Enhancing the Trapping of Melon Fruit Fly, *Zeugodacus cucurbitae* Coquilette through Synergizing the Odour and Visual Cues

ABSTRACT

The melon fruit fly (*Zeugodacus cucurbitae* Coquillett) poses a significant threat to cucurbit crops with substantial yield losses and challenging sustainable vegetable production. This study systematically investigated efficient color-based visual cues for attracting melon flies and explored the synergistic effects of these visual cues in conjunction with odour cues. This study was conducted in Agricultural College and Research Institute, TNAU, Madurai during 2024. Our studies included investigations on preferred colour by melon fly through olfactometer & insect cage bioassays in no choice & multiple choice conditions. The additive effect of the preferred colour when combined with the fruit fly attractive odour cue was investigated under field conditions. For both male and female melon fruit flies, yellow colour (RBG coordinates - 255:255:0) consistently emerged as the most efficient visual cue followed by white (255:255:255) and red (255:0:0). Field trials also confirmed the attractiveness of yellow colour as it outperformed other colours. The visual cue, yellow colour and odour cue (synthetic blend of four fruit fly EAG active synthetic compounds in a known ratio) were combined and found to be synergistic as this fusing captured significantly more flies than the either cues alone. These results highlighted the yellow colour as the most attractive visual cue for melon flies and combining effective of visual cues with established odour attractant to greatly enhance the trapping efficiency. This integrated approach offers a promising strategy for the management of melon fly and reduction of reliance on chemical pesticides contributing to more sustainable pest control in cucurbit production. The findings have significant implications for pest management strategies, especially in regions facing melon fly infestations that threaten crop yields and export potential.

Keywords: *Melon fruit fly – Zeugodacus cucurbitae - Visual cues – Colour - Yellow - Odour cues - Synergistic effect*

1. INTRODUCTION

Among the vegetable crops, cucurbits (cucumbers, gourds, melons, squashes and pumpkins) are the most important as they can be grown year round except in winter. Tephritid fruit flies are the major insect pests of cucurbits with 250 economically important species (David and Ramani, 2011) and can cause significant yield losses ranging from 2.5 to 100% depending on the crop and season (Ruiz *et al*., 2014). Fruit fly maggots feed on flowers, tender stems and fruit pulp making the produce unfit for consumption (Dhillon *et al.,* 2005). Fruit flies attack over 70 species of cucurbits and among them, the most preferred are bitter gourd, snake gourd and musk melon (Doharey, 1983). In India, fruit fly damage can reach up to 50% in cucurbits (Atwal and Dhaliwal, 2005). Singh *et al.,* 2000 reported 28.56% yield loss in bitter gourd by melon fly, *Zeugodacus cucurbitae* Coquillette and damage in snake gourd can reach up to 95% (Hollingsworth *et al.,* 1997). Fruit fly infestations also pose a threat to the export industry due to the strict quarantine regulations (Vasudha *et al.,* 2019). Chemical control

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methods i.e., insecticides are less effective due to the hidden life stages of the insect and moreover, they disturb the insect-natural enemy balance, cause environmental contamination and lead to issues like insecticide resistance (Dhillon *et al.,* 2005; Gogi *et al.,* 2010). Currently, male-targeted parapheromones like cue lure are commonly used to control fruit flies, but these only attract male flies (Royer, 2015) resulting in a partial control. As protein baits attract both females and males, research on exploration of protein baits is the need of the hour in fruit fly research. In this context, the present study was undertaken to evaluate the odour cue *i.e.,* fruit fly attractive synthetic blend (prepared by blending four EAD active odorous compounds identified from a protein bait in a known ratio) formulated in our previous research studies in combination with the attractive colour (visual cue) to enhance the trapping of both male and female melon flies in field conditions.

2. MATERIALS AND METHODS

Melon flies needed for laboratory studies were obtained by mass culturing of fruit flies. For this, fruit fly infested cucurbit fruits were collected from the farmer's fields, kept in insect rearing cages with a layer of sand on the bottom of the cage for pupation of fruit fly maggots. Emerged fruitflies were fed with adult fruit fly diet (honey, protein powder and water mixed in 1:1:3 ratio). Laboratory studies were conducted at the Department of Agricultural Entomology, Agricultural College and Research Institute, Madurai.

