Comparative Efficacy of Certain Bio-Pesticides against Tomato Fruit Borer, *Helicoverpa armigera* (Hub.)

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**Abstract**

The field experiment on “Comparative efficacy of certain bio-pesticides against tomato fruit borer, *Helicoverpa armigera* (Hub.)” was conducted during 2014-15 at Central Research Farm and Department of Entomology SHTAIS, Naini, Allahabad (U.P). The relative efficacy of biorational- insecticides viz., spinosad 45 SC (0.005%), quinalphos 25 EC (0.05%), HaNPV (350 LE/ha), *Beauveria bassiana* (0.3ml/lit), *Verticillium lecanii* (2.5kg/ha) and *Metarhizium anisopliae* (1000ml/ha) were evaluated against fruit borer (*Helicoverpa armigera*). The data on incremental percent reduction of different treatments revealed that the treatment Spinosad (74.97%), followed by quinalphos (66.31%), HaNPV (59.74%) > *Beauveria bassiana* (57.58%) > *Verticillium lecanii* (47.10%) > *Metarhizium anisopliae* (44.46%) found to be the most economically viable treatment. The highest cost benefit ratio was obtained from quinalphos (1:15.68) and the application of biorational- insecticides two spray at 15 days interval during *rabi* 2014-15.

**Keywords**

*Helicoverpa armigera* (Hub.), HaNPV, Spinosad, B:C Ratio and Tomato variety Selection - 22.

**Introduction**

Tomato (*Lycopersicon esculentum* Mill) is one of the most important vegetables in the world, ranking second in importance to potato in many countries. It is a warm season crop. It is grown as an off-season vegetable in the hills of India and farmers fetch good income after sending their produce in the plains from June to September. Tomato supplies vitamin C and adds variety of colors and flavors to the foods. The fruits are eaten raw or cooked. Large quantities of tomatoes are used to prepare soup, juice, ketchup, puree, pickle, paste and powder (Choudhary, 2002). About 16 insect and other pest species which caused damage to tomato crop in India Bhutani, (1977). Among the various pests, the tomato fruit borer, *Helicoverpa armigera* (Hub.) (Lepidoptera: Noctuidae) is the most destructive. The crop losses by *H. armigera* the extent of 80 per cent have been reported.
by Singh and Singh, (1975) and Yadav, (1980). The insect has developed resistance against many recommended insecticides (Srinivasan and Krishnamoorthy, 1992). Therefore, eco-friendly approaches have been evaluated for the management of *H. armigera* in tomato (Sivaprakasam, 1996, Khanam *et al.*, 2003 and Selvanarayanan and Narayanasamy, 2006). There are some encouraging reports on the use of bio-rational insecticides against tomato fruit borer (*Helicoverpa armigera*) by Tripathi and Singh, (2005) and Dhaka *et al.*, (2010). Such studies on tomato will be more fruitful because the fruits are free from toxic residues of insecticides. The pest is highly polyphagous and is reported on nearly 181 host plants Manjunath *et al.*, (1987). The efficacy of different sequential application of nucleopolyhedro virus of *H. armigera* (HaNPV), *Bacillus thuringiensis* var. *kurstaki* Berliner (*Bt. K*), neemazol and spinosad as the alternatives to the synthetic chemical pesticides for the sustainable management of *Helicoverpa armigera* on tomato (Ravi *et al.*, 2008).

**Materials and Methods**

**Layout and design**

The experiment on “Comparative efficacy of certain bio-pesticides against tomato fruit borer, *Helicoverpa armigera* (Hub.)” in trans Yamuna region of Allahabad. In Allahabad region at field condition was carried out during October 2014 to April, 2015 at Agricultural Research Farm at SHIATS (Allahabad Agricultural Institute) Deemed University, Allahabad, Uttar Pradesh, India. The experiment was conducted in the randomized block design (RBD) with seven treatments schedules including control, and each treatment schedule was replicated two time at 15 days interval initiating first spray in the last week of February when the pest infestation started viz., 28 February and 14 March during *rabi* 2015, respectively. The tomato variety Selection -22 was transplanted on 27 January during *rabi* 2015. The plot size was 3.60 x 3.60 m² with row to row and plant to plant spacing of 45 x 45 cm, respectively.

