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BIOEFFICACY OF NOVEL INSECTICIDES, NEEM OIL AND ENTOMOPATHOGENIC FUNGI AGAINST OKRA LEAF HOPPER (*AMRASCA BIGUTELLA BIGUTELLA* ISHIDA)

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ABSTRACT

A field experiment was carried out to assess the bioefficacy of various novel insecticides, neem oil (Margo) and Entomopathogenic fungi viz., *Verticillium leccani*, *Beauveria bassiana* and *Metarhizium anisopliae* against okra leaf hoppers (*Amrasca bigutella bigutella* (Ishida)). This study involved 9 treatments and each replicated three times within a randomized block design with plot size 3 m × 2 m. Insecticides, neem oil, and entomopathogenic fungi were administered in two spray sessions, with a 14-day interval between applications. The results revealed that among the tested insecticides, the most significant effect with least number of hoppers per plant was observed in the treatment Betacyfluthrin 8.49 WV + Imidacloprid 19.81 W/W OD (Solomon @ 0.5ml/l) followed by Imidacloprid 17.8 SL at 0.3 ml/l, Chlorpyrifos + Cypermethrin 5 EC at 0.5 ml/l, and Thiamethoxam 25% WG at 0.4 g/l. Additionally, a notable effect of Econeem @ 5 ml/l was observed on the hoppers during the investigation. The application of entomopathogenic fungi also yielded positive results in two spray while the effectiveness was observed in ascending order as *Verticillium leccani* > *Beauveria bassiana* > *Metarhizium anisopliae*.

Keywords : Bioefficacy, insecticides, entomopathogenic fungi, Econeem, leaf hoppers, okra.

Introduction

Okra (*Abelmoschus esculentus* [L.] Moench; 2n = 2x = 130), which is part of the Malvaceae family, a significant vegetable crop (Gemede *et al.*, 2015) grown in various climatic condition from tropical, subtropical, and warm temperate. In India, total production of okra was 7,305.43 tonnes, in which Gujarat was at first place with 1,133.08 tonnes (per cent share of 15.51%) followed by Madhya Pradesh (965.48 tonnes with 13.22 % share) and West Bengal and Bengal with 954.95 (13.07 %) and 810.70 (11.10 %) tonnes, respectively (National Horticulture Board, 2024). In Uttarakhand, okra is among the leading vegetables grown alongside potato, cauliflower, cabbage, broccoli, tomato, onion, European carrot, brinjal, French bean, and pea (Kishor and Kumar, 2022). The main districts producing okra in Uttarakhand include Dehradun, Udham Singh Nagar,

Pithoragarh, Tehri, Nainital, Haridwar and Chamoli (Rajveer *et al.*, 2016).

Okra is infested by 72 various insect pests (Srinivasa and Rajenran, 2003), with pest prevalence increasing as the crop progresses towards maturity (Bhandari *et al.*, 2022). These pests cause damage to the crop from the moment of sowing until the time of harvest (Sharma *et al.*, 1997; Jagtab *et al.*, 2007). A wide range of insect pests impacting okra, some of which result in significant reductions in yield (Dhamdhare *et al.*, 1984; Dubey *et al.*, 1999; Kumar *et al.*, 2014; Singh and Joshi, 2004).

A major constraint in the effective cultivation of okra is the damage caused by insect pests, particularly fruit borers and sucking insects (Rajveer *et al.*, 2016). Key species of fruit borers include *Earias vittella* (Fabricius) (Krishnaiah *et al.*, 1978; Rawat and Sadu, 1973), *E. insulana* (Bioduval) (Tripathi and Singh, 1990), and *Helicoverpa armigera* (Hubner) (Rawat and

Sahu, 1973). Sucking insects such as cotton jassids, *Amrasca biguttula biguttula* (Ishida) (Lal *et al.*, 1990), whitefly, *Bemisia tabaci* (Gennadius), *Aphis gossypii* (Glover) (Rawat and Sahu, 1973), and the red spider mite, *Tetranychus telascius* (Linn.) (Khair and Naik, 1986), are also significant. The combination of the leaf hopper and *E. vittella* is reported to cause approximately 69% loss in okra (Rawat and Sahu, 1973).

