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Evaluation of different modules against major pests of cucumber (*Cucumis sativus* L.)

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Abstract
An experiment was conducted during *kharif* 2018 for evaluation of different modules against major pests of cucumber (*Cucumis sativus* L.). During the course of study, three pest management modules *viz*., Chemical, Bio-intensive and IPM module consisting spraying of different pesticides as well as biopesticides were evaluated with untreated control in Randomized Block Design (RBD) with five replications. The studies on evaluation of pest management modules for major pests of cucumber revealed that in for control of thrips, whitefly and aphids IPM module observed 4.31 thrips, 3.80 whitefly and 3.90 aphids/3 leaves/plant, respectively.
Whereas, in case of leaf miner and fruit fly, the IPM module was significantly superior module and observed 21.15% damaged leaves and 10.84% damaged fruits, respectively.
Effect of different strategies on predatory coccinellids showed that the Bio-intensive module recorded the highest grub population per plant (3.85 grubs/plant) and was at par with the IPM module which recorded 3.36 grubs/plant indicating their relative safety to the grubs of lady bird beetles. The highest yield of cucumber fruits 230q/ha was registered from the IPM module with highest ICBR 1:13.86 as against 160 q/ha in untreated control.

Keywords: *Cucumis sativus*, IPM module, *Thrips palmi*, *Bemisia tabaci*, *Aphis gossypii*, *Liriomyza trifolii*, *Bactrocera cucurbitae*

1. Introduction
Cucumber (*Cucumis sativus* L.) is one of the most important cultivated vegetable crop belongs to the family *cucurbitaceae*. In India, cucumber is grown over an area of 82,000 ha and annual production of 12,60,000 MT. Whereas, in Maharashtra, cucumber is grown over an area of 44700 hectares with the annual production of 5,89,500 tones and productivity of 14 tones/ha (Anonymous., 2017-18) [2]. The cucumber fruits are consumed fresh in the form of salads and since they have great demand in the altered food scenario. Hence, most care be given to reduce pesticide residues.
The cucumber crop suffered mainly due to infestation of sucking pests viz; whitefly (*Bemisia tabaci* Gennadius), Leaf hopper (*Amrasca biguttula biguttula* Ishida), aphids (*Aphis gossypii* Glover and *Myzus periscae* Sulzer), Thrips (*Thrips palmi* Karny). Whereas, fruit fly (*Bactrocera cucurbitae* Coq), American serpentine leaf miner (*Liriomyza trifolii* Burgess) recorded to be the most destructive pests. Severe outbreak was noticed during 1992 in Maharashtra state on cucurbits (Wakchaure, 1998) [22]. The fruit flies accounts a major group of pests infesting cucurbitaceous crops. Two species namely *Bactrocera cucurbitae* (Coquillett) and *Bactrocera tau* (Walker) commonly called as melon fruit flies are the major species found infesting cucurbits. About 50% cucurbits are partially or completely damaged by fruit flies in India (Gupta and Verma 1992) [9]. Several insecticides have been recommended and are imposed by the farmers for control of the sucking pests. However, on account of economics and efficacy of pesticides, satisfactory control should not be obtained in many cases due to misuse of insecticides, development of resistance by pests and improper application techniques of sprays. Furthermore, heavy doses of insecticides has posed problems of residue in the fruits which cause human hazards upon consumption and also cause pest resurgence, insecticide resistance and destruction of natural enemies. However, the chemical pesticides can be minimized by Integrating it with botanical and microbial pesticides for producing healthy and good quality crop. Recently, new molecules of pesticides are introduced in the market which are comparatively safe to natural enemies of the pest. Some pesticides are being used judiciously along with other reliable method of pest management in cucumber.

