Original Research Article

Comparative efficacy of organic based management modules against different stages of *Myzus persicae* Suzler on capsicum under polyhouse condition in Kashmir Valley, India

ABSTRACT

To evaluate the comparative efficacy of organic based management modules were carried out against different stages of green peach aphid, *Myzus persicae* Sulzer on capsicum crop under polyhouse condition. The nymphal population reduction was highest as compared to the three forms of aphids, the alate population reduction was showed lowest by all treatments Similarly, in case of apterous form, the reduction was quite low as compared to nymphal population but higher than the apterous population of *M. persicae*. With the concerned of organic based management module, the highest reduction of total aphid population was observed against Azadirachtin @ 0.03% followed by Neem Seed Kernel Extract (NSKE) @ 5 % as compared to standard check (Thiacloprid 21.7 SC) @ 0.4ml/L. As a result, the azadirachtin @ 0.03% being an organic product is considered safe to the environment and be recommended for management of vegetable pests as an important component of eco-friendly management.

Key words: Capsicum, *Myzus persicae*, polyhouse condition, Organic management.

INTRODUCTION

Capsicum (*Capsicum annuum* L.) is one of the most widely grown commercial polyhouse crops and also referred to as "Shimla Mirch". It is a powerful source of essential vitamins, minerals, fibers, and amino acids and has good antioxidant qualities (Buddidathi *et al.*, 2016). Nearly one-fourth of the world's capsicum crop comes from India (Singh and Joshi, 2020). Due to its nutritional qualities, its consumption is currently steadily rising in India, particularly among urban customers, and there is a strong demand for its export as well (Shukla *et al*., 2016).The Indian Union Territory of Jammu & Kashmir, especially in areas with mild weather that are conducive to its cultivation (Mir *et al.,* 2021).The most important early invaders of the capsicum crop by green peach aphid *Myzus persicae*, which are challenging to control because they are said to be extremely active all year long and reduce yield by an estimated 50 t /ha^{-1} when no chemical action is done (Pathipati *et al.,* 2018). Population growth of aphid is very conducive under polyhouse condition (Nowsheen *et al*., 2024). Chemical control became an unavoidable aphid management method in order to prevent the crop's financial loss (Khan and Riyaz, 2018). Currently, the Central Insecticide Board and Registration Committee of India has approved and recommended

insecticide formulations for use on green chilies to combat a variety of pests; however, no such registered insecticides are available for use on capsicum crops grown under protection (CIBRC 2020). In order to eradicate aphids, farmers are mostly using conventional insecticides that are not advised, which has resulted in the issue of pesticide residues and also harmful for natural enemies (Khan and Riyaz, 2017; Khan and Shah, 2018).

Biological control agents, such as parasitoids and predators have been employed to regulate aphid populations on bell peppers, proving effective under certain conditions (Khan, 2020a). However, pesticide resistance has been observed in *M. persicae* populations, posing challenges to chemical control measures (Foster *et al.,* 2017). Integrated pest management (IPM) strategies that combine biological control, resistant bell pepper cultivars, and minimal pesticide use have shown promise in maintaining *M. persicae* populations at manageable levels (Georghiou & Lagunes-Tejeda, 2020; Khan, *et al*., 2020a).The use of entomopathogenic fungi as biopesticides aligns with sustainable and integrated pest management practices, providing an alternative approach to conventional chemical pesticides (Khan *et al*., 2017). The approach also aims to reduce the environmental impact and the development of resistance in insect populations (Gabarty *et al*,. 2014; Khan, *et al*., 2020b). This manuscript contributes valuable insights into the efficacy of organic-based management modules against different stages of *Myzus persicae* on capsicum under polyhouse conditions. The findings demonstrate the potential of Azadirachtin as a promising eco-friendly alternative to synthetic insecticides for aphid control, offering a sustainable and environmentally sound approach to pest management in protected agriculture. This research provides crucial information for farmers, researchers, and policymakers to develop and implement effective and sustainable integrated pest management strategies for capsicum production.

