Plant Archives Vol. 25, No. 1, 2025 pp. 1643-1652 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.1.240

MANAGEMENT OF MELON FRUIT FLY, *BACTROCERA CUCURBITAE* COQUILLETT INFESTING CUCUMBER IN RIVER-BED AREA OF ORSANG IN MIDDLE GUJARAT CONDITION

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(Date of Receiving : 08-02-2025; Date of Acceptance : 12-04-2025)

ABSTRACT

The current study was intended to evaluate the efficacy of integrated pest management modules against melon fruit flies in the Chhotaudepur district of Gujarat. The demonstration was conducted in the farmer's fields in the Orsang riverbed area during the year of 2018–19 and 2019–20. Of the six distinct modules of treatment, Module T5 [Field sanitation at weekly intervals + Installation of cue lure traps @16/ha at flowering stage of crop + Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays)] was found to be superior to the other treatment modules and was able to suppress the melon fruit fly infesting cucumber in the river-bed area. Furthermore, the treatment module T5 yielded the more fruit as compared to others modules.
Keywords: *Bactrocera cucurbitae,* River-bed, cucumber

Introduction

River-bed cultivation is very old practice of growing vegetables on the bank or basin of river after when flood level receded. Presently, in South Asian countries, cucurbitaceous vegetables are extensively being grown in river beds. According to survey report, 60 % of total cucurbit cropped area of the country falls under river beds. In India, cultivation of cucurbits like water melon, musk melon, long melon, pumpkin, summer squash, ridge gourd, smooth gourd, snake gourd, bitter gourd, bottle gourd and snap melon mostly in North and Central India, bitter gourds *etc* in some areas like Kerala and pointed gourd in Eastern Uttar Pradesh, Bihar and West Bengal is more common under river bed condition (Pandey and Karmakar, 2015). In Gujarat, cucurbitaceous vegetables are grown on river-beds of Sabarmati, Panam, Vatrak and Orsang (Mor*et al.,* 2018). Among cucurbitaceous vegetables, cucumber, *Cucumis sativus* Linnaeus is important fruit vegetable. In India, cucumber is grown in the area of 77,000 hectares with annual production of 12.46 Lakh metric tons (Anonymous 2017). In Gujarat, slicing cucumbers is available round the year and becoming one of the daily items in food dish. However, the data on acreages under cucumber cultivation in Gujarat are not available but total cucurbits cultivation was recorded to be 3940 hectares and total production was 60,085 metric tons in 2013-14 (Anonymous 2015).

Insect pest is one among the factors affecting adversely on qualitative and quantitative production of cucumber. Insect pests damaging cucumbers reported world over are fruit flies, leaf miners, red and black pumpkin beetle, pumpkin caterpillar, mites, hadda beetle, flea beetle, fruit borer, white flies, thrips, cucumber striped beetles, seed corn maggot, grass hopper, and Jassids (Vignesh and Viraktamath, 2015). Among above pests, fruit fly and leaf miner are the major pests of cucumber particularly in middle

Gujarat.Fruit flies are recognized as one of the most important group of pests of cucumber. Nearly 250 species are of economic importance and are distributed widely in temperate and sub- tropical and tropical regions of the world. Senior-White (1924) listed 87 species of Tephritidae in India. A number of species have been reported damaging the cucurbit fruits in India, these include *Bactrocera cucucrbitae*, *Dacus ciliates*, *Bactrocera diversus*, *Bactrocera latifrins*, *Bactrocera parvulus*, *Batrocera tau*, *Bactrocera zanotus* and *Myriopardis pardaliva*. of these, the melon fly, *Bactrocera cucurbitae* is comparatively more common, destructive and threat to cucurbits in India (Shah *et al.,* 1948, Abhilash *et al.,* 2017) and Asia (Nagappan *et al.,* 1971). The first report on melon fruit fly was published by Bezzi (1913) who listed 39 species from India. It is distributed widely in temperate, sub-tropical and tropical region of world and India (Dhillon *et al.,* 2005, Jha *et al.,* 2007, Sisodiya, 2007). Generally, fruit fly females are most preferred to lay the eggs in soft tender fruit tissues by piercing them with the ovipositor. A watery fluid oozes from puncture, which become slightly concave with seepage of fluids and transforms into a brown resinous deposit. Sometimes pseudo-punctures have also been observed on the fruit skin. This reduces the market value of the produce. Infected fruits become distorted and usually drop. The fallen fruits are unfit for human consumption and have no market value. The oviposition punctures and larval tunnels provide entry points for bacteria and fungi that cause the fruit to rot. The extent of losses variesbetween 30 to 100 %, depending on the cucurbit species and season (Sisodiya, 2007). This pest is reported to cause up to 100% damage (Vignesh, 2015).

