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Management of fruit flies in mango, guava and vegetables by using basil plants (*Ocimum sanctum* L.) as attractant

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Abstract
Experiments on management of fruit flies by basil plants (*Ocimum sanctum L. Lamiaceae*) as attractant were conducted in mango, guava and vegetable farm located at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.). 5 treatments were used for attraction of fruit flies. These treatments were leaf extract (T_1), stem extract (T_2), inflorescence extract (T_3), root extract (T_4) and methyl eugenol (T_5) as control. *B. cucurbitae* was attracted to all the basil plant parts in maximum numbers in vegetable farm (103.25) fruit flies/week followed by in guava (41.77) fruit flies/week and mango orchard (23.01) fruit flies/week. The result obtained in this investigation indicates that there is possibility to use *Ocimum* plant part extract (leaf, stem, inflorescence and root) and methyl eugenol for the management of fruit flies in mango, guava and vegetables. In the present study it was found that the basil being the cheapest source of methyl eugenol is able to decrease substantially pest attack and consequently increase the farmers income. Thus farmers can apply this bio-chemical, eco-friendly, method to enhance the productivity of mango, guava and vegetables in organic farming.

Keywords: Basil plant, mango, guava, vegetables, eco-friendly, organic farming

Introduction
Fruit flies belong to the family tephritidae, which is one of the largest, most diversified and fruits damaging family of this order. These are commonly called as fruit flies due to their close association with fruits and vegetables. Of the 4500 known species of fruit fly worldwide, nearly 200 are considered as pests. (David and Ramani 2011) [1] reported that 325 species of fruit flies are known to occur in Indian sub-continent of which 243 in 79 genera are from India alone. The tribe dacini with genus *Bactrocera* is of importance in India and from the economic point of view, oriental fruit fly or mango fruit fly *Bactrocera dorsalis* (Hendel), guava fruit fly *Bactrocera correcta* (Bazzi) and peach fruit fly *Bactrocera zonata* (Saunders) are very important pest of fruit crops and are recognized worldwide as the most important threat to horticulture. *Bactrocera dorsalis* is considered to be among the five most damaging and aggressive fruit fly in the world (Lablank and putoa 2000) [3]. Besides fruit crops they are also destructive to many vegetables, oilseed crops and ornamental plants. Female fruit flies lay eggs in fruits and ruin more than 400 different fruits and vegetables including mango, guava, citrus, melon, papaya, peach, passion fruit, plum, apple and star fruit. They are strong flier and can fly up to two kilometers in search of food. Beside the direct damage of fruits, indirect loss is associated with quarantine restriction because infestation and sometimes mere presence of the flies in a particular country could also restrict the free trade and export of fresh horticulture produce to large lucrative markets. In India, a total loss of 2558 and 26,902 million rupees was estimated due to fruit flies with and without control measures, respectively (Stonehouse, 2001) [7]. Because of their infestation, India has been included in the list of those countries from where the import of fruits to developed countries has been banned. Important fruits flies damaging fruit crops in Uttar Pradesh include *Bactrocera cucurbitae, B. dorsalis, B. diversa, B. nigrotibialis, B. zonata* and *B. caudata* etc. Common host plant of *Bactrocera cucurbitae* are all cucurbitaceous crops. While that of *B. dorsalis* attack on mango, guava, peach, citrus, pear, ber; *B. zonata* attack guava, peach mango ber etc. (Kapoor 1993) [2]. Fruit flies deposit their eggs in host fruits when they are physiologically ripe. On hatching, maggots bore their way to the interior and feed on the fruit pulp. Area fed by maggot is discolored due to rotting

Of the fruit and the fruit drops prematurely. The methods of management of fruit flies are largely determined by their biological attributes. Only adults are exposed to control measures while eggs and maggots remain protected in the host tissues and most of insecticidal treatments are ineffective (Sharma *et al*. 2011) [6].

