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Influence of colour and design on the trapping efficiency of fruit flies in snake gourd

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Abstract
Vegetable acts an important role in human health for providing the essential nutrients, vitamins, minerals, phytochemicals and dietary fibre to reduce the health illness and disease. Cucurbits are the most important summer vegetables, which includes about 130 genera and 800 species around the world. The seed and fruit parts contains secondary metabolite compound like cucurbitacin, which act as laxative, cures nausea, vomiting and destroy parasitic worms in the human body. Snake gourd is an annual climber belongs to the family cucurbitaceae; is originated from India and regionally called it as serpent gourd, viper gourd, club gourd, snake squash, chichinda, padwal and pudalangai. Fruit flies are the most serious pest in snake gourd ecosystem and infestation start from fruit initiation stage to end of the crop. To reduce the fruit fly infestation and ecofriendly management of fruit flies, coloured traps were used in the field to maximize the trap catches. For the reason, the field experiment was carried out in farmer's field at Kumaravadi village, Tiruchirappalli during second fortnight of February to second fortnight of March 2020. From our findings, the melon fruit fly, *Zeugodacus cucurbitae* trap catches was maximum in yellow coloured traps (29.56 fruit flies/trap/week) followed by green (24.25 fruit flies/trap/week), white (19.38 fruit flies/trap/week), transparent (15.31 fruit flies/trap/week) and red (11.50 fruit flies/trap/week). The oriental fruit fly, *Bactrocera dorsalis* population was trapped more in yellow trap (19.25 fruit flies/ trap/week) followed by transparent, green, red and white traps with the mean fruit fly catches of 14.81, 10.81, 10.38 and 8.94 fruit flies/trap/week, respectively. On comparing the overall trap catches, yellow coloured trap was the superior and trapped 195.25 fruit flies/trap followed by green (140.25 fruit flies/trap), transparent (120.50 fruit flies/trap), white (113.5 fruit flies/trap) and red colour traps (87.50 fruit flies/trap). The fruit fly catches in coloured traps were positively correlated with maximum and minimum temperature and negative correlation with rainfall and relative humidity in both cue lure and methyl eugenol attractant placed traps.

Keywords: snake gourd, trap colour, *Zeugodacus cucurbitae*, *Bactrocera dorsalis*

Introduction
Snake gourd (*Trichosanthes anguina*, 2n = 22) belongs to the family cucurbitaceae, is an annual climber originated from India (Deepa devi, 2017) [6]. The 100 g of fruit contains water (94.6 g), protein (0.5 g), fat (0.3 g), minerals (0.5 g), fibre (0.8 g), carbohydrates (3.3 g), energy (18 calories), calcium (50 mg), magnesium (53 mg), potassium (34 mg), phosphorus (20 mg), iron (1.1 mg), sodium (25.4 mg), copper (0.11 mg), sulphur (35 mg), chlorine (21 mg), vitamin A (160 IU), thiamine (0.04 mg), riboflavin (0.06 mg), vitamin C (5 mg), nicotinic acid (0.3 mg) and oxalic acid (34 mg) (Rahman *et al*., 2008) [19]. In Tamil Nadu, snake gourd is cultivated in a total area of 1439 ha with the production and productivity of 35,411 tonnes and 17.66 t/ha, respectively (Anonymous, 2016) [1]. Fruit flies, snake gourd semilooper, pumpkin beetle, pumpkin caterpillar, clear winged moth, bottle gourd plume moth, stem gall fly and leaf miners are the devastating pest attacking cucurbit crops in our country. The infestation starts at the seedling stage of the crop to fruit maturation stage and damages all the plant parts (Lal *et al*, 2014) [16]. Currently 932 fruit fly species were recorded out of these 10% are the pests of vegetable and fruit ecosystem and acts as frugivorous and florivorous in plants (Vargas *et al*., 2015) [28]. Among them melon fruit fly, *Zeugodacus cucurbitae* (Coquillett) and oriental fruit fly, *Bactrocera dorsalis* (Hendel) are the most serious pest (De Meyer *et al*., 2015; Ekesi *et al*., 2016) [7,10]. The melon fruit fly is the most significant nuisance in cucurbitaceous vegetable and infests nearly 81 host plants. The yield loss occurs upto 30 to 70 per cent depends on nature of host and the weather factors (Dhillon *et al*., 2005) [8].