The jassid (*A. bigutula bigutula*, Cicadellidae: Hemiptera) is a polyphagous pest with sucking mouthparts. It is regarded as the most damaging sucking pest affecting this crop (Dhandapani *et al.*, 2003). Okra serves as the most appropriate host for the survival and nourishment of its nymphs, leading to a yield loss ranging from 50% to 63.41% (Sharma and Singh, 2002). Additionally, the incidence of leafhoppers resulted in a decrease of 49.80% in plant height and 45.10% in the number of leaves (Rawat and Sadu, 1973). This pest transfers toxins into the plant, which subsequently reduces the photosynthetic area. Both nymphs and adults stages feed on the undersides of the leaves, causing them to curl upward along the margins, resulting in a crinkled appearance; this is a distinctive sign of Jassid infestation (Bhutto *et al.*, 2017). In cases of severe infestation, the typical symptom known as "hopper burn" is observed, characterized by the browning of leaves (Devi *et al.*, 2017). Other symptoms *viz.*, dried leaves that crumble when crushed, broken leaf margins, and stunted growth also observed. Since the feeding stages inhabit the undersides of the leaves, their exudates can be found there, with a higher quantity present on younger leaves compared to older ones (Rahman, 2014).

Entomopathogenic fungi such as *Beauveria bassiana* and *Lecanicillium lecanii* in okra represent a sustainable method for effectively managing insect pests, including aphids, whiteflies, leafhoppers, and fruit borers. This approach reduces dependence on chemical pesticides and fosters a more sustainable pest control strategy in okra farming (Irsad *et al.*, 2023). To improve the effectiveness of pest management while decreasing pesticide usage, it is essential to accurately assess pest populations in the field. In addition to lowering pesticide application, there is an urgent need to develop cost-effective and environmentally sustainable alternative methods for managing significant agricultural insect pests.

The aim of this research was to create and assess the effectiveness of pest management strategies, taking into account economic feasibility and environmental sustainability as vital elements, with the primary objective of diminishing pest populations in okra.

Consequently, this study highlights that the implementation of sustainable practices can enhance food security, safeguard environmental health, and strengthen economic stability while mitigating the negative effects of pest outbreaks on okra cultivation.

Materials and Methods

A field experiment was conducted to evaluate the efficacy of various novel insecticides, entomopathogenic fungi and neem oil against okra plant hoppers (*A. bigutella bigutella* Ishida) in Mandawar region of Haridwar, Uttarakhand at Agricultural Research Field, School of Agricultural Studies, Quantum University, Roorkee, Uttarakhand in the year 2025. The specifics regarding insecticides include Betacyfluthrin 8.49WV + Imidacloprid 19.81 W/W OD (Solomon at 0.5 ml/l), Imidacloprid 17.8 SL (Bildor at 0.3 ml/l), Chlorpyrifos + Cypermethrin 5 EC (Bilbo at 0.5 ml/l), and Thiamethoxam 25% WG (Actara at 0.4 g/l), along with neem oil (Margo @ 5 ml/l) and entomopathogenic fungi such as *Metarhizium anisopliae* 1% WP at 10 g/l (1×10^8 CFU/gram), *Verticillium lecanii* 1% WP at 10 g/l (1×10^8 CFU/gram), and *Beauveria bassiana* 1% WP at 10 g/l (1×10^8 CFU/gram). The research comprised nine treatments, each replicated three times within a randomized block design with plot size 3 m × 2 m. Insecticides, neem oil, and entomopathogenic fungi were administered in two spray sessions, with a 14-day interval between applications. During the initial spray application, all entomopathogenic fungi (each at a concentration of 10 ml/liter) and insecticides were applied at the designated dosages. The second spray, carried out 14 days after the first, utilized the same dosages of insecticides as in the initial application. Population metrics related to hopper species were meticulously recorded one day prior to the pesticide application (DBS) and subsequently at intervals of 3, 5, 7, 10, and 14 days following both the first and second applications. The arithmetic means of the gathered data were computed for analysis. The various observations will be subjected to statistical analysis employing a randomized block design (RBD) as delineated by Gomez and Gomez (1984). The mean differences were assessed using an F-test at a significance level of 5 percent. A critical difference (CD) at a probability level of 5 per cent was utilized for treatment comparisons through one-way analysis of variance (ANOVA), in accordance with Snedecor and Cochran (1967). The results will be presented in the form of tables and figures. The Duncan Multiple Range Test (DMRT) was employed to compare the means, as described by Duncan (1955).