Materials and Methods

The experiment was carried out at three locations of mango, guava orchard and vegetable farm, in the Chandra Shekhar Azad University of Agriculture and Technology, Kalyanpur Kanpur (U.P.). This experiment was conducted during 1st December, 2016 to 31st May, 2017 by randomly selecting three places in Kanpur. In each trap charging with the extracts of basil plant (leaf, stem, root, inflorescence and methyl eugenol) prepared with 2:1 ratio of water and plant parts was done. The trap used in experiment is Rakshak trap 1000 ml quantity, transparent with four windows of equal size with cotton pieces charged by basil plant extract placed in the loop of this trap. These cotton pieces were recharged every week by basil extract of different plant parts.

Preparation of plant extracts

Plants of *Ocimum sanctum* mostly black variety of *Ocimum* were collected. The leaves, stems, roots, and inflorescence were crushed in a grinder completely after mixing water and plant parts in (2:1) ratio. This extract was then boiled for 5-10 minutes till the quantity of water become half after that cooled at room temperature and then sieved under 0.25 mm mesh size. The extract was collected within the bottle and stored in cool place for long time at 4 °C temperatures.

Charging of cotton wick with basil plant extract and methyl eugenol

After preparation of basil plant extracts the fresh mixture of plant parts extract (100ml) + Malathian 50 EC (1.25 ml) were mixed together and stored in a plastic container for further use. Fresh mixture of Methyl eugenol + Malathion 50 EC was prepared in ratio of 4:0.05 and kept in screw capped glass container. Then 4 ml of mixture was taken with the help of disposable syringe of 5 ml capacity and injected in the wick already hanged in the trap. The traps were recharged after one week. Traps were hung at a height of 1.5 -2.0 metre in triplicate at each location. In case of mango, guava, the traps were tied on the trees while in vegetables the traps were hung on a bamboo pole or nearby tree. The number of fruit flies trapped in all places/trap/week were collected and identified. The number of fruit flies belonging to different species were counted and preserved every week for further studies, which were attracted to ME traps and basil extract traps, at all the three experimental sites.

Evaluation of fruit fly populations belonging to different species at different locations

The peak catches of fruit fly were recorded at weekly intervals and identified to species level and recorded. A great number of males which may have been attracted from the vicinity of the place were also trapped by the methyl eugenol trap. The trap catch study carried out was co-related with abiotic factors. The trap data of the first week could serve as a useful index to predict fruit fly population of subsequent weeks.

Results and Discussion

Fruit flies (Tephritidae: Diptera) are major pest of several fruits and vegetables throughout the tropical and sub-tropical world. In mango it is declared as international pest. Due to increased awareness among farmers, scientist and socialists about the harmful effect of pesticides, lure baited traps are gaining popularity among the farmers as these are eco-friendly. Among these methyl eugenol and cue lure impregnated with a suitable substrate such as malathian makes a most effective fruit fly trap. But, due to unavailability and cost of these lures, these are out of reach to the common farmers. Therefore, a technique by using basil (*Ocimum* species) extract was developed to combat the problem of fruit flies, by conducting various experiments to obtain most promising plant part as attractant to fruit fly species. Efforts were also made to identify various fruit flies species which were attracted in various locations. Methyl eugenol was used as control.

As table 1 indicates, the experiment conducted in mango orchard during December 2016 to May 2017, showed that maximum numbers of fruit flies were observed in 21st standard week in basil leaf extract with mean number12.67. The lowest number of fruit flies was recorded in leaf extract in 7th standard week with mean of 0.33 fruit flies. The maximum number of fruit flies in T_2 (Stem extract) was in 20th standard week with mean of 8.67 fruit flies. The lowest number of fruit flies was observed in 5th standard week with mean 0.33 fruit flies. In case of inflorescence extract (T_3) maximum numbers of fruit flies were trapped in the standard week 21st with mean number of 10.33. In T_4 (root extract) maximum 10.33 fruit flies were collected in the standard week 21. Lowest population attracted to root extract was 0.67 in the standard week 4th in the last week of January. In the treatment number T_5 (methyl eugenol) used as a control, maximum number of fruit flies were attracted on methyl eugenol in the standard week 11th with mean 127.00 fruit flies**.** Shah and Patel (1976) [8] studied in southern Gujarat in India on the extent and timing of attacks by *Dacus correcta* (Bez.) on mango. This fruit-fly was found for the first time on an aromatic plant, *Ocimum sanctum* (Tulsi plant), but only males were attracted to it. Chemical analysis showed that 40% of the essential oil content of this plant consisted of methyl eugenol, which was found in subsequent studies to be a sex attractant for the males. In guava orchard, the data presented in Table 2 showed that maximum number of fruit flies trapped in 21st standard week with mean number of 18.33 in leaf extracts of basil. The lowest number of fruit flies were recorded in T_1 (Leaf extract) in 6thstandard week with mean of 0.67. The maximum number of fruit flies were trapped in T_2 (Stem extract) in 50th standard week with mean of 14.67 fruit flies. In case of inflorescence extract maximum number of fruit flies was trapped in the 50th standard week with mean of 51.67 flies. As regards the root extract a mean of 30.33 flies were trapped in 49th SW. The lowest population attracted to root extract was 7.67 in the standard week 3 in the last week of January. In the treatment number T_5 methyl eugenol was used as control. The maximum number of fruit flies was attracted on methyl eugenol in the standard week 12th with mean 108.67 flies. (Rahmann and Aksoy 2014) [5] reported control of fruit flies in guava fruit (*Psidium guajava*). Its production reaches 15 tons per ha per harvest at every three day interval. Nevertheless, one of the obstacles in securing the

