Enhancement of Trap catches of Melon Fruit fly *Zeugodacus cucurbitae* (Coquillett) by Gel Formulations of Protein Bait

ABSTRACT

Fruit flies (Tephritidae: Diptera) are the devastating insect pests of quarantine importance and damage several vegetable crops particularly of Cucurbitaceae family in tropical, subtropical and temperate zones around the world. As capturing male fruit flies only does not bring desirable reduction in infestation levels, researchers are now focusing on female attractants. Among them, protein baits are prominent. Hence, an improved gel formulation of proteinex bait was tested in field conditions for attracting both the sexes of fruit flies. In bitter gourd, gel proteinex bait traps attracted more number of female fruit flies followed by liquid proteinex bait. More number of male fruit flies were recorded in cue-lure traps followed by gel proteinex bait traps. More female fruit fly catches in gel proteinex traps in bitter gourd indicated the requirement of more proteins for maturation of ovaries in females. Attraction of males to gel proteinex bait clearly showed the importance of protein sources for reproduction success of male fruit flies. Per cent incidence of cucurbit fruit fly was low in gel proteinex bait placed bitter gourd fields than the fields in which liquid proteinex bait and cue-lure were placed. In gel proteinex bait experimental plots, reduction of cucurbit fruit fly incidence was more than the cue-lure. This is due to their high trap catches besides trapping more female fruit flies which would have decreased the oviposition levels in the field.

Key words: Zeugodacus cucurbitae, gel proteinex bait, liquid proteinex bait, cuelure, bitter gourd

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1. INTRODUCTION

Cucurbits are a group of wide vegetables in the family Cucurbitacae which include 825 species in 118 genera (Lira *et al.,* 2002). Among them bitter gourd, snake gourd and ridge gourd are widely grown as commercially vegetables. Various insect pests infest cucurbit crops *viz.,* whitefly, mite, melon fruit fly, mealy bug, red pumpkin beetle, aphids etc., which causes tremendous yield losses. Among them, melon fruit fly, *Zeugodacus cucurbitae* (Coquillett) (Tephritidae: Diptera) is a polyphagous insect pest with a wide distribution throughout the subtropical & tropical regions and is a major frugivorous pest causing extensive damage to several commercially cultivated fruit and vegetable crops (~~Kamala~~ Jayanthi *et al.,* 2021).

The melon fruit fly, *Z. cucurbitae* is an invasive insect, distributed widely in temperate, tropical and sub-tropical regions of the world (Dhillon *et al.,* 2005). There are about 325 species of fruit flies occurring in the Indian subcontinent of which 205 are from India alone (Allwood *et al.,* 1999; Nair *et al.,* 2017). The most vulnerable

hosts of cucurbit fruit flies are bitter gourd, ribbed gourd, bottle gourd, long melons, squash melons, snap melons and cucumber (Kapoor *et al.,* 2005).

Z._cucurbitae is an important tephritid agricultural pest known to infest more than hundred varieties of fruits and vegetables and causes considerable damage wherever it occurs (Dhillon *et al.,* 2005; White and Elson-Harris, 1992). In India, 40–60% of damage to vegetables was attributed due to the melon fruit fly (Kapoor, 1993; Jakhar *et al.,* 2020). The insect has high dispersive potential and reproductive rates (Mwatawala, *et al.,* 2009; Dhillon, *et al.,* 2005). Dhillon *et al. (*2005) reported 30–100% yield losses due to melon fruit fly depending on environmental factors and host species in sub-Saharan Africa. Among the eco-friendly management methods of this insect, male annihilation method using the parapheromones is the most important one. However, parapheromones are generally species specific and attract only males, reducing the mating proportion and in turn their population to some extent (Mwatawala *et al.,* 2009). Most of the commercially available traps attract males only and trapping the females could be more advantageous (Siderhurst and Jang, 2010). Baits that attract both male and females are much more advantageous and these baits need to be protein-rich (Iqbal *et al.,* 2020). In our previous research studies on evaluation on the attractiveness of various protein and food baits, proteinex protein bait was found to be the most attractive. However, we have found that in fields conditions, because of evaporation of bait, it's attractiveness is reduced. To reduce the evaporation of water from the bait, several gel powders were tested and a proteinex gel formulation was formulated. In this background, the present study was conducted to evaluate the fruit fly luring potential of gel proteinex bait, an improvised version of liquid proteinex in bitter gourd.