Result and Discussion

Impact of treatments in first spray

The findings illustrated in table-1 indicate that the day prior to the first spraying, the population of hoppers was non-significantly varied, ranging from 14.00 to 19.67 hoppers per plant. The effects of the treatments were assessed three days after spraying (DAS), revealing that among all treatments, the significantly lowest number of hoppers was observed in treatment T1 (Betacyfluthrin 8.49WV + Imidacloprid 19.81 W/W OD at 0.5 ml/l), which recorded 2.33 hoppers per plant. This was followed by T3 (Chlorpyrifos + Cypermethrin 5 EC at 0.5 ml/l) and T4 (Thiamethoxam 25% WG at 0.4 g/l), which had 2.67 and T2 (Imidacloprid 17.8 SL at 0.3 ml/l) with 3.67 hoppers per plant, respectively. The effect of neem oil (T5; Econeem at 5 ml/l) was comparatively lower than that of the insecticides, resulting in 8.33 hoppers per plant. Among the entomopathogenic fungi, treatment T7 (7.67 hoppers per plant) with *V. leccani* 1% WP at 10 g/l (1×10^8 CFU/gram) demonstrated a better effect than treatment T8 (10.33 hoppers per plant) with *B. bassiana* 1% WP at 10 g/l (1×10^8 CFU/gram). The impact of treatment T6 (*M. anisopliae* 1% WP at 10 g/l (1×10^8 CFU/gram)) was the least among the three, with 11.33 hoppers per plant. In the control group, a population of 20.67 hoppers per plant was recorded.

Following the application of 5 DAS, the treatment T1 (Betacyfluthrin 8.49WV + Imidacloprid 19.81W/W OD @ 0.5ml/l) exhibited the significantly lowest count of 3.00 hoppers per plant. While similar effect of insecticides was noted in T2 (Imidacloprid 17.8 SL @ 0.3 ml/l) and T4 (Thiamethoxam 25% WG @ 0.4g/l), both showing 4.00 hoppers per plant, while T3 (Chlorpyrifos + Cypermethrin 5 EC @ 0.5ml/l) recorded 4.33 hoppers per plant, with these treatments being statistically at par. The treatment utilizing neem oil resulted in a better outcome with 8.33 hoppers per plant compared to the application of entomopathogenic fungi. In the control, the highest insect count was observed at 23.67 hoppers per plant.

The effects of the treatments after a 7-day period post-spray indicated a gradual rise in hopper populations across all treatments. Notably, the treatment T1 (Betacyfluthrin 8.49WV + Imidacloprid 19.81W/W OD @ 0.5ml/l) again yielded the lowest number of plant hoppers with 4.00 hoppers/ plant, followed by T2 (Imidacloprid 17.8 SL @ 0.3 ml/l), T3 (Chlorpyrifos + Cypermethrin 5 EC @ 0.5ml/l), and T4 (Thiamethoxam 25% WG @ 0.4g/l) with counts of

5.00, 5.33, and 5.67 hoppers per plant, respectively. In contrast, the control recorded 27.33 hoppers per plant.

In 10 DAS, the most pronounced effect of treatment T2 (Imidacloprid 17.8 SL @0.3 ml/l) was observed, yielding 7.67 hoppers per plant. A nearly equivalent effect was noted in treatments T3 (Chlorpyrifos + Cypermethrin 5 EC @ 0.5ml/l) and T1 (Betacyfluthrin 8.49WV + Imidacloprid 19.81W/W OD @ 0.5ml/l), which recorded 8.33 and 8.67 hoppers per plant, respectively, and were statistically comparable. Treatment T7 (*V. leccani* 1% WP @ 10 g/l (1×10^8 CFU/gram)), which had 15.67 hoppers per plant showed hopper population lower than treatment T5 (Econeem @ 5ml/l) that recorded 16.00 hoppers per plant. The control exhibited 31.67 hoppers per plant.

