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Effect of fabricated of indigenous fruit fly traps for control of fruit flies in mango and guava orchard and to identify effect of colour of traps on fruit flies

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Abstract
Experiment was carried out in Insectary (Dept. of Entomology), College of Home Science and guava orchard (Dept. of Horticulture) located at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P) during 2017-18. There were 4 treatments were used for attraction of fruit flies. These treatments were green, yellow, transparent and Rakshak traps and methyl eugenol was used as attractant. The *Bactrocera* species which were attracted on coloured traps were *Bactrocera dorsalis, B. correcta, B. zonata, B. nigrotibialis.* The most predominant spp. attracted in guava orchard was *B. zonata* followed by *B. dorsalis, B. nigrotibialis and B. correcta* in all the traps tested. Out of four traps green trap was more attractive to all the *Bactrocera* species in Insectary (Dept. of Entomology) with a mean number of 66.25 fruit flies, in guava orchard (Dept. of Horticulture) 75.50 fruit flies and in College of Home Science 78.0 fruit flies.

Keywords: *Bactrocera dorsalis Bactrocera correcta, Bactrocera zonata, Bactrocera nigrotibialis*

Introduction
True fruit flies also known as tephritidae flies, belong to the class Insecta, Order: Diptera and family Tephritidae. According to White and Elson Harris (1992), the family Tephritidae is represented in all regions of the world except Antarctica. Because of increasing international movement of produce and individuals, alien invasions are on the increase. The order Diptera (true flies) originated in Permian period (250 million years ago) is one of the six mega- diverse insect orders comprising morphologically and ecologically varied group of taxa (Illango, 2012) [6]. Family Tephritidae, is one of the largest, most diversified and fascinating acalypterate family of this order. These are commonly called as fruit flies due to their close association with fruits and vegetables. They are also known as peacock flies because of their habit of strutting about and vibrating spotted and striped wings. Of the 4500 known species of fruit fly worldwide, nearly 200 are considered as pests but about 70 species are regarded as agriculturally important throughout the world (Clark *et al.* 2005) [2]. According to Freidberg (2006) [4] only five percent of all Tephritid species are economically important. David and Ramani (2011) [3] 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 (Verghese *et al.* 2004, Kapoor 2005, Ekesi and Mohamed 2011, Sharma *et al.* 2011) [1, 17]. *Bactrocera dorsalis* is considered to be among the five most damaging and aggressive fruit flies in the world (Lablank and Putoa 2000) [9]. 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 2 kilometers in search of food (Butani 1979) [1]. Beside the direct damage of fruits, indirect loss is associated with quarantine restriction because of 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,

(Ole-Moi Yoi and lux 2004 Mumford (2001) [11] estimated a loss of Rs. 29,460 million in India due to fruit flies but Narayan and Batra (1960) [10] reported 50 to 60 percent annual losses on different hosts in India. In India, a total loss of 26,902 million rupees was estimated due to fruit flies with and without control measures, respectively (Stonehouse, 2001) [19].

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 *B. cucurbitae, B. dorsalis, B. diversa, B. nigrotibialis, B. zonata B. caudata and B. correcta* etc. Common host plant of *Bactrocera cucurbitae* are all cucurbitaceous crops. While *B. dorsalis* attack on mango, guava, peach, citrus, pear, ber while *B. zonata* attack guava, peach mango ber etc. (Kapoor 1993) [8]. 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 discoloured 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) [17].

