 50 EC showed slight variation in reducing the leaf infestation, it was on par with azadirachtin 1%. Considering the toxicity and residual effect of malathion 50 EC on brinjal fruits, azadirachtin 1% is found to be best for controlling *S. docilis*. Nuaman (1996), Jacob and Sheila (1994) and Dreyer (1986) reported that neem extract was highly effective against *S. docilis* in increasing the larval mortality and reducing the pupation. The present study is also in line with reports of the earlier works.

5.2.5 Population build up of natural enemies on brinjal ecosystem during summer and *kharif* season

The results given in Table 15; Fig. 11 showed that the activity of predatory insects like coccinellids and spiders (Table 16; Fig. 12) were found to be higher in the plots treated with microbial insecticides. However, a constant population of predators was seen in the plots treated with spinosad 45 SC (T_6) both in summer and *kharif* season.

Tillman and Mulrooney (2000) reported that spinosad 45 SC exhibited excellent selectivity against coccinellid predatory beetles. The present findings are in agreement with the findings of Tillman and Mulrooney (2000).

Fig. 10. Mean per cent of leaf infestation at different intervals after application of treatments against *S. docilis* during summer and *kharif* season



DAFS- Days after first spray; DASS- Days after second spray; DATS- Days after third spray; DAFRS- Days after fourth spray.