Productivity is fruit flies pest (*Bactrocera* spp.) which can cause 50% or even up to 100% yield losses.

The third experiment was conducted on vegetable farm, Kalyanpur at CSAUA&T Kanpur (Table 3) treatment T_1 (Leaf extract) registered the maximum number of mean flies in the standard week 12 with mean 65.67 flies. The minimum numbers of fruit flies were observed in the 3rd standard week with mean value of 8.00. In case of T_2 (stem extract) maximum numbers of fruit flies were trapped in the standard week 8 with mean 25.67 fruit flies. It was observed that the mean value of fruit flies catch on inflorescence extract was maximum in the 10th standard week and this was followed by standard week 9th with mean value 27.67. The minimum mean value of fruit flies captured during this period was in 8th standard week. As far as the root extract traps in vegetable farm is concerned, the maximum number of fruit flies were attracted in standard week 12, with mean value of 38.33. The treatment (T5) used as control recorded maximum number of fruit flies which were attracted on methyl eugenol in the standard week 12 with mean of 75.00. (Mohanadas and Mukund 2013) [4] reported a safe and eco-friendly approach to manage the vegetable and mango fruit pests, *Bactrocera cucurbitae* and *B. dorsalis* (Diptera: Tephritidae) using crushed tulsi leaves. *B. cucurbitae* is a well-known pest affecting a variety of vegetables such as cucumber species, bitter gourd, snake gourd, ash gourd, pumpkin, etc. and *B. dorsalis* affects mango. A simple mechanism using crushed tulsi leaves, *Ocimum sanctum* L. is found to attract the flies of *B. dorsalis*, if they are present in and around the vegetable and mango growing fields.

Table 1: Effect of basil plant extract on fruit flies catches fom December 2016 to May 2017 in mango orchard at CSAUA&T Kanpur

S. No.	Treatment	Mean number of fruit flies attracted																						
		Standard week (S.W.)																						
		49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1.	T1	10.67	5.33	4.33	4.00	4.33	4.33	3.67	1.33	1.00	1.00	0.33	0.67	0.33	0.33	5.67	9.67	7.67	7.33	8.33	7.00	10.00	9.67	11.67	9.00	12.67
2.	T2	8.33	6.00	3.67	3.33	4.00	2.67	3.33	1.00	0.33	0.67	1.00	0.67	1.00	1.33	4.33	8.33	6.33	5.67	4.33	4.66	7.00	4.33	6.33	8.67	8.67
3.	T3	5.33	5.00	3.00	2.66	5.00	2.67	4.00	1.00	1.33	0.33	0.00	0.00	0.67	0.67	3.33	6.00	4.33	3.67	2.67	2.66	5.00	4.67	7.00	9.67	10.33
4.	T4	10.00	8.33	3.67	4.00	3.67	4.00	4.67	0.67	1.00	1.33	3.67	3.33	3.00	3.67	3.00	6.67	4.67	4.33	4.00	4.33	6.33	4.00	7.33	10.33	10.33
5.	Control	37.67	38.33	23.67	20.66	17.67	13.33	14.67	13.67	13.00	13.33	23.33	37.33	43.33	31.00	127.00	123.33	95.67	93.67	83.00	86.00	83.66	77.67	84.67	94.67	94.67
SE. m.±		4.57	2.38	2.34	2.39	2.14	1.63	.94	4.78	3.82	4.86	4.86	8.20	7.05	5.27	27.77	26.50	19.85	18.70	16.80	17.50	14.73	14.78	15.01	15.43	15.94
CD at 5%		14.42	7.50	7.38	7.54	6.75	5.16	2.97	15.09 NS	12.05 NS	15.31 NS	15.32	25.84	22.22	16.62	87.51	83.50	62.55	58.95	52.95	55.14	46.44	46.58	47.30	48.63	50.23