The control of fruit flies through chemical sprays leads to imbalance in environmental condition, increase the production cost of the farmer and toxic to human health (Pedigo and Rice, 2014) [18]. Field sterilization and trap placement is the alternative and ecofriendly method to reduce the pest population (Babu and Viraktamath, 2003) [2]. Apart from olfactory stimulus, visual stimulus like shape and colour of the trap also an important criteria in trap catches of fruit flies (Katsoyannos, 1989) [13]. Hence, the identified design of bottle trap half cut model fruit flies trap were taken and coated with various colours to assess the attractancy of flies through both visual and olfactory stimulus and increase of trap catches in snake gourd ecosystem.

Materials and Methods

Assessment of trap design and colour preference of fruit flies is the main criteria to increasing the fruit fly catches for the effective management strategy. For the reason, the identified bottle trap half cut model design was coated with various colours and erected in the field to assess the efficiency of modified design and colour impacts on the trap catches of fruit flies in snake gourd ecosystem. The experiment was conducted in farmer's field at Kumaravadi village, Vaiyampatti block, Tiruchirappalli district ($10^0$32'N latitude and $78^0$18'E longitude) during second fortnight of February to second fortnight of March 2020. The experiment was carried out in Randomized Block Design with four replications.

Selection of trap design

Totally seven types of traps *viz*., horizontal cylindrical trap, bottle trap two opening model, cylindrical bucket trap, vertical cylindrical trap, bulb trap, coconut shell trap and bottle trap half cut model trap were designed by using locally available low cost inputs. The efficiency of these designs/models on the trapping of fruit flies is compared with the standard NIPHM design of pet bottle trap in earlier experiment to assess its increased or decreased performance on trapping of fruit flies over check. Among them, bottle trap half cut model is identified as one of the good design in trapping maximum number of fruit flies. Hence in this experiment, the ideal trapping design of bottle trap half cut model was taken and coloured with green, red, yellow and white colour to assess the influence of colour in addition to design on the trapping efficiency of fruit flies (Plate 1).

Preparation of bottle trap half cut model with various colours

The disposed transparent plastic mineral water bottle having 1 L capacity was taken to modify it as bottle trap half cut model. The bottle was cut into 2/3rd portion at a height of 10 cm from the top and kept it in inverted position in inner side of the bottom portion of the bottle. The edges of the top and bottom portion were linked together by using a tie wire and opened top portion was covered, glued and sealed with transparent sheets. Three square shaped (1.5 cm^2) entry slits were provided at a height of 9 cm from the bottom.

The prepared bottle trap half cut model trap was painted with the colour paints of green, red, yellow and white using paint brush. Only the outer portion the trap is coloured and inner portion remained as such. After painting the coloured traps were shade dried overnight.

Lure preparation and placement of lure in traps

The fruit fly attractant materials were prepared by using commercially available cue lure and methyl eugenol lure. The 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 use.

Placement of traps in field

The coloured bottle trap half cut model trap was baited with cue lure and methyl eugenol wicks placed inside the traps near the entry hole. The traps were then hung at a height of 1.5 m in the snake gourd field. The trapped fruit flies in different coloured traps were observed and recorded at weekly intervals and collected fruit flies were taxonomically identified. The lure placed inside the traps were recharged and the trap was replaced in weekly interval to avoid the positional effects.

Statistical analysis

The data on number of fruit flies trapped in colour traps were statistically analysed by one factor analysis RBD with AGRES software after square root transformation. The mean values were compared by Least Significant Difference. The meteorological parameters *viz.*, maximum temperature, minimum temperature, relative humidity and rainfall during the entire experimental period were collected from NASA ARC POWER website. The weather parameters were summarized into weekly averages and correlation was made with trapped fruit flies in varied designed traps. The correlation analysis was worked out using MS Excel software.

