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Evaluation of cost effective natural attractants for fruit fly in snake gourd ecosystem

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Abstract

Tephritid fruit flies are the most economic insect pest in fruits and vegetable ecosystem. It damages the crop from fruit initiation stage to harvesting of the crop. The management of fruit flies in snake gourd ecosystem is troublesome because their partial life time completed within the host and pupates in soil. The only eco friendly and safe method of management of fruit flies is through para pheromonal traps. In the large scale cultivation, depending on commercial lure are uneconomical, moreover most of the farmers are unaware of its availability and utility. Hence, the identification of cost effective, locally available resources may highly helpful to the farming community. Focusing this in view, the low cost and easily available natural sources of banana, grapes, molasses, fishmeal, red pumpkin, snake gourd, ocimum and crucifers in combination with yeast, black jaggery and acetic acid or ammonium acetate (5%) were evaluated in snake gourd field for trapping of both the sexes of fruit flies. The result of the present investigation showed that the male fruit flies were captured maximum (17.67 fruit flies/ trap) in the natural extracts of banana with yeast, black jaggery and 5% acetic acid followed by grapes (15.33 fruit flies/trap). The snake gourd red pumpkin are next in performance. The ocimum and cruciferous leaf extracts to be least in attraction of male fruit flies. The female fruit flies are highly attracted to the ammonium acetate combination of banana and grapes with the fruit fly catches of 11.00 and 6.00 fruit flies/trap. The fruit extracts of red pumpkin and snake gourd was found to be next. The synthetic attractants of methyl eugenol and cue lure was found to be least performance of female fruit flies (1.67 and 1.00 fruit flies/trap). On comparing the overall natural attractant sources, banana and grapes was found to be effective in trapping of fruit flies with the highest cost benefit ratio of 1.82 and 1.74. The farmers are advised to use banana or grapes for fruit flies management and to increasing the yield with high benefit cost ratio in snake gourd ecosystem.

Keywords: snake gourd, fruit flies, acetic acid, ammonium acetate, cue lure, methyl eugenol

Introduction

The Dacini fruit flies have four genera viz., *Bactrocera* Macquart, *Dacus* Fabricius, *Zeugodacus* Hendel and *Monacrostichus* Bezzi (De Meyer *et al.*, 2015; Virgilio *et al.*, 2015) [3, 22]. Currently 932 fruit fly species are recorded out of these 10% are the pest in vegetable and horticultural ecosystem and act as frugivorous and florivorous in plants (Vargas *et al.*, 2015; Friedberg *et al.*, 2017) [21, 7]. Among these the fruit fly species viz., oriental fruit fly, *Bactrocera dorsalis* (Hendel), melon fruit fly, *Zeugodacus cucurbitae* (Coquillett) and carambola fruit fly, *Bactrocera carambolae* (Drew & Hancock) are considered as most serious pest (Ekesi *et al.*, 2016) [5]. The parapheromones viz., Methyl eugenol (4-allyl-1,2-dimethoxy benzene carboxylate) and Cue-lure [4- (p-acetoxyphenyl) - 2-butanone] were used for trapping of *B. dorsalis* and *Z. cucurbitae* fruit flies (Metcalf, 1990) [13]. Females are the main factor for multiplication of pest for the reason attractive baits are developed to increasing the effectiveness on monitoring and pest management. In bait preparation, proteins and fermenting sugars were used for attraction, because it needs in egg maturation and egg development (Epsky *et al.*, 1999) [6]. The food based attractants used in fruit flies are protein hydrolysate, torula yeast, brewer's yeast, ammonium acetate, GF -120, biolure and trimethylamine (Moustafa, 2009; Ekesi *et al.*, 2014) [14, 4]. Acetic acid and ammonium acetate combinations both attract male and female fruit flies of *Ceratitis capitata*, but comparing the attraction acetic acid was suitable for male fruit flies and ammonium acetate for female fruit flies (Mazor, 2018) [12]. Cue lure contains the impurities of acetic acid and acetic anhydride which is highly volatile in nature and used as a attractant for male melon flies (Keiser *et al.*, 1976) [10]. Farmers are lack in the knowledge of synthetic attractants and it is not easily available and high cost. For the ecofriendly management of fruit flies in snake gourd field, the locally available zero cost or low cost natural sources of inputs were evaluated to assess the maximum trapping of fruit flies with high yield and cost benefit ratio.

