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## Integration of various approaches to manage sucking pests of green gram

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### ABSTRACT

An investigation was carried out to evaluate various integrated pest management modules against sucking pests of green gram [*Vigna radiata* (L.) Wilczek] at Agronomy Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar- 385 506 during summer, 2019. The experiment was laid out in Completely Randomized Design (large plot sampling). Among various five modules, module M<sub>1</sub> comprised of border crop with maize + seed treatment with imidacloprid 600 FS + yellow sticky trap + two sprays of azadirachtin 10,000 ppm 0.3% was the most effective module as it recorded lowest number of sucking pests viz., aphid (0.72/3 leaves), jassid (0.40/3 leaves), whitefly (1.28/3 leaves) and thrips (0.58/3 flowers) without interfering population of natural enemies viz., ladybird beetle, green lacewing and spiders which resulted into highest seed yield (1006 kg/ha), increase in yield over control (80.61%) and economics (1:8.61) in summer green gram.

**Keywords:** Integrated Pest Management, green gram, sucking pests

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### INTRODUCTION

Green gram [*Vigna radiata* (L.) Wilczek], Family: Leguminosae is third most important pulse crop of India after chickpea and pigeon pea (Veds *et al.*, 2008), commonly known as mung, moong, mungo, mung bean, golden gram, Chickasaw pea, oreganpea etc. Contribution of green gram to the overall pulse production in India accounted for 10% of the total pulse production (Anon., 2021). Area occupied by pulses in India is 29.03 million hectares with 23.40 million tonnes production and productivity of 806 kg/ha. Major green gram growing states are Odisha, Andhra Pradesh, Maharashtra, Karnataka, Gujarat and Bihar. In Gujarat, total area under cultivation of green gram is 153000 ha with 86000 tonnes production and 561 kg/ha productivity (Anon., 2018). Sucking pests viz., aphid, *Aphis craccivora* Koch; jassid, *Empoasca kerri* Pruthi; whitefly, *Bemisia tabaci* Gennadius; flower thrips, *Megalurothrips usitatus* Bagnall are known to cause significant damage to green gram foliage and flowers besides causing damage to other related legumes. The annual yield loss due to insect-pests has been estimated to the tune of 30 per cent in green gram (Soundarajan and

Chitra, 2011). Whitefly alone can cause losses ranging from 30 to 70 per cent in green gram (Swaminathan *et al.*, 2012) and 80 to 100 per cent in green gram and black gram (Naimuddin, 2001), whereas thrips cause at least 40 per cent yield loss in green gram (Sreekanth, 2002). Meena *et al.* (2025) also confirmed that flower thrips and whiteflies contribute significantly to production decline in green gram. The cowpea aphid, *A. craccivora* may cause 20 to 40 per cent yield loss in case of vegetable cowpea and other pulses (Reddy *et al.*, 2014). Chemical insecticides are used as the frontline defense sources against insect pests in India. However, indiscriminate and repeated use of chemical pesticides creates a few consequences such as development of resistance, pest resurgence and environmental hazards including residue in soil, water and food chain. Integration of various control measures not only bring down the pest population below a certain limit, also it minimizes the load of hazardous chemical pesticides from the crop as well as environment. Research on IPM modules against sucking pests of green gram in past was found scanty. Therefore, the present investigation was carried out on integration of various approaches to manage sucking pests of green gram.

## MATERIALS AND METHODS

To evaluate the different five modules (Table 1) against sucking pests infesting green gram, a field experiment was conducted at Agronomy Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar during summer, 2019. The experiment was laid out in Completely Randomized Design (large plot

sampling). Green gram cultivar, GM 4 was grown following recommended agronomical practices in plot size of 4.8 m × 4.0 m (for each module) at spacing of 30 cm between two rows and 10 cm within the row. Four quadrates (1.5 m × 1.5 m) from each module were selected randomly and five plants from each quadrate were selected randomly for recording observations. Each quadrate was considered as a repetition.

**Table 1 : Details of treatments in various modules**

| Module No.     | Treatments                                                                                                                                                                                                                                   |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| M <sub>1</sub> | Two rows of maize as border crop during sowing of main crop + Seed treatment with imidacloprid 600 FS @ 5 ml/kg seed + Installation of yellow sticky trap @ one/module + Two sprays of azadirachtin 10000 ppm 0.3% (30 ml/10 liter of water) |
| M <sub>2</sub> | Alternate spray of cow urine 10% + neem leaf extract 10% and cow urine 10% + custard apple leaf extract 10%                                                                                                                                  |
| M <sub>3</sub> | Alternate spray of cow urine 10% + <i>Ipomea</i> leaf extract 10% and cow urine 10% + <i>Lantana camera</i> leaf extract 10%                                                                                                                 |
| M <sub>4</sub> | Alternate spray of <i>Lecanicillium lecanii</i> ( $1 \times 10^9$ cfu/g) 1.15 WP 0.5% (50g/10 liter of water) and <i>Beauveria bassiana</i> ( $1 \times 10^9$ cfu/g) 1.15 WP 0.5% (50g/10 liter of water)                                    |
| M <sub>5</sub> | Untreated control                                                                                                                                                                                                                            |

In module M<sub>1</sub>, green gram seeds were treated thoroughly with imidacloprid 600 FS. For the purpose, insecticidal solution was prepared by mixing imidacloprid 600 FS 0.06% @ 5 ml/kg seed in water (50 ml/kg seed) and the seeds were smeared with insecticidal solution in the polythene bag and dried in shade before sowing. Two weeks after sowing yellow sticky trap @ one/module was installed at the centre of the module. At the initiation of any pests, foliar spray of azadirachtin 10000 ppm 0.3% @ 30 ml/ 10 litre water was applied using manually operated knapsack sprayer and second spray was applied after 10 days of 1<sup>st</sup> spray. In module M<sub>2</sub>, M<sub>3</sub> and M<sub>4</sub> first spray was applied at the

appearance of any sucking pests and subsequent two sprays were applied at the 10 days interval.