Materials and Methods

In order to manage melon fruit fly, an experiment was conducted on farmer's field in Orsang river-bed area during the yearof2018-19 and 2019-20. For the purpose, six different farmers' fields each of 0.25 ha were selected for execution of treatments module*viz;*Module T1=Field sanitation (Collection and destruction of damaged fruits) at weekly interval, ModuleT2= Installation of cue lure traps @16/ha at flowering stage of crop, ModuleT3= Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays), ModuleT4= Installation of cue lure traps @16/ha at flowering stage of crop + Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays), ModuleT5= Field sanitation at weekly interval + Installation of cue lure traps @16/ha at flowering stage of crop + Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays), ModuleT6= Farmer's practices. The isolation distance of at least 1 km was maintained between treatments. A knapsack sprayer was used to accomplish the spray. Damaged fruits were collected and destroyed by deeply buried into soil at weekly interval. For recording the observations, number of healthy and damaged fruit(s) was recorded from five randomly selected quadrates each of 1 x 1 m size. Thus, data were converted to damage (%) and finally subjected to ANOVA.

Result and Discussions

Mean number of fruits with ovipositor marks

In first year study (2018-19), the data obtained on impact of treatments of IPM modules against fruit fly in the field trial are given in Table 4.The data on the mean number of fruits revealed that all the treatment modules were significantly superior in reducing the mean number of fruits with ovipositor marks over farmer practices (T6). On 45th day after sowing, module T5[Field sanitation at weekly interval + Installation of cue lure traps @16/ha at flowering stage of crop + Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays)] found most effective which resulted in minimum mean number of fruits with ovipositor marks (3.32) per five quadrates. The module T4 [Installation of cue lure traps @16/ha at flowering stage of crop + Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays)]proved to be the next effective against fruit fly infesting cucumber with 3.56 mean numbers of fruits with ovipositor marks followed by treatment module T3 [Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays)]and T2 [Installation of cue lure traps @16/ha at flowering stage of crop]. The treatment module T1 and T6 exhibited less effective module with5.93 and 6.36 mean number of fruits with ovipositor marks per five quadrates, respectively. Treatment module T6 (untreated control) recorded significantly highest mean numbers of fruits with ovipositor marks. Similarly, more or less similar trends were observed in 52, 59, 66 and 73 days after sowing.

The data (Table 4 and 6) on the mean number of fruits (pooled over periods) revealed that all the treatment modules were significantly superior in reducing the mean number of fruits with ovipositor marks over farmer practices (T6). The treatment module T5 found most effective which resulted in minimum mean number of fruits with ovipositor marks (2.73) per five quadrates. The treatment module T4 proved to be the next effective against fruit fly infesting cucumber with 3.07 mean numbers of fruits with ovipositor marks. The treatment module T1 and T6 exhibited less effective module with 5.15 and 6.77 mean number of fruits with ovipositor marks per five quadrates, respectively.

In contrast to the first year, the population attraction for the mean number of fruits with ovipositor marks was more aggressive during the second year (2019-20) of the study. The data on mean number of ovipositor marks on fruit at different days after sowing are presented in Table 5. Based on mean number of fruits with ovipositor marks after 45 days, the chronological order of effectiveness of various treatment modules was treatment module T5 (3.26) >treatment module T4 (3.56) >treatment module T3 (5.17) > treatment module T2 (5.52) > treatment module T1 (6.07) > treatment module T6 (7.21). All the treatment modules recorded lesser mean number of fruits with ovipositor marks as compared to treatment module T6. Similar trends were observed in case of 52, 59, 66 and 73 days after sowing in mean number of fruits with ovipositor marks by *B. cucurbitae* infesting cucumber in river-bed area.