Despite the observed decline in treatment effects, a significant increase in hopper populations was recorded across all treatments. The persistent impact of insecticides was noted, revealing that treatments T1 (Betacyfluthrin 8.49WV + Imidacloprid 19.81W/W OD @ 0.5ml/l) and T2 (Imidacloprid 17.8 SL @0.3 ml/l) resulted in fewer hoppers compared to treatments T3 (Chlorpyrifos + Cypermethrin 5 EC @ 0.5ml/l) and T4 (Thiamethoxam 25% WG @ 0.4g/l), which had 14.67, 14.33, 15.00, and 16.00 hoppers per plant, respectively. The efficacy of neem oil was less pronounced, resulting in a higher number of hoppers (24.67) compared to the aforementioned treatments. The overall mean from the initial spray indicated that among all treatments, T1 (Betacyfluthrin 8.49WV + Imidacloprid 19.81W/W OD @ 0.5ml/l) exhibited the highest efficacy with 7.78 hoppers per plant, followed by T2 and T3 (Chlorpyrifos + Cypermethrin 5 EC @ 0.5ml/l) and T4 (Thiamethoxam 25% WG @ 0.4g/l) which recorded 8.06, 8.28, and 8.78 hoppers per plant, respectively. The effect of neem oil was found to be more effective than that of entomopathogenic fungi, resulting in 13.89 hoppers per plant.

Impact of treatments after Second spraying

Data on hopper populations were collected the day prior to the second spray, revealing that the hopper population ranged from 14.67 to 27.67 hoppers per plant in the insecticide treatments, while the control recorded 35.67 hoppers per plant.

Following 3 days after the second spray (3DAS), it was noted that the lowest hopper population was in T1 (Betacyfluthrin 8.49WV + Imidacloprid 19.81W/W OD @ 0.5ml/l) with only 1.33 hoppers per plant, demonstrating superiority over the other treatments. Treatments T2 (Imidacloprid 17.8 SL @ 0.3 ml/l), T3 (Chlorpyrifos + Cypermethrin 5 EC @ 0.5ml/l), and T4 (Thiamethoxam 25% WG @ 0.4g/l) exhibited

comparable effects on hopper populations, with counts of 2.33, 2.00, and 2.67 hoppers per plant, respectively, and were statistically similar. In the case of the treatment T7 (*Verticillium leccani* 1% WP @ 10 g/l), T8 (*Beauveria bassiana* 1% WP @ 10 g/l), and T5 (Econeem @ 5ml/l), which recorded 11.00, 11.33, and 12.00 hoppers per plant, respectively. The least impact was observed in treatment T6, which had 16.33 hoppers per plant, while the control recorded 41.33 hoppers per plant.

The analysis of the treatments conducted after a 5-day spray indicated that treatment T1 (Betacyfluthrin 8.49WV + Imidacloprid 19.81W/W OD at 0.5ml/l) and T3 (Chlorpyrifos + Cypermethrin 5 EC at 0.5ml/l) yielded comparable results, each resulting in 3.33 hoppers per plant, and were deemed superior. This was followed by treatment T2 (Imidacloprid 17.8 SL at 0.3 ml/l) and T4 (Thiamethoxam 25% WG at 0.4g/l), which recorded 4.33 and 4.67 hoppers per plant, respectively. Furthermore, treatment T7 (*V. leccani* 1% WP at 10 g/l (1×10⁸ CFU/gram) showed better results with 12.33 hoppers/ plant than *B. bassiana* and Econeem with counts of 14.00 hoppers per plant.. In contrast, *M. anisopliae* did not yield favorable results, resulting in a higher insect count of 18.33 hoppers per plant, while the control recorded 47.00 hoppers per plant.