### Method of recording observations

For the purpose, the number of sucking pests were recorded weekly from three leaves (top, middle and bottom) on five randomly selected plants in each quadrate starting from second week after sowing till maturity of the crop. Number of natural enemies (lady bird beetle, green lacewing and spider) were also counted from same selected plants in each quadrate. At harvest, the seed yield was recorded separately from each quadrate. Avoidable losses and increase in yield over control was calculated applying formula suggested by Khosla (1977).

$$\text{Avoidable loss (\%)} = \frac{\text{Highest yield in treated plot} - \text{Yield in treatment}}{\text{Highest yield in treated plot}} \times 100$$

$$\text{Increase in yield over control (\%)} = \frac{\text{Yield in treatment} - \text{Yield in control}}{\text{Yield in control}} \times 100$$

### Statistical analysis

The data on the population of sucking pests were statistically analysed. On the basis of yield, the economics were calculated as per the methodology adopted by Patel (2019).

## RESULTS AND DISCUSSION

### Evaluation of various modules against sucking pests of green gram

#### Aphid, *A. craccivora*

The data (Table 2) pertaining to aphid population on green

gram during 3<sup>rd</sup> week after sowing (WAS) showed that all modules had similar population except module M<sub>1</sub> as it recorded significantly the lowest aphid population (0.05/3 leaves). During 4<sup>th</sup> week after sowing, all the modules were significantly superior over untreated control (1.15/ 3 leaves). Significantly the lowest (0.10/3 leaves) number of aphid was registered in module M<sub>1</sub> comprising of border crop with maize + seed treatment with imidacloprid 600 FS + yellow sticky trap + two sprays of azadirachtin 10,000 ppm 0.3%. The superiority of module M<sub>1</sub> was noticed at

subsequent week after sowing from 5<sup>th</sup> WAS till maturity of the crop. It was obvious that module M<sub>1</sub> exhibited minimum aphid (0.72/3 leaves) population in summer green gram and proved to be the most effective module. Module M<sub>4</sub> stood as second most efficient module with 1.56 aphid/3 leaves. Module M<sub>2</sub> and M<sub>3</sub> registered 2.04 and 2.22 aphids per three leaves and found as less effective. Saranya *et al.* (2010) and Saranya and Ushakumari (2011) reported that higher effectiveness of *B. bassiana* and *V. lecanii* against *A. craccivora* in black gram. Shobharani *et al.* (2017) revealed that the higher dose of imidacloprid 600 FS @ 15 ml/kg seed as seed treatment proved superior in protecting the black gram against the early season attack of aphid, *A. craccivora*. Thus, present results are in conformity with earlier findings.

#### **Jassid, *E. kerri***

The data presented in Table 3 revealed that all modules had more or less similar jassid population except module M<sub>1</sub> 4<sup>th</sup> WAS. No jassid population was observed in the plot framed with module M<sub>1</sub> at 4<sup>th</sup> WAS which clearly showed its effectiveness against *E. kerri* in green gram. At 5<sup>th</sup> WAS, module M<sub>1</sub> exhibited significantly the lowest (0.05) jassid population per three leaves and found to be most effective. However, highest population (0.60 jassid/3 leaves) was observed in the module M<sub>3</sub> which was at par with module M<sub>2</sub> and M<sub>4</sub> with 0.39 jassid per 3 leaves. Similarly, module M<sub>1</sub> stood as most effective against jassid throughout the observation period (6<sup>th</sup> to 11<sup>th</sup> WAS). It was evident from the overall mean that module M<sub>1</sub> proved as most effective module in protecting the crop from jassid (0.40/3 leaves) infestation followed by module M<sub>4</sub> (0.82), M<sub>2</sub> (0.93) and module M<sub>3</sub> (1.24) as against the jassid population in untreated control (1.77). Singh and Singh (2015) reported that green gram seed treatment with Imidacloprid 600 FS (5ml kg<sup>-1</sup>) followed by one spray of NSKE (5%) at 30 days after sowing and triazophos 40 EC 0.04% were effective in reducing the incidence of *E. kerri*. Shobharani *et al.* (2017) revealed that seed treatment with imidacloprid 600 FS @ 15 ml/kg seed as proved superior in protecting the black gram against the early season attack of *E. kerri* (1.63/3 leaves). Thus, present results are in conformity with earlier findings.

#### **Whitefly, *B. tabaci***

Data (Table 4) of whitefly population recorded in summer green gram during 4<sup>th</sup> WAS showed that there was no significant difference in whitefly population among various modules except module M<sub>1</sub>. There was no incidence of whitefly in module M<sub>1</sub> at 4<sup>th</sup> WAS which clearly showed its effectiveness against *B. tabaci* in green gram. Module M<sub>1</sub> continued to remain as most effective against whitefly throughout the observation period till maturity (11<sup>th</sup> WAS). It was obvious that module M<sub>1</sub> exhibited minimum mean population of whitefly (1.28/3 leaves) in green gram and proved as most effective module followed by module M<sub>4</sub> (2.23). Module M<sub>2</sub> (2.72) and M<sub>3</sub> (3.03) harboured higher number of whiteflies and they were less effective. Jat and Jeyakumar (2006) reported that *B. bassiana* in cotton found

highly effective whereas neem products viz., neem oil and NSKE proved to be mediocre in their effectiveness against *B. tabaci*. Singh and Singh (2015) reported that green gram seed treatment with Imidacloprid 600 FS (5ml kg<sup>-1</sup>) followed by one spray of NSKE (5%) and triazophos 40 EC 0.04 per cent were effective in reducing the incidence of white fly, *B. tabaci*. Thus, present results are in accordance with earlier findings.

