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Short Communication

Efficacy of integrated pest management (IPM) modules against fruit fly (*Bactrocera cucurbitae* C.) in bitter gourd

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Bitter gourd (*Mormodica charantia,* Cucurbitaceae) is one of the popular vegetable crops in the tropical and sub-tropical regions of the world and grown extensively in India which accounts for about 31% of global production. The demand of this vegetable is constantly increasing owing to its better nutritional and medicinal value as the fresh fruits are excellent source of folates, vitamin-C, flavonoids and high dietary fiber. Most importantly, it contains an insulin-like polypeptide that has been suggested as an insulin replacement in diabetic patients and therefore, always enjoys a premium price in the market which ultimately makes it a highly remunerative crop. Bitter gourd is attacked by 24 species of insect pests at different growth stages belonging to five different Orders (Sunil, 2017) and among them melon fruit fly (*Bactrocera cucurbitae* Coq. Tephritidae, Diptera) is the most destructive insect pests (Panday et al. 2008) and continues to be the major production constraint in cultivation of cucurbits worldwide. The fruit fly has been observed on 81 host plants and out of which bitter gourd is highly preferred (Panday et al. 2009) and infestation by this insect pest causes a yield loss ranging from 30-100% depending upon crop species and the season (Dhillon et el. 2005) and in bitter gourd it accounts for a yield loss of around 31.27% (Singh et al. 2000). Nath and Bhushan (2006) screened thirteen cucurbit crops *viz.,* bottle gourd, cucumber, water melon, round gourd, musk melon, bitter gourd, long melon, pumpkin, sponge gourd, smooth gourd, ridge gourd, ash gourd and snake gourd for their resistance to the *B. cucurbitae* in Varanasi, Uttar Pradesh during summer and rainy season and observed maximum damage in bitter gourd (26.11 and 31.96 %) during summer and rainy, respectively. The adult female lays eggs 2 to 4 mm deep in the fruit pulp by inserting its ovipositor and the maggots upon hatching feed inside the developing fruit leading to rotting and premature fall. The larvae pupate in the soil at a depth of 0.5 to 15 cm and the depth up to which the larvae move in the soil for pupation, and survival depend on soil texture and moisture (Dhillon et el. 2005). As this pest has concealed nature of feeding, external application of insecticides often found to be ineffective and uneconomic with hazardous effect on non-target organisms and surrounding environment. Keeping the extent of damage inflicted by fruit fly, the increasing frequency of pest infestation under the changing climatic scenario and the undesirable consequences of indiscriminate application of highly toxic insecticides in view there is an urgent need to look at some alternate management strategies for minimizing the pest damage and restoring human and agro-ecosytem health. Most of the recent efforts in fruit fly management have primarily focused on trapping and killing of mature adults using bait application techniques (BAT) and male annihilation techniques. Vargas et al. (2005) also reported that poison bait and male annihilation techniques, separately and in conjugation play an important role in suppression of fruit flies. Mass-trapping of fruit flies through pheromone and other bait traps will reduce the fruit fly population, minimize the use of pesticides and help establish a safe control measure to produce pesticide-free cucurbit vegetables (Pandey et al. 2010). Besides, destruction of damaged fruits and killing of soil inhabiting pupae are also considered as an important component of IPM. Burying damaged fruits 0.46 m deep in the soil prevents adult fly eclosion and reduces population increase (Klungness et al. 2005). The present investigation was aimed at evaluating the efficacy of some IPM modules for minimizing the infestation of fruit fly in bitter gourd.

