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**ENTOMOLOGY**

# Bioefficacy of Certain Insecticides and Biopesticides against Spotted Pod Borer, *Maruca vitrata* Infesting Greengram

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**ABSTRACT**

A filed study was conducted to evaluate the efficacy of certain insecticides and biopesticides for the management of *Maruca vitrata* on greengram during *Kharif* 2014-15 and 2015-16. The data indicated that Spinosad 60g a.i./ha followed by Emamectin benzoate 8g a.i./ha were the most effective treatments in reducing *M. vitrata* larval population whereas *Verticillium lecanii* ($1\times10^8$ Spores/g) 5g/L was observed to be the least effective treatment. Spinosad 60g a.i. /ha treatment produced maximum and *Verticillium lecanii* ($1\times10^8$ Spores/g) 5g/L produced minimum yield during both the years of experimentation.

**Highlights**

- Spinosad 60g a.i./ha and Emamectin benzoate 8g a.i./ha were the most effective treatments and significantly superior than the other treatments
- *Verticillium lecanii* ($1\times10^8$ Spores/g) 5g/L was the least effective treatment
- Maximum yield was obtained from Spinosad 60g a.i./hatreated plots

**Keywords:** Greengram, *Maruca vitrata*, insecticides, biopesticides

Pulses are grown in the semi-arid regions under a wide range of agro-climatic conditions of India. Among the pulses, mungbean or green gram, *Vigna radiata* (L.) Wilczek is the important pulse crop of India. Greengram is cultivated throughout the year in all the cropping seasons due to its short duration and suitability to crop rotation and crop mixtures. The low productivity in greengram may be attributed to factors like limited varietal improvement, low resilience to soil moisture stress, pest infestation etc., among them, ravage of insect pests is the most important (Sandhya *et al.* 2015). Legume pod borer, *Maruca vitrata* contributes to a major yield loss. It becomes a menace especially during the flowering and pod formation stages and has been reported to be a pest on 39 host plants in Asia (Atachi and Djihou 1994; Yadav and Singh 2014). The larvae cause direct damage to flowers and pods, hence stands responsible for major yield loss in all the host crops. The grain yield losses due to legume pod borer are estimated from 10 to 80 per cent in various crops (Sharma 1998; Sambath Kumar *et al.* 2014). The present study was thus carried out to evaluate certain insecticides and biopesticides for the management of the spotted pod borer on green gram.

## MATERIALS AND METHODS

Field trials were conducted during *Kharif* 2014-15 and 2015-16 at Agricultural Research Farm, Banaras Hindu University, Varanasi (U.P.), to evaluate the efficacy of certain insecticides and biopesticides viz., Spinosad 60g a.i./ha($T_1$), Imidacloprid 50g a.i./ha($T_2$), Emamectin benzoate 8g a.i./ha ($T_3$), Fipronil 100g a.i./ha($T_4$), Acetamiprid 20g a.i./ha ($T_5$), *Metarhizium anisopliae* ($1\times10^8$ Spores/g) 5 g/L

($T_6$), *Beauveria bassiana* ($2\times10^8$ Spores/mL) 2.5 mL/L ($T_7$), *Verticillium lecanii* ($1\times10^8$ Spores/g) 5g/L ($T_8$) and NSKE 5% ($T_9$) with Control ($T_{10}$) for the management of spotted pod borer. The crop was grown at a spacing of 30cm × 10cm with three replications in a randomized block design. The experimental field was monitored for incidence of the spotted pod borer at the weekly interval to observe the economic threshold level of the insects. Spraying was done by using pre-calibrated ASPEE foot sprayer with cone type nozzle. The concentration of insecticides required on the basis of active ingredient, the desired amount of each insecticide was measured by an electronic balance and micro pipette and subsequently mixed with water (600L/ha). Insecticides application was done during hours of the day when the wind speed was suitable for the application. This helped in avoiding drift of spray solution to the impending plots. The following observations were recorded after the spraying of insecticides. The population density of spotted pod borer, *M. Vitrata* was recorded by randomly picking 5 plants per plot from each treatment a day prior to insecticide application and three, seven and fifteen days after each application.

The percentage reduction of the population over control in different treatments was calculated using Henderson and Tilton's (1955) formula as given below:

$$\text{Percent efficacy} = 1-\left[\frac{T_a}{T_b}\times\frac{C_b}{C_a}\right]\times 100$$

Where,

$T_a$ = Population in the treated plot after spray.
$T_b$ = Population in the treated plot before spray.
$C_a$ = Population in the control plot after spray.
$C_b$ = Population in the control plot before spray.