#### **Thrips, *M. usitatus***

The results (Table 5) showed that all modules were significantly different from untreated control (0.74 thrips/3 flowers) as far as number of thrips is concerned at 6<sup>th</sup> WAS. The lowest (0.05/3 flowers) thrips population was recorded in the module M<sub>1</sub> and it was at par with module M<sub>4</sub> (0.10) and M<sub>2</sub> (0.19). However, module M<sub>3</sub> recorded 0.30 thrips per three flowers and proved to be least effective in green gram. Similarly, the lowest number of thrips was recorded from plots framed with module M<sub>1</sub> at subsequent weekly observations till maturity of crop and it was at par with module M<sub>4</sub>. It was evident from overall mean that the module M<sub>1</sub> proved the most effective module in reducing the thrips (0.58/3 flowers) population followed by module M<sub>4</sub> (0.87). Module M<sub>2</sub> (1.09) and M<sub>3</sub> (1.34) registered comparatively higher number of thrips in summer green gram and found less effective. Singh and Singh (2015) reported that green gram seed treatment with Imidacloprid 600 FS (5ml kg<sup>-1</sup>) followed by one spray of NSKE (5%) and triazophos 40 EC 0.04 per cent were effective in reducing the incidence of thrips, *Caliothrips indicus*. Shobharani *et al.* (2017) revealed that the higher dose of imidacloprid 600 FS @15 ml/kg seed as seed treatment proved superior in protecting the blackgram against the early season attack of thrips (1.96/3 leaves). Thus, present results are more or less in accordance with earlier findings.

#### **Impact of various modules on natural enemies in summer green gram**

The data on number of coccinellids (grubs + adults), *Chrysoperla* spp. (grubs) and spiders (adults + spiderlings) recorded in different modules are presented in Table 6, 7 and 8, respectively. The population of various natural enemies were homogenous in all modules as the difference was non-significant at each observation starting from 4<sup>th</sup> WAS till crop maturity i.e., 11<sup>th</sup> WAS which clearly indicated that all the modules did not interfere the predatory fauna in summer green gram.

#### **Yield, increase in yield over control and avoidable loss**

##### **Seed yield**

The results indicated that all the modules were significantly different from untreated control (557 kg/ha) in terms of seed yield (Table 9). Significantly the highest green gram seed yield (1006 kg/ha) was harvested from module M<sub>1</sub>. Plots treated with module M<sub>4</sub> produced 880 kg seed per hectare and stood as second best module as far as yield is concerned. Module M<sub>2</sub> and M<sub>3</sub> yielded comparatively lower (727 and 697 kg/ha, respectively).

Table 2: Evaluation of various modules against aphid, *A. craccivora* on green gram during summer 2019

| Module No.     | Treatments                                                                                                                                                | Number of aphid/ 3 leaves at Week After Sowing (WAS) |                             |                             |                             |                             |                             |                             |                             |                              | Mean |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|------------------------------|------|
|                |                                                                                                                                                           | 3 <sup>rd</sup>                                      | 4 <sup>th</sup>             | 5 <sup>th</sup>             | 6 <sup>th</sup>             | 7 <sup>th</sup>             | 8 <sup>th</sup>             | 9 <sup>th</sup>             | 10 <sup>th</sup>            | 11 <sup>th</sup>             |      |
| M <sub>1</sub> | Border crop with maize + seed treatment with imidacloprid 600 FS + yellow sticky trap + two sprays of Azadirachtin 10,000 ppm 0.3%                        | 0.74 <sup>a</sup><br>(0.05)                          | 0.77 <sup>a</sup><br>(0.10) | 0.83 <sup>a</sup><br>(0.19) | 1.16 <sup>a</sup><br>(0.87) | 1.44 <sup>a</sup><br>(1.57) | 1.57 <sup>a</sup><br>(1.97) | 1.38 <sup>a</sup><br>(1.41) | 0.91 <sup>a</sup><br>(0.30) | 0.74 <sup>a</sup><br>(0.05)  | 0.72 |
| M <sub>2</sub> | Alternate spray of cow urine 10% + neem leaf extract 10% and cow urine 10% + custard apple leaf extract 10%                                               | 1.09 <sup>b</sup><br>(0.70)                          | 1.00 <sup>b</sup><br>(0.49) | 1.24 <sup>c</sup><br>(1.03) | 1.71 <sup>c</sup><br>(2.44) | 2.12 <sup>c</sup><br>(3.99) | 2.91 <sup>c</sup><br>(5.23) | 1.89 <sup>b</sup><br>(3.09) | 1.24 <sup>b</sup><br>(1.05) | 0.92 <sup>bc</sup><br>(0.34) | 2.04 |
| M <sub>3</sub> | Alternate spray of cow urine 10% + <i>Ipomea</i> leaf extract 10% and cow urine 10% + <i>Lantana camara</i> leaf extract 10%                              | 1.12 <sup>b</sup><br>(0.75)                          | 1.07 <sup>b</sup><br>(0.64) | 1.26 <sup>c</sup><br>(1.08) | 1.77 <sup>c</sup><br>(2.64) | 2.19 <sup>c</sup><br>(4.28) | 2.45 <sup>c</sup><br>(5.48) | 1.97 <sup>b</sup><br>(3.39) | 1.32 <sup>b</sup><br>(1.25) | 1.02 <sup>c</sup><br>(0.54)  | 2.22 |
| M <sub>4</sub> | Alternate spray of <i>Lecanicillium lecanii</i> ( $1 \times 10^9$ cfu/g) 1.15 WP 0.5% and <i>Beauveria bassiana</i> ( $1 \times 10^9$ cfu/g) 1.15 WP 0.5% | 1.09 <sup>b</sup><br>(0.69)                          | 0.99 <sup>b</sup><br>(0.49) | 1.04 <sup>b</sup><br>(0.59) | 1.58 <sup>b</sup><br>(1.99) | 1.92 <sup>b</sup><br>(3.18) | 2.03 <sup>b</sup><br>(3.61) | 1.74 <sup>b</sup><br>(2.53) | 1.13 <sup>b</sup><br>(0.77) | 0.83 <sup>ab</sup><br>(0.19) | 1.56 |
| M <sub>5</sub> | Untreated control                                                                                                                                         | 1.12 <sup>b</sup><br>(0.75)                          | 1.28 <sup>c</sup><br>(1.15) | 1.46 <sup>d</sup><br>(1.64) | 2.06 <sup>d</sup><br>(3.73) | 2.51 <sup>d</sup><br>(5.82) | 2.79 <sup>d</sup><br>(7.26) | 2.26 <sup>c</sup><br>(4.59) | 1.55 <sup>c</sup><br>(1.90) | 1.18 <sup>d</sup><br>(0.89)  | 3.08 |
| S.Em. ±        |                                                                                                                                                           | 0.04                                                 | 0.05                        | 0.05                        | 0.07                        | 0.09                        | 0.10                        | 0.08                        | 0.05                        | 0.04                         | -    |
| C.V. %         |                                                                                                                                                           | 8.16                                                 | 9.55                        | 8.79                        | 7.98                        | 8.38                        | 8.98                        | 8.49                        | 8.67                        | 8.15                         | -    |