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The experiments were carried out at the research plot of Regional Research and Technology Transfer Station (RRTTS), Ranital of Odisha University of Agriculture and Technology located at 21.1463° N, 86.5656° E during the summer seasons of 2017, 2018 and 2019 to evaluate the efficacy of some IPM modules for the management of fruit fly in bitter gourd. The trial was laid out in randomized block design with four treatments (3 IPM module and control) and five replications with individual plot size of 5 X 4 m. Bitter gourd variety *Green Long* was sown during the last week of January with row to row spacing of 1.0 m and plant to plant distance of 60 cm and the crop was maintained with recommended agronomic package of practices and standard intercultural operation. Treatment wise IPM components (table 1) were imposed during the crop growth period. The poison bait was prepared and placed at 2.5 m interval and the bait solution was sprayed @ 30 ml at one spot in each plot at 10 days interval from flowering initiation. The bait materials used for placement were changed at 5 days interval and freshly prepared poison baits were placed there for further use. Data on infested and healthy fruits on number and weight basis were recorded separately during each harvest. Cumulative numbers of infested and healthy fruits from all the pickings during crop seasons were considered to work out the per cent fruit fly damage. The data on fruit damage (both on number and weight basis) after necessary transformation were subjected to statistical analysis to find out the efficacy of the IPM modules. The total fruit yield of the crop was calculated by cumulating the weight of each harvest in individual plot and converted into per hectare yield. Similarly, avoidable yield loss was worked out with respect to treatments in which maximum yield was obtained (Mathur and Jain 2009). Based on the mean fruit yield data, comparative economics of the IPM modules was calculated in terms of net return and B:C ratio.

Table 1: IPM modules evaluated for the management of melon fruit fly in bitter gourd

Treatments	Details of Module
T_1 (Module 1)	Soil application of chlorpyriphos 1.5 % dust in the interspaces @ 25 kg/ ha at 30 DAS + Placement and spot application of Jaggery (100 g), cartap hydrochloride (2 g) & water (1 liter) poison bait + Installation of cuelure @ 20/ha + Periodic removal and destructions of damaged fruits
T_2 (Module 2)	Soil application of Fenvalarate 2 % dust in the interspaces @ 25 kg/ ha at 30 DAT + Placement of carbofuran 3 G (10 g) , citric acid (5 ml) and rotten banana (1 kg) poison bait + Installation of cuelure @ 20/ha + Periodic removal and destructions of damaged fruits
T_3 (Module 3)	Soil drenching of chlorpyriphos 20 EC in the interspaces @ 2.5 l/ ha at 30 DAG + Placement and spot application of Jaggery (100 g), malathion (5 ml) & water (1 liter) poison bait + Installation of cuelure @ 20/ha + Periodic removal and destructions of damaged fruits
T_4	Untreated Control

Per cent avoidable yield loss = [(Yield obtained from the most effective module-Yield obtained from the reference module) / Yield obtained from the most effective module] X 100

Significant difference was remarkably observed among the treatments regarding the extent of fruit infestation and all the IPM modules were found to be highly effective in controlling the fruit fly infestation in bitter gourd. The IPM module 1 retained its superiority in effectively suppressing the fruit damage throughout the period of investigation with the minimum mean fruit infestation (6.43 and 5.13 % fruit damage on number and weight basis, respectively) against as high as 26.76 and 22.13 % fruit damage on number and weight basis, respectively in the untreated control plot. The maximum fruit infestation in the control plot justified the severe damage potential of fruit fly in bitter gourd crop in the absence of any crop protection measures. The IPM module 3 with 8.53 and 7.11 % fruit damage on number and weight basis, respectively was found to be the next effective treatment with around 68 % reduction in fruit damage over the untreated control, whereas, the module 2 offered a moderate control with 13.35 and 11.21 % fruit damage on number and weight basis, respectively i.e. around 50 % decrease over the untreated control. A comparatively lesser efficacy of IPM module 2 might be due to the absence of bait spraying technique which otherwise could kill a sizable population of fruit fly adults. The lower fruit fly damage in the IPM plots was mainly attributed to the cumulative effect of bait application technique (BAT) comprising of poison bait placement and spraying of bait solutions which attracted and killed the adult flies, male annihilation technique (MAT) to trap the adult males and restricted the pest population build up, destruction of soil inhabiting pupae through the application of pesticide and periodic destruction of infested fruits to restrict the perpetuation of damage.