The data on grain of all the plants were harvested and the sample yield was added to this yield to get the plot yield for each treatment. The plot yield was then converted in to yield for each treatment on the hectare basis.

## RESULTS AND DISCUSSION

### Effect of certain insecticides and biopesticides on the population of *M. Vitrata* during *Kharif* 2014-2015

The data of the larval population density of *M. vitrata* a day before the first spray was recorded and presented in Table 1. A day before the first spray revealed that the larval population of *M. vitrata* was distributed uniformly in all the treatments and it ranged from 2.33-2.60 larvae/plant. The data of 3 DAS (Days after spray) showed that the minimum larval population of *M. vitrata* was recorded in the plot treated with $T_1$-Spinosad 60g a.i. /ha (1.40 larvae/plant) followed by$T_3$-Emamectin benzoate 8g a.i. /ha (1.47 larvae/plant) with the maximum in $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (2.33 larvae/plant) treated plot. Same trend was observed from 7 DAS and minimum larval population of *M. vitrata* was recorded from $T_1$-Spinosad 60g a.i. /ha (0.80 larvae/plant) followed by $T_3$-Emamectin benzoate 8g a.i. /ha (0.93 larvae/plant) and the maximum was seen in $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (2.13 larvae/plant) treated plot. The data of larval population of 15 DAS depicted that the lowest larval population was in $T_1$-Spinosad 60g a.i. /ha (0.47 larvae/plant) followed by$T_3$-Emamectin benzoate 8g a.i. /ha (0.67 larvae/plant) and the highest in $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (2.07 larvae/plant) treated plot. Mean larval population of *M. Vitrata* on 3,7 and 15 days first spray showed that $T_1$-Spinosad 60g a.i./ha (0.89 larvae/plant) followed by $T_3$-Emamectin benzoate 8g a.i./ha (1.02 larvae/plant) was the most effective treatment and $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (2.22 larvae/plant) was the least effective one.

The data of the second spray revealed that the larval population a day before spray varied from 1.60-3.13 larvae/plant among the different treatments. The data of 3 DAS showed that minimum larval population of *M. vitrata* was recorded from the plot treated with $T_1$-Spinosad 60g a.i./ha (0.93 larvae/plant) followed by$T_3$-Emamectin benzoate 8g a.i./ha (1.20 larvae/plant) and maximum was in $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (2.47 larvae/plant) treated plot. At 7 DAS (Days after spray) same trend was observed and the minimum larval population of *M. vitrata* was recorded from the plot treated with $T_1$-Spinosad 60g a.i. /ha (0.53 larvae/plant) followed by$T_3$-Emamectin benzoate 8g a.i. /ha (0.73 larvae/plant) and was found maximum in $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (2.27 larvae/plant) treated plot. The data of the larval population of 15 DAS depicted that the lowest larval population was recorded from the plot treated with $T_1$-Spinosad 60g a.i./ha (0.27 larvae/plant) followed by$T_3$-Emamectin benzoate

**Table 1.** Bioefficacy of certain insecticides and biopesticides against spotted pod borer, *M. vitrata* during *Kharif* 2014-15