Results and Discussion

Impact of colour on the trapping of *Z. cucurbitae*

The mean number of melon fruit fly, *Z. cucurbitae* captured in bottle trap half cut model painted with varied colour *viz*., green, yellow, red, white along with transparent check trap are presented in Table 1. Colour plays a vital role in attraction of insects in addition to the lure component. Considering the trapping efficiency, among the five coloured bottle trap half cut model traps, the yellow colour attracted more number of melon fruit flies with the mean catches of 29.56 fruit flies followed by green (24.25 fruit flies/trap/week), white (19.38 fruit flies/trap/week), transparent (15.31 fruit flies/trap/week) and red (11.50 fruit flies/trap/week). Trap catches on yellow and green colour traps were statistically on par with each other on 9th and 11th SMW by registering the trap catches of 27.00 , 24.25 and 32.75, 28.50 fruit flies/trap/week, respectively. It was followed by white and transparent colour with the trapped fruit fly catches range between 15.75 to 24.00 and 12.00 to 20.00 fruit flies/trap/week. The performance of green and white colour trap was on par in 8th SMW with catches of 21.00 and 16.75 fruit flies/trap/week. The fruit fly catches was minimum in red colour trap with the range between 8.00 to 17.75 fruit flies/trap/week. The melon fruit fly, *Z. cucurbitae* was highly attracted to yellow colour followed by green and transparent colour and least in red colour painted trap. The colour preference of *Z. cucurbitae* towards the yellow colour assessed in the current study is in tune with the earlier reports of Kumar and Laskar (2019) [15] in cue lure traps erected in Coochbehar, West Bengal.

Impact of colour on the trapping of *B. dorsalis*

Certain colours are strongly attracted to some insects, it is due to the visual stimuli and behaviour of the insect where they oviposit. For the reason, along with lure component colours

also used as one of the main component in trapping and widely used in management strategy. Oriental fruit fly, *B. dorsalis* fruit flies were highly attracted and captured in yellow trap (19.25 fruit flies/ trap/week) followed by transparent, green, red and white traps with the mean fruit fly catches of 14.81, 10.81, 10.38 and 8.94 fruit flies/trap/week, respectively (Table 2). The performance of yellow colour trap was superior in the entire study period in the range of 18.00 to 22.00 fruit flies/trap/week. Yellow colour trap was captured statistically equal number of fruit flies same as transparent trap on 9th and 10th SMW. Trap catches on green, red and white traps are same in 10th SMW with the fruit fly catches of 11.50, 11.75, 9.25 fruit flies/trap. The performance of white colour trap on the attraction of oriental fruit fly, *B. dorsalis* was low with a minimum population of 8.94 fruit flies/trap/week. In snake gourd ecosystem, the *B. dorsalis* fruit flies are highly attracted to yellow trap followed by transparent, green, white and red colour in attraction. The results on the preference of *B. dorsalis* towards the yellow trap in the present study is in confirmity with the findings of Sikandar *et al*., (2017) [23] and Bajaj and singh (2020) [3] conveyed fruit flies baited in methyl eugenol baited traps were prefers to yellow colour in citrus, guava, pear, peach and kinnow orchards. The experiment of Robacker *et al*., (1990) [22] in laboratory condition showed mexican fruit fly prefers on yellow and green colour in McPhail trap. Jalaluddin *et al*., (1998) [12] and Madhura (2001) [17] also reported the attraction of *Bactrocera* fruit flies to yellow colour traps. The result was controversy with the reports of Ravikumar and Viraktamath (2007) [21] that green colour trap was attracted more number of oriental fruit fly in guava orchard. In this current study transparent trap was second in position in trapping, it was in accordance with the reports of Rajitha and Viraktamath (2005) [20] that transparent colour trap influence more attraction of *B. dorsalis* fruit flies in guava orchard. Stark and Vargas (1992) [25] evidenced the response of fruit flies was high on white and yellow traps compared to green and red colour in guava orchard.