The lowest fruit damage in the module 1 resulted in the highest mean fruit yield of 69.39 q/ ha (33.05 % higher than the untreated control) followed by module 3 (67.07 q/ ha i.e. 28.60 % higher than the control) and both the module were statistically comparable effect as far as the crop yield was concerned. The module 2 registered a 19.19 % higher yield (62.16 q/ ha), whereas, the lowest fruit yield was recorded in the untreated plots (52.15 q/ ha). Maximum avoidable yield loss of 24.84 % was estimated in the untreated control plot which revealed that adoption of IPM module 1 could have saved

Table 2: Effect of IPM modules on fruit fly infestation in bitter gourd

IPM Modules	Fruit damage on number basis (%)					Fruit damage on number basis (%)				
	2017	2018	2019	Mean	% decrease over control	2017	2018	2019	Mean	% decrease over control
M1	6.87 (2.70)	7.48 (2.82)	4.94 (2.33)	6.43 (2.63)	75.97	5.12 (2.36)	6.23 (2.58)	4.05 (2.12)	5.13 (2.37)	76.81
M2	13.24 (3.70)	15.11 (3.95)	11.70 (3.48)	13.35 (3.72)	50.11	10.35 (3.29)	13.05 (3.67)	10.23 (3.26)	11.21 (3.42)	49.35
M3	9.05 (3.08)	9.52 (3.16)	7.03 (2.73)	8.53 (3.00)	68.12	7.17 (2.76)	8.07 (2.92)	6.08 (2.55)	7.11 (2.76)	67.88
Control	25.56 (5.09)	28.51 (5.38)	26.21 (5.16)	26.76 (5.21)		19.89 (4.50)	23.64 (4.90)	22.87 (4.82)	22.13 (4.75)	
SE (m) ±	0.131	0.123	0.138	0.086		0.144	0.114	0.149	0.077	
CD (0.05)	0.40	0.38	0.43	0.27		0.44	0.35	0.46	0.24	

Table 3: Effect of IPM modules on yield and economic of bitter gourd production

IPM Modules	Fruit Yield (Q/ ha)				% increase over control	% Avoidable yield loss	Net Return (₹)	B:C ratio
	2017	2018	2019	Mean		2017	2018	2019
M1	69.38	66.69	72.09	69.39	33.05	-	78859.33	2.32
M2	64.13	58.23	64.12	62.16	19.19	10.42	65660.00	2.12
M3	67.41	64.08	69.71	67.07	28.60	3.34	74811.33	2.26
Control	53.68	50.17	52.60	52.15	-	24.84	49136.00	1.89
SE (m) ±	2.811	1.212	1.30	0.766				
CD (0.05)	3.20	3.73	3.99	2.36				

24.84 % yield loss in bitter gourd crop. The maximum net return of Rs. 78859.33 and B:C ratio of 2.32 indicated the economically superiority of IPM module 1 closely followed by the module 3 (net return of Rs. 74811.33 and B:C ratio of 2.26).

The result of this experiment derived ample support from the findings of Ranganath et al. (2015) who opined that the IPM package comprising of bait sprays coupled with installation of cuelure traps and stringent sanitation resulted in low melon fly damage and higher yield as compared to all chemical treatments and control. Rana and Kanwar (2014) further reported that combined treatment of cue-lure baited traps and poison bait spray was most effective in management of fruit flies with significantly less fruit damage as compared to their separate application. Chaudhary and Patel (2008) also reported lower fruit fly infestation and higher yield of pumpkin with the combined use of male annihilation technique and poison bait spray. Bait spray encourages the adults (especially female) to feed on the spray residue and can provide good rates of kill in comparison to the sole application of insecticides (Sunil et al. 2016). Birah et al. (2015) also observed that installation of cue-lure baited traps @ 50 traps/ha for mass trapping and weekly clipping of infested fruits resulted in 56.5 % less fruit damage and 36.0 % higher fruit yield in comparison to the untreated control. Hence, it can be concluded from the present investigation that combined use of cue-lure baited traps, placement and spot application of poison bait, killing of soil inhabiting pupae and destruction of damaged fruits proved to be highly effective for the management of fruit flies in bitter gourd crop as evidenced by lower fruit damage and higher fruit yield.

Among the three IPM modules, the module comprising of soil application of chlorpyriphos 1.5% dust in the interspaces @ 25 kg/ha at 30 DAS, placement and spot application of poison bait [Jaggery (100 g), cartap hydrochloride (2 g) & water (1 liter)], installation of cue lure @ 20/ha for mass trapping of adult male flies and periodic removal and destructions of damaged fruits offered the maximum control of fruit fly with the least fruit damage (5.43 and 4.13 on number and weight basis, respectively) which was around 76 % reduction over the untreated control. The lowest fruit damage in this module contributed to the highest fruit yield (69.39 q/ ha) and resulted in the maximum net return and B:C ratio.

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