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# Eco-friendly management of pod bugs of yard long bean (*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcourt) under field conditions

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**ABSTRACT**: The study on the eco-friendly management of pod bugs *viz.*, *Riptortus pedestris* (F.) (Hemiptera: Coreidae); *Clavigralla gibbosa* Spinola (Hemiptera: Coreidae); *Nezara viridula* (L.) (Hemiptera: Pentatomidae) of yard long bean (*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcourt) under field conditions3 was conducted during kharif and rabi seasons in the year 2016. Among the biopesticides treated, Azadirachtin 1% resulted in complete reduction of pod infestation by pod bugs even after fifteen days of second spray followed by *Lecanicillium lecanii* where complete reduction of pod bug infestation was noticed fifteen days after third spray.

**KEY WORDS:** *Vigna unguiculata* subsp. *sesquipedalis*, *Riptortus pedestris*, *Clavigralla gibbosa*, *Nezara viridula*, management, biopesticides, azadirachtin

## INTRODUCTION

One of the key components of Indian agricultural production is the legumes, among which vegetable cowpea or yard long bean (*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcourt) imparts a major contribution. Cowpea is popularly known as 'vegetable meat' because of its high protein content. It is a crop of high value which requires only fewer inputs. The most important constraint that reduces the production and productivity of vegetable cowpea is the insect pests. Among the insect pests of vegetable cowpea, the important and the destructive post flowering pests are the pod bugs *viz., Riptortus pedestris* (F.); *Clavigralla gibbosa* Spinola; *Clavigralla tomentosicollis* Stal. (Hemiptera: Coreidae) and *Nezara viridula* (L.) (Hemiptera: Pentatomidae) (Jackai and Daoust, 1986). In Kerala, the nymph and adult population of *N. viridula* attains its peak during May- April and the population of nymphs of *R. pedestris* was high during May and adults of *R. pedestris* was on its peak during first and second fortnight of June (Bharathimeena *et al.,* 2008). The attack of pod sucking bug, *C. tomentosicollis* results in desiccation and shrivelling of pods prematurely and formation of half filled pods. During its peak infestation, more than 80 per cent of yield loss occurs (Singh *et al*., 1990). For the management of these pests, different chemical insecticides are available in the market with different modes of action. The inappropriate use of insecticides causes build up of resistance in target species, resurrection of other pest species, devastation of natural enemies, disarray of ecosystem and considerable health impacts (Khade *et al*., 2014). Taking into consideration of these

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issues, some viable environment friendly alternatives have to be found out especially in Kasaragod district as it has been under organic cultivation for the past five years. The lessons from the adoption of organic cultivation in Kasaragod district have been abstracted in the report of Menon (2015) which highlighted the need for studies with organic v/s insecticidal management in Kasaragod district.

The entomopathogenic fungi like *Beauveria bassiana* and *Metarhizium anisopliae* were reported as an important part of integrated pest management in cowpea (Srinivasan *et al*., 2009). The compounds of neem acts as insect growth regulator, oviposition repellent, inhibition of fecundity and antifeedant (Ascher, 1993). Spinosad 45 SC exhibits very low toxicity to mammals and no catastrophic effects on exposure for a long time (Gour and Sreedevi, 2012). With this view the present study aimed at studying the efficacy of different microbial agents, neem based and bio rational insecticides against pod bugs of yard long bean.

## MATERIALS AND METHODS

The research work was carried out in the Instructional Farm of College of Agriculture, Padannakkad from May 2016 to August 2016 and September 2016 to December 2016 in RBD with 9 treatments and 3 replications @ twelve plants per treatment. The yard long bean variety 'Lola' released by KAU was selected for conducting the

Table 1. Mean per cent of pods infested by nymphs and adults of pod bugs taken at weekly intervals during kharif season from May to August 2016