Total number of fruit flies in coloured traps

On comparing the overall bottle trap half cut model with varied colours, the number of fruit flies captured was observed and recorded as maximum in yellow coloured trap (195.25 fruit flies/trap) followed by green (140.25 fruit flies/trap), transparent (120.50 fruit flies/trap), white (113.5 fruit flies/trap) and red colour (87.50 fruit flies/trap), respectively (Table 3, Fig 1). Likewise, the maximum number of *Z. cucurbitae* and *B.dorsalis* was trapped in yellow trap with 118.25 and 77.00 fruit flies/trap/week. Yellow colour trap was found to be a high potential to attract maximum number of *Z. cucurbitae* and *B. dorsalis* fruit flies in snake gourd ecosystem. The preference of *Zeugodacus* and *Bactrocera* species of fruit flies towards the yellow colour trap observed in the present investigation is in accordance with the earlier reports. The earlier findings Vargas *et al*., (1991) [27] and Cornelius *et al*., (1999) [4] endorsed the fruit fly response based on its oviposition preference towards host. Yellow rectangles were more attractive than orange, green or red colour in *Anastrepha fraterculus* and *Ceratitis capitata* (Cytrynowicz *et al*., 1982) [5]. Toorani and Abbasipour (2017) [26] reported fluorescent yellow trap (583 nm) captured highest number of *ceratitis capitata* in citrus orchard.

Coloured traps efficiency in relation with weather parameters

The maximum and minimum temperature plays a vital role in increasing the trap catches and positively correlated with coloured traps *viz*., green, yellow, red, transparent and white colours baited with both cue lure and methyl eugenol attractant. The weather parameters of rainfall and relative humidity shows negative correlation with coloured trap catches. In cue lure traps, maximum temperature showed highly significant and positive correlation (r= +0.732 to +0.961), minimum temperature had positive correlation (r= +0.120 to +0.651), whereas rainfall (r= -0.012 to -0.661) and relative humidity (r= -0.272 to -0.923) showed negative correlation with melon fruit fly catches (Table 4). The result was similar with Dubale *et al*., (2018) [9] on ridge gourd crop at konkan region. Ghule *et al*., (2014) [11] fruit fly incidence had positive correlated with maximum temperature (r = +0.870), minimum temperature (r = + 0.730) but had negatively correlated with relative humidity (r = -0.738) in cucumber. The weather parameters of relative humidity and rainfall showed negative correlation by Sowmiya *et al*., (2020) [24] and other parameters *viz*., maximum temperature, minimum temperature, maximum wind speed and minimum wind speed had negative correlation with trap catches of fruit flies in both *Kharif* and *Rabi* season. The traps baited with methyl eugenol lure combined with various colours indicated that the trap catches of fruit flies in coloured traps were positive correlation with maximum (r= +0.544 to +0.950) and minimum temperature (r= +0.307 to +0.985) and negative correlation with rainfall (r= -0.030 to -0.785) and relative humidity (r= -0.595 to -0.963) (Table 5). The result was in tune with the earlier reports of Vignesh *et al*., (2020) [29] that temperature increases the incidence of *B. dorsalis*, whereas rainfall and relative humidity reduces the population in mango orchard. The correlation of trap catches of fruit fly shows positive correlation to temperature and negative relationship with relative humidity which was found to be in accordance with the report of Khan and Naveed (2017) [14] in mango ecosystem.

Table 1: Trapping of fruit flies in coloured traps baited with cue lure attractant

Trap colour	Number of flies trapped/trap/week				Mean
	8th SMW*	9th SMW	10th SMW	11th SMW	
Green	21.00 (4.62)^{b}	24.25 (4.96)^{ab}	23.50 (4.88)^{b}	28.25 (5.36)^{ab}	24.25 (4.97)^{b}
Yellow	28.50 (5.36)^{a}	27.00 (5.24)^{a}	30.00 (5.51)^{a}	32.75 (5.76)^{a}	29.56 (5.48)^{a}
Red	10.50 (3.31)^{d}	9.75 (3.19)^{d}	8.00 (2.90)^{d}	17.75 (4.22)^{d}	11.50 (3.46)^{e}
Transparent	13.75 (3.76)^{cd}	15.50 (3.99)^{c}	12.00 (3.53)^{c}	20.00 (4.52)^{cd}	15.31 (3.98)^{d}
White	16.75 (4.14)^{bc}	21.00 (4.63)^{b}	15.75 (4.02)^{c}	24.00 (4.95)^{c}	19.38 (4.46)^{c}