The details of different treatment schedules are as follows

**Management schedule of treatments**

Pre-calibrated knap sack sprayer was used for spraying the biopesticides care was taken to check the drift of insecticides, by putting polythene sheet screen around each plot at the time of spraying. In all sprays were applied, first spray was done during the last week of February and subsequent second spray was applied at 15 days interval.

**Observations**

Pretreatment population of *Helicoverpa armigera* (Hub.) was recorded 24 hours before the scheduled spray.

**Layout of Experimental Field**

![Layout of Experimental Field](image)
**Table 1** Details of treatments

| Treatment | Chemical name                        | Dose (concentration) | References                  |
|-----------|-------------------------------------|-----------------------|-----------------------------|
| \( T_0 \) | Control                             | --------             | --------                    |
| \( T_1 \) | *Verticillium lecanii*              | 2.5kg/ha             | Kaur and Singh (2013)       |
| \( T_2 \) | *Metarhizium anisopliae*            | 1000ml/ha            | Lad *et al.*, (2009)        |
| \( T_3 \) | *Beauveria bassiana*                | 0.3ml/ litre         | Sreekanth and Seshamahalakshmi (2010) |
| \( T_4 \) | HaNPV                               | 250 LE/ha            | Kaur and Singh (2013)       |
| \( T_5 \) | Quinalphos (Organophosphate)        | 0.05% (2ml/lit.)     | Naik *et al.*, (2013)       |
|           | Spinosad (Spinosyns)                | 0.005 % (0.1 ml/lit.)| Shinde *et al.*, (2011)     |
Post treatment population of *H. armigera* was recorded on 3, 7 and 10 day after each spray, on 5 plants were selected randomly in each plot and tagged from each plot.

**Preparation of insecticidal solution**

The insecticidal spray of desired concentration as per treatment was freshly prepared every time at the time of experimentation just before the start of spraying operations. The spray solution of a desired concentration was prepared by adopting the following formula (Katyayan, 2010).

\[
V = \frac{C \times A}{a.i. \%}
\]

Where,

- \( V \) = Volume/ weight of commercial insecticide ml or gm.
- \( C \) = Concentration required.
- \( A \) = Volume of solution to be prepared.
- \( a.i. \% \) = Percentage active ingredient

**Application of spray solution**

Spray solution was applied with the help of hand compression sprayer. Spraying was done at dawn and desk time and their must not be much wind currents.

**Reduction per cent by fruit borer**

The total numbers of infested and un infested plants at fruiting stage were counted from selected five plants of each plot. Thus the larvae was calculated using the following formula:

\[
\text{Reduction percent} = \frac{\text{Control} - \text{Treatment}}{\text{Control}} \times 100
\]

**Benefit cost ratio**

Gross return was calculated by multiplying total yield with the market price of the produce. Cost of cultivation and cost of treatment imposition was deducted from the gross returns, to find out net returns and cost benefit ratio by following formula

\[
\text{B: } C = \frac{\text{Gross Returns}}{\text{Total Cost of Incurred}}
\]

**Results and Discussion**

The results of studies undertaken during *Rabi*, 2014-15 on “Comparative efficacy of certain bio-pesticides against tomato fruit borer, *Helicoverpa armigera* (Hubner)” in trans yamuna region of Allahabad” are presented in the following heads.