MATERIAL AND METHOD

An experiment was laid out under polyhouse at Experimental field, Faculty of Horticulture, SKUAST-K Shalimar during year 2020 to check the efficacy of organic based management modules against three viz., nymph, apterous and alate stages of Green peach aphid (*M. persicae*) on Capsicum. Seedlings of Capsicum (*Capsicum annum*) viz: Sp-461 Ly, California wonder red and Nishat 1, were raised in field and later on transplanted in two vegetable polyhouses with spacing of 50 cm x 45 cm from row to row and plant to plant. The different organic treatments were evaluated, which included eight (08) treatments (including control) and each treatment was replicated three times. Organic based treatments also included a standard check (Thiacloprid 21.7 SC) @ 0.4 ml/L. The different treatments were sprayed/released at peak infestation and data on

per cent reduction of aphid was recorded on 1, 3, 7, 10 and 15 days after treatment (DAT). After application of different organic based modules, plants were tagged to check the aphid population reduction. The treatment details are as under:

List 1- Organic management module

Treatment No	Treatment Details	Dosage
T1	Neem Seed Kernel Extract (NSKE)	5%
T2	Azadirachtin (Insecticide)	0.03%
T3	*Lecanicilliumlecani* ($1x10^8$CFU's/ml)	2 ml^{-1}
T4	*Beauveria bassiana* ($1x10^8$CFU's/ml)	$2ml^{-1}$
T5	*Metarhizium anisopliae* ($1x10^8$CFU's	$2ml^{-1}$
T6	*Adalia tetraspilota*	3/plant
T7	Standard check (Thiacloprid 21.7 SC)	$0.4ml^{-1}$
T8	Control	Use water only

Statistical analysis: The population reduction was worked out after each post treatment count observation by using the following formula. Data was analyzed using the "SPSS" software package at 5% level of significance.

$$\text{Per cent reduction in pest population} = \frac{\text{Pre count} - \text{Post count (DAT)}}{\text{Pre} - \text{count}} \times 100$$

Pre-count = Population before treatment

Post-count = population after treatment

RESULTS AND DISCUSSION

Efficacy of Organic management module against different forms of *M. persicae*

Nymphs: The efficacy of different organic based treatments on nymphal population of *M. persicae* were evaluated and recorded all the organic treatments were effective to cause appreciable reduction of aphid nymphs in comparison to untreated control (water). Among the organic treatments *viz*., azadirachtin @ 0.03% resulted in highest nymphs reduction were increased from 54.90 to 88.97 per cent after 1st to 15th day of spray application (DAS) followed by *Lecanicillium lecani* ($1x10^8$CFU's/ml) @ 2 ml/L (43.09 to 83.74 % reduction). The least reduction was showed by *Adalia tetraspilota* @3/plant against *M. persicae* nymphs from 1st DAS to 15th DAS. However, the standard check (Thiacloprid 21.7 SC @ 0.4ml/L) were recorded 56.07 to 97.67 % reduction from 1st DAS to 15th DAS which was statistically at par with result of Azadirachtin @ 0.03% (Table 1).

Apterous: The different organic treatments on apterous population of *M. persicae* showed sufficient reduction as compared to untreated control (water). The application of azadirachtin @ 0.03% resulted in highest apterous population reduction which were 44.68 to 76.15 % after 1st to 15th DAS followed by NSKE @ 5% , *Beauveria bassiana* (1x10^{8}CFU's/ml) @ 2 ml/L, *Adalia tetraspilota* @3/plant and *Lecanicillium lecani* (1x10^{8}CFU's/ml) @ 2 ml/L respectively. The least *M. persicae* apterous reduction was recorded with the application of *Metarhizium anisopliae* (1x10^{8}CFU's/ml) @ 2ml/L while as the standard check showed statistically similar but high reduction to as azadirachtin @ 0.03% (Table 2).