SE(d)	0.30	0.22	0.26	0.33	-
CD (p=0.05)	0.64	0.49	0.57	0.72	-
CV (%)	9.75	7.21	8.81	9.41	-

*Mean of four replications / *SMW – Standard Meteorological Week
Figures in parentheses are √x+0.5 transformed values
Values in the column followed by same letters are not different statistically, (p=0.05) by LSD

Table 2: Trapping of fruit flies in coloured traps baited with methyl eugenol attractant

Trap colour	Number of flies trapped/trap/week				Mean
	8th SMW*	9th SMW	10th SMW	11th SMW	
Green	10.00 (3.22)^{c}	10.75 (3.34)^{b}	11.50 (3.42)^{b}	11.00 (3.37)^{c}	10.81 (3.36)^{c}
Yellow	18.25 (4.32)^{a}	18.75 (4.37)^{a}	18.00 (4.29)^{a}	22.00 (4.74)^{a}	19.25 (4.44)^{a}
Red	8.50 (2.98)^{c}	6.50 (2.62)^{c}	11.75 (3.48)^{b}	14.75 (3.90)^{b}	10.38 (3.77)^{d}
Transparent	13.75 (3.76)^{b}	13.50 (3.72)^{ab}	14.25 (3.82)^{ab}	17.75 (4.26)^{b}	14.81 (3.91)^{b}
White	8.00 (2.90)^{c}	9.00 (3.07)^{bc}	9.25 (3.09)^{b}	9.50 (3.14)^{c}	8.94 (3.07)^{e}
SE(d)	0.24	0.32	0.34	0.18	-
CD (p=0.05)	0.53	0.70	0.75	0.39	-
CV (%)	9.92	13.27	13.35	5.78	-

*Mean of four replications / *SMW – Standard Meteorological Week
Figures in parentheses are √x+0.5 transformed values
Values in the column followed by same letters are not different statistically, (p=0.05) by LSD

Table 3: Collective population of fruit flies in coloured traps

Trap colour	Number of fruit flies /trap/week		Collective population
	Z. cucurbitae	*B. dorsalis*	
Green	97.00 (9.87)^{b}	43.25 (6.61)^{c}	140.25 (11.86)^{b}
Yellow	118.25 (10.90)^{a}	77.00 (8.80)^{a}	195.25 (14.00)^{a}
Red	46.00 (6.82)^{e}	41.50 (6.48)^{d}	87.50 (9.38)^{e}
Transparent	61.25 (7.86)^{d}	59.25 (7.73)^{b}	120.50 (11.00)^{c}
White	77.50 (8.83)^{c}	35.75 (6.02)^{e}	113.25 (10.67)^{d}
SE(d)	0.05	0.05	0.05
CD (p=0.05)	0.11	0.10	0.12
CV (%)	0.82	0.92	0.68

Figures in parentheses are √x+0.5 transformed values
Values in the column followed by same letters are not different statistically, (p=0.05) by LSD

Table 4: Correlation of weather parameters with coloured traps baited with cue lure attractant

Weather parameters	Green	Yellow	Red	Transparent	White
Maximum temperature	0.961	0.879	0.820	0.784	0.732
Minimum temperature	0.651	0.506	0.120	0.152	0.226
Rainfall	-0.661	-0.012	-0.161	-0.405	-0.612
Relative humidity	-0.702	-0.923	-0.514	-0.371	-0.272

Table 5: Correlation of weather parameters with coloured traps baited with methyl eugenol attractant

Weather parameters	Green	Yellow	Red	Transparent	White
Maximum temperature	0.903	0.544	0.861	0.950	0.826
Minimum temperature	0.307	0.985	0.590	0.435	0.944
Rainfall	-0.347	-0.588	-0.030	-0.213	-0.785
Relative humidity	-0.595	-0.728	-0.963	-0.798	-0.761