| Treatments | Mean per cent of infested pods | | | | | |
|---|---|---|---|---|---|---|
| | 7 DAFS | 15DAFS | 7 DASS | 15DASS | 7 DATS | 15DATS |
| $T_1$ - *Beauveria bassiana* @ $10^7$ spores/ml | 29.36 (5.51) | 24.80 (5.08) | 30.69 (5.63) | 34.04 (5.92) | 26.24 (5.22) | 46.74 (6.91) |
| $T_2$ - *Metarhizium anisopliae* @ $10^7$ spores/ml | 40.99 (6.48) | 46.19 (6.87) | 88.11 (9.44) | 70.23 (8.44) | 49.55 (7.11) | 66.40 (8.21) |
| $T_3$ – *Lecanicillium lecanii* @ $10^7$ spores/ml | 10.08 (3.33) | 8.61 (3.10) | 4.47 (2.34) | 3.00 (2.00) | 1.13 (1.46) | 0.00 (1.00) |
| $T_4$ – *Bt* formulation @ $2\times 10^8$ cfu/ml @ 1 ml/l | 42.42 (6.59) | 46.47 (6.89) | 43.22 (6.65) | 38.43 (6.28) | 25.62 (5.16) | 40.60 (6.45) |
| $T_5$ – Neem (Azadirachtin 1%) @ 5ml/l | 2.31 (1.82) | 1.43 (1.56) | 0.96 (1.40) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) |
| $T_6$ – Neem oil emulsion 5% 50ml/l | 4.76 (2.40) | 3.12 (2.03) | 0.87 (1.37) | 1.25 (1.5) | 1.25 (1.5) | 1.95 (1.72) |
| $T_7$ – Spinosad 45 SC @ 0.4 ml/l | 30.47 (5.61) | 25.31 (5.13) | 24.30 (5.03) | 31.37 (5.69) | 38.31 (6.27) | 33.81 (5.90) |
| $T_8$ – Malathion 50 EC @ 2ml/l | 7.00 (2.83) | 5.35 (2.52) | 5.55 (2.56) | 6.50 (2.74) | 12.39 (3.66) | 12.69 (3.70) |
| $T_9$ – Absolute control | 49.55 (7.11) | 58.13 (7.69) | 87.73 (9.42) | 91.16 (9.60) | 76.96 (8.83) | 83.82 (9.21) |
| C.D.(0.05 %) | 1.57 | 2.2 | 1.90 | 1.79 | 1.99 | 1.40 |

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

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

Table 2. Mean per cent of pods infested by nymphs and adults of pod bugs taken at weekly intervals during rabi season from September 2016 to December 2016

| Treatments | Mean per cent of infested pods | | | | | |
|---|---|---|---|---|---|---|
| | 7 DAFS | 15DAFS | 7 DASS | 15DASS | 7 DATS | 15DATS |
| $T_1$ - *Beauveria bassiana* @ $10^7$ spores/ml | 44.02 (6.71) | 30.02 (5.57) | 15.89 (4.11) | 11.53 (3.54) | 3.16 (2.04) | 6.78 (2.78) |
| $T_2$- *Metarhizium anisopliae* @ $10^7$ spores/ml | 51.56 (7.25) | 53.90 (7.41) | 44.15 (6.72) | 25.21 (5.12) | 24.70 (5.07) | 19.34 (4.51) |
| $T_3$ – *Lecanicillium lecanii* @ $10^7$ spores/ml | 25.83 (5.18) | 14.68 (3.96) | 3.24 (2.06) | 2.13 (1.77) | 0.44 (1.20) | 0.00 (1.00) |
| $T_4$ – *Bt* formulation @ 2× $10^8$ cfu/ ml @ 1 ml/l | 67.39 (8.27) | 49.83 (7.13) | 36.82 (6.15) | 42.42 (6.59) | 40.08 (6.41) | 31.14 (5.67) |
| $T_5$ – Neem (Azadirachtin 1%) @ 5ml/l | 3.24 (2.06) | 1.95 (1.72) | 0.87 (1.37) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) |
| $T_6$ – Neem oil emulsion 5% @ 50ml/l | 17.74 (4.33) | 14.13 (3.89) | 6.89 (2.81) | 4.01 (2.24) | 3.92 (2.22) | 5.45 (2.54) |
| $T_7$ – Spinosad 45 SC @ 0.4 ml/l | 54.65 (7.46) | 46.74 (6.91) | 30.24 (5.59) | 32.29 (5.77) | 31.83 (5.73) | 25.31 (5.13) |
| $T_8$ – Malathion 50 EC @ 2ml/l | 0.00 (1.00) | 4.61 (2.37) | 1.59 (1.61) | 13.06 (3.75) | 3.53 (2.13) | 3.36 (2.09) |
| $T_9$ – Absolute control | 81.62 (9.09) | 78.03 (8.89) | 81.81 (9.10) | 69.05 (8.37) | 82.17 (9.12) | 70.57 (8.46) |
| C.D.(0.05 %) | 1.81 | 1.94 | 1.78 | 1.27 | 1.16 | 0.86 |

