Indian Journal of Entomology 86(2): 519-526 (2024) DoI. No.: 10.55446/IJE.2023.1576

FIELD EVALUATION OF PROTEIN BAIT IN ATTRACTING THE MELON FRUIT FLY *ZEUGODACUS CUCURBITAE* (COQUILLETT) IN SNAKE GOURD

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ABSTRACT

In India, melon fruit fly *Zeugodacus cucurbitae* Coquillett is a destructive insect pest of cucurbits. This study evaluated its attraction towards gel protein bait, an improvised version of liquid protein bait, found to be attractive in previous studies in snake gourd. Two field experiments were conducted for four months each (preliminary one - January to April, 2023; and confirmatory one - April to July, 2023). In early fruiting and fruiting stages, gel protein bait significantly attracted more females than the liquid protein bait; as regards male, cuelure trap attracted more followed by gel protein and liquid protein bait traps. Evaporation of gel protein bait in the field conditions was comparatively less from that of liquid protein bait.

Key words: *Zeugodacus cucurbitae*, gel protein bait, liquid protein bait, cuelure, negative control, untreated control, snake gourd, attraction capacity, male to female ratio, evaporation

India is the world's second largest producer of vegetables cultivated in an area of 1.10 crore ha with a production of 19.98 mt (2021-2022), and in Tamil Nadu, it is 3.39 lakh ha and 90.74 mt (Indiastat, 2022). Among the cucurbitaceous vegetables, snake gourd (*Trichosanthes cucumerina* L) is an important nutritious one (Liyanage et al., 2016). The melon fruit fly *Zeugodacus cucurbitae* (Coquillett) is an important tephritid pest known to infest > 100 varieties of fruits and vegetables. In India, 40 to 60% damage to vegetables had been attributed to this pest (Kapoor, 1993; Jakhar et al., 2020). Among its management methods, use of insecticides results in insect resurgence, resistance, secondary pest outbreak and eradication of natural enemies (Hagen and Franz, 1973). Ecofriendly and sustainable IPM practices are essential (Verghese et al., 2013). An important alternative is male annihilation, using the male lures, and parapheromones. 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 focus on attraction of males only; focus towards the trapping of female could be more advantageous (Siderhurst and Jang, 2010). Still more advantageous are the baits that attract both male and females, which need to be protein-rich; and attractiveness of protein source is an important part (Iqbal et al., 2020). Hence, the present study, to evaluate the fruit fly luring potential of gel protein bait, an improvised version of liquid protein bait which was found to be attractive in previous studies.

MATERIALS AND METHODS

Two field trials were conducted to evaluate the trapping efficiency of gel protein bait in comparison with liquid protein bait, cuelure, negative control and untreated control in snake gourd. Preliminary field experiments were conducted at Kesampatti village (10.14º N, 78.28º E) during January to April of 2023 and confirmatory experiments at Sekkipatti village (10.19º N, 78.30º E) during April to July of 2023, Melur block, Madurai district, Tamil Nadu. For each treatment, five replications were maintained with an isolation distance of 50 m and the experiment was conducted in a randomized block design. Liquid protein bait formulation was prepared by addition of protein powder, sweetener, inorganic salt, preservatives in the ratio (10:10:5:2), respectively and 0.001% malathion to 1000 ml of water. Gel protein bait formulation was prepared by dissolving 0.8 g of gel powder in 1000 ml of liquid protein bait (gel protein bait is a simple gel formulation of liquid protein bait which was developed to minimize the evaporation of the bait in field conditions). Negative control was prepared with the base materials of liquid protein bait except protein powder. In untreated control, empty traps were placed.

Bait traps were designed by modifying 1 litre capacity plastic containers of 10 cm diameter and 20 cm height. 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 prepared baits were subjected to fermentation for 36 hr and transferred to the designed traps @ 300 ml/ trap, these were installed at a height of 1.5 to 2 m in the iron wires of pandal with jute coir under shade. 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) was made and continued for four months. During early fruiting stage it was 45 days after sowing, and at fruiting stage 120 days after, in both preliminary and confirmatory trials. Number of trapped males and females were counted separately and male to female ratio was arrived. 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).

RESULTS AND DISCUSSION

Among the treatments, no female fruit flies were collected in cuelure trap. So, observations in rest of the treatments (gel protein bait, liquid protein bait, negative control and untreated control) are discussed. In the preliminary field experiment, among the six observations, gel protein bait was found to be significantly effective in trapping females -30-40/ trap (TFT/ T) at 5 DAPT. Next to this treatment, liquid protein bait attracted more females (18.00 TFT/ T). Gel protein bait was found to be significantly more attractive than the liquid protein bait; in negative control, least number was observed (3.60 TFT/ T). In the confirmatory field experiment also, gel protein bait traps attracted more females (79.20 TFT/ T) at 5 DAPT confirming the results of the preliminary trial. Traps with liquid protein bait attracted 54.00 females/ trap and in negative and untreated controls, it was 6.00 and 0.00, respectively. With regard to the overall mean of preliminary and confirmatory field trials, females trapped in gel protein bait traps was significantly more (54.80 TFT/ T) when compared to the liquid protein bait traps (36.00 TFT/ T) (Table 1). Ravikumar and Viraktamath (2007) also reported good attraction of fruit flies i.e., *B. correcta, B. dorsalis* and *Z. cucurbitae* with the placement of protein and 5% ammonium acetate in guava orchard.

