

Original Research Article

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Comparative Efficacy of Latest Chemical Insecticides and Bio-Pesticides against (*Leucinodes orbonalis* Guenee.) on Brinjal at Trans Yamuna Region of Prayagraj (U.P.)

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ABSTRACT

The present study entitled, to study the comparative efficacy of latest chemicals insecticides and Bio-pesticides against brinjal shoot and fruit borer, (*Leucinodes orbonalis* Guenee) on brinjal at trans Yamuna region of prayagraj .The present investigation was conducted at the Central Research Farm of “Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh” during Kharifseason 2019. The research farm is situated on the right side of Prayagraj, Rewa road at 20 degrees and 15⁰ North, 60⁰ east longitude city and is about 129.2 cm above sea level. The site selected was uniform, cultivable with typical sandy loam soil having good drainage.The efficacy of chemical insecticides and bio-pesticides against brinjal shoot and fruit borer (*Leucinodes orbonalis*, Guenee). Frist spray per cent infestation of 3 DAS The data on the percent infestation of shoot and fruit borer on third day after first spray revealed that all the chemical treatments were significantly superior over control. Among all the treatments lowest percent shoot, infestation was recorded in Chlorantraniliprole (8.31%) followed by Spinetoram (9.53%) and Spinosad (11.25%). Treatments Sixer Plus (18.46%), *Metarrhizium anisopliae* (22.64%) were statistically at par with each other and treatments *Beauveria bassiana* (23.62%), Neem oil (24.99%) were found be least effective then on 7 DAS was among all the treatments lowest per cent shoot, infestation was recorded in Chlorantraniliprole (7.77%) followed by Spinetoram (9.57%) and Spinosad (10.17%). Treatments Sixer Plus (17.81%), *Metarrhizium anisopliae* (21.39%) were statistically at par with each other and treatments Neem oil (23.90%), *Beauveria bassiana* (23.92%) were found be least effective then on 14 DAS was found Among all the treatments lowest per cent shoot, infestation was recorded in Chlorantraniliprole (8.00%) followed by Spinetoram (9.96%) and Spinosad (12.16%). Treatments Sixer Plus (19.07%), *Metarrhizium anisopliae* (23.15%) were statistically at par with each other and treatments *Beauveria bassiana* (24.34%), Neem oil (25.94%) was found to be least effective. Then the Second spray: Per cent fruit infestation was revealed that on 3 DAS was among all the treatments lowest per cent shoot, infestation was recorded in Chlorantraniliprole (5.42%) followed by Spinetoram (8.27%) and Spinosad (9.12%). Treatments Sixer Plus (13.15%), *Metarrhizium anisopliae* (18.55%) were statistically at par with each other and treatments *Beauveria bassiana* (19.42%), Neem oil (20.64%) were found be least effective followed by on 7 DAS Among all the treatments lowest per cent shoot, infestation was recorded in Chlorantraniliprole (5.78%) followed by Spinetoram (8.62%) and Spinosad (9.24%). Treatments Sixer Plus (13.65%), *Metarrhizium anisopliae* (18.38%) were statistically at par with each other and treatments *Beauveria bassiana* (19.41%), Neem oil (20.14%) were found be least effective then on 14 DAS the data Among all the treatments lowest per cent shoot and fruit borer infestation was recorded in Chlorantraniliprole (6.27%) followed by Spinetoram (9.07%) and Spinosad (9.59%). Treatments Sixer Plus (14.07%), *Metarrhizium anisopliae* (19.12%) were statistically at par with each other and treatments *Beauveria bassiana* (20.64%), Neem oil (21.72%) but significantly superior over the

Keywords

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Introduction

Vegetable cultivation is one of the most profitable and dynamic branches of agriculture. Vegetables are an important constituent of the human diet. Brinjal is an important dietary vegetable crop. Brinjal (*Solanum melongena* Linnaeus) also known as eggplant is referred to as the "King of vegetables" originated from India and now grown as a vegetable throughout the tropical, sub-tropical and warm temperate areas of the world. It is the most important vegetable in the Indian Subcontinent that accounts for almost 50% of the world's area under its cultivation. (Kolhe, 2017) Under sustainable farming, brinjal provides regular daily income to meet the day-to-day expenditure. (Murugesan, 2009) It has become an important source of income for both farmers and field labourers, service charges for the machinery, serving as a vehicle for reducing poverty in rural areas (Nawale, 2018). Brinjal occupies an important position among the other regular vegetable crops that are available throughout the year and popular vegetable grown as a poor man's crop in India. Brinjal, *Solanum melongena* L. is one of the major vegetables in India extensively grown under diverse agro-climatic conditions throughout the year. (Singh, 2018) 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 a vegetable in the country (Singh *et al.*, 2016). It is also used as a raw material in pickle making and as an excellent remedy for curing diabetes. It is also used as a good appetizer. It is a good aphrodisiac, cardiogenic, laxative and reliever of inflammation (Shridhara, 2019; Sahu, 2018). The major brinjal growing states in India are Andhra Pradesh, Karnataka, West Bengal, Tamil Nadu, Maharashtra, Orissa, Uttar Pradesh, Bihar, and Rajasthan. The yield loss by this pest varied from 0.081.11 q/ha based