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2. MATERIALS AND METHODS

In bitter gourd, preliminary and confirmatory field trials were conducted to evaluate the trapping potential of gel proteinex bait in comparison with liquid proteinex bait, cuelure, negative control and untreated control. Preliminary field experiments were conducted at Kesampatti village, Melur block, Madurai district (10.140ºN, 78.288ºE) during January to –April of 2023. Confirmatory trials were conducted at Sekkipatti village, Melur block, Madurai district (10.201ºN,78.311 ºN)

during April to July of 2023. Each treatment was replicated five times with 50 m isolation distance in between and the experiment was conducted in a randomized block design. The treatment details are given below

~~List~~ Table 1 : Treatment details including the formulations and dosages

S. No.	Treatments
1.	T1 - Gel proteinex bait (liquid proteinex bait + gel powder @ 0.8 g in 1 litre)
2.	T2 - Liquid proteinex bait (proteinex powder + inorganic salt + preservative + sweetener in 10:10:5:2 ratio) + insecticide
3.	T3 - Cue lure trap
4.	T4 - Negative control (base materials of liquid proteinex bait except proteinex powder)
5.	T5 - Untreated control (water)

One litre capacity plastic containers of 10 cm diameter and 20 cm height were modified as bait traps. Four square shaped holes of 20 mm^2 were made in the middle and around the circumference of the container with a heated blade to allow the entry of attracted fruit flies. The baits were allowed to ferment for 36 hours duration and placed in the traps @ 300 ml/trap, tied at a height of 1.5 to 2 metres in pandal system. Baits were replaced once in 10 days.

Observations on the number of attracted fruit flies on 5^{th} and 10^{th} ~~-~~days after placement of traps (DAPT) were recorded continuously for four months. Number of trapped males and females were counted separately and male to female ratio was arrived. In each treatment, 300 fruits were observed randomly (100 fruits / replication) at ten days interval, number of healthy ~~&~~ and infested fruits were counted and per cent fruit infestation in each treatment was calculated by using the following formula.

$$\text{~~Per cent~~ fruit infestation (\%)} = \frac{\text{No. of infested fruits}}{\text{Total no. of fruits (healthy and infested)}} \times 100$$

In each treatment, 60 fruits were collected randomly (20 fruits/replication), fruits were cut open and number of maggots in each fruit was noted at ten days

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interval. Level of incidence in each treatment was calculated by using the following formula.

$$\text{Level of incidence} = \frac{\text{Total no. of maggots observed}}{\text{No. of fruits observed}}$$

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The data were subjected to statistical analysis using SPSS software (version 26) to carry out ANOVA and grouping of data by Tukey post hoc test (Tukey, 1977).

3. RESULTS AND DISCUSSION

3.1. Evaluation of gel proteinex bait in trapping melon fly, *Z.cucurbitae*

3.1.1. Preliminary field experiment

3.1.1.1. Female fruit flies

Observations during early fruiting stage revealed that, at 5 ~~days after placement of traps (~~DAPT~~)~~, liquid proteinex bait attracted 23.60 female fruit flies (FF) / trap while this number is high in gel proteinex bait *i.e.,*36.80 FF / trap (Table 2~~1~~). At 10 DAPT, highest trap catch was recorded in gel proteinex bait treatment *i.e.,* 40.20 FF / trap as against 28.60 in liquid proteinex bait treatment. As cuelure is a male attractant, no female fruit flies were observed in these traps and in untreated control also trap catch was nil.

Observations during the fruiting stage showed that, liquid proteinex bait attracted 25.80 to 30.60 FF/trap. Number of fruit flies in the traps in which gel proteinex bait was placed was more than the liquid preteinex bait traps *i.e.,*40.20 to 42.20 FF / trap (Table 2~~1~~). In cuelure traps and untreated control, no fruit flies were recorded. In negative control, 3.80 to 5.60 FF/trap were noted.

3.1.1.2. Male fruit flies

Observations on trap catches of fruit flies in early fruiting stage of the crop showed the highest catch of 69.60 and 78.00 male fruit flies (MF)/trap (Table 1) at 5 and 10 DAPT respectively. Next to this was gel proteinex bait with 31.20 to 39.00 MF/trap. Among the treatments, lowest catch was recorded in liquid proteinex bait (19.00 to 26.80 MF/trap). No fruit flies were recorded in untreated control. Negative control traps recorded 3.00 to 4.20 MF/trap.

3.1.2. Confirmatory field experiment

3.1.2.1. Female fruit flies

At 5 DAPT, comparatively gel proteinex bait attracted more number of female fruit flies *i.e.,* 75.10 and 73.44 FF/trap (Table 2~~1~~) at 5 DAPT and 10 DAPT respectively. Next to this was, liquid proteinex bait which attracted 53.10 and 55.42 FF/trap at 5 DAPT and 10 DAPT respectively. In cuelure and untreated control treatments, no fruit flies were recorded. In negative control, comparatively more number of fruit flies (9.74 to 11.20 FF/trap) were trapped than in the preliminary trial (4.00 to 4.60 FF/trap).