2. Materials and methods

The three modules with untreated control replicated five times were evaluated in R.B.D. during *kharif* season of 2018 at AICRP on Vegetable Crops, MPKV, Rahuri. Cucumber cv. Gypsi dibbled on 25th July, 2018 in a plot size 4 x 3 m. with 1.5 x 0.5 m. plant spacing. Spraying was under taken in the morning hours using manually hand operated knap sack sprayer by using 500 litre of water per hector. Four sprays in each module were given at fortnightly interval starting from infestation of pests. The three module consists of

I. Chemical Module:

1. Spraying of chlorantraniliprole 18.5 SC 0.3 ml/l at 30 DAS followed by
2. Spraying of emamectin benzoate 5 WG @ 0.4 g/l at 45 DAS followed by
3. Spraying of spinosad 45 SC @0.3 ml/l at 60 DAS followed by
4. Spraying of abamectin 1.9 EC 0.3 ml/l at 75 DAS.

II. Bio-intensive Module:

1. Seed treatment with cow dung slurry and *Trichoderma viride*, soil application of neem cake @ 250 kg/ha at the time of sowing.
2. Spray of Neem oil (300 ppm) @ 5 ml/l at 30 DAS.
3. Installation of yellow sticky traps @ 25/ha
4. Installation of Cu-lure traps @ 12/ha.
5. Spraying of Pongamia oil @ 1% at 45 DAS.
6. Spraying of *Lecanicillium lecanii* @ 5g/l @ 60 DAS.
7. Spraying of NSE @ 5% at 75 DAS.

III. Integrated Pest Management Module:

1. First spray of *Metarhizium anisopliae* @ 5 g/l of water at 30 DAS.
2. Installation of yellow sticky traps @ 25/ha.
3. Installation of Cu-lure traps @ 12/ha.
4. Spraying of spinosad 45 SC @ 0.3 ml/l at 45 DAS.
5. Spraying of *Lecanicillium lecanii* @ 5g/l @ 60 DAS.
6. Spraying of neem oil (300 ppm) @ 5 ml/l at 75 DAS.

IV. Untreated control.

Observations on sucking pests such as whitefly, thrips and aphids were recorded on five randomly selected plants from each replication**.** Total number of whitefly, thrips and aphids were recorded from three leaves of each selected plant. Observations on per cent damaged leaves were recorded on randomly selected plants in each replication. The observations were recorded by counting total number of leaves per plant and number of leaf miner infested leaves. The observations for post treatment counts were recorded on 15, 30, 45, 60 and 75 DAS.

At the time of harvesting at picking, the entire marketable size fruits of the crop irrespective of healthy and infested fruits were plucked and infested and healthy fruits were sorted out to calculate the per cent fruit infestation Adult coccinellid beetles were counted per five plants in each replication at 15, 30, 45, 60 and 75 DAS.

The data on yield of cucumber fruits from each plot was recorded at the time of each picking and then total yield from the plot (kg/plot) was converted to quintals per hectare. The data on average survival population of pests were translated into square root formation $\sqrt{x+0.5}$ as well as data on the per cent infestation caused by the pests was transformed into arcsine formation and then subjected to statistical analysis as suggested by Panse and Sukhatme (1985) [15]. The yield data was subjected to statistical analysis. Finally Incremental Cost Benefit Ratio (ICBR) was worked out for each treatment.

3. Results and Discussions

The cumulative data of four sprays pertaining to effect of different modules on the average population of thrips, whitefly, aphids, leaf miner, fruit fly and adult coccinellid beetles were counted and presented at 15, 30, 45, 60 and 75 days after sprays presented in Table 1-4.

A) Thrips

The overall results from Table 1 states that IPM module (4.31 thrips/3 leaves/plant) was effective in controlling the thrips on cucumber followed by Chemical module (5.11 thrips) as against 11.08 thrips/3 leaves/plant in untreated control.

The present investigation is in agreement with the results of Rajkumar *et al.* (2002) [16] who reported that Nimbecidine (*Azadirachta indica*) significantly reduced the damage caused by thrips. The present results are also in support with the findings of Annamalai *et al*. (2014) [1] who reported that *B. bassiana* and *L. lecanii* significantly decrease the *T. tabaci* infestations in onion crop under the greenhouse as well as field conditions.