on the inconsumable pest of damaged fruits and 0.46- 3.80 q/ha when the whole of damaged fruits was taken into consideration. The Larvae of this pest cause 12-16% damage to shoots and 20-60% damage to fruits. The pest is very active during the rainy and summer season and often causes more than up to 95% in India. It is also reported that the infestation of fruit borer causes a reduction in Vitamin 'C' content to an extent of 68 % in the infested fruits (Anwar *et al.*, 2015). Reported that the 26 pests which attacked by brinjal crop in India, whereas 140 species of insect pests belonging to 50 families from 10 orders reported on the crop of the world. (Sharma, 2017). Brinjal is one of the most important solanaceous vegetables in South-East Asian countries. Brinjal occupies 39.34 % (0.68 Million ha.) of the world's area of 1.72 million ha. China rank 1st in production they contribute 62% of global production 31855430 tonnes in 2016 and 3283567 tonnes in 2017 India and 2nd with production 12515000 tonnes in 2016 12510000 tonnes in 2017 3rd position acquired by Egypt they having 1300265 tonnes in the year 2016 and 1307793 tonnes in the year 2017. The year 2017-18 in India West Bengal rank 1st in production 3,027.75 tonnes and contributing 23.69 % followed by on 2nd position Orissa, 3rd Gujarat, 4th Bihar, 5th Madhya Pradesh and at 13th position Uttar Pradesh producing 2013.02, 1423, 1241.71, 1073.63, 275.40 tonnes Respectively and contributing 15.75%, 11.14%, 9.72%, 8.40%, 2.16% respectively. (APEDA). The Brinjal fruit and shoot borer (BFSB), *Leucinodes orbonalis* (Lepidoptera: Pyralidae) is the most obnoxious detrimental and ubiquitous pest one of the most important destructive pests it alone causes damage as high as 85.90% and even up to 100% damage is also recorded in Brinjal and other solanaceous vegetables. *Leucinodes orbonalis* was described and classified by Guenee in 1854. It is an internal borer which damages

the tender shoots and fruits. The attack of this pest causes considerable damage to brinjal crop each year, affecting the quality and yield of the crop. The Larvae of this pest cause 12-16% damage to shoots and 20-60% damage to fruits. The pest is very active during the rainy and summer season and often causes more than up to 95% in India. The larvae bore into tender shoots and cause wilting and dead heart and in the later stage, they bore the tender fruits rendering them unfit for human consumption. So far, *L. orbonalis* is considered as a major pest of brinjal as a shoot and fruit borer in the established crop in the main field (Halder *et al.*, 2015). After hatching from eggs, young caterpillars search for and bore into tender shoots near growing points into flower buds or the fruits. Caterpillars prefer fruits over other plant parts. Larvae go through at least five instars and there are reports of the existence of six larval instars. The larval period lasts from 12 to 15 days in the summer and up to 22 days in winter (Rahman, 2006). Climatic conditions are important in the life cycle of the borer. As temperature increases and humidity decreases fecundity increases and the duration of life cycle decreases (Srinivasan, 2009). Within one hour after hatching, the larvae bore into the nearest tender shoot, flower, or fruit, they plug the entrance hole with excreta. In young plants, caterpillar bores midrib of large leaves (Netam, 2018). As a result, the affected leaves may drop off. Larvae feeding inside shoots result in wilting of young shoots. The presence of wilted shoots in a brinjal field is a symptom of damage by this pest. The damaged shoots ultimately wither and drop off. This reduces plant growth, which in turn, reduces fruit number and size. New shoots can arise but this delays crop maturity and the newly formed shoots are also subjected to larval damage. Larval feeding in flowers is a relatively rare occurrence failing to form fruits from damaged flowers. Larval feeds inside the fruit which destroys the tissue of