T1 = Leaf extract
T2 = Stem extract
T3 = Inflorescence extract
T4 = Root extract
T5 = Control (methyl eugenol)

Table 2: Effect of basil plant extract on fruit flies catches from December 2016 to May 2017 in guava orchard at CSAUA&T Kanpur

S. No.	Treatment	Mean number of fruit flies attracted																						
		Standard week (S.W.)																						
		49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1.	T1	13.67	14.67	8.33	7.00	6.67	5.00	4.00	0.67	0.67	0.67	5.67	10.00	8.00	6.33	7.00	7.33	9.33	12.00	10.33	12.00	10.00	7.67	10.67	14.00	18.33
2.	T2	14.33	14.67	8.67	5.67	3.33	3.67	3.00	0.67	1.00	0.67	2.67	2.00	1.33	1.33	4.00	4.33	4.67	4.00	4.33	6.33	5.33	5.00	6.00	9.33	10.33
3.	T3	47.67	51.67	39.00	29.33	20.00	16.67	15.00	36.00	47.00	50.00	35.67	45.67	31.00	33.67	26.67	25.33	20.33	20.33	22.33	18.67	22.33	23.00	28.33	32.67	29.33
4.	T4	30.33	25.67	14.67	12.67	8.67	9.67	7.67	13.33	16.67	18.33	22.33	35.33	15.33	15.33	19.33	17.00	15.33	12.67	16.33	13.00	15.00	14.00	13.00	16.00	16.33
5.	Control	29.67	30.33	14.00	9.67	10.67	8.67	7.67	18.00	16.67	16.00	16.00	15.00	26.33	30.00	103.33	108.67	80.00	71.67	79.00	81.67	73.33	77.33	91.00	91.00	99.33
SE. m.±		5.60	3.50	5.54	4.10	3.06	3.57	1.52	7.03	9.17	9.82	9.03	10.47	10.55	11.17	10.49	11.21	12.56	13.67	13.59	13.98	11.38	12.29	13.86	10.7	12.52
CD at 5%		17.66	11.05	17.48	12.92	9.64	8.10	4.79	22.17	28.97	30.94	28.47	33.00 NS	33.25 NS	35.21 NS	33.07	35.34	39.59	43.09	42.83	44.07	35.87	38.75	43.69	33.40	39.47

T1 = Leaf extract
T2 = Stem extract
T3 = Inflorescence extract
T4 = Root extract
T5 = Control (methyl eugenol)

Table 3: Effect of basil plant extract on fruit flies catches from December 2016 to May 2017 in vegetable farm Kalyanpur at CSAUA&T Kanpur