B) Whitefly

The overall results indicates from Table 1 that IPM module (3.80 whitefly/3 leaves/plant) was effective in controlling the whitefly infestation on cucumber and was found at par with Chemical module (4.86 whitefly). The least intensity of whitefly was observed in Bio-intensive module (5.37 whitefly).

The results are comparable with the findings of Dimetry *et al.* (1996) [5] who reported that the bioactivity of different formulations of neem seed extracts against *Bemisia tabaci* reduced the population density of the adults compared with the untreated control. The present results also in agreement with the of results of Moreau and Isman (2011) [13] who observed that yellow sticky traps were effective at trapping adult whiteflies and significantly reduced adult populations on the main crops (peppers) when compared with the control.

Table 1: Effect of different modules on thrips (*Thrips palmi*) and whitefly (*B. tabaci*) population

Module	Number of thrips /3leaves/plant on						Number of whitefly /3leaves/plant on					
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	Mean	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	Mean
M_1	6.1 (2.57)	5.67 (2.48)	4.72 (2.28)	4.59 (2.26)	4.45 (2.22)	5.11 (2.36)	4.82 (2.32)	4.97 (2.33)	5.27 (2.40)	4.65 (2.27)	4.64 (2.26)	4.86 (2.32)
M_2	6.43 (2.63)	6.39 (2.62)	6.26 (2.60)	5.45 (2.44)	5.45 (2.44)	6.00 (2.55)	6.25 (2.60)	5.95 (2.54)	5.78 (2.51)	5.60 (2.47)	5.37 (2.42)	5.37 (2.51)
M_3	4.41 (2.22)	4.51 (2.24)	4.36 (2.20)	4.46 (2.23)	3.81 (2.08)	4.31 (2.19)	4.43 (2.22)	4.23 (2.17)	4.49 (2.23)	3.87 (2.09)	3.80 (2.07)	3.80 (2.16)
M_4	10.57	10.98	11.65	11.24	10.98	11.08	12.23	11.39	12.24	11.79	11.75	11.75

	(3.33)	(3.39)	(3.49)	(3.43)	(3.39)	(3.40)	(3.57)	(3.46)	(3.51)	(3.51)	(3.50)	(3.52)
SE (±)	0.05	0.06	0.06	0.06	0.06	0.30	0.04	0.05	0.06	0.06	0.07	0.06
CD	0.17	0.18	0.18	0.20	0.20	0.09	0.15	0.18	0.21	0.21	0.22	0.20

*Average of five observations taken at 15, 30, 45, 60 and 75 DAS.

(Figures in the parathenses indicates $\sqrt{x+0.5}$ values)

M_1 = Chemical Module M_3 = Integrated Pest Management Module

M_2 = Bio-intensive module M_4 = Untreated module

C) Aphids

The overall results indicates from Table 2 that IPM module (3.90 aphids/3 leaves/plant) was effective in controlling the aphids on cucumber and was found at par with Chemical module (4.43 aphids).

The present investigation is in agreement with the findings of Ghosh (2017) [7] who reported that among the bio-pesticides combination of neem and *Spilanthes* gave higher control (77.58%) very closely followed by neem (71.63%) over control and recommended use of biopesticides in IPM programme against aphids on tomato plants. The findings of Bade *et al*. (2017) [4] who reported that insecticidal treatments with *Lecanicillium lecanii* @ 2.5 kg/ha was found most effective treatment against aphids after four sprays also support the present investigation.

D) Leaf miner

The overall results seems from Table 2 that IPM module (21.15% damaged leaves) was effective in controlling the leaf miner on cucumber and found at par with Chemical module (25.94% damaged leaves).

The results are confirmatory with the findings of Schuster and Taylor (1987)[18] who stated that single application of abamectin @ 4.54 g a.i./378.5 liters of water, control the *Liriomyza trifolii* on tomato in the field and concluded that single application of abamectin at a suitable dose controlled *Liriomyza trifolii* on tomato in the field for at least a week.