| Tr. No. | Treatments | Dose | Larval population of spotted pod borer/plant | | | | | | | | | | Yield (q/ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | First Spray | | | | | Second Spray | | | | | |
| | | | DBS | 3 DAS | 7 DAS | 15 DAS | Mean | DBS | 3 DAS | 7 DAS | 15 DAS | Mean | |
| $T_1$ | Spinosad | 60g a.i./ha | 2.60 | 1.40 | 0.80 | 0.47 | 0.89 | 1.60 | 0.93 | 0.53 | 0.27 | 0.58 | 8.51 |
| | | | (1.76) | (1.38) | (1.14) | (0.98) | (1.18) | (1.45) | (1.20) | (1.02) | (0.88) | (1.04) | |
| $T_2$ | Imidacloprid | 50g a.i./ha | 2.47 | 1.80 | 1.47 | 1.33 | 1.53 | 2.13 | 1.60 | 1.33 | 1.13 | 1.36 | 7.59 |
| | | | (1.72) | (1.52) | (1.40) | (1.35) | (1.43) | (1.62) | (1.45) | (1.35) | (1.28) | (1.36) | |
| $T_3$ | Emamectin benzoate | 8g a.i./ha | 2.53 | 1.47 | 0.93 | 0.67 | 1.02 | 1.80 | 1.20 | 0.73 | 0.47 | 0.80 | 6.05 |
| | | | (1.74) | (1.40) | (1.20) | (1.08) | (1.23) | (1.52) | (1.30) | (1.11) | (0.98) | (1.14) | |
| $T_4$ | Fipronil | 100g a.i./ha | 2.33 | 1.60 | 1.27 | 1.13 | 1.33 | 1.93 | 1.33 | 1.00 | 0.73 | 1.02 | 7.06 |
| | | | (1.68) | (1.45) | (1.33) | (1.28) | (1.35) | (1.56) | (1.35) | (1.22) | (1.11) | (1.23) | |
| $T_5$ | Acetamiprid | 20g a.i./ha | 2.53 | 1.87 | 1.53 | 1.40 | 1.60 | 2.20 | 1.67 | 1.47 | 1.27 | 1.47 | 6.23 |
| | | | (1.74) | (1.54) | (1.43) | (1.38) | (1.45) | (1.64) | (1.47) | (1.40) | (1.33) | (1.40) | |
| $T_6$ | *Metarhizium anisopliae* (1×10^8 Spores/g) | 5 g/L | 2.47 | 2.07 | 1.87 | 1.73 | 1.89 | 2.60 | 2.27 | 2.07 | 1.87 | 2.07 | 5.22 |
| | | | (1.72) | (1.60) | (1.87) | (1.49) | (1.55) | (1.76) | (1.66) | (1.60) | (1.54) | (1.60) | |
| $T_7$ | *Beauveria bassiana* (2×10^8 Spores/mL) | 2.5 mL/L | 2.47 | 2.00 | 1.80 | 1.67 | 1.82 | 2.53 | 2.13 | 1.93 | 1.73 | 1.93 | 5.00 |
| | | | (1.72) | (1.58) | (1.80) | (1.47) | (1.52) | (1.74) | (1.62) | (1.56) | (1.49) | (1.56) | |
| $T_8$ | *Verticillium lecanii* (1×10^8 Spores/g) | 5g/L | 2.67 | 2.33 | 2.13 | 2.07 | 2.22 | 2.73 | 2.47 | 2.27 | 2.07 | 2.27 | 4.87 |
| | | | (1.78) | (1.68) | (1.62) | (1.60) | (1.65) | (1.80) | (1.72) | (1.66) | (1.60) | (1.66) | |
| $T_9$ | NSKE | 5 % | 2.53 | 1.93 | 1.73 | 1.60 | 1.76 | 2.40 | 1.93 | 1.60 | 1.40 | 1.64 | 5.83 |
| | | | (1.74) | (1.56) | (1.49) | (1.45) | (1.50) | (1.70) | (1.56) | (1.45) | (1.38) | (1.46) | |
| $T_{10}$ | Control (Water Spray) | — | 2.47 | 2.73 | 2.93 | 3.20 | 2.96 | 3.13 | 3.40 | 3.73 | 4.07 | 3.73 | 3.77 |
| | | | (1.72) | (1.80) | (2.93) | (1.92) | (1.86) | (1.91) | (1.97) | (2.06) | (2.14) | (2.06) | |
| | **SEm±** | | — | **(0.029)** | **(0.031)** | **(0.042)** | **(0.031)** | — | **(0.022)** | **(0.025)** | **(0.031)** | **(0.23)** | **0.593** |
| | **$CD_{(P=0.05)}$** | | **(NS)** | **(0.086)** | **(0.094)** | **(0.126)** | **(0.093)** | — | **(0.065)** | **(0.074)** | **(0.094)** | **(0.069)** | **1.763** |

*Figures in the parenthesis are transformed values, NS= Non-significant, DBS= A Day before spray, DAS= Days after spray.*

8g a.i./ha (0.47 larvae/plant) and the highest in $T_8$-*V. lecanii* (1×10$^8$ Spores/g) 5g/L (2.07 larvae/plant) treated plot. Mean larval population of 3,7 and 15 days first spray showed that $T_1$-Spinosad 60g a.i./ha (0.58 larvae/plant) followed by$T_3$-Emamectin benzoate 8g a.i./ha (0.80 larvae/plant) was the most effective treatment and $T_8$-*V. lecanii* (1×10$^8$ Spores/g) 5g/L (2.27 larvae/plant) was the least effective one.