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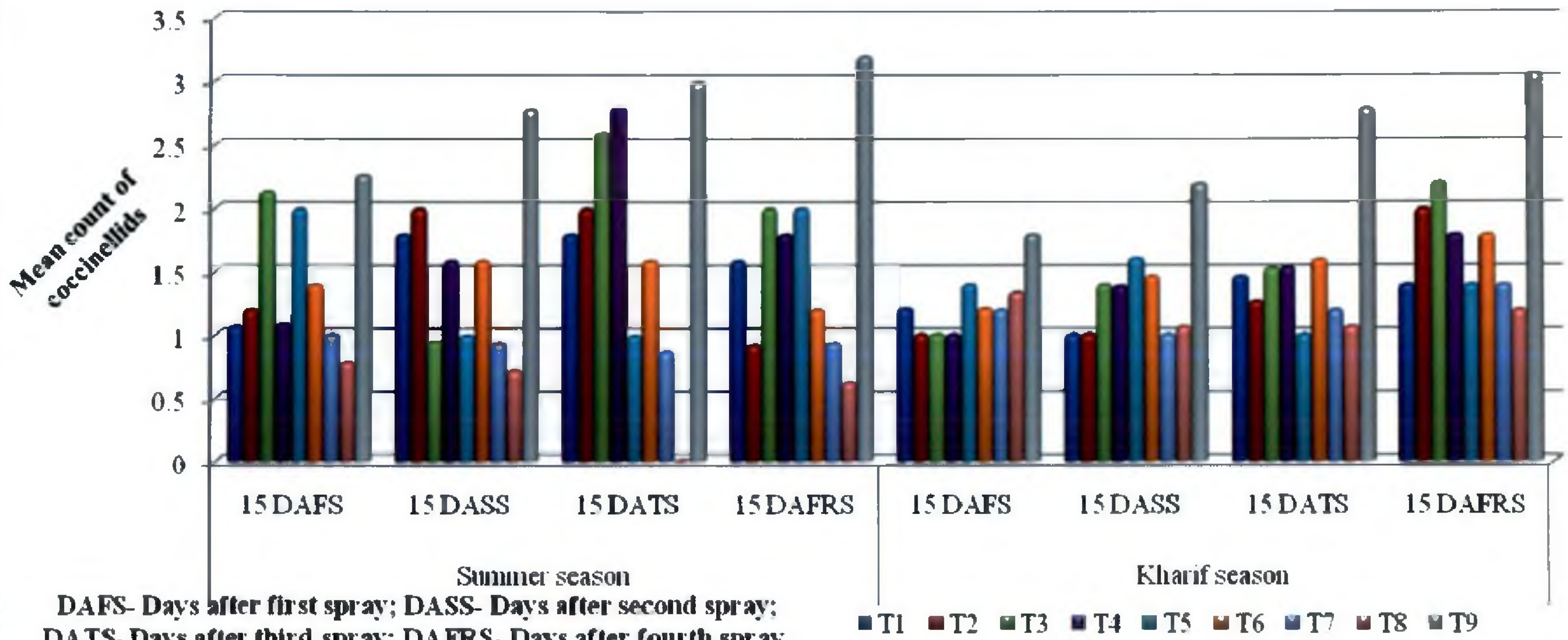
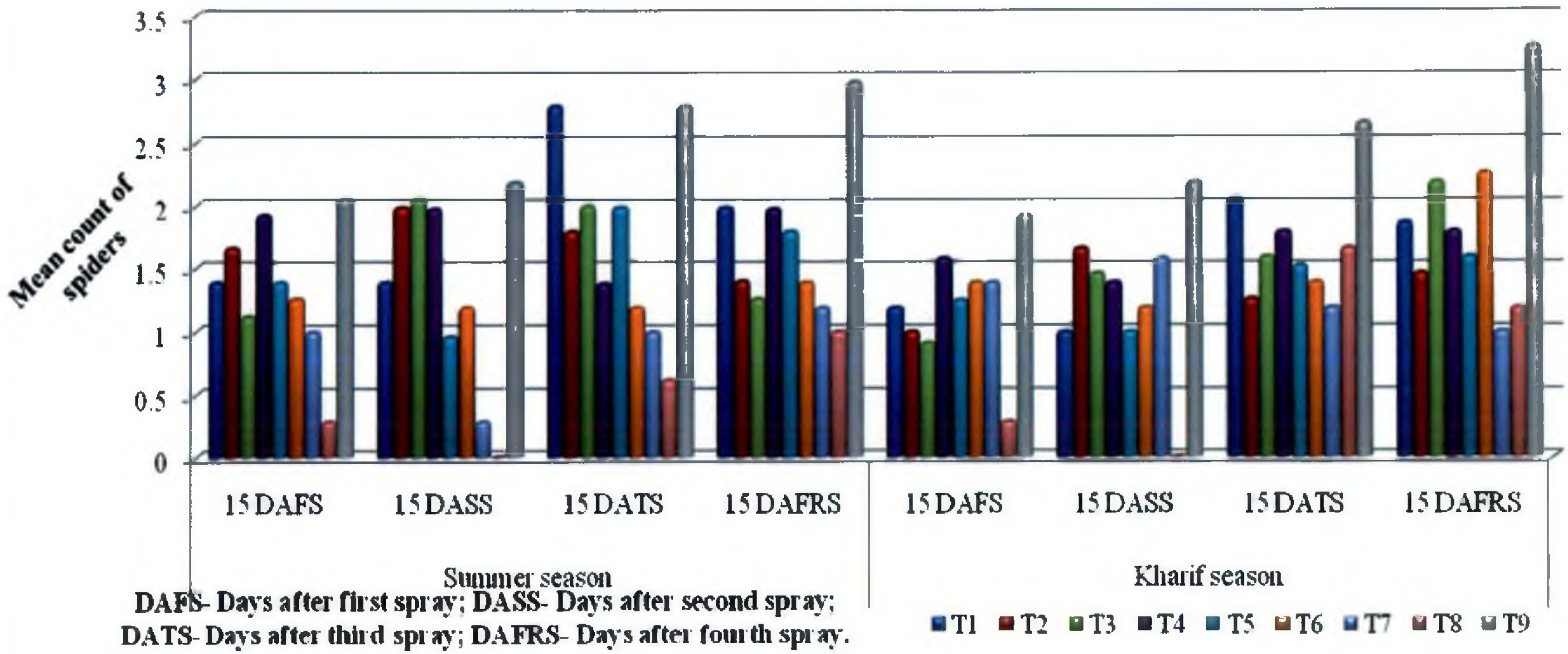
Fig. 11. Mean number of coccinellids at different intervals after application of treatments during summer and *kharif* season



DAFS- Days after first spray; DASS- Days after second spray; DATS- Days after third spray; DAFRS- Days after fourth spray.

Fig. 12. Mean number of spiders at different intervals after application of treatments during summer and *kharif* season



DAFS- Days after first spray; DASS- Days after second spray; DATS- Days after third spray; DAFRS- Days after fourth spray.

120

5.2.6 Yield of brinjal crop during summer and *kharif* season.

The yield was maximum (Table 17; Fig. 13) in plots sprayed with T_6 (spinosad 45 SC) followed by T_8 (malathion 50 EC) and T_7 (azadirachtin 1%) during both summer and *kharif* season. This may be due to the per cent reduction in the fruit damage by T_6 (spinosad 45 SC) against *L. orbonalis* for a longer period. The azadirachtin 1% was most effective against *E. vigintioctopunctata* and *S. docilis*. This was in agreement with the earlier reports by Tayde and Simon (2010) that spinosad 45 SC (at 0.01 per cent) produce more yield due to its contact and ingestion action of insecticide to insect pests. Similar observations were made by Pareet and Basavanagoud (2012) that highest fruit yield was obtained in spinosad treated plots in brinjal as compared to microbial and other biorational insecticides.