Alate: The efficacy of organic treatments were observed against alate population of *M. persicae*, among all, azadirachtin @ 0.03% revealed the highest reduction as 44.96 to 83.21% after 1st to 15th DAS followed by NSKE @ 5%, *L. lecani* (1x10^{8}CFU's/ml) @ 2 ml/L, *A. tetraspilota* @3/plant, *M. anisopliae* (1x10^{8}CFU's/ml) @ 2ml/L and *B. bassiana* (1x10^{8}CFU's/ml) @ 2 ml/L respectively. However, the standard check (Thiocloprid 21.7 SC@ 0.4ml/L) was recorded 43.75 to 89.21 alate population reduction from 1st to 15th DAS.

The highest mean nymphal population reduction (84.23%) was recorded against Standard check (74.46) and among the organic treatments it was highest (78.82 %) against azadirachtin @ 0.03% and lowest (62.16%) against *A. tetraspilota* @3/plant (Table 1 and Table 4). Similarly, in case of apterous form, the reduction was quite low as compared to nymphal population of *M. persicae*. The highest apterous population reduction (84.23%) was recorded against Standard check (74.46) and it was quite higher (64.49 %) than azadirachtin @ 0.03% and lowest (44.27 %) against *A. tetraspilota* @3/plant (Table 2 and Table 4). As compared to the three forms of aphids, the alate population reduction was showed lowest by all treatments except azadirachtin @ 0.03% which was given 68.48 % reduction (Table 3 and Table 4). A comparative efficacy of organic management module on the total aphid forms was showed the highest by the azadirachtin @ 0.03% which was significantly similar to the standard check (Thiacloprid 21.7 SC @ 0.4ml/L) and rest showed quite good result but statistically inferior than the azadirachtin (Table 4).

In organic based management module, amongst all the treatments, the highest cumulative mean reduction of all the aphid forms was 70.93 per cent; however, the mortality of nymphs, apterous and alate forms was recorded as 78.82, 65.49, 68.48 per cent, respectively with the application of azadirachtin @ 0.03%. Though, the minimum cumulative mean reduction of all the aphid forms was 44.53 per cent; `whereas, the reduction of individual forms of *M. persicae* nymphs, apterous and alate was recorded as 62.16, 43.27, 28.16 per cent, respectively with the

application of *Adalia tetraspilota* @ 3/plant. The standard check, Thiacloprid 21.7 SC @ 0.4 ml/L reduced the total aphid population to 72.78 per cent; with individual mortality of *M. persicae* forms i.e, ,nymphs, apterous and alate as 84.23, 74.46, 59.66 per cent, respectively. The present findings are in agreement with the findings of Khan (2020) who too observed highest mean mortality of green apple aphid as 68.91 per cent; and 66.5 per cent of Cabbage aphid with the treatment application of Azadirachtin @ 0.3 % and this finding also supported by Khan (2021) who reported similar results against *Brevicoryne brassicae*. The treatment of Neem Seed Kernel Extract (NSKE) @ 5% was second effective organic treatment application in recording 60.00 per cent mean mortality of all aphid forms. These findings are in agreement with Singh *et al.* (2011) who reported the treatment of (NSKE) @ 5 % in significant reduction of aphid population (17.8 to 64.6 per cent). Similarly, Radha, (2013) studies on the effectiveness of pesticides for aphid control in cowpea and concluded that all the studied pesticides proved effective against the aphids but the toxicity studies of the pesticides was observed as the current findings. Koul (1999) also given similar findings and reported Field evaluation data with formulated neem extracts revealed the effect to be more of growth regulatory nature thereby showing that azadirachtin is a physiological toxin for aphid species. Neem seed extracts reduced the population of aphid on respective host plants significantly. Bio-efficacy of neem products and essential oils against thrips (*Scirtothrips dorsalis* Hood) in capsicum were studied and and recorded similar result to our findings (Moorthy *et al*., 2013). Singh and Joshi (2020) studied various EPF formulations, *Lecanicillium lecanii, Beauveria bassiana* and *Metarhizium anisopliae*, were examined along with Azadirachtin @1 per cent for the managing pests such as aphid and whitefly on capsicum under protected cultivation. Results discovered that the talc formulations of *L. lecanii* MTCC 956 at 10 and 12 g/l reduced aphid population by 60.5 and 61.6 per cent, respectively and whitefly population by 60.0 and 61.6 per cent. On the other hand Azadirachtin @1 per cent at 4 and 5 ml/l reduced aphid population by 71.2 and 74.7 per cent and whitefly population by 68.5 and 71.0 per cent after the third spray, respectively and was effective in lowering aphid and whitefly populations on crop and these results supports to the present findings.

