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Bio-intensive management of fruit fly, *Bactrocera cucurbitae* (Coquillett.) in cucumber

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Abstract
The present investigation was conducted to evaluate the bio-efficacy of different bio-intensive treatment modules against cucurbit fruit fly, *Bactrocera cucurbitae* in cucumber laid out at Horticulture Farm of Rajasthan College of Agriculture, Udaipur during *kharif*, 2016. The results revealed that among eight spray combinations of biopesticides *viz.,* Spinosad (200ml/ha), Azadirachtin (0.03%) and NSKE (5%), three sprays of Spinosad (200ml/ha), first spray applied as soon as the ovipositor marks were seen on the fruits and subsequent sprays at an interval of twelve days proved to be the most effective treatment module in controlling the fruit fly with least mean number of fruits with ovipositor marks (1.50), mean number of pupae of fruit fly formed from damaged fruits (5.92) and mean per cent fruit infestation (8.28 per cent) and avoiding maximum losses up to 56.88 per cent with highest fruit yield (555.56 q/ha). The treatment module comprising two spray applications of Spinosad (200ml/ha) followed by a spray of Azadirachtin (0.03%) was the next effective treatment.

Keywords: Cucumber, bio-intensive management, cucurbit fruit fly, *Bactrocera cucurbitae*

1. Introduction
Cucurbits (*Cucurbita* spp) belonging to family Cucurbitaceae constitutes the largest group of summer vegetables grown all over the world. In India, it accounts for an area of 39.1 lakh ha with annual production of 6889 MT [1]. The climate of India is favourable for growing most of the cucurbit crops especially cucumber and its production is increasing day by day. But one of the major constraints to sustain increasing productivity of cucumber is the high incidence and losses caused by the insect pests. The fruit flies constitute an important group of pests infesting cucurbit vegetables. The extent of losses caused by *B. cucurbitae* varies from 30 to 100 per cent depending on the cucurbit species and the season [2]. *B. cucurbitae* has been reported to damage 81 host plants and is considered as a major pest of cucurbitaceous vegetables, especially bitter gourd, musk melon, snap melon, snake gourd, ridge gourd and cucumber [3]. About 50 per cent of cucurbits are partially or completely damaged by fruit flies in India [4]. This insect pest reduces the quality as well as quantity of cucurbit fruits and adversely affects the growth of plants. The infested fruits become unfit for human consumption and hence become unmarketable. To combat the losses caused by insect pests the farmers conventionally used various types of chemical insecticides recommended by various workers [5, 6] but this not only involves heavy expenditure on pesticides but also causes number of problems on human health and environment. The excessive use of chemicals is not only leading to destruction of natural enemies but is also risky, as vegetables retain pesticide residues. The indiscriminate use of chemicals is not desired in vegetables as these are harvested in shorter interval and waiting period can't be increased due to perishable nature of vegetables. The bio-intensive pest management technology provides the most effective, environmentally sound and socially acceptable method of managing pests. Considering the above points in view, the present study was undertaken to find out the efficacy of different bio-intensive control measures against fruit fly, *Bactrocera cucurbitae*

2. Material and Methods
The present study experiment was carried out at Horticulture Farm of Rajasthan College of Agriculture, Udaipur during *kharif*, 2016 to evaluate the efficacy of eight treatment modules on cucumber (variety Aviva) with three replications, in the plots of size of 4 x 5m^2. The details of the treatment modules are presented in Table 1. First spray was applied as soon as the ovipositor marks of fruit fly were observed on the fruits and the subsequent sprays were

scheduled at an interval of twelve days. The efficacy of different bio-intensive treatment modules against cucurbit fruit fly was evaluated on the basis of mean number of fruits with ovipositor marks, mean number of pupae of fruit fly formed from damaged fruits, mean per cent fruit infestation, mean marketable fruit yield (q/ha) and avoidable losses (%). The marketable sized fruits were harvested at a week interval from the spray in each treatment. The observations on five randomly selected and tagged plants per plot were recorded by sorting out the healthy and infested fruits separately after each picking to calculate the mean per cent fruit infestation. Five randomly selected damaged fruits from each plot were reared for about ten days in jars containing some sand. A total of four harvests were done and for each harvest, data taken included number of fruits with ovipositor marks and number of pupae of cucurbit fruit fly formed.