5.2.7 Economics of brinjal crop during summer and *kharif* season.

Spinosad 45 SC (T_6) gave higher returns of Rs. 2.52 in summer and Rs. 2.67 in *kharif* season for every one rupee invested. The spinosad 45 SC was followed by malathion 50 EC (T_8) and azadirachtin 1% (T_7). The higher yield in these treatments account for the higher benefit cost ratio.

5.3 EFFECT AND COMPATIBILITY OF SPINOSAD 45 SC ON ENTOMOPATHOGENIC FUNGI USING POISONED FOOD TECHNIQUE UNDER *IN VITRO* CONDITION.

5.3.1 *In vitro* evaluation of spinosad 45 SC by poisoned food technique

The spinosad 45 SC at recommended concentration (40 µl) inhibit only 5.23 per cent (Table 19; Fig. 14) of colony growth of *M. anisopliae*. However, at 120 µl concentration, there was 26.75 per cent growth inhibition. Hence, it can be inferred that spinosad 45 SC is not compatible with *M. anisopliae*.

Fig. 13. Yield obtained due to the application of different treatments during summer and *kharif* season

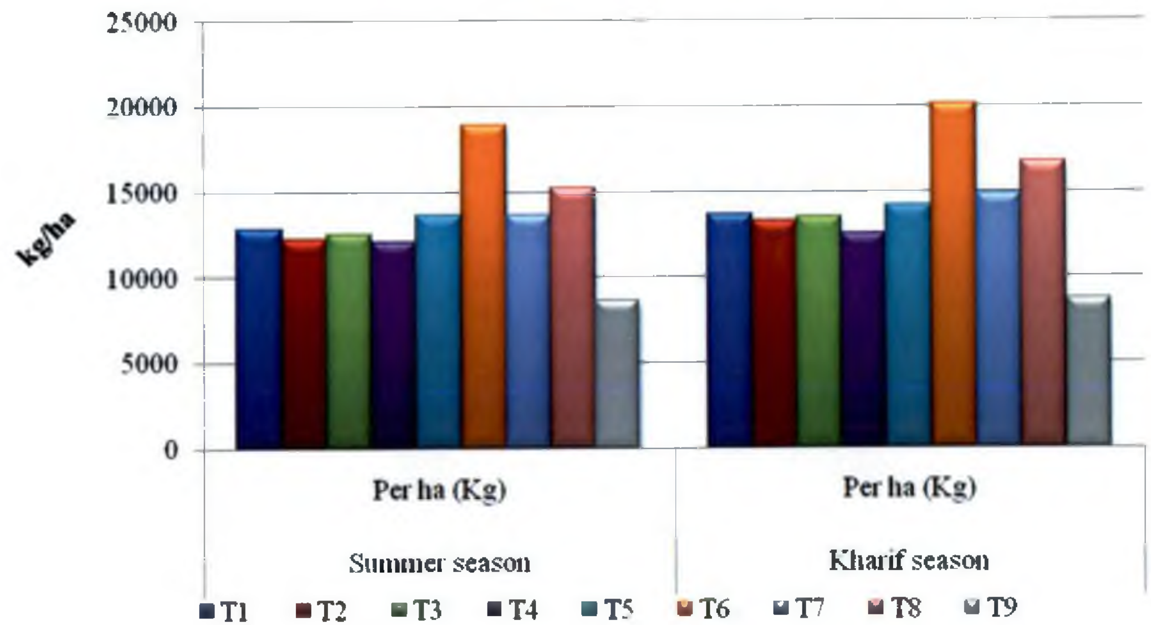


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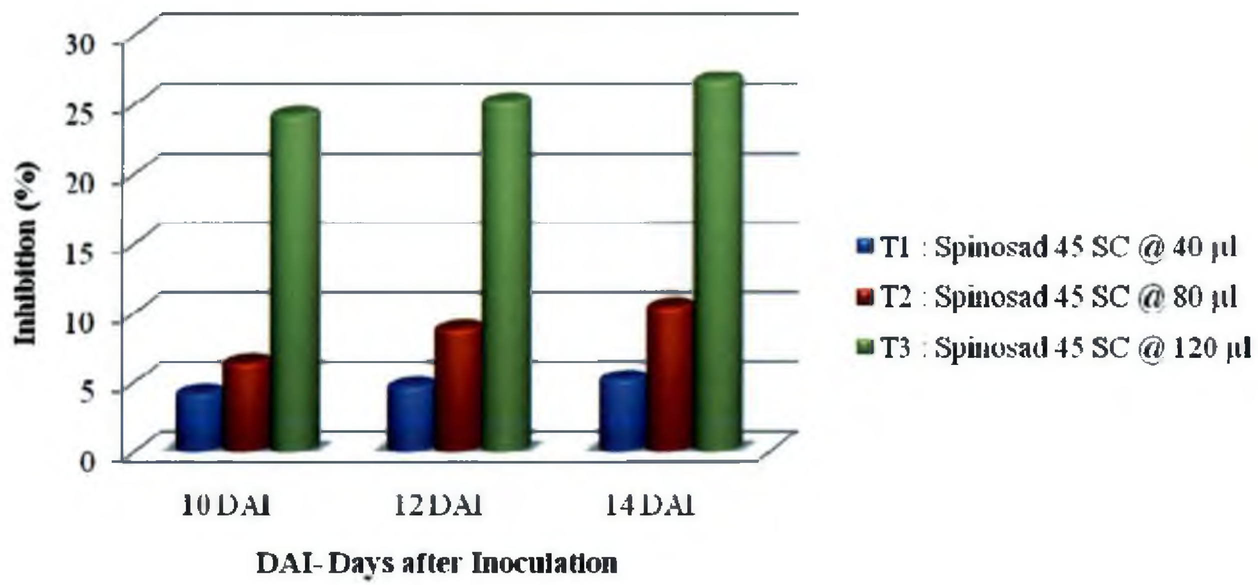