2.1 Preliminary evaluation of colours for their attraction to cucurbit fruit flies

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The colours screened for their attractiveness to fruit flies were yellow (RBG coordinates - 255:255:0), white (255:255:255), green (0:125:0), orange (255:180:0), blue (0:0:255), red (255:0:0) and black (0:0:0). The colours were reproduced thorough RGB colour model in which the primary colors of light i.e., red, green and blue are added together in various ways to reproduce the necessary shade. Preliminary screening of colours was done through olfactometer bioassays in no choice conditions. In this experiment, at the entrance of one odour arm, a known colour was fixed. The second odour arm was kept empty and considered as the control. Three replications were done and with each replication, position of test colour was changed to prevent the positional bias. After 2 hours of food deprivation, 20 numbers of melon flies were released at the center of the olfactometer and number of flies around the zone of test colour, control and neutral zones (flies present in the center of olfactometer) was counted for every 10 minutes up to 60 minutes. The data obtained at 60 minutes was considered as the final. The experiment was conducted with male and female fruit flies separately. Per cent attraction and attraction index were worked out.

The above results were re-examined through insect cage studies in multiple choice conditions. Colour sheets along with the transparent sheet (control) were cut in the dimension of 16×5cm, smeared glue uniformly on it and pasted them on three walls and top of the insect cage (45×45×45cm). Empty space inside the cage was considered as neutral zone. 100 numbers of 2 hours pre-starved melon flies were released inside the cage and number of attracted flies to each colour, control and neutral zone were counted after 24 hours. This experiment was conducted with male and female flies separately and replicated thrice. With each replication, position of the colours was changed.

Based on the results of olfactometer and insect cage bioassays, four colours were selected for further confirmation. All the four selected colours were pasted at the

entrance of odour arms of four arm olfactometer. The experiment was replicated thrice with male and female fruit flies separately and with each replication, position of test colour was changed. 20 numbers of prestarved melon flies were released at the center of olfactometer and number of flies around the zone of test colour and neutral zones was noted.

2.2 Field evaluation of selected colours for their attraction to cucurbit fruit flies

Field experiments were conducted in snake gourd fields in Nagamangalam village (10.279ºN, 78.384ºE) and Surappatti village (10.285ºN, 78.374ºE) of Melur block, Madurai district. Sticky gum coated photosheets of the selected colours (30×20 cm) were suspended in snake gourd fields at a height of 1.5 meters. Experiment was conducted in a randomized block design with three replications. A separation distance of 50 meters was maintained between the treatments and replications. Traps were hung during early fruiting stage of the crop. Observations were taken on number of trapped female and male fruit flies at ten days interval for two months in all the treatments and replications. From the above experiments, the most attractive colour (MAC) to melon fruit flies was selected.

2.3 Field evaluation of the attraction of combination of most attractive colour (MAC) and odour cue to cucurbit fruit flies

In the previous research studies, a most preferred blend (MPB) for melon fruit flies was formulated by mixing four fruit fly EAG active synthetic compounds identified from the protein bait in a known ratio. Attractiveness of the combination of MAC+MPB was evaluated in comparison with MAC alone and MPB alone. Plywood blocks were used as carriers of MPB for their evaluation in field conditions. Plywood blocks (4×2.5×2cm) with a 2 mm central hole were saturated with the mixture of MPB (3.5 ml), hexane (1.5 ml) and malathion (0.05%) as killing agent for 24 hours. Hexane was added as it is a good spreading agent and to fully saturate the plywood block.

Plastic containers of yellow colour (most preferred colour) of 1 litre capacity (10 cm diameter and 20 cm height) were modified as fruit fly traps. A 5 mm diameter hole was made in the middle of the container and four holes of 2 cm diameter were made in all the four sides of the container with a heated blade to allow the entry of fruit flies inside. MPB impregnated plywood blocks were hung in the centre of the yellow colour fruit fly traps through a central hole and were tied at a height of 1.5 meters. This experiment was conducted in a randomized block design with three replications. An isolation distance of 50 meters was maintained between the treatments and replications. In this experiment, traps were placed at early fruiting stage of the crop. Observations were recorded on number of female and male fruit flies trapped at ten days interval for two months in all the treatments and replications. Sticky gum coated transparent sheet served as control.

