



Synthesis and development of pest management modules against major insect pests of pumpkin (*Cucurbita moschata*)

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ABSTRACT

Field experiment was conducted in pumpkin (*Cucurbita moschata* Duch. ex Poir.) during summer seasons of 2018 and 2019 at Varanasi, Uttar Pradesh with a view to develop adaptable and rational pest management technology for the major insect pests of pumpkin. Among the three pest management modules, viz. biointensive module (M1), integrated module (M2) and chemical module (M3) synthesized and formulated against major insect pests of pumpkin including red pumpkin beetle (*Raphidopalpa foveicollis*), white fly (*Bemisia tabaci*) and mirid bugs (*Nesidiocoris cruentatus*), the integrated module (M2) comprising sprayings of DDVP 76% EC @0.75 ml/l at 20 and 30 days after sowing (DAS), *Bacillus thuringiensis* var. *Kurstaki* @ 2 g/l at 40 DAS, Imidacloprid 17.8 SL @ 0.33 ml/l at 50 DAS, *Lecanicillium lecanii* @5 g/l at 60 DAS and Azadirachtin 300 ppm @5 ml/l at 70 DAS was most effective in reducing the red pumpkin beetle (75 and 67.27% during 2018 and 2019, respectively), white fly (44.12 and 66.55) and mirid bug population on leaves (74.24 and 84.62) with maximum increase in the yield (291 q/ha) over chemical (287 q/ha), biointensive modules (269 q/ha) and untreated control (208 q/ha). Considering economics of the treatments, integrated module (M2) recorded highest cost benefit ratio of 1:7.06 followed by biointensive module (1:3.41) and chemical module (1:2.77).

Key words: Cost benefit ratio, Major insect pests, Pest management modules, Pumpkin

Insect pests are the major biotic constraints in vegetable production in India. The crop losses to the tune of 10-30% have been reported in vegetable crops (Halder *et al.* 2018(a)). Apart from causing direct damage, many of them also act as vectors for several viral diseases. In recent years, with changes in the cropping systems and climate and introduction of highly input intensive high yielding varieties/hybrids, a shift in pest status has been observed (Rai *et al.* 2014). In addition to regular pests, many emerging insect pests are also coming in a big way. Pumpkin (*Cucurbita moschata* Duch. ex Poir.), an important round the year cucurbitaceous vegetable in India, is attacked by several regular insect pests, viz. red pumpkin beetle (*Raphidopalpa foveicollis* Lucas), white fly (*Bemisia tabaci* (Gennadius)), fruit fly (*Bactrocera cucurbitae* (Coq.)) throughout its growth period. Apart from these regular pests, recently the incidence of mirid bug (*Nesidiocoris cruentatus* (Ballard)) as sap sucker from leaf, flower and tender fruits has also been seen in serious proportion in many cucurbitaceous vegetables like bottle gourd and pumpkin many parts of India (Rangnath *et al.* 2015; Halder *et al.* 2017(b)). Fruit damage up to 68% was observed on pumpkin due to fruit fly alone.

To control these biotic stresses, farmers mostly rely on chemical pesticides which are often used indiscriminately, unwanted and excessively leading to resistance to pesticides, resurgence of target insects and secondary pest outbreak, residues in food and beverages, contamination of groundwater, adverse effect on human health and widespread killing of non-target organisms (Halder *et al.* 2014, 2016). It is not unusual for the pumpkin growers to give 11-14 rounds of chemical sprays in a season, often unnecessary and unjustified furthermore without any appreciable increase in the yield. Development of suitable and ecofriendly integrated pest management (IPM) protocol for sustainable pumpkin production is the need of the hour. Keeping this in view, synthesis and development of multifaceted adaptable and economically viable IPM technology in pumpkin was carried out to reduce the over dependence and reliance on chemical pesticides and protecting the ecosystem as a whole.