Fig. 14. Inhibition of colony diameter of *M. anisopliae* (%)



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The *in vitro* evaluation of spinosad 45 SC on entomopathogenic fungi *B. bassiana* (Table 20; Fig. 15) revealed that, the spnosad 45 SC at 120 µl concentration inhibited *B. bassiana* colony up to 47.76 per cent. The recommended concentration of spinosad 45 SC (40 µl) reduced the colony growth by 23.22 per cent. Hence, it is evident that spinosad is having lesser compatibility with *B. bassiana* as compared to *M. anisopliae.*

The present findings are not in agreement with the earlier report of Asi *et al.* (2010) that, spinosad 45 SC was safe to conidial germination and growth of fungi *M. anisopliae*. Amutha *et al.* (2010) reported that the spinosad 45 SC is slightly toxic to *B. bassiana.* The present finding is not in agreement with Amutha *et al.* (2010) where in there was drastic reduction of colony growth of *B. bassiana* when treated with recommended dosage of spinosad 45 SC.

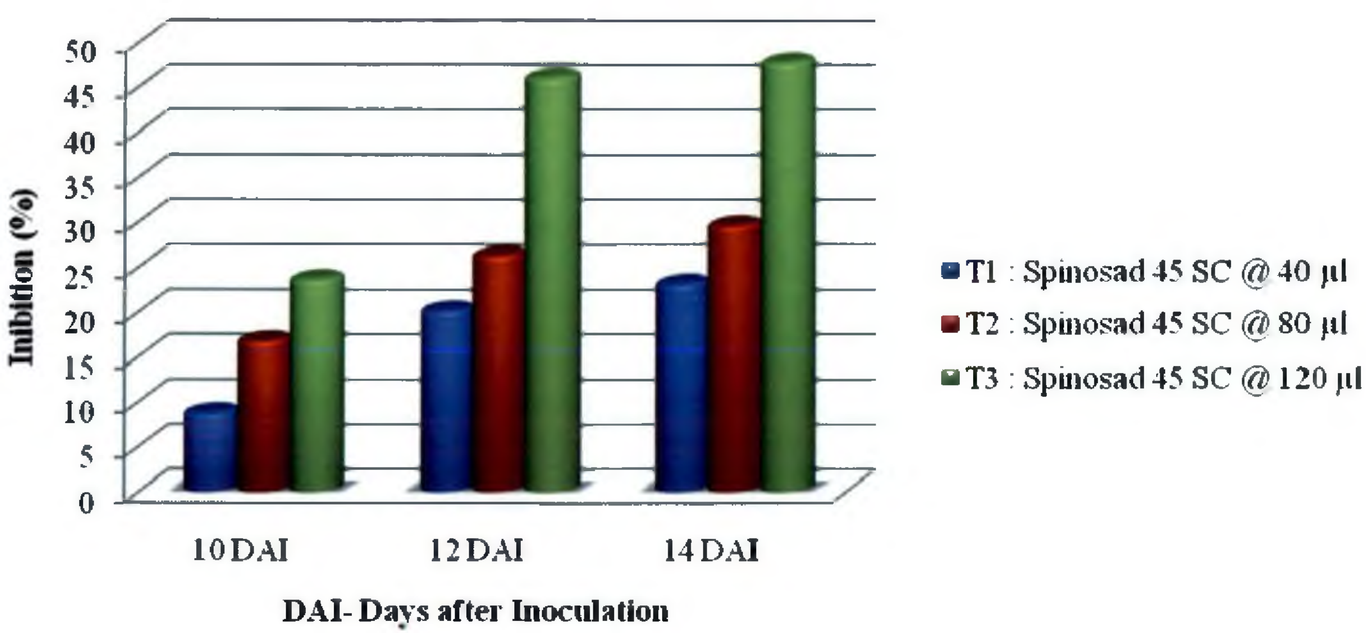
5.3.2 *In vitro* evaluation of spinosad 45 SC on entomopathogenic fungi by sporulation inhibition study