In the preliminary field experiment, at 10 DAPT, among the bait treatments, gel protein bait trapped more females (33.60 TFF/ T); ranged between 5.20 (I and II obs.) and 6.60 (VI obs.); liquid protein bait recorded 22.40 TFT/ T with a range from 3.20 FF/ T (I obs.) to 4.20 FF/ T (V obs.). In negative control, least number was observed (0.80). In the confirmatory field experiment, at 10 DAPT, maximum number of females got trapped in gel protein bait and in liquid protein bait trap it varied -14.40 (III and IV obs.) and 10.20/ trap (VI obs.), respectively; females/ trap was significantly more in gel protein bait treatment (82.00) than the liquid protein bait treatment (57.80). In negative and untreated controls, total female fruit fly catch/ trap was 5.00 and 0.00, respectively. Overall mean of preliminary and confirmatory field trials revealed the superiority of gel protein bait traps (Table 1; Fig. 1). Devi et al. (2020) observed good attractancy of hydrolysed protein to both male and female of *Bactrocera tau*. Sruthi et al. (2021) reported that the females were attracted more to the protein-based baits when compared to the food baits and they reasoned this to the protein requirement of female for development and sexual maturation.

During the fruiting stage, in preliminary field experiment, at 5 DAPT, comparatively more females/ trap- 7.20 (IV obs.) was noted. In the liquid protein bait, it was 4.00, and was significantly more (37.80) in gel protein bait than the liquid protein ones (21.60); in negative control, it was 0.60 (V and VI obs.) to 1.20 (IV obs.). In the confirmatory field experiment also, at 5 DAPT, gel protein bait traps lured more females (65.80) followed by liquid protein bait (48.50); treatments were significantly different in their trapping efficiency. In gel protein bait treatment, females/ trap ranged from 9.60 (I obs.) to 12.60 (II obs.) while in liquid protein bait it was 6.80 (II obs.) and 9.60 (IV obs.). Overall means at 5 DAPT in both the preliminary and confirmatory field trials also confirmed that gel protein bait traps significantly attracted more (51.80)

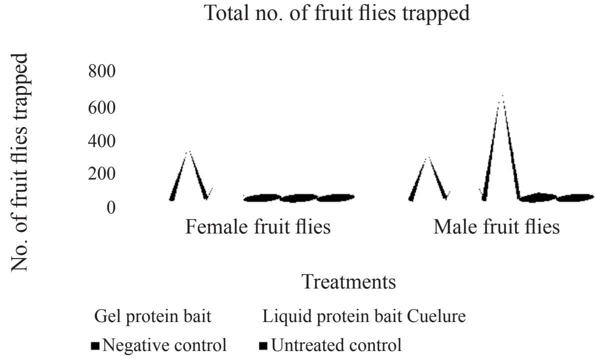

Fig. 1. Fruit flies trapped- preliminary and confirmatory (pooled data)

Table 1. Trapping efficiency of gel protein bait to *Z. cucurbitae* in snake gourd- early fruiting stage