**Note:** Figures in parentheses are retransformed value of  $\sqrt{x + 0.5}$  transformed values; Treatment means with the letter(s) in common are not significant by DNMRT at 5 per cent level of significance

Table 3 : Evaluation of various modules against jassid, *E. kerri* on green gram during summer 2019

| Module No.     | Treatments                                                                                                                                                      | Number of jassid/3 leaves at Week After Sowing (WAS) |                             |                              |                              |                             |                              |                              |                              |      | Mean |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|-----------------------------|------------------------------|------------------------------|-----------------------------|------------------------------|------------------------------|------------------------------|------|------|
|                |                                                                                                                                                                 | 4 <sup>th</sup>                                      | 5 <sup>th</sup>             | 6 <sup>th</sup>              | 7 <sup>th</sup>              | 8 <sup>th</sup>             | 9 <sup>th</sup>              | 10 <sup>th</sup>             | 11 <sup>th</sup>             |      |      |
| M <sub>1</sub> | Border crop with maize + seed treatment with imidacloprid 600 FS + yellow sticky trap + two sprays of Azadirachtin 10,000 ppm 0.3%                              | 0.71 <sup>a</sup><br>(0.00)                          | 0.74 <sup>a</sup><br>(0.05) | 0.89 <sup>a</sup><br>(0.28)  | 1.19 <sup>a</sup><br>(0.91)  | 1.22 <sup>a</sup><br>(0.99) | 1.01 <sup>a</sup><br>(0.53)  | 0.97 <sup>a</sup><br>(0.43)  | 0.74 <sup>a</sup><br>(0.05)  | 0.40 |      |
| M <sub>2</sub> | Alternate spray of cow urine 10% + neem leaf extract 10% and cow urine 10% + custard apple leaf extract 10%                                                     | 0.96 <sup>b</sup><br>(0.42)                          | 0.95 <sup>b</sup><br>(0.39) | 1.20 <sup>b</sup><br>(0.95)  | 1.50 <sup>b</sup><br>(1.74)  | 1.68 <sup>c</sup><br>(2.33) | 1.34 <sup>bc</sup><br>(1.29) | 1.26 <sup>bc</sup><br>(1.09) | 0.89 <sup>ab</sup><br>(0.30) | 0.93 |      |
| M <sub>3</sub> | Alternate spray of cow urine 10% + <i>Ipomea</i> leaf extract 10% and cow urine 10% + <i>Lantana camera</i> leaf extract 10%                                    | 0.97 <sup>b</sup><br>(0.44)                          | 1.05 <sup>b</sup><br>(0.60) | 1.24 <sup>b</sup><br>(1.05)  | 1.59 <sup>bc</sup><br>(2.04) | 1.77 <sup>c</sup><br>(2.63) | 1.41 <sup>c</sup><br>(1.49)  | 1.34 <sup>c</sup><br>(1.29)  | 0.92 <sup>bc</sup><br>(0.34) | 1.24 |      |
| M <sub>4</sub> | Alternate spray of <i>Lecanicillium lecanii</i> (1 × 10 <sup>9</sup> cfu/g) 1.15 WP 0.5% and <i>Beauveria bassiana</i> (1 × 10 <sup>9</sup> cfu/g) 1.15 WP 0.5% | 0.95 <sup>b</sup><br>(0.39)                          | 0.95 <sup>b</sup><br>(0.39) | 1.07 <sup>ab</sup><br>(0.64) | 1.37 <sup>ab</sup><br>(1.38) | 1.53 <sup>b</sup><br>(1.84) | 1.22 <sup>b</sup><br>(0.98)  | 1.15 <sup>ab</sup><br>(0.83) | 0.80 <sup>ab</sup><br>(0.14) | 0.82 |      |
| M <sub>5</sub> | Untreated control                                                                                                                                               | 0.99 <sup>b</sup><br>(0.49)                          | 1.18 <sup>c</sup><br>(0.89) | 1.46 <sup>c</sup><br>(1.63)  | 1.81 <sup>c</sup><br>(2.78)  | 2.03 <sup>d</sup><br>(3.62) | 1.64 <sup>d</sup><br>(2.19)  | 1.55 <sup>d</sup><br>(1.89)  | 1.07 <sup>d</sup><br>(0.64)  | 1.77 |      |
| S.Em. ±        |                                                                                                                                                                 | 0.04                                                 | 0.04                        | 0.05                         | 0.07                         | 0.06                        | 0.06                         | 0.05                         | 0.04                         | -    |      |
| C.V. %         |                                                                                                                                                                 | 8.37                                                 | 8.90                        | 8.23                         | 8.91                         | 8.31                        | 8.92                         | 8.75                         | 8.95                         | -    |      |

**Note:** Figures in parentheses are retransformed value of  $\sqrt{x+0.5}$  transformed values; Treatment means with the letter(s) in common are not significant by DNMRT at 5 per cent level of significance