Spinosad 45 SC when applied at recommended concentration (40 µl), the sporulation of *M. anisopliae* was affected up to 3.76 to 17.86 (Table 21; Fig. 16). While, there was inhibition of sporulation when applied at 120 µl (17.86 per cent). However, when spinosad 45 SC applied at recommended concentration to *B. bassiana* colony, there was no sporulation. This reveals that at recommended concentration, it is moderately compatible with *M. anisopliae.*

5.3.3 *In vitro* evaluation of spinosad 45 SC on entomopathogenic fungi by spore germination inhibition study

Spinosad 45 SC when applied at recommended concentration (40 µl), 73.18 per cent (Table 22; Fig. 17) spore germination of *M. anisopliae* was observed. The present findings were not in agreement with the earlier report of Akbar *et al.* (2012) that the spinosad is compatible with *M. anisopliae* and was found safe to conidial germination and growth of the fungi. However, there was

Fig. 15. Inhibition of colony diameter of *B. bassiana* (%)



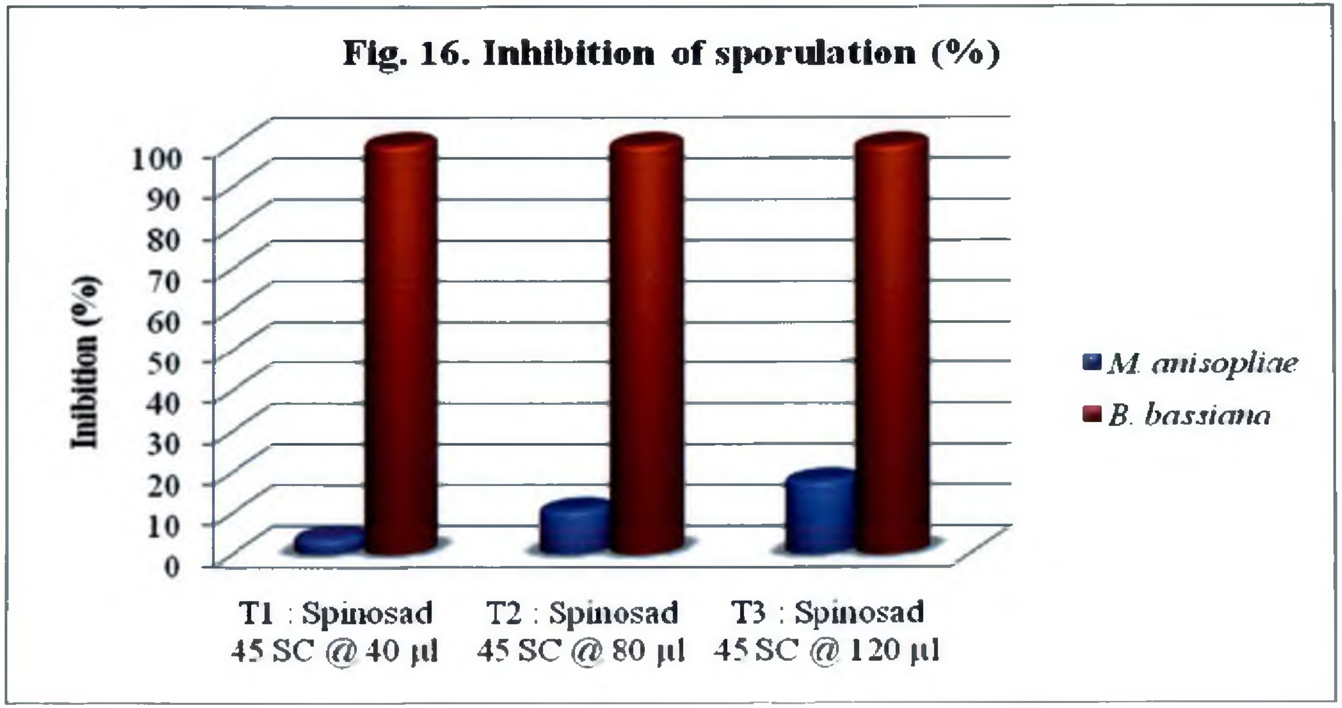


Fig. 16. Inhibition of sporulation (%)
Inhibition (%)
100
90
80
70
60
50
40
30
20
10
0
T1 : Spinosad 45 SC @ 40 µl
T2 : Spinosad 45 SC @ 80 µl
T3 : Spinosad 45 SC @ 120 µl
M. anisopliae
B. bassiana

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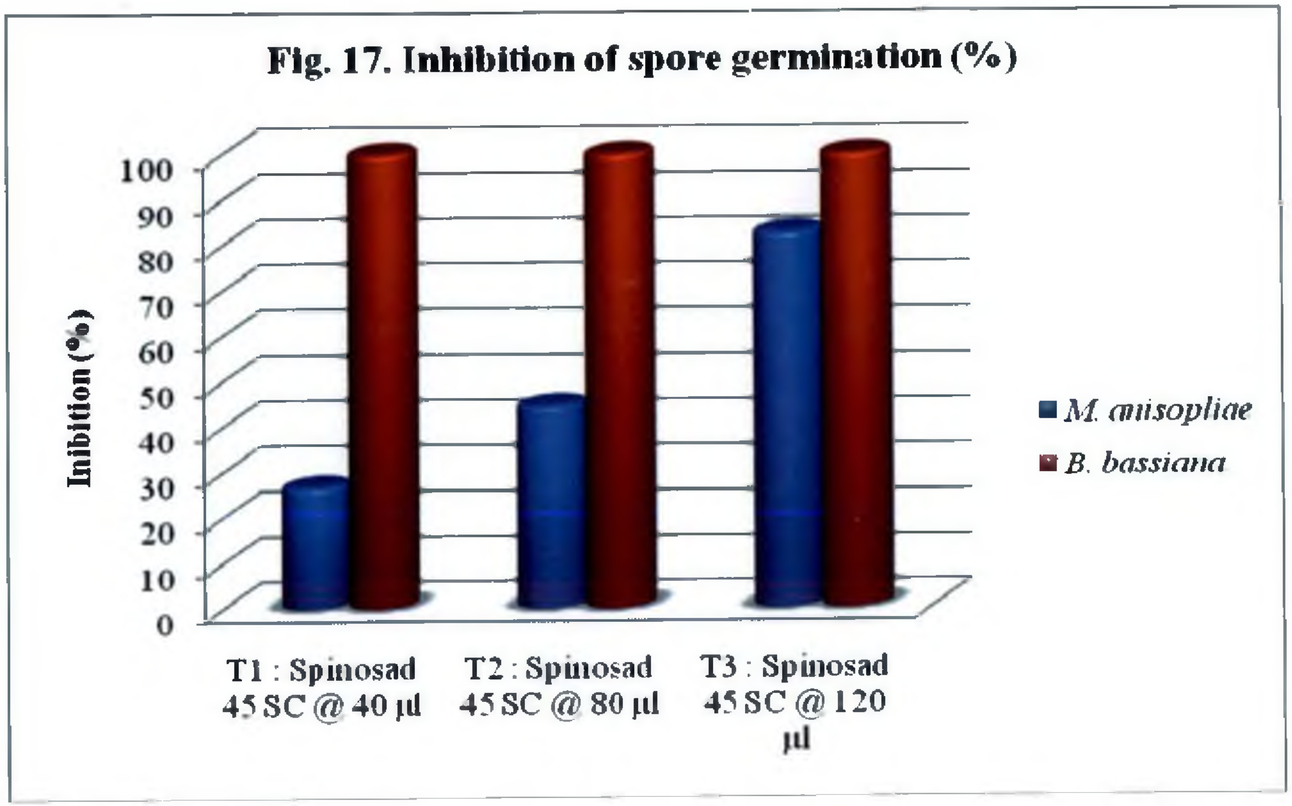
Fig. 17. Inhibition of spore germination (%)
Inhibition (%)
100
90
80
70
60
50
40
30
20
10
0
T1 : Spinosad 45 SC @ 40 µl
T2 : Spinosad 45 SC @ 80 µl
T3 : Spinosad 45 SC @ 120 µl
M. anisopliae
B. bassiana

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100 per cent inhibition of germination of *B. bassiana* spores in all concentration of spinosad 45 SC. The present finding is not in agreement with the earlier reports by Rajanikanth *et al.* (2010) that *B. bassiana* can be compatible with spinosad.