Comment [h4]: Also mention that whether the flies trapped were removed from the trap or kept as such after each observation

2.4 Statistical analysis

The data recorded in the present study were subjected to appropriate transformations before subjecting to statistical analysis. Means were separated by Tukey's HSD test. Statistical analyses were performed using SPSS Windows (version 22.0) (IBM Corp. Released 2013) (Gomez and Gomez, 1984).

3. Results and Discussion

3.1 Preliminary Bioassays

3.1.1 Olfactometer studies in no choice conditions

Among the various colours evaluated, yellow (R:255, G:255, B:0.00) attracted more number of female fruit flies (FF) (15.33) followed by white (R:255, G:255, B:255)

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(12.33) and red (R:255, G:0.00, B:0.00) (12.00) (Table 1). Orange (R:255, G:180, B:0.00), green (R:0.00, G:125, B:0.00) and black (R:0.00, G:0.00, B:0.00) were moderate in their attraction with 10.34, 8.34 and 8.33 fruit flies in their colour zone respectively while blue (R:0.00, G:0.00, B:255) was the least attractive. All the test colours attracted maximum number of fruit flies at 10 minutes itself. Among the preferred three colours, retention of fruit flies in the colour zone itself was more in yellow followed by white and red. Yellow colour recorded more attraction index (60.00) followed by white (38.30) and red (35.00).

Male fruit flies preferred yellow colour and this was evident with 16.00 fruit flies in it's colour zone followed by white (13.33 FF) (Table 1). Red was on par with white in it's attraction to fruit fly with 12.33 fruit flies and was also on par with green (11.33 FF). Among the colours, moderately attractive were orange and blue with 10.00 and 9.33 fruit flies, respectively. The least attractive was black colour. Attraction index was more (66.70) in yellow followed by white (48.35) and red (40.00).

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Table 1. Preliminary bioassay on the attraction of various colours to cucurbit fruit flies (Olfactometer Bioassay - No choice)

S. No.	Colour	Mean no. of fruit flies attracted*		Percent fruit flies attracted**		Attraction index	
		Female	Male	Female	Male	Female	Male
1.	Yellow (R:255, G:255, B:0.00)	15.33 (3.91)^{a}	16.00 (4.00)^{a}	76.65 (61.17)^{a}	80.00 (63.54)^{a}	60.00	66.70
2.	White (R:255, G:255, B:255)	12.33 (3.51)^{b}	13.33 (3.65)^{b}	61.65 (51.75)^{b}	66.65 (54.75)^{b}	38.30	48.35
3.	Green (R:0.00, G:125, B:0.00)	8.34 (2.88)^{d}	11.33 (3.36)^{c}	41.70 (40.23)^{d}	56.65 (48.83)^{c}	10.05	31.65
4.	Orange (R:255, G:180, B:0.00)	10.34 (3.21)^{c}	10.00 (3.16)^{d}	51.70 (45.99)^{c}	50.00 (45.00)^{d}	23.40	21.70
5.	Red (R:255, G:0.00, B:0.00)	12.00 (3.46)^{b}	12.33 (3.51)^{bc}	60.00 (50.77)^{b}	61.65 (51.75)^{bc}	35.00	40.00
6.	Blue (R:0.00, G:0.00, B:255)	7.34 (2.70)^{e}	9.33 (3.05)^{d}	36.70 (37.28)^{d}	46.65 (43.08)^{d}	3.40	18.35
7.	Black (R:0.00, G:0.00, B:0.00)	8.33 (2.88)^{d}	8.00 (2.82)^{e}	41.65 (40.18)^{d}	40.00 (39.22)^{e}	8.30	5.00
S.E(d)		0.36	0.27	1.48	1.62		
CV		3.13	2.75	3.68	3.91		
CD (0.05)		0.17	0.16	3.02	3.38		

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Figures in parentheses are square root transformed values (*) and arc sin transformed values (**)
Means followed by the same letter in a column are not significantly different by Tukey's HSD test. (*P*=0.05)

With this bioassay, it was found that, for both female and male cucurbit fruit flies, yellow was the preferred colour and next to this were white and red. To reconfirm this result, the same experiment was done in insect cages under multiple choice conditions and the results are given below.

3.1.2 Insect cage studies in multiple choice conditions

When female fruit flies were given a choice among the colours, more fruit fly attraction (27.66%) was found with yellow followed by red (19.33%) and white (18.66%) which were statistically on par. With 12.66 per cent fruit fly attraction, orange was in third place. Attraction Index was high (27.00) (Table 2) in yellow and was succeeded by white (17.67) and red (14.67).

