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Refinement of male annihilation technique (Mat) and bait attractant technique (Bat) for fruit flies

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Abstract
An experimental study was carried out at fruit orchards, SKUAST-J for two consecutive years (2019 and 2020) to refine Male Annihilation Technique (MAT) and Bait Attractant Technique (BAT) against fruit flies in mango, peach and guava. The results of the study revealed that highest trap catches of fruit flies were recorded in commercially available green valley fruit fly traps followed by another commercially available traps (PCI) and least trap catches were recorded in cue-lure+absorbent plastic in all the three fruit crops. The pooled data of two years (2019 and 2020) revealed that commercially available green valley fruit fly traps followed by commercially available PCI traps attracted the highest fruit fly population of 371.50, 378.50 and 319.83 fruit flies/trap catch and 325.00, 334.00 and 276.50 fruit flies/trap catch in mango, guava and peach, respectively. Cue-lure+absorbent plastic recorded mean trap catch of 89.67, 100.83 and 66.33 fruit flies per trap in mango, guava and banana, respectively.

Keywords: Fruit fly, guava, mango, peach, male annihilation technique, bait attractant technique

1. Introduction

Fruit production in Indian subcontinent is of paramount importance both socially and economically wherein, millions of farmers earn livelihoods from mango, guava and peach fruit crops. Mango and Guava keeps a prominent position in sub-tropical regions of Indian sub-continent and world while Peach thrives well and is grown extensively in sub-tropics as well in temperate region. The major constraint in the production of these crops is the ravages caused by insect pests which not only result in the low production but also drastically impair their quality by reducing marketable value and thereby posing a serious threat to fruits for the export potential. Among the insect pests, fruit flies of the family Tephritidae are the most destructive pests of mango around the world (White and Elson-Harris 1994) [14]. Fruit flies (Diptera: Tephritidae) are considered as one of the most damaging agricultural pests around the globe and cause huge threats to mango crops (Hasyim *et al*. 2008; Hendrichs *et al*. 2015) [4, 5]. Tephritid fruit flies cause 90 to 100% yield loss in fruits and vegetables depending upon several factors such as area, season, variety and their population (Sapkota *et al*. 2010). Fruit fly causes direct loss in the form of yield and indirect loss such as reduction in trade and export prospect (Sharma *et al*. 2015) [8]. In an Indian context, *B. dorsalis* is a major fruit fly pest, especially on mango, affecting local and export markets. The crop loss due to *B. dorsalis* varies with season and region. According to an estimate the loss to mango in an unsprayed situation varies from 2.5 to 59.0% depending on the variety (Verghese *et al*. 2002) [10]. About 80 species of insect pests are recorded on guava (*Psidium guajava* L.) (Tandon and Verghese 1987) [10] wherein, a total loss of 2,558 and 26,902 million rupees was estimated due to fruit flies with and without control measures in India. The reliance of farmers on chemical pesticides as the single method of control causes numerous externalities and disruption of ecosystem. To avoid such grim situation, the present scenario warrants need of integrated approach for managing the fruit flies on important sub-tropical fruits for its sustainable production. Fruit fly invasions can be prevented by using the traps of various sizes around the perimeter of large orchards which not only show promising results but also act ecofriendly (Epsky *et al.* 2014) [1]. Without broadcasting of insecticide, toxic baits are considered as pest management means to diminish the fruit fly population (Hafsi *et al.* 2015) [3]. Therefore, the present study was carried out to refine different MAT and BAT techniques for the management of fruit fly on mango, peach and guava in Jammu sub-tropic.

2. Materials and Methods

An experiment was carried out at three fruit orchards *viz*., mango, peach and guava for two consecutive years (2019 and 2020) to evaluate the efficacy of Male Annihilation Technique (MAT) and Bait Attractant Technique (BAT) in attracting the population of fruit flies on three fruit crops under study. For the fruit fly management, different permutation and combination of modified treatments in BAT and MAT techniques were evaluated in three replications. A total of ten treatment combinations *viz*., Cue-lure + wooden block; Cue-lure + absorbent plastic; Protein hydrolysate + wooden block; Protein hydrolysate + absorbent plastic; Mineral bottle traps (ME + wooden block + malathion); Mineral bottle traps (ME + absorbent plastic + spinosad); fishmeal + diazinon; mashed banana + malathion; commercially available green valley fruit fly traps and commercially available PCI traps were evaluated during both the years of experimentation. Regular monitoring was carried out through the weekly collections of fruit flies in different treatments and data was collected to ascertain the efficacy of refinements in MAT and Bait techniques.