the fruit. The feeding tunnels are often clogged with feces. This makes even slightly damaged fruit unfit for marketing. The yield loss varies from season to season and from location to location. Damage to fruits particularly in autumn is very severe and the whole crop can be destroyed. (Anwar *et al.*, 2015). It is one of the most serious pests of Brinjal fruits and plants. Long and narrow are less susceptible to attack 21% of fruits are found damaged by this pest. The infestation starts a few weeks after transplanting. The caterpillars bore into the growing shoots, midribs, and petioles of large leaves and feed on internal tissues. As a result of damage, affected shoots wither and dry up and plants exhibit the symptoms of dropping. After fruit formation, larvae make their entry under the calyx, when they are young. The holes are later plugged with excreta leaving no visible sign of infestation. Large circular holes seen on the fruits are the exit holes. Such fruits lose market value and are unfit for human consumption. Egg period: 3-4 days. Eggs are 150-350 creamy-white and laid singly on tender shoots, ventral side of leaves, fruits, and on a flower. (Alam S. N. 2014). Incubation period: 7 days in winter and 3-5 days in summer. The larva is pink coloured with sparsely distributed hairs on warts on the body and brownish head. Larval period 12-15 days in summer and 22 days in winter. A full-grown larva before going for pupation comes out of the fruit by making exit holes. Pupation takes place in the boat-shaped silken cocoon in the fallen leaves or soil. Pupa: 6-8 days in boat-shaped cocoon also in a tough greyish cocoon on the plant itself. Adult: 2-3 days. Medium-sized adults with white wings flashed with triangular brown and red markings on forewing. Total life cycle: 17-50 days. ETL: 1-5% of fruit damage. Being high in economic value, now a day's cultivation of brinjal is becoming the menace to the farmer because of the attack of the insect pest. Among the several problems

that create an obstacle for brinjal productivity and quality fruits, heavy losses caused by insect pests right from seeding stage till harvest. (Vevai E. J. 1970) has reported that the 26 pests which attacked by brinjal in India, whereas 140 species belonging to 50 families from 10 orders reported on this crop in the world (Frengpong and Buohing, 1978). Among these, the important insect pests which invade this crop regularly are brinjal shoot and fruit borer (*Leucinodes orbonalis* Guen.) Brinjal stem borer (*Euzophera perticella* Peg.), Brinjalhadda beetle (*Epilachnadeudo* casting Wiesel.), Jassid (*Amras cabigutulla* Ishida.), Aphid (*Aphis gossypii* Glov., *Myzus persicae* Suiz.), Whitefly (*Bemisia tabaci* Genn.) and Red spider mites (*Tetranychus telericus*, Lo.), (Ratual 1986). The bio-pesticides play an important role in insect pest management by their various inhibitory actions on insect physiology and behavior. They are the best alternative to chemical insecticides against *Leucinodes orbonalis* on brinjal. They are locally available, relatively cheap, biodegradable, and easy to handle. They are bringing about the balance back to the ecosystem. As the agriculture shift toward organic farming the organic farming, they have much better scope in the management tactics. (Warghat *et al.*, 2019).

Materials and Methods

The present investigations were carried out with a view to find out the bio-efficiency of some eco-friendly materials like botanicals, microbials, with newer and convectional insecticides against the pest of brinjal. Materials and methods adopted in the present study entitled Comparative efficacy of certain chemical insecticides and bio-pesticides against (*Leucinodes orbonalis* Guenee.) on brinjal at Trans Yamuna region of Prayagraj (U.P.). The details of the material used and the method followed during these studies are

described herewith.

Experimental site

The present investigation was conducted at the Central Research Farm of “Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh” during *Kharif* season 2019. The research farm is situated on the right side of Prayagraj, Rewa road at 20 degrees and 150 North, 600 east longitude city and is about 129.2 cm above sea level. The site selected was uniform, cultivable with typical sandy loam soil having good drainage.

Materials

For conducting the studies, various eco-friendly chemicals and insecticides (Table 1), brinjal seed (Banaras Purpal), agricultural implements manure and fertilizers, knapsack sprayer, measuring cylinder, buckets, labels, threads, polythene bags, wax, hand lance, chemicals balance, weighing balance, labours etc. were used. These materials were provided by the department of Agriculture Plant Protection and Entomology, “Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh.

Method adopted

Cultural operations

Preparatory tillage

The plot soil was thoroughly prepared by ploughing followed by two harrowing. The field was cleaned by picking stubbles of previous crop and weeds. Before sowing of seeds on raised beds, one harrowing was done and the experimental plots were laid out as per the statistical design (RBD).

Sowing of seeds on raised bed

The seeds of Brinjal 'Banaras purple long' variety were sown on 24.07.2019 to raise the seedling in nursery. Regular watering and weeding were done up to transplanting of seedling to the main field.

Transplanting and gap filling

The seedlings were transplanted approximately after 4 weeks, in the main field on 13.08.2019 and two gap filling was done to maintain the plant population, keeping one plant per hill.

Application of fertilizers

Application of fertilizers was done at the rate 60: 50: 50 kg N.P.K per hectare. Half dose of Nitrogen and full dose of Phosphorus and Potash were given at the time of transplanting. The remaining dose of nitrogen was applied one month after transplanting. Fertilizers were applied by ring method in the form of single super phosphate, urea and murate of potash.

Hoeing and weeding

Timely hoeing and weeding operations were carried out to conserve soil moisture and to remove weeds as and when needed.

