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Bio-efficacy of insecticides against fruit fly, *Bactrocera cucurbitae* (Coquillett) in cucumber

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Abstract
Field experiment on the effect of different insecticides against fruit fly, *Bactrocera cucurbitae* (Coquillett) infesting cucumber was carried out during *kharif* 2017 and summer 2018 at Chikkamagaluru. The results revealed that significantly lowest number of ovipositional punctures (0.72 and 0.98 /fruit), lowest number of maggots (8.0 and 8.93 /fruit), lowest percent fruit infestation (14.92 and 17.90 %), highest marketable fruit yield (15.63 and 16.49 t/ha.) and more cost-benefit ratio (1: 2.30 and 1: 2.43) was recorded in the treatment with spinosad 45 SC (0.15 ml/l) during both *kharif* and summer season, respectively and it was on par with the treatment dichlorvos 76 EC (1.0 ml/l). However, highest number of ovipositional punctures (2.72 and 3.01 /fruit), highest number of maggots (19.13 and 19.80 /fruit), highest percent of fruit infestation (46.91 and 56.79 %) and lowest marketable fruit yield (10.75 and 9.01 t/ha.) was obtained in the jaggery treatment (10 g/l) which was followed by control in both *kharif* and summer season, respectively. During the *kharif* season the lowest cost-benefit ratio (1: 1.62) was obtained in jaggery treatment while in summer season cyantraniliprole 10.26 OD recorded the lowest cost-benefit ratio (1: 1.34).

Keywords: Cucumber, fruit fly, insecticides, *kharif*, management, summer

1. Introduction
Cucumber (*Cucumis sativus* L.) the popular crop of the Cucurbitaceae family is grown throughout the world. The melon fruit fly, *Bactrocera cucurbitae* (Coquillett) is a serious pest of cultivated cucurbits. It was first reported in India by Lefroy during 1907 which reduce not only the quality of fruits and vegetables but also a serious limiting factor in the production of gourds, cucumber, melon and other cucurbits to the extent that it's growing may become highly unprofitable. Generally, the female fruit flies puncture the soft and tender fruits by their sharp ovipositor and lay the eggs under fruit tissues and guumy fluid oozes from the puncture. The fruit flies also oviposit in the tender plant tissues such as terminals, unopened flowers, young stems and seedlings which may result in the death of the plant (Kate *et al.*, 2009) [1]. After hatching, the maggots feed on the pulp of the fruits by making galleries and simultaneously the secondary infection also arises, resulting in rotting of fruits (Gupta and Verma, 1995) [2]. The extent of losses caused by *B. cucurbitae* varies from 30 to 100 percent depending on the cucurbit species and season (Dhillon *et al.*, 2005) [3].

The control measures are as difficult as in the Tephritidae family of insects. Some weak link in the life history of the pest is exploited by the economic entomologists. Several management techniques are being applied against this pest because three of its life stages are hidden and the only adult stage is the usual target for its management. Mostly chemically-based insecticides are used for their control without knowing the ill effects of these chemicals on the environment. The residues of pesticide affected the export potential of gourd because of serious concern of the importing countries (Quasem, 2003) [4]. Moreover, repeated use of toxic insecticides is not only hazardous to the environment but also directly affects the health of the farmers and consumers. Therefore, it is necessary to explore economically sustainable and environment-friendly insecticides for management of fruit fly.

However, the information on the use of safer insecticides to manage this pest on cucumber is very scanty. Therefore, the present investigation was undertaken to evaluate the bio-efficacy of some insecticides against *B. cucurbitae* attacking cucumber under hill zone of Karnataka.

