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Evaluation of food-based attractants with low cost fruit fly trap against cucurbit fruit fly, *Zeugodacus cucurbitae* (Coq.) (Diptera: Tephritidae)

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ABSTRACT: Field experiments on effectiveness of food baits in attracting fruit flies under cucurbit ecosystem were conducted at Coimbatore ($11^0$1'6''N 76^0 58'21''E and Dharmapuri (40^0 26.767'N $79^0$58.9331'W) Tamil Nadu, India. The pulps of banana, papaya, sapota, snake gourd and pumpkin were used as base baits at different concentrations and food grade alcohol and vinegar were used as additives to endure attraction of fruit flies. The newly designed low cost fruit fly trap was used for keeping the food bait to trap the fruit flies. Among the fruit pulps tested, the banana and papaya attracted more number of fruit flies (116.25 and 96.25 flies/ trap/ day, respectively) at 30g concentration. Among the additives tested, 30g base bait added with alcohol was effective in attracting fruit flies at 3 ml concentration. The combination of 30 g of banana with 3 ml alcohol (157.5 flies/ trap/ day) and 30 g of papaya with 3ml of alcohol (153.25 flies/ trap /day) was found best food base baits for fruit flies under cucurbit ecosystem. The combination of 30 g of banana with 3 ml alcohol was highly economic and longevity (5-14 days) was more as compare to 30 g of papaya with 3ml of alcohol. The highest female to male ratio was recorded in ridge gourd in Coimbatore (0.78:1) and Dharmapuri (0.67:1). The F: M ratio in the trap catches revealed that parapheromones were completely male biased while the food bait based traps were attractive to both sexes. Thus, the indigenously designed low cost trap is highly economic, effective and target oriented.

Keywords: Baits, fruit pulps, additives, fruit fly trap, *Zeugodacus cucurbitae*

INTRODUCTION

The fruit flies (Diptera: Tephritidae) are highly diversified and destructive pests of fruits and vegetables. Especially cucurbits are majorly infested by *Zeugodacus cucurbitae* (Coq.).The parapheromones *viz.*, cue lure and methyl eugenol were most commonly used for the management of fruit flies (Steiner, 1961; Metcalf, 1990) because of their easy method of trapping. Majorly methyl eugenol traps were used under fruit crops *viz*., mango, guava etc. and cue lure traps in cucurbit ecosystem to attract *Z. cucurbitae* but these parapheromones are weak attractants of *Dacus ciliatus* (Loew) (White and Elson-Harris, 1994) which cause little proportion of damage to cucurbits (Krisna Kumar *et al*., 2006). Moreover these parapheromones are unable to attract female fruit flies and have many constraints *viz*., most of them are synthetic and have a problem of low biodegradation (Sankaram, 1999). The present study is mainly focused on finding suitable bait to attract the female fruit flies under cucurbit ecosystem.

MATERIALS AND METHODS

The preliminary study was conducted in farmers' fields (Bitter gourd, *Momardica charantia*, L, Snake gourd, *Trichosanthes anguina*, Ridge gourd, *Luffa acutangula*) at Coimbatore (11^0 N latitude and 76^0 longitude) and later at large scale in both districts (11^0 N latitude and 76^0 longitude) and Dharmapuri (N 11^0 latitude and78^0 longitude) districts of Tamil Nadu, India. Low cost trap was designed and compared locally for the purpose of catching fruit flies and easily available fruit pulps of banana, sapota, papaya, snake gourd, pumpkin and additives vinegar, alcohol were used for preparation of food baits and kept for a day to ferment then used for the purpose of catching fruit flies.