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Materials and Methods

The experiment was conducted in snake gourd ecosystem at farmer's field (2-5 SMW, 2021) located at Kumaravadi village, Vaiyampatti block, Tiruchirappalli district by following the below given methodologies. Food baits is used as a main component in fruit fly suppression of both male and female flies. Olfactory and gustatory stimulus acts as a important factor in attraction. However, the protein baits are not a species specific. The bottle trap half cut model trap was used for evaluation of attractants against fruit fly. For preparation of trap model, 1 L disposed transparent mineral water bottle was cut into 2/3rd portion from the top and kept as inverted position in the inner side of bottom portion. Three square shaped (1.5 cm²) entry way was provided 9 cm from the bottom as a passage of fruit flies. Furthermore, in increasing the fruit fly attraction and trap catches of both the sexes apart from commercially available lures, extracts of fruits and vegetables along with some attractant materials were evaluated against fruit flies in field condition. To increase the attractancy of natural sources, the acetic acid and ammonium acetate solution were added. The experiments were laid out in a Randomized Block Design (RBD) with ten treatments and replicated thrice. The treatment details of each experiment is given below.

Treatment details for Experiment 1

- T₁ - Snake gourd fruit pulp + yeast + Black jaggery (1:1:1) + Acetic acid (5%)
- T₂ - Cruciferous leaf extract + yeast + Black jaggery (1:1:1) + Acetic acid (5%)
- T₃ - Ocimum leaf extract + yeast + Black jaggery (1:1:1) + Acetic acid (5%)
- T₄ - Red Pumpkin fruit pulp + yeast + Black jaggery (1:1:1) + Acetic acid (5%)
- T₅ - Banana fruit pulp + yeast + Black jaggery (1:1:1) + Acetic acid (5%)
- T₆ - Grapes fruit pulp + yeast + Black jaggery (1:1:1) + Acetic acid (5%)
- T₇ - Molasses + yeast + Black jaggery (1:1:1) + Acetic acid (5%)
- T₈ - Fish meal + yeast + Black jaggery (1:1:1) + Acetic acid (5%)
- T₉ - Cue lure
- T₁₀ - Methyl eugenol

Treatment details for Experiment 2

For evaluating the female fruit fly catches, Acetic acid (5%) is replaced with 5% of Ammonium acetate and the experiment was carried out with ten treatments and three replications. The treatment details

- T₁ - Snake gourd fruit pulp + yeast + Black jaggery (1:1:1) + Ammonium acetate (5%)
- T₂ - Cruciferous leaf extract + yeast + Black jaggery (1:1:1) + Ammonium acetate (5%)
- T₃ - Ocimum leaf extract + yeast + Black jaggery (1:1:1) + Ammonium acetate (5%)
- T₄ - Red Pumpkin fruit pulp + yeast + Black jaggery (1:1:1) + Ammonium acetate (5%)
- T₅ - Banana fruit pulp + yeast + Black jaggery (1:1:1) + Ammonium acetate (5%)
- T₆ - Grapes fruit pulp + yeast + Black jaggery (1:1:1) + Ammonium acetate (5%)
- T₇ - Molasses + yeast + Black jaggery (1:1:1) + Ammonium acetate (5%)

T₈ - Fish meal + yeast + Black jaggery (1:1:1) + Ammonium acetate (5%)

T₉ - Cue lure

T₁₀ - Methyl eugenol

Preparation of attractants

a. Black jaggery solution preparation

Black jaggery was purchased from nearby local shops. 100 g of the black jaggery was diluted in 200 ml of distilled water to make a solution and used as attractant material (Parab *et al.*, 2018)^[15].