2. Materials and Methods

The experiment was conducted during *kharif* 2017 and summer 2018 at Amble village, Chikkamagaluru to evaluate the insecticide components for the management of fruit fly. The field experiment was laid out in a randomized block design with three replications and ten treatments. The cucumber seeds (variety Indam Swadist (43)) were sown during the third week of September during *Kharif* and the second week of March during the summer season in an area of 500 m². All cultural practices as recommended in the package of practices of agricultural and horticultural crops - 2015 by University of Agricultural Sciences, Bengaluru was adopted. The treatments included malathion 50 EC (2.0 ml/l), cyantraniliprole 10.26 OD (1.8 ml/l), dichlorvos 76 EC (1.0 ml/l), acephate 75 SP (1.0 g/l), spinosad 45 SC (0.15 ml/l), deltamethrin 2.8 EC (0.5 ml/l), azadirachtin 10000 ppm (1.0 ml/l), azadirachtin 300 ppm (5 ml/l), jaggery alone (10 g/l) and control (water spray). However, jaggery (@ 10 g/l of water) was added for all the insecticides at the time of spraying except the control to encourage the adults (especially females) to feed on the spray residue which could provide good rates of kill.

A total of two foliar spray applications was taken at 15 days interval. The treatments for the management of fruit fly were imposed at 5^{th} and 8^{th} week after sowing by using Knapsack sprayer after taking the pre-treatment count of fruit fly damage. The first foliar spray was taken at the fruit setting stage when oviposition marks were noticed on cucumber fruits and when the fruit flies caught in the pheromone trap crossed the economic threshold level of 1.46 adults per trap per day. From each treatment, five plants were selected (randomly during *kharif* season and tagged plants during summer season) and the observations on the number of ovipositional punctures per fruit, number of maggots per fruit and percent fruit infestation due to fruit fly before treatment and three, five and ten days after treatment was recorded. Percent fruit damage was worked out by using formula.

$$\text{Per cent fruit damage} = \frac{\text{Number of fruits infested}}{\text{Total number of fruits observed}} \times 100$$

Furthermore, five infested fruits from each treatment were randomly selected, plucked and brought to the laboratory to count the number of maggots. These infested fruits were cut open near the damaged part of the fruit and the numbers of maggots in the pulp of the infested fruit were recorded.

In each plot, irrespective of healthy and infested, marketable sized cucumber fruits were harvested. At each fruit picking, the healthy and infested fruits were sorted out separately, weighed and noted. The weight of the healthy fruits from all the fruit pickings in each plot was pooled to get yield per plot (kg) and was converted to yield per hectare (tonnes). Further, the Cost-Benefit ratio (C: B ratio) was also worked out to determine the best treatment. The data about efficacy trial were analyzed using one way ANOVA. The mean values for all the parameters were calculated and the analysis of variance was accomplished and means were separated by Duncan's Multiple Range Test (DMRT).

3. Results and Discussion

The results of the present investigation on the efficacy of different insecticides against melon fruit fly in cucumber crop exhibited variable efficacy in reducing the number of ovipositional punctures, number of maggots as well as a fruit infestation over untreated control and jaggery alone treatment during *kharif* 2017 and summer 2018 at Chikkamagaluru (Table 1). The data revealed that the treatment spinosad 45 SC was found significantly more effective in reducing the fruit fly infestation at three, five and ten days after spraying at first and second spray during both the seasons. The treatment, spinosad 45 SC recorded significantly lowest mean number of ovipositional punctures (0.72 and 0.98 /fruit), lowest mean number of maggots (8.0 and 8.93 /fruit), lowest mean percent of fruit infestation (14.92 and 17.90 %) and fetched significantly higher fruit yield (15.63 and 16.49 t/ha.) as well as the highest cost-benefit ratio (1: 2.30 and 1: 2.43) as compared to the other treatments during *kharif* and summer season, respectively (Table 1). The present results were in close agreement with the earlier report of Shivangi *et al.* (2017) [5] opined that spinosad (200 ml/ha.) was the most effective treatment module against fruit fly in cucumber with the least mean number of ovipositor marks, mean number of pupae formed from damaged fruits, mean percent fruit infestation and avoiding maximum losses with highest fruit yield. Vinutha and Kotikal (2018) [6] also found that spinosad 45 SC @ 0.3 ml/l of water were found very effective in minimizing the fly population, *B. cucurbitae* on oriental pickling melon and were superior in reducing the fruit damage (4.83 %) and also fetched higher yield (18.16 t/ha). The effectiveness of spinosad was mainly due to its toxicity by rapid contact and ingestion activity which is unusual for a biological product.