Preparation of food bait and bottle trap

Locally available fruits *viz*., banana, papaya, were collected, manually crushed and kept separately for a day in closed container for fermentation. Black colour cloth was covered around the container for quick fermentation. The trap was designed for trapping fruit fly with baits (Plate 1). Transparent plastic water bottle of one litre capacity was used for preparing female fruit fly attracting trap. Initially bottle was cut at bottom, 23 cm from the top and it would be used as fly collecting chamber. The mouth of bottle was closed with the removable lid to avoid escape of fruit flies. Lid was knotted with wire to tie the trap from roof of the pandal. Fly gate of 10 cm size was made inside bottle to prevent return from the collecting chamber. Below the fly gate 6 to 8 entry holes of 1 cm diameter were made just above the base plate

Table 1. Evaluation of fruit pulps as base food attractants to *Z. cucurbitae*

Food attractant	Mean no. fruit flies/trap/day			
	Male	Female	Total	F:M
Banana	70.5 (8.42)[a]	61 (7.84)[a]	131.5 (11.48)[a]	0.86: 1
Sapota	24.5 (5)[e]	13.5 (3.74)[b]	38 (6.20)[b]	0.55: 1
Pumpkin	32 (5.70)[c]	12 (3.53)[b]	44 (6.67)[b]	0.37: 1
Snake gourd	29 (5.43)[d]	14 (3.80)[b]	43 (6.59)[b]	0.48: 1
Papaya	65 (8.09)[b]	57.5 (7.61)[a]	122.5 (11.09)[a]	0.88: 1
SEd	0.0370	0.0633	0.309	
LSD (0.05)	0.0806	0.1380	0.6180	

Values in parentheses are square root transformed

to facilitate fruit fly entry and a foldable bait window of size 3cm^2 was made to facilitate bait placement. Totally the trap measures about 33 cm length.

Trapping technique

Food bait was kept inside the trap at the base bait plate at 0060 h. by using a tea spoon through the foldable window, which could be closed after keeping bait. The fly entry holes above the base bait plate allow volatile dispersion via air which results in attraction of fruit flies. The trap was tied in between the crops from the roof of the pandal with the help of wire at canopy level. Attracted fruit flies would enter into trap via fly's entry holes and move into the transparent collecting chamber through fly gate and get trapped (Plate 1).Fruit flies collected in the trap were killed within the traps by using chloroform / ethyl acetate dipped cotton. Once all the flies died, flies were collected with the help of camel hair brush by removing lid and transferred to plastic tray with size 25 X 20 cm then counted and separated species and grouped into different sexes. The collection and identification of fruit flies was done after 1700 h.

Food Bait evaluation

Experiment 1

Commonly available fruits like banana, sapota, papaya, pumpkin and crushed snake gourd were used as base baits. Initially to test the attracting ability of these fruits, they were manually squeezed and kept in closed container allowed for overnight fermentation next day rough quantity of fermented fruit pulps and placed as base bait inside the low cost female fruit fly traps separately and means were separated by LSD.

Experiment 2

Efficacy of different fruit pulps with different quantities (10 g, 20 g, 30 g, 40 g, 50 g) starting from 10 g of fruit pulp of all five fruits as base bait, followed by in order to study the attraction of female fruit flies. Experiment was repeated for four times for each concentration. Based on the number of fruit flies collected in trap the best two base baits and concentrations were confirmed and used for further experiment.

Experiment 3

The experiment was conducted separately for both base baits (selected based on results obtained from experiment 2) by using vinegar as an additive. The experiment was started with 1 ml of vinegar and ended up to 5 ml. Experiment was repeated for four times for each concentration and based on number of female fruit flies collected, the suitable concentration was selected and used for further experiment.

Experiment 4

This experiment was conducted separately for both

Table 2. Evaluation of different quantities of selected base food attractants to *Z. cucurbitae*