At 10 DAPT, number of fruit flies per trapped were highest in gel proteinex bait traps *i.e.,* 80.40 and 82.20 FF/trap at early and fruiting stages respectively. In liquid proteinex bait traps, the number of fruit flies trapped ranged between 57.96 and 59.44 respectively. Cuelure and untreated control traps were found with no fruit flies.

3.1.2.2. Male fruit flies

Generally fruit fly catches in various traps were more in confirmatory field trial (April to July of 2023) than the preliminary trial (January to April of 2023). With regard to male fruit flies, more number was trapped in cuelure traps *i.e.,* 136.30 to 160.60 MF/trap (Table 2~~1~~) during early fruiting stage and 145.60 to 153.90 MF/trap during fruiting stage. In gel proteinex bait traps, fruit fly count ranged from 68.60 to 78.74 MF/trap while in liquid proteinex bait trap, it was 52.10 to 57.50 MF/trap. Negative control traps recorded 7.90 to 12.60 MF/trap.

When total number of fruit flies *i.e.,* both male and female in various traps was probed in to, gel proteinex bait traps showed their superiority with 602.92 fruit flies (Fig 1.) followed by cuelure (596.40) and liquid proteinex bait traps (447.60). Attractiveness of gel proteinex bait to male fruit flies is due to the reason that they depend on protein sources for reproduction purpose. Statement of Kotikal and Math (2017) that protein or food baits attract male fruit flies for sperm development also supported our opinion.

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Fig 1. Total number of female and male fruit fly catches in bitter gourd

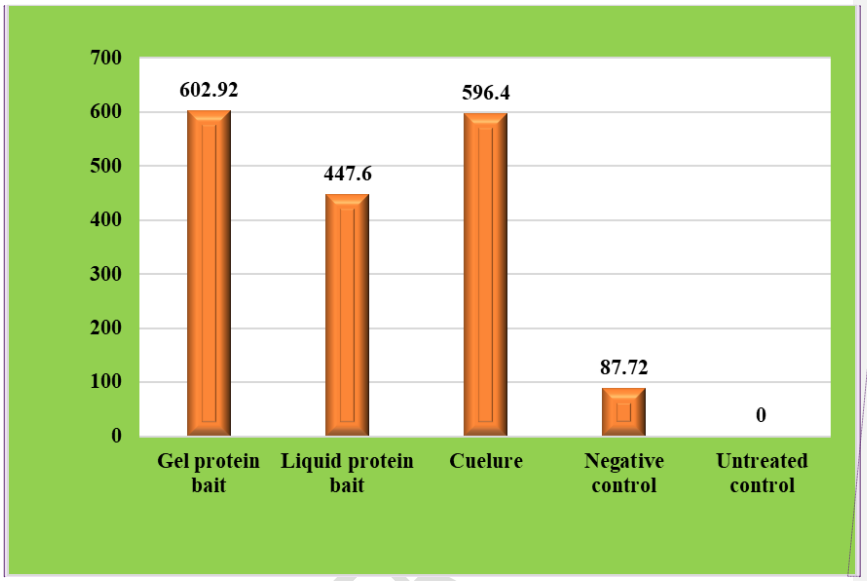

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Table 21. Evaluation of trapping efficiency of gel proteinex bait to cucurbit fruit flies in bitter gourd