Protective irrigation

The protective irrigation was given in field experimental plots during dry spell and as it and when essential.

Picking

Picking were done plot wise manually.

Yield of brinjal fruits

In order to compare the effectiveness of different treatments on the basis of fruit yield.

The picking of marketable brinjal fruit was done periodically and yield obtained in the net plot at each treatment was recorded. The plot wise yield thus obtained was further converted into hectare basis.

Experimental Details

Season : *Kharif*
Crop : Brinjal
Design : Randomized Block Design
Replication : 03.
Plot size : 2m x 1m
Total no. of plots : 27
Total no of plots for objective no. 1 : 24
(Layout no.1) Total length of area : 12.5m.
Total width of area : 5m.
Spacing : 60x45 cm.
Row to row distance : 60 cm.
Plant to plant : 45 cm.
Dose of Fertilizer : 60:50:50, N.P.K.
Kg/ha,
FYM : 10 tones/ha.
Variety : Banaras Purple long
Seed rate : 500 g /ha.
Total length of the area : 12 mt.
Total width of the area : 8.8 mt.
Gross cultivated area : 105.6 m²
Net cultivated area : 63 m²
Main irrigation channel : 1.0 m.
Sub irrigation channel : 0.5 m.
Width of bund : 0.3 m.

Preparation of insecticidal spray solution

The desired concentration of insecticidal spray solution of desired concentration for each treatment was freshly prepared each time at the site of experiment, just before spraying. The quantity of spray materials required for crop was gradually increased as the crop advanced in age.

The spray solution of desired concentration was prepared by adoption the following formula:

$$V = \frac{C \times A}{\% \text{ a. i.}}$$

Where,

V= Volume of a formulated pesticide required.

C= Concentration required.

A= Volume of total solution to be prepared.

% a.i. = given Percentage strength of a formulated pesticide (David, 2012).

Application of spray solution

The required quantity of insecticides was being thoroughly mixed with water as per the concentration of spray at times of spraying and then the solution was used for spraying. From that the total quantity of water required to cover 1 ha area was determined and then the actual quantity of insecticide to be mixed on gram active ingredient or milli per litre basis was calculated. The spraying was done during morning hours with the help of knapsack sprayer. The suspension was thoroughly mixed before spraying and stirred frequently during the time of spray due care was taken for even distribution of spray solution, thoroughly coverage of entire plant and avoiding drifting of spray solution. Spraying and containers were washed thoroughly with fresh water after each application to avoid contamination.

Methods of recording observations

Efficacy of treatments

The incidence and damage of brinjal shoot and fruit borer were recorded before 1-day spraying and on 3rd day, 7th day and 14th day after insecticidal application. The damage of brinjal shoot and fruit borer were recorded on 5 randomly selected and tagged plants from each plot and then it was converted into per cent of infestation by following formula.,

On Shoot -

Number Basis: The total number of shoots and number of shoots infested of six selected plants from each treatment replication wise were recorded.

$$\text{percent shoot damage(number basis)} = \frac{\text{Number of infested shoot}}{\text{Total number of shoots}} \times 100$$

On fruit

Number basis: At each picking the total number of fruits and number of fruits infested of six selected plants from each treatment replication wise were recorded.

$$\begin{aligned} \text{percent fruit damage(number basis)} \\ = \frac{\text{Number of damage fruits}}{\text{Total number of fruits plucked}} \times 100 \end{aligned}$$

Yadav *et al.*, (2015)

To evaluate the efficacy of chemical insecticides and bio-pesticides against brinjal shoot and fruit borer (*Leucinodes orbonalis*, Guenee)

The infestation in all the treatment were taken a day before imposition of treatments as indicated in tables.

Per cent infestation: Number basis

First spray: Per cent shoot infestation

The Efficacy of certain chemicals and bio-pesticides against brinjal shoot and fruit borer (*Leucinodes orbonalis*, Guenee) are depicted in table 4.3 and figure 4.3.

Per cent infestation of 3 DAS

The data on the per cent infestation of shoot and fruit borer on third day after first spray revealed that all the chemical treatments were significantly superior over control. Among all the treatments lowest per cent shoot, infestation was recorded in

Chlorantraniliprole (8.31%) followed by Spinetoram (9.53%) and Spinosad (11.25%). Treatments Sixer Plus (18.46%), *Metarrhizium anisopliae* (22.64%) were statistically at par with each other and treatments *Beauveria bassiana* (23.62%), Neem oil (24.99%) were found be least effective but significantly superior over the control and were statistically at par each other.