CONCLUSION

The studies conducted to determine the efficacy of different organic based management modules against the different forms viz., nymphs, apterous alate of green peach aphid, *M. persicae* revealed that among different organic modules used for the management of *M. persicae* on

capsicum under protected cultivation, Azadirachtin @ 0.03% provided efficient control of the aphid pest. Azadirachtin @ 0.03 % being an organic product is considered safe to the environment and be recommended for management of vegetable pests as an important component of eco-friendly management. To overcome such situations and minimize the damage to human and natural enemies the use of organic based management module should be advocated for use on vegetables required for human consumption keeping in consideration the concepts of integrated pest management.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

REFERENCES

Buddidathi R., Mohapatra S., Siddamallaiah L., Manikrao G., Hebbar S.S. (2016). *Journal of Environmental Science and Health-Part B Pesticides, Food Contaminants, and Agricultural Wastes*, 51(1), 44-51.

CIBRC. (2020) Major Uses of Pesticides (Insecticides)-A Document of Central Insecticide Board & Registration Committee Government of India Ministry of Agriculture & Farmers Welfare, 2020

Foster, S. P., Devine, G., and Devonshire, A. L. (2017). Insecticide resistance in *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) and the introduction of new aphicide chemistries. *Pest Management Science*, **7**3(3), 486-496. https://doi.org/10.1002/ps.4452

Gabarty, A., Salem, H. M., Fouda, M. A., Abas, A. A., Ibrahim, A. A. (2014). Pathogenicity induced by the entomopathogenic fungi *Beauveria bassiana* and *Metarhizium anisopliae* in *Agrotis ipsilon* (Hufn.). *J Radiat Res Appl Sci* 7:95–100

Georghiou, G. P., and Lagunes-Tejeda, A. (2020). *The Occurrence of Resistance to Pesticides in Arthropods.* FAO & United Nations.

Koul, O. (1999). Insect growth regulating and antifeedant effects of neem extracts and azadirachtin on two aphid species of ornamental plants. *Journal of Bioscience*, 24(1), 85-90.

Khan, A. A. (2020a) Bio-efficacy of insecticides against mealy cabbage aphid (Brevicoryne brassicae L.) and bio-safety against its natural enemies in cruciferous vegetable ecosystem of Kashmir. *Journal of Entomology and Zoology Studies*, 2020; 8(5): 1052-1057.

Khan, A. A. (2020b). Bio-efficacy of botanical pesticides against green apple aphid (*Aphis pomi*) and biosafety against its natural enemies in apple orchard of Kashmir. *Journal of Entomology and Zoology Studies*, 8(4): 1445-1448.

Khan, A. A. (2021). Bio-efficacy of botanical pesticides against mealy cabbage aphid (Brevicoryne brassicae L.) and biosafety against its natural enemies in cruciferous vegetable ecosystem of Kashmir. *Journal of Entomology and Zoology Studies*, 9(2), 1332-1336.

Khan, A. A. and Riyaz, S. (2017). Effect of insecticides on distribution, relative abundance, species diversity and richness of syrphid flies in vegetable ecosystem of Kashmir. *Journal of Entomology and Zoology Studies*, 5(4), 808-817.