Particulars	Treatment	No. of fruit flies/trap							
		Preliminary field experiment*				Confirmatory field experiment*			
		5 DAPT		10 DAPT		5 DAPT		10 DAPT	
		Early fruiting stage	Fruiting stage	Early fruiting stage	Fruiting stage	Early fruiting stage	Fruiting stage	Early fruiting stage	Fruiting stage
Female fruit flies	Gel proteinex bait	36.80 (6.11)[a]	40.20 (6.38)[a]	40.20 (6.38)[a]	42.20 (6.53)[a]	75.10 (8.69)[a]	73.44 (8.60)[a]	82.20 (9.09)[a]	80.40 (8.99)[a]
	Liquid proteinex bait	23.60 (4.80)[b]	25.80 (5.13)[a]	28.60 (5.33)[b]	30.60 (5.58)[b]	53.20 (7.33)[b]	55.42 (7.48)[b]	57.96 (7.65)[b]	59.44 (7.74)[b]
	Cue-lure	0.00 (0.71)[d]	0.00 (0.71)[b]	0.00 (0.71)[c]	0.00 (0.71)[d]	0.00 (0.71)[d]	0.00 (0.71)[d]	0.00 (0.71)[d]	0.00 (0.71)[d]
	Negative control	4.00 (2.12)[c]	4.60 (2.26)[c]	3.80 (2.07)[b]	5.60 (2.46)[c]	11.20 (3.42)[c]	9.74 (3.20)[c]	13.70 (3.77)[c]	13.28 (3.71)[c]
	Untreated control	0.00 (0.71)[d]	0.00 (0.71)[c]	0.00 (0.71)[c]	0.00 (0.71)[d]	0.00 (0.71)[d]	0.00 0.71)[d]	0.00 (0.71)[d]	0.00 (0.71)[d]
	S.E(d)	0.0733	0.3808	0.0525	0.4544	0.0511	0.0373	0.0316	0.0363
	P	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Male fruit flies	Gel proteinex bait	31.20 (5.63)[b]	33.80 (5.86)[b]	33.60 (5.84)[b]	39.00 (6.28)[b]	68.60 (8.31)[b]	69.54 (8.37)[b]	74.90 (8.68)[b]	78.74 (8.90)[b]
	Liquid proteinex bait	19.00 (4.39)[c]	22.60 (4.80)[c]	20.80 (4.61)[c]	26.80 (5.22)[c]	52.10 (7.25)[c]	55.40 (7.48)[b]	56.58 (7.56)[c]	57.50 (7.62)[c]
	Cue-lure	69.60 (8.37)[a]	81.20 (9.04)[a]	78.00 (8.86)[a]	75.80 (8.73)[a]	136.30 (11.70)[a]	145.60 (12.09)[a]	160.60 (12.69)[a]	153.90 (12.43)[a]
	Negative control	4.20 (2.17)[d]	3.00 (1.87)[d]	3.80 (2.07)[d]	4.20 (2.17)[c]	8.80 (3.05)[d]	12.60 (3.62)[c]	7.90 (2.90)[d]	10.50 (3.32)[d]
	Untreated control	0.00 (0.71)[e]	0.00 (0.71)[d]	0.00 (0.71)[d]	0.00 (0.71)[c]	0.00 (0.71)[e]	0.00 (0.71)[d]	0.00 (0.71)[e]	0.00 (0.71)[e]
	S.E(d)	0.2976	0.6017	0.0579	0.0400	0.5318	0.0488	0.0407	0.0525
	P	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

* Mean of 5 replications

DAPT – Days after placement of traps

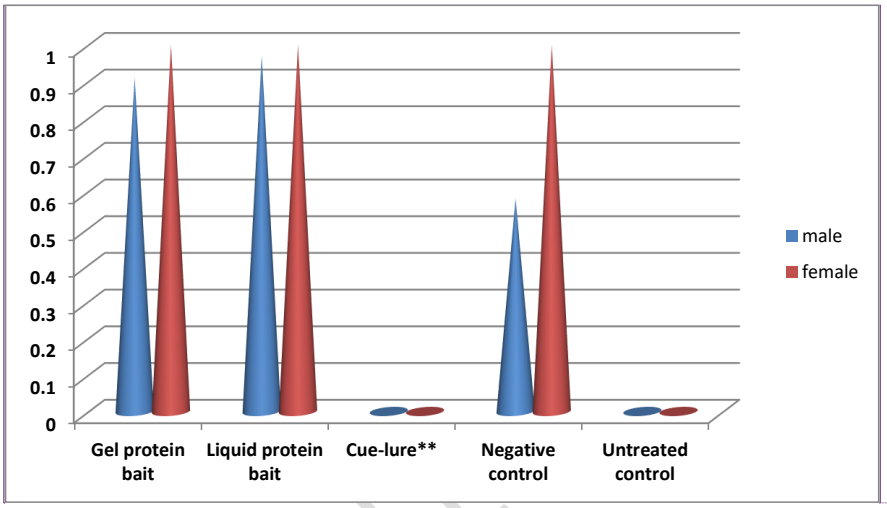
Figures in parentheses are square root transformed values

Means followed by the same letter in a column are not significantly different by Tukey's HSD test. (P=**0.05**)

3.1.3. Male to female ratio of cucurbit fruit flies in various traps

Male to female ratio was more in liquid proteinex bait followed by gel protein bait (Fig 2.). As in cuelure traps, no males were trapped, ratio was not arrived. Negative control attracted more female fruit flies than the males.