The treatment spinosad was statistically on par with dichlorvos 76 EC in which 1.02 and 1.12 mean number of ovipositional punctures, 9.38 and 9.67 mean number of maggots per fruit, 18.29 and 21.77 mean percent of fruit infestation, 13.91 and 14.28 tonnes/ ha. of fruit yield with a cost-benefit ratio of 1: 2.06 and 1: 2.12 was recorded during *kharif* and summer season respectively (Table 1). The results were in agreement with results of Sawai *et al.* (2014) [7] who reported that the treatment DDVP (dichlorvos) was also found better in managing the fruit fly in ridge gourd after the treatment deltamethrin with lowest fruit damage (22.83 %), highest marketable yield (19.96 t/ha.) and highest incremental benefit-cost ratio (1: 26.51).

Further, deltamethrin 2.8 EC was the next better insecticide against fruit fly as it recorded 1.14 and 1.21 mean number of ovipositional punctures, 10.10 and 10.04 mean number of maggots, 19.99 and 24.21 mean percent fruit infestation, 13.35 and 13.68 tonnes/ha. of fruit with a cost-benefit ratio of 1: 1.99 and 1: 2.05 during *kharif* and summer season, respectively and it was statistically on par with azadirachtin 10000 ppm and azadirachtin 300 ppm (Table 1). The present results partly conform with Oke (2008) [8] who observed that deltamethrin and lambda-cyhalothrin were effective against *B. cucurbitae* on cucumber. Deltamethrin being a pure cis-isomer rapidly paralyze the insect giving a quick knock down effect. However, the decrease in efficacy of deltamethrin in the present study might be because of high temperature (29.24 ℃ and 35.57 ℃ during *kharif* and summer, respectively) as it exhibits negative temperature coefficient (Deken *et al.* 1998) [9].

Whereas, treatments of azadirachtin 10000 ppm, azadirachtin 300 ppm, malathion 50 EC, cyantraniliprole 10.26 OD and acephate 75 SP were found superior over control during both *kharif* and summer season. Further, the highest number of ovipositional punctures (2.72 and 3.01 /fruit), highest number of maggots (19.13 and 19.80 /fruit), highest percent of fruit infestation (46.91 and 56.79 %), lowest yield (10.75 and 9.01 t/ha.) and lowest cost-benefit ratio (1: 1.62 and 1: 1.36) was recorded in jaggery treatment which was followed by control during both *kharif* and summer season respectively (Table 1). The results obtained with the jaggery are in close congruity with the reports of Waseem *et al.* (2009) [10] as highest fruit infestation (45.33 %) was recorded in jaggery treatment than control (41.00 %). Maximum infestation in jaggery was because, jaggery acts as a phagostimulant, which induces sustained feeding and attract pests resulting in more number of ovipositional punctures and more number of maggots. Most dipterans, especially adult tephritids, for their survival and reproduction they actively search for food sources such as honeydew, nectar, plant juice, bacteria, yeast and animal excreta (Prokopy and Roitberg, 1992) [11]. Hence, the order of efficacy of insecticides against melon fruit fly is spinosad 45 SC > dichlorvos 76 EC > deltamethrin 2.8 EC > azadirachtin 10000 ppm > azadirachtin 300 ppm > malathion 50 EC > cyantraniliprole 10.26 OD.

Table 1: Efficacy of insecticides against fruit fly, *Bactrocera cucurbitae* in cucumber