Application of insecticides further disrupt the ecosystem and cause numerous hazards, which in the present scenario warrants the need of integrated approach for fruit fly management (Vergiese *et al.* 2002, Sharma *et al.* 2011, Vergies *et al.* 2012) [17]. Among the various alternate strategies available for the management of fruit flies, the use of methyl eugenol traps and cue lure is also used for trapping the fruit flies. Methyl eugenol traps stand as the most outstanding alternative. Methyl eugenol has both olfactory as well as phagostimulatory action and is known to attract fruit flies from a distance of 800 meter (Roomi *et al.* 1993). Methyl eugenol, when used together with insecticide impregnated into a suitable substrate, forms the basis of male annihilation technique. This technique has been successfully used for the eradication and control of several *Bactrocera spp.* Hancock *et al.* 2000 [5], Alloved *et al.* 2003, Vergies *et al.* 2006, Stoenhouse *et al.* 2007 and Stoenhouse *et al.* 2005 reported that MAT with methyl eugenol traps @ 4 trap / acre in mango and guava was found effective in controlling fruit flies in different parts of India. Methyl eugenol specially attracts the male of B. *dorsalis*, B. *correcta*, B. zonata (Vergies *et al.* 2006), while cue lure attracts the B. *cucurbitae*, B. *correcta*, B. *zonata*, and *B. diversa etc.*

Thus, the tendency of *Bactrocera* males to re-visit a methyl eugenol source following initial exposure was explored to study the population buildup of different fruit flies. The sanitation combined with the use of lures and traps as well as baits proved to be one of the best alternatives for management of fruit flies. These traps have high efficiency, low cost and are environmentally quite safe (Sureshbabu and Virakthamath, 2003). Since adult flies use visual and olfactory stimuli to locate hosts, traps that combine visual and olfactory cues were proved to be most effective for capturing fruit flies (Epsky and Health, 1994). The response of fruit flies to visual stimuli depends on the colour, shape and size of the stimulus (Katsoyannos, 1989).

Thus, keeping in view the economic importance of fruit flies on fruit crops, the present studies were made on fabrication of low cost indigenous fruit fly traps for the control of fruit flies in guava orchard and identify effect of trap colour on fruit flies.

Results of this study will assist in knowing the low cost preparation of traps and assessment of loss in guava due to fruit flies. This will give a new concept of fruit fly management and formulation of on-farm IPM technologies. This study will help in evolving some remedial measures to reduce the infestation of fruit flies on different crops without polluting the environment which is the most imposrtant issue in modern agriculture.

Materials and Methods

The present study was made on fabrication of indigenous fruit fly traps for control of fruit flies in mango and guava orchard and to identify effect of colour of traps on fruit flies was conducted during December 2017 to May 2018. The details of materials used and methods employed during the course of investigation are being described as follows.

The experiment was carried out at the three locations of departmental Insectary (Dept. of Entomology), guava orchard (Dept. of Horticulture) and College of Home Science in the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.).

This experiment was conducted during 1st December, 2017 to 31st May, 2018 by selecting three places in Kanpur. These places were Guava-orchard (Dept. of Horticulture), Insectary (Dept. of Entomology) and College of Home Science CSAUA&T. In each traps charging with alcohol, methyl Eugenol and Malathion (50 EC) prepared in the ratio of 6:4:1 was done. The trap used in experiment are fabricated traps of green and yellow of 2.0 lit size and white color of 1lit respectively with three windows. Wooden piece of 5x5x0.5cm charged with 6:4:1 (alcohol: methyl eugenol: Malathion) were placed in the loop of plastic wire. Rakshak trap of 1lit capacity, was transparent with three windows of equal size. Cotton wicks with string on the lid were also charged with 6:4:1 alcohol: Methyl eugenol: malathion. These wooden pieces and cotton wicks were recharged every month.

The traps used were fabricated in cylindrical and square shape and Rakshak traps were recommended by Agricultural and Processed Food Products Export Development Authority (APEDA), Ministry of Commerce and Industry, Government of India and supplied by Dr. Bala Saheb Sawant Konkan Agricultural University, Dapoli (Gujarat).The two cylindrical traps are of different colours like green and yellow of 2.0 lit capacity and one white square shaped trap of 1lit capacity. These bottles were cut at the neck and that cut piece was reversed on the top and the plastic wire was passed from the top to the bottom to hold the 5x5x0.5cm wooden piece. Rakshak trap is one litre plastic container (Fig.-1) with 10 cm base, 9cm diameter top and 11.5 cm deep. It has a yellow coloured screw top lid. Four entry holes of 2.5 cm in diameter evenly spaced 1.5 cm below the lid are located in trap. A plastic chain is hooked in the centre on the upper side of screw top. On the lower side of the lid there is a hook for holding the wick/plywood.