Fruit pulp	10g			20g			30g			40g			50g		
	Mean no. of fruit flies/trap/day			Mean no. of fruit flies/trap/day			Mean no. of fruit flies/trap/day			Mean no. of fruit flies/trap/day			Mean no. of fruit flies/trap/day		
	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total
Banana	37.5 (6.16) ^{de}	32.5 (5.74) ^{lm}	70 (8.39) ^{c}	42 (6.51 ^{a}	37 (6.12) ^{c}	79 (8.91) ^{bc}	63.75 (8.01) ^{b}	52.5 (7.28) ^{a}	116.25 (10.80) ^{a}	36.25 (6.06) ^{de}	28.75 (5.40) ^{de}	65 (8.09) ^{c}	27.5 (5.29) ^{g}	18.25(4.33) ^{fg}	45.75 (6.8) ^{de}
Sapota	17 (4.18) ^{jk}	10 (3.24) ^{o}	27 (5.24) ^{if}	16.25 (4.09) ^{gh}	10 (3.24) ^{if}	26.25 (5.17) ^{if}	18.75 (4.38) ^{ij}	12 (3.53) ^{j}	30.75 (5.59) ^{gh}	22 (4.74) ^{gh}	14 (3.80) ^{hi}	28.5 (5.29) ^{hi}	11 (3.39) ^{lj}	8.5 (3) ^{j}	19.5 (4.47) ^{j}
Pumpkin	18.75 (4.38) ^{ij}	13.5 (3.74) ^{n}	32.25 (5.72) ^{fg}	27.5 (5.29) ^{c}	20.5 (4.58) ^{e}	48 (6.96) ^{d}	24 (4.94) ^{gh}	15.75 (4.03) ^{i}	39.75 (6.34) ^{de}	23.75 (4.92) ^{gh}	13 (3.67) ^{j}	36.75 (6.10) ^{de}	10 (3.24) ^{l}	9 (3.08) ^{j}	19 (4.41) ^{j}
Snake gourd	24 (4.94) ^{gh}	15.75 (4.03) ^{n}	39.75 (6.34) ^{de}	19.25 (4.44) ^{ef}	16.25 (4.09) ^{gh}	33 (5.78) ^{ef}	21.25 (4.66) ^{hi}	12.5 (3.60) ^{j}	33.75 (5.85) ^{de}	24.25 (4.97) ^{gh}	17.75 (4.27) ^{fg}	42 (6.51) ^{de}	19.25 (4.44) ^{ij}	11.25 (3.42) ^{e}	25.5 (5.09) ^{ij}
Papaya	40 (6.36) ^{ef}	28 (5.33) ^{m}	68 (8.27) ^{de}	45 (6.74) ^{a}	31 (5.61) ^{d}	76 (8.74) ^{bc}	52.5 (7.28) ^{k}	43.75 (6.65) ^{b}	96.2 (9.83) ^{ab}	42.5 (6.55) ^{cd}	27.5 (5.29) ^{e}	70(8.39) ^{c}	27.75 (5.31) ^{fg}	19.5 (4.47) ^{de}	47.25 (6.9) ^{de}
SEd	0.1600	0.0967	0.3918	0.1678	0.0475	0.5776	0.1435	0.1029	0.5377	0.1182	0.1701	0.5963	0.0889	0.0812	0.6037
LSD (0.05)	0.3486	0.2108	0.8536	0.3656	0.1035	1.2585	0.3127	0.2241	1.1715	02576	0.3706	1.2992	0.1936	0.1770	1.3153

Values in parantheses are square root transformed M- Male, F- Female

base baits (selected based on results obtained from experiment 2) by using food grade alcohol as an additive. The experiment was started with 1 ml, 2 ml, 3 ml, 4 ml, and 5 ml of alcohol. Experiment was repeated for four times.

Based on results obtained from the experiments 3 and 4 the best additive and its concentration were finalized and used for further experiment.

Experiment 5

In this experiment efficacy of base bait with best additive selected from preliminary experiments was tested in a randomized block design (RBD).

Experiment 6

In this experiment, combination of fruit pulps and additive were selected from preliminary experiment was tested in both districts in all three gourds at Coimbatore and Dharmapuri districts a large-scale experiment (Plate 3 and 4) in a randomized block design (RBD).

RESULTS AND DISCUSSION

Bait experiments

Experiment 1

Banana and papaya pulps were significantly more attractive to *Z. cucurbitae* (131.5 flies/trap/day) (61 females and 70.5 males) with female to male sex ratio of 0.86:1 (Table 1) and it was followed by papaya pulp (122.5 flies/trap/day) (57.5 females and 65 males) with female to male sex ratio of 0.88:1. However, sapota attracted fewer number of fruit flies (38 flies/trap/day).