In multiple choice conditions, more male fruit flies were attracted to yellow colour (27.00% attraction) (Table 2). Even though white was the next (19.00% attraction) to yellow, much difference was noted in their levels of attraction. Red and green were the next attractive colours with 16.00% and 14.66% of attractions respectively. The least attractive was blue (6.67%) and black (4.00%). Attraction Index ranged from 25.67 in yellow to 2.67 in black.

Our study found that blue and black colours were the least effective in attracting melon fruit flies. This may be due to the low contrast and visibility of these colours in natural environments. These results suggest that the visual response of melon flies to colour is closely tied to the environmental contrast provided by different hues, with yellow standing out as the most effective due to its high contrast.

Table 2. Preliminary bioassay on the attraction of various colours to cucurbit fruit flies - (Insect cage study- Multiple choice)

S. No.	Colour	Female		Male	
		% fruit flies attracted*	Attraction index	% fruit flies attracted*	Attraction index
1.	Yellow (R:255, G:255, B:0.00)	27.66 (31.72)[a]	27.00	27.00 (31.30)[a]	25.67
2.	White (R:255, G:255, B:255)	18.66 (25.59)[b]	18.00	19.00 (26.07)[b]	17.67
3.	Green (R:0.00, G:125, B:0.00)	11.33 (19.66)[d]	10.67	14.66 (22.51)[c]	13.33
4.	Orange (R:255, G:180, B:0.00)	12.66 (20.84)[c]	12.00	11.00 (19.35)[d]	9.67
5.	Red (R:255, G:0.00, B:0.00)	19.33 (25.08)[b]	18.67	16.00 (23.57)[c]	14.67
6.	Blue (R:0.00, G:0.00,	4.00 (11.53)[f]	3.34	6.67 (14.92)[e]	5.34

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	B:255)				
7.	Black (R:0.00, G:0.00, B:0.00)	5.33 (13.35) [e]	5.00	4.00 (11.53) [f]	2.67
8.	Control	0.66 (3.92) [g]	-	1.33 (6.53) [g]	0.00
9.	Neutral zone	0.00 (2.87) [h]	0.00	0.00 (2.87) [h]	0.00
	S.E(d)	0.36		0.41	
	CV	3.08		4.59	
	CD (0.05)	1.02		1.54	

*Figures in parentheses are arc sin transformed values
Means followed by the same letter in a column are not significantly different by Tukey's HSD test. *(P*=0.05)

The results of insect cage studies confirmed the olfactometer bioassay results i.e., female and male cucurbit fruit flies preferred yellow colour mostly and was succeeded by white and red. In the above two experiments, orange and green stood in fourth place regarding the female and male fruit fly attraction respectively. Hence, in the confirmatory bioassay, orange and green were also included.

3.2 Confirmatory Bioassay

3.2.1 Olfactometer bioassay in multiple choice conditions

Among the selected attractive colours, preference of female fruit flies to yellow (R:255, G:255, B:0.00) colour was apparent with comparatively high per cent attraction to fruit flies (44.44%) (Table 3). The next were white (R:255, G:255, B:255) and red (R:255, G:0.00, B:0.00) with 23.34 and 24.46 per cent of attractions respectively and were on par with each other. Orange (R:255, G:180, B:0.00) was the least attractive with 7.76 attraction index.

Yellow (R:255, G:255, B:0.00) was the most attractive to male fruit flies as it attracted 14.00 fruit flies among the thirty released with 46.67% attraction (Table 3). White (R:255, G:255, B:255) and red (R:255, G:0.00, B:0.00) colours exhibited only half of the attraction of yellow (R:255, G:255, B:0.00) *i.e.,* 23.33% and 22.24% respectively. AI was highest in yellow (R:255, G:255, B:0.00) (46.67) and low in green (R:0.00, G:125, B:0.00) (7.76).