The mean number of fruits collected pooled over the periods (Table 6), all of the treatment modules significantly exceeded farmer methods (T6) in lowering the mean number of fruits with ovipositor marks. The most successful treatment module was T5, which produced a lowest mean fruits with ovipositor marks (2.79) out of five quadrates. Similar results found by Sandeep *et. al.* (2019) who reported that the population of fruit fly was also observed lower in IPM plot (1.83 and 1.78 larvae/plant) than control plot (5.12 and 4.92 larvae/plant). Mean numbers of fruits (3.22) with ovipositor marks, the treatment module T4 was the next most effective against cucumbers infested with fruit flies. The mean number of fruits with ovipositor marks per five quadrates for treatment modules T1 and T6 was 5.47 and 7.79, respectively, indicating lower efficacy.

The data on mean number of ovipositor marks on fruit (pooled over periods and year) are presented in Table 6. The chronological order of effectiveness of various treatment modules was treatment module T5 (2.76) > treatment module T4 (3.14) > treatment module T3 (4.42) > treatment module T2 (4.54) > treatment module T1 (5.31) > treatment module T6 (7.27). All the treatment modules recorded lesser mean number of fruits with ovipositor marks as compared to farmer practices (T6). The treatment module T5 was found most effective which resulted in minimum mean number of fruits with ovipositor marks (2.76) per five quadrates. The treatment module T4 proved to be the next effective against fruit fly infesting cucumber with 3.14 mean numbers of fruits with ovipositor marks. The treatment module T1 and T6 proved to be less effective module with 5.31 and 7.27 mean number of fruits with ovipositor marks per five quadrates, respectively.

Mean per cent fruit damage by fruit fly

After 45 days after sowing, the data on the per cent of fruit damaged (Table 1)was found in different treatment modules was as follows: treatment module T5 (20.52%) > treatment module T4 (24.11%) > treatment module T3 (30.39%) > treatment module T2 (31.52%) > treatment module T1 (38.51%) > treatment module T6 (41.11%). Fruit damage was lower in all treatment modules than in treatment module T5. More or less similar trends were observed in case of 52, 59, 66 and 73 days after sowing in fruit damaged by *B. cucurbitae* infesting cucumber in river-bed area during *Rabi* 2018-19.

The data recorded on mean per cent fruit damage in different treatment modules against fruit fly infesting cucumber during *Rabi* 2018, are presented in Table 1 revealed that the minimum fruit damage (15.48 %) was recorded in treatment module T5. It is the most effective treatment module. The treatment module T4 proved to be the next effective treatment module against fruit fly infesting cucumber with 21.98 % mean per cent fruit damage. The treatment module T2 and T3 found statistically at par with each other. The treatment module T1 and T6 exhibited less effective treatment module with 35.60 and 41.00 per cent fruit damage, respectively.

As it is obvious from the data on per cent fruit damaged (Table 1) after 45 days, the effectiveness order of various treatment modules was treatment module T5 (14.19%) >treatment module T4 (20.65 %) >treatment module T2 (27.02) > treatment module T3 (28.63 %) > treatment module T1 (36.85%) > treatment module T6 (42.07 %). All the treatment modules recorded less fruit damaged as compared to treatment module T6. More or less similar trends were observed in case of 52, 59, 66 and 73 days after sowing

in fruit damaged by *B. cucurbitae* infesting cucumber in river-bed area during *Rabi* 2019-20.

The pooled over periods data recorded on mean per cent fruit damage in different treatment modules against fruit fly infesting cucumber are presented in Table 1 and revealed that the minimum fruit damage (13.33 %) was recorded in treatment module T5. It is the most effective treatment module. Similar findings were made by Sandeep *et al.* (2019), who stated that during both seasons, the IPM plot exceeded the control based on data on yield and fruit damage at harvest time. More or less similar result found by Zahir *et al.* (2022) reported that 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. The treatment module T4 proved to be the next effective treatment module against fruit fly infesting cucumber with 19.31 % mean per cent fruit damage. The treatment module T2 and T3 were found statistically at par with each other. The treatment module T1 and T6 proved to be less effective treatment module with 34.54 and 41.66 per cent fruit damage, respectively.