Experiment 2

Among the different quantities of fruit pulps tested,banana pulp (30g) and papaya pulp (30g) were significantly more attractive to *Z. cucurbitae* (116.25flies/trap/day) (52.5 females and 63.75 males) and 96.25flies/trap/day (43.75 females and 52.5 males) respectively (Table 2).

Experiment 3

Among the different concentrations of food grade alcohol tested, 3ml alcohol in combination with 30g of banana pulp attracted greater number of *Z. cucurbitae* (157.5 flies/trap/day) (61.25 females and 96.25 males) (Table 3) as compared to banana pulp alone (80 flies/trap/day) (35 females and 45 males).

Among different concentrations of food grade alcohol, 3ml of food grade alcohol with combination 30g of papaya attracted a greater number of fruit flies 153.25 flies/trap/day (78 males and 78.25 females) (Table 3) as compared to papaya pulp alone 86.75 flies/trap/day (44.5 males and 42.25 females).

Experiment 4

Addition of vinegar to 30g of banana pulp and papaya pulp attracted fewer number of *Z. cucurbitae* as compared to 30 g of banana pulp and papaya pulp alone (45 flies/trap/day) (Table 4).

Experiment 5

Banana pulp + food grade alcohol (30g+3ml) and papaya pulp + food grade alcohol(30g+3ml) attracted significantly a greater number of *Z. cucurbitae* (143.2 flies/trap/day) (85 females and 97.75 males) and146.2 flies/trap/day (85 females and 97.75 males) respectively(Table 5). Banana pulp alone attracted 104.4 flies/trap/day. The highest female to male ratio 0.87: 1 was observed in banana pulp + food grade alcohol(30g+3ml).

Experiment 6

Large scale experiments at two locations revealed that the combination of 30 g banana pulp with 3 ml food grade alcohol in Coimbatore attracted significantly more number (139.23 flies/trap/day) of *Z. cucurbitae* in snake gourd (Table 6) followed by bitter gourd (135.42 flies/trap/day) (51.31females and 84.11 males) and ridge gourd (133.44 flies/trap/day with 61.02 females and 78.21 males). The highest female to male ratio was recorded in ridge gourd with 0.78:1.

The combination of 30 g banana pulp with 3 ml food grade alcohol attracted significantly more number of fruit flies in snake gourd ecosystem with 141.6 fruit flies/trap/day (56.16 females and 85.44 males) (Table 6) followed by bitter gourd (139.33 flies/trap/day, 55 females and 84.33 males) and ridge gourd (137.66 flies/trap/day, 55.56 females and 82.1 males) at Dharmapuri district. The highest female to male ratio 0.67:1.was recorded in ridge gourd.

The fruit flies adults are attractive to fermented food products. Elaiyabharathi *et al*. (2004) reported that the 20 ml of fermented banana pulp and grapes pulp are suitable attractants when mixed with 3 ml beer as bait-component with one drop of palm oil but in present study the results of experiments conducted with different fruit pulps as food baits on the attraction of fruit flies shown that the 30 g of fermented banana pulp with combination of 3 ml of food grade alcohol attracted more number of

Table 3. Evaluation of food grade alcohol as bait additive in different concentration (1ml – 5ml) in attracting fruit flies using banana pulp 30g as base bait and papaya pulp 30g as base bait