The present investigations are also supporting with findings of Apte (2001) [3] who documented average efficacy of 66.95, 51.95 and 48.04% on azadirachtin, fipronil and quinalphos against *Liriomyza trifolii* on gerbera respectively as well as Gahbiche (2001) [6] who studied the toxicity of spinosad against *L. trifolii* and observed 100% mortality of first instar and 89.3% mortality of third instar larvae, respectively.

Table 2: Effect of different modules on number of aphids (*Aphis gossypii*) and leaf miner (*L. trifolii*) population

Module	Number of aphids /3leaves/plant on						Incidence of leaf miner (per cent damaged leaves) on					
	15 DAS	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**	**Mean**	**15 DAS**	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**	**Mean**
M_1	4.59 (2.25)*	4.34 (2.19)	4.27 (2.18)	4.52 (2.24)	4.42 (2.21)	4.43 (2.22)	27.5 (31.63)**	25.31 (30.20)	27.2 (31.44)	26.37 (30.90)	23.33 (28.88)	25.94 (30.61)
M_2	6.04 (2.55)	5.53 (2.45)	5.79 (2.51)	5.86 (2.52)	5.58 (2.47)	5.76 (2.50)	33.9 (35.61)	33.01 (35.07)	29.68 (33.01)	28.76 (32.41)	28.03 (31.97)	30.68 (33.62)
M_3	4.02 (2.12)	3.70 (2.04)	3.59 (2.02)	4.04 (2.13)	4.15 (2.15)	3.90 (2.10)	24.06 (29.37)	23.94 (29.29)	23.68 (29.12)	24.21 (29.47)	21.15 (27.38)	21.15 (28.93)
M_4	12.20 (3.56)	12.25 (3.57)	12.37 (3.59)	12.45 (3.60)	12.78 (3.64)	12.41 (3.59)	47.08 (43.33)	46.14 (42.79)	45.98 (42.69)	43.71 (41.30)	42.14 (40.48)	42.14 (42.13)
SE (±)	0.05	0.06	0.07	0.06	0.06	0.05	0.67	0.78	0.88	0.88	0.83	0.35
CD	0.17	0.20	0.22	0.18	0.18	0.17	2.07	2.41	2.73	2.73	2.64	1.53

* Figures in the parathenses indicates $\sqrt{x+0.5}$ values)

** Figures in parathenses are arcsine transform values

E) Fruit fly and yield

The overall results indicates from Table 3 that IPM module (10.84% damaged fruits) was effective in controlling the fruit fly on cucumber followed by Chemical module (18.12% damaged fruits). In Biointensive module least control of fruit fly was observed (34.84% damaged fruits). The present investigation are in support with Ranganath *et al.* (1997) [17] who tested a number of botanicals and chemical insecticides against *B. cucurbitae* on cucumber and ridge gourd in Southern Andaman, India and revealed that neem oil (1.20%) was the most effective in reducing the damage in cucumber and recorded 6.20 per cent infestation over 39.00 per cent in the control. The present results also confirmatory with the findings of Vargas *et al.* (2009) [21] who tested various traps with methyl eugenol and cu-lure for capturing fruit flies and observed that *B. dorsalis* was captured in methyl eugenol traps and *B. cucurbitae* in cu-lure traps. The present investigation is also in agreement with the findings of Sharma and Sinha (2009) [19] who reported that for the control of *B. cucurbitae* most effective insecticide was emamectin benzoate (15 g a.i./ha) followed by neem ban (1 ml/liter of water).

Amongst the modules, the IPM module obtained maximum (230.00 q/ha) yield of marketable fruits of cucumber as against (160.00 q/ha) in untreated control. Whereas, the Chemical module which was found at par with IPM module and recorded (225.00 q/ha) yield of cucumber fruits. The Biointensive module observed less yield (200.00 q/ha) as compared to IPM module and Chemical control. The highest incremental cost benefit ratio (ICBR 1:13.86) was recorded in the IPM module. Considerable yield advantages due to effective control of pests of cucumber particularly through the use of IPM was observed in the present investigation is in agreement with Gundannavar (2007) [8] and Pandey and Satpathy (2009) [14], Mondal and Mondal (2012) [12] and Tripathy *et al.* (2013) [20]. These workers reported IPM to be effective in controlling pests in various crops with highest yield. Thus, the observations of earlier workers in respect of these strategies influencing yield of crops could support the findings of present investigation.