**First spray**

**Reduction of fruit borer (First spray)**

The data on per cent reduction of fruit borer before spraying (Table 2) revealed that the results were statistically non significant.

|     | T4  | T5   | T6   | T1   | T2   | T3   | T0  |
|-----|-----|------|------|------|------|------|-----|
| %   | 72.22| 63.03| 56.07| 55.42| 44.37| 43.42| 0.00|
The data on population reduction percent of fruit borer, \textit{(Helicoverpa armigera)} on 3\textsuperscript{rd} day after spraying showed that all the treatment was significantly superior over control. Maximum reduction was observed with spinosad (72.22\%), followed by quinalphos (63.03\%), HaNPV (56.07\%), \textit{Beauveria bassiana} (55.42\%) \textit{Verticillium lecanii} (44.37\%), and \textit{Metarhizium anisopliae} (44.37\%), were most effective treatment.

\begin{table}[h]
\centering
\begin{tabular}{llcccc}
\hline
\textbf{Treatment} & \textbf{Before} & \textbf{3DAS} & \textbf{7DAS} & \textbf{14DAS} & \textbf{Mean} \\
\hline
\textit{T}_1 & \textit{Verticillium lecanii} & 4.95 & 55.42 & 58.95 & 46.27 & 53.54 & (48.11)$^*$ & (50.15)$^*$ & (42.86)$^*$ \\
\textit{T}_2 & \textit{Beauveria bassiana} & 5.4 & 44.37 & 45.55 & 44.85 & 44.92 & (41.76)$^*$ & (42.44)$^*$ & (42.04)$^*$ \\
\textit{T}_3 & \textit{Metarhizium anisopliae} & 4.8 & 43.42 & 44.56 & 35.17 & 41.05 & (41.22)$^*$ & (41.87)$^*$ & (36.37)$^*$ \\
\textit{T}_4 & \textit{Spinosad} & 5.05 & 72.22 & 73.85 & 70.77 & 72.28 & (58.20)$^*$ & (59.25)$^*$ & (57.27)$^*$ \\
\textit{T}_5 & \textit{Quinalphos} & 5.05 & 63.07 & 65.50 & 63.03 & 63.86 & (52.58)$^*$ & (54.03)$^*$ & (52.56)$^*$ \\
\textit{T}_6 & \textit{HaNPV} & 4.7 & 56.07 & 59.52 & 54.30 & 56.63 & (48.49)$^*$ & (50.49)$^*$ & (47.46)$^*$ \\
\textit{T}_0 & \textit{Untreated control} & 4.95 & 0.00 & 0.00 & 0.00 & 0.0 & (0.54)$^*$ & (0.54)$^*$ & (0.54)$^*$ \\
\hline
\textbf{Over all Mean} & & & & & & 47.79 & 49.70 & 44.91 \\
\textbf{F- test} & & & & & & S & S & S \\
\textbf{S. Ed. (±)} & & & & & & 0.96 & 0.83 & 0.89 \\
\textbf{C. D. (P = 0.05)} & & & & & & 2.03 & 1.76 & 1.87 & 4.60 \\
\hline
\end{tabular}
\caption{Comparative efficacy of certain bio-pesticides against tomato fruit borer \textit{(Helicoverpa armigera} (Hubner)] on different days after 1st spray during Rabi season 2014-2015}
\end{table}
Table 3: Comparative efficacy of certain bio-pesticides against tomato fruit borer *Helicoverpa armigera* (Hubner) on different days after 2nd spray during Rabi season 2014-2015

| Treatment               | Before | 3DAS  | 7DAS  | 14DAS | Mean   |
|-------------------------|--------|-------|-------|-------|--------|
| T<sub>1</sub> Verticillium lecanii | 2.6    | 57.95 | 62.72 | 64.22 | 61.63  |
|                         |        |       |       |       | (49.57)*|
| T<sub>2</sub> Beauveria bassiana | 3.15   | 46.25 | 48.46 | 53.17 | 49.29  |
|                         |        |       |       |       | (42.84)*|
| T<sub>3</sub> Metarhizium anisopliae | 3.1    | 45.07 | 47.05 | 51.50 | 47.87  |
|                         |        |       |       |       | (42.17)*|
| T<sub>4</sub> Spinosad   | 1.5    | 73.75 | 77.07 | 82.17 | 77.66  |
|                         |        |       |       |       | (59.18)*|
| T<sub>5</sub> Quinalphos | 1.75   | 65.65 | 66.92 | 73.72 | 68.76  |
|                         |        |       |       |       | (54.12)*|
| T<sub>6</sub> HaNPV      | 2.05   | 58.55 | 62.45 | 67.55 | 62.85  |
|                         |        |       |       |       | (49.92)*|