Figures in parenthesis denotes $\sqrt{x+1}$ transformed values.
DAFS- Days after first spray; DASS- Days after second spray; DATS- Days after third spray.

study. The crop was raised on trellis at a spacing of 1.5 x 0.45m. All the planting operations were done based on the Package of Practice recommendations: crops of KAU, 2016. The treatments included; T1- *Beauveria bassiana* (liquid formulation @ $10^7$ spores/ml of water), T2- *Metarhizium anisopliae* (liquid formulation @ $10^7$ spores/ml of water), T3- *Lecanicillium lecanii* (liquid formulation @ $10^7$ spores/ml of water), T4- *Bt* formulation 2× $10^8$ cfu/ml @ 1 ml/l of water, T5- Neem based insecticide (Azadirachtin 1% @ 5 ml/ l of water), T6- Neem oil emulsion 5% (50ml/l of water), T7- Spinosad 45 SC @ 0.4 ml/l of water, T8- Malathion 50 EC @ 2ml/l of water (standard check), T9- Absolute control.

The pure culture of entomopathogenic fungi *Beauveria bassiana*, *Metarhizium anisopliae* and *Lecanicillium lecanii* needed for the conduct of the research work were brought from National Bureau of Agricultural Insect Resources (NBAIR), Bangalore and were maintained throughout the period by sub culturing it on Potato Dextrose Agar medium (PDA) under laboratory conditions at regular intervals and mass multiplied on Potato Dextrose Broth (PDB). All the treatments were imposed at fortnightly intervals just after the initial attack of pest was seen and observations were recorded at weekly intervals corresponding to standard weeks by counting the number of nymphs/ adults of pod bugs, number of infested pods out of total number of pods. The crop was harvested 60 days after planting. The data were subjected to square root transformation and analyzed using ANOVA.

## RESULTS AND DISCUSSION

The efficacy of different entomopathogenic fungi, *Bt*, biorational and neem based insecticides against pod infestation by pod bugs during kharif season (May 2016 to August 2016) and rabi season (September 2016 to December 2016) are presented in the Table 1and 2. During kharif season, minimum per cent of pod infestation was noticed in $T_5$ (Azadirachtin 1%) with 2.31%, 1.43% and 0.96% infestation on 7th day after fist spray, 15th day after first spray and 7th day after second spray respectively. Thereafter no infestation on pods was noticed. Maximum infestation was noticed on $T_9$ with a range of 49.55 to 91.16% of pod infestation. Next to Azadirachtin, *Lecanicillium lecanii* ($T_3$) was effective in reducing the percentage of infestation after three consecutive sprays with a range of 10.08% on 7 days after first spray to 0.00% on 15 days after third spray. *L. lecanii* became on par with Azadirachtin only after fifteen days of third spray. This was followed by $T_6$ (neem oil 5%) which exhibited a minimum of 1.72% of infestation after three consecutive sprays (Table 1).

During rabi season, the percentage of pod infestation was found minimum in $T_5$ (Azadirachtin 1%) treated plot with 3.24%, 1.95% and 0.87% on 7th day after fist spray, 15th day after first spray and 7th day after second spray respectively. Complete reduction in pod infestation. $T_5$ followed by *L. lecanii* ($T_3$) having 0.44% infestation on 7 days after third spray and no infestation (0.00%) on 15 days after third spray. *L. lecanii* ($T_3$) was found to be on par with Azadirachtin 1% ($T_5$) only after fifteen days of third spray. Maximum infestation was noticed on $T_9$ with a range of 69.05 to 82.17% of pod infestation (Table 2).