Table 3: Effect of different modules on incidence of fruit fly *(Bactrocera cucurbitae*) and yield of cucumber

Module	Incidence of fruit fly on cucumber fruits							
	I	II	III	IV	V	Mean	Yield q/ha	ICBR
M_1	19.60 (26.28)	19.20 (25.99)	18.20 (25.25)	17.20 (24.50)	16.40 (23.89)	18.12 (25.18)	225.00	1:10.66
M_2	35.80 (36.75)	35.80 (35.73)	33.80 (35.55)	33.00 (35.06)	35.80 (36.75)	34.84 (36.17)	200.00	1:6.12
M_3	11.20 (19.55)	10.60 (19.00)	10.80 (19.19)	11.60 (19.91)	10.00 (18.43)	10.84 (19.22)	230.00	1:13.86
M_4	51.60 (45.92)	51.40 (45.80)	48.80 (44.31)	48.80 (43.74)	48.00 (43.85)	43.85 (44.72)	160.00	--
SE (±)	1.03	1.04	1.03	1.07	1.11	0.31	5.08	--
CD	3.19	3.21	3.18	3.30	3.44	0.95	15.66	--

Figures in the parathenses arcsine transformed values.

F) Natural enemy

The overall results seems from Table 4 that Bio-intensive module (3.85 grubs/plant) was most favourable and safest module for coccinellids on cucumber and was found at par with IPM module (3.36 grubs /plant). The chemical module that was found most toxic to natural enemies and recorded least coccinellids population (1.37 grubs/plant). The present investigation are in agreement with the findings of Hoelmer *et al*. (1990) [10] who observed that the commercial neem insecticide was not toxic to adult coccinellid predators. The results of present investigation support findings of Kaspi and Parrella (2005) [11] who reported that abamectin residues on plants negatively affect the natural enemies. Earlier, Bade *et al*., (2017) [4] who reported the use of *L. lecanii* @ 2.5 kg/ha recorded highest population of 4.49 lady bird beetles/plant and it was superior over all the treatments for control of aphid except, untreated control also support the present findings.

Table 4: Effect of different modules on coccinellids per plant

Module	Number of coccinellids (grubs/plant)					
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	Mean
M_1	2.19 (1.64)	1.45 (1.40)	1.11 (1.27)	1.30 (1.34)	0.81 (1.14)	1.37 (1.36)
M_2	3.70 (2.05)	3.61 (2.03)	3.60 (2.02)	3.85 (2.09)	4.51 (2.24)	3.85 (2.09)
M_3	3.36 (1.96)	3.24 (1.93)	3.19 (1.92)	3.26 (1.93)	3.76 (2.09)	3.36 (1.98)
M_4	4.27 (2.18)	4.40 (2.21)	4.93 (2.33)	5.33 (2.41)	5.65 (2.48)	4.92 (2.32)
SE (±)	0.06	0.05	0.05	0.06	0.05	0.05
CD	0.18	0.15	0.17	0.20	0.18	0.15

*Average of five observations taken at 15, 30, 45, 60 and 75 DAS.

(Figures in the parathenses indicates $\sqrt{x+0.5}$ values)

4. Conclusion

Among the four management modules for controlling pests of cucumber, the Integrated Pest Management Module was found to be most effective for the suppression of whitefly, thrips, aphids, leaf miner and fruit fly on cucumber. The Bio-intensive pest management strategy was observed to be less toxic to predatory coccinellids, while chemical control showed toxic effects on the coccinellids on cucumber. Among the different pest management strategies IPM was found effective for the control of whitefly, thrips, aphids, leaf miner and fruit fly with good marketable yield of cucumber (230 q/ha) with 1:13.86 ICBR.

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