## Effect of certain insecticides and biopesticides on the population of *M. Vitrata* during *Kharif* 2015-2016

A day before the first spray revealed that larval population of *M. vitrata* was distributed uniformly in all the treatments and it ranged from 1.93-2.27 larvae/plant. The data of 3 DAS (Days after spray) showed that the minimum larval population of *M. vitrata* was recorded in the plot treated with $T_1$-Spinosad 60g a.i. /ha (1.00 larvae/plant) followed by $T_3$-Emamectin benzoate 8g a.i. /ha (1.27 larvae/plant) and was maximum in $T_8$-*V. lecanii* (1×10$^8$ Spores/g) 5g/L (2.07 larvae/plant) treated plot (Table 2). At 7 DAS same trend was observed and the minimum larval population of *M. vitrata* was recorded from $T_1$-Spinosad 60g a.i. /ha (0.47 larvae/plant) followed by $T_3$-Emamectin benzoate 8g a.i. /ha (0.87 larvae/plant) and the maximum was seen in $T_8$-*V. lecanii* (1×10$^8$ Spores/g) 5g/L (1.87 larvae/plant) treated plot. The data of the larval population of 15 DAS depicted that the lowest larval population was in $T_1$-Spinosad 60g a.i./ha (0.20 larvae/plant) followed by$T_3$-Emamectin benzoate 8g a.i./ha (0.53 larvae/plant) and the highest was in $T_8$-*V. Lecanii* (1×10$^8$ Spores/g) 5g/L (1.67 larvae/plant) treated plot. Mean

**Table 2:** Bioefficacy of certain insecticides and biopesticides against spotted pod borer, *M. vitrata* during *Kharif* 2015-16

| Tr. No. | Treatments | Dose | Larval population of spotted pod borer/plant | | | | | | | | | | Yield (q/ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | First Spray | | | | | Second Spray | | | | | |
| | | | DBS | 3 DAS | 7 DAS | 15 DAS | Mean | DBS | 3 DAS | 7 DAS | 15 DAS | Mean | |
| $T_1$ | Spinosad | 60g a.i./ha | 2.00 (1.58) | 1.00 (1.22) | 0.47 (0.98) | 0.20 (0.84) | 0.56 (1.03) | 1.40 (1.38) | 0.80 (1.14) | 0.47 (0.98) | 0.20 (0.84) | 0.49 (0.99) | 9.21 |
| $T_2$ | Imidacloprid | 50g a.i./ha | 1.93 (1.56) | 1.60 (1.45) | 1.40 (1.38) | 1.20 (1.30) | 1.40 (1.38) | 1.80 (1.52) | 1.33 (1.35) | 1.13 (1.28) | 0.93 (1.20) | 1.13 (1.28) | 8.11 |
| $T_3$ | Emamectin benzoate | 8g a.i./ha | 2.07 (1.60) | 1.27 (1.33) | 0.87 (1.17) | 0.53 (1.02) | 0.89 (1.18) | 1.47 (1.40) | 0.87 (1.17) | 0.60 (1.05) | 0.40 (0.95) | 0.62 (1.06) | 6.97 |
| $T_4$ | Fipronil | 100g a.i./ha | 2.07 (1.60) | 1.47 (1.40) | 1.13 (1.28) | 0.87 (1.17) | 1.16 (1.29) | 1.73 (1.49) | 1.27 (1.33) | 1.00 (1.22) | 0.80 (1.14) | 1.02 (1.23) | 7.54 |
| $T_5$ | Acetamiprid | 20g a.i./ha | 2.20 (1.64) | 1.73 (1.49) | 1.53 (1.43) | 1.33 (1.35) | 1.53 (1.43) | 1.93 (1.56) | 1.47 (1.40) | 1.27 (1.27) | 1.07 (1.25) | 1.27 (1.33) | 6.93 |
| $T_6$ | *Metarhizium anisopliae* ($1\times10^8$ Spores/g) | 5 g/L | 2.13 (1.62) | 1.93 (1.56) | 1.73 (1.49) | 1.53 (1.43) | 1.73 (1.49) | 2.33 (1.68) | 2.07 (1.60) | 1.87 (1.54) | 1.67 (1.47) | 1.87 (1.54) | 5.57 |
| $T_7$ | *Beauveria bassiana* ($2\times10^8$Spores/mL) | 2.5 mL/L | 2.07 (1.60) | 1.80 (1.52) | 1.60 (1.45) | 1.40 (1.38) | 1.60 (1.45) | 2.33 (1.68) | 2.00 (1.58) | 1.80 (1.52) | 1.60 (1.45) | 1.80 (1.52) | 5.61 |
| $T_8$ | *Verticillium lecanii* ($1\times10^8$ Spores/g) | 5g/L | 2.27 (1.66) | 2.07 (1.60) | 1.87 (1.54) | 1.67 (1.47) | 1.87 (1.54) | 2.67 (1.78) | 2.40 (1.70) | 2.20 (1.64) | 1.93 (1.56) | 2.18 (1.64) | 5.31 |
| $T_9$ | NSKE | 5 % | 2.07 (1.60) | 1.73 (1.49) | 1.53 (1.43) | 1.33 (1.35) | 1.53 (1.43) | 2.53 (1.74) | 2.07 (1.60) | 1.87 (1.54) | 1.67 (1.47) | 1.87 (1.54) | 6.14 |
| $T_{10}$ | Control (Water Spray) | — | 1.93 (1.56) | 2.20 (1.64) | 2.40 (1.70) | 2.67 (1.78) | 2.42 (1.71) | 2.80 (1.82) | 3.00 (1.87) | 3.27 (1.94) | 3.47 (1.99) | 3.24 (1.94) | 4.25 |
| | **SEm±** | | **—** | **(0.029)** | **(0.025)** | **(0.021)** | **(0.023)** | **—** | **(0.022)** | **(0.030)** | **(0.035)** | **(0.025)** | **0.414** |
| | **CD $_{(P=0.05)}$** | | **(NS)** | **(0.088)** | **(0.075)** | **(0.065)** | **(0.068)** | **—** | **(0.065)** | **(0.091)** | **(0.104)** | **(0.076)** | **1.232** |