Table 3. Effect of treatments on the yield attributes of yard long bean during kharif season from May 2016 to August 2016

| Treatments | Fresh weight of pods (g/plant) | | | | Total yield (g/plant) | Marketable yield (g/plant) |
|---|---|---|---|---|---|---|
| | First harvest | Second harvest | Third harvest | Fourth harvest | Total | Total |
| $T_1$ - *Beauveria bassiana* @ $10^7$ spores/ml | 69.03 | 94.40 | 107.25 | 128.46 | 399.14 | 377.16 |
| $T_2$ - *Metarhizium anisopliae* @ $10^7$ spores/ml | 64.75 | 97.56 | 92.66 | 113.58 | 368.56 | 291.78 |
| $T_3$ – *Lecanicillium lecanii* @ $10^7$ spores/ml | 85.45 | 97.83 | 109.16 | 108.27 | 400.73 | 346.43 |
| $T_4$ – *Bt* formulation @ $2\times 10^8$ cfu/ml @ 1 ml/l | 58.99 | 67.19 | 100.08 | 117.63 | 343.89 | 323.19 |
| $T_5$ – Neem (Azadirachtin 1%) @ 5ml/l | 87.80 | 99.08 | 86.04 | 110.84 | 383.76 | 347.19 |
| $T_6$ – Neem oil emulsion 5% @ 50ml/l | 71.58 | 108.18 | 104.11 | 104.23 | 388.11 | 325.28 |
| $T_7$ – Spinosad 45 SC @ 0.4 ml/l | 83.78 | 145.75 | 123.33 | 131.01 | 483.88 | 466.46 |
| $T_8$ – Malathion 50 EC @ 2ml/l | 60.66 | 79.58 | 85.75 | 104.09 | 330.09 | 302.59 |
| $T_9$ – Absolute control | 63.58 | 78.30 | 91.83 | 89.74 | 323.45 | 237.17 |
| C.D. (0.05 %) | 17.47 | 15.54 | 14.13 | 12.62 | 30.02 | 35.33 |

Table 4. Effect of treatments on the yield attributes of yard long bean during rabi season from September 2016 to December 2016

| Treatments | Fresh weight of pods (g/plant) | | | | | | | Total yield (g/plant) | Marketable yield (g/plant) |
|---|---|---|---|---|---|---|---|---|---|
| | First harvest | Second harvest | Third harvest | Fourth harvest | Fifth harvest | Sixth harvest | Seventh harvest | Total | Total |
| $T_1$ - *Beauveria bassiana* @ $10^7$ spores/ml | 17.25 | 35.33 | 39.08 | 41.50 | 90.83 | 331.31 | 137.40 | 692.71 | 629.13 |
| $T_2$ - *Metarhizium anisopliae* @ $10^7$ spores/ml | 16.76 | 28.33 | 90.41 | 89.83 | 90.98 | 168.12 | 203.54 | 688.00 | 456.91 |
| $T_3$ – *Lecanicillium lecanii* @ $10^7$ spores/ml | 20.62 | 27.31 | 83.62 | 74.77 | 101.66 | 151.69 | 143.08 | 602.78 | 580.72 |
| $T_4$ – *Bt* formulation @ $2\times 10^8$ cfu/ml @ 1 ml/l | 6.00 | 23.45 | 72.66 | 59.90 | 43.66 | 166.66 | 63.65 | 436.00 | 410.37 |
| $T_5$ – Neem (Azadirachtin 1%) @ 5ml/l | 13.00 | 30.25 | 66.58 | 38.04 | 71.66 | 162.75 | 109.01 | 491.31 | 455.62 |
| $T_6$ – Neem oil emulsion 5% @ 50ml/l | 12.50 | 24.66 | 105.70 | 39.66 | 76.33 | 166.79 | 129.54 | 555.20 | 529.10 |
| $T_7$ – Spinosad 45 SC @ 0.4 ml/l | 24.30 | 41.00 | 144.25 | 75.04 | 117.00 | 191.74 | 145.40 | 738.74 | 718.24 |
| $T_8$ – Malathion 50 EC @ 2ml/l | 12.46 | 32.50 | 52.83 | 78.66 | 87.00 | 123.62 | 107.30 | 494.40 | 473.03 |
| $T_9$ – Absolute control | 19.16 | 28.35 | 40.00 | 55.96 | 39.33 | 77.50 | 60.00 | 320.31 | 249.25 |
| C.D.(0.05 %) | 5.38 | 6.57 | 16.04 | 26.42 | 31.12 | 48.12 | 33.81 | 47.73 | 54.92 |

Four harvests were done during kharif season and seven harvests were done during rabi season. During kharif season, from the total yield calculated, treatment $T_7$ recorded higher yield of 483.88 g per plant followed by $T_3$ with yield of 400.73 g per plant. Treatments *viz.,* $T_3$, $T_1$, $T_6$ and $T_5$ were statistically on par with each other recording 400.73, 399.14, 388.11 and 383.73 g per plant respectively. The total yield obtained was low in treatment $T_9$ (323.45 g per plant) followed by $T_8$ (330.09 g per plant). Highest marketable yield was also recorded in Treatment $T_7$ (466.46 g per plant) followed by $T_1$ with yield of 377.16 g per plant. Treatment $T_9$ recorded the lowest marketable yield of 237.17 g per plant. Treatments $T_1$, $T_5$ and $T_3$ were found to be on par with each other with 377.16, 347.19 and 346.43 g per plant respectively (Table 3).