Concentration of Additive (Food grade alcohol)	Banana pulp			Papaya pulp		
	Mean no. of flies/trap/day			Mean no. of flies/trap/day		
	Male	Female	Total	Male	Female	Total
Control	45 (6.74) [d]	35 (5.95) [d]	80 (8.97) [d]	44.5 (6.70) [d]	42.25 (6.53) [d]	86.75 (9.34) [d]
1ml	55 (7.44) [c]	53.75 (7.36) [c]	106.25 (10.33) [c]	57.5 (7.61) [c]	53 (7.31) [c]	108 (10.41) [c]
2ml	83.5 (8.83) [b]	57.25 (7.98) [b]	140.75 (11.88) [b]	72.5 (8.54) [b]	55.25 (7.46) [b]	127.75 (11.32) [b]
3ml	96.25 (9.83) [a]	61.25 (7.85) [a]	157.5 (12.56) [a]	78 (8.86) [a]	78.25 (8.87) [a]	153.25 (12.39) [a]
4ml	58.75 (7.69) [c]	46.75 (6.87) [c]	105.5 (10.29) [c]	72.75 (8.55) [c]	56.75 (7.56) [c]	104.5 (10.24) [c]
5ml	48.5 (7) [d]	34.75 (5.93) [d]	83.25 (9.15) [d]	47.25 (6.91) [d]	37.25 (6.14) [d]	83.5 (9.16) [d]
LSD (0.05)	**1.0709**	**0.8795**	**0.5977**	**0.1983**	**0.1811**	**0.5689**

* Values in the parenthesis are square root transformed

Table 4. Evaluation of vinegar as bait additive in different concentration (1ml – 5ml) in attracting fruit flies using banana pulp 30g as base bait and papaya pulp 30g as base bait

Concentration of Additive(Vinegar)	Banana pulp			Papaya pulp		
	Mean no. of flies/trap/day			Mean no. of flies/trap/day		
	Male	Female	Total	Male	Female	Total
Control	21 (4.64) [a]	24 (4.95) [a]	45 (6.75) [a]	21 (4.63) [a]	24 (4.94) [a]	43 (6.59) [a]
1ml	10 (3.24) [b]	7 (2.74) [b]	17 (4.18) [b]	10 (3.24) [b]	7 (2.73) [b]	17 (4.18) [b]
2ml	19 (4.42) [b]	10 (3.24) [b]	29 (5.43) [b]	19 (4.41) [b]	10 (3.24) [b]	29 (5.43) [b]
3ml	21 (4.64) [b]	11 (3.39) [b]	32 (5.70) [b]	14 (3.80) [b]	10 (3.24) [b]	24 (4.94) [b]
4ml	20 (4.53) [b]	5 (2.35) [b]	25 (5.05) [b]	15 (3.93) [b]	10 (3.24) [b]	25 (5.04) [b]
5ml	24 (4.95) [b]	9 (3.08) [b]	33 (5.79) [b]	17 (4.18) [b]	11 (3.39) [b]	28 (5.33) [b]
LSD (0.05)	**3.7887**	**0.4172**	**1.0604**	**0.4057**	**1.3406**	**2.2612**

* Values in the parenthesis are square root transformed

fruit flies per day per trap.

Fruit flies attracted to banana because of its high sugar content (Bose and Mitra, 1990) and Thomas *et al.* (2005) reported that sugar base in food baits attract fruit flies, similar results was reported by Stone house *et al*. (2007). Fruit flies will attract to fermented sugars (Mc Phail, 1937). As reported by Ripley and Hepburn (1929), for attracting insects the mixtures are more attractive than single compound the attractiveness of bait was increased with addition of additives, more number of fruit flies collected when alcohol was added to the base bait. The CO_2 and gasses released from the fermented baits attracts flies (Gow, 1954; Morton and Bateman, 1981). The results shown that the attractiveness of food bait was reduced with high concentration of additives (Table.1) it may because increase in the concentration of additives masks the volatile of fruit pulp and surprisingly increase in the bait concentration (Table 2).

The longevity of banana with alcohol was high (5-12 days) as compared to papaya (4-5 days) may be its due to the high moisture and sugar content of banana, sugars acts as preservatives. If the bait dried the emission of volatile from the bait get reduced (Elaiyabharathi *et al*., 2004). The use of coconut oil and glycerine to improve the longevity was not effective we found that it reduced the attractiveness of bait by masking the emission of volatile from the bait. We tied the trap at different heights to test the attractiveness of food bait at different heights but we found no significant difference in the attractiveness of bait. The food bait had shown positive results in pumpkin and cucumber.