Khan, A. A. and Riyaz, S. (2018). Bioefficacy of pesticides against green apple aphid *Aphis pomi* De Geer and biosafety to natural enemies in apple orchards. *Indian Journal of Entomology*, 80(2): 315-319. DOI No. : 10.5958/0974-8172.2018.00049.4

Khan, A. A., Riyaz, S. and Kundoo, A. A. (2017). Evaluation of efficacy of predators against green apple aphid (Aphis pomi) in apple orchards and cabbage aphid (Brevicoryne brassicae) in cabbage field of Kashmir. *Journal of Entomology and Zoology Studies*, 5(4), 112-116.

Khan, A. A., Meinaz, N., Kundoo, A. A., & Rasool, I. (2020a). Sucking pests of temperate Vegetables. (Book Chapter). Sucking pests of crops (eds): Omkar. Springer Nature Singapore Pte Ltd. pp341- 367. DOI: https://doi.org/10.1007/978-981- 15-6149-8_11

Khan A. A., Kundoo, A. A., Khan, Z. H. (2020b) Identification of the most conservative plant species for promising natural enemies of arthropods pests of Vegetable crops. *Journal of Entomology and Zoology Studies*, 8(5), 2244- 2250.

Khan, A. A. and Shah, M. A. (2018). Population dynamics of green apple aphid *Aphis pomi* De Geer (Homoptera: Aphididae) and its natural enemies in apple orchard of Kashmir. *Indian Journal of Entomology*, 80(2). 320-329. DOI No. : 10.5958/0974-8172.2018.00050.0

Mir, R. A., Yousuf, A., and Lone, A. A. (2021). Status and scope of capsicum cultivation in Jammu & Kashmir: A review. *Journal of Horticultural Sciences*, 16(1), 12-18. https://doi.org/10.2134/jhs.2021.10002

Moorthy, P. N. K., Saroja, S., Shivaramu, K. (2013). Bio-efficacy of neem products and essential oils against thrips (*Scirtothrips dorsalis* Hood) in Capsicum *Pest Management in Horticulture Ecosystem*, 19,191-193.

Nowsheen, M; Khan, A. A., Mushtaq, T. and Pathania, S. S. (2024). Population Dynamics, Incidence and Damage of *Myzus persicae* on *Capsicum annuum* under Polyhouse Conditions in Kashmir Valley. *Journal of Advances in Biology & Biotechnology*, 27(12), 255-263. DOI: https://doi.org/10.9734/jabb/2024/v27i121772

Pathipati, V. L., Singh, T., Vemuri, S.B. (2018). Bio-efficacy, dissipation of new insecticide molecules on capsicum (*capsicum annuum* L. Var. *grossum sendt*) pest complex under field conditions *International Journal of Pure and Applied Science*, 6,772-785.

Radha. R. (2013). Comparative studies on the Effectiveness of Pesticides for Aphid control in Cowpea. Research Journal of Agriculture and Forestry Sciences. 1(6), 1-7.

Shukla, V. · Parmar, K. · Vaghela, K. (2016). Persistence of pesticides in capsicum (*capsicum annuum* L.) under greenhouse and open field *Pesticide Research Journal*, 28,159-167

Singh, H. and Joshi, N. 2020. Management of the aphid, *Myzus persicae* (Sulzer) and the whitefly, *Bemisia tabaci* (Gennadius), using biorational on capsicum under protected cultivation in India. *Egyptian Journal of Biological Pest Control*, 30, 1-9.

Table 1: Efficacy of different organic based modules against nymphal population of *M. persicae* on capsicum under polyhouse condition