The results observed after a 7-day spray were consistent across treatments T1 (Betacyfluthrin 8.49WV + Imidacloprid 19.81W/W OD at 0.5ml/l), T2 (Imidacloprid 17.8 SL at 0.3 ml/l), T3 (Chlorpyrifos + Cypermethrin 5 EC at 0.5ml/l), and T4 (Thiamethoxam 25% WG at 0.4g/l), which resulted in 7.00 and 7.33 hoppers per plant. The efficacy of other treatments ranged from 16.00 to 20.33 hoppers per plant.

After 10 and 14 days post-application, treatment T3 (Chlorpyrifos + Cypermethrin 5 EC at 0.5ml/l) exhibited the most favorable results, with 8.33 and 12.00 hoppers per plant, followed by T1 (Betacyfluthrin 8.49WV + Imidacloprid 19.81W/W OD at 0.5ml/l) with 10.33 and 14.67, T2 (Imidacloprid 17.8 SL at 0.3 ml/l) with 12.00 and 15.33, and T4 (Thiamethoxam 25% WG at 0.4g/l) with 12.00 and 15.00 hoppers per plant. The impact of the entomopathogenic fungi was observed to range from 16.00 to 19.67 and 23.33 to 26.67 hoppers per plant, respectively.

The overall mean varied between 8.56 and 22.11 hoppers per plant, while the control group exhibited 47.44 hoppers per plant.

The findings indicated that the effectiveness of insecticides from various groups, each with distinct modes of action, surpassed that of the other treatments. This superiority may be attributed to the rapid and lasting effects of the insecticides on leaf hoppers. Neem oil (Econeem) demonstrated better performance compared to Entomopathogenic fungi, while among the EPFS, *V. leccani* and *B. bassiana* showed more favorable results than *M. anisopliae*.

This finding is corroborated by the research conducted by Naik and Shekharappa (2009), which indicated that an oil-based formulation of *M. anisopliae* resulted in a minimum of 5.25 leafhoppers per 3 leaves, followed by *B. bassiana* oil-based at 6.88 and *V. lecanii* oil-based at 7.75 after the second spray. In a similar vein, Arvinda *et al.* (2024) demonstrated that among the treatments evaluated against leafhoppers, *L. lecanii* at 5 g/l was found to be the most effective. Conversely, for aphids, Neem oil at 0.5% was superior, while *L. lecanii* at 5 g/l was the most effective against whiteflies at 3, 7, and 10 days following the first and second sprays, respectively. The combination of entomopathogenic fungi, specifically *V. lecanii* 1.15% WP and *M. anisopliae* 1.15% WP, emerged as the most effective treatment when compared to the standard check, dimethoate, for the suppression of aphid populations on okra (Palthiya and Nakat, 2017). The results from the experiment conducted by Manju *et al.* (2017) indicated that among the various treatments, the foliar spray of spinosad 45 SC outperformed the other foliar treatments by achieving the lowest leafhopper population, followed by acetamiprid 20 SP. In contrast, the sequential spray of sesame oil at 5% and spiromesifen 240 SC resulted in the highest leafhopper population. The foliar spray of spinosad 45 SC was confirmed to be the most effective treatment, providing the highest percentage of protection, followed by acetamiprid 20 SP. The sequential application of sesame oil at 5% followed by spiromesifen 240 SC yielded the lowest percentage of protection.

Conclusion

It can be inferred from the aforementioned results that these insecticides with diverse modes of action significantly impacted leaf hoppers when applied judiciously and as required. Insecticides exhibiting a systemic mode of action, which translocate within the plant system, proved effective against hoppers, which are classified as sucking pests. Among these, the combination of insecticides known as Solomon yielded the most favorable results, followed by Bilbo, and subsequently Imidacloprid and Thiamethoxam. There were no observed phytotoxic effects on the leaves, as

the insecticides were applied judiciously. Neem oil, which has broad-spectrum actions, also serves to repel insects from plants. Additionally, entomopathogenic fungi, which are environmentally friendly and non-toxic, demonstrated improved efficacy against okra leaf hoppers. Notably, the impact of *V. leccani* and, to some extent, *B. bassiana* was found to be superior to

that of *M. anisopliae*. Thus it clears that combination of these methods can lessen dependence on traditional chemical pesticides, thus promoting sustainable pest management in okra farming. Implementing such strategies will not only assist in preserving crop yield but also protect ecological integrity and reduce pesticide residues in the food supply.