MATERIALS AND METHODS

Three pest management modules, viz. biointensive, integrated and chemical pest management modules for pumpkin was synthesized and developed based on the base line information collected on the crop, pests and natural enemies status in Varanasi, recommendations made by ICAR-Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh; ICAR-National Research Centre for Integrated Pest Management, New Delhi and Banaras Hindu University,

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Varanasi, Uttar Pradesh for pumpkin insect pest management and research literature published by eminent entomologists on pumpkin. The details of these pest management modules are as follows:

M1= Biointensive pest management module

Spraying of Azadirachtin (Nimbecidine 0.03%, M/s T. Stanes and Co. Ltd.) @ 5ml/l at 20 and 30 days after sowing (DAS)

Spraying of *Bacillus thuringiensis* var. *Kurstaki* (18000 IU mg⁻¹; M/s Agri Life) @ 2 g/l at 40 DAS

Spraying of *Lecanicillium lecanii* (1×10⁸ cfug⁻¹; M/s Agri Life) @ 5 g/l at 50 DAS

Spraying of *Beauveria bassiana* (1×10⁸ cfug⁻¹; M/s Agri Life) @ 5 g/l at 60 DAS

Spraying of Azadirachtin (Nimbecidine 0.03%, M/s T. Stanes and Co. Ltd.) @ 5ml/l at 70 DAS

M2= Integrated pest management module

Spraying of DDVP (Nuvan 76% EC, M/s Insecticides (India) Ltd.) @ 0.75 ml/l at 20 and 30 DAS,

Spraying of *Bacillus thuringiensis* var. *Kurstaki* (18000 IU mg⁻¹, M/s Agri Life) @ 2 g/l at 40 DAS

Spraying of Imidacloprid (Mida17.8% SL, M/s Nagarjuna Agrichem Ltd.) @ 1 ml/3 l at 50 DAS

Spraying of *Lecanicillium lecanii* (1×10⁸ cfug⁻¹; M/s Agri Life) @ 5 g/l at 60 DAS

Spraying of Azadirachtin (Nimbecidine 0.03%, M/s T. Stanes and Co. Ltd.) @ 5ml/l at 70 DAS

M3= Chemical pest management module

Spraying of DDVP (Nuvan 76% EC, M/s Insecticides (India) Ltd.) @ 0.75 ml/l at 20 and 30 DAS

Spraying of Chlorantraniliprole (Coragen 18.5% SC, M/s EI Du Pont India Pvt. Ltd.) @ 0.25 ml/l at 40 DAS

Spraying of Imidacloprid (Mida17.8% SL, M/s Nagarjuna Agrichem Ltd.) @ 1 ml/3 l at 50 DAS

Spraying of Thiacloprid (Alanto 21.7% SC, M/s Bayer Crop Science Ltd.) @ 1 ml/l at 60 DAS

Spraying of Cyantraniliprole (Benevia 10.26 % w/w OD, M/s E.I. Dupont India Pvt Ltd) @ 1.8 ml/l at 70 DAS

M4= Untreated control

All the insecticides were procured from the local markets, whereas microbials were supplied by M/s Agri Life.

Physiographic situation and lay out of the experiments

The field experiments were conducted during the two consecutive years, viz. summer seasons of the year 2018 and 2019 at the experimental farm of ICAR-Indian Institute Vegetable Research, Varanasi (82°52' E longitude and 25°12' N latitude), Uttar Pradesh, India. The climate of the site is subtropical humid type which receives an average annual rainfall of 900 mm. The experiment site comes under the alluvial zone of Indo-Gangetic plains having soils silt loam in texture and low in organic carbon (0.43%) and available nitrogen (185 kg ha⁻¹). The above

described three pest management modules were formulated and evaluated against major insect pests of pumpkin, i.e. red pumpkin beetle, whitefly and mirid bugs of pumpkin along with untreated control.

The pumpkin (cv. Kashi Harit) was sown during second fortnights of February (summer crop) at a spacing of 2.5 m × 0.6 m (row to row and plant to plant) in a large plot size of 10 × 10 m for each module and all recommended agronomic practices were followed. In addition to this, cue lure traps (Male Annihilation Technique) @30 per ha were installed coinciding with the first flowering in each plot except untreated control. For the same, untreated control plots of equal size were maintained in a separate block of the experimental farm having an isolation distance of 500 m. As such four such plots were prepared. From each plot, five fixed spots (1 × 1 m each, four in corners and one in centre of plot) were selected randomly considering one spot as one replication. Thus five replications were maintained for each module. The spray liquids were prepared just before application and the spray for respective module as per mentioned schedule was done using of Knap Sack Power Sprayer during evening hours.

