



Comparative Efficacy of Organic Based Management Modules against Different Stages of *Myzus persicae* Sulzer on Capsicum under Polyhouse Condition in Kashmir Valley, India

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Authors' contributions

This work was carried out in collaboration among all authors. 'All authors read and approved the final manuscript.

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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

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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.

Keywords: *Capsicum*; *Myzus persicae*; polyhouse condition; organic management.

1. 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 & 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.

2. MATERIALS AND METHODS

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 annuum*) 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

List 1. Organic management module

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

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:

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

3. 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* (1x10⁸CFU'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* (1x10⁸CFU's/ml) @ 2 ml/L, *Adalia tetraspilota* @3/plant and *Lecanicillium lecani* (1x10⁸CFU's/ml) @ 2 ml/L respectively. The least *M. persicae* apterous reduction was recorded with the application of *Metarhizium anisopliae* (1x10⁸CFU'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* (1x10⁸CFU's/ml) @ 2 ml/L, *A. tetraspilota* @3/plant, *M. anisopliae* (1x10⁸CFU's/ml) @ 2ml/L and *B. bassiana* (1x10⁸CFU's/ml) @ 2 ml/L respectively. However, the standard check (Thiacloprid 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 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)					Mean
			*Days After Spray 1DAS	3DAS	7DAS	10DAS	15DAS	
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)
<i>Lecanicillium lecani</i> (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)
<i>Beauveria bassiana</i> (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)
<i>Metarhizium anisopliae</i> (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)
<i>Adalia tetraspilota</i>	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
<i>Lecanicillium lecani</i> (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)
<i>Beauveria bassiana</i> (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)
<i>Metarhizium anisopliae</i> (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)
<i>Adalia tetraspilota</i>	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)					Mean
			*Days After Spray 1DAS	3DAS	7DAS	10DAS	15DAS	
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)
<i>Lecanicillium lecani</i> (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)
<i>Beauveria bassiana</i> (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)
<i>Metarhizium anisopliae</i> (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)
<i>Adalia tetraspilota</i>	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 (Thiaclopid 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 <i>M. persicae</i> /leaf)	Percent population reduction of various stages of <i>Myzus persicae</i>			Total <i>M. persicae</i> 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
<i>Lecanicillium lecani</i> (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
<i>Beauveria bassiana</i> (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
<i>Metarhizium anisopliae</i> (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
<i>Adalia tetraspilota</i>	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 Fig in parenthesis are square root transformed values.

(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 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.

4. 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)

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 writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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