Fig 2. Male to female ratio of *Z. cucurbitae* in various traps in bitter gourd



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In bitter gourd field, when gel proteinex bait traps were placed, female fruit fly catch was more than the males because females need more amount of proteins for maturation of ovaries and this is evident with high female captures. This was in line with the experiments of Chinajariyawong *et al.,* 2003 who reported more attraction to female fruit flies to protein-based baits, pinnacle and Thailand bait in bitter gourd in Thailand. They also suggested that the female fruit flies need more protein for oviposition.

Eventhough, the number of trapped males are comparatively less, their attraction to gel proteinex bait traps reiterates the importance of protein sources for reproduction success of male fruit flies. This finding was supported by McInnis *et al.* (2004) who observed nil or very low levels of mating and impaired male sexual signals when they totally lack protein in *Z .cucurbitae* males.

3.1.4. Evaluation of gel proteinex bait in reducing the cucurbit fruit fly incidence

3.1.4. 1. Early fruiting stage

In the preliminary field experiment, in untreated control where empty traps were installed, highest fruit fly incidence (80.37) was observed. Among the treatments, lowest fruit fly incidence observed was 32.33% in gel proteinex bait installed bitter gourd fields. Next to this was liquid proteinex bait (42.36%). In the fields where, cue-lure traps were installed, 56.05% fruit fly incidence was observed. In negative control, where protein component was missing, 75.83% incidence was recorded (Table 32).

In the confirmatory field experiment also, gel proteinex bait traps placed in the fields recorded less fruit fly incidence ranging from 21.70% (III obs.) to 26.10% (VI obs.). The next mean low incidences were 34.13% and 48.34% in liquid proteinex bait and cue-lure treatments respectively. Untreated control plots recorded 72.37% mean incidence. Overall mean of per cent incidences of both preliminary and confirmatory field trials revealed the superiority of gel proteinex bait in reducing the cucurbit fruit fly incidence (28.03%) when compared to liquid proteinex bait (38.24%) and cue-lure (52.19%).

3.1.4. 2. Fruiting stage

Observations recorded on cucurbit fruit fly incidence during the preliminary field experiment showed that, when compared to rest of the treatments *i.e.,* liquid protein baitex (42.38%); cue-lure (56.57%); negative control (71.23%) and untreated control (77.03%), in gel proteinex bait installed plots, less number of fruits were infested with the fruit flies (30.68%) (Table 32).

Confirmatory field experiment also affirmed the above results. Gel proteinex bait treatment was found to be effective in reducing the cucurbit fruit fly incidence as it recorded 26.72% incidence followed by 37.83% in liquid proteinex bait treatments while it was 74.60% and 68.97% in untreated and negative controls respectively. Overall results of both preliminary and confirmatory field trials established the effectiveness of gel proteinex bait in reducing the cucurbit fruit fly incidence (26.72%).

In India, Ravindranath and Pillai, (1986) reported 89.0% incidence due to cucurbit fruit fly in bitter gourd and Gupta *et al.,* 1992 reported 60% incidence in bitter gourd. Gogi *et al.* (2009) recorded a maximum infestation of 75.0% and 31.3%

yield losses due to melon fruit fly in bitter gourd. In the present study, in untreated control plots of bitter gourd, 80.37% melon fruit fly incidence was observed while in gel proteinex bait traps installed fields it was 26.72% in fruiting stage. This clearly indicated the effectiveness of gel proteinex bait in reducing the melon fruit fly incidence by attracting more number of female and male fruit flies.

Table 32. Evaluation of various traps in reducing the percent incidences of cucurbit fruit flies