Table 4 : Evaluation of various modules against whitefly, *B. tabaci* on green gram during summer 2019

| Module No.     | Treatments                                                                                                                                                      | Number of whitefly/3 leaves at Week After Sowing (WAS) |                              |                              |                             |                             |                             |                              |                              |      | Mean |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|------------------------------|------------------------------|-----------------------------|-----------------------------|-----------------------------|------------------------------|------------------------------|------|------|
|                |                                                                                                                                                                 | 4 <sup>th</sup>                                        | 5 <sup>th</sup>              | 6 <sup>th</sup>              | 7 <sup>th</sup>             | 8 <sup>th</sup>             | 9 <sup>th</sup>             | 10 <sup>th</sup>             | 11 <sup>th</sup>             |      |      |
| M <sub>1</sub> | Border crop with maize + seed treatment with imidacloprid 600 FS + yellow sticky trap + two sprays of Azadirachtin 10,000 ppm 0.3%                              | 0.71 <sup>a</sup><br>(0.00)                            | 0.89 <sup>a</sup><br>(0.30)  | 0.99 <sup>a</sup><br>(0.48)  | 1.26 <sup>a</sup><br>(1.08) | 1.64 <sup>a</sup><br>(1.57) | 1.70 <sup>a</sup><br>(2.37) | 1.76 <sup>a</sup><br>(2.59)  | 1.53 <sup>a</sup><br>(1.84)  | 1.28 |      |
| M <sub>2</sub> | Alternate spray of cow urine 10% + neem leaf extract 10% and cow urine 10% + custard apple leaf extract 10%                                                     | 0.99 <sup>b</sup><br>(0.48)                            | 1.16 <sup>b</sup><br>(0.84)  | 1.32 <sup>bc</sup><br>(1.24) | 1.83 <sup>c</sup><br>(2.84) | 2.05 <sup>b</sup><br>(3.69) | 2.15 <sup>b</sup><br>(4.13) | 2.23 <sup>b</sup><br>(4.47)  | 2.13 <sup>bc</sup><br>(4.03) | 2.72 |      |
| M <sub>3</sub> | Alternate spray of cow urine 10% + <i>Ipomea</i> leaf extract 10% and cow urine 10% + <i>Lantana camara</i> leaf extract 10%                                    | 1.02 <sup>b</sup><br>(0.54)                            | 1.22 <sup>bc</sup><br>(0.98) | 1.41 <sup>c</sup><br>(1.50)  | 1.88 <sup>c</sup><br>(3.03) | 2.15 <sup>b</sup><br>(4.13) | 2.34 <sup>b</sup><br>(4.96) | 2.31 <sup>b</sup><br>(4.84)  | 2.19 <sup>c</sup><br>(4.28)  | 3.03 |      |
| M <sub>4</sub> | Alternate spray of <i>Lecanicillium lecanii</i> (1 × 10 <sup>9</sup> cfu/g) 1.15 WP 0.5% and <i>Beauveria bassiana</i> (1 × 10 <sup>9</sup> cfu/g) 1.15 WP 0.5% | 0.99 <sup>b</sup><br>(0.48)                            | 1.07 <sup>ab</sup><br>(0.64) | 1.22 <sup>b</sup><br>(0.99)  | 1.56 <sup>b</sup><br>(1.94) | 1.92 <sup>b</sup><br>(3.20) | 2.10 <sup>b</sup><br>(3.90) | 2.05 <sup>ab</sup><br>(3.70) | 1.87 <sup>b</sup><br>(3.01)  | 2.23 |      |
| M <sub>5</sub> | Untreated control                                                                                                                                               | 1.05 <sup>b</sup><br>(0.60)                            | 1.40 <sup>c</sup><br>(1.45)  | 1.61 <sup>d</sup><br>(2.10)  | 2.20 <sup>d</sup><br>(4.33) | 2.44 <sup>c</sup><br>(5.44) | 2.65 <sup>c</sup><br>(6.53) | 2.66 <sup>c</sup><br>(6.59)  | 2.49 <sup>d</sup><br>(5.69)  | 4.09 |      |
| S.Em. ±        |                                                                                                                                                                 | 0.04                                                   | 0.05                         | 0.06                         | 0.07                        | 0.09                        | 0.10                        | 0.10                         | 0.10                         | -    |      |
| C.V. %         |                                                                                                                                                                 | 7.97                                                   | 8.08                         | 8.75                         | 8.52                        | 8.77                        | 8.84                        | 8.98                         | 9.81                         | -    |      |

**Note:** Figures in parentheses are retransformed value of  $\sqrt{X+0.5}$  transformed values; Treatment means with the letter(s) in common are not significant by DNMRT at 5 per cent level of significance

Table 5: Evaluation of various modules against thrips, *M. usitatus* on green gram during summer 2019

| Module No.     | Treatments                                                                                                                                                | Number of thrips/3 flowers at Week After Sowing (WAS) |                              |                              |                              |                              | Mean                         |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
|                |                                                                                                                                                           | 6 <sup>th</sup>                                       | 7 <sup>th</sup>              | 8 <sup>th</sup>              | 9 <sup>th</sup>              | 10 <sup>th</sup>             | 11 <sup>th</sup>             |
| M <sub>1</sub> | Border crop with maize + seed treatment with imidacloprid 600 FS + yellow sticky trap + two sprays of Azadirachtin 10,000 ppm 0.3%                        | 0.74 <sup>a</sup><br>(0.05)                           | 0.83 <sup>a</sup><br>(0.19)  | 1.06 <sup>a</sup><br>(0.63)  | 1.36 <sup>a</sup><br>(1.34)  | 1.09 <sup>a</sup><br>(0.68)  | 1.04 <sup>a</sup><br>(0.58)  |
| M <sub>2</sub> | Alternate spray of cow urine 10% + neem leaf extract 10% and cow urine 10% + custard apple leaf extract 10%                                               | 0.83 <sup>ab</sup><br>(0.19)                          | 1.01 <sup>b</sup><br>(0.53)  | 1.28 <sup>bc</sup><br>(1.15) | 1.64 <sup>ab</sup><br>(2.19) | 1.36 <sup>b</sup><br>(1.34)  | 1.30 <sup>ab</sup><br>(1.19) |
| M <sub>3</sub> | Alternate spray of cow urine 10% + <i>Ipomea</i> leaf extract 10% and cow urine 10% + <i>Lantana camara</i> leaf extract 10%                              | 0.89 <sup>b</sup><br>(0.30)                           | 1.15 <sup>bc</sup><br>(0.83) | 1.39 <sup>c</sup><br>(1.44)  | 1.74 <sup>b</sup><br>(2.52)  | 1.37 <sup>b</sup><br>(1.38)  | 1.44 <sup>bc</sup><br>(1.59) |
| M <sub>4</sub> | Alternate spray of <i>Lecanicillium lecanii</i> ( $1 \times 10^9$ cfu/g) 1.15 WP 0.5% and <i>Beauveria bassiana</i> ( $1 \times 10^9$ cfu/g) 1.15 WP 0.5% | 0.77 <sup>ab</sup><br>(0.10)                          | 0.94 <sup>ab</sup><br>(0.38) | 1.16 <sup>ab</sup><br>(0.84) | 1.55 <sup>ab</sup><br>(1.89) | 1.26 <sup>ab</sup><br>(1.08) | 1.20 <sup>ab</sup><br>(0.95) |
| M <sub>5</sub> | Untreated control                                                                                                                                         | 1.12 <sup>c</sup><br>(0.74)                           | 1.32 <sup>c</sup><br>(1.25)  | 1.59 <sup>d</sup><br>(2.03)  | 2.15 <sup>c</sup><br>(4.14)  | 1.72 <sup>c</sup><br>(2.44)  | 1.70 <sup>c</sup><br>(2.39)  |
| S.Em. $\pm$    |                                                                                                                                                           | 0.04                                                  | 0.05                         | 0.06                         | 0.07                         | 0.06                         | 0.06                         |
| C.V. %         |                                                                                                                                                           | 9.03                                                  | 8.64                         | 9.84                         | 8.53                         | 8.64                         | 8.63                         |