b. Acetic acid (5%) and Ammonium acetate (5%)

The commercially available 5 ml of acetic acid was mixed with 95 ml of distilled water. Ammonium acetate was prepared by adding 5 g of laboratory grade AA is diluted in 100 ml of distilled water to make 5% solution.

c. Vegetable pulp extract

The fresh vegetables of snake gourd and pumpkin were collected from local market. 100 g of fruit pulp was macerated by adding 5-10 ml of acetic acid or ammonium acetate (5%) using pestle and mortar and the solution was filtered through muslin cloth. The filtration was added with 1:1 ratio of yeast, black jaggery and kept until fermentation upto 24 hours.

d. Fruit pulp extract

Weigh 100 g of banana and grapes which was bought from local market. The fruit was macerated with 5-10 ml of acetic acid or ammonium acetate (5%) and filtered the pulp juice using muslin cloth. 1:1 ratio of yeast, black jaggery were added with equal amount of filtration and leave for 24 hours until fermentation.

e. Leaf extract

The ocimum leaves was collected from nearby field and home and cruciferous waste was purchased from nearby local market. The leaves were weighed upto 100 g and macerated using pestle and mortar by adding 5-10 ml of acetic acid or ammonium acetate (5%) and the leaf extract was separated by using muslin cloth. The yeast, black jaggery in the ratio of 1:1 was added with the filtrate and kept it as such for next 24 hours.

f. Molasses and fish meal

The molasses was purchased from the jaggery production unit of nearby village. The attractant was prepared by adding molasses, yeast, black jaggery and acetic acid or ammonium acetate (5%) in the ratio of 1:1:1.

The fishmeal was purchased from local shops and soak in 5-10 ml of acetic acid or ammonium acetate (5%) and macerate using pestle and mortar. The solution was allow to fermentation for 24 hours by adding 1:1 ratio of yeast, black jaggery. The molasses was added with 1:1 ratio of yeast and black jaggery and 5-10 ml of acetic acid or ammonium acetate (5%) was mixed as the attractant material.

g. Lure preparation

The commercially available para pheromone attractant was prepared by mixing of cue lure or methyl eugenol, ethanol and malathion 50 EC in the rate of 6:4:2. The cotton wick (2.5 x 1 cm) was impregnated in the prepared para pheromonal attractants for 24 hours before tie inside the trap.

Placement of attractant in traps

The food lure was added with 2 ml of dichlorovos in the paper cups containing 10 ml of the attractant material. In checks, the impregnated cotton wick was placed inside the trap near entry hole. The trap was hung in the field at 1.5 m height and lure and attractant material was changed every week. The bait was kept in semi liquid state by adding 5 ml water at regular intervals.

Statistical analysis

The data's on number of fruit flies attracted in the individual attractants were recorded at weekly intervals. The collected data was statistically analysed by one factor analysis RBD with AGRES software after square root transformation.

Results and Discussion

Performance of adult male fruit flies to natural attractants

The fruit flies are having the tendency of high attraction towards the para pheromone based compounds. The olfactory and gustatory stimulus are the proved reasons for fruit fly attraction. Cue lure attracted the maximum number of male melon fruit flies (43.00 fruit flies/trap) followed by *Bactrocera dorsalis* in methyl eugenol lure (23.67 fruit flies/trap) (Table 1, Fig 1). The attraction of melon fruit fly and oriental fruit flies towards cue lure and methyl eugenol lure are clearly explained by the earlier reports of Vargas *et al.*, (2000) [20]. The attractant efficiency of natural extracts indicated that the fruit flies were attracted and trapped maximum in the food baits of banana fruit pulp + yeast +