During rabi season, from the total yield calculated, treatment $T_7$ recorded higher yield of 738.74 g per plant followed by $T_1$ (692.71 g per plant) and $T_2$ (688 g per plant). Thus $T_1$ and $T_2$ were statistically on par with $T_7$. Minimum yield was recorded in treatment $T_9$ with 320.31 g per plant. Treatments $T_3$ and $T_6$ were found on par with each other with 602.78 g and 555.20 g per plant respectively. Highest marketable yield was also recorded in Treatment $T_7$ (718.24 g per plant) followed by $T_1$ and $T_3$ with yield of 629.13 g per plant and 580.72 g per plant respectively. Thus treatments $T_1$ was found statistically on par with $T_7$. Treatment $T_9$ recorded the lowest marketable yield of 249.25 g per plant. Treatments $T_3$ and $T_6$ was found to be on par with each other having 580.72 g per plant and 529.10 g per plant respectively (Table 4).

During kharif season, maximum net returns were recorded in treatment $T_7$ (63250.00) followed by $T_1$ and $T_3$ with net returns 36249.80 and 23803.50 respectively. By applying treatment $T_7$, an amount

Table 5. Economics of cultivation of yard long bean during kharif season from May 2016 to August 2016

| Treatments | Economics of yard long bean | | | | | |
|---|---|---|---|---|---|---|
| | Production cost excluding insecticides (Rs./ha) | Cost of insecticides (Rs./ha) | Total expenditure (Rs./ha) | Gross Income (Rs./ha) | Net income (Rs./ha) | B : C ratio |
| $T_1$ - *Beauveria bassiana* @ $10^7$ spores/ml | 115062.00 | 1440.00 | 116502.00 | 152751.80 | 36249.80 | 1.31 |
| $T_2$ - *Metarhizium anisopliae* @ $10^7$ spores/ml | 115062.00 | 1440.00 | 116502.00 | 118172.30 | 1670.30 | 1.01 |
| $T_3$ – *Lecanicillium lecanii* @ $10^7$ spores/ml | 115062.00 | 1440.00 | 116502.00 | 140305.00 | 23803.50 | 1.20 |
| $T_4$ – *Bt* formulation @ $2\times 10^8$ cfu/ml @ 1 ml/l | 115062.00 | 1240.00 | 116302.00 | 130895.30 | 14593.30 | 1.12 |
| $T_5$ – Neem (Azadirachtin 1%) @ 5ml/l | 115062.00 | 2947.50 | 118009.50 | 140612.60 | 22602.63 | 1.19 |
| $T_6$ – Neem oil emulsion 5% @ 50ml/l | 115062.00 | 13500.00 | 128562.00 | 131739.80 | 3177.75 | 1.02 |
| $T_7$ – Spinosad 45 SC @ 0.4 ml/l | 115062.00 | 10607.00 | 125669.00 | 188919.00 | 63250.00 | 1.50 |
| $T_8$ – Malathion 50 EC @ 2ml/l | 115062.00 | 1350.00 | 116412.00 | 122549.60 | 6137.62 | 1.05 |
| $T_9$ – Absolute control | 115062.00 | 0.00 | 115062.00 | 96055.88 | -61679.60 | 0.46 |