**Note:** Figures in parentheses are retransformed value of  $\sqrt{X + 0.5}$  transformed values; Treatment means with the letter(s) in common are not significant by DNNMRT at 5 per cent level of significance.

Table 6: Impact of various modules on ladybird beetle in green gram during summer, 2019

| Module No.     | Treatments                                                                                                                                                      | Number of ladybird beetle/plant at Week After Sowing (WAS) |                             |                             |                             |                             |                             |                             |                             |      | Mean |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|------|------|
|                |                                                                                                                                                                 | 4 <sup>th</sup>                                            | 5 <sup>th</sup>             | 6 <sup>th</sup>             | 7 <sup>th</sup>             | 8 <sup>th</sup>             | 9 <sup>th</sup>             | 10 <sup>th</sup>            | 11 <sup>th</sup>            |      |      |
| M <sub>1</sub> | Border crop with maize + seed treatment with imidacloprid 600 FS + yellow sticky trap + two sprays of Azadirachtin 10,000 ppm 0.3%                              | 1.07 <sup>a</sup><br>(0.65)                                | 1.04 <sup>a</sup><br>(0.59) | 1.49 <sup>a</sup><br>(1.72) | 1.64 <sup>a</sup><br>(2.19) | 1.54 <sup>a</sup><br>(1.88) | 1.83 <sup>a</sup><br>(2.84) | 1.26 <sup>a</sup><br>(1.10) | 1.00 <sup>a</sup><br>(0.50) | 1.43 |      |
| M <sub>2</sub> | Alternate spray of cow urine 10% + neem leaf extract 10% and cow urine 10% + custard apple leaf extract 10%                                                     | 0.97 <sup>a</sup><br>(0.45)                                | 1.09 <sup>a</sup><br>(0.69) | 1.48 <sup>a</sup><br>(1.69) | 1.67 <sup>a</sup><br>(2.28) | 1.56 <sup>a</sup><br>(1.94) | 1.84 <sup>a</sup><br>(2.89) | 1.20 <sup>a</sup><br>(0.95) | 0.97 <sup>a</sup><br>(0.45) | 1.41 |      |
| M <sub>3</sub> | Alternate spray of cow urine 10% + <i>Ipomea</i> leaf extract 10% and cow urine 10% + <i>Lantana camara</i> leaf extract 10%                                    | 1.07 <sup>a</sup><br>(0.65)                                | 1.02 <sup>a</sup><br>(0.55) | 1.46 <sup>a</sup><br>(1.64) | 1.64 <sup>a</sup><br>(2.18) | 1.65 <sup>a</sup><br>(2.23) | 1.89 <sup>a</sup><br>(3.07) | 1.21 <sup>a</sup><br>(0.97) | 0.89 <sup>a</sup><br>(0.28) | 1.45 |      |
| M <sub>4</sub> | Alternate spray of <i>Lecanicillium lecanii</i> (1 × 10 <sup>9</sup> cfu/g) 1.15 WP 0.5% and <i>Beauveria bassiana</i> (1 × 10 <sup>9</sup> cfu/g) 1.15 WP 0.5% | 0.96 <sup>a</sup><br>(0.42)                                | 1.02 <sup>a</sup><br>(0.55) | 1.37 <sup>a</sup><br>(1.38) | 1.61 <sup>a</sup><br>(2.08) | 1.55 <sup>a</sup><br>(1.89) | 1.78 <sup>a</sup><br>(2.67) | 1.18 <sup>a</sup><br>(0.90) | 0.86 <sup>a</sup><br>(0.25) | 1.26 |      |
| M <sub>5</sub> | Untreated control                                                                                                                                               | 1.00 <sup>a</sup><br>(0.50)                                | 1.15 <sup>a</sup><br>(0.80) | 1.43 <sup>a</sup><br>(1.54) | 1.62 <sup>a</sup><br>(2.13) | 1.62 <sup>a</sup><br>(2.13) | 1.83 <sup>a</sup><br>(2.87) | 1.22 <sup>a</sup><br>(1.00) | 0.92 <sup>a</sup><br>(0.35) | 1.41 |      |
| S.Em. ±        |                                                                                                                                                                 | 0.05                                                       | 0.04                        | 0.06                        | 0.08                        | 0.08                        | 0.06                        | 0.06                        | 0.05                        | -    |      |
| C.V. %         |                                                                                                                                                                 | 9.33                                                       | 8.90                        | 9.07                        | 10.61                       | 9.56                        | 9.39                        | 9.68                        | 8.80                        | -    |      |

**Note:** Figures in parentheses are retransformed value of  $\sqrt{X + 0.5}$  transformed values; Treatment means with the letter(s) in common are not significant by DNMRT at 5 per cent level of significance.