Over all Mean

| % reduction in *Helicoverpa armigera* |
|---------------------------------------|
| *F* test                              |
| S. Ed. (±)                            |
| C. D. (P = 0.05)                      |
| (±)                                   |
| 1.82                                  |
| 3.02                                  |

Table 4: Comparative efficacy of certain bio-pesticides against tomato fruit borer *Helicoverpa armigera* (Hubner) during Rabi season in tomato. (Mean of 1st and 2nd spray) 2014-15

| Treatments           | I<sup>th</sup> spray | II<sup>nd</sup> spray | Overall mean |
|----------------------|-----------------------|-----------------------|--------------|
| T<sub>1</sub> Verticillium lecanii | 53.54                 | 61.63                 | 57.58        |
| T<sub>2</sub> Beauveria bassiana    | 44.92                 | 49.29                 | 47.10        |
| T<sub>3</sub> Metarhizium anisopliae | 41.05                 | 47.87                 | 44.46        |
| T<sub>4</sub> Spinosad              | 72.28                 | 77.66                 | 74.97        |
| T<sub>5</sub> Quinalphos            | 63.86                 | 68.76                 | 66.31        |
| T<sub>6</sub> HaNPV                 | 56.63                 | 62.85                 | 59.74        |
| T<sub>0</sub> Untreated control     | 0.0                   | 0.0                   | 0.0          |
| Water spray                     | (0.54)*               | (0.54)*               | (0.54)*      |

| % reduction in *Helicoverpa armigera* |
| *F* test                              |
| S. Ed. (±)                            |
| C. D. (P = 0.05)                      |
| (±)                                   |
| 1.82                                  |
| 3.02                                  |

C. D. (P = 0.05)
### Table 5: Economic of treated tomato crop of cultivation/ha

| S.n. | Particular                      | Requirement       | Rate/unit Rs.  | Cost  |
|------|---------------------------------|-------------------|----------------|-------|
| (A)  | Land preparation                |                   |                |       |
| I.   | Ploughing                       | 3 hours           | 500 Rs/hours   | 1500  |
| II.  | Harrow                          | 3 hours           | 500 Rs/hours   | 1500  |
| III. | Layout of field & showing       | 15 labours        | 150 Rs/labour  | 2250  |
| (B)  | Manures and fertilizer          |                   |                |       |
| I.   | Urea                            | 260 kg            | 12 Rs./Kg      | 3120  |
| II.  | SSP                             | 150 kg            | 7.8 Rs./Kg     | 1170  |
| III. | MOP                             | 90 kg             | 19 Rs./Kg      | 1710  |
| IV.  | Labour                          | 2 labours         | 150            | 300   |
| (C)  | Seed sowing                     | 400-500 gm/ ha    | 800 Rs./Kg     | 400   |
| I.   | Seed material                   | 3 labours         |                |       |
| II.  | Weeding                         | 150Rs/labour      | 450            |       |
| (D)  | Irrigation                      |                   |                |       |
| I.   | First time                      | 4 hours           | 100 Rs./hours  | 400   |
| II.  | Second time                     | 4 hours           | 100 Rs./hours  | 400   |
| III. | Labour                          | 2 Labours         | 100 Rs/labour  | 200   |
| (F)  | Harvesting                      | 15 labours        | 150 Rs/labour  | 2250  |
| I.   | Labour                          | 6 Labour          | 150 Rs/hours   | 900   |
| II.  | Transport charge                | 1 Truck           | 5000           | 5000  |
| (G)  | Total cost of cultivation       |                   |                | 21550 |