Particulars	Treatment	No. of fruit flies/ trap														Overall Mean
		Preliminary field experiment*							Confirmatory field experiment*							
		I obs.	II obs.	III obs.	IV obs.	V obs.	VI obs.	Mean	I obs.	II obs.	III obs.	IV obs.	V obs.	VI obs.	Mean	
Early fruiting stage	Gel protein bait	37.40 (37.72)[a]	33.20 (35.20)[a]	34.20 (35.81)[a]	26.60 (31.06)[a]	30.74 (33.69)[a]	31.82 (34.36)[a]	32.33 (34.66)[a]	24.60 (29.75)[a]	25.74 (30.50)[a]	21.70 (27.78)[a]	22.44 (28.29)[a]	21.80 (27.85)[a]	26.10 (30.74)[a]	23.73 (29.16)[a]	28.03 (31.98)[a]
	Liquid protein bait	45.96 (42.70)[b]	43.90 (41.52)[b]	42.90 (40.94)[b]	36.00 (36.89)[b]	42.60 (40.77)[b]	42.80 (40.88)[b]	42.36 (40.63)[b]	33.56 (35.42)[b]	36.00 (36.89)[b]	33.70 (35.50)[b]	31.50 (34.16)[b]	36.50 (37.19)[b]	33.50 (35.38)[b]	34.13 (35.76)[b]	38.24 (38.22)[b]
	Cue-lure	62.80 (52.44)[c]	55.20 (48.01)[c]	52.50 (46.46)[c]	56.60 (48.82)[c]	54.02 (47.33)[c]	55.20 (48.01)[c]	56.05 (48.49)[c]	51.20 (45.71)[c]	51.80 (46.05)[c]	44.20 (41.69)[c]	40.84 (39.74)[c]	48.00 (43.88)[c]	54.00 (47.32)[c]	48.34 (44.06)[c]	52.19 (46.28)[c]
	Negative control	76.40 (60.97)[d]	79.26 (62.94)[d]	72.10 (58.15)[d]	75.30 (60.23)[d]	77.70 (61.85)[d]	74.20 (59.50)[d]	75.83 (60.56)[d]	67.00 (54.97)[d]	62.90 (52.50)[d]	67.30 (55.15)[d]	73.10 (58.79)[d]	67.10 (55.03)[d]	67.48 (55.26)[d]	67.48 (55.26)[d]	71.65 (57.86)[d]
	Untreated control	80.32 (63.70)[e]	82.60 (65.38)[e]	75.40 (60.30)[e]	79.76 (63.30)[e]	81.00 (64.19)[e]	83.16 (65.81)[e]	80.37 (63.70)[e]	70.80 (57.32)[e]	69.00 (56.20)[e]	70.70 (57.26)[e]	79.20 (62.90)[e]	71.70 (57.89)[e]	72.80 (58.59)[e]	72.37 (58.31)[e]	76.37 (60.94)[e]
	S.E(d)	0.7978	0.9154	0.5018	0.7052	0.7320	0.9182	0.3950	0.7957	0.7210	0.5873	0.6114	1.0354	0.0401	0.4011	0.7978
	P	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Fruiting stage	Gel protein bait	28.40 (32.22)[a]	28.40 (32.22)[a]	31.70 (34.28)[a]	31.00 (33.85)[a]	31.20 (33.97)[a]	33.40 (35.32)[a]	30.68 (33.65)[a]	21.90 (27.92)[a]	22.70 (28.47)[a]	25.20 (30.15)[a]	23.40 (28.94)[a]	21.30 (27.50)[a]	22.10 (28.06)[a]	22.77 (28.47)[a]	26.72 (31.15)[a]
	Liquid protein bait	41.60 (40.18)[b]	42.00 (40.42)[b]	39.10 (38.72)[b]	42.40 (40.65)[b]	47.00 (43.30)[b]	42.20 (40.53)[b]	42.38 (42.30)[b]	32.20 (34.59)[b]	34.00 (35.69)[b]	33.10 (35.14)[b]	36.20 (37.01)[b]	33.20 (35.20)[b]	31.00 (33.85)[b]	33.28 (35.24)[b]	37.83 (37.96)[b]
	Cue-lure	56.10 (48.53)[c]	59.26 (50.36)[c]	53.10 (46.80)[c]	56.60 (48.82)[c]	58.98 (50.20)[c]	55.40 (48.12)[c]	56.57 (56.56)[c]	45.70 (42.55)[c]	46.60 (43.07)[c]	42.70 (40.82)[c]	54.80 (47.78)[c]	48.22 (44.00)[c]	42.50 (40.71)[c]	46.75 (43.15)[c]	51.66 (45.97)[c]
	Negative control	76.90 (61.30)[d]	72.70 (58.53)[d]	68.00 (55.58)[d]	70.50 (57.13)[d]	67.30 (55.15)[d]	72.00 (58.08)[d]	71.23 (71.20)[d]	63.10 (52.62)[d]	68.00 (55.58)[d]	67.20 (55.09)[d]	68.30 (55.76)[d]	67.50 (55.27)[d]	66.18 (54.47)[d]	66.71 (54.78)[d]	68.97 (56.17)[d]
	Untreated control	80.90 (64.12)[e]	76.00 (60.70)[e]	71.30 (27.64)[e]	75.08 (60.08)[e]	81.40 (64.48)[e]	77.50 (61.71)[e]	77.03 (77.02)[e]	74.70 (59.83)[e]	72.10 (58.15)[e]	72.50 (58.40)[e]	72.40 (58.34)[e]	70.60 (57.19)[e]	70.78 (57.31)[e]	72.18 (58.21)[e]	74.60 (59.70)[e]
	S.E(d)	0.6970	0.9042	0.4884	0.7334	0.6783	0.7608	0.3886	0.8725	0.7223	1.0424	0.8175	0.4193	0.5045	0.5457	0.5806
	P	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