In the confirmatory bioassay, attraction of both female and male fruit flies to yellow followed by white and red colours was established. Our results are supported by the findings of Cytrynowicz *et al.* (1982). They reported significant attraction of sticky coated yellow rectangles to South American fruit flies, *Anastrepha fraterculus* and Mediterranean fruit flies, *Ceratitis capitata*. Abu-Ragheef *et al.* (2020) tested different combinations of colours (yellow, white, green and red) and traps (Jackson trap, local trap and McPhail trap) and concluded that colour of the traps greatly influenced the numbers of Mediterranean fruit flies captured in different traps. They found that yellow traps attracted more flies followed by white and green, while red traps captured less number of insects. This suggests that yellow acts as a supernormal stimulus, mimicking natural cues like ripe fruits or foliage, which fruit flies often use for foraging or oviposition. Vargas et al. (1991) observed the yellow colour as the most attractive to

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oriental fruit fly, D. dorsalis followed by white in guava orchard.

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Table 3. Confirmatory bioassay on the attraction of selected colours to cucurbit fruit flies (Olfactometer experiment - Multiple choice)

S. No.	Particulars	Attractive colours	Mean no. of melon flies attracted*	% fruit flies attracted**	Attraction index
1.	Female fruit flies	Yellow (R:255, G:255, B:0.00)	13.33 (3.65) [a]	44.44 (41.80)[a]	44.44
2.		White (R:255, G:255, B:255)	7.00 (2.64) [b]	23.34 (28.88) [b]	23.34
3.		Red (R:255, G:0.00, B:0.00)	7.34 (2.70) [b]	24.46 (29.63) [b]	24.46
4.		Orange (R:255, G:180, B:0.00)	2.33 (1.52) [c]	7.76 (16.18) [c]	7.76
5.		Neutral zone	0.00 (0.71) [d]	0.00 (2.87) [d]	0.00
		S.E(d)	0.24	0.81	
		CV	3.02	3.51	
		CD (0.05)	0.15	1.92	
1.	Male fruit flies	Yellow (R:255, G:255, B:0.00)	14.00 (3.74) [a]	46.67 (43.08) [a]	46.67
2.		White (R:255, G:255, B:255)	7.00 (2.64) [b]	23.33 (28.88) [b]	23.33
3.		Red (R:255, G:0.00, B:0.00)	6.67 (2.58) [b]	22.24 (28.15) [b]	22.24
4.		Green (R:0.00, G:125, B:0.00)	2.33 (1.52) [c]	7.76 (16.21) [c]	7.76
5		Neutral zone	0.00 (0.71) [d]	0.00 (2.87) [d]	0.00
		S.E(d)	0.24	0.66	
		CV	3.00	2.81	
		CD (0.05)	0.14	1.54	

Figures in parentheses are square root transformed values (*) and arc sin transformed values (**)

Means followed by the same letter in a column are not significantly different by Tukey's HSD test. (*P*=0.05)

3.3 Field evaluation of selected colours for their attraction to cucurbit fruit flies

When the total number of fruit flies attracted at 10, 20, 30, 40, 50 and 60 days after placement of traps was probed through, more number (132.60) (Table 4) of fruit flies were observed to be stuck on the yellow colour in field conditions. Followed by this, white and red colours attracted more number of fruit flies *i.e.,* 104.60 and 103.30 respectively. Comparatively, orange and green attracted minimum number of fruit flies (77.10 and 76.70 respectively).

Field observations on fruit fly attraction to the selected colours revealed the superiority of yellow as it recorded more number of attracted fruit flies (126.50) (Table 4) during the two months experimental period. Followed this, white and red were equally attractive with 96.90 FF and 96.60 FF respectively. Comparatively, preference of male fruit flies was less to green (73.40 FF) and orange (71.50 FF).

Table 4. Field studies on the attraction of selected colours to cucurbit fruit flies