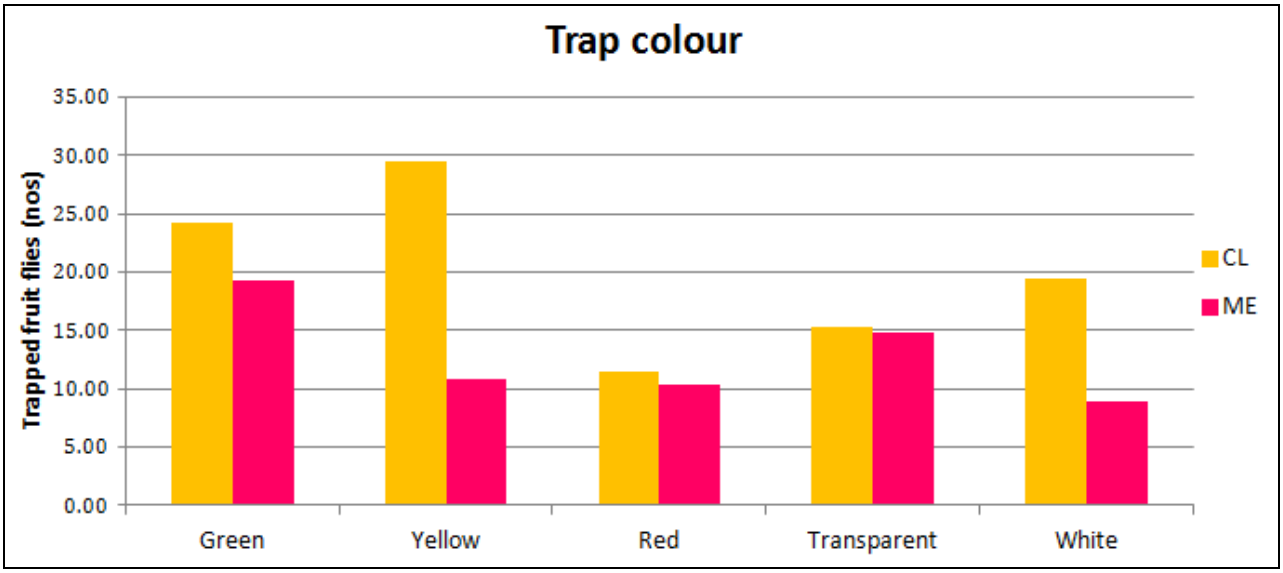

Fig 1: Total number of fruit fly catches in coloured traps baited with cue lure and methyl eugenol attractant

Red cylindrical trap White cylindrical trap Yellow cylindrical trap

Green cylindrical trap Transparent cylindrical trap

Plate 1: Trap colour

Conclusion

Fruit flies cause a serious threat in vegetables and fruit ecosystem and the damage starts from fruit initiation stage to severe damage occurs till maturity of the crop. Almost all the cucurbitaceous vegetables, the time lapse between one harvests to another is very short, mostly the fruit picking was

done in alternate days. For fruit fly management, application of insecticide is considered as a serious problem and risk to human health. For the reason, farmers are required the alternate method other than pesticide for effective management. Pheromone traps are the only way to reduce the pest attack in vegetables with pesticide free produce, low cost, ecofriendly and no human ill effects. The para pheromones are widely used as an attractant material for capturing of fruit flies. Trap design and colour also an important components along with lure use, hence to increase the fly catches, traps were coated with attractive colours for its effectiveness and better use of trap in field condition. Visual and olfactory cues are the important source for fruit fly catches. The preference of trap colour is mainly based on the fruit colour and oviposition behaviour of the insect. The performance of coloure traps in increasing fruit fly trapping efficiency revealed that *Z. cucurbitae* fruit flies highly attracted to yellow coloured trap followed by green, white, transparent and red colour. Likewise, *B. dorsalis* fruit flies were highly captured in yellow trap than transparent, green, red and white traps. On comparing the overall trap catches, the maximum number of fruit flies recorded and trapped in traps coloured with yellow (195.25 fruit flies/trap) followed by green (140.25 fruit flies/trap), transparent (120.50 fruit flies/trap), white (113.5 fruit flies/trap) and red colour (87.50 fruit flies/trap) in snake gourd ecosystem. The weather parameters *viz*., maximum temperature, minimum temperature were positive correlation, whereas relative humidity and rainfall had negative correlation with fruit fly catches in both cue lure and methyl eugenol lure attractants.

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