Table 7: Impact of various modules on green lacewing in green gram during summer, 2019

| Module No.     | Treatments                                                                                                                                                | Number of green lacewing/ plant at Week After Sowing (WAS) |                             |                             |                             |                             |                             | Mean |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|------|
|                |                                                                                                                                                           | 6 <sup>th</sup>                                            | 7 <sup>th</sup>             | 8 <sup>th</sup>             | 9 <sup>th</sup>             | 10 <sup>th</sup>            | 11 <sup>th</sup>            |      |
| M <sub>1</sub> | Border crop with maize + seed treatment with imidacloprid 600 FS + yellow sticky trap + two sprays of Azadirachtin 10,000 ppm 0.3%                        | 0.77 <sup>a</sup><br>(0.10)                                | 0.86 <sup>a</sup><br>(0.25) | 1.16 <sup>a</sup><br>(0.85) | 1.05 <sup>a</sup><br>(0.60) | 1.02 <sup>a</sup><br>(0.55) | 0.80 <sup>a</sup><br>(0.15) | 0.41 |
| M <sub>2</sub> | Alternate spray of cow urine 10% + neem leaf extract 10% and cow urine 10% + custard apple leaf extract 10%                                               | 0.77 <sup>a</sup><br>(0.10)                                | 0.89 <sup>a</sup><br>(0.30) | 1.18 <sup>a</sup><br>(0.90) | 1.04 <sup>a</sup><br>(0.59) | 0.95 <sup>a</sup><br>(0.39) | 0.83 <sup>a</sup><br>(0.19) | 0.42 |
| M <sub>3</sub> | Alternate spray of cow urine 10% + <i>Ipomea</i> leaf extract 10% and cow urine 10% + <i>Lantana camara</i> leaf extract 10%                              | 0.80 <sup>a</sup><br>(0.15)                                | 0.86 <sup>a</sup><br>(0.25) | 1.16 <sup>a</sup><br>(0.85) | 1.07 <sup>a</sup><br>(0.64) | 1.00 <sup>a</sup><br>(0.50) | 0.80 <sup>a</sup><br>(0.15) | 0.42 |
| M <sub>4</sub> | Alternate spray of <i>Lecanicillium lecanii</i> ( $1 \times 10^9$ cfu/g) 1.15 WP 0.5% and <i>Beauveria bassiana</i> ( $1 \times 10^9$ cfu/g) 1.15 WP 0.5% | 0.71 <sup>a</sup><br>(0.00)                                | 0.80 <sup>a</sup><br>(0.14) | 1.06 <sup>a</sup><br>(0.63) | 1.00 <sup>a</sup><br>(0.50) | 0.89 <sup>a</sup><br>(0.28) | 0.77 <sup>a</sup><br>(0.10) | 0.27 |
| M <sub>5</sub> | Untreated control                                                                                                                                         | 0.80 <sup>a</sup><br>(0.15)                                | 0.92 <sup>a</sup><br>(0.35) | 1.16 <sup>a</sup><br>(0.84) | 1.02 <sup>a</sup><br>(0.54) | 1.00 <sup>a</sup><br>(0.50) | 0.80 <sup>a</sup><br>(0.15) | 0.43 |
| S.Em. $\pm$    |                                                                                                                                                           | 0.05                                                       | 0.05                        | 0.05                        | 0.08                        | 0.07                        | 0.09                        | -    |
| C.V. %         |                                                                                                                                                           | 9.33                                                       | 9.14                        | 9.81                        | 9.47                        | 9.09                        | 9.41                        | -    |

**Note:** Figures in parentheses are retransformed value of  $\sqrt{x+0.5}$  transformed values; Treatment means with the letter(s) in common are not significant by DNMRT at 5 per cent level of significance