The data (Table 5) on per cent fruit damaged by *B. cucurbitae* infesting cucumber in river-bed area (pooled over periods and year) indicated that the chronological order of effectiveness of various treatment modules was treatment module T5 (14.38%) > treatment module T4 (20.62%) > treatment module T2 (27.86%) > treatment module T3 (27.92%) > treatment module T1 (35.11%) > treatment module T6 (41.33%). The minimum fruit damage (14.38%) was recorded in treatment module T5. It is the most effective treatment module. The treatment module T4 proved to be the next effective treatment module against fruit fly infesting cucumber with 20.62 % mean per cent fruit damage. The treatment module T2 and T3 were found statistically at par with each other. The treatment module T1 and T6 exhibited less effectiveness with 35.11 and 41.33 per cent fruit damage, respectively.

Fruit yield

The data on marketable fruit yield of cucumber among different treatment modules revealed that significantly higher yield was recorded in all the treatments over farmer's practices (Table 7). The marketable fruit yield recorded in different treatment modules ranged from 112 to 275 q/ha. The maximum fruit yield (275 q/ha) was harvested from the treatment module T5 followed by treatment module T4 (198 q/ha). The lowest fruit yield was harvested in treatment module T6.

Data on the marketable fruit yield of cucumbers across various treatment modules showed that all treatments had yields that were noticeably higher than those of farmers' practices. The fruit yield recorded in different treatment modules ranged from 122 to 312 q/ha. The maximum fruit yield (312 q/ha) was harvested from the treatment module T5 followed by treatment module T4 (220 q/ha). The lowest fruit yield (122 q/ha) was harvested in treatment module T6.

According to statistics on marketable fruit yield (Table 7) of cucumbers in riverbed areas across several treatment modules, all treatments exhibited noticeably higher yields than farmer practices. Fruit production ranged from 117 to 294 q/ha across the different treatment modules. Treatment module T5 had the highest fruit output (294 q/ha), followed by treatment module T4 (210 q/ha). Harvesting in farmer practices (T6) produced the lowest fruit yield (117 q/ha). Similar findings were made by Zahir *et al.* (2022) who reported that during study period maximum fruit yield (35 t/ha) were obtained in M-I with highest cost - benefit ratio (1: 3.96) for the whole cropping period.

Conclusion

From the present results it can be inferred that treatment module T5 [Field sanitation at weekly interval + Installation of cue lure traps @16/ha at flowering stage of crop + Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays)] could suppress the melon fruit fly infesting cucumber in the river-bed area and was found superior over rest of the treatment modules. The maximum fruit yield was also harvested from the treatment module T5.

Table 1: Effect of differenttreatment modules against melon fruit fly infesting cucumberin river-bed area during *Rabi* 2018-19

Sr. No.	Treatment modules	Mean number of fruits with ovipositor marks at different DAS					Pooled over periods
		45	52	59	66	73	
T_1	Field sanitation (Collection and destruction of damaged fruits) at weekly interval	2.33ab (5.93)	2.29b (5.74)	2.32ab (5.88)	1.93b (4.22)	1.91b (4.15)	2.16b (5.15)
T_2	Installation of cue lure traps @16/ha at flowering stage of crop	2.16ab (5.17)	2.10b (4.91)	2.02b (4.58)	1.81bc (3.78)	1.64c (3.19)	1.95c (4.29)
T_3	Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays)	2.11b (4.95)	2.16b (5.17)	2.05b (4.70)	1.91b (4.15)	1.70bc (3.39)	1.99c (4.44)
T_4	Installation of cue lure traps @16/ha at flowering stage of crop (T2) + Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays) (T3)	1.75c (3.56)	1.69c (3.36)	1.51c (2.78)	1.58cd (3.00)	1.49c (2.72)	1.60d (3.07)
T_5	Field sanitation at weekly interval (T1) Installation of cue lure traps @16/ha at flowering stage of crop (T2) + Application of bait prepared from black jaggery(5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays) (T3)	1.68c (3.32)	1.63c (3.16)	1.51c (2.78)	1.42d (2.52)	1.22d (1.99)	1.49d (2.73)
T_6	Farmer's practices	2.42a (6.36)	2.70a (7.79)	2.44a (6.45)	2.42a (6.36)	2.54a (6.95)	2.50a (6.77)
	(±) Treatment (T)	0.08	0.09	0.11	0.08	0.07	0.04
	Period (P)	-	-	-	-	-	0.03
	T ×P	-	-	-	-	-	0.09
	t 5 % Treatment (T)	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	C.V. (%)	8.95	10.16	13.34	9.93	10.07	10.62

Notes: 1) * Treatment means with common letter(s) are/is not significant at 5 % level of significance by DNMRT

2) ** Figures in parentheses are retransformed values, those outside are $\sqrt{x+0.5}$ transformed values.