This study reveals that all the fruit pulps tested, attracts both males and females of *Z. cucurbitae*. The combination of 30 g of banana with 3 ml of food grade alcohol is suitable fruit fly management strategy under cucurbit ecosystem because of its easy availability, low cost and high longevity whereas 30 g of papaya with 3 ml food grade alcohol is for only 4-5 days.

Table 5. Evaluation of two selected base baits banana 30g + food grade alcohol 3ml and 30g papaya + food grade alcohol 3ml in attracting fruit flies in gourds ecosystem

Base bait and base bait with additive	Mean no. of fruit flies/trap/day		
	Male	Female	Total
Banana (30gm)	78 (8.86)[b]	52.5 (7.28)[b]	104.4 (10.24)[b]
Papaya (30gm)	78.75 (8.90)[b]	47.75 (6.94)[b]	101.2 (10.08)[b]
Banana(30gm) + food grade alcohol(3ml)	95.5 (9.79)[a]	83.5 (9.16)[a]	143.2 (11.98)[a]
Papaya(30gm)+ food grade alcohol(3ml)	97.75 (9.91)[a]	85 (9.24)[a]	146.2 (12.11)[a]
LSD (0.05)	**0.1435**	**0.1671**	**0.8687**

* Values in the parenthesis are square root transformed

Table 6. Large scale evaluation of base food attractants and their combinations against fruit flies in gourds

M= Male F= Female

Locations	Snake gourd				Ridge gourd				Bitter gourd			
	Mean no. of flies/trap/day				Mean no. of flies/trap/day				Mean no. of flies/trap/day			
	M	F	Total*	F:M	M	F	Total*	F:M	M	F	Total*	F: M
Coimbatore	85.43	53.80	139.23	0.62:1	78.21	61.02	133.44	0.78:1	84.11	51.31	135.42	0.61:1
Dharmapuri	85.44	56.16	141.6	0.65:1	82.1	55.56	137.66	0.67:1	84.33	55	139.33	0.65:1

Plate 1. Fruit flies collected in the trap

Plate 2. Large scale field evaluation of food based attactants in gourds at Coimbatore

REFERENCES

Bose, T. and Mitra, S. 1990. *Fruits: Tropical and Subtropical.* Naya prakash. Bidhan Sarani: Calcutta 206Pp.

Eliyabharathi, T., Sathiyanandam, V. K. and David, P. 2004. Attractiveness of some food baits to the melon fruit fly, *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae). *International Journal of Tropical Insect Science,* **24** (2): 125-134.

Kumar, N. K., Verghese, A., Shivakumara, B., Krishnamoorthy, P. and Ranganath, H. 2006. Relative incidence of *Bactrocera cucurbitae* (Coquillett) and Dacus ciliatus Loew on cucurbitaceous vegetables. Proceedings of the 7th international symposium on fruit flies of economic importance.

Mc Phail, M. 1937. Relation of time of day, temperature and evaporation to attractiveness of fermenting sugar solution to Mexican fruitfly. *Journal of Economic Entomology,* **30** (5): 793-799.

Metcalf, R. L. 1990. Chemical ecology of Dacinae fruit flies (Diptera: Tephritidae). *Annals of the Entomological Society of America,* **83** (6): 1017-1030.

Ripley, L.and Hepburn, G. 1929. Studies on reaction of the Natal fruit fly to fermenting baits. *Union. State Dept. Agr. Ent. Mem,* **8**:19-53.

Sankaram, A. 1999. Integrated pest management: Looking back and forward. Current Science, 77 (1): 26-32.

Stonehouse, J., Mumford, J., Verghese, A., Shukla, R., Satpathy, S., Singh, H.and Jhala, R. 2007. Village-level area-wide fruit fly suppression in India: Bait application and male annihilation at village level and farm level. *Crop Protection,* **26** (5): 788-793.

White, I. M. and Elson-Harris, M. M. 1992. *Fruit flies of economic significance: their identification and bionomics:* CAB International.

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