Particulars	Treatment	No. of fruit flies/ trap (5 DAPT)														
		Preliminary field experiment							Confirmatory field experiment							Over all Mean
		I obs.	II obs.	III obs.	IV obs.	V obs.	VI obs.	Total	I obs.	II obs.	III obs.	IV obs.	V obs.	VI obs.	Total	
No. of female fruit flies/ trap at 5 DAPT*	Gel protein bait	4.80 (2.30)^{a}	4.60 (2.27)^{a}	4.60 (2.27)^{a}	5.20 (2.39)^{a}	5.40 (2.43)^{a}	5.80 (2.51)^{a}	30.40 (12.49)^{a}	13.00 (3.67)^{a}	14.00 (3.81)^{a}	14.80 (3.91)^{a}	14.60 (3.89)^{a}	12.20 (3.56)^{a}	10.60 (3.33)^{a}	79.20 (8.93)^{a}	54.80 (7.44)^{a}
	Liquid protein bait	3.00 (1.86)^{b}	2.60 (1.75)^{b}	3.00 (1.86)^{b}	3.40 (1.97)^{b}	3.20 (1.91)^{b}	2.80 (1.81)^{b}	18.00 (10.62)^{b}	9.60 (3.18)^{b}	8.80 (3.05)^{b}	9.20 (3.11)^{b}	9.20 (3.11)^{b}	9.00 (3.08)^{b}	8.20 (2.95)^{b}	54.00 (7.38)^{b}	36.00 (6.04)^{b}
	Cuelure	0.00 (0.71)^{c}	0.00 (0.71)^{c}	0.00 (0.71)^{c}	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)^{c}	0.00 (0.71)^{d}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.00 (0.71)^{d}
	Negative control	0.60 (1.02)^{c}	0.40 (0.91)^{c}	0.60 (1.02)^{c}	0.80 (1.12)^{c}	0.60 (1.02)^{c}	0.60 (1.02)^{c}	3.60 (3.08)^{c}	0.60 (1.02)^{c}	1.40 (1.32)^{c}	1.60 (1.39)^{c}	0.40 (0.91)^{c}	1.60 (1.39)^{c}	0.40 (0.91)^{c}	6.00 (2.55)^{c}	4.80 (2.30)^{c}
	Untreated control	0.00 (0.71)^{c}	0.00 (0.71)^{c}	0.00 (0.71)^{c}	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)^{c}	0.00 (0.71)^{d}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.00 (0.71)^{d}
	SEd	0.1086	0.1169	0.1311	0.10193	0.1155	0.1492	0.10390	0.0923	0.1308	0.1349	0.1189	0.1473	0.0915	0.6619	0.0585
	P	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**
No. of male fruit flies/ trap at 5 DAPT*	Gel protein bait	4.20 (2.17)^{b}	4.20 (2.17)^{b}	4.60 (2.27)^{b}	4.00 (2.12)^{b}	4.60 (2.27)^{b}	5.00 (2.34)^{b}	26.60 (5.16)^{b}	10.40 (3.30)^{b}	11.40 (3.45)^{b}	11.00 (3.39)^{b}	10.60 (3.33)^{b}	11.20 (3.42)^{b}	11.00 (3.39)^{b}	65.60 (8.10)^{b}	46.10 (6.83)^{b}
	Liquid protein bait	2.80 (1.81)^{b}	2.60 (1.75)^{c}	2.20 (1.61)^{c}	2.60 (1.75)^{c}	3.20 (1.91)^{b}	3.20 (1.91)^{c}	16.60 (4.07)^{c}	8.80 (3.05)^{b}	8.60 (3.01)^{c}	8.40 (2.98)^{b}	8.80 (3.05)^{b}	8.20 (2.95)^{c}	9.60 (3.18)^{c}	52.40 (7.27)^{c}	34.50 (5.92)^{c}
	Cuelure	10.00 (3.24)^{a}	11.40 (3.45)^{a}	11.80 (3.49)^{a}	12.20 (3.56)^{a}	9.60 (3.18)^{a}	13.20 (3.70)^{a}	68.20 (8.26)^{a}	26.00 (5.15)^{a}	27.00 (5.24)^{a}	26.20 (5.16)^{a}	26.40 (5.18)^{a}	27.00 (5.24)^{a}	30.00 (5.51)^{a}	162.60 (12.78)^{a}	115.40 (10.77)^{a}
	Negative control	0.60 (1.02)^{c}	0.80 (1.12)^{d}	1.20 (1.26)^{d}	0.40 (0.91)^{d}	0.60 (1.02)^{c}	0.80 (1.12)^{d}	4.40 (2.09)^{d}	1.60 (1.39)^{c}	1.40 (1.32)^{d}	1.40 (1.32)^{c}	2.20 (1.61)^{c}	0.60 (1.02)^{d}	0.40 (0.91)^{d}	7.60 (2.84)^{d}	6.00 (2.55)^{d}
	Untreated control	0.00 (0.71)^{e}	0.00 (0.71)^{e}	0.00 (0.71)^{e}	0.00 (0.71)^{d}	0.00 (0.71)^{c}	0.00 (0.71)^{e}	0.00 (0.71)^{e}	0.00 (0.71)^{d}	0.00 (0.71)^{e}	0.00 (0.71)^{d}	0.00 (0.71)^{d}	0.00 (0.71)^{d}	0.00 (0.71)^{d}	0.00 (0.71)^{e}	0.00 (0.71)^{e}
	SEd	0.1381	0.1251	0.1631	0.1087	0.1644	0.1063	0.0608	0.0929	0.1430	0.1821	0.1144	0.1044	0.1056	0.0793	0.0799
	P	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**

(contd.)

(Table 1 contd.)