3) NS: Not-significant DAS : Day after sowing

Table 2: Effect of different treatment modules against melon fruit fly infesting cucumber in river-bed area during *Rabi* 2019-20

Sr. No.	Treatment modules	Mean number of fruits with ovipositor marks at different DAS					Pooled over periods
		45	52	59	66	73	
T_1	Field sanitation (Collection and destruction of damaged fruits) at weekly interval	2.36ab (6.07)	2.41ab (6.31)	2.33ab (5.93)	2.11b (4.95)	1.94b (4.26)	2.23b (5.47)
T_2	Installation of cue lure traps @16/ha at flowering stage of crop	2.24ab (5.52)	2.26b (5.61)	2.15b (5.12)	1.95b (4.30)	1.78b (3.67)	2.08bc (4.81)
T_3	Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays)	2.16b (5.17)	2.20b (5.34)	2.04bc (4.66)	1.86bc (3.96)	1.62bc (3.12)	1.98c (4.40)
T_4	Installation of cue lure traps @16/ha at flowering stage of crop (T2) + Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays) (T3)	1.75c (3.56)	1.79c (3.70)	1.68cd (3.32)	1.53cd (2.84)	1.49bc (2.72)	1.65d (3.22)
T_5	Field sanitation at weekly interval (T1) Installation of cue lure traps @16/ha at flowering stage of crop (T2) + Application of bait prepared from black jaggery(5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays) (T3)	1.66c (3.26)	1.70c (3.39)	1.55d (2.90)	1.44d (2.57)	1.22c (1.99)	1.51d (2.79)
T_6	Farmer's practices	2.59a (7.21)	2.69a (7.74)	2.71a (7.84)	2.81a (8.40)	2.70a (7.79)	2.70a (7.79)
	(±) Treatment (T)	0.12	0.13	0.14	0.11	0.17	0.06
	Period (P)	-	-	-	-	-	0.05
	T ×P	-	-	-	-	-	0.14
	: 5 % Treatment (T)	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	C.V. (%)	13.20	13.47	15.46	13.56	21.46	15.40

Notes: 1) * Treatment means with common letter(s) are/is not significant at 5 % level of significance by DNMRT

2) ** Figures in parentheses are retransformed values, those outside are $\sqrt{x+0.5}$ transformed values.

3) NS: Not-significant DAS : Day after sowing

Table 3: Effect of different treatment modules against melon fruit fly infesting cucumber in river-bed area during *Rabi* – 2018-19 and 2019-20

Sr. No.	Treatment modules	Mean number of fruits with ovipositor marks		
		2018-19	2019-20	Pooled
T_1	Field sanitation (Collection and destruction of damaged fruits) at weekly interval	2.16b (5.15)	2.23b (5.47)	2.19b (5.31)
T_2	Installation of cue lure traps @16/ha at flowering stage of crop	1.95c (4.29)	2.08bc (4.81)	2.01c (4.54)
T_3	Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays)	1.99c (4.44)	1.98c (4.40)	1.98c (4.42)
T_4	Installation of cue lure traps @16/ha at flowering stage of crop (T2) + Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays) (T3)	1.60d (3.07)	1.65d (3.22)	1.63d (3.14)
T_5	Field sanitation at weekly interval (T1) Installation of cue lure traps @16/ha at flowering stage of crop (T2) + Application of bait prepared from black jaggery(5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays) (T3)	1.49d (2.73)	1.51d (2.79)	1.50e (2.76)
T_6	Farmer's practices	2.50a (6.77)	2.70a (7.79)	2.60a (7.27)
	S. Em.(±) Treatment (T)	0.04	0.06	0.03
	Period (P)	0.03	0.05	0.03
	Year (Y)	-	-	0.02
	T×P	0.09	0.14	0.08
	T×Y	-	-	0.05
	Y×P	-	-	0.04
	T ×P×Y	-	-	0.11
	C.D. at 5% Treatment (T)	0.11	0.17	0.10
	Period (P)	0.10	0.16	0.09
	Year (Y)	-	-	0.06
	T×P	NS	NS	NS
	T×Y	-	-	NS
	Y×P	-	-	NS
	T ×P×Y	-	-	NS
	C.V. %	10.62	15.40	13.32

Notes: 1) * Treatment means with common letter(s) are/is not significant at 5 % level of significance by DNMRT

2) ** Figures in parentheses are retransformed values, those outside are $\sqrt{x} + 0.5$ transformed values.

