Indian Journal of Ecology (2022) 49(5) (SI): 2005-2007
DOI: https://doi.org/10.55362/IJE/2022/3775

Manuscript Number: 3775
NAAS Rating: 5.79

Evaluation of Different IPM Modules for Management of Fruit Fly *Bactrocera cucurbitae* (Coquillett) in Summer Squash (*Cucurbita pepo* L.)

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***Abstract*:** Six integrated pest management (IPM) modules were evaluated with cost benefit ratio was calculated. M-I and M-II were tested with integration of pest management strategies i.e., use of methyl eugenol trap, weekly clipping of infested fruits, maize as a trap crop and use of chemical insecticides i.e., spinosad in M-I and imidacloprid in M-II. Malathion with sugar was tested in M-III. In M-IV, recommended package of practices were followed and in M-V, farmers practice was tested while as M-VI was control. All IPM modules were significantly superior over control in reducing fruit fly damage. However, module-I showed least percent damage in summer squash fruit on number basis (16.15%) and on weight basis (11.69%). The maximum adult fruit fly mortality (87.00%) was with spot application of spinosad and maximum fruit yield (35 t/ha) were obtained in M-I with highest cost -benefit ratio (1: 3.96) for the whole cropping period.

***Keywords*:** Summer squash, *Bactrocera cucurbitae*, Methyl eugenol, Spinosad, IPM

Cultivation of summer squash (*Cucurbita pepo* L.) is now gaining momentum and popularization among farming community due to higher nutritional value, short duration nature, accompanied with higher economic returns in shorter span of time. In India, summer squash along with other gourd crops cultivated on 4.77 m ha with annual production of 5.10 million tonnes which brings up the average productivity of 9.72 tonnes/ha (FAO 2017). In Jammu region, the cucurbits cover an area of 2486 ha with annual production of 51707.11 MT (Anonymous 2017). The major limiting factors responsible for considerable crop damage at different stages from nursery raising to the harvest are insect pests. Among them, tephritid fruit fly, *Bactrocera cucurbitae* is the most destructive insect pests of cucurbits and squash (Sapkota et al 2010). The extent of losses inflicted by dipteran flies vary from 30 to 100 per cent depending upon cucurbit species and environmental conditions (Dhillon et al 2005, Jayraj 2013, Shooker et al 2006,). Their attack not only results in reduced crop yield but also causes indirect loss such as reduction in trade and export prospect (Sharma et al 2015) thereby affecting local and export markets and thus making farming unprofitable. The management of fruit fly in cucurbitaceous is reasonably difficult because the maggot of *B.cucurbitae* is an internal feeder due to which the farmers rely largely on different kinds of broad spectrum chemical insecticides. However, the increasing use of chemical insecticides has led to number of problems such as development of resistance in insect pests against insecticides, resurgence of pests, secondary pest outbreaks, ecological imbalance, risk to human health and environment. Also, before the non-judicious use of chemical insecticides has aggregated the problem of pesticidal residue in crops which is a matter of serious concern. Thus emphasis is on integrated pest management strategies as an alternative tool that can be explore for developing an effective, cheap and eco-friendly pest control devise. Keeping these facts in view, the present experiment was carried out to evaluate different IPM modules for management of fruit fly in Jammu region.

MATERIAL AND METHODS

The experiment comprised of 6 treatments (Table 1) and was conducted in randomized block design with four replications in plot size of 5×4 m^2 at Sher-e-Kashmir University of Agricultural Sciences and Technology Chatha, Jammu (Skuast-Jammu). The summer squash variety "DON 17" was sown in polybags in February 2018, and transplanted in main field in March, 2018. All cultural practices recommended as per the package of practices of Skuast-Jammu were followed. Observations on percent fruit damage (number basis and weight basis), adult fruit fly mortality and yield in each module were recorded to calculate benefit cost ratio on the basis of increased yield over control. Data were statistically analysed by SPSS-16.0 software and means were compared with Tukey's HSD test at P≤0.05.

RESULTS AND DISCUSSION

All the IPM modules were significantly superior over control wherein, M-I out yielded all other treatments and recorded highest cost: benefit ratio (1:3.96), least per cent damage on number basis (16.15%) and on weight basis (11.69%) along with maximum fruit fly mortality (87.00%) with spot application of spinosad for whole cropping period. The descending order of performance of different modules was Module I> Module II > Module III > Module IV > Module V> Module VI. Birah et al (2015) also observed that IPM module comprising of installation of cue-lure baited traps was most effective for managing fruit fly (*B. cucurbitae*) in cultivated cucurbits.

Damage of summer squash fruit (Number basis): Among different IPM modules, module I was found to be superior and showed least percent damage (16.15%) followed by module II with 17.15% damage. The module III recorded 23.40% fruit damage followed by module IV and module V with 28.35% and 40.19% fruit damage respectively. The descending order of performance of modules was as follows: Module I > Module II > Module III > Module IV > Module V>Module VI (Table 2). Shinde et al (2007) also reported that spinosad 75 SC @75 a.i per ha resulted in minimum fruit infestation as in module I in which application of spinosad with gur as spot application along with maintaining field sanitation by weekly clipping of infested fruits, using maize as a trap crop and use of low cost innovative traps showed least fruit infestation.