Table 8: Impact of various modules on spiders in green gram during summer, 2019

| Module No.     | Treatments                                                                                                                                                      | Number of spider/ plant at Week After Sowing (WAS) |                             |                             |                             |                             |                             |                             |                             |      | Mean |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|------|------|
|                |                                                                                                                                                                 | 4 <sup>th</sup>                                    | 5 <sup>th</sup>             | 6 <sup>th</sup>             | 7 <sup>th</sup>             | 8 <sup>th</sup>             | 9 <sup>th</sup>             | 10 <sup>th</sup>            | 11 <sup>th</sup>            |      |      |
| M <sub>1</sub> | Border crop with maize + seed treatment with imidacloprid 600 FS + yellow sticky trap + two sprays of Azadirachtin 10,000 ppm 0.3%                              | 0.86 <sup>a</sup><br>(0.25)                        | 1.07 <sup>a</sup><br>(0.65) | 1.38 <sup>a</sup><br>(1.40) | 1.64 <sup>a</sup><br>(2.20) | 1.74 <sup>a</sup><br>(2.54) | 1.50 <sup>a</sup><br>(1.74) | 1.16 <sup>a</sup><br>(0.84) | 0.86 <sup>a</sup><br>(0.25) | 1.23 |      |
| M <sub>2</sub> | Alternate spray of cow urine 10% + neem leaf extract 10% and cow urine 10% + custard apple leaf extract 10%                                                     | 0.84 <sup>a</sup><br>(0.20)                        | 1.09 <sup>a</sup><br>(0.70) | 1.40 <sup>a</sup><br>(1.45) | 1.70 <sup>a</sup><br>(2.39) | 1.71 <sup>a</sup><br>(2.43) | 1.48 <sup>a</sup><br>(1.69) | 1.16 <sup>a</sup><br>(0.84) | 0.80 <sup>a</sup><br>(0.15) | 1.22 |      |
| M <sub>3</sub> | Alternate spray of cow urine 10% + <i>Ipomea</i> leaf extract 10% and cow urine 10% + <i>Lantana camera</i> leaf extract 10%                                    | 0.89 <sup>a</sup><br>(0.30)                        | 1.16 <sup>a</sup><br>(0.84) | 1.28 <sup>a</sup><br>(1.15) | 1.70 <sup>a</sup><br>(2.39) | 1.71 <sup>a</sup><br>(2.43) | 1.50 <sup>a</sup><br>(1.74) | 1.12 <sup>a</sup><br>(0.74) | 0.80 <sup>a</sup><br>(0.15) | 1.21 |      |
| M <sub>4</sub> | Alternate spray of <i>Lecanicillium lecanii</i> (1 × 10 <sup>9</sup> cfu/g) 1.15 WP 0.5% and <i>Beauveria bassiana</i> (1 × 10 <sup>9</sup> cfu/g) 1.15 WP 0.5% | 0.80 <sup>a</sup><br>(0.15)                        | 1.02 <sup>a</sup><br>(0.54) | 1.24 <sup>a</sup><br>(1.05) | 1.63 <sup>a</sup><br>(2.14) | 1.64 <sup>a</sup><br>(2.20) | 1.39 <sup>a</sup><br>(1.44) | 1.07 <sup>a</sup><br>(0.64) | 0.74 <sup>a</sup><br>(0.05) | 1.02 |      |
| M <sub>5</sub> | Untreated control                                                                                                                                               | 0.89 <sup>a</sup><br>(0.28)                        | 1.15 <sup>a</sup><br>(0.83) | 1.40 <sup>a</sup><br>(1.47) | 1.66 <sup>a</sup><br>(2.25) | 1.74 <sup>a</sup><br>(2.53) | 1.50 <sup>a</sup><br>(1.76) | 1.09 <sup>a</sup><br>(0.69) | 0.84 <sup>a</sup><br>(0.20) | 1.25 |      |
| S.Em. ±        |                                                                                                                                                                 | 0.06                                               | 0.04                        | 0.06                        | 0.08                        | 0.08                        | 0.06                        | 0.06                        | 0.05                        | -    |      |
| C.V. %         |                                                                                                                                                                 | 9.18                                               | 8.90                        | 10.07                       | 9.61                        | 9.56                        | 9.39                        | 9.68                        | 8.80                        | -    |      |

**Note:** Figures in parentheses are retransformed value of  $\sqrt{X + 0.5}$  transformed values; Treatment means with the letter(s) in common are not significant by DNMRT at 5 per cent level of significance.

Table 9 : Impact of various modules on yield, increase in yield over control, avoidable loss and economics in green gram

| Module No.     | Treatments                                                                                                                                                      | Seed yield<br>(kg/ha) | Increase in yield over<br>control<br>(%) | Avoidable loss<br>(%) | PCBR   |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------------------------------------------|-----------------------|--------|
| M <sub>1</sub> | Border crop with maize + seed treatment with imidacloprid<br>600 FS + yellow sticky trap + two sprays of Azadirachtin<br>10,000 ppm 0.3%                        | 1006 <sup>a</sup>     | 80.61                                    | -                     | 1:8.61 |
| M <sub>2</sub> | Alternate spray of cow urine 10% + neem leaf extract 10%<br>and cow urine 10% + custard apple leaf extract 10%                                                  | 727 <sup>c</sup>      | 30.52                                    | 27.73                 | 1:1.71 |
| M <sub>3</sub> | Alternate spray of cow urine 10% + <i>Ipomea</i> leaf extract 10%<br>and cow urine 10% + <i>Lantana camara</i> leaf extract 10%                                 | 697 <sup>c</sup>      | 25.13                                    | 30.71                 | 1:1.23 |
| M <sub>4</sub> | Alternate spray of <i>Lecanicillium lecanii</i> ( $1 \times 10^9$ cfu/g) 1.15<br>WP 0.5% and <i>Beauveria bassiana</i> ( $1 \times 10^9$ cfu/g) 1.15 WP<br>0.5% | 880 <sup>b</sup>      | 57.99                                    | 12.52                 | 1:1.86 |
| M <sub>5</sub> | Untreated control                                                                                                                                               | 557 <sup>d</sup>      | -                                        | 44.63                 | -      |
| S.E.m.±        |                                                                                                                                                                 | 33.83                 | -                                        | -                     | -      |
| C.V. %         |                                                                                                                                                                 | 8.75                  | -                                        | -                     | -      |

**Note:** Treatment means with the letter(s) in common are not significant by DNMRT at 5 per cent level of significance.

### Increase in yield over control

Maximum increase in yield was obtained in the plots framed with  $M_1$  (80.61%) followed by module  $M_4$  which recorded 57.99 per cent over control (Table 9). Module  $M_2$  and  $M_3$  registered 30.52 and 25.13 per cent increase in yield over control, respectively.

### Avoidable loss

It can be seen from the data that the maximum seed yield was obtained in the module  $M_1$  which proved as the best module (Table 9). The avoidable losses in green gram yield was minimum in module  $M_4$  (12.52%) followed by module  $M_2$  (27.73%) and module  $M_3$  (30.71%). The maximum avoidable loss in green gram yield due to sucking pests was incurred in untreated control (44.63%).

### Economics

The economics of various modules presented in Table 9 revealed that the highest Protection Cost Benefit Ratio (PCBR) was calculated from the module  $M_1$  (1:8.61) which clearly indicated that module  $M_1$  was most economical among various modules. Module  $M_4$ ,  $M_2$  and  $M_3$  showed PCBR of 1:1.86, 1:1.71 and 1:1.23, respectively and found less economical.

## CONCLUSION

It can be concluded that among various modules,  $M_1$  comprised of border crop with maize + seed treatment with imidacloprid 600 FS + yellow sticky trap + two sprays of Azadirachtin 10,000 ppm 0.3% was the most effective module as it recorded lowest number of sucking pests viz., aphid (0.72/3 leaves), jassid (0.40/3 leaves), whitefly (1.28/3 leaves) and thrips (0.58/3 flowers) without interfering natural enemies viz., ladybird beetle, green lacewing and spider resulting in to highest seed yield (1006 kg/ha), increase in yield over control (80.61%) and found most economical (1:8.61) in summer green gram.

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