3) NS: Not-significant

Table 4: Impact of various treatment modules based on fruit damaged by melon fruit fly infesting cucumber in river-bed area during *Rabi* 2018-19

Sr. No.	Treatment modules	Mean fruit damage (%) at different DAS					Pooled over periods
		45	52	59	66	73	
T_1	Field sanitation (Collection and destruction of damaged fruits) at weekly interval	38.36ab (38.51)**	37.36ab (38.82)	36.56a (35.48)	35.79b (34.20)	35.36b (33.49)	36.69b (35.60)
T_2	Installation of cue lure traps @16/ha at flowering stage of crop	34.16abc (31.52)	34.16b (31.52)	33.01b (29.67)	31.43c (27.19)	29.92cd (24.87)	32.54c (28.93)
T_3	Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays)	33.46bc (30.39)	32.10bc (28.23)	31.99b (28.06)	33.03c (29.71)	33.68bc (30.75)	32.85c (29.42)
T_4	Installation of cue lure traps @16/ha at flowering stage of crop (T2) + Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays) (T3)	29.41cd (24.11)	26.73cd (20.23)	28.60c (22.91)	26.81d (20.34)	28.21d (22.34)	27.95d (21.96)

T_5	Field sanitation at weekly interval (T1) Installation of cue lure traps @16/ha at flowering stage of crop (T2) + Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays) (T3)	26.94d (20.52)	25.05d (17.92)	22.86d (15.09)	19.56e (11.20)	21.44e (13.36)	23.17e (15.48)
T_6	Farmer's practices	39.88a (41.11)	40.20a (41.16)	39.90a (41.14)	38.78a (39.22)	40.34a (41.90)	39.82a (41.00)
	S. Em.(±) Treatment (T)	1.92	1.79	1.05	0.60	1.30	0.63
	Period (P)	-	-	-	-	-	0.58
	T ×P	-	-	-	-	-	1.42
	C.D. at 5 % Treatment (T)	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	C.V. (%)	12.76	12.30	7.30	4.36	9.29	9.87

Notes: 1) * Treatment means with common letter(s) are/is not significant at 5 % level of significance by DNMRT
2) **Figures in parentheses are retransformed values, those outside are arc sine transformed values
3) NS: Not-significant DAS : Day after sowing

Table 5: Impact of various treatment modules based on fruit damaged by melon fruit fly infesting cucumber in river-bed area during *Rabi* 2019-20

Sr. No.	Treatment modules	Mean fruit damage (%) at different DAS					Pooled over periods
		45	52	59	66	73	
T_1	Field sanitation (Collection and destruction of damaged fruits) at weekly interval	37.38ab (36.85)**	37.52ab (37.09)	36.01ab (34.56)	34.81ab (32.58)	34.28ab (31.72)	36.00b (34.54)
T_2	Installation of cue lure traps @16/ha at flowering stage of crop	31.22c (27.02)	33.07bc (29.77)	32.21b (28.41)	29.96bc (24.93)	29.51b (24.26)	31.19c (26.81)
T_3	Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays)	32.35bc (28.63)	31.64cd (27.51)	32.10b (28.23)	29.43bc (24.14)	29.19bc (23.78)	30.94c (26.43)
T_4	Installation of cue lure traps @16/ha at flowering stage of crop (T2) + Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays) (T3)	27.83c (20.65)	27.52de (21.34)	26.51c (19.92)	24.60cd (17.32)	23.90cd (16.41)	26.07d (19.31)
T_5	Field sanitation at weekly interval (T1) Installation of cue lure traps @16/ha at flowering stage of crop (T2) + Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays) (T3)	22.13d (14.19)	23.20e (15.51)	23.10c (15.39)	19.67d (11.33)	18.98d (10.57)	21.42e (13.33)
T_6	Farmer's practices	40.44a (42.07)	40.56a (42.28)	40.64a (42.41)	40.00a (41.31)	39.36a (40.21)	40.20a (41.66)
	S. Em.(±) Treatment (T)	1.32	1.38	1.61	1.78	1.76	0.72
	Period (P)	-	-	-	-	-	0.66
	T ×P	-	-	-	-	-	1.62
	C.D. at 5 % Treatment (T)	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	C.V. (%)	9.29	10.97	11.39	13.38	13.49	11.71