*Figures in the parenthesis are transformed values, NS= Non-significant, DBS= A Day before spray, DAS= Days after spray.*

larval population of *M. vitrata* on 3, 7 and 15 DAS showed that $T_1$-Spinosad 60g a.i. /ha (0.56 larvae/plant) followed by$T_3$-Emamectin benzoate 8g a.i. /ha (0.89 larvae/plant) was the most effective treatment and $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (1.87 larvae/plant) was least effective.

The data of the second spray revealed that the larval population a day before spray varied from 1.60-3.13 larvae/plant among the different treatments. The data of 3 DAS (Days after spray) showed that the minimum larval population of *M. vitrata* was recorded from the plot treated with $T_1$-Spinosad 60g a.i. /ha (0.80 larvae/plant) followed by$T_3$-Emamectin benzoate 8g a.i./ha (0.87 larvae/plant) and the maximum was in $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (2.40 larvae/plant) treated plot. At 7 DAS (Days after spray) same trend was observed and the minimum larval population of *M. vitrata* was recorded from the plot treated with $T_1$-Spinosad 60g a.i. /ha (0.47 larvae/plant) followed by $T_3$-Emamectin benzoate 8g a.i./ha (0.60 larvae/plant) and the maximum was seen in $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (2.20 larvae/plant) treated plot. The data of larval population of 15 DAS depicted that the lowest the larval population was recorded from the plot treated with $T_1$-Spinosad 60g a.i./ha (0.20 larvae/plant) followed by $T_3$-Emamectin benzoate 8g a.i./ha (0.40 larvae/plant) and the highest was in $T_8$-*V. Lecanii* ($1\times10^8$ Spores/g) 5g/L (1.93 larvae/plant) treated plot. Mean larval population of 3, 7 and 15 DAS showed that $T_1$-Spinosad 60g a.i. /ha (0.49 larvae/plant) followed by $T_3$-Emamectin benzoate 8g a.i. /ha (0.62 larvae/plant) was the most effective treatment and in $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (2.18 larvae/plant) it was the least effective one. Present findings are conformity with the findings of Kaushik *et al.* (2016); Yadav and Singh, (2014) and Umbarkar and Parsana, (2014) reported that Spinosad is the most effective treatment in reducing *M. Vitrata* population.

### Per cent bioefficacy of certain insecticides and biopesticides on population of *M. Vitrata* during *Kharif* 2014-2015