Observations

The data were recorded from five randomly selected plants from each spot for the respective module. Observation on red pumpkin beetle was taken on random five leaves per plant and as such five plants were randomly selected from each plot. Similarly, whitefly was counted from three leaves (top, middle and bottom region) sampled from each of 5 random plants from each plot. Mirid bug (both nymphs and adults) population was recorded from twenty tender fruits (10 days after anthesis), 30 tender leaves and 30 apical shoots and expressed in number per plant part. The observations were recorded at weekly intervals in each plot of respective modules including untreated control. As regards the yield, different pickings made separately from entire plot from each module were added and converted to ha basis.

Statistical analysis

The data were subjected to Analysis of Variance (ANOVA) with least significant difference (p=0.05) as test criterion using SAS software (version 9.3). The yield data were converted to hectare basis and the economics was calculated. Cost-benefit analysis was expressed in terms of ratio by using the following formula:

$$\text{Cost benefit ratio} = \frac{\text{Net return (₹ ha}^{-1}\text{)}}{\text{Cost of treatment (₹ ha}^{-1}\text{)}}$$

RESULTS AND DISCUSSION

Red pumpkin beetle control: From Table 1 and 2 it is evident that the integrated module (M2) was the most effective in controlling red pumpkin beetle population during both the seasons of experimentation. Integrated module registered lowest beetle population of 0.55 and 0.90 per five leaves with 75 and 67.27% reduction over control (PROC)

Table 1 Effect of different pest management modules against insect pests in pumpkin during 2018 (summer season)

Treatment	Red pumpkin beetle (per 5 leaves /plant)			Whitefly / leaf			Mirid bugs per								
							Leaf			Twigs			Fruit		
	Before spray	After spray	PROC	Before spray	After spray	PROC	Before spray	After spray	PROC	Before spray	After spray	PROC	Before spray	After spray	PROC
M1	2.88	0.87 b	60.46	10.37	5.60a	31.38	2.69	0.89a	66.29	2.11	0.64a	66.14	2.89	1.33a	38.71
M2	3.01	0.55a	75.00	10.23	4.56a	44.12	3.02	0.68a	74.24	2.05	0.39a	79.37	2.67	1.06a	51.15
M3	2.35	0.76a	65.45	10.57	5.70ab	30.15	2.36	0.72a	72.73	2.16	0.42a	77.78	2.59	1.12a	48.39
Control	2.93	2.20c	--	9.83	8.16c	--	2.87	2.64b	--	1.97	1.89b	--	2.83	2.17b	--
SEm (±)	--	0.14	--	--	0.37	--	--	0.18	--	--	0.14	--	--	0.19	--
LSD (P=0.05)	--	0.31	--	--	1.07	--	--	0.45	--	--	0.37	--	--	0.54	--

Table 2 Effect of different pest management modules against insect pests in pumpkin during 2019 (summer season)

Treatment	Red pumpkin beetle (per 5 leaves /plant)			Whitefly/ leaf			Mirid bugs per								
							Leaf			Tender fruit			Twigs		
	Before spray	After spray	PROC	Before spray	After spray	PROC	Before spray	After spray	PROC	Before spray	After spray	PROC	Before spray	After spray	PROC
M1	2.39	1.35b	50.91	2.84	1.20a	57.30	2.73	0.60a	79.45	1.57	0.22a	75.28	4.12	1.60b	31.91
M2	2.51	0.90a	67.27	2.39	0.94a	66.55	2.36	0.38a	84.62	1.44	0.13a	85.39	4.08	0.84a	64.26
M3	2.17	1.05a	61.81	3.17	1.47a	47.69	2.60	0.44a	82.19	1.69	0.17a	80.90	3.83	1.06a	84.89
Control	2.89	2.75c	--	3.22	2.81b	--	2.92	2.47b	--	1.51	0.89b	--	3.94	2.35a	--
SEm (±)	--	0.17	--	--	0.26	--	--	0.38	--	--	0.11	--	--	0.22	--
LSD (P=0.05)	--	0.43	--	--	0.58	--	--	0.87	--	--	0.24	--	--	0.52	--

during the 2018 and 2019, respectively, with an average of 0.73 beetle per five leaves which was the lowest amongst the test modules. This was followed by chemical module (M3) with 0.76 and 1.05 beetle per five leaves. However, both these modules were statistically at par with each other.