Particulars	Treatment	No. of fruit flies/ trap at 10 DAPT														
		Preliminary field experiment							Confirmatory field experiment							Over all mean
		I obs.	II obs.	III obs.	IV obs.	V obs.	VI obs.	Total	I obs.	II obs.	III obs.	IV obs.	V obs.	VI obs.	Total	
No. of female fruit flies/ trap at 10 DAPT*	Gel protein bait	5.20 (2.39)^{a}	5.20 (2.39)^{a}	5.40 (2.43)^{a}	5.40 (2.43)^{a}	5.80 (2.51)^{a}	6.60 (2.65)^{a}	33.60 (5.85)^{a}	12.80 (3.65)^{a}	12.20 (3.56)^{a}	14.40 (3.86)^{a}	14.40 (3.86)^{a}	14.20 (3.83)^{a}	14.00 (3.81)^{a}	82.00 (9.11)^{a}	57.80 (7.64)^{a}
	Liquid protein bait	3.20 (1.91)^{b}	3.80 (2.07)^{a}	3.60 (2.02)^{b}	3.60 (2.02)^{b}	4.20 (2.17)^{b}	4.00 (2.12)^{b}	22.40 (4.81)^{b}	9.40 (3.15)^{b}	9.60 (3.18)^{b}	9.40 (3.15)^{b}	9.60 (3.18)^{b}	9.60 (3.18)^{b}	10.20 (3.27)^{b}	57.80 (7.64)^{b}	40.10 (6.37)^{b}
	Cuelure	0.00 (0.71)^{d}	0.00 (0.71)^{d}	0.00 (0.71)^{c}	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)^{c}	0.00 (0.71)^{d}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.00 (0.71)^{d}
	Negative control	0.60 (1.02)^{c}	0.60 (1.02)^{c}	0.60 (1.02)^{c}	0.80 (1.12)^{c}	0.40 (0.91)^{c}	0.40 (0.91)^{c}	3.40 (1.93)^{c}	1.00 (1.19)^{c}	1.00 (1.19)^{c}	1.20 (1.25)^{c}	0.40 (0.91)^{c}	1.00 (1.19)^{c}	0.40 (0.91)^{c}	5.00 (2.34)^{c}	4.20 (2.17)^{c}
	Untreated control	0.00 (0.71)^{d}	0.00 (0.71)^{d}	0.00 (0.71)^{c}	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)^{c}	0.00 (0.71)^{d}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.00 (0.71)^{d}
	SEd	0.0887	0.0887	0.1232	0.1171	0.0879	0.1208	0.6920	0.0965	0.1047	0.1523	0.0852	0.1097	0.0985	0.6979	0.0603
	P	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**
No. of male fruit flies/ trap at 10 DAPT*	Gel protein bait	4.40 (2.09)^{b}	5.00 (2.34)^{b}	5.20 (2.39)^{b}	5.00 (2.34)^{b}	5.20 (2.39)^{b}	6.00 (2.55)^{b}	30.80 (5.54)^{b}	12.60 (3.62)^{b}	11.80 (3.49)^{b}	11.60 (3.48)^{b}	12.00 (3.53)^{b}	12.60 (3.62)^{b}	12.40 (3.59)^{b}	73.00 (8.58)^{b}	51.90 (7.24)^{b}
	Liquid protein bait	2.80 (1.81)^{c}	3.00 (1.87)^{c}	3.80 (2.07)^{c}	3.20 (1.91)^{c}	3.40 (1.93)^{c}	3.00 (1.87)^{c}	19.20 (4.46)^{c}	9.20 (3.11)^{c}	9.40 (3.15)^{b}	9.00 (3.08)^{b}	9.40 (3.15)^{c}	10.20 (3.27)^{b}	9.20 (3.11)^{b}	56.40 (7.57)^{c}	37.80 (6.19)^{c}
	Cuelure	10.20 (3.27)^{a}	10.40 (3.30)^{a}	11.80 (3.49)^{a}	14.20 (3.83)^{a}	13.60 (3.75)^{a}	14.00 (3.80)^{a}	74.20 (8.64)^{a}	27.40 (5.28)^{a}	27.00 (5.24)^{a}	27.80 (5.31)^{a}	25.60 (5.11)^{a}	27.00 (5.24)^{a}	32.20 (6.24)^{a}	167.00 (12.95)^{a}	120.60 (11.00)^{a}
	Negative control	0.60 (1.02)^{d}	1.00 (1.19)^{d}	0.20 (0.81)^{c}	0.60 (1.02)^{d}	0.60 (1.02)^{d}	0.60 (1.02)^{d}	3.60 (2.01)^{d}	2.20 (1.61)^{d}	1.40 (1.32)^{c}	2.60 (1.73)^{c}	2.20 (1.61)^{d}	1.40 (1.32)^{c}	1.60 (1.39)^{c}	11.40 (3.45)^{d}	7.50 (2.83)^{d}
	Untreated control	0.00 (0.71)^{d}	0.00 (0.71)^{e}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.00 (0.71)^{d}	0.00 (0.71)^{d}	0.00 (0.71)^{e}	0.00 (0.71)^{e}	0.00 (0.71)^{d}	0.00 (0.71)^{d}	0.00 (0.71)^{e}	0.00 (0.71)^{d}	0.00 (0.71)^{d}	0.00 (0.71)^{e}	0.00 (0.71)^{e}
	SEd	0.1225	0.1176	0.1231	0.1258	0.1407	0.1250	0.6867	0.1304	0.1370	0.1558	0.1136	0.1362	0.1905	0.6743	0.0359
	P	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**