Treatments	Dosage	Pre count (population of nymphs/ leaf)	Post count (Per cent population reduction of nymphs/ leaf) *Days After Spray					
			1DAS	3DAS	7DAS	10DAS	15DAS	Mean
Neem Seed Kernel Extract (NSKE)	5%	11.46	47.22±12.72** (6.82± 0.95)***	61.17±2.83 (7.82 ±0.18)	71.94±2.92 (8.48± 0.17)	76.94±1.7 (8.77± 0.09)	79.44±1.73 (8.91±0.09)	67.34±13.30 (8.16± 0.87)
Azadirachtin (1500 ppm)	0.03%	12.39	54.90±3.77 (7.40± 0.25)	75.49±4.24 (8.68 ±0.24)	86.02±1.27 (9.27± 0.06)	88.72±1.52 (9.41±0.08)	88.97±1.27 (9.43 ±0.06)	78.82±13.58 (8.84± 0.80)
Lecanicillium lecani ($1x10^8$CFU's/ml)	2 ml/L	10.94	43.09±5.69 (6.55± 0.43)	55.82±4.17 (7.46± 0.28)	76.42±1.40 (8.74 ±0.08)	80.76±2.04 (8.98± 0.11)	83.74±2.44 (9.15 ±0.13)	67.96±16.63 (8.18± 1.06)
Beauveria bassiana ($1x10^8$CFU's/ml)	2ml/L	12.04	35.45±1.57 (5.95± 0.13)	52.42±6.18 (7.23± 0.43)	71.82±7.76 (8.46 ±0.46)	76.97±8.83 (8.76 ±0.50)	81.82±9.09 (9.03± 0.50)	63.69±18.91 (7.89± 1.24)
Metarhizium anisopliae ($1x10^8$CFU's/ml)	2ml/L	11.56	47.69±4.17 (6.90± 0.30)	49.32±10.45 (6.99 ±0.76)	68.56±1.87 (8.27 ±0.11)	72.35±1.40 (8.50± 0.08)	75.88±2.85 (8.70± 0.16)	62.76±13.08 (7.87± 0.86)
Adalia tetraspilota	3/plant	11.87	50.00±0.00 (7.07 ±0.00)	54.44±4.19 (7.37 ±0.28)	64.72±3.37 (8.04± 0.21)	68.33±1.44 (8.26± 0.08)	73.33±1.44 (8.56± 0.08)	62.16 ±9.24 (7.86± 0.59)
Standard check (Thiacloprid 21.7 SC)	0.4ml/L	12.17	56.07±4.47 (7.48 ±0.29)	76.74±11.47 (8.74 ±0.67)	94.57±0.00 (9.72 ±0.00)	96.12±1.33 (9.80 ±0.06)	97.67±0.00 (9.88± 0.00)	84.23±17.19 (9.12± 0.99)
Control	Water	12.48	3.90± 5.31 (1.21±1.74)	5.29 ±2.56 (1.91±0.55)	11.11± 0.00 (3.33± 0.00)	7.78 ±0.00 (2.78 ±0.00)	11.11 ±0.00 (3.33± 0.00)	7.83± 2.29 (2.51± 0.87)

*DAS: Days after spray, **each value is mean of 03 replications ±S.E, ***Figure in parenthesis are square root transformed values.

Table 2: Efficacy of different organic based modules against apterous population of *M. persicae* on capsicum under polyhouse condition