Damage of summer squash fruit (Weight basis) : IPM modules showed significant difference over each other for percent damage of fruits on weight basis. Module I was superior with lowest per cent damage of summer squash fruit (11.69%) followed by module II, III, IV and V. Module VI (control) recorded maximum per cent damage of fruit on weight basis (52.39%). Raghuvanshi et al (2008) and Vargas et al (2005) reported that male annihilation techniques play an important role in suppression of fruit flies that results in minimum percent damage. In present study use of low cost methyl eugenol trap played key role beside spot application of spinosad resulted in minimum damage on weight basis.

Adult fruit fly mortality in summer squash on spot application of insecticides: Module I was superior and recorded highest adult fruit fly mortality (87%)for the whole cropping period followed by module II , III , IV (Table 2). Module V recorded lowest fruit fly mortality (40.32%). In module VI (control) no adult fruit fly mortality was recorded. Yee et al (2006) who also reported that application of spinosad and traps baited with spinosad cause maximum adult mortality in fruit fly and also observed that spinosad was more effective.

Economics of different IPM modules for management of fruit fly in summer squash: During 2018 all modules were cost effective (Table 3). The highest yield was in module I with 35 t/ha followed by module II, module III, module IV and module V with 32t/ha, 26t/ha, 22t/ha and 16t/ha respectively. The least yield was in module control (8 t/ha). The increase in yield of cucurbits using bait technique has also been reported by

Table 2. Performance of different IPM modules

Modules	Fruit damage (%) (Number basis)	Fruit damage (%) (Eight basis)	Adult fruit fly mortality (%)
M I	16.15^{e}	11.69^{e}	87.00^{a}
M II	17.15^{e}	12.51^{e}	84.82^{b}
M III	23.40^{d}	17.98^{d}	73.92^{c}
M IV	28.35^{c}	22.03^{c}	60.64^{d}
M V	40.19^{b}	32.81^{b}	40.32^{e}
M VI (Control)	60.19^{a}	52.39^{a}	0.00^{f}
F-value (P-value)	5394.00** (<0.01)	3584.00** (<0.01)	1540.00** (<0.01)

In a column means followed by different alphabets are significantly different by Tukey's HSD (0.05)

Table 1. The treatment details of experiment

Modules	Treatments
Module-I	• Weekly clipping of infested fruits • Low-cost methyl eugenol trap with spinosad • Maize as a trap crop • Spraying as spot application with spinosad+gur
Module-II	• Weekly clipping of infested fruits • Low-cost methyl eugenol trap with spinosad • Maize as a trap crop • Spraying as spot application with imidacloprid+gur
Module-III	• Bait spray 0.1 % malathion and sugar i.e. 40 ml of malathion and 200g of sugar in 20 lit of water per ha.
Module-IV	• Package of Practice:Spraying as spot application with deltamethrin+gur
Module-V	• Farmer's Practice: Spraying of profenophos @ 1000 ml/ha
Module-VI	• Control: Sole crop (water spray)

Table 3. Economics of different IPM modules for management of fruity fly in summer squash during 2018-19

Treatment	Average yield (t/ha)	Increase over control (t)	Value of additional yield (Rs./ha)	Cost of treatment (Rs./ha)	Net profit (Rs.)	Benefit cost ratio
Module I	35.00[a]	27.00	270000.00	54450.00	215550.00	1 : 3.96
Module II	32.00[b]	24.00	240000.00	50732.00	189268.00	1 : 3.73
Module III	26.00[c]	18.00	180000.00	42500.00	154345.00	1 : 3.63
Module IV(PoP)	22.00[d]	14.00	140000.00	40000.00	100000.00	1 : 2.5
Module V (Farmers practice)	16.00[e]	8.00	80000.00	36000.00	44000.00	1 : 1.22
Module VI (Control)	8.00[f]	_	_	_	_	_
CD at 5 %	1.504	_	_	_	_	_

In a column means followed by different alphabets are significantly different by Tukey's HSD (0.05)
Cost of summer squash during 2018 was Rs. 10000/tonnes
Labour charges @ Rs. 300/labour/day

Stonehouse et al (2002). The present study thus indicates the superiority of using innovative lure baited traps in combination with chemical insecticides as evidenced by minimum fruit infestation and more fruit yield in this experimentation. Module I provided highest benefit of Rs. 215550 followed by module II (Rs. 189268). The highest cost benefit ratio was obtained in case of module I with 1:3.96 followed by module II, module III and module IV with 1:3.73, 1:3.63 and 1:2.5 respectively. The least cost benefit ratio was recorded in module V with 1:1.22. Similar Satpathy and Rai (2002) and Birah et al (2015) during the studies on management of fruit fly in cucurbit crops observed that IPM strategies could provide higher yields and returns beside judicious use of pesticides which is an important component of IPM .

CONCLUSION

Module-I was significantly superior over all other treatments wherein clipping of infested fruits, installation of low-cost mineral bottle methyl-eugenol traps with spinosad, along with maize grown as trap crop and need based spot application of spinosad with gur effectively managed the fruit fly population in summer squash. The same module M-I revealed highest benefit of Rs. 2, 15,550 with highest cost benefit ratio (1:3.96).

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Received 06 August, 2022; Accepted 15 September, 2022