black jaggery + acetic acid (17.67 fruit flies/trap). The result is also endorsed by the reports of Satpathy and Rai (2002) [19] that the attraction of melon fruit fly was good in the bait combinations of over ripe banana + carbofuran + acetic acid in the peak incidence of *Z. cucurbitae* in Varansi. The fruit pulps of banana captured more number of *B. dorsalis* followed by guava was registered by Rajpal (2008) [17] in guava orchard. The fruit extracts of Grape fruit pulp + yeast + black jaggery + acetic acid is the second preferred attractant for fruit flies, because it mainly contains sugars in the form of D- glucose and attracted 15.33 fruit flies/trap. The attractant nature of grape pulp was also strengthened by the experimental results of Bharathi *et al.*, (2004) [2] obtained in snake gourd field at Killikulam. The combination of molasses + yeast + black jaggery + acetic acid and snake gourd fruit pulp + yeast + black jaggery + acetic acid captured the equal number of fruit flies with a trap catches of 12.33 fruit flies/trap. Molasses combined with malathion and water in the ratio of 1:0.1:100 highly captured melon flies in Japan (Akhtaruzzaman *et al.*, 2000) [1]. The fruit flies attracted in red pumpkin and fish meal + yeast + black jaggery + acetic acid attractants were 7.67 and 6.00 fruit flies/trap. The lowest number of fruit fly catches were observed and recorded in the baits containing cruciferous + yeast + black jaggery + acetic acid and ocimum leaf extracts + yeast + black jaggery + acetic acid with 2.00 fruit flies/trap. Parab *et al.*, (2018) [15] revealed black ocimum combination with malathion compound attracted high numbers of fruit flies in mango orchard.

Table 1: Natural attractant sources containing acetic acid for male fruit fly attraction in snake gourd

Treatments	Number of fruit flies trapped/ trap/ week				
	Week 1	Week 2	Week 3	Week 4	Total
T ₁ - Snake gourd fruit pulp + yeast + Black jaggery (1:1:1) + Acetic acid (5%)	3.67 (2.04) ^{de}	3.00 (1.57) ^{def}	2.33 (1.67) ^{cd}	3.33 (1.95) ^c	12.33 (3.58) ^e
T ₂ - Cruciferous leaf extract + yeast + Black jaggery (1:1:1) + Acetic acid (5%)	0.33 (0.94) ^g	0.67 (1.05) ^f	0.33 (0.88) ^e	0.67 (1.05) ^{ef}	2.00 (1.58) ^h
T ₃ - Ocimum leaf extract + yeast + Black jaggery (1:1:1) + Acetic acid (5%)	0.67 (1.10) ^g	0.67 (1.05) ^f	0.33 (0.88) ^e	0.33 (0.88) ^f	2.00 (1.58) ^h
T ₄ - Red pumpkin fruit pulp + yeast + Black jaggery (1:1:1) + Acetic acid (5%)	2.33 (1.71) ^{ef}	1.67 (1.46) ^{def}	2.00 (1.58) ^{cd}	1.67 (1.46) ^{de}	7.67 (2.86) ^f
T ₅ - Banana fruit pulp + yeast + Black jaggery (1:1:1) + Acetic acid (5%)	5.33 (2.43) ^{bc}	4.33 (2.20) ^{bc}	3.67 (2.04) ^{bc}	4.33 (2.10) ^{bc}	17.67 (4.26) ^d
T ₆ - Grape fruit pulp + yeast + Black jaggery (1:1:1) + Acetic acid (5%)	4.33 (2.21) ^{cd}	3.33 (1.95) ^{cd}	3.67 (2.00) ^{bc}	4.00 (2.10) ^{bc}	15.33 (3.99) ^d
T ₇ - Molasses + yeast + Black jaggery (1:1:1) + Acetic acid (5%)	3.67 (2.06) ^{cde}	3.00 (1.86) ^{cde}	2.67 (1.77) ^{cd}	3.00 (1.86) ^{cd}	12.33 (3.58) ^e
T ₈ - Fish meal + yeast + Black jaggery (1:1:1) + Acetic acid (5%)	1.67 (1.50) ^f	1.33 (1.34) ^{ef}	1.67 (1.46) ^d	1.33 (1.34) ^{ef}	6.00 (2.55) ^g
T ₉ - Cue lure alone	13.33 (3.73) ^a	10.67 (3.34) ^a	9.00 (3.06) ^a	10.00 (3.23) ^a	43.00 (6.60) ^a
T ₁₀ - Methyl eugenol alone	6.67 (2.69) ^b	6.00 (2.54) ^b	5.33 (2.40) ^b	5.67 (2.46) ^b	23.67 (4.92) ^b
SE(d)	0.18	0.27	0.23	0.23	-
CD (p=0.05)	0.38	0.56	0.49	0.46	-