Treatments	Dosage	Pre count (population of apterous/leaf)	Post count (Per cent population reduction of apterous/leaf) *Days After Spray					
			1DAS	3DAS	7DAS	10DAS	15DAS	MEAN
Neem Seed Kernel Extract (NSKE)	5%	6.48	31.76±3.81** (5.62 ±0.34)***	44.3±1.63 (6.65±0.12)	55.03±1.96 (7.41 ±0.13)	62.26±0.00 (7.89± 0.00)	64.62±0.54 (8.03± 0.03)	52.41±12.71 (7.18± 0.93)
Azadirachtin (1500 ppm)	0.03%	7.27	44.68±2.93 (6.68± 0.22)	65.89±1.77 (8.11 ±0.10)	74.36±2.69 (8.62 ±0.15)	73.33±1.60 (8.56 ±0.09)	76.15±1.32 (8.72± 0.07)	65.49± 13.03 8.05± 0.85
Lecanicillium lecani ($1x10^8$CFU's/ml)	2 ml/L	5.99	29.92±3.26 (5.46± 0.29)	35.98±3.57 (5.99 ±0.30)	50.74±2.04 (7.12± 0.14)	56.63±1.53 (7.52 ±0.10)	59.88±1.84 (7.73 ±0.11)	45.58±12.63 (6.68 ±0.96)
Beauveria bassiana ($1x10^8$CFU's/ml)	2ml/L	6.96	31.28±5.55 (5.57± 0.50)	41.46±1.40 (6.43± 0.10)	49.59±3.72 (7.03 ±0.26)	53.93±4.69 (7.33 ±0.31)	57.45±4.89 (7.57±0.32)	45.77 ±10.84 (6.71 ±0.83)
Metarhizium anisopliae ($1x10^8$CFU's/ml)	2ml/L	7.12	28.29±7.92 (5.27 ±0.79)	41.34±3.98 (6.42 ±0.30)	50.64±2.72 (7.11 ±0.19)	53.22±2.36 (7.29± 0.16)	56.07±2.71 (7.48± 0.18)	44.81±11.78 (6.62 ±0.96)
Adalia tetraspilota	3/plant	7.23	30.06±2.80 (5.47± 0.25)	40.82±2.72 (6.38 ±0.21)	46.51±1.33 (6.81± 0.09)	49.09±1.78 (7.00± 0.12)	54.26±1.33 (7.36± 0.09)	44.27±9.17 (6.54± 0.72)
Standard check (Thiacloprid 21.7 SC)	0.4ml/L	6.87	47.67±1.39 (6.90 ±0.10)	69.16±1.30 (8.31±0.07)	80.20±2.64 (8.95± 0.14)	88.47±1.56 (9.40± 0.08)	95.74±1.73 (9.78 ±0.08)	74.46 ±18.32 (8.56± 1.10)
Control	Water	7.41	11.11± 0.00 (3.33 ±0.00)	3.70± 6.41 (1.11± 1.92)	5.90± 3.90 (1.91±0.76)	3.70 ±6.41 (1.11 ±1.92)	11.00± 0.00 (3.31± 0.00)	7.38 ±5.05 (2.10 ±1.49)

*DAS: Days after spray, **Each value is mean of 03 replications ±S.E, ***Figure in parenthesis are square root transformed values.

Table 3: Efficacy of different organic based modules against alate population of *M. persicae* on capsicum under polyhouse condition

Treatments	Dosage	Pre count (population of alate/leaf)	Post count (Per cent population reduction of apterous/leaf) *Days After Spray					
			1DAS	3DAS	7DAS	10DAS	15DAS	Mean
Neem Seed Kernel Extract (NSKE)	5%	4.96	28.45±1.40** (5.33± 0.13)***	43.08±0.005 (6.56 ±0.00)	49.32±0.94 (7.02 ±0.06)	52.03±1.40 (7.21± 0.09)	52.03±1.40 (7.26 ±0.09)	45.14 ±9.38 (6.68± 0.74)
Azadirachtin (1500 ppm)	0.03%	6.04	44.96±6.61 (6.69 ±0.49)	60.62 ±4.15 (7.78± 0.26)	69.78±1.24 (8.35 ±0.07)	76.02±2.52 (8.71 ±0.14)	83.21±2.52 (9.12± 0.13)	68.48±13.08 (8.23 ±0.82)
Lecanicillium lecani ($1x10^8$CFU's/ml)	2 ml/L	9.91	25.19±5.56 (5.00 ±0.55)	29.13±7.88 (5.36± 0.73)	34.64±4.09 (5.87 ±0.35)	37.27±4.33 (6.09 ±0.36)	39.37±4.08 (6.26± 0.33)	33.68 ±6.81 (5.77± 0.61)
Beauveria bassiana ($1x10^8$CFU's/ml)	2ml/L	6.30	28.57±0.00 (5.34± 0.00)	23.28±5.57 (4.80± 0.58)	29.10±3.99 (5.38± 0.36)	31.74±3.63 (5.62 ±0.32)	34.92±3.46 (5.90 ±0.28)	29.59 ±5.30 (5.41± 0.50)
Metarhizium anisopliae ($1x10^8$CFU's/ml)	2ml/L	7.62	22.48±0.00 (4.74 ±0.00)	25.06±4.47 (4.99± 0.43)	31.00±1.34 (5.56± 0.12)	33.59±1.78 (5.79± 0.15)	35.91±1.78 (5.99± 0.14)	30.12 ±5.47 (5.46± 0.51)
Adalia tetraspilota	3/plant	7.60	27.75±1.56 (5.25± 0.14)	26.46±6.53 (5.11± 0.62)	26.22±2.58 (5.11± 0.25)	29.6±2.78 (5.44± 0.25)	30.70±3.65 (5.53± 0.33)	28.16 ±3.82 (5.29 ±0.36)
Standard check (Thiacloprid 21.7 SC)	0.4ml/L	6.66	43.75±3.63 (6.61± 0.27)	49.26±12.15 (6.98 ±0.84)	49.51±1.69 (7.03± 0.12)	61.27±1.70 (7.82± 0.10)	89.21±5.89 (9.44 ±0.31)	59.66±17.88 (7.64± 1.11)
Control	Water	5.81	11.11±0.00 (3.33 ±0.00)	7.21± 6.41 (2.19±1.92)	9.31± 2.36 (3.01±0.38)	11.11± 0.00 (3.33 ±0.00)	1.11± 1.92 (0.60 ±1.05)	7.66± 4.81 (2.38± 1.40)