S. No.	Particulars	Colour	No. of fruit flies attracted at						Total no. of fruit flies attracted
			10 DAPT*	20 DAPT*	30 DAPT*	40 DAPT*	50 DAPT*	60 DAPT*	
1.	Female fruit flies	Yellow (R:255, G:255, B:0.00)	20.80 (4.56) [a]	19.30 (4.39) [a]	23.20 (4.81) [a]	24.00 (4.89) [a]	21.50 (4.63) [a]	23.80 (4.87) [a]	132.60 (11.51) [a]
2.		White (R:255, G:255, B:255)	18.20 (4.26) [b]	15.00 (3.87) [c]	18.50 (4.30) [b]	17.70 (4.20) [b]	16.50 (4.06) [b]	18.70 (4.31) [b]	104.60 (10.22) [b]
3.		Red (R:255, G:0.00, B:0.00)	17.50 (4.18) [b]	16.80 (4.10) [b]	19.00 (4.35) [b]	17.10 (4.13) [b]	14.90 (3.85) [c]	18.00 (4.24) [b]	103.30 (10.16) [b]
4.		Orange (R:255, G:180, B:0.00)	12.50 (3.53) [c]	13.70 (3.69) [d]	13.00 (3.60) [c]	13.10 (3.61) [c]	11.30 (3.35) [d]	13.60 (3.68) [c]	77.10 (8.77) [c]
5.		Green (R:0.00, G:125, B:0.00)	12.00 (3.46) [c]	13.80 (3.70) [cd]	13.10 (3.62) [c]	12.60 (3.54) [c]	12.00 (3.46) [d]	13.30 (3.64) [c]	76.70 (8.75) [c]
6.		Control	2.30 (1.51) [d]	1.80 (1.34) [e]	2.10 (1.44) [d]	1.60 (1.26) [d]	2.00 (1.41) [e]	1.60 (1.26) [d]	11.40 (3.37) [d]
		S.E(d)	0.41	0.39	0.44	0.42	0.38	0.43	0.40
		CV	2.75	2.72	2.76	2.76	2.76	2.77	2.77
		CD (0.05)	0.17	0.17	0.18	0.17	0.17	0.18	0.43
1.	Male fruit flies	Yellow (R:255, G:255, B:0.00)	22.10 (4.70) [a]	16.40 (4.04) [a]	21.60 (4.64) [a]	23.80 (4.87) [a]	22.00 (4.69) [a]	20.60 (4.53) [a]	126.50 (11.24) [a]
2.		White (R:255, G:255, B:255)	17.80 (4.21) [b]	12.90 (3.58) [b]	19.00 (4.35) [b]	15.30 (3.91) [b]	16.00 (4.00) [b]	16.00 (3.99) [b]	96.90 (9.84) [b]
3.		Red (R:255, G:0.00, B:0.00)	18.30 (4.28) [b]	12.00 (3.46) [b]	17.60 (4.19) [b]	15.00 (3.86) [b]	17.40 (4.17) [b]	16.30 (4.04) [b]	96.60 (9.82) [b]
		Orange (R:255, G:180, B:0.00)	10.10 (3.17) [c]	10.50 (3.24) [c]	12.00 (3.46) [c]	11.00 (3.31) [c]	13.90 (3.72) [c]	14.00 (3.74) [c]	71.50 (8.45) [c]
4.		Green (R:0.00, G:125, B:0.00)	10.20 (3.19) [c]	10.00 (3.16) [c]	12.70 (3.55) [c]	11.80 (3.43) [c]	14.44 (3.80) [c]	14.20 (3.76) [c]	73.40 (8.56) [c]
6.		Control	1.50 (1.22) [d]	2.10 (1.44) [d]	2.40 (1.54) [d]	1.80 (1.34) [d]	2.50 (1.58) [d]	1.00 (1.00) [d]	11.30 (3.36) [d]
		S.E(d)	0.40	0.31	0.42	0.39	0.42	0.40	0.75
		CV	2.86	2.70	2.74	2.79	2.71	2.75	2.35
		CD (0.05)	0.17	0.15	0.17	0.17	0.17	0.17	0.42

*Mean of three replications DAPT – Days after placement of traps Figures in parentheses are square root transformed values
Means followed by the same letter in a column are not significantly different by Tukey's HSD test. (P=0.05)

3.4 Alluring potential of the combination of most preferred blend and most attractive colour – Field study

The present study demonstrated the superiority of combining 4C-SB with the MAC in attracting melon fruit flies. During the experimental period (from 10 to 60 DAPT), combination of 4C-SB + MAC attracted more number of flies (62.30 to 70.60 FF) (Table 5) followed by 4C-SB alone (50.60 to 60.10 FF) and MAC alone (22.60 to 25.97 FF). No fruit flies were attracted to the control. During the two months observation period, 4C-SB + MAC attracted a total of 400.20 flies, outperforming 4C-SB alone (322.10 FF) and MAC alone (151.80 FF). This highlighted the synergistic effect of combining visual and chemical cues, making 4C-SB + MAC combination as the most potent attractant for melon fruit fly control.