### Table 6: Cost of Insecticides/ha

| Treatment        | Use of chemical (2TimeSpray) | Cost of Insecticides (Rs.) | Total Cost of Insecticides (Rs.) | Use of 2 labours (Rs.) | Total labour cost (Rs.) | Total cost of Treatment |
|------------------|------------------------------|----------------------------|----------------------------------|------------------------|-------------------------|-------------------------|
| Control          |                              |                            |                                  |                        |                         |                         |
| Verticilliumlecanii | 5 kg/ha                     | 200 Rs/kg                  | 1000                             | 150                    | 600                     | 1600                    |
| Beauveriabassiana | 5 kg./ha                     | 180 Rs./kg                 | 900                              | 150                    | 600                     | 1500                    |
| Metarhiziumanisopliae | 5 kg/ha                     | 220 Rs./kg                 | 1100                             | 150                    | 600                     | 1700                    |
| Spinosad         | 900 ml/ha                    | 13000 Rs./lit.             | 9750                             | 150                    | 600                     | 10350                   |
| Quinalphos       | 2 lit/ha                     | 400 Rs./lit.               | 800                              | 150                    | 600                     | 1400                    |
| HaNPV            | 500 LE/ha                    | 200 Rs/ LE                 | 800                              | 150                    | 600                     | 1400                    |
Table.7 Economics of treatment

| Treatment          | Yield of q/ha (Rs/q) | Cost of yield (Rs.) | Total cost of yield (Rs.) | Common cost (Rs.) | Treatment cost (Rs.) | Total cost (Rs.) | C:B ratio |
|--------------------|----------------------|---------------------|---------------------------|------------------|----------------------|------------------|-----------|
| Control            | 110                  | 2000                | 220000                    | 21550            | --                   | 21550            | 1:10.20   |
| Verticillium lecanii | 165                  | 2000                | 330000                    | 21550            | 1600                 | 23150            | 1:14.25   |
| Beauveria bassiana | 158                  | 2000                | 316000                    | 21550            | 1500                 | 23050            | 1:13.70   |
| Metarhizium anisopliae | 150                  | 2000                | 300000                    | 21550            | 1700                 | 23250            | 1:12.90   |
| Spinosad           | 200                  | 2000                | 400000                    | 21550            | 10350                | 31900            | 1:12.53   |
| Quinalphos         | 180                  | 2000                | 360000                    | 21550            | 1400                 | 22950            | 1:15.68   |
| HaNPV              | 172                  | 2000                | 344000                    | 21550            | 1400                 | 22950            | 1:14.98   |

Treatments T₃, T₂, and T₁, T₆ were par with each other. The descending order of different treatment is given below.

| T₄   | T₅   | T₆   | T₁   | T₂   | T₃   | T₀   |
|------|------|------|------|------|------|------|
| 73.85| 65.50| 59.52| 58.95| 45.55| 44.56| 0.00 |

Some treatments were non significantly and some significantly superior over control. The data on population reduction percent of fruit borer (*Helicoverpa armigera*) on 7th day after spraying showed that all the treatment were significantly superior over control. Maximum reduction was observed with spinosad (73.85%), followed by quinalphos (65.50%), HaNPV (59.52%), *Beauveria bassiana* (58.95%), *Verticillium lecanii* (45.55%), and *Metarhizium anisopliae* (44.46%), were most effective treatment. Treatments T₃, T₂, and T₁, T₆ were par with each other.

14th day after 1st spraying

The descending order of different treatment is given below.

| T₄   | T₅   | T₆   | T₁   | T₂   | T₃   | T₀   |
|------|------|------|------|------|------|------|
| 70.77| 63.03| 54.30| 46.27| 44.85| 35.17| 0.00 |

Treatments were significantly superior over Control. The data on population reduction percent reduction of *Helicoverpa armigera* over control on 14th day after spraying revealed that the treatment were superior to control. The data on population reduction...
percent of fruit borer (*Helicoverpa armigera*) on 14\textsuperscript{th} day after spraying showed that all the treatments were significantly superior over control. Maximum reduction was observed with spinosad (70.77%), followed by quinalphos (63.03%), HaNPV (54.30%), *Beauveria bassiana* (46.27%), *Verticillium lecanii* (44.85%), and *Metarhizium anisopliae* (35.17%), were most effective treatments. Treatments T\textsubscript{2} and T\textsubscript{1} were par with each other.