T. No.	Treatments	Dosage/l	Mean no. of ovipositional punctures /fruit*		Mean no. of maggots /fruit*		Mean % fruit infestation**		Yield (t/ha.)		C: B ratio	
			Kharif 2017	Summer 2018	*Kharif* 2017	Summer 2018	*Kharif* 2017	Summer 2018	*Kharif* 2017	Summer 2018	*Kharif* 2017	Summer 2018
T_1	Malathion 50 EC	2.0 ml	1.38 $(1.37)^{d}$	1.41 $(1.38)^{bc}$	11.28 $(3.43)^{de}$	10.94 $(3.38)^{c}$	25.28 $(30.13)^{de}$	29.57 $(32.90)^{c}$	11.48	10.62	1.72	1.59
T_2	Cyantraniliprole 10.26 OD	1.8 ml	1.39 $(1.37)^{d}$	1.41 $(1.38)^{bc}$	11.43 $(3.45)^{de}$	10.73 $(3.35)^{bc}$	25.22 $(30.13)^{de}$	27.58 $(31.63)^{c}$	11.60	10.52	1.47	1.34
T_3	Dichlorvos 76 EC	1.0 ml	1.02 $(1.23)^{b}$	1.12 $(1.27)^{ab}$	9.38 $(3.14)^{b}$	9.67 $(3.19)^{ab}$	18.29 $(25.25)^{ab}$	21.77 $(27.76)^{ab}$	13.91	14.28	2.06	2.12
T_4	Acephate 75 SP	1.0 g	1.44 $(1.39)^{d}$	1.40 $(1.38)^{bc}$	11.63 $(3.48)^{e}$	10.77 $(3.36)^{c}$	26.71 $(31.11)^{e}$	29.18 $(32.65)^{c}$	11.93	10.43	1.77	1.54
T_5	Spinosad 45 SC	0.15 ml	0.72 $(1.10)^{a}$	0.98 $(1.21)^{a}$	8.00 $(2.92)^{a}$	8.93 $(3.07)^{a}$	14.92 $(22.71)^{a}$	17.90 $(25.03)^{a}$	15.63	16.49	2.30	2.43
T_6	Delatmethrin 2.8 EC	0.5 ml	1.14 $(1.28)^{bc}$	1.21 $(1.31)^{bc}$	10.10 $(3.26)^{bc}$	10.04 $(3.25)^{bc}$	19.99 $(26.49)^{bc}$	24.21 $(29.47)^{bc}$	13.35	13.68	1.99	2.05
T_7	Azadirachtin 10000 ppm	1.0 ml	1.29 $(1.34)^{cd}$	1.30 $(1.34)^{bc}$	10.55 $(3.32)^{cd}$	10.39 $(3.30)^{bc}$	22.58 $(28.32)^{cd}$	26.62 $(31.05)^{c}$	12.53	12.74	1.87	1.91
T_8	Azadirachtin 300 ppm	5.0 ml	1.32 $(1.35)^{cd}$	1.33 $(1.35)^{bc}$	10.73 $(3.35)^{cde}$	10.42 $(3.30)^{bc}$	23.05 $(28.66)^{cd}$	26.84 $(31.18)^{c}$	12.28	12.17	1.80	1.78
T_9	Jaggery alone	10.0 g	2.72 $(1.79)^{e}$	3.01 $(1.87)^{d}$	19.13 $(4.43)^{g}$	19.80 $(4.51)^{e}$	46.91 $(43.22)^{f}$	56.79 $(48.85)^{d}$	10.75	9.01	1.62	1.36
T_{10}	Control (water)		2.57 (1.75)e	2.59 $(1.76)^{c}$	17.66 $(4.26)^{f}$	18.34 $(4.34)^{d}$	43.98 $(41.50)^{f}$	54.05 $(47.29)^{d}$	10.98	9.10	1.67	1.39
	S. Em.±		0.03	0.02	0.05	0.05	0.77	1.08	0.89	0.40		
	CD @ 5%		0.08	0.07	0.14	0.16	2.30	3.21	2.66	1.19		

*Figures in the parentheses are square root transformed values;
**Figures in the parentheses are angular transformed values

4. Conclusion

The bio-efficacy of the insecticides revealed that, significantly lowest number of ovipositional punctures, lowest number of maggots, lowest percent fruit infestation, highest marketable fruit yield and more cost-benefit ratio was recorded in the treatment with spinosad 45 SC (0.15 ml/l) during both *kharif* and summer season, respectively and it was on par with the treatment dichlorvos 76 EC (1.0 ml/l).

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