Figures in parentheses are $\sqrt{x+0.5}$ transformed values

Values in the column followed by same letters are not different statistically, (p=0.05) by LSD

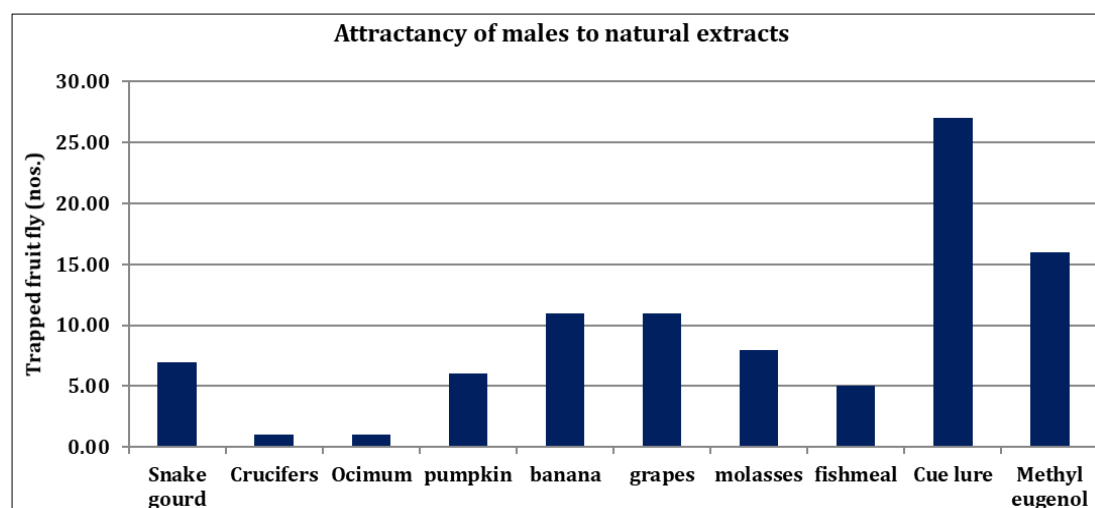


Fig 1: Attractant efficiency of natural sources on male fruit fly catches

Performance of adult female fruit flies to attractants

Female fruit flies are usually not attracted to any para pheromonal lure compounds. Protein is the main component for its development and ovarian development of fruit flies. Hence, the bait admixtures of protein rich compounds are used along with ammonium acetate for attraction of female fruit flies. The food bait combination of banana+ yeast + black jaggery + ammonium acetate captured higher number of female fruit flies with 11.00 fruit flies/trap. The attractant capacity of banana pulp to fruit flies was strengthened by Rajitha and Viraktamath (2005) [16] that soybean + sugar + banana was considered as the better protein bait and trapped more number of fruit flies in guava orchard, and fruit bait with casein + sugar + papaya also performs well in mango ecosystem. Ravikumar (2006) [18] revealed fruit fly diet + sugar + banana was the good efficiency of trapping in guava and mango orchard. The fruit extracts of grapes + yeast + black jaggery + ammonium acetate and red pumpkin + yeast + black jaggery + ammonium acetate attracted 6.00 and 5.67 fruit flies/trap. The ammonium acetate combination extracts of red pumpkin and snake gourd attracted significantly equal