*Mean of five replications; DAPT – Days after placement of traps; obs. – observation; **Highly significant; Figures in parentheses square root transformed values ; Means followed by same letter in a column not significantly different (Tukey's HSD test, p=0.05)

(Table 2). Pinero et al. (2020) tested the combination of beer waste (protein-rich waste brewer's yeast product) and ammonium acetate to attract *B. dorsalis* and *Z. cucurbitae* and found that this mixture was more attractive than the commercially available GF-120 bait. The efficacy of protein-rich diets combined with ammonia in attracting fruit flies has been reported by Bayoumy and El-Metwally (2017).

At 10 DAPT, in the preliminary field experiment, highest number of female fruit flies/trap recorded were 7.20 (II obs.) and 5.40 (III obs.) in gel protein bait and liquid protein bait traps respectively. In these traps, the lowest catches noted were 5.20 (VI obs.) and 3.60FF/T (I, V and VI obs.) in gel protein bait and liquid protein bait traps, respectively. Female fruit flies trapped was significantly more in gel protein bait (38.40) than the liquid protein bait (26.00). In confirmatory field experiment, trap catches in gel protein bait traps at 10 DAPT were comparatively more (73.60/ trap) followed by liquid protein bait (54.60). Average of the trap catches of preliminary and confirmatory field trials proved the superior alluring capacity of gel protein bait traps (56.00 vs 40.30 TFT/ T). Thus, gel protein bait was found to be superior over liquid protein bait in attracting both female and male fruit flies (Table 2). This is due to the reduction of evaporation in gel protein bait due to the addition of gel powder. Maung et al. (2019) stated that protein-based bait formulation of brewers spent grain (33.3% in water) was an efficient fruit fly attractant and suggested this mixture for area wide integrated pest management of Oriental fruit fly, *B. dorsalis* in Myanmar. In Thailand, Chinajariyawong et al. (2003) evaluated Australian protein bait, Pinnacle® (420 g/ l) and Thai brewery waste (33 ml/ l) and found that both baits considerably reduced the incidence levels of *Z. tau* and *Z. cucurbitae* in angled luffa and bitter gourd, respectively. The results of Manikantha et al. (2022) indicated that proteinex bait attracted more melon fruit flies in snake gourd and bitter gourd followed bait soybean bait. Their observation revealed that, majority of the fruit flies collected were females, proving that females require proteins in their food for growth and sexual maturation.

As regards trap catch of male during early fruiting stage of snake gourd, in the preliminary field experiment, at 5 DAPT, cuelure trap recorded more TMF/ T at 68.20 and fruit flies/trap ranged from 9.60 (V obs.) to 13.20 (VI obs.) (Table 1). In untreated control, no fruit flies were noted while in negative control, 0.40 (IV obs.) to 1.20 (III obs.) male fruit flies were recorded. In the confirmatory field experiment, these counts ranged between 26.00 (I obs.) and 30.00 (VI obs.) with 162.60 TMF/ T at 5 DAPT; and gel protein bait was the next alluring bait with 65.60 TMF/ T followed by liquid protein bait (52.4 TMF/ T) (Table 1). Overall mean of the two field trials revealed that cuelure trapped more (115.40 TMF/ T) followed by gel protein bait (46.10 TMF/ T). In the preliminary field experiment, at 10 DAPT, male fruit fly catch was high in cuelure traps (74.20 TMF/ T) (Table 1); in gel protein bait and liquid protein bait traps, highest number was 6.00 (VI obs.) and 3.80 (III obs.) respectively; male fruit flies/ trap was 30.80 in gel protein bait trap. At 10 DAPT, in the confirmatory field experiment, minimum catches by cuelure was 25.60/ trap (IV obs.) and maximum was 32.20/trap (VI obs.). Totally, 167.00 male fruit flies were trapped/trap during all the six observation periods. Gel protein bait traps attracted the male fruit flies to the tune of 11.60 (III obs.) to 12.60/ trap (I and V obs.). Total number of male fruit flies/ trap was significantly more (73.00) in gel protein bait traps when compared to liquid protein bait trap (56.40). Trap catch of two field trials revealed that cuelure trapped more no. of male fruit flies (120.60/ trap) followed by the gel protein bait (51.90/ trap) and liquid protein bait (37.80/ trap) (Fig. 1)