The of per cent bioefficacy of insecticides and biopesticides data of 3 days after the first spray showed that maximum reduction in the population of *M. vitrata* was recorded in $T_1$-Spinosad 60g a.i./ha (51.47%) followed by $T_3$-Emamectin benzoate 8g a.i./ha (47.80%) and minimum in $T_8$-*V. lecanii* ($1 \times 10^8$ Spores/g) 5g/L (18.68%). 7 days after the first spray data indicated that $T_1$-Spinosad 60g a.i./ha (74.06%) followed by $T_3$-Emamectin benzoate 8g a.i./ha ($T_3$) (68.95%) showed the highest and $T_8$-*V. lecanii* ($1 \times 10^8$ Spores/g) 5g/L (30.54%) showed the lowest reduction in the population of *M. vitrata*. 15 days after the first spray data indicated that maximum reduction in the population of *M. Vitrata* was recorded in $T_1$-Spinosad 60g a.i./ha (86.14%) followed by $T_3$-Emamectin benzoate 8g a.i./ha (79.84%) and minimum in $T_8$-*V. lecanii* ($1 \times 10^8$ Spores/g) 5g/L (40.11%). Mean reduction in the population of *M. Vitrata* was recorded maximum in $T_1$-Spinosad 60g a.i. /ha (70.56%) followed by $T_3$-Emamectin benzoate 8g a.i./ha (65.53%) and minimum in $T_8$-*V. lecanii* ($1 \times 10^8$ Spores/g) 5g/L (29.78%).

The of per cent bioefficacy of insecticides and biopesticides data of 3 days after the second spray showed that the maximum reduction in the population of *M. vitrata* was recorded in $T_1$-Spinosad 60g a.i./ha (46.20%) followed by $T_3$-Emamectin benzoate 8g a.i./ha (37.99%) and minimum in $T_8$-*V. lecanii* ($1 \times 10^8$ Spores/g) 5g/L (16.78%). 7 days after the first spray data indicated that $T_1$-Spinosad 60g a.i./ha (72.18%) followed by $T_3$-Emamectin benzoate 8g a.i./ha ($T_3$) (65.53%) showed the highest and $T_8$-*V. lecanii* ($1 \times 10^8$ Spores/g) 5g/L (30.54%) showed

**Table 3:** Per cent bioefficacy of certain insecticides and biopesticides against spotted pod borer, *M. vitrata* during *Kharif* 2014-15

| Tr. No. | Treatments | Dose | Per cent Reduction of spotted pod borer larval population over control | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | First Spray | | | | Second Spray | | | |
| | | | 3 DAS | 7 DAS | 15 DAS | Mean | 3 DAS | 7 DAS | 15 DAS | Mean |
| $T_1$ | Spinosad | 60g a.i./ha | 51.47 (45.84) | 74.06 (59.38) | 86.14 (68.14) | 70.56 (57.14) | 46.20 (42.82) | 72.18 (58.17) | 87.12 (68.97) | 68.50 (55.86) |
| $T_2$ | Imidacloprid | 50g a.i./ha | 33.94 (35.63) | 49.77 (44.87) | 57.86 (49.52) | 47.19 (43.39) | 30.63 (33.61) | 47.61 (43.63) | 59.10 (50.24) | 45.78 (42.58) |
| $T_3$ | Emamectin benzoate | 8g a.i./ha | 47.80 (43.74) | 68.95 (56.14) | 79.84 (63.32) | 65.53 (54.05) | 37.99 (38.05) | 65.53 (54.05) | 79.95 (63.40) | 61.15 (51.45) |
| $T_4$ | Fipronil | 100g a.i./ha | 38.36 (38.27) | 54.65 (47.67) | 62.83 (52.43) | 51.95 (46.12) | 36.47 (37.15) | 56.50 (48.73) | 70.84 (57.32) | 54.60 (47.64) |
| $T_5$ | Acetamiprid | 20g a.i./ha | 33.30 (35.24) | 48.86 (44.35) | 56.92 (48.98) | 46.36 (42.91) | 30.06 (33.25) | 44.05 (41.58) | 55.54 (48.18) | 43.21 (41.10) |
| $T_6$ | *Metarhizium anisopliae* ($1 \times 10^8$ Spores/g) | 5 g/L | 24.15 (29.43) | 36.15 (36.96) | 45.54 (42.44) | 35.28 (36.44) | 19.11 (25.93) | 33.05 (35.09) | 44.41 (41.79) | 32.19 (34.57) |
| $T_7$ | *Beauveria bassiana* ($2 \times 10^8$ Spores/mL) | 2.5 mL/L | 26.76 (31.15) | 38.60 (38.41) | 47.82 (43.75) | 37.73 (37.90) | 22.02 (27.98) | 35.83 (36.77) | 47.16 (43.37) | 35.00 (36.27) |
| $T_8$ | *Verticillium lecanii* ($1 \times 10^8$ Spores/g) | 5g/L | 18.68 (25.61) | 30.54 (33.55) | 40.11 (39.30) | 29.78 (33.07) | 16.78 (24.18) | 30.54 (33.55) | 41.82 (40.29) | 29.71 (33.03) |
| $T_9$ | NSKE | 5 % | 31.14 (33.92) | 42.50 (40.69) | 51.26 (45.72) | 41.63 (40.18) | 25.59 (30.39) | 44.08 (41.60) | 55.08 (47.92) | 41.58 (40.15) |
| $T_{10}$ | Control (Water Spray) | — | — | — | — | — | — | — | — | — |
| | **SEm±** | | **(1.866)** | **(1.887)** | **(2.199)** | **(1.797)** | **(1.864)** | **(1.443)** | **(1.804)** | **(1.423)** |
| | **CD $_{(P=0.05)}$** | | **(5.544)** | **(5.608)** | **(6.536)** | **(5.341)** | **(5.538)** | **(4.287)** | **(5.360)** | **(4.229)** |