numbers of female fruit flies. According to Mangan and Thomas (2014) [11] the grape juice attracted more number of Mexican fruit flies in Valencia orange orchard. The bait combination of red pumpkin fruit pulp + yeast + black jaggery + ammonium acetate and snake gourd fruit pulp+ yeast + black jaggery + ammonium acetate are significantly on par and captured the adult female flies range between 1.00 to 1.67 fruit flies/trap/week. The commercially available para pheromone lures of methyl eugenol and cue lure attracted least number of female fruit flies with the trap catches of 1.67 and 1.00 numbers/trap (Table 2, Fig 2). The females of *Dacus* spp. attracted very low numbers in cue lure and methyl eugenol traps by Hill (1986) [8] in orange trees, Australia. In the ammonium acetate combinations the female fruit flies are highly attracted to the natural extracts of banana pulp next to grape fruit pulp. Bharathi *et al.*, (2004) [2] that melon fruit flies are highly attracted to banana followed by soybean hydrolysate compared to fish meal, beef extract, bread and dog biscuit. The lure combination with yeast extract and ammonium acetate was highly attracted to melon flies by Iqbal *et al.*, (2020) [9] in cucurbit ecosystem.

Table 2: Natural attractant sources containing ammonium acetate for female fruit fly attraction in snake gourd

Treatments	Number of fruit flies trapped/ trap/ week				
	Week 1	Week 2	Week 3	Week 4	Total
T ₁ - Snake gourd fruit pulp + yeast + Black jaggery (1:1:1) + Ammonium acetate (5%)	1.00 (1.22) ^d	2.00 (1.57) ^b	1.33 (1.34) ^b	1.33 (1.35) ^c	5.67 (2.47) ^c
T ₂ - Cruciferous leaf extract + yeast +Black jaggery (1:1:1) +Ammonium acetate (5%)	1.33 (1.35) ^c	1.00 (1.22) ^d	1.00 (1.22) ^c	0.67 (1.08) ^e	4.00 (2.11) ^d
T ₃ - Ocimum leaf extract + yeast + Black jaggery (1:1:1) + Ammonium acetate (5%)	0.33 (0.91) ^f	0.33 (0.91) ^f	0.67 (1.07) ^d	1.00 (1.22) ^d	2.33 (1.68) ^f
T ₄ - Red pumpkin fruit pulp + yeast +Black jaggery (1:1:1) +Ammonium acetate (5%)	1.33 (1.35) ^c	1.33 (1.35) ^c	1.33 (1.35) ^b	1.67 (1.46) ^b	5.67 (2.48) ^c
T ₅ - Banana fruit pulp + yeast + Black jaggery (1:1:1) + Ammonium acetate (5%)	3.00 (1.87) ^a	2.33 (1.68) ^a	2.67 (1.77) ^a	3.00 (1.86) ^a	11.00 (3.38) ^a
T ₆ - Grape fruit pulp + yeast + Black jaggery (1:1:1) + Ammonium acetate (5%)	2.33 (1.68) ^b	1.00 (1.23) ^d	1.33 (1.35) ^b	1.33 (1.35) ^c	6.00 (2.54) ^b
T ₇ - Molasses + yeast + Black jaggery (1:1:1) + Ammonium acetate (5%)	1.33 (1.34) ^c	1.00 (1.22) ^d	0.67 (1.07) ^d	1.00 (1.22) ^d	4.00 (2.14) ^d
T ₈ - Fish meal + yeast + Black jaggery (1:1:1) + Ammonium acetate (5%)	1.33 (1.35) ^c	0.67 (1.07) ^e	0.33 (0.91) ^e	1.00 (1.22) ^d	3.33 (1.95) ^e
T ₉ - Cue lure alone	0.33 (0.93) ^f	0.00 (0.70) ^g	0.33 (0.91) ^e	0.33 (0.91) ^f	1.00 (1.22) ^h
T ₁₀ - Methyl eugenol alone	0.67 (1.07) ^e	0.33 (0.91) ^f	0.33 (0.91) ^e	0.33 (0.91) ^f	1.67 (1.41) ^g
SE(d)	0.01	0.01	0.01	0.01	-
CD (p=0.05)	0.02	0.01	0.02	0.02	-