During fruiting stage of snake gourd, in the preliminary field experiment, at 5 DAPT, cuelure trap attracted 11.00 (II obs.) to 14.0 male fruit flies/trap (MF/T) (V obs.) with total number of 79.60 TMF/ T (Table 2). Next to this was, gel protein bait with 32.60 TMF/ T with a range from 5.0 (II obs.) to 5.80 (IV and V obs.) MF/ T. With regard to luring male fruit flies also, gel protein bait was significantly superior (32.60 TMF/T) than the liquid protein bait (18.80 TMF/ T). In the confirmatory field trial also, cuelure trap attracted more male fruit flies/ trap (160.0); and get protein bait was comparatively attractive to male (58.30 TMF/ T) than the liquid protein bait (47.00 TMF/ T). Average of the two field trials revealed more number in cuelure trap (119.80) and next to this was gel protein bait (45.45/trap). At 10 days after placement of traps, in preliminary field experiment, at 10 DAPT, more male fruit flies/ trap was recorded in cuelure trap [11.60 (III obs.) to 14.20 (II obs.)] with total number of 78.60 TMF/T. In the confirmatory field experiment too similar results were obtained. Overall mean trap catches of the two field trials showed that, cuelure trap attracted more males (123.70 TMF/ T) (Table 2). With regard to the attraction to male fruit flies, in the present study, cuelure was found to be more efficient than the protein baits. However, in contrast, Mwatawala et al. (2006),

Table 2. Trapping efficiency of gel protein bait to *Z. cucurbitae* in snake gourd- fruiting stage

Particulars	Treatment	No. of fruit flies/ trap at 5 DAPT														
		Preliminary field experiment							Confirmatory field experiment							Over all mean
		I obs.	II obs.	III obs.	IV obs.	V obs.	VI obs.	Total	I obs.	II obs.	III obs.	IV obs.	V obs.	VI obs.	Total	
No. of female fruit flies/ trap at 5 DAPT*	Gel protein bait	5.80 (2.51)^{a}	6.80 (2.70)^{a}	6.80 (2.70)^{a}	7.20 (2.77)^{a}	6.20 (2.58)^{a}	5.00 (2.34)^{a}	37.80 (6.17)^{a}	9.60 (3.18)^{a}	12.60 (3.62)^{a}	11.20 (3.42)^{a}	11.00 (3.39)^{a}	10.60 (3.33)^{a}	10.80 (3.36)^{a}	65.80 (8.13)^{a}	51.80 (7.23)^{a}
	Liquid protein bait	3.40 (1.93)^{b}	3.60 (2.02)^{b}	3.40 (1.93)^{b}	4.00 (2.12)^{b}	3.40 (1.93)^{b}	3.80 (2.07)^{b}	21.60 (4.73)^{b}	7.00 (2.74)^{b}	6.80 (2.70)^{b}	8.20 (2.95)^{b}	9.60 (3.18)^{b}	8.60 (3.02)^{b}	8.30 (2.97)^{b}	48.50 (6.97)^{b}	35.05 (6.00)^{b}