From the present study, it was clear that both the fungi tested are not compatible with the spinosad 45 SC in the laboratory condition. This need to be ascertained under field condition, since, the field condition may have lower dose of insecticide due to drift and further break down of insecticide.

5.4 RESIDUE OF SPINOSAD 45 SC ON BRINJAL FRUITS

The results from the residue estimation of spinosad 45 SC on brinjal (Table 23) revealed that residue of major component of spinosad *i.e., spinosin* A recorded the residue of 0.104 mg/kg of fruits, while the minor component of spinosad *i.e., spinosin* D showed the residue of 0.025 mg/kg of fruits one day after harvest. The maximum residue limit of spinosad is 0.7 mg/kg (EFSA, 2012). The residue of major and minor components of spinosad 45 SC on brinjal fruits were below the maximum residue limit as evidenced from the result. This was in agreement with the earlier reports by Deshmukh and Bhamare (2006 b) that spinosad 45 SC at 0.1 per cent were found below the detection limit on brinjal fruits.

SUMMARY

6. SUMMARY

The study entitled, "Biorational management of major pests in brinjal (*Solanum melongena* L.)" was carried out in the Instructional Farm and Department of Agricultural Entomology, College of Agriculture at Padanakkad. Investigation was under taken to study the efficacy of different microbial preparation, biorational and neem based insecticides against major pests of brinjal *viz.,* shoot and fruit borer, *Leucinodes orbonalis*; epilachna beetle, *Epilachna vigintioctopunctata*; leaf roller, *Antoba olivacea* and hairy caterpillar, *Selepa docilis*. The salient findings of the study are summarized below.

1. A survey was carried out in the brinjal growing tracts of Kasargod district representing three agro climatic regions *viz.,* low land, mid land and high land. The survey revealed that per cent incidence of pests like *L. orbonalis*, *E. vigintioctopunctata* and *A. olivacea* are severe on brinjal in low, mid and high land area of Kasargod district. However, severe infestation of *S. docilis* was noticed in low land, compared to mid and high land area of Kasargod district.

2. The efficacy testing of microbial preparations, biorational and neem based insecticides against *L. orbonalis* revealed that the spinosad 45 SC is found to be effective during both summer and *kharif* season in controlling the shoot and fruit borer of brinjal.

3. Azadirachtin (1%) was found to be most effective in controlling *E. vigintioctopunctata* adults as well as grubs. It was also found to be effective in reducing mean per cent leaf infestation by *E. vigintioctopunctata* during both summer and *kharif* season.

4. The *Bt* formulation was found to be highly effective for early larval instars of *A. olivacea*. However, for the later instars, malathion 50 EC was found to be effective during both summer and *kharif* season.

5. The azadirachtin 1% was found to be highly effective against *S. docilis* as compared to other treatments *viz.,* microbial preparations and other biorational insecticides during both summer and *kharif* season.

6. The spinosad 45 SC was safer to natural enemies like predatory coccinellids and spiders in brinjal ecosystem during both summer and *kharif* season as revealed from the results.

7. The yield of brinjal plant was higher in spinosad 45 SC treated plots and higher return was obtained with Rs. 2.52 and Rs. 2.67 during both summer and *kharif* season respectively for every one rupee invested.

8. Laboratory experiments were conducted to find the effect and compatibility of spinosad 45 SC on entomopathogenic fungi using poisoned food technique under *in vitro* condition. The results revealed that spinosad 45 SC is not compatible with *M. anisopliae* and *B. bassiana* in terms of colony development, sporulation and spore germination.

9. Laboratory experiment was conducted to find the residue of spinosad 45 SC on brinjal fruits. The results revealed that the residue of major and minor component of spinosad 45 SC were below the maximum residue limit one day after harvest.