Beyond colour, our study also emphasizes the importance of integrating visual and olfactory cues to maximize the fly capture. In our study, combining yellow traps with the most preferred fruit fly blend significantly increased the trap catch than the traps with only visual or odour cues. Our present findings aligns with the work of Pinero *et al* (2006), who observed high attraction of female melon flies to yellow spherical objects followed by white or orange with a odour of cucumber. In guava orchard, good response of male oriental fruit fly, *D.dorsalis* to yellow and white coloured plastic bucket traps baited with methyl eugenol was reported by Stark and Vargas (1992). Ravikumar and Viraktamath (2007) stated that yellow methyl eugenol traps significantly attracted high number of *B.correcta* in guava orchard when compared to green, orange, black and red coloured methyl eugenol traps in Dharwad.

Cornelius *et al.* (1999) provided further evidence, showing that yellow sticky traps paired with ammonia-based baits attracted more female oriental fruit flies than either cue used alone. Stark and Vargas (1992) found that painting methyl eugenol-baited traps white or yellow improved male captures. The study of Stenliski and Liburd (2002) supported the use of red sticky spheres baited with the synthetic volatile blend as a selective and effective tool for monitoring apple maggot populations. Alyokhin *et al.* (2000) highlighted the synergistic effect of combining yellow-coloured traps and hydrolyzed liquid protein odours in increasing the attractiveness to oriental fruit flies, suggesting that colour and odour cues can be optimized to enhance trap efficacy.

The broader implications of these results are significant for developing environmentally sustainable pest management practices. The use of yellow traps, particularly when combined with odour lures offers a promising alternative to chemical insecticides. This integrated pest management strategy can help reduce pesticide use, minimize environmental damage and provide a cost-effective method for controlling melon fly populations. However, it is important to note that the effectiveness of trap colours can vary depending on environmental factors such as crop type, light conditions and specific behavioral patterns of the target pest species. These variations underscore the need for context-specific studies to fine-tune trap designs based on the particular characteristics of each pest species and the conditions in which they are being used. Future research should explore other visual factors, such as trap shape, size and reflective properties which have also been shown to influence trap effectiveness.

Table 5. Field evaluation of the alluring potential of combination of most preferred blend (MPB) and most attractive colour (MAC)

S. No	Particulars	No. of fruit flies attracted at						Total no. of fruit flies attracted
		10 DAPT*	20 DAPT*	30 DAPT*	40 DAPT*	50 DAPT*	60 DAPT*	
1.	MPB + MAC	70.60 (8.40)[a]	68.10 (8.25)[a]	63.00 (7.93)[a]	70.50 (8.39)[a]	65.70 (8.10)[a]	62.30 (7.89)[a]	400.20 (20.00)[a]
2.	MPB alone	60.10 (7.75)[b]	52.40 (7.23)[b]	55.30 (7.43)[b]	50.60 (7.11)[b]	52.80 (7.26)[b]	50.90 (7.13)[b]	322.10 (17.94)[b]
3.	MAC alone	26.50 (5.14)	27.16 (5.21)[c]	25.97 (5.09)[c]	24.33 (4.93)[c]	22.60 (4.75)[c]	25.20 (5.02)[c]	151.80 (12.31)[c]
4.	Control	0.00 (0.71)	0.00 (0.71)[d]	0.00 (0.71)[d]	0.00 (0.71)[d]	0.00 (0.71)[d]	0.00 (0.71)[d]	0.00 (0.71)[d]
S.E(d)		1.21	1.87	1.49	1.59	1.00	1.40	6.46
CV		2.13	3.49	5.09	3.29	1.42	2.58	1.98
CD (0.05)		0.34	0.54	0.78	0.50	0.21	0.39	0.75

*Mean of three replications
DAPT – Days after placement of traps
Figures in parentheses are square root transformed values
Means followed by the same letter in a column are not significantly different by Tukey's HSD test. (P=0.05)

4. Conclusion

Male and females of the melon fruit fly have shown more attraction to yellow colour (255:255:0) and this colour was found to be the promising visual cue followed by white (255:255:255) and red (255:0:0). Luring capacity of yellow colour was also confirmed in field studies. When yellow colour was combined with the most attractive odour cue (synthetic blend of four fruit fly EAG active synthetic compounds in a known ratio), their combination lured significantly more flies than the either cues alone.

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