	Cuelure	0.00 (0.71)^{c}	0.00 (0.71)^{c}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.00 (0.71)^{d}	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}	0.00 (0.71)^{d}	0.00 (0.71)^{d}
	Negative control	1.00 (1.16)^{c}	0.80 (1.12)^{c}	0.80 (1.12)^{c}	1.20 (1.25)^{c}	0.60 (1.02)^{c}	0.60 (1.02)^{c}	5.00 (2.38)^{c}	0.60 (1.02)^{c}	0.60 (1.02)^{c}	0.60 (1.02)^{c}	0.40 (0.91)^{c}	1.20 (1.25)^{c}	0.60 (1.02)^{c}	4.00 (2.21)^{c}	4.50 (5.03)^{c}
	Untreated control	0.00 (0.71)^{c}	0.00 (0.71)^{c}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.00 (0.71)^{d}	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}	0.00 (0.71)^{d}	0.00 (0.71)^{d}
	SEd	0.1861	0.12754	0.1472	0.0933	0.1229	0.0953	0.5224	0.1096	0.1076	0.0953	0.1184	0.1239	0.0822	0.9529	0.0281
	P	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**
No. of male fruit flies/ trap at 5 DAPT*	Gel protein bait	5.20 (2.39)^{b}	5.00 (2.35)^{b}	5.60 (2.47)^{b}	5.80 (2.51)^{b}	5.80 (2.51)^{b}	5.20 (2.39)^{b}	32.60 (5.77)^{b}	9.20 (3.11)^{b}	10.40 (3.30)^{b}	9.60 (3.18)^{b}	9.54 (3.17)^{b}	9.80 (3.21)^{b}	9.80 (3.21)^{b}	58.30 (7.69)^{b}	45.45 (6.78)^{b}
	Liquid protein bait	2.80 (1.81)^{c}	3.20 (1.91)^{c}	3.00 (1.86)^{c}	3.60 (2.02)^{c}	3.20 (1.91)^{c}	3.00 (1.86)^{c}	18.80 (4.34)^{c}	7.60 (2.84)^{b}	7.60 (2.84)^{c}	8.00 (2.91)^{c}	8.60 (3.02)^{c}	7.60 (2.84)^{c}	7.60 (2.84)^{c}	47.00 (6.94)^{c}	32.90 (5.78)^{c}
	Cuelure	13.80 (3.78)^{a}	11.00 (3.38)^{a}	13.80 (3.78)^{a}	13.40 (3.72)^{a}	14.00 (3.80)^{a}	13.60 (3.76)^{a}	79.60 (8.95)^{a}	29.60 (5.47)^{a}	29.60 (5.70)^{a}	25.80 (5.13)^{a}	25.00 (5.04)^{a}	24.00 (4.92)^{a}	26.00 (5.15)^{a}	160.00 (12.68)^{a}	119.80 (10.97)^{a}
	Negative control	0.80 (1.12)^{d}	0.60 (1.02)^{d}	1.00 (1.19)^{d}	0.80 (1.12)^{d}	0.60 (1.02)^{d}	0.80 (1.12)^{d}	4.60 (2.27)^{d}	1.20 (1.25)^{c}	1.20 (1.25)^{d}	0.60 (1.02)^{d}	1.00 (1.15)^{d}	1.20 (1.25)^{d}	0.60 (1.02)^{d}	5.80 (2.51)^{d}	5.20 (2.38)^{d}
	Untreated control	0.00 (0.71)^{e}	0.00 (0.71)^{d}	0.00 (0.71)^{e}	0.00 (0.71)^{d}	0.00 (0.71)^{d}	0.00 (0.71)^{e}	0.00 (0.71)^{e}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.00 (0.71)^{d}	0.00 (0.71)^{e}	0.00 (0.71)^{e}	0.00 (0.71)^{d}	0.00 (0.71)^{e}	0.00 (0.71)^{e}
	SEd	0.1024	0.1209	0.1184	0.1451	0.1196	0.0979	0.0851	0.1912	0.1227	0.0927	0.1710	0.2111	0.1049	0.6085	0.0814
	P	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**