Absorbent cotton wool was used for wick preparation. After taking-out required quantity of cotton from the pack, the same was put in between two palms and rolled with a light pressure to make a wick. From one pack weighing 250 g about 833-834 wicks could be prepared *i.e.* about 0.3 g cotton was required to prepare one wick. The wooden piece of 5x5x0.5 cm is cut with the help of cutter and the hole is made in the middle of the piece to hold the thread.

Solution was prepared by taking alcohol, methyl Eugenol and Malathion in the ratio of 6:4:1. To make the solution 150 ml of alcohol, 100 ml of methyl eugenol and 25 ml of Malathion (50EC) was taken and mixed in a beaker and kept in a bottle covered with a lid. The wooden pieces were dipped in this mixture for one week.

After preparation of mixture of Alcohol (150ml) + Methyl eugenol (100ml) + Malathion 50 EC (25ml) the mixture was stored 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 wooden pieces were soaked for a week and they were taken out from the jar and tied on the hanging traps. They were taken out from the hanging traps after one month and were recharged by dipping in mixture. The charging of wick and wooden piece was done as per treatment *i.e.* after one month.

Traps were hung at a height of 1.5 -2.0 Metre at each location. In guava, 4 traps of green, yellow, transparent and Rakshak traps were hung on the trees at a distance of 50 meters.

The fruit flies from all three places were collected separately at weekly intervals and identified to the species level by using keys given by Ramani (1997) [13], with the help of microscope. The number of fruit flies trapped in 3 places/trap/week was calculated.

The field experiments were subjected to statistical analysis under Completely Randomized Design (CRD). The analysis of variance was calculated to find out Standard error (SE) at T = 5% for error degree of freedom and critical difference (CD) at 5%.

Results and Discussion

Fruit flies are a serious impediment to fruit cultivation in our country. In India many species of fruit flies occur which infest a number of fruit and vegetable crops. Realising the importance of fruit flies in the production of fruits and vegetables, a number of experiments were conducted to study the effect of colour and shape of the fruit fly traps on catches of fruit flies by using methyl eugenol, different fruit fly species abundant in the area and assessment of economic loss due to fruit flies in guava orchard. Results of the studies were presented in this chapter.

Effect of colour of traps on total fruit fly catches/trap from December 2017 to May 2018 at Insectary, Dept. of Entomology CSAUA&T, Kanpur An experiment was conducted to evaluate effect different of coloured trap on total fruit fly catches from December 2017 to May 2018 at Insectary, Dept. of Entomology. In this experiment 4 treatments were used for the attraction of fruit flies. These treatments are green trap, yellow trap, transparent trap and Rakshak trap.

It is evident from the data presented in the Table-1 that in green trap maximum number of fruit flies were observed in the month of April-2018 with the mean number of fruit flies 66.25. Minimum number of fruit flies were recorded in December-2017 with a mean number of 43.75 fruit flies/trap.

Table 1: Effect of colour of traps on total fruit fly catches from December 2017 to May 2018 at Insectary, Dept. of Entomology CSAUA&T, Kanpur

S.N	Treatments	Mean number of fruit fly catches during months						
		Dec-17	Jan-18	Feb-18	Mar-18	April-18	May-18	Total
1	T1	43.75	53.50	46.50	49.50	66.25	61.75	321.25
2	T2	38.00	35.75	37.50	45.75	63.75	49.25	270.00
3	T3	37.75	42.00	36.00	40.75	64.00	52.75	273.25
4	T4	35.25	39.50	32.50	35.00	51.00	45.00	238.25
5	SE.m	3.580	3.700	2.970	3.330	5.450	8.970	-
6	CD at 5%	11.05(N S)	11.41	9.16	10.263	16.8(N S)	27.65(N S)	-

T1 Green trap
T2 Yellow trap
T3 Transparent trap
T4 Rakshak

In yellow trap maximum number of fruit flies were observed in April-2018 with 63.75 mean number of fruit flies/trap and the lowest number of fruit flies were observed in January-2018 with mean number of 35.75 fruit flies/trap.