1. Mean per cent fruit damage was worked out by using the following formula:

$$\text{Mean fruit damage (\%)} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits}} \times 100$$

2. Marketable Fruit yield: The weight of healthy fruits of all pickings was pooled together to calculate the marketable fruit yield/ha in each schedule separately.

3. The avoidable loses in yield corresponding to different treatments or modules were worked out by using following formula:

$$\text{Avoidable loses (\%)} = \frac{\text{Yield in treatment - Yield in control}}{\text{Yield in treatment}} \times 100$$

The data obtained were statistically analysed for analysis of variance (ANOVA) and the randomised block design (RBD) was used to separate treatment means.

Table 1: Details of different treatments used in the present study.

Treatments	I Spray	II Spray	III Spray
T_1	Azadirachtin (0.03%)	Azadirachtin (0.03%)	Azadirachtin (0.03%)
T_2	Spinosad 45SC (200ml/ha)	Spinosad 45SC (200ml/ha)	Spinosad 45SC (200ml/ha)
T_3	NSKE (5%)	NSKE (5%)	NSKE (5%)
T_4	Azadirachtin (0.03%)	Spinosad 45SC (200ml/ha)	NSKE (5%)
T_5	Azadirachtin (0.03%)	Azadirachtin (0.03%)	NSKE (5%)
T_6	Spinosad 45SC (200ml/ha)	Spinosad 45SC (200ml/ha)	NSKE (5%)
T_7	Spinosad 45SC (200ml/ha)	Azadirachtin (0.03%)	NSKE (5%)
T_8	Control	Control	Control

3. Results

The results of the investigations carried out to identify a suitable and environmentally safe bio-intensive treatment module against fruit fly in cucumber during *kharif*, 2016 are presented in Table 2. The results revealed that all the treatments were significantly superior over control in respect to mean number of fruits with ovipositor marks, mean numbers of pupae of fruit fly formed, mean fruit damage (%), marketable fruit yield (q/ha) and avoidable losses (%).

3.1 Mean number of fruits with ovipositor marks

The results on the mean number of fruits with ovipositor marks revealed that all the treatments were significantly superior in reducing the mean number of fruits with ovipositor marks over control. The treatment module of three foliar applications of Spinosad 45SC (200ml/ha) at an interval of 12 days was the most effective treatment module which resulted in minimum mean number of fruits with ovipositor marks (1.50) per five plants. The treatment module comprising application of two sprays of Spinosad 45SC (200ml/ha) and one spray of Azadirachtin (0.03%) at an interval of 12 days proved to be the next effective treatment against fruit fly infesting cucumber with 2.83 mean number of fruits having ovipositor marks per five plants. Three foliar applications of NSKE (5%) at an interval of 12 days was recorded least effective treatment module against fruit fly with maximum mean number of fruits with ovipositor marks (7.17) per five plants which was at par with treatment module comprising three sprays of Azadirachtin (0.03%) with 5.92 mean numbers of fruits with ovipositor marks per five plants.

3.2 Mean number of pupae of fruit fly

The results on mean number of pupae of fruit fly formed from the five randomly selected and reared fruits revealed that all the treatments were significantly superior over control in reducing the mean number of pupae of fruit fly formed per five damaged fruits. The treatment module comprising foliar application of three sprays of Spinosad 45SC (200ml/ha) at an interval of 12 days was the most effective treatment with minimum mean number of pupae of fruit fly (5.92) formed per five damaged fruits. The treatment module comprising application of two sprays of Spinosad 45SC (200ml/ha) followed by a spray of Azadirachtin (0.03%) at an interval of 12 days proved to be the next effective treatment against fruit fly infesting cucumber with 12.00 mean number of pupae of fruit fly formed per five damaged fruits. Three foliar applications of NSKE (5%) at an interval of 12 days proved least effective treatment module with maximum mean number of pupae of fruit fly (61.92) formed per five damaged fruits.