**Mean of 1\textsuperscript{st} spray. (3\textsuperscript{rd}, 7\textsuperscript{th}, and 14\textsuperscript{th} DAS)**

The descending order of different treatment is given below.

| T\textsubscript{4} | T\textsubscript{5} | T\textsubscript{6} | T\textsubscript{1} | T\textsubscript{2} | T\textsubscript{3} | T\textsubscript{0} |
|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| 72.78             | 63.86             | 56.63             | 53.54             | 44.92             | 41.05             | 0.00              |

Treatments were significantly superior over Control. The data on population reduction percent reduction of (*Helicoverpa armigera*) over control on 14\textsuperscript{th} day after spraying revealed that the treatment were superior to control. The data on population reduction percent of fruit borer (*Helicoverpa armigera*) on 1\textsuperscript{st} spraying mean showed that all the treatment were significantly superior over control. Maximum reduction was observed with spinosad (72.28%), followed by quinalphos (63.86%), HaNPV (56.63%), *Beauveria bassiana* (53.54%), *Verticillium lecanii* (44.92%), and *Metarhizium anisopliae* (41.05%), were most effective treatment. Treatments T\textsubscript{3}, T\textsubscript{2} and T\textsubscript{1}, T\textsubscript{6} were par with each other. Similar finding was observed by Gandhi et al., (2013) evaluate the bio efficacy of spinosad 45 SC (0.1 ml/l), cypermethrin 10EC (0.5 ml/l), novaluran 10EC (1 ml/l), azadirachtin 5\% and Bacillus thringiensis (1 ml/l) insecticides against ear head caterpillar *Helicoverpa armigera* in sorghum, spinosad 45 SC (0.1ml/l), novaluran 10 EC (1 ml/l) and azadirachtin 5\% emerged as superior by recording 72.0, 66.0 and 63.0\% population reduction. Kale et al., (2008) reported that the treatments, spinosad (0.01\%) was most efficacious and recorded the lowest larval population and highest grain yield. Other effective microbial insecticides were HaNPV (250 LE ha\textsuperscript{-1}) and Bt (750 ml ha\textsuperscript{-1}), which stood only next to endosulfan (0.06\%). *Metarhizium anisopliae* (2.5 kg ha\textsuperscript{-1}) and *Beauveria bassiana* (2.5 kg ha\textsuperscript{-1}) were less efficacious, but performed better than their combinations with either HaNPV or Bt and combination of HaNPV with Bt at reduced doses.

**Second spray**

**Reduction of fruit borer second (spray)**

The data on per cent reduction of fruit borer before spraying revealed that the results were statistically non significant.

**3\textsuperscript{rd} day after II\textsuperscript{nd} spraying**

The descending order of different treatment is given below.

| T\textsubscript{4} | T\textsubscript{5} | T\textsubscript{6} | T\textsubscript{1} | T\textsubscript{2} | T\textsubscript{3} | T\textsubscript{0} |
|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| 73.75             | 65.55             | 58.55             | 57.95             | 46.25             | 45.07             | 0.00              |

Some treatments were non significantly and some significantly superior over control. The data on population reduction percent of fruit borer (*Helicoverpa armigera*) on 3\textsuperscript{rd} day after spraying showed that all the treatment were significantly superior over control. Maximum
reduction was observed with spinosad (73.75%), followed by quinalphos (65.65%), HaNPV (58.55%), *Beauveria bassiana* (57.95%), *Verticillium lecanii* (46.25%), and *Metarhizium anisopliae* (45.07%), were most effective treatment. Treatments T₃, T₂ and T₁, T₆ were par with each other.