*DAS: Days After Spray, **Each value is mean of 03 replications ±S.E, ***Figure in parenthesis are square root transformed values

Table 4: Comparative bio-efficacy of different organic based modules against various stages of *Myzus persicae* on capsicum under polyhouse condition.

Treatments	Dosage	Pre count (Population of *M. persicae* /leaf)	Percent population reduction of various stages of *Myzus persicae*			Total *M. persicae* population reduction (%)
			nymph	apterous	alate	
Neem Seed Kernel Extract (NSKE)	5%	24.7	67.34±13.30 (8.16± 0.87)	52.41±12.71 (7.18± 0.93)	45.14 ±9.38 (6.68± 0.74)	60.00
Azadirachtin (1500 ppm)	0.03%	25.7	78.82±13.58 (8.84± 0.80)	65.49± 13.03 8.05± 0.85	68.48±13.08 (8.23 ±0.82)	70.93
Lecanicillium lecani ($1x10^8$CFU's/ml)	2 ml/L	26.3	67.96±16.63 (8.18± 1.06)	45.58±12.63 (6.68 ±0.96)	33.68 ±6.81 (5.77± 0.61)	49.07
Beauveria bassiana ($1x10^8$CFU's/ml)	2ml/L	25.3	63.69±18.91 (7.89± 1.24)	45.77 ±10.84 (6.71 ±0.83)	29.59 ±5.30 (5.41± 0.50)	46.35
Metarhizium anisopliae ($1x10^8$CFU's/ml)	2ml/L	26.3	62.76±13.08 (7.87± 0.86)	44.81±11.78 (6.62 ±0.96)	30.12 ±5.47 (5.46± 0.51)	45.89
Adalia tetraspilota	3/plant	26.7	62.16 ±9.24 (7.86± 0.59)	43.27±9.17 (6.54± 0.72)	28.16 ±3.82 (5.29 ±0.36)	44.53
Standard check (Thiacloprid 21.7 SC)	0.4ml/L	25.7	84.23±17.19 (9.12± 0.99)	74.46 ±18.32 (8.56± 1.10)	59.66±17.88 (7.64± 1.11)	72.78
Control	Water	25.7	7.83± 2.29 (2.51± 0.87)	7.38 ±5.05 (2.10 ±1.49)	7.66± 4.81 (2.38± 1.40)	7.62

C.D at 5% level of significance

Stages : 0.12
Treatments : 0.30
Stages*treatment : 0.90

Figure in parenthesis are square root transformed values.