Per cent infestation of 7 DAS

The data on the per cent infestation of shoot and fruit borer on seventh day after first spray revealed that all the chemical treatments were significantly superior over control. Among all the treatments lowest per cent shoot, infestation was recorded in Chlorantraniliprole (7.77%) followed by Spinetoram (9.57%) and Spinosad (10.17%). Treatments Sixer Plus (17.81%), *Metarrhizium anisopliae* (21.39%) were statistically at par with each other and treatments Neem oil (23.90%), *Beauveria bassiana* (23.92%) were found be least effective but significantly superior over the control and were statistically at par each other.

Per cent infestation of 14 DAS

The data on the per cent infestation of shoot and fruit borer on fourteenth day after first spray revealed that all the chemical treatments were significantly superior over control. Among all the treatments lowest per cent shoot, infestation was recorded in Chlorantraniliprole (8.00%) followed by Spinetoram (9.96%) and Spinosad (12.16%). Treatments Sixer Plus (19.07%), *Metarrhizium anisopliae* (23.15%) were statistically at par with each other and treatments *Beauveria bassiana* (24.34%), Neem oil (25.94%) was found to be least effective but significantly superior over the control.

Mean (3th, 7th and 14th DAS) per cent infestation of first spray

The data on the per cent infestation of shoot borer on third, seventh and fourteenth day after spray revealed that all the chemical treatments were significantly superior over control. Among all the treatments lowest per cent shoot, infestation was recorded in Chlorantraniliprole (8.02%) followed by Spinetoram (9.69%) and Spinosad (11.19%). Treatments Sixer Plus (18.45%), *Metarrhizium anisopliae* (22.39%) were statistically at par with each other and treatments *Beauveria bassiana* (23.96%), Neem oil (24.94%) was found to be least effective but significantly superior over the control.

Second spray: Per cent fruit infestation

The Efficacy of certain Chemical insecticides and bio-pesticides against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee) are depicted in table 4.4 and figure 4.4

Per cent infestation of 3 DAS

The data on the per cent infestation of shoot and fruit borer on third day after first spray revealed that all the chemical treatments were significantly superior over control.

Among all the treatments lowest per cent shoot, infestation was recorded in Chlorantraniliprole (5.42%) followed by Spinetoram (8.27%) and Spinosad (9.12%). Treatments Sixer Plus (13.15%), *Metarrhizium anisopliae* (18.55%) were statistically at par with each other and treatments *Beauveria bassiana* (19.42%), Neem oil (20.64%) were found be least effective but significantly superior over the control and were statistically at par each other.

Per cent infestation of 7 DAS

The data on the per cent infestation of shoot and fruit borer on seventh day after first spray revealed that all the chemical treatments were significantly superior over control. Among all the treatments lowest per cent shoot, infestation was recorded in Chlorantraniliprole (5.78%) followed by Spinetoram (8.62%) and Spinosad (9.24%). Treatments Sixer Plus (13.65%), *Metarrhizium anisopliae* (18.38%) were statistically at par with each other and treatments *Beauveria bassiana* (19.41%), Neem oil (20.14%) were found be least effective but significantly superior over the control and were statistically at par each other.

Per cent infestation of 14 DAS

The data on the per cent infestation of shoot borer on fourteenth day after spray revealed that all the chemical treatments were significantly superior over control. Among all the treatments lowest per cent shoot and fruit borer infestation was recorded in Chlorantraniliprole (6.27%) followed by Spinetoram (9.07%) and Spinosad (9.59%). Treatments Sixer Plus (14.07%), *Metarrhizium anisopliae* (19.12%) were statistically at par with each other and treatments *Beauveria bassiana* (20.64%), Neem oil (21.72%) but significantly superior over the control.

Mean (3th, 7th and 14th DAS) per cent infestation of second spray

The data on the per cent infestation of shoot and fruit borer on 3rd, 7th, and 14th days after spray revealed that all the chemical treatments were significantly superior over control. Among all the treatments lowest per cent infestation of shoot and fruit borer was recorded in Chlorantraniliprole (5.82%)

followed by Spinetoram (8.66%) and Spinosad (9.32%). Treatments Sixer Plus (13.60%), *Metarrhizium anisopliae* (18.68%) were statistically at par with each other and treatments *Beauveria bassiana* (19.82%), Neem oil (20.84%) is found be least effective but significantly superior over the control.

Results and Discussion

The present study entitled, “Comparative efficacy of certain chemical insecticides and bio-pesticides against (*Leucinodes orbonalis* Guenee.) Onbrinjal at Trans Yamuna region of Prayagraj (U.P.)” was undertaken at the Central research field, Department of Entomology SHUATS, Prayagraj. The data so obtained through observation on various aspects were subjected to statistical analysis wherever necessary and the data was compiled. Results, thus obtained are presented aspect wise here under. The data on the per cent infestation of shoot borer on third, seventh and fourteenth day after spray revealed that all the chemical treatments were significantly superior over control. Among all the treatments lowest per cent shoot, infestation was recorded in Chlorantraniliprole (8.02%) followed by Spinetoram (9.69%) and Spinosad (11.19%). Treatments Sixer Plus (18.45%), *Metarrhizium anisopliae* (22.39%) were statistically at par with each other and treatments *Beauveria bassiana* (23.96%), Neem oil (24.94%) was found to be least effective but significantly superior over the control. The data on the per cent infestation of fruit borer on 3rd, 7th, and 14th days after spray revealed that all the chemical treatments were significantly superior over control. Among all the treatments lowest per cent infestation of shoot and fruit borer was recorded in Chlorantraniliprole (5.82%) followed by Spinetoram (8.66%) and Spinosad (9.32%). Treatments Sixer Plus (13.60%), *Metarrhizium anisopliae* (18.68%) were