* Mean of five replications DAPT – Days after placement of traps Means followed by the same letter in a column are not

obs. – observation

Figures in parentheses are arcsine transformed values

significantly different by Tukey's HSD test. (P=0.05)

3.1.5. Evaluation of gel proteinex bait in reducing the level of incidence of cucurbit fruit fly

3.1.5.1. Early fruiting stage

In the preliminary field experiment, level of incidence (LoI) of fruit fly ranged from 3.00 (III obs.) to 3.74 (IV obs.) in gel proteinex bait and mean LoI (3.33) was the lowest among all the treatments. Liquid proteinex bait and cue-lure recorded 5.82 and 8.14 LoI respectively. In untreated control, highest LoI (25.28) was observed (Table 43).

Mean LoI in the confirmatory field experiment ranged from 2.29 (gel proteinex bait) to 24.03 (untreated control). Negative control recorded LoI of 19.70. When compared to gel proteinex bait, liquid proteinex bait and cue-lure recorded more LoI of 4.69 and 7.39 respectively. Overall mean values of preliminary and confirmatory field trials indicated that placing of gel proteinex bait traps reduced the level of incidences (2.81) of cucurbit fruit fly in bitter gourd fields effectively than the other treatments.

3.1.5.2. Fruiting stage

In the preliminary field experiment among the observation periods, low LoI recorded in gel proteinex bait, liquid proteinex bait and cue-lure installed plots were 4.10 (V obs.), 5.74 (II obs.) and 7.78 (III obs.) with mean LoI 4.47, 6.13 and 8.63 respectively. LoI of untreated and negative controls were very high *i.e*., 26.35 and 22.59 respectively (Table 43).

In the confirmatory field experiment, efficacy of gel proteinex bait treatment was evident with 2.20 LoI when compared to liquid proteinex bait (4.59) and cue-lure (7.74) and untreated control with LoI of 26.40. Overall mean level of incidence was lowest (3.33) in gel proteinex bait treatment followed by liquid proteinex bait (5.36) and cue-lure (8.18).

Table 43. Evaluation of various traps in reducing the level of incidences of cucurbit fruit flies in bitter gourd