*Figures in the parenthesis are Arcsine transformed values, DAS= Days after spray.*

**Table 4:** Per cent bioefficacy of certain insecticides and biopesticides against spotted pod borer, *M. vitrata* during *Kharif* 2015-16

| Tr. No. | Treatments | Dose | Per cent Reduction of spotted pod borer larval population over control | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | First Spray | | | | Second Spray | | | |
| | | | 3 DAS | 7 DAS | 15 DAS | Mean | 3 DAS | 7 DAS | 15 DAS | Mean |
| $T_1$ | Spinosad | 60g a.i./ha | 55.84 (48.35) | 81.30 (64.38) | 92.65 (74.27) | 76.60 (61.07) | 47.23 (43.41) | 71.51 (57.74) | 88.31 (70.01) | 69.02 (56.18) |
| $T_2$ | Imidacloprid | 50g a.i./ha | 26.87 (31.22) | 41.39 (40.04) | 54.95 (47.84) | 41.07 (39.86) | 31.04 (33.86) | 46.28 (42.87) | 58.39 (49.83) | 45.24 (42.27) |
| $T_3$ | Emamectin benzoate | 8g a.i./ha | 45.56 (42.45) | 65.93 (54.29) | 80.76 (63.99) | 64.08 (53.18) | 45.00 (42.13) | 65.55 (54.06) | 78.55 (62.41) | 63.03 (52.55) |
| $T_4$ | Fipronil | 100g a.i./ha | 37.29 (37.64) | 55.66 (48.25) | 69.61 (56.55) | 54.19 (47.40) | 31.76 (34.30) | 51.02 (45.59) | 63.20 (52.65) | 48.66 (44.23) |
| $T_5$ | Acetamiprid | 20g a.i./ha | 30.08 (33.26) | 43.33 (41.17) | 55.57 (48.20) | 42.99 (40.97) | 29.00 (32.58) | 43.78 (41.43) | 55.44 (48.12) | 42.74 (40.83) |
| $T_6$ | *Metarhizium anisopliae* ($1\times10^8$ Spores/g) | 5 g/L | 20.20 (26.71) | 34.48 (35.96) | 47.95 (43.83) | 34.21 (35.80) | 17.29 (24.57) | 31.46 (34.12) | 42.33 (40.59) | 30.36 (33.43) |
| $T_7$ | *Beauveria bassiana* ($2\times10^8$ Spores/mL) | 2.5 mL/L | 23.21 (28.80) | 37.47 (37.74) | 50.86 (45.49) | 37.18 (37.57) | 19.88 (26.48) | 33.77 (35.53) | 44.52 (41.86) | 32.72 (34.89) |
| $T_8$ | *Verticillium lecanii* ($1\times10^8$ Spores/g) | 5g/L | 19.70 (26.35) | 33.56 (35.40) | 46.67 (43.09) | 33.31 (35.25) | 15.83 (23.44) | 29.25 (32.74) | 41.29 (39.98) | 28.79 (32.45) |
| $T_9$ | NSKE | 5 % | 26.03 (30.68) | 40.09 (39.28 | 53.31 (46.90) | 39.81 (39.12) | 23.73 (29.15) | 34.70 (36.09) | 46.85 (43.19) | 35.09 (36.33) |
| $T_{10}$ | Control (Water Spray) | — | — | — | — | — | — | — | — | — |
| | **SEm±** | | **(1.743)** | **(1.219)** | **(1.376)** | **(1.262)** | **(1.572)** | **(2.167)** | **(2.450)** | **(1.745)** |
| | **CD** $_{(P=0.05)}$ | | **(5.179)** | **(3.623)** | **(4.088)** | **(3.750)** | **(4.672)** | **(6.440)** | **(7.282)** | **(5.185)** |

*Figures in the parenthesis areArcsine transformed values, DAS= Days after spray.*