statistically at par with each other and treatments *Beauveria bassiana*(19.82%), Neem oil (20.84%) is found be least effective but significantly superior over the control. These results are in support with Sen *et al.*, (2017), Sharma *et al.*, (2018), who reported that Chlorantraniliprole benzoate was superior in reducing the population of shoot and fruit borer. Muthukrishnan *et al.*, (2013), Visnupriya M. and Muthukrishnan N. (2019) found that Spinetoram was best in controlling shoot and fruit borer. Mainali *et al.*, (2015), Devi *et al.*, (2014) and Mamun, *et al.*, (2014) found that Spinosad was best in controlling shoot and fruit borer. Among botanicals the highest reduction of brinjal shoot and fruit borer infestation was found in the plots treated by Sixer Plus. Dharmagadda *et al.*, (2005) and Manzoor *et al.*, (2011) also

reported that Sixer Plus is best in controlling the pest population of shoot and fruit borer. *Metarrhizium anisopliae* is found the next best treatments which is in line with the findings of Budhavat and Magar (2014), Sharma *et al.*, (2017) and Karmakar *et al.*, (2018) reported as *Metarrhizium anisopliae* was effective in the reduction of damage of shoot and fruit infestation. Kumar *et al.*, (2017). The *Beauveria bassiana* was next effective treatment which is in line with the finding and supported by Singh *et al.*, (2018), Mohit Singh and S. K. Sachan (2015). Among all the treatments Neem Oil found to be least effective but comparatively superior over the control these findings are supported by Singh *et al.* (2016), Karkar *et al.* (2014) and Kalawate and Dethe (2012).

Table.1 Details of insecticides used in experiment

S. No.	TREATMENTS	CHEMICALS NAME AND FORMULATIONS	GROUP	WAITING PERIOD* (Days)	DOSAGE (gm/ml/ltr)	REFERENCE
1	T ₀	Untreated	-	-	-	-
2	T ₁	Neem oil 2 %	Botanical	3	5ml	Kolhe <i>et al.</i> (2017)
3	T ₂	Spinosad 45 SC 0.1%.	Synthetic pyrethroid \Naturalyte	2	0.25ml	Nawale <i>et al.</i> (2018)
4	T ₃	<i>Spinetoram</i> 11.7 SC 0.02%	Semi-Synthetic Spinosyn	2	0.6ml	Maru <i>et al.</i> (2018)
5	T ₄	Sixer Plus	Organic molecule	1	1ml	Manzoor <i>et al.</i> (2011)
6	T ₅	Chlorantraniliprole 18.5 SC 0.2%	Diamides Ryanodine	2	0.2ml	Tripura <i>et al.</i> (2017)
7	T ₆	<i>Metarrhizium anisopliae</i> 1X10 ⁸ spore/gm (Bb)	Biological insecticide	2	2.5 gm	Sharma <i>et al.</i> (2017)
8	T ₇	<i>Beauveria bassiana</i> 1X10 ⁸ spore/gm (Bb)	Biological insecticide	2	2.5 gm	Kumar <i>et al.</i> (2017)
*Waiting period according to the recommendation of Gov. of India, Ministry of Agriculture-Major use of pesticide: Registered under the Insecticide Act, 1968. As on 7.11.2009.						

Table.2 Dates of spray application

Sr. No.	Spray application	Date of application
1	First spray	8.10.2019
2	Second spray	24.10.2019

Table.3 To evaluate the efficacy of chemical insecticides and bio-pesticides against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee). (First Spray): (% shoot infestation)