Notes: 1) * Treatment means with common letter(s) are/is not significant at 5 % level of significance by DNMRT
2) **Figures in parentheses are retransformed values, those outside are arc sine transformed values
3) NS: Not-significant DAS : Day after sowing

Table 6: Impact of various treatment modules based on fruit damaged by melon fruit fly infesting cucumber in river-bed area during *Rabi* 2018-19 and 2019-20

Sr. No.	Treatment modules	Mean fruit damage (%)		
		2018-19	2019-20	Pooled
T_1	Field sanitation (Collection and destruction of damaged fruits) at weekly interval	36.69b (35.60)	36.00b (34.54)	36.34b (35.11)
T_2	Installation of cue lure traps @16/ha at flowering stage of crop	32.54c (28.93)	31.19c (26.81)	31.86c (27.86)
T_3	Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays)	32.85c (29.42)	30.94c (26.43)	31.90c (27.92)
T_4	Installation of cue lure traps @16/ha at flowering stage of crop (T2) + Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays) (T3)	27.96d (21.98)	26.07d (19.31)	27.01d (20.62)
T_5	Field sanitation at weekly interval (T1) Installation of cue lure traps @16/ha at flowering stage of crop (T2) + Application of bait prepared from black jaggery(5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays) (T3)	23.17e (15.48)	21.42e (13.33)	22.29e (14.38)
T_6	Farmer's practices	39.82a (41.00)	40.20a (41.66)	40.01a (41.33)
	S. Em.(±) Treatment (T)	0.63	0.72	0.48
	Period (P)	0.58	0.66	0.44
	Year (Y)	-	-	0.27
	T×P	1.42	1.62	1.07
	T×Y	-	-	0.68
	Y×P	-	-	0.62
	T ×P×Y	-	-	1.52
	C.D. at 5% Treatment (T)	1.78	2.03	1.35
	Period (P)	1.62	1.85	1.23
	Year (Y)	-	-	0.78
	T×P	NS	NS	NS
	T×Y	-	-	NS
	Y×P	-	-	NS
	T ×P×Y	-	-	NS
	C.V. %	9.87	11.71	10.80

Notes: 1) * Treatment means with common letter(s) are/is not significant at 5 % level of significance by DNMRT
2) ** Figures in parentheses are retransformed values, those outside are arc sine transformed values
3) NS: Not-significant

Table 7: Impact of different treatment modules on fruit yield of cucumber in river-bed area

Sr. No.	Treatment modules	Marketable fruit yield(q/ha)		
		2018-19	2019-20	Pooled
T_1	Field sanitation (Collection and destruction of damaged fruits) at weekly interval	124b	135b	129c
T_2	Installation of cue lure traps @16/ha at flowering stage of crop	151b	190b	171bc
T_3	Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays)	164b	183b	174bc
T_4	Installation of cue lure traps @16/ha at flowering stage of crop (T2) + Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays) (T3)	198ab	220ab	210b
T_5	Field sanitation at weekly interval (T1) Installation of cue lure traps @16/ha at flowering stage of crop (T2) + Application of bait prepared from black jaggery (5 %) + Spinosad 0.004 % @ 8 lit./ha at weekly interval starting from fruit setting (four sprays) (T3)	275a	312a	294a
T_6	Farmer's practices	112b	122b	117c

	S. Em.(±)	Treatment (T)	28.38	34.60	23.00
		Year (Y)	-	-	13.00
		T ×Y	-	-	32.00
	C.D. at 5 %	Treatment (T)	82.84	100.09	66.10
		Year (Y)	-	-	-
		T ×Y	-	-	NS
	C.V. (%)		37.16	39.85	38.77

Notes: 1) * Treatment means with common letter(s) are/is not significant at 5 % level of significance by DNMRT
2) NS: Not-significant

Plate 1: Cucumber crop in river-bed area of Orsang

Plate 2: Fruit damaged by melon fruit fly, *B. cucurbitae* infesting cucumber

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