**7th day after IInd spraying**

The descending order of different treatment is given below.

|   | T₄   | T₅   | T₆   | T₁   |
|---|------|------|------|------|
| T₀| 77.07| 66.92| 62.45| 62.72|

Some treatments were non significantly and some significantly superior over control. The data on population reduction percent of fruit borer (*Helicoverpa armigera*) on 7th day after spraying showed that all the treatment were significantly superior over control maximum reduction was observed with spinosad (77.07%), followed by quinalphos (66.92%), HaNPV (62.45%), *Beauveria bassiana* (62.72%)

**14th day after IInd spraying**

The descending order of different treatment is given below.

|   | T₂ | T₃ | T₀ |
|---|----|----|----|
| T₀| 53.17| 51.50| 0.00|

Treatments were significantly superior over Control. The data on population reduction percent reduction of (*Helicoverpa armigera*) over control on 14th day after spraying revealed that the treatment were superior to control. The data on population reduction percent of fruit borer (*Helicoverpa armigera*) on 14th day after spraying showed that all the treatment were significantly superior over control maximum reduction was observed with spinosad (82.17%), followed by quinalphos (73.72%), HaNPV (67.55%), *Beauveria bassiana* (64.22%) *Verticillium lecanii* (53.17%), and *Metarhizium anisopliae* (51.50%), were most effective treatment. Treatments T₃ and T₂ were par with each other.

**Mean of IIst spray. (3rd, 7th, and 14th DAS)**

The descending order of different treatment is given below.

|   | T₃  | T₀ |
|---|-----|----|
| T₀| 47.87 | 0.00 |

Treatments were significantly superior over Control. The data (Table 3) on population reduction percent reduction of *Helicoverpa armigera* over control on 14th day after spraying revealed that the treatment were superior to control.

The data on population reduction percent of fruit borer *Helicoverpa armigera* on 2nd spraying mean showed that all the treatment were significantly superior over control maximum reduction was observed with spinosad (77.66%), followed by quinalphos (68.76%), HaNPV (62.85%), *Beauveria bassiana* (61.63%) *Verticillium lecanii* (49.29%), and *Metarhizium anisopliae* (47.87%) were most effective treatment.
Treatments T₃, T₂ and T₁, T₆ were par with each other.

Randhawa et al., (2009) reported that five insecticides, i.e. endosulfan 35 EC at 1250 ml endosulfan 35 EC at 2500 ml, spinosad 48 SC at 150 ml, indoxacarb 15 EC at 500 ml, cypermethrin 25 EC at 200 ml, chlorpyriphos 20 EC at 2500 ml per hectare, along with untreated control, were evaluated against gram caterpillar (Helicoverpa armigera) on seed crop of berseem. Spinosad 48 SC was found to be the most effective insecticide for the control of H. armigera, followed closely by indoxacarb 15 EC. Phukon et al., (2014) revealed the reduction in fruit damage was up to 92.20 per cent in cypermethrin treated plot followed by 91.12 per cent, 88.74 per cent and 87.01 per cent in the plots treated with Neem oil, B. Bassiana and M. Anisopliae, respectively due to H. armigera larvae over control. The highest increase in yield over control was noticed in cypermethrin treated plots (62.85%) followed by neem oil treated plots (41.83%).

The descending order of different treatment is given below.

|    | T₄ | T₅ | T₆ | T₁ | T₂ |    |
|----|----|----|----|----|----|----|
|    | 72.78 | 63.86 | 56.63 | 53.54 | 44.92 |    |
| T₀ | 41.05 | 0.00 |

Treatments were significantly superior over Control. The data on population reduction percent reduction of (Helicoverpa armigera) over control on 14th day after spraying revealed that the treatment were superior to control. The data on population reduction percent of fruit borer (Helicoverpa armigera) on 1st spraying mean showed that all the treatment were significantly superior over control Maximum reduction was observed with spinosad (72.28%), followed by quinalphos (63.86%), HaNPV (56.63%), Beavveria bassiana (53.54%) Verticillium lecanii (44.92%), and Metarhizium anisopliae (41.05%), were most effective treatment. Treatments T₃, T₂ and T₁, T₆ were par with each other.