Particulars	Treatment	No. of fruit flies/ trap													
		Preliminary field experiment*							Confirmatory field experiment*							Over all Mean
		I obs.	II obs.	III obs.	IV obs.	V obs.	VI obs.	Mean	I obs.	II obs.	III obs.	IV obs.	V obs.	VI obs.	Mean	
Early fruiting stage	Gel protein bait	3.28 (1.94) [a]	3.04 (1.88) [a]	3.00 (1.87) [a]	3.74 (2.06) [a]	3.20 (1.92) [a]	3.70 (2.05) [a]	3.33 (0.22) [a]	2.20 (1.63) [a]	2.74 (1.80) [a]	2.34 (1.68) [a]	1.96 (1.57) [a]	2.16 (1.63) [a]	2.34 (1.68) [a]	2.29 (0.20) [a]	2.81 (0.30) [a]
	Liquid protein bait	6.22 (2.60) [b]	5.60 (2.46) [b]	5.66 (2.48) [b]	5.78 (2.51) [b]	6.11 (2.57) [b]	5.56 (2.46) [b]	5.82 (2.51) [b]	5.16 (2.38) [b]	5.26 (2.40) [b]	4.20 (2.17) [b]	3.50 (2.00) [b]	4.90 (2.32) [b]	5.12 (2.37) [b]	4.69 (0.67) [b]	5.25 (2.40) [b]
	Cue-lure	7.94 (2.91) [c]	7.32 (2.79) [c]	8.44 (2.99) [c]	8.14 (2.94) [c]	8.60 (3.01) [c]	8.39 (2.98) [c]	8.14 (0.58) [c]	7.02 (2.74) [c]	7.14 (2.76) [c]	7.30 (2.79) [c]	7.20 (2.77) [c]	7.34 (2.80) [c]	8.34 (2.97) [c]	7.39 (0.23) [c]	7.76 (0.13) [c]
	Negative control	19.50 (4.47) [d]	22.44 (4.79) [d]	21.60 (4.70) [d]	8.60 (3.01) [d]	24.40 (4.99) [d]	21.60 (4.70) [d]	19.69 (1.35) [d]	19.00 (4.39) [d]	19.26 (4.44) [d]	20.90 (4.62) [d]	20.00 (4.53) [d]	19.02 (4.42) [d]	20.00 (4.52) [d]	19.70 (0.45) [d]	19.69 (0.44) [d]
	Untreated control	22.40 (4.78) [e]	25.70 (5.11) [e]	26.40 (5.18) [e]	24.40 (4.99) [e]	27.80 (5.32) [e]	25.00 (5.04) [e]	25.28 (0.90) [e]	21.40 (4.68) [d]	23.00 (4.85) [e]	25.20 (5.07) [e]	23.60 (4.90) [d]	25.40 (5.09) [d]	25.60 (5.11) [d]	24.03 (0.78) [d]	24.65 (1.19) [e]
	S.E(d)	0.1011	0.1084	0.0883	0.1960	0.0957	0.1104	0.0695	0.1474	0.0613	0.0713	0.0972	0.0644	0.0749	0.0526	0.0460
	P	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Fruiting stage	Gel protein bait	4.34 (2.20) [a]	4.66 (2.27) [a]	4.28 (2.18) [a]	4.80 (2.30) [a]	4.10 (2.14) [a]	4.62 (2.26) [a]	4.47 (2.25) [a]	1.88 (1.54) [a]	1.86 (1.53) [a]	2.54 (1.74) [a]	2.76 (1.80) [a]	1.88 (1.54) [a]	2.30 (1.67) [a]	2.20 (1.63) [a]	3.33 (0.25) [a]
	Liquid protein bait	6.30 (2.61) [b]	5.74 (2.50) [b]	6.08 (2.56) [b]	6.44 (2.63) [bc]	5.98 (2.54) [b]	6.26 (2.60) [b]	6.13 (0.70) [b]	3.10 (1.90) [b]	5.02 (2.35) [b]	4.46 (2.24) [b]	4.42 (2.22) [b]	5.24 (2.40) [b]	5.30 (2.41) [b]	4.59 (0.42) [b]	5.36 (0.19) [b]
	Cue-lure	9.12 (3.10) [c]	9.20 (3.11) [c]	7.78 (2.88) [b]	8.32 (2.97) [c]	8.26 (2.96) [b]	9.08 (3.10) [c]	8.63 (3.02) [c]	7.30 (2.79) [c]	7.24 (2.78) [c]	9.66 (3.19) [c]	7.62 (2.85) [c]	7.16 (2.77) [c]	7.46 (2.82) [c]	7.74 (0.29) [c]	8.18 (0.60) [c]
	Negative control	22.84 (4.83) [d]	23.60 (4.91) [d]	21.60 (4.70) [c]	22.80 (4.82) [d]	22.00 (4.74) [c]	22.70 (4.82) [d]	22.59 (1.22) [d]	17.80 (4.27) [d]	18.60 (4.37) [d]	25.20 (5.06) [d]	22.30 (4.77) [d]	21.96 (4.74) [d]	22.20 (4.76) [d]	21.34 (0.82) [d]	21.96 (1.02) [d]
	Untreated control	21.90 (4.73) [d]	29.40 (5.45) [e]	23.80 (4.92) [c]	25.60 (5.11) [d]	27.80 (5.32) [c]	29.60 (5.48) [e]	26.35 (1.16) [e]	24.60 (5.01) [e]	22.60 (4.81) [e]	30.00 (5.52) [e]	25.10 (5.05) [e]	29.80 (5.50) [e]	26.30 (5.18) [e]	26.40 (1.43) [e]	26.37 (26.38) [e]
	S.E(d)	0.0585	0.1711	0.1104	0.1219	0.0927	0.0630	0.0695	0.0683	0.066	0.1117	0.0936	0.0623	0.0558	0.0569	0.0720
	P	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

* Mean of five replications

obs. – observation

DAPT – Days after placement of traps

Figures in parentheses are square root transformed values

Means followed by the same letter in a column are not significantly different by Tukey's HSD test. (P=**0.05**)

4. Conclusion

In bitter gourd, attraction of female fruit flies was more in gel protein bait traps followed by liquid protein bait. More number of male fruit flies was recorded in cue-lure traps followed by gel protein bait trap. Female fruit fly preference to gel protein bait proved that they require more proteins for maturation of ovaries. When compared to the females, preference of males to gel protein bait was less. However, considerable number of male fruit flies also was observed in these traps with which it was evident that males also need protein sources for their reproduction. Per cent incidence of cucurbit fruit fly was low in gel protein bait placed bitter gourd fields than the fields in which liquid protein bait and cue-lure were placed. This may be due to the decreased egg laying in field conditions as more number of females was trapped.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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