In case of transparent trap maximum number of fruit flies were trapped in the April-2018 (64.00 fruit flies/trap) and minimum mean number of fruit flies were recorded 36.00 in the February-2018 In Rakshak trap maximum number of fruit flies were calculated in the month of April-2018 with mean number of 51 fruit flies/trap and the lowest population attracted to Rakshak trap was 32.50 in the month of February-2018.

Statistically all the treatments were significant during the experimental period except in December, April and May months. The result shows that highest number of fruit flies were captured in green coloured trap.

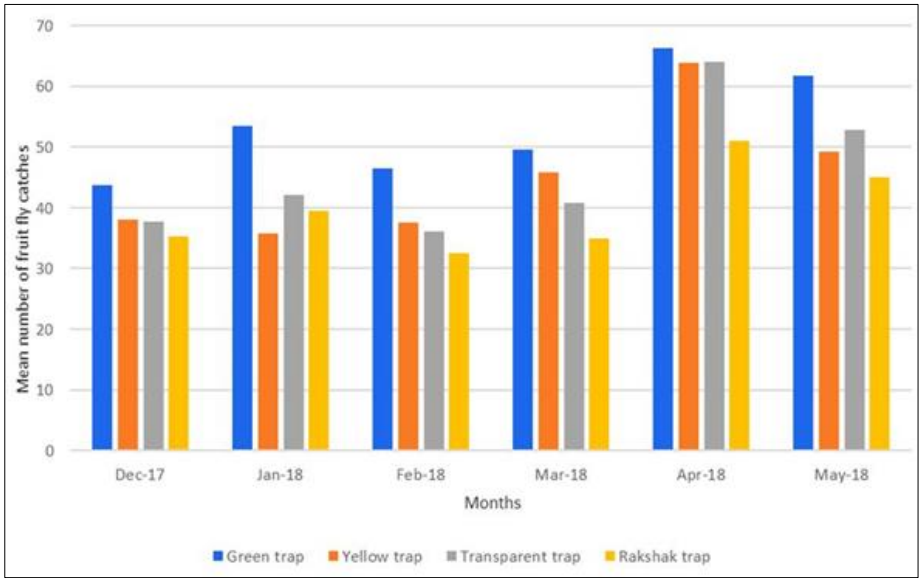

Fig 1: Demographic representation showing trap catches in different coloured traps at Insectary, Dept. of Entomology.

Table 2: Effect of colour of traps on total fruit fly catches from December 2017 to May 2018 at Guava orchard, Dept. of Horticulture CSAUA&T, Kanpur

S.N	Treatment s	Mean number of fruit fly catches during months						
		Dec-17	Jan-18	Feb-18	Mar-18	April-18	May-18	Total
1	T1	45.00	49.25	53.25	54.75	75.50	64.25	342.00
2	T2	43.75	47.50	43.00	45.00	58.75	46.50	284.50
3	T3	49.25	48.25	42.25	41.50	56.00	48.00	280.00
4	T4	33.00	37.75	34.25	35.50	56.50	42.25	239.25
5	SE.m	2.690	3.310	2.280	3.670	8.440	7.07	-
6	CD at 5%	8.310	10.21(N S)	7.030	11.32	26.02(N S)	21.79(N S)	-