3. Observations and Statistical analysis

Regular monitoring through the weekly collections of fruit flies in different treatments were made and data were collected to ascertain the efficacy of refinements in different MAT and BAT techniques. The original trap catches in different treatments were subjected to the transformation by using the formulae Log (X+0.5), wherein, X denoted the original trap catches value. Further, the transformed values were analysed statistically for the Tukey HSD test by using SPSS 20.0 IBM pack to draw valuable inferences.

4. Results and Discussion

To attract the adults of fruit flies, Male Annihilation Technique (MAT) and Bait Attractant Technique (BAT) was refined in the orchards of mango, guava and peach during 2019 and 2020 which has been presented in Table 1 and Table 2**.** The perusal of the data revealed that in 2019, among all the treatments used *viz*., Cue-lure + wooden block; Cue-lure + absorbent plastic; Protein hydrolysate + wooden block; Protein hydrolysate + absorbent plastic; Mineral bottle traps (ME + wooden block + malathion and ME + absorbent plastic + spinosad); fishmeal + diazinon; meshed banana + malathion; commercially available traps (Green valley fruit fly traps and PCI), the highest trap catches were recorded in commercially available green valley fruit fly traps on mango (359.00 fruit flies/trap), guava (375.33 fruit flies/trap) and peach (329.67 fruit flies/trap). It was followed by another commercially available traps (PCI) which recorded the mean trap catch of 317.33, 330.00 and 283.00 fruit flies per trap on mango, guava and peach, respectively. However, the least trap catches were recorded in cue-lure+absorbent plastic wherein mean number of 88.00, 96.33 and 64.67 fruit flies per trap were recorded on mango, guava and peach, respectively. During 2020, the highest trap catches were recorded in commercially available green valley fruit fly traps on mango (384.00 fruit flies/trap), guava (381.67 fruit flies/trap) and peach (310.00 fruit flies/trap). It was at par with another commercially available traps (PCI) which recorded the mean trap catch of 332.67, 338.00 and 270.00 fruit flies per trap on mango, guava and peach, respectively. However, the least trap catches were recorded in cue-lure+absorbent plastic wherein mean number of 91.33, 105.33 and 68.00 fruit flies per trap were recorded on mango, guava and peach, respectively. All the treatments were significantly different from each other. The pooled data of two years (2019 and 2020) on the refinement of Male Annihilation Technique (MAT) and Bait Attractant Technique (BAT) for fruit flies has been illustrated in Table 3. The perusal of the data revealed that commercially available green valley fruit fly traps followed by commercially available PCI traps had highest efficacy in attracting the fruit flies wherein 371.50, 378.50 and 319.83 fruit flies/trap catch and 325.00, 334.00 and 276.50 fruit flies/trap catch were recorded in mango, guava and peach, respectively. Cue-lure+absorbent plastic was least effective in attracting the fruit flies in all the three experimental orchards and recorded the mean trap catches of 89.67, 100.83 and 66.33 fruit flies per trap in mango, guava and banana, respectively. All the treatments were significantly different from each other. The current findings are in line with the results obtained by Ormsby (2021) [6] who developed models which rely primarily on fruit fly biology and the effectiveness of surveillance trapping systems for establishing a control system and responding to fruit fly outbreaks would provide considerable economic benefits to international trade. A major advance in the composition of baits occurred when Steiner (1952) [9] showed that the inclusion of protein hydrolysate with sugar and insecticide produced highly attractive and effective bait sprays for control of Oriental fruit fly (*Bactrocera dorsalis*). Protein bait sprays have become the principal means of controlling many species of tropical fruit flies. The approach takes advantage of the female flies need for a protein source to maximize egg production. For many years, bait spray formulations for controlling fruit flies were mainly comprised of protein hydrolysate (Nu-Lure) as the bait and malathion as the toxicant (Vargas *et al*. 2008) [11]. Concerns about negative impacts of organophosphorus insecticides on natural enemies and human health prompted the development of improved baits and reliance on reduced-risk insecticides. New formulations based on hydrolysed protein from maize were developed and when combined with the naturally derived insecticide, spinosad, were highly effective in controlling several fruit fly species (Vargas *et al*. 2001) [12]. A mixture of spinosad, protein, sugar, ammonium acetate and other ingredients was subsequently produced for control of many fruit fly species as GF-120 or NF Naturalyte (Corteva Agriscience, Indianapolis, IN, USA). Modifying bait colour is another possible avenue for improving the attraction of fruit fly baits. The location of mates, oviposition sites, food and many other aspects of insect behaviour are guided by visual cues (Giurfa and Menzel 1997) [2].

Table 1: Refinement of Male Annihilation Technique (MAT) and Bait Attractant Technