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Evaluation of vegetable extracts as natural lures for female *Bactrocera cucurbitae* (Diptera: Tephritidae)

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Abstract
The experiments on the attraction of female fruit flies *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae) to the extracts of different vegetables as lures was conducted at the Nuclear Institute for Food and Agriculture (NIFA), Peshawar. The experiment was laid out in Completely Randomized Design. There were seven treatments including a control and each treatment was replicated three times. The lures were first tested in the field cages (controlled conditions) initially and then at Farmer's field. The treatments included the combination of round gourd and bitter gourd in ratios of 20:80 (T_1), 40:60 (T_2), 60:40 (T_3), 80:20 (T_4), 00:100 (T_5), 100:00 (T_6), respectively, and a control (T_7). Overall results revealed that extracts of bitter gourd (T_6) and round gourd (T_5) were significantly more attractive to female fruit flies than its other different combinations. These extracts reduced the infestation to 11.63% and 31.05% in experimental field and in farmer's field, respectively. However, no significant difference in yield was found between farmer and experimental field. Thus extracts of bitter gourd as well as round gourd were found to be effective in attracting the females of *B. cucurbitae* and can be used for effective control of fruit fly in IPM programs.

Keywords: natural lures, *Bactrocera cucurbitae*, toxicants bait, fruit fly

Introduction
Fruit flies (Diptera: Tephritidae) are among the world's worst pests attacking many types of fruits, vegetables, ornamentals and some nuts. The true fruit flies comprising over 4,000 species distributed over most of this planet. Depending on the environmental conditions and susceptibility of the crop species, the extent of losses varies between 30 to 100% (Gupta and Verma 1992; Dhillon *et al.* 2005; Shooker *et al.* 2006) [6, 4, 14]. The larvae damage the fruit internally, causing it to ripen prematurely and rot. Up to 100% of fruit may be damaged by fruit flies when infestations are uncontrolled (Hardy 1997) [7].

In Pakistan, the fruit fly complex may cause losses that range from 20 to 90% in different areas of the country. Fruits and vegetables suffer extensive damage due to impacts on yields and fruit quality. Citrus, mango, guava and peach industries on average suffer loss by 7.5, 15, 35 and 30%, respectively. In melons, levels of infestation of 50, 37 and 23% were found in Dera Ismail Khan, Rahim Yar Khan and Kulachi areas of Pakistan, respectively (Stone house *et al.* 1998) [16].

For the management of fruit flies, increasing applications of pesticides are facing resistance from environmentalists and the general public (Cark *et al.* 1996) [3]. The situation is further complicated because biological and cultural control methods do not yield immediate results necessary for successful eradication programs (Baranowski *et al.*1993; Aliniazee and Croft 1999) [1].

Female fruit flies are the dominant factor for multiplication of the pest. Female fruit flies attractive baits are needed in any applicative system for their monitoring and direct control (Mazor *et al.* 2002) [11]. They need protein source to mature sexually and also for the development of their eggs. Exploiting this need, female targeted system normally consists of traps baited with a liquid solution made from protein and fermenting sugar (Epsky *et al.* 1999; Mazor *et al.* 2002) [5, 11]. Increasing knowledge on behavior associated with attraction of both sexually immature females and egg laying females would improve detection and delimitation of fruit flies and provide increased protection of crops adversely affected by their presence (Ravikumar and Viraktamath 2007) [13]

For the effective control of fruit flies, different conventional and modern techniques have been used to avoid the losses. However, in large control applications, such traps may eliminate large numbers of beneficial or non-target insects if they are not selective. Furthermore, aqueous protein hydrolysate-baited traps are difficult to deploy and are not very specific for fruit flies (Katsoyannos 1994) [10]. The use of synthetic food attractant lures for tephritid fruit flies trapping is presently being incorporated. These lures consist of ammonium acetate, trimethylamine hydrochloride and putrescine contained in individual packages that are attached to the inside (top) of plastic McPhail-type traps. Results in open field tests indicated that the three-component synthetic food attractant in a single cone unit was just as effective in capturing wild male and female Medflies (Jang *et al.*2007) [8].
The present was study planned to exploit their feeding behavior with the aim to test the natural lures for developing an effective pesticide based female attracting system as an eco-friendly technique.

Materials and methods

The present experiment was conducted at Nuclear Institute for Food and Agriculture (NIFA), Tarnab, Peshawar. The vegetable field was selected for the research purpose in the infested area. An area of two kanals was marked as an experimental unit for seven respective treatments in RCB design replicated three times.

Preparation of natural host extracts

Dried cucurbits seeds (Round gourd and bitter gourd) were purchased from local market, were grinded and sieved through nylon cloth separately, and were kept in For the preparation of 100 ml solution of each extract, 10 g sugar and 5 g insecticide (Diptrex Trichlorophyn 80% w/w) was added. The solution was prepared by using following ratio:

Natural extracts = 85%, Sugar =10%, Insecticide = 5% (Qureshi *et al.*1991)

Treatments	Round gourd : Bitter gourd
T1	20:80
T2	40:60
T3	60:40
T4	80:20
T5	00:100
T6	100:00

T7 Synthetic bait chemical (5 g ammonium acetate, 5 g sugar, 5 g Diptrex and 5 g protein hydrate dissolved in 100 ml water) used as a monitoring and control purpose.

Experimental procedure

Cotton swab soaked with different extracts were used as fruit flies bait in the standard fruit flies traps. The traps comprising of the different natural lure extracts were installed in the respective treatments. In the field, different places were selected randomly, for the installation of traps, for each respective treatment. A buffer area of 8 meter was left between each treatment for minimizing the intra-treatment effect. The traps were installed at height of about 1.0 m from the ground level in shady place opposite to wind direction. Cotton swab that contained the natural extracts was replenished after every 7-10 days. Three traps of synthetic bait were installed randomly at different places in field for monitoring and control purpose. The number of fruit flies collected in each trap was recorded on weekly intervals.

Infestation data

Infestation data were recorded by comparison of experimental field with a farmer field (control field) 550 m away from experimental field. The total yields in Kg per week from both fields were compared.

Statistical analysis

The data obtained was analyzed statistically with the help of MSTAT-C statistics package on computer. One-way analysis of variance (ANOVA) was performed for each and every constituent and then Least Significant Difference (LSD) test were applied to assess the critical difference between different means.

Results and discussion

Attraction caused by different levels of round gourd and bitter guard

The combined seasonal data on fruit flies attraction are presented in Table 1.
During March 16.3, female fruit flies were trapped by T_6, followed by T_5 (15.03) with no significant difference. The lowest number (8.03) of female fruit flies was found in T_3. No significant difference was found among T_1, T_2, T_3, T_4 and control. The data shows that both the T_5 and T_6 are significantly superior to rest of the treatments.
Almost similar results have been recorded in April. Data shows that T_3, T_4, T_5 and T_6 are statistically similar in trapping female fruit flies with an average of 34.63, 38.80, 36.76 and 43.73 female fruit flies per treatment respectively. These treatments were significantly superior to T_1, T_2 and control. It can be interpreted from the given results in Table 1 that lure made of bitter gourd or round gourd alone were more attractive for female fruit flies but the combination of the two treatments in different ratios reduce its attractiveness.

Table 1: Monthly comparative efficacy of different lures on trapping of fruit flies (*Bactrocera cucurbitae*).

Treatments	Round gourd: Bitter gourd	March	April	May	June	July
T1	20 : 80	8.20b	26.60bcd	41.90cd	54.63b	74.57cd
T2	40 : 60	8.23b	23.53cd	38.60cd	53.63bc	70.27d
T3	60 : 40	8.03b	34.63abc	50.86bc	59.93b	79.17c
T4	80 : 20	10.40b	38.80a	58.43ab	77.40a	98.49b
T5	100 : 00	15.03a	36.76ab	57.30ab	82.66a	104.97ab
T6	00 : 100	16.16a	43.73a	57.30ab	89.03a	110.73a
T7	Control	9.03b	20.26d	30.93d	41.73c	59.03e
	LSD Value	3.9186	11.184	12.287	12.657	7.8094

During May, T_4, T_5 and T_6 attracted significantly more female fruit flies as compared to other treatments. Here T_4, which is the combination of round gourd and bitter gourd in the ratio 80:20, was the highest (58.43) in attracting female fruit flies followed by T_5 and T_6 (57.30), but there is no significant difference among the three treatments. Thus it was observed that combination of round gourd and bitter gourd (80:20) and bitter gourd was as much effective as the lure extracted

separately from both these vegetables. T_1 and T_2 were statistically similar to control.

Attraction of female fruit flies to the vegetable lure continued in similar fashion during the June. During the period T_4, T_5 and T_6 attracted significantly more female fruit flies than other treatments. These three treatments are statistically similar to one another. The results of June were almost similar to those of May.

The cumulative data obtained in July showed that all the treatments were significantly better than control. Data showed that pure bitter gourd and pure round gourds attracted 110.73 and 104.97 female fruit flies during the entire season and were the best lures for attracting female fruit flies. It was also clear from the data that all the treatments were significantly better than control.

Fruit flies are economically important pests of cucurbits. Most of the work has been done on the attraction of male fruit flies, while little work has been done on the attraction of female fruit flies. In the present study the effect of natural extracts on the attraction of female fruit flies was stretched. The data showed that pure bitter gourd T_5 attracted the highest number of fruit flies in March, while the lowest number of fruit flies was recorded from T_3, the combination of round gourd and bitter gourd (60:40). The highest number of female fruit flies was recorded in the month of April at T_6 which is the extract obtained from round gourd, while lowest number was recorded in T_2 which is the combination of round gourd and bitter gourd in the ratio 40:60.

During the month of May, highest attraction (58.43) of female fruit flies was recorded on T_4 which is the combinations of round gourd and bitter gourd in the ratio 80:20. The lowest population (38.60) of female fruit flies was noted on T_2 which is the combinations of round gourd and bitter gourd in the ratio 40:60.

In the month of June, highest tendency (89.03) was recorded in T_6, while lowest tendency was recorded in T_2 (53.63). Similarly, highest population (110.73) of female fruit flies was recorded in T_6 in the month of July, while the lowest tendency (70.27) was recorded in T_2. Ravikumar and Viraktamath (2007) found that food bait containing proteinex and 5 per cent ammonium acetate attracted significantly more *Bactrocera correcta* (5.17), *B. dorsalis* (9.42), *B. cucurbitae* (2.25) and total (16.84) female fruit flies/trap/week in guava. While in mango, fruit fly diet and mango pulp combined with 5 per cent ammonium acetate were attractive to *B. dorsalis* followed by *B. cucurbitae*. Food baits containing guava pulp with ammonium acetate in guava and casein with ammonium acetate, mango pulp and proteinex with 5 per cent acetic acid were the next best treatments in mango.

Siderhurst and Jang (2006) [15] studied that the melon fly, *B. cucurbitae* is a serious pest throughout the Southeast Asia, causing serious damage to tree fruits, cucurbits and related crops. Attractants for female melon flies are of particular interest as they could be used in control tactics to reduce pest levels. The freshly sliced cucumbers are attractive to female melon flies, but the compounds responsible for this attraction were not identified. Akhtar *et al.* (2004) [2] found significantly lower number of fruit flies settled in a cage on the fruits treated with acetone extract of neem. However, all the plants have significant effect on settling response of the fruit flies. Significantly lower numbers of the pupae were obtained from the exposed guava treated with turmeric as compared with sweet flag and neem extracts, although comparatively more number of flies settled on the fruits treated with turmeric extracts. They also found that turmeric extracts had suppressed egg laying and development of pupae and adults. Minimum number of pupae and adults were obtained from the fruits treated with 2% concentration of plant extracts.

Population increase was observed during the trial. This increase might be due to the fact that the nearby fields to the experimental plots had flies in it which due to the attractant moved towards the experimental plot. Besides increase in population the infestation in crop was decreased. It might be due to the reason that the traps installed at field attracted and killed the trapped flies and due to attractants in the traps, more flies were attracted to field but infestation become lower and were killed inside the traps.

The present studies revealed that vegetable lure can be used in fruit flies control programs. The control program can be further improved if is supplemented with male fruit fly. Therefore further work is needed to use this extract along with other control measures for the management of fruit flies in IPM program.

Table 2 shows the comparison of yield and infestation between farmer and experimental field. According to SPSS (independent sample T-test) analysis the yield data is non-significant; infestation was significantly reduced in experimental field when compared with farmer field. No significant difference was found between the yield of farmer and experimental fields. However, rate of infestation in the experimental field was 11.69% as compared to farmer field where the infestation was 31.05% as shown in table 2.

Table 2: Percent infestation data in experimental field vs farmer field.

Picking No /week	Total yield(kg)		Infested yield(kg)		% Infested fruit (in kg)	
	Experimental field	Farmer field	Experimental field	Farmer field	Experimental field	Farmer field
1	13	13	0.8	3.2	6.15	24.61
2	27.5	28.5	2	7.6	7.27	26.66
3	37	38	4.3	11.6	11.62	30.5
4	42.5	43	5	14.4	11.76	33.4
5	44	46.2	5.3	16.3	12.05	35.2
6	50.5	53.6	6.2	17.2	12.28	32.08
7	54.7	55.8	6.8	19.7	12.43	35.3
8	59.8	59	6.9	20	11.54	33.8
9	73	74	11.1	24.8	15.21	33.5
10	70.3	72	9.3	21.9	13.23	30.4
11	75	77.3	10.2	22.4	13.60	28.9
12	68.7	71.5	8.6	20.3	12.52	28.3
Mean	51.3333	52.6583	6.3750	16.61	11.63	31.05
P-value	.230		.000			
T-value	-1.234		-5.379			

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