T1 Green trap
T2 Yellow trap
T3 Transparent trap
T4 Rakshak trap

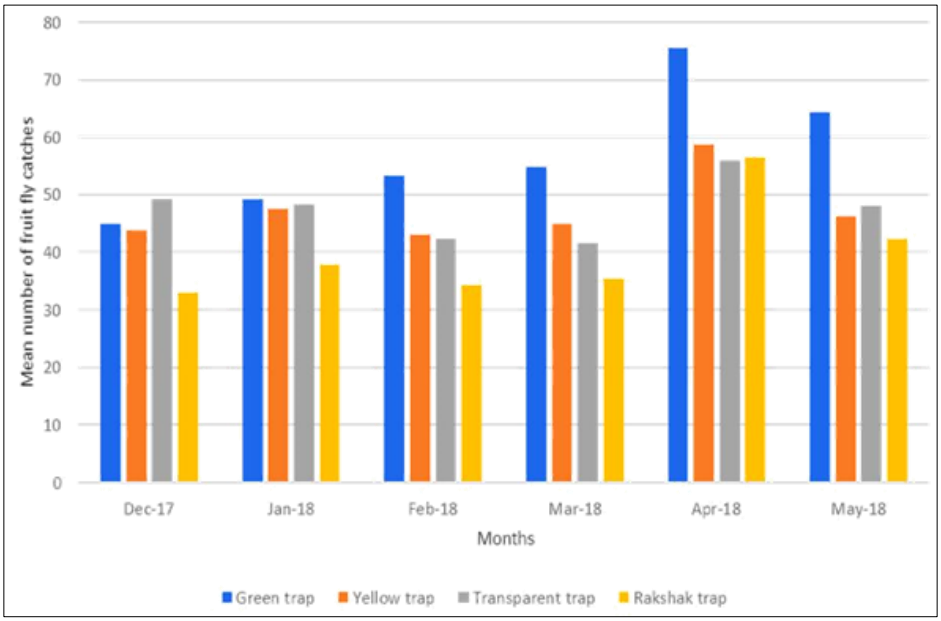

Fig 2: Demographic representation showing trap catches in different coloured traps at Guava orchard, Dept. of Horticulture CSAUA&T, Kanpur.

Effect of colour of traps on total fruit fly catches/trap from December 2017 to May 2018 at Guava orchard, Dept. of Horticulture CSAUA&T, Kanpur.

It is evident from the data presented in the Table-2 that in green trap maximum number of fruit flies were observed in the month of April-2018 with the mean number of 75.50 fruit flies/trap. Minimum number of fruit flies were recorded in December-2017 with a mean number of 45.00 fruit flies/trap.

In yellow trap maximum number of fruit flies in yellow trap were observed in April-2018 with mean number of 58.75 fruit flies and the lowest number of fruit flies was observed in February-2018 with mean number of 43.00 fruit flies/trap.

In case of transparent trap maximum number of fruit flies were trapped in the April-2018 with a mean number of 56.00 fruit flies/trap while minimum mean number of fruit flies were recorded in March-2018 (41.50fruit flies/trap).
The maximum number of fruit flies were recorded in Rakshak trap in the month of April-2018 with the mean number of 56.50 fruit flies/trap and the lowest population was attracted in the December-2018 (33.00 fruit flies/trap).
Here also maximum fruit flies during the period of study were captured in green coloured trap
Statistically all the treatments were significant during the experimental period except in January, April and May months.

Table 3: Effect of colour of traps on total fruit fly catches from December 2017 to May 2018 at College of Home Science CSAUA&T, Kanpur.