Mean of 2nd spray. (3rd, 7th, and 14th DAS)

The descending order of different treatment is given below.

|    | T₂ | T₃ | T₀ |    |
|----|----|----|----|----|
|    | 49.29 | 47.87 | 0.00 |

Treatments were significantly superior over Control. The data on population reduction percent reduction of (Helicoverpa armigera) over control on 14th day after spraying revealed that the treatment were superior to control. The data on population reduction percent of fruit borer (Helicoverpa armigera) on 2nd spraying mean showed that all the treatment were significantly superior over control Maximum reduction was observed with spinosad (77.66%), followed by quinalphos (68.76%), HaNPV (62.85%), Beavveria bassiana (61.63%) Verticillium lecanii (49.29%), and Metarhizium anisopliae (47.87%), were most effective treatment. Treatments T₃, T₂ and T₁,T₆ were par with each other.

Mean of 1st spray. (3rd, 7th, and 14th DAS)

The descending order of different treatment is given below.
Treatments were significantly superior over Control. The data (Table 4) population reduction percent reduction of *Helicoverpa armigera* over control on 14th day after spraying revealed that the treatment were superior to control.

The data on population reduction percent of fruit borer *Helicoverpa armigera* on 1st and 2nd spraying mean showed that all the treatments were significantly superior over control Maximum reduction was observed with spinosad (74.97%), followed by quinalphos (66.31%), HaNPV (59.74%), *Beauveria bassiana* (57.58%), *Verticillium lecanii* (47.10%), and *Metarhizium anisopliae* (44.46%), were most effective treatment. Treatments T1 and T6 were par with each other. Similar founding was observed by Singh *et al.*, (2009) reported that spinosad 45 SC proved to be the best treatment in reducing the incidence in shed fruiting bodies and damage on boll and loculi basis followed by novaluron @ 50 and 37.5 g a.i./ha. Although the incidence of American bollworm was less in spinosad but yield was comparatively higher in novaluron @ 50 and 37.5 g a.i./ha as against spinosad and chlorpyriphos. Lad *et al.*, (2009) reported that *Metarhizium anisopliae* @ 1x108 conidia ha-1, *Beauveria bassiana*1x108 conidia ha-1, *Metarhizium anisopliae* @ 1x106 conidia ha-1, *Beauveria bassiana* 1x106 conidia ha-1, were at par with each other, but significantly inferior to first three biological treatments. However, the microbials were significantly better than Neemark and NSE 5%.

**Cost benefit ratio**

The tables 5,6 and 7 with respect to cost benefit ratio (CB) as influenced by various treatments is presented in table 4.8 and which revealed that the higher amount of monetary return was obtained with quinalphos 25 EC (1:15.68) followed by HaNPV 250LE/ha (1:14.98), *Verticillium lecanii* (1:14.25), *Beauveria bassiana* (1:13.70), *Metarhizium anisopliae* (1:12.90) spinosad 45 SC (1:12.53), and Control (1:14.84). The similar finding was observed by the following researcher Naik *et al.*, (2013) reported that among the insecticides and biodepesticides evaluated against *H. armigera*, the insecticide quinalphos (0.05) recorded the least leaf damage of 9.55% and it was at par with chlorpyriphos (0.05) (11.22%). Highest pod yield of 9.86 q/ha was recorded with chlorpyriphos (0.05) followed by quinalphos(0.05) 9.41 q/ha. The maximum cost:benefit ratio of 1:6.12 was obtained in quinalphos (0.05). Tayde and Simon (2010) revealed that Spinosad 45 SC @ 0.01% was found most effective and showed (09.84%) shoot infestation, per cent fruit infestation (06.87% on number basis and 07.35% on weight basis) and increasing yield of brinjal fruit (239.30q/ha). Whereas, carbaryl 50 WP @ 0.2% and endosulfan 35 EC @0.05% were also found effective in reducing per cent infestation shoot and fruit infestation and increasing yield. Amongst neem products NSKE 5% was found to be superior in terms of efficacy and yield. However, the increment cost benefit ratio (ICBR) showed that the application of quinalphos 25 EC @ 0.05% was economically most viable treatment (1:67.86) followed by endosulfan 35 EC @ 0.05% (1:66.19).

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