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APPENDICES

10. Natural enemies

Natural enemies	1 MAT	3 MAT	4 MAT
Coccinellids			
Rove beetles			
Syrphids			
Ants			
Spiders			
others			

11. Control measure adopted

Pesticide applied (name and dosage)			Freque-ncy of applic-ation	Equip-ment used	Other control measures	Level of control			
Chemical	Botanical	Others				Poor	Satisf-actiory	Fair	Good

12.
   a. Is he aware of any resistant variety :
   b. If so, details of that variety :

13. Whether the insecticide is applied as prophylactic or curative :

14.
   a. Whether 2 insecticides are applied in combination :
   b. If then, details :

15.
   a. Sources of information of plant production :
   b. If not dependent on agencies, reasons :

16. Whether they are in need of advice for handling problem :

17. Yield obtained :

18. Fruit quality : Low/ Medium/ High

APPENDIX - I

PROFORMA

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

CROP MANAGEMENT PRACTICE

6. Type of manures applied : Organic (alone) / Organic + Chemical fertilizers
7. Whether the recommended practice followed : Yes/ No
8.
   a. Farming practice are carried by :
   b. If by farmer himself, whether family laborer engaged :

PEST MANAGEMENT

9. (i) Pests	Intensity of damage			Stage of plant infested			Season of occurrence
	Mild	Moderate	Severe	1MAT	2MAT	13and 4 MAT	
a. Leucinodes							
b. Epilachna							
c. Leaf roller							
d. Hairy caterpillar							
e. Aphids							
f. White flies							
g. Jassids							
(ii) Diseases							
a. Bacterial wilt							
b. Little leaf							
c. others							

10. Natural enemies

Natural enemies	1 MAT	3 MAT	4 MAT
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Rove beetles			
Syrphids			
Ants			
Spiders			
others			

11. Control measure adopted

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13. Whether the insecticide is applied as prophylactic or curative :

14.
   a. Whether 2 insecticides are applied in combination :
   b. If then, details :

15.
   a. Sources of information of plant production :
   b. If not dependent on agencies, reasons :

16. Whether they are in need of advice for handling problem :

17. Yield obtained :

18. Fruit quality : Low/ Medium/ High

ABSTRACT

BIORATIONAL MANAGEMENT OF MAJOR PESTS IN BRINJAL (*Solanum melongena* L.)

by

GOWRISH K.R.

(2012 - 11 - 175)

ABSTRACT

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ABSTRACT

Brinjal (*Solanum melongena* L.) is a plant of considerable economic importance in many tropical and sub tropical parts of the world. It is a popular vegetable grown as poor man's crop in India. It is a native of India and is grown throughout the country. The brinjal crop is usually infested by a number of pests right from nursery stage till harvest. Among the insect pests, the most important and destructive ones are shoot and fruit borer, *Leucinodes orbonalis*; epilachna beetle, *Epilachna vigintioctopunctata*; leaf roller, *Antoba olivacea* and hairy caterpillar, *Selepa docilis*. For the management of these pests, the conventional pest management practices often provide unsatisfactory results. Further, the use of chemical pesticide results in insecticide resistance, pest resurgence, destruction of natural enemies and pesticide residue in the harvested produce and related environment and health hazards. Hence, there is an impetus for research and development of eco-friendly and biorational alternative for the sustainable management of major pests of brinjal.

A survey was conducted in the three agro climatic regions of Kasargod district *viz.*, low, mid and high land area. The survey revealed that per cent incidence of pests like *L. orbonalis*, *E. vigintioctopunctata* and *A. olivacea* were severe on brinjal in low, mid and high land area of Kasargod district. However, severe infestation of *S. docilis* was noticed in low land, compared to mid and high land area of Kasargod district.

Spinosad 45 SC was found to be effective in controlling the shoot and fruit borer of brinjal during both summer and *kharif* season. Azadirachtin 1% was found to be most effective in controlling *E. vigintioctopunctata* adults as well as grubs. It was also found to be effective in reducing mean per cent of leaf infestation during both summer and *kharif* season. The *Bt* formulation was found to be highly effective for early instar larvae of *A. olivacea*. However, for older instar caterpillars, malathion 50 EC was found to be effective during both summer

and *kharif* season. The azadirachtin 1% was found to be highly effective against *S. docilis* as compared to other treatments during both summer and *kharif* season. The spinosad 45 SC was safer to natural enemies like predatory coccinellids and spiders in brinjal ecosystem.

The yield of brinjal plant was higher in spinosad 45 SC treated plots and a higher return was obtained worth Rs. 2.52 and Rs. 2.67 during both summer and *kharif* season respectively for every one rupee invested.

Effect and compatibility of spinosad 45 SC on entomopathogenic fungi using poisoned food technique under *in vitro* condition revealed that spinosad 45 SC is not compatible with *M. anisopliae* and *B. bassiana* in terms of colony development, sporulation and spore germination.

Residue of major and minor component of spinosad 45 SC were below the maximum residue limit.