Figures in parentheses are $\sqrt{x+0.5}$ transformed values

Values in the column followed by same letters are not different statistically, (p=0.05) by LSD

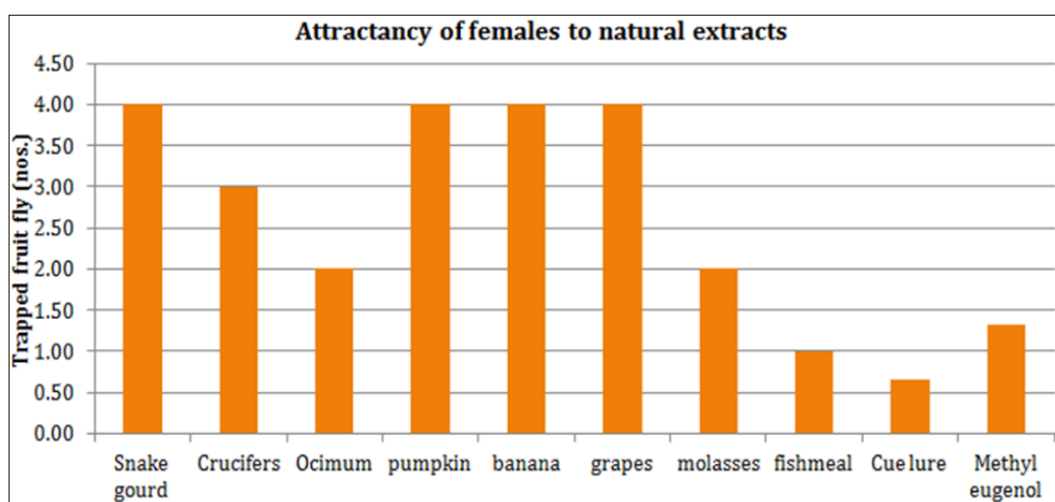


Fig 2: Attractant efficiency of natural sources on female fruit fly catches

Influence of alternative trapping sources on yield and cost benefit ratio

In the present investigation, different types of naturally available zero cost or low cost trapping sources were evaluated on its efficiency towards the trapping of male and female species of both *Z. cucurbitae* and *B. dorsalis*. In the source of attractant, acetic acid and ammonium acetate in synthetic formulations were added towards the trapping of

male and female flies of both the species, respectively. The observations based on the trapped populations clearly indicated that cue lure and other natural sources along with acetic acid trapped more number of male fruit flies of *Z. cucurbitae*, methyl eugenol and other natural sources with the combination of ammonium acetate shown its effectiveness on the trapping of female fruit flies. In particular, the traps kept with methyl eugenol alone trapped the maximum number of

B. dorsalis alone when compared with the fruit fly species of *Z. cucurbitae*. It showed that the para pheromone methyl eugenol alone is found to be ineffective in the attraction of cucurbit fruit fly, *Z. cucurbitae*. The few insects of *Z. cucurbitae* trapped and observed in the methyl eugenol traps might be accidental due to abiotic factors etc. Considering the influence of varied natural trapping sources along with parapheromonal lures on protected condition for its percent trapping efficiency in addition to yield and cost benefit ratio indicated that, banana and grape sources found to be good when compared to synthetic parapheromonal checks viz., cue lure and methyl eugenol. Observing the natural attractants along with acetic acid combination, the fully ripened banana combined with yeast, black jaggery and acetic acid shown high percent attraction of 12.44 and it was significantly followed by grapes (10.80) with the maximum yield and cost benefit ratio (1.82 and 1.74) compared with cue lure on percent trapping efficiency (30.28) with the cost benefit ratio of 2.04 (Table 3). The other natural sources registered less than 10% efficiency. Focusing the cost benefit ratio the four natural attractants viz., banana, grape, snake gourd and pumpkin found to be a good cost effective alternative to the commercial cue lure component. Doubling the natural