Treatments		Per cent shoots infestation of <i>Leucinodes orbonalis</i>				
		One day before spray	After spray			
			3 rd Day	7 th Day	14 th Day	Mean
T ₀	Untreated	24.82 (29.87)	26.33 (30.86)	27.11 (31.35)	27.81 (31.82)	27.08 (31.35)
T ₁	Neem oil 2 %	26.71 (31.11)	24.99 (29.99)	23.90 (29.25)	25.94 (30.61)	24.94 (29.95)
T ₂	Spinosad 45 SC 0.1%.	24.68 (29.78)	11.25 (19.59)	10.17 (18.59)	12.16 (20.28)	11.19 (19.53)
T ₃	Spinetoram 11.7 SC 0.02%	23.16 (28.73)	9.53 (17.97)	9.57 (17.99)	9.96 (18.39)	9.69 (18.13)
T ₄	Sixer Plus	22.89 (28.46)	18.46 (25.44)	17.81 (24.96)	19.07 (25.89)	18.45 (25.43)
T ₅	Chlorantraniliprole 18.5 SC 0.2%	22.57 (28.35)	8.31 (16.75)	7.77 (16.17)	8.00 (16.41)	8.02 (16.45)
T ₆	<i>Metarhiziumanisopliae</i>	24.42 (29.61)	22.64 (28.41)	21.39 (27.54)	23.15 (28.75)	22.39 (28.24)
T ₇	<i>Beauveria bassiana</i>	25.97 (30.63)	23.62 (29.08)	23.92 (29.28)	24.34 (29.56)	23.96 (29.31)
Overall Mean		24.40	18.14	17.70	18.80	18.21
F- test		NS	S	S	S	S
S. Ed. (±)		2.26	0.64	1.07	1.24	0.34
C. D. (P = 0.05)		4.85	1.36	2.29	2.65	0.84

(Figures in parenthesis are arc sin transformed values.)

Table.4 To evaluate the efficacy of chemical insecticides and bio-pesticides against brinjal shoot and fruit borer (*Leucinodes orbonalis*, Guenee). (Second Spray): (% fruit infestation)

Treatments		Per cent fruit infestation of <i>Leucinodes orbonalis</i>				
		One day before spray	After spray			
			3 rd Day	7 th Day	14 th Day	Mean
T ₀	Untreated	23.15 (28.74)	22.72 (28.44)	23.02 (28.65)	24.29 (29.51)	23.34 (28.89)
T ₁	Neem oil 2 %	21.91 (27.89)	20.65 (27.01)	20.14 (26.66)	21.72 (27.76)	20.84 (27.15)
T ₂	Spinosad 45 SC 0.1%.	20.73 (27.04)	9.12 (17.57)	9.24 (17.68)	9.59 (18.03)	9.32 (17.77)
T ₃	Spinetoram 11.7 SC 0.02%	20.79 (27.12)	8.27 (16.69)	8.62 (17.07)	9.07 (17.51)	8.66 (17.11)
T ₄	Sixer Plus	21.37 (27.50)	13.15 (21.25)	13.65 (21.67)	14.07 (21.97)	13.60 (21.64)
T ₅	Chlorantraniliprole 18.5 SC 0.2%	20.90 (27.19)	5.42 (13.45)	5.78 (13.85)	6.27 (14.47)	5.82 (13.95)
T ₆	<i>Metarhiziumanisopliae</i>	21.53 (27.59)	18.55 (25.51)	18.38 (25.38)	19.12 (25.92)	18.68 (25.60)
T ₇	<i>Beauveria bassiana</i>	21.23 (27.43)	19.42 (26.14)	19.41 (26.14)	20.64 (27.02)	19.82 (26.43)
Overall Mean		21.45	14.66	14.75	15.59	15.01
F- test		NS	S	S	S	S
S. Ed. (±)		2.03	0.93	0.92	1.04	0.23
C. D. (P = 0.05)		4.35	2.00	1.98	2.24	0.49

Fig.1 Efficacy of chemical insecticides and bio-pesticides against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee). (First Spray) (% shoot infestation)