3.3 Mean fruit damage (%)

The observations recorded on the mean per cent fruit damage in different treatment modules against fruit fly infesting cucumber during *kharif*, 2016, presented in Table 2 revealed that the minimum mean per cent fruit damage of 8.28 per cent was recorded in treatment module comprising three foliar applications of Spinosad 45SC (200ml/ha) at a 12 days interval, making it the most effective treatment module. The treatment module comprising application of two sprays of Spinosad 45SC (200ml/ha) followed by a spray of Azadirachtin (0.03%) at an interval of 12 days proved to be the next effective treatment against fruit fly infesting cucumber with 15.03 mean per cent fruit damage, which was at par with the treatment modules comprising foliar application of two sprays of Spinosad 45SC (200ml/ha) followed by a spray of NSKE (5%) with 23.33 mean per cent fruit damage. The treatment module comprising three applications of NSKE (5%) at an interval of 12 days proved least effective treatment module with 36.92 mean per cent fruit damage by cucurbit fruit fly in cucumber during *kharif*, 2016.

3.4 Marketable fruit yield (q/ha)
The results on marketable fruit yield in cucumber among different treatment modules during *kharif*, 2016 revealed that a significant higher yield was recorded in all the treatments over the control. The mean marketable fruit yield recorded in eight treatments ranged from 555.56 q/ha in treatment module comprising three foliar applications of Spinosad 45SC (200ml/ha) at 12 days interval to 241.67 q/ha in the control. The results revealed that the mean marketable fruit yield in treatment module comprising three foliar applications of Spinosad 45SC (200ml/ha) at 12 days interval was at par with the treatment modules comprising application of two sprays of Spinosad 45SC (200ml/ha) followed by a spray of Azadirachtin (0.03%) and two sprays of Spinosad 45SC (200ml/ha) followed by a spray of NSKE (5%) with 544.44 and 502.78q/ha of mean marketable fruit yield, respectively. The treatment module comprising three sprays of Azadirachtin (0.03%) at an interval of 12 days with a mean marketable fruit yield of 402.78 q/ha was the least effective treatment module.

3.5 Avoidable losses (%)
The results on avoidable losses in cucumber among different treatment modules during *kharif*, 2016 revealed that the mean avoidable losses in eight treatment modules were significantly higher over the control. The mean avoidable losses varied from 56.88 per cent in treatment module comprising three foliar applications of Spinosad 45SC (200ml/ha) at 12 days interval each to 0.00 percent in control. The results revealed that the mean avoidable losses in treatment module comprising three foliar applications of Spinosad 45SC (200ml/ha) at 12 days interval were at par with the treatment modules comprising application of two sprays of Spinosad 45SC (200ml/ha) followed by a spray of Azadirachtin (0.03%) and one spray each of Spinosad 45SC (200ml/ha), Azadirachtin (0.03%) and NSKE (5%) with 54.30 and 50.66 per cent of mean avoidable losses, respectively. The treatment module comprising one spray each of Spinosad 45SC (200ml/ha), Azadirachtin (0.03%) and NSKE (5%) was at par with two sprays of Spinosad 45SC (200ml/ha) followed by a spray of NSKE (5%), two sprays of Azadirachtin (0.03%) followed by a spray of NSKE (5%), three sprays of Azadirachtin (0.03%) and three sprays of NSKE (5%) each at an interval of 12 days with 50.25, 44.41, 40.45 and 38.91per cent of mean avoidable losses, respectively.

Table 2: Efficacy of different treatment modules against cucurbit fruit fly infesting cucumber during *kharif*, 2016.