White fly control: In case of whitefly infestation, the significantly lowest whitefly population was recorded from the integrated module (M2) and the corresponding whitefly populations per leaf were 4.56 and 0.94 for the summer seasons of 2018 and 2019, respectively. Maximum per cent reduction of whitefly population over control was 44.12 and 66.55 and these were recorded from integrated module followed by biointensive module (31.38 and 57.30%). In addition, the occurrence of lowest yellow vein mosaic virus (YVMV) disease transmitted by whitefly, *Bemisia tabaci*

was also noted in integrated module.

Mirid bug control: This emerging sucking pest was observed to infest leaves, apical buds, twigs and fruits of pumpkin in the region. Amongst the three tested modules, integrated module had lowest number of mirid bug population per leaf (0.68), fruit (0.39) and twigs (1.06) and there by registered maximum 74.24, 79.37 and 51.15% reduction over control, respectively, during summer season of 2018. Same trend was recorded during the summer season of 2019 and the per cent reduction over control was 84.62, 85.39 and 64.26, respectively. The next best treatment was chemical module and the corresponding values were 82.19, 80.90 and 84.89 PROC, respectively, during the summer season of 2019.

Marketable fruit yield: In pooled analysis, the integrated

Table 3 Economics (pooled) of different pest management modules against major insect pests of pumpkin

Treatment	Yield of healthy fruits (q/ha)	Increase in yield over control (q/ha)	Increase in yield per cent over control	Cost of increase yield (₹/ha)	Cost of treatment (₹/ha)	Net profit (₹/ha)	Cost benefit ratio
M1	269b	61	29.33	61000	13830	47170	1:3.41
M2	291c	83	39.90	83000	10297	72703	1:7.06
M3	287c	79	37.98	79000	20932	58068	1:2.77
M4	208a	--	--	--	--	--	--
SEm (±)	3.40	--	--	--	--	--	--
LSD (P=0.05)	7.79	--	--	--	--	--	--

Spray volume – 600 l/ha; Average cost of pumpkin was ₹ 1000/q during 2018 and 2019 (summer season)

module (M2) registered highest marketable fruit yield (291 q/ha), followed by chemical module (287 q/ha), whereas untreated control plots recorded significantly the lowest yield (208 q/ha). A large amount of pumpkin fruits were damaged by the cucurbit fruit fly due to absence of cue traps (MAT) in the untreated control plots was the reason for its lowest yield.

Cost-benefit ratio: Integrated module had the highest cost benefit ratio of 1:7.06 as compared to other two modules, viz. biointensive (1:3.41) and chemical (1:2.77) modules. Highest crop yield accompanied by lowest plant protection expenditure in integrated module were the reasons for its highest return and thereby recording maximum cost benefit ratio.

Integrated module comprised both entomo pathogens, botanical, conventional and newer insecticide molecules for pest management. Inputs like *B. thuringiensis* var. *Kurstaki* causes mortality of the lepidopteran insects due to cell lyses by creating the pores in the insect mid gut after the crystal protein binding the specific receptor of the mid gut wall (Bravo *et al.* 2007). White halo fungus, *L. lecanii* was able to kill the insects by both mycosis as well as toxins lethal to phytophagous insects (Halder *et al.* 2017a). Neem and/or its derivatives have multicide action. This diverse mode of actions could be the reason for greater efficacy of integrated module against leaf feeder and sucking pest complex in pumpkin. Similarly, conventional (Dichlorvos) and newer (Imidacloprid) insecticide molecules had different mechanisms of action in its schedule. Imidacloprid acts as nicotinic acetylcholine receptor (nAChR) agonists, whereas Dichlorvos, being an organophosphate compound, acts as Acetylcholinesterase (AChE) inhibitors (IRAC 2014) in irreversible manner. Presence of these pesticides including biopesticides with diverse mode of action could be the reason for making integrated module to be most successful. Kodandaram *et al.* (2017) reported that integrated module comprising sprayings of Chlorantraniliprole, NSKE 4%, Emamectinbenzoate, *Bacillus thuringiensis* and Nimbecidine at 10 days intervals starting from 25 DAS onwards was the most effective in reducing the fruit borer damage (71.74%) and yellow veinmosaic disease (17.75%) in okra with significant increase in the yield (177.7 q/ha) over chemicals and biointensive modules. In another study, Halder *et al.* (2018b) documented that the IPM technology for bitter melon comprising seed treatment with *Trichoderma viride*; need based spraying of Azadirachtin, *Bacillus thuringiensis*, Imidacloprid and installation of cue lure traps were found very effective in reducing the incidence of pests and minimizing the yield losses with higher cost benefit (C:B) ratio of 1:2.59 compared to farmers' practices (1:1.93). Birah *et al.* 2012 reported that integrated module involving seed treatment with Imidacloprid + sowing of maize as barrier crop + weekly clipping of infested shoots and fruits + erection of pheromone trap + foliar spray of NSKE, Spinosad and Karanj oil registered significantly lower jassid population (3.32 jassids/leaf) than farmers' practices (5.31 jassids/