trapping sources may compensate the difference recorded between cue lure and grape/ banana. The performance of molasses and fish meal sources are in equal in trapping, but the efficiency of crucifers and ocimum in combination with both acetic acid (<2) and ammonium acetate (5.22-8.95) solutions found to be average with the cost benefit ratio of 1.45 and 1.47. The natural attractant sources along with 5% ammonium acetate solution shown high percent trapping of female fruit flies in banana fruit pulp extract (24.63) followed by grape (13.43), red pumpkin and snake gourd (12.69). The other natural sources viz., molasses, crucifers, fish meal and ocimum recorded less than 10% efficiency in attraction of female fruit flies of *Z. cucurbitae* with least cost benefit ratio. However, methyl eugenol lure alone trapped maximum population of *Bactrocera* including the species viz., *dorsalis*, *zonata* and *correcta*. It indicates that methyl eugenol trap found to be suited in mango or guava ecosystem rather than snake gourd ecosystem. In snake gourd ecosystem, erection of traps with the natural sources of banana or grape along with ammonium acetate and acetic acid combination in equal numbers may give effective reduction in fruit fly population with maximum yield equivalent to the commercial cue lure para pheromone component.

Table 3: Influence of natural attractant sources on per cent fruit fly trapping, yield and CBR

Treatments	% Male fruit flies Trapped	% Female fruit flies trapped	Yield (t/ha)	% Reduction in yield over protected cultivation	Cost benefit ratio (CBR)*
T ₁ - Snake gourd fruit pulp + yeast + Black jaggery (1:1:1) + Acetic acid or Ammonium acetate (5%)	8.68	12.69	9.36	33.16	1.62
T ₂ - Cruciferous leaf extract + yeast +Black jaggery (1:1:1) + Acetic acid or Ammonium acetate (5%)	1.41	8.95	8.40	40.04	1.45
T ₃ - Ocimum leaf extract + yeast + Black jaggery (1:1:1) + Acetic acid or Ammonium acetate (5%)	1.41	5.22	8.52	39.16	1.47
T ₄ - Red pumpkin fruit pulp + yeast +Black jaggery (1:1:1) + Acetic acid or Ammonium acetate (5%)	5.40	12.69	9.22	34.18	1.60
T ₅ - Banana fruit pulp + yeast + Black jaggery (1:1:1) + Acetic acid or Ammonium acetate (5%)	12.44	24.63	10.50	25.00	1.82
T ₆ - Grape fruit pulp + yeast + Black jaggery (1:1:1) + Acetic acid or Ammonium acetate (5%)	10.80	13.43	10.01	28.49	1.74
T ₇ - Molasses + yeast + Black jaggery (1:1:1) + Acetic acid or Ammonium acetate (5%)	8.68	8.95	8.92	36.31	1.55
T ₈ - Fish meal + yeast + Black jaggery (1:1:1) + Acetic acid or Ammonium acetate (5%)	4.23	7.45	8.86	36.74	1.53
T ₉ - Cue lure alone	30.28	2.24	12.02	14.18	2.04
T ₁₀ - Methyl eugenol alone	16.67	3.74	8.70	37.86	1.50
Protected cultivation	-	-	14.00	-	2.21

*CBR – Cost benefit ratio

Conclusion

The attractancy of male fruit flies of *Z. cucurbitae* to the natural attractant combination with yeast, black jaggery and acetic acid was in the hierarchy of banana fruit pulp > grape fruit pulp > molasses > snake gourd fruit pulp > red pumpkin > fish meal > cruciferous and ocimum leaf extracts. The female fruit flies of *Z. cucurbitae* are highly attracted to the yeast, black jaggery and ammonium acetate combination of banana followed by grapes, red pumpkin, snake gourd, molasses, crucifers, fish meal, ocimum, methyl eugenol and cue lure. In snake gourd ecosystem, traps baited with cue lure as attractant material recorded high yield. While using natural extracts as attractant material, the performance of banana fruit pulp was good in high per cent trapping of fruit flies with maximum yield. The fruit extracts of grapes was found to be the second in trapping and registered higher yield than snake gourd, red pumpkin, molasses and fish meal components.

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