S.N	Treatments	Mean number of fruit fly catches during months						
		Dec-17	Jan-18	Feb-18	Mar-18	April-18	May-18	Total
1	T1	46.50	47.25	52.00	51.25	78.00	51.00	326.00
2	T2	40.75	40.75	39.50	48.75	75.75	55.00	300.50
3	T3	39.25	38.25	43.50	45.00	62.25	43.25	271.50
4	T4	36.75	34.00	42.00	41.25	57.50	42.00	253.50
5	SE.M	4.430	6.060	2.900	3.290	9.850	7.100	-
6	CD at 5%	13.65	18.70(N S)	8.940	10.14(N S)	30.36(N S)	21.89	-

T1 Green trap
T2 Yellow trap
T3 Transparent trap
T4 Rakshak trap

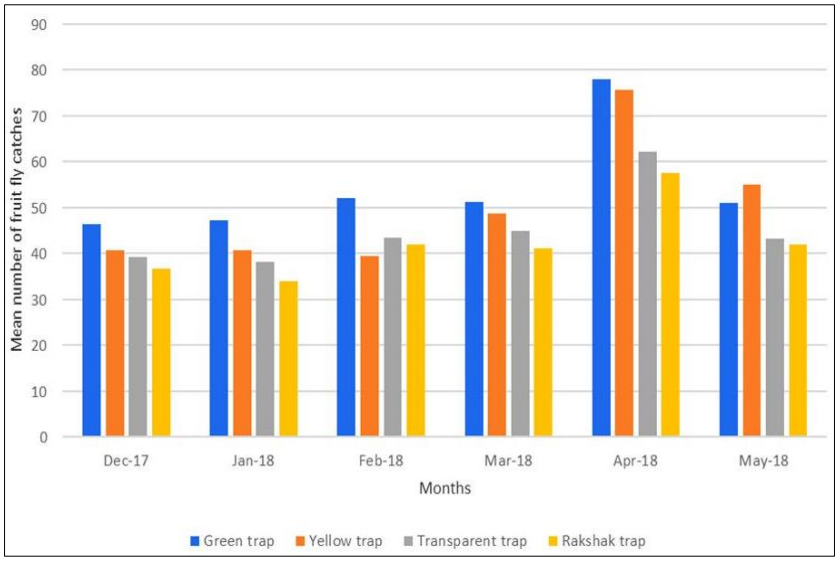

Fig 3: Demographic representation showing trap catches in different coloured traps at College of Home Science CSAUA&T, Kanpur

3 Effect of colour of traps on total fruit fly catches/trap from December 2017 to May 2018 at College of Home Science CSAUA&T, Kanpur It is evident from the data presented in the Table-3 that in green trap maximum number of fruit flies were observed in the month of April-2018 with the mean number of 78.00 fruit flies/trap. Minimum number of fruit flies were recorded in December-2017 with a mean number of 46.50 fruit flies/trap.
In yellow trap maximum number of fruit flies were observed in April-2018 with mean number of 75.75 fruit flies/trap and the lowest number of fruit flies was observed in February-2018 with mean number of 39.50 fruit flies/trap.
In case of transparent trap maximum number of fruit flies were trapped in the April-2018 with a mean number of 62.25 fruit flies/trap while minimum mean number of fruit flies were recorded in January-2018 (38.25 fruit flies/trap). In Rakshak trap maximum number of fruit flies were caught in the month of April-2018 with the mean number of 57.50 fruit flies/trap and the lowest population attracted to rakshak trap was 34.00 in January-2018.
Statistically all the treatments were significant during the experimental period except January, March and April.
The result shows that maximum fruit flies during the period of study were captured in green coloured trap.
An experiment was conducted to evaluate effect of coloured trap on total fruit fly catches from December 2017 to May 2018 at Insectary, Dept. of Entomology, guava orchard (Dept. of Horticulture) and College of Home Science. In this experiment 4 treatments were used for the attraction of fruit flies. These treatments are green trap, yellow trap, transparent trap and Rakshak trap.
It is revealed from the present experiment conducted at 3 places green trap (T1) captured maximum number of fruit flies/trap (321.25) during December 2017to May 2018 and lowest number in Rakshak trap (T4) (238.25). In Insectary (Dept. of Entomology) green trap (T1) attracted maximum number of fruit flies/trap in the month of April-2018 with the mean number of fruit flies 66.25/trap and lowest population attracted to Rakshak trap (T4) was 32.50 in the month of February-2018.
In the guava orchard (Dept. of Horticulture) same trend was observed where in green trap (T1) maximum number of fruit flies were caught in the month of April-2018 with the mean number of 75.50 fruit flies/trap and the minimum mean

number of fruit flies was 33.00 in the December-2017 in Rakshak trap (T4). However, total fruit fly catch was 342.00 followed by 284.00 in green and yellow trap, respectively.