Table 6. Economics of cultivation of yard long bean during rabi season from September 2016 to December 2016

| Treatments | Economics of yard long bean | | | | | |
|---|---|---|---|---|---|---|
| | Production cost excluding insecticides (Rs./ha) | Cost of insecticides (Rs./ha) | Total expenditure (Rs./ha) | Gross Income (Rs./ha) | Net income (Rs./ha) | B : C ratio |
| $T_1$ - *Beauveria bassiana* @ $10^7$ spores/ml | 115062.00 | 1440.00 | 116502.00 | 254799.00 | 138297.00 | 2.18 |
| $T_2$ - *Metarhizium anisopliae* @ $10^7$ spores/ml | 115062.00 | 1440.00 | 116502.00 | 185051.30 | 68549.25 | 1.58 |
| $T_3$ – *Lecanicillium lecanii* @ $10^7$ spores/ml | 115062.00 | 1440.00 | 116502.00 | 235193.60 | 118691.60 | 2.01 |
| $T_4$ – *Bt* formulation @ $2\times 10^8$ cfu/ml @ 1 ml/l | 115062.00 | 1240.00 | 116302.00 | 166201.90 | 49899.88 | 1.42 |
| $T_5$ – Neem (Azadirachtin 1%) @ 5ml/l | 115062.00 | 2947.50 | 118009.50 | 184528.10 | 66518.63 | 1.56 |
| $T_6$ – Neem oil emulsion 5% @ 50ml/l | 115062.00 | 13500.00 | 128562.00 | 214288.90 | 85726.88 | 1.66 |
| $T_7$ – Spinosad 45 SC @ 0.4 ml/l | 115062.00 | 10607.00 | 125669.00 | 290887.90 | 162325.90 | 2.26 |
| $T_8$ – Malathion 50 EC @ 2ml/l | 115062.00 | 1350.00 | 116412.00 | 191578.50 | 65909.5 | 1.52 |
| $T_9$ – Absolute control | 115062.00 | 0.00 | 115062.00 | 100946.30 | -15465.8 | 0.86 |

of Rs.1.5 was obtained for every one rupee invested against the treatment T9 which had a return of only Rs. 0.46. Treatment $T_1$ when applied earned a return of Rs. 1.31 for every one rupee invested. Treatment $T_5$ gave a return of Rs. 1.19 for every one rupee invested (Table 5).

During rabi season maximum net returns were recorded in treatment $T_7$ (162325.90) followed by $T_1$ and $T_3$ with net returns 138297.00 and 118691.60. Application of biorationals insecticide, Spinosad ($T_7$) gave a return of Rs. 2.26 for every one rupee invested. By applying treatment $T_1$, an amount of Rs.2.18 was obtained for every one rupee invested against the treatment $T_9$ which had a return of only Rs. 0.86. Treatment $T_5$ gave a return of Rs. 1.56 for every one rupee invested (Table 6).

Azadirachtin exhibited a drastic reduction in the per cent of pod damage even after two sprays and no pod damage was found after third spray which proved it to be the effective treatment. Azadirachtin helps in increasing the market value of the pods by reducing the pod damage. The findings of Koona *et al.* (2001) that with increase in the pod age the damage to the pods were minimized and the crucial period of infestation was seen in pods of eight days old was supporting to the present finding. Soyelu and Akingbhohungbe (2007) reported that greater reduction in the yield was caused by fourth instar nymphs of *Anoplocnemis curvipes, Riptortus dentipes, Mirperus jaculus* and *Clavigralla tomentosicollis*. The findings of Mordue and Nisbet (2000) that hemipterans are sensitive to high concentration of azadirachtin resulting in 100 per cent antifeedancy. Thus reducing the pod damage to a great extent was also a supporting fact. Next to Azadirachtin, another biopesticide which proved to be effective in controlling pod bugs was *L. lecanii* which reduced the percentage of infestation completely after three consecutive sprays. The findings of Suharsona and Prayago (2014) that *L. lecanii* @ $10^7$ conidia/ml exhibited high degree of control on soyabean brown stink bug, *Riptortus linearis* in Indonesia was in line with the above study.

The total and marketable yield was found maximum in spinosad treated plot during both kharif and rabi season. The highest benefit-cost ratio was given by spinosad during both kharif and rabi seasons followed by *B. bassiana* treated plot. Spinosad though it is costly, high yield from spinosad treated plot could provide an additional amount than the amount invested which compensated the high cost of spinosad. The net returns were high for Spinosad during both seasons. Though *B. bassiana* encountered major pests, it didn't affect the yield severely during both seasons. The efficiency of bio pesticides in controlling insect pests without harming non-target species and its non-toxicity towards humans found to be the best approach among pest management strategies. Through this it is possible to increase good quality produce. Thus bio pesticides play a promising tool in pest management and are gaining prior importance in the present scenario.

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