**Plate 1:** Infestation of *M. vitrata* on green gram

the lowest reduction in the population of *M. vitrata***.** 15 days after the first spray data indicated that maximum reduction in the population of *M. Vitrata* was recorded in $T_1$-Spinosad 60g a.i./ha (87.12%) followed by $T_3$-Emamectin benzoate 8g a.i./ha (79.95%) and minimum in $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (41.82%). Mean reduction in the population of *M. vitrata* 3, 7 and 15 DAS was recorded maximum in $T_1$-Spinosad 60g a.i./ha (68.50% ) followed by $T_3$-Emamectin benzoate 8g a.i./ha (61.15%) and minimum in $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (29.71%) (Table 3).

### Per cent bioefficacy of certain insecticides and biopesticides on population of *M. Vitrata* during *Kharif* 2015-2016

The of per cent bioefficacy of insecticides and biopesticides data of 3 days after the first spray showed that maximum reduction in the population of *M. vitrata* was recorded in $T_1$-Spinosad 60g a.i./ha (55.84%) followed by $T_3$-Emamectin benzoate 8g a.i./ha (45.56%) and minimum in $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (19.70%). 7 days after the first spray data indicated that $T_1$-Spinosad 60g a.i./ha (81.30%) followed by $T_3$-Emamectin benzoate 8g a.i./ha ($T_3$) (65.93%) showed the highest and $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (33.56%) showed the lowest reduction in the population of *M. vitrata*. 15 days after first spray data indicated that maximum reduction in the population of *M. Vitrata* was recorded in $T_1$-Spinosad 60g a.i./ha (92.65%) followed by $T_3$-Emamectin benzoate 8g a.i./ha (80.76%) and minimum in $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (46.67%). Mean reduction in the population of *M. Vitrata* was recorded maximum in $T_1$-Spinosad 60g a.i. /ha (76.60 %) followed by $T_3$-Emamectin benzoate 8g a.i. /ha (64.08%) and minimum in $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (33.31%).

The of per cent bioefficacy of insecticides and biopesticides data of 3 days after the second spray showed that maximum reduction in the population of *M. vitrata* was recorded in $T_1$-Spinosad 60g a.i./ha (47.23% ) followed by $T_3$-Emamectin benzoate 8g a.i./ha (45.00%) and minimum in $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (15.83%). 7 days after the first spray data indicated that $T_1$-Spinosad 60g a.i./ha (71.51%) followed by $T_3$-Emamectin benzoate 8g a.i./ha ($T_3$) (65.55%) showed the highest and $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (29.25%) the lowest reduction in the population of *M. vitrata*. 15 days after the first spray data indicated that maximum reduction in the population of *M. vitrata* was recorded in $T_1$-Spinosad 60g a.i./ha (88.31%) followed by $T_3$-Emamectin benzoate 8g a.i./ha (78.55%) and minimum in $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (41.29%). Mean reduction in the population of *M. vitrata* 3, 7 and 15 DAS was recorded maximum in $T_1$-Spinosad 60g a.i./ha (69.02%) followed by $T_3$-Emamectin benzoate 8g a.i./ha (63.03%) and minimum in $T_8$-*V. lecanii* ($1\times10^8$ Spores/g) 5g/L (28.79%). Present findings are conformity with the findings of Kaushik *et al.* (2016); Yadav and Singh, (2014) and Umbarkar and Parsana, (2014) reported that Spinosad is the most effective treatment in reducing *M. Vitrata* population (Table 4).

### Effect of various insecticides and biopesticides on the yield of greengram during *Kharif* 2014-15 and 2015-16

During *Kharif* 2014-15 maximum grain yield was obtained from $T_1$-Spinosad 60g a.i. /ha (8.51q/ha) and minimum in *V. lecanii* ($1\times10^8$ Spores/g) 5g/L (5.83) treated plot. The same trend was observed during *Kharif* 2015-16 and $T_1$-Spinosad 60g a.i. /ha (9.21q/ha) and minimum in *V. lecanii* ($1\times10^8$ Spores/g) 5g/L (5.31q/ha) treated plot. Kaushik *et al.* (2016); Yadav and Singh, (2014) and Umbarkar and Parsana, (2014) reported that Spinosad treated plot produd the maximum yield (Table 1& 2).

## CONCLUSION

With regard to the present study it can be concluded that Spinosad is an effective insecticide in the management of *M. vitrata* in greengram. Among the treatments, biopesticides were also effective but lesser extent when compared to other insecticides and NSKE.

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