Treatments	Mean number of fruits with ovipositor marks (a)	Mean number of pupae of fruit fly (b)	Mean per cent fruit damage (%)(c)	Marketable Yield (q/ha) (d)	Avoidable loss (%) (e)
T_1	5.92 (2.53)	49.58 (7.07)	34.95 (32.87)	402.78 (20.07)	39.28 (40.45)
T_2	1.50 (1.38)	5.92 (2.50)	15.92 (8.28)	555.56 (23.56)	49.02 (56.88)
T_3	7.17 (2.77)	61.92 (7.90)	37.41 (36.92)	411.11 (20.26)	37.67 (38.91)
T_4	4.58 (2.25)	28.33 (5.35)	28.86 (23.33)	502.78 (22.40)	45.07 (50.25)
T_5	4.92 (2.32)	40.50 (6.38)	31.30 (27.06)	441.67 (21.02)	41.59 (44.41)
T_6	2.83 (1.82)	12.00 (3.50)	22.68 (15.03)	544.44 (23.31)	47.64 (54.30)
T_7	4.67 (2.27)	30.00 (5.52)	29.48 (24.23)	488.89 (22.10)	45.42 (50.66)
T_8	12.75 (3.64)	77.75 (8.84)	53.34 (64.23)	241.67 (15.44)	0.00 (0.00)
S. Em (±)	0.11	0.26	2.08	0.88	3.18
CD (5%)	0.32	0.79	6.31	2.66	9.64

Note- In columns (a), (b) and (d) - figures in parentheses are $\sqrt{x+0.5}$ values
In columns (c) and (e) - figures in parentheses are retransformed per cent values

4. Discussion
It can be inferred from the results that the sprays of Spinosad 45SC (200ml/ha), Azadirachtin (0.03%) and NSKE (5%) alone and their different combinations can significantly suppress the cucurbit fruit fly infestation in cucumber and were found superior over control. It appeared from the results that three sprays of Spinosad 45SC @ 200ml/ha alone at an interval of 12 days was most effective against fruit fly infesting cucumber. The effectiveness of Spinosad was reported by Stark *et al.* [7], Urbaneja *et al.* [8] and Birah *et al.* [9]. In the present investigation it has been indicated that the integration of bio-pesticide; Azadirachtin (0.03%) and plant product; NSKE (5%) in combination with Spinosad 45SC (200ml/ha) was not only effective in managing the cucurbit fruit fly in cucumber but also reduces the pesticides load as in three sprays of Spinosad 45SC (200ml/ha) at an interval of twelve days. The results further revealed that bio-pesticide; Azadirachtin (0.03%) alone and in combination with spinosad 45SC (200ml/ha) or NSKE (5%) was also superior over three sprays of NSKE (5%) alone, at an interval of twelve days. The positive results of using Azadirachtin were obtained by Stark *et al.* [10]. However, treatment module with three sprays of Spinosad 45SC (200ml/ha) was found the most effective against cucurbit fruit fly in cucumber but the integration of Azadirachtin (0.03%) and NSKE (5%) with Spinosad 45SC (200ml/ha) was also found as effective as the individual treatment module of three sprays of Spinosad 45SC (200ml/ha) alone and the treatment module with three sprays of NSKE (5%) was found to be least effective against cucurbit fruit fly in cucumber but the integration of Azadirachtin (0.03%) and NSKE (5%) was found more effective than the individual treatment of NSKE (5%) and Azadirachtin (0.03%). Integration of Azadirachtin with other insecticides and bio-pesticides giving better results has been reported by Nathan and Kalaivani [11] and Hummelbrunner and Isman [12]. Thus, by integrating Spinosad 45SC (200ml/ha) with Azadirachtin (0.03%) and NSKE (5%), the application of Spinosad can be reduced minimizing the pesticide load in cucumber and reducing the cost of pest management.

5. Conclusion
From the present discussion it can be inferred that sprays of Spinosad 45SC (200ml/ha), Azadirachtin (0.03%) and NSKE (5%) alone and their different combinations can significantly suppress the cucurbit fruit fly infestation in cucumber and were found superior over control. Treatment module comprising three foliar applications of Spinosad 45SC (200ml/ha) yielded better results against cucurbit fruit fly

infestation in cucumber but by integrating Spinosad 45SC (200ml/ha) with Azadirachtin (0.03%) and NSKE (5%), the application of Spinosad can be reduced minimizing the pesticide load in cucumber and reducing the cost of pest management. The treatment module with three sprays of NSKE (5%) was found to be least effective against cucurbit fruit fly in cucumber but the integration of Azadirachtin (0.03%) and NSKE (5%) was found more effective than the individual treatment of NSKE (5%) and Azadirachtin (0.03%).

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