(contd.)

(Table 2 contd.)

Particulars	Treatment	No. of fruit flies/ trap at 10 DAPT														
		Preliminary field experiment							Confirmatory field experiment							Over all Mean
		I obs.	II obs.	III obs.	IV obs.	V obs.	VI obs.	Total	I obs.	II obs.	III obs.	IV obs.	V obs.	VI obs.	Total	
No. of female fruit flies/ trap at 10 DAPT*	Gel protein bait	6.80 (2.70)^{a}	7.20 (2.77)^{a}	7.00 (2.74)^{a}	6.60 (2.66)^{a}	5.60 (2.47)^{a}	5.20 (2.39)^{a}	38.40 (6.02)^{a}	12.00 (3.53)^{a}	13.40 (3.73)^{a}	12.80 (3.65)^{a}	12.20 (3.56)^{a}	11.40 (3.45)^{a}	11.80 (3.49)^{a}	73.60 (8.62)^{a}	56.00 (7.52)^{a}
	Liquid protein bait	3.60 (2.02)^{b}	5.20 (2.39)^{a}	5.40 (2.43)^{b}	4.60 (2.27)^{b}	3.60 (2.02)^{b}	3.60 (2.02)^{b}	26.00 (5.15)^{b}	8.80 (3.02)^{b}	9.40 (3.14)^{b}	9.60 (3.18)^{b}	9.30 (3.13)^{b}	9.00 (3.08)^{b}	8.50 (3.00)^{b}	54.60 (7.38)^{b}	40.30 (6.40)^{b}
	Cuelure	0.00 (0.71)^{c}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.00 (0.71)	0.00 (0.71)	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}	0.00 (0.71)^{d}	0.00 (0.71)^{d}	0.00 (0.71)^{d}
	Negative control	0.40 (0.91)^{c}	0.60 (1.02)^{b}	0.80 (1.12)^{c}	0.80 (1.12)^{c}	0.60 (1.02)^{c}	1.40 (1.35)	4.60 (2.27)	1.00 (1.19)^{c}	0.60 (1.02)^{c}	0.60 (1.02)^{c}	0.40 (0.91)^{c}	1.20 (1.25)^{c}	0.60 (1.02)^{c}	4.40 (2.24)^{c}	4.50 (2.23)^{c}
	Untreated control	0.00 (0.71)^{c}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.00 (0.71)	0.00 (0.71)	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}	0.00 (0.71)^{d}	0.00 (0.71)^{d}	0.00 (0.71)^{d}
	SEd	0.1095	0.1256	0.1165	0.1157	0.1232	0.0943	0.6965	0.1654	0.0991	0.0887	0.0832	0.1318	0.0915	0.5197	0.0466
	P	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**
No. of male fruit flies/ trap at 10 DAPT*	Gel protein bait	5.60 (2.47)^{b}	6.40 (2.63)^{b}	6.60 (2.66)^{b}	6.80 (2.70)^{b}	5.40 (2.43)^{b}	4.80 (2.30)^{b}	35.60 (3.20)^{b}	12.00 (3.53)^{b}	12.80 (3.65)^{b}	10.00 (3.24)^{b}	10.10 (3.25)^{b}	11.40 (3.45)^{b}	10.80 (3.36)^{b}	67.10 (8.22)^{b}	51.35 (7.20)^{b}
	Liquid protein bait	4.20 (2.17)^{b}	3.60 (2.02)^{c}	3.80 (2.07)^{c}	4.00 (2.12)^{c}	3.80 (2.07)^{b}	3.20 (1.91)^{c}	22.60 (2.71)^{c}	9.20 (3.11)^{b}	9.60 (3.18)^{c}	8.40 (2.98)^{c}	8.70 (3.03)^{c}	9.20 (3.11)^{c}	8.70 (3.03)^{c}	53.80 (7.38)^{c}	*38.20 (6.22)^{c}
	Cuelure	13.00 (3.66)^{a}	14.20 (3.83)^{a}	11.60 (3.47)^{a}	13.40 (3.73)^{a}	13.40 (3.73)^{a}	13.00 (3.67)^{a}	78.60 (071)^{a}	33.00 (5.78)^{a}	33.80 (5.85)^{a}	26.20 (5.17)^{a}	25.60 (5.10)^{a}	24.20 (4.94)^{a}	26.00 (5.15)^{a}	168.80 (12.99)^{a}	123.70 (11.14)^{a}
	Negative control	1.20 (1.25)^{c}	0.60 (1.02)^{d}	1.80 (1.48)^{d}	0.60 (1.02)^{d}	0.60 (1.02)^{d}	0.20 (0.81)^{d}	5.00 (2.34)^{d}	2.00 (1.51)^{c}	1.40 (1.35)^{d}	1.20 (1.25)^{d}	1.40 (1.35)^{d}	1.20 (1.25)^{d}	1.60 (1.39)^{d}	8.80 (3.02)^{d}	6.90 (2.72)^{d}
	Untreated control	0.00 (0.71)^{c}	0.00 (0.71)^{c}	0.00 (0.71)^{e}	0.00 (0.71)^{d}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.00 (0.71)^{e}	0.00 (0.71)^{d}	0.00 (0.71)^{e}	0.00 (0.71)^{e}	0.00 (0.71)^{e}	0.00 (0.71)^{e}	0.00 (0.71)^{e}	0.00 (0.71)^{e}	0.00 (0.71)^{e}
	SEd	0.1147	0.1046	0.1636	0.1453	0.1286	0.1113	0.0804	0.1664	0.1189	0.1215	0.1467	0.2081	0.1085	0.8274	0.0463
	P	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**

*Mean of five replications; DAPT – Days after placement of traps; obs. – observation; **Highly significant; Figures in parentheses square root transformed values; Means followed by same letter in a column not significantly different (Tukey's HSD test, p=0.05) who evaluated synthetic food baits, protein-baits and parapheromones in Morogoro region, Tanzania found that protein-based traps were superior in attracting *Ceratitis cosyra* and *Dacus humeralis* than the more specific parapheromones. Eventhough, male fruit fly catch was more in cuelure, gel protein bait had the added advantage of attracting both male and female fruit flies.

ACKNOWLEDGEMENTS

The authors thank the farmers for providing field to facilitate research; and the Department of Agricultural Entomology, Agricultural College and Research Institute, Madurai for providing facilities and technical support.

AUTHOR CONTRIBUTION STATEMENT

ZK and MS hypothesized the idea of the research and provided materials, KN performed the experiment, made statistical analysis, interpretation of data and drafting the manuscript. ZK, MS, KS and MLM provided guidance in conduct of the experiments as advisory committee members. All the authors equally contributed towards the experiment, read and approved the manuscript.

FINANCIAL SUPPORT

Recurring contingencies provided by the Syngenta India Private Limited is duly acknowledged.

CONFLICT OF INTEREST

No conflict of interest.

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(Manuscript Received: August, 2023; Revised: September, 2023;
Accepted: October, 2023; Online Published: October, 2023)
Online First in www.entosocindia.org and indianentomology.org Ref. No. e23576