As in the above two places the same observation was noted in College of Home Science also. Highest number of fruit flies were captured in the month of April-2018 with mean number of 78.00 fruit flies/trap in green trap (T1) while Rakshak trap (T4) attracted very low population of fruit flies with mean number of 34.00 fruit flies/trap in the month of January-2018. Total fruit fly catch was 326.00 in green trap followed by 300.50 in yellow trap.

The present investigation endorse the study conducted by Sivinski (1990) [16], who worked on coloured spherical traps of different sizes against Caribbean fruit fly, *Anastrepha suspensa*. He reported that, spherical bolls of orange, green white white captured maximum females while males did not have any significant preference for the size and colour. However most of the males were caught in orange Bolls with protein hydrolysate bait with 20cm diameter which was superior to all other trap followed by yellow bolls.

Robacker (1992) [14] evaluated 24 trap types of 4 colour, 3 shape and 2 sizes in combination for visual attractiveness to irradiated laboratory reared Mexican fruit fly, *Anastrepha ludens*. He found that, horizontal, rectangular traps were less attracted than spheres and vertical rectangles. Relative attractiveness of yellow compared to green was less affected by season. Overall vertical rectangles were more attractive than spheres in spring but in autumn it was vice-versa. Traps in trees with matured grape fruit generally captured more fruit flies than trees with immature fruits. Overall large sized traps of yellow, green and red spheres and vertical rectangles captured eight times as compared to other traps.

Rajita and Viraktamath (2005) [12] evaluated response of fruit flies to the traps with different size, shape and colour in mango orchard. Medium and big traps attracted significantly more flies than small traps. Fruit flies showed greater response to spheres than to the bottles and cylinders while responses to different colours varied among different species. *Bactrocera dorsalis* was more attracted to green medium and big spheres and all size orange spheres (0.45to0.49fruit flies/trap/day).

Similar work was done by (Ravikumar and Viraktamath, 2006). They studied on attraction of different species of fruit flies to different coloured traps in guava and mango orchards during 2005-06 near Dharwad. Yellow and transparent traps attracted significantly high number of *B. correcta* in guava (70.45 fruit flies/trap/week) and mango (5.13 fruit flies/trap/week), respectively. Green and orange coloured traps in guava (3.79 and 3.75 fruit flies/trap/week, respectively) black coloured traps in mango (3.88 fruit flies/trap/week) were attractive to *B. dorsalis. B. zonata* was attracted to red coloured traps (3.75 fruit flies/trap/week) in mango ecosystem. When total fruit flies irrespective of species were considered, yellow colour traps were attractive in guava (71.91 fruit flies/trap/week) while black colour traps in mango (8.68 fruit flies/ trap/week).

According to Murmaini and Saputra, (2016) [15] only one type of fruit fly was trapped namely *Bactrocera dorsalis* Hendel. There were more fruit flies trapped in yellow colour baited traps with methyl eugenol, the average number of the fruit fly trapped was 11.74, followed by the Green colour trap by the number of average 8.67, then the trap without colour (control) (7.46) and the Red traps (7.28).

Toorani and Abbasipour (2017) worked on effect of geographical directions, height and colour of yellow traps in capturing Mediterranean fruit fly, *Ceratitis capitata*. He found that, during August to November 2016 fluorescent yellow traps at a height of 1.5 and 2cm in south direction during the month of October has the highest number of capture of fruit flies.

These results strongly support the effectiveness of green and yellow coloured vertical traps as compare to transparent and Rakshak trap.

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