S. No.	Treatment	Mean number of fruit flies attracted																						
		Standard week (S.W.)																						
		49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1.	T1	28	23.33	17	11	14.67	10.67	8	22.33	26.67	27.33	38	40.67	55	59.67	58.33	65.67	53.67	46.67	52.33	47.33	44.67	46	39.33	38.67	39.33
2.	T2	14	16.33	11.33	7.67	5.33	5.67	5	6.00	5.33	5.67	21.33	25.67	18.33	18.00	20.67	21.00	18.67	18.33	20.67	18.00	21.67	23.33	18.00	17.00	14.33
3.	T3	22	20	15.33	10.67	8	9.33	8.67	7.33	7.67	7.67	17.67	16.33	27.67	32.67	19.67	24.33	20.67	20.33	19.33	18.33	23.67	18.67	12.33	13.00	11.00
4.	T4	15	16	15.33	10	7.67	9	6.67	5.67	6.00	5.67	9.33	8.33	21.00	25.00	30.67	38.33	32.67	28.67	32.00	29.33	33.00	35.00	29.00	23.00	25.33
5.	Control	32.67	49.67	17.67	12	10.33	8.67	7.67	21.67	22.33	27.67	42.00	40.00	45.00	44.33	71.67	75.00	64.67	64.00	57.00	65.00	71.33	63.33	64.67	68.00	61.33
SE. m.±		7.43	3.68	3.64	2.34	2.32	1.59	1.71	3.81	5.67	6.31	8.34	8.66	13.44	14.84	22.84	23.00	20.20	18.29	17.42	18.01	16.97	17.03	14.82	12.92	14.52
CD at 5%		23.43 NS	11.62	11.48 NS	7.39 NS	7.31 NS	5.03 NS	5.39 NS	12.02	17.92 NS	19.89 NS	26.30 NS	27.30 NS	42.36 NS	46.77 NS	71.99 NS	72.00 NS	63.65 NS	57.64 NS	54.89 NS	56.75 NS	53.48 NS	53.68 NS	46.70 NS	40.73 NS	45.77 NS

T1 = Leaf extract
T2 = Stem extract
T3 = Inflorescence extract
T4 = Root extract
T5 = Control (methyl eugenol)

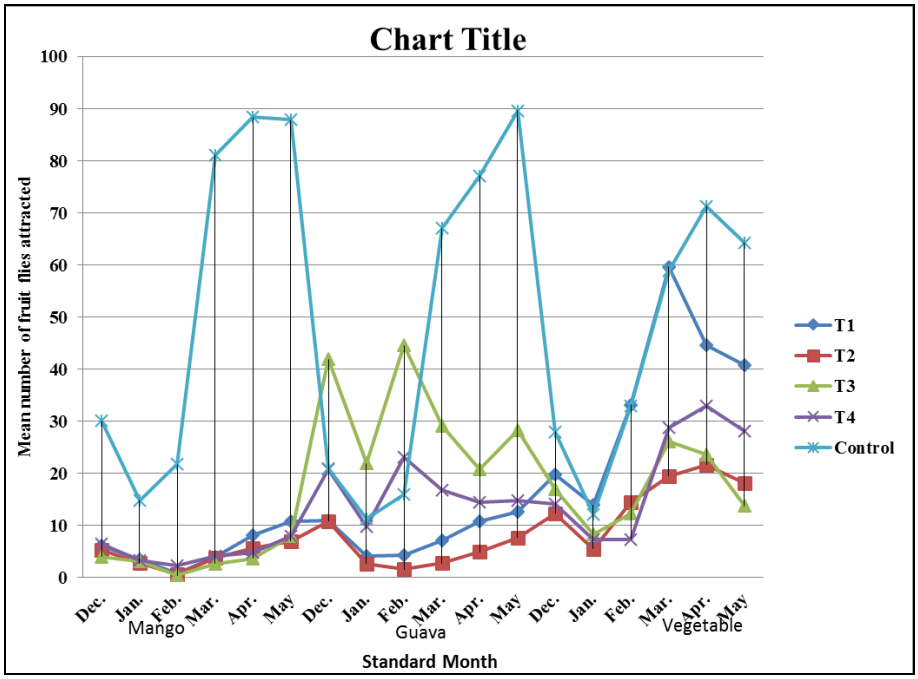

Fig 1: Effect of basil plant extract on fruit flies catches from December 2016 to May 2017 in mango, guava and vegetables orchard at CSAUA&T Kanpur

Conclusion

Fruit flies are difficult to manage because they lay eggs in fruit epidermis therefore, basil plant (*Ocimum sanctum*) has been investigated in the present study which can be an effective control measure for fruit flies in fruits and vegetables. In the present study it was found that the basil being cheapest source of methyl eugenol is able to decrease substantially pest attack and consequently increase the farmer income. Thus farmers can apply this bio-chemical, eco-friendly, method to enhance the productivity of mango, guava and vegetables in organic farming. The greatest strength of this technique is its simplicity and cost effectiveness.

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