Table 1 : Effect of novel insecticides, neem oil and entomopathogenic fungi against plant hoppers on okra

| Treatments | Population of hoppers/ plant in first spray | | | | | | OVERALL MEAN |
|--|---|------------------------------|------------------------------|------------------------------|------------------------------|-------------------------------|-------------------------------|
| | DBS | 3DAS | 5DAS | 7DAS | 10DAS | 14DAS | |
| T1 Betacyfluthrin 8.49WV+ Imidacloprid19.81W/W OD @ 0.5ml/l | 14.00 ^a (3.87) | 2.33 ^a (1.82) | 3.00 ^a (1.98) | 4.00 ^a (2.22) | 8.67 ^{ab} (3.10) | 14.67 ^a (3.95) | 7.78 ^a (2.83) |
| T2 Imidacloprid 17.8 SL @0.3 ml/l | 13.67 ^a (3.82) | 3.67 ^b (2.15) | 4.00 ^a (2.23) | 5.00 ^{ab} (2.44) | 7.67 ^b (2.94) | 14.33 ^a (3.91) | 8.06 ^a (2.92) |
| T3 Chlorpyriphos + Cypermethrin 5 EC @ 0.5ml/l | 14.00 ^a (3.87) | 2.67 ^{ab} (1.91) | 4.33 ^a (2.30) | 5.33 ^b (2.51) | 8.33 ^a (3.05) | 15.00 ^a (3.99) | 8.28 ^a (2.94) |
| T4 Thiamethoxam 25% WG@ 0.4g/l | 14.67 ^{ab} (3.95) | 2.67 ^{ab} (1.91) | 4.00 ^a (2.23) | 5.67 ^b (2.58) | 9.67 ^b (3.26) | 16.00 ^a (4.12) | 8.78 ^a (3.01) |
| T5 Econeem @ 5ml/l | 16.33 ^{bc} (4.16) | 7.33 ^c (2.88) | 8.33 ^b (3.05) | 10.67 ^c (3.41) | 16.00 ^c (4.12) | 24.67 ^c (5.06) | 13.89 ^b (3.78) |
| T6 <i>Metarhizium anisopliae</i> 1 % WP @ 10 g/l (1×10 ⁸ CFU/gram | 16.33 ^{bc} (4.16) | 11.33 ^c (3.51) | 13.00 ^c (3.74) | 14.67 ^d (3.95) | 19.00 ^d (4.46) | 27.67 ^d (5.35) | 17.00 ^{ab} (4.20) |
| T7 <i>Verticillium leccani</i> 1% WP @ 10 g/l (1×10 ⁸ CFU/gram) | 17.00 ^c (4.24) | 7.67 ^c (2.94) | 9.33 ^b (3.21) | 11.33 ^c (3.50) | 15.67 ^c (4.08) | 21.33 ^b (4.72) | 13.72 ^{ab} (3.78) |
| T8 <i>Beauveria bassiana</i> 1% WP @ 10 g/l (1×10 ⁸ FU/gram) | 17.00 ^c (4.24) | 10.33 ^d (3.36) | 12.33 ^c (3.65) | 14.33 ^d (3.91) | 19.67 ^c (4.54) | 23.00 ^{bc} (4.89) | 16.11 ^b (4.10) |
| T9 Control | 19.67 ^d (4.54) | 20.67 ^d (4.65) | 23.67 ^d (4.96) | 27.33 ^e (5.32) | 31.67 ^d (5.71) | 35.67 ^e (6.05) | 26.44 ^c (5.21) |
| CD | 1.95 | 1.05 | 1.70 | 1.26 | 1.73 | 1.86 | 2.67 |
| CV (%) | 7.06 | 7.68 | 10.68 | 6.68 | 6.60 | 5.12 | 16.29 |
| SEM (±) | 0.65 | 0.47 | 0.57 | 0.42 | 0.57 | 0.62 | 0.92 |