leaf) and untreated control (10.12 jassids/leaf) in okra. The minimum incidence of shoot borer (4.23%) and fruit borer (5.64%) and more fruit yield (8.66 t/ha) was also recorded in integrated module.

Conclusion

Based on overall analysis, it can be inferred that though all the tested (biointensive, integrated and chemical) modules were almost equally effective in terms of recording lower incidence of red pumpkin beetle, whitefly and mirid bugs in pumpkin. However, in terms of yield, integrated module was far superior to the other two test modules. Considering economics of the treatments, integrated module (M2) recorded highest cost benefit ratio of 1:7.06 followed by chemical module (1:2.77) and biointensive module (1:3.41).

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REFERENCES

- Birah A, Srivastava R C, Kumar K, Singh P K and Bhagat S. 2012. Efficacy of pest management practices against pest complex of okra (*Abelmoschus esculentus*) in Andaman. *Indian Journal of Agricultural Sciences* **82**: 470-2.
- Bravo A, Gill S S and Soberón M. 2007. Mode of action of *Bacillus thuringiensis* Cry and Cyt toxins and their potential for insect control. *Toxicon* **49**(4):423-5.
- Halder J and Rai A B. 2016. Suitability of different prey aphids on the growth, development and reproduction of *Chrysoperla zastrowi sillemi* (Esben-Petersen) (Chrysopidae: Neuroptera). *Proceedings of the Zoological Society* **69**(1):89-95. (DOI 10.1007/s12595-014-0131-6).
- Halder J, Rai A B and Kodandaram M H. 2014. Parasitization preference of *Diaeretiella rapae* (McIntosh) (Hymenoptera: Braconidae) among different aphids in vegetable ecosystem. *Indian Journal of Agricultural Sciences* **84**(11):1431-3.
- Halder J, Rai A B, Dey D and Singh B. 2018(a). Abundance of important parasitoids in the vegetable ecosystem and their prospects in integrated pest management. *Journal of Entomology and Zoology Studies* **6**(4):762-9.
- Halder J, Sardana H R, Nagendran K, Pandey M K, Bhat M N and Banerjee K. 2018(b). Synthesis and area-wide validation of adaptable IPM technology and its economic analysis for bitter melon (*Momordica charantia*) in a farmers' driven approach. *Indian Journal of Agricultural Sciences* **88**(9): 1378-82.
- Halder J, Kushwaha D, Rai, A B, Singh A and Singh B. 2017a. Potential of entomopathogens and neem oil against two emerging insect pests of vegetables. *Indian Journal of Agricultural Sciences* **87**(2):220-4.
- Halder J, Kushwaha D, Deb D and Rai A B. 2017(b). Effect of meteorological parameters on abundance of mirid bug, *Nesidiocoris cruentatus* (Ballard) (Hemiptera: Miridae): An emerging insect pest of bottle gourd. *Journal of Agrometeorology* **19**(2):180-2.
- IRAC. 2014. Mode of Action, Classification Scheme. Issued-February 2014, Version 7.3, Insecticide Resistance Action Committee, pp 1-24.
- Kodandaram M H, Halder J, Singh N and Rai A B. 2017. Pest

- management modules against major insect pests of okra. *Pesticide Research Journal* **29**(2):153-7.
- Rai A B, Halder J and Kodandaram M H. 2014. Emerging insect pest problems in vegetable crops and their management in India: An appraisal. *Pest Management in Horticultural Ecosystems* **20**(2):113-22.
- Ranganath H R, Naveena N L, Saroja S and Yeshwanth H M. 2015. Mirid bug, *Nesidiocoris cruentatus* (Ballard) - an emerging pest on bottle gourd, *Lagenaria siceraria* (Molina) Standley. *Pest Management in Horticultural Ecosystem* **21**(1):104-5.