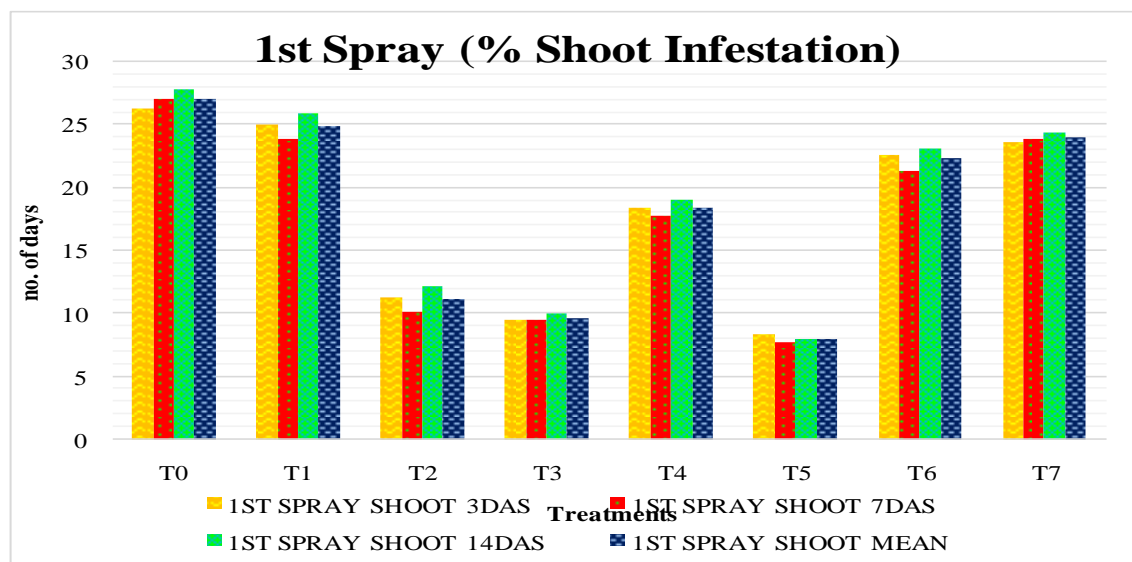
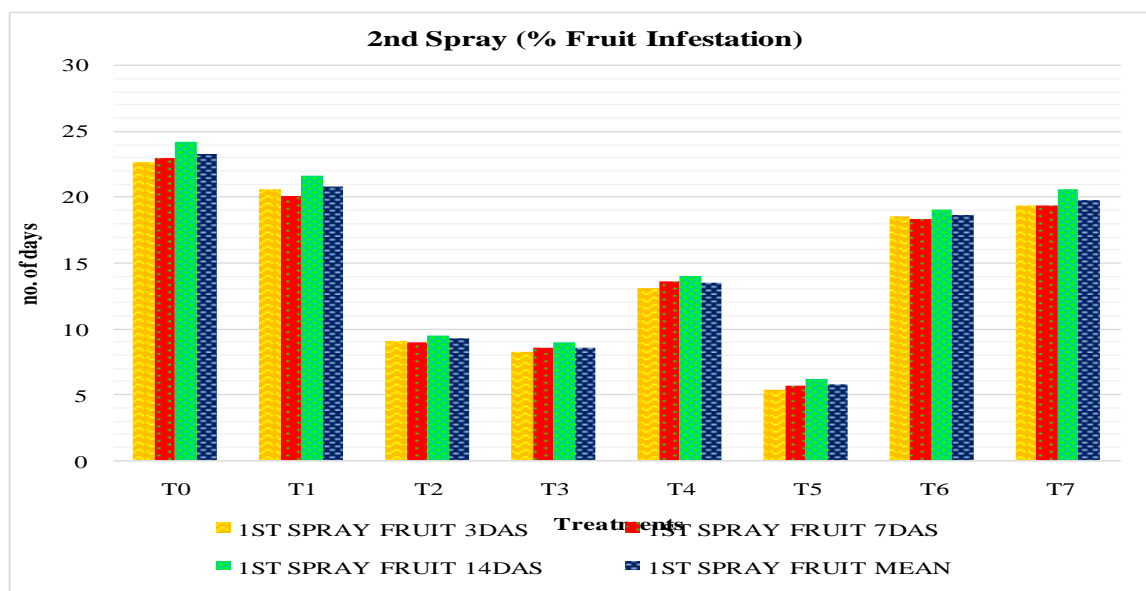


Fig.2 Efficacy of Chemical insecticides and bio-pesticides against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee). (Second Spray) (% fruit infestation)



The present field study on Comparative efficacy of certain chemical insecticides and bio-pesticides against (*Leucinodes orbonalis* Guenee.) on brinjal at Trans Yamuna region of Prayagraj (U.P.)” was carried out at Central field Department of Entomology, SHUATS, Prayagraj. In case of shoot and fruit borer, all the two sprays revealed that among the Chemical insecticides and bio-pesticides Chlorantraniliprole 18.5 SC 0.2% was found to be more effective, next to which Spinetoram 11.7 SC 0.02%, Spinosad 45 SC 0.1% was most effective among all other treatments followed by Sixer Plus. Treatments *Metarrhizium anisopliae* and *Beauveria bassiana* were at par with each other were next effective treatments. Neem Oil 2% recorded as least effective among the treatments but significant and superior over control. In shoot infestation Chlorantraniliprole 18.5 SC 0.2%, Spinetoram 11.7 SC 0.02%, Spinosad 45 SC 0.1%, Sixer Plus, *Metarrhizium anisopliae*, *Beauveria bassiana* and Neem Oil 2% recorded the shoot infestation by 8.02, 9.69, 11.19, 18.45, 22.39, 23.96 and 24.94 per cent respectively.

In fruit infestation Chlorantraniliprole 18.5 SC 0.2%, Spinetoram 11.7 SC 0.02%, Spinosad 45 SC 0.1%, Sixer Plus, *Metarrhizium anisopliae*, *Beauveria bassiana* and Neem Oil 2% recorded the fruit infestation by 5.82, 8.66, 9.32, 13.60, 18.68, 19.82 and 20.84 per cent respectively.

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