Data presented in parentheses are $\sqrt{x+0.5}$ (square root transformed); Mean followed by common letters in a column do not differ significantly by DMRT (P≤0.05)

Table 2: Effect of novel insecticides, neem oil and entomopathogenic fungi against plant hoppers on okra

| Treatments | Population of hoppers/ plant in second spray | | | | | | OVERALL MEAN |
|--|--|------------------------------|------------------------------|------------------------------|-------------------------------|------------------------------|------------------------------|
| | DBS | 3DAS | 5DAS | 7DAS | 10DAS | 14DAS | |
| T1 Betacyfluthrin 8.49WV+ Imidacloprid19.81W/W OD @ 0.5ml/l | 14.67 ^a (3.95) | 1.33 ^a (1.52) | 3.33 ^a (2.07) | 7.00 ^a (2.82) | 10.33 ^{ab} (3.36) | 14.67 ^b (3.95) | 8.56 ^a (2.95) |
| T2 Imidacloprid 17.8 SL @0.3 ml/l | 14.33 ^a (3.91) | 2.33 ^a (1.82) | 4.33 ^a (2.30) | 7.33 ^a (2.88) | 12.00 ^b (3.59) | 15.33 ^b (4.03) | 9.28 ^a (3.09) |
| T3 Chlorpyriphos + Cypermethrin 5 EC @ 0.5ml/l | 15.00 ^a (3.99) | 2.00 ^a (1.73) | 3.33 ^a (2.07) | 7.00 ^a (2.81) | 8.33 ^a (3.05) | 12.00 ^a (3.60) | 7.94 ^a (2.88) |
| T4 Thiamethoxam 25% WG@ 0.4g/l | 16.00 ^a (4.12) | 2.67 ^a (1.91) | 4.67 ^a (2.37) | 7.33 ^a (2.88) | 12.00 ^b (3.60) | 15.00 ^b (4.00) | 9.61 ^a (3.15) |
| T5 Econeem @ 5ml/l | 24.67 ^c (5.06) | 12.00 ^b (3.60) | 14.00 ^b (3.87) | 16.33 ^b (4.16) | 18.33 ^c (4.39) | 22.67 ^c (4.86) | 18.00 ^b (4.32) |
| T6 <i>Metarhizium anisopliae</i> 1 % WP @ 10 g/l (1×10 ⁸ CFU/gram | 27.67 ^d (5.35) | 16.33 ^c (4.16) | 18.33 ^c (4.39) | 20.33 ^c (4.61) | 23.33 ^d (4.93) | 26.67 ^d (5.26) | 22.11 ^b (4.78) |
| T7 <i>Verticillium leccani</i> 1% WP @ 10 g/l (1×10 ⁸ CFU/gram) | 21.33 ^b (4.72) | 11.33 ^b (3.51) | 14.00 ^b (3.87) | 17.33 ^b (4.28) | 20.67 ^c (4.65) | 22.67 ^c (4.86) | 17.89 ^b (4.31) |
| T8 <i>Beauveria bassiana</i> 1% WP @ 10 g/l (1×10 ⁸ CFU/gram) | 23.00 ^{bc} (4.89) | 11.00 ^b (3.45) | 12.33 ^b (3.64) | 16.00 ^b (4.11) | 20.33 ^c (4.61) | 23.00 ^c (4.89) | 17.61 ^b (4.27) |
| T9 Control | 35.67 ^e (6.05) | 41.33 ^d (6.50) | 47.00 ^d (6.92) | 50.00 ^d (7.14) | 53.33 ^e (7.37) | 57.33 ^e (7.63) | 47.44 ^c (6.94) |
| CD (5%) | 1.86 | 1.40 | 1.56 | 2.27 | 2.53 | 2.04 | 3.32 |
| CV (%) | 5.12 | 7.45 | 6.88 | 8.15 | 7.52 | 5.15 | 16.49 |
| SEM (±) | 0.62 | 0.46 | 0.52 | 0.75 | 0.84 | 0.68 | 1.16 |

Data presented in parentheses are $\sqrt{x+0.5}$ (square root transformed); Mean followed by common letters in a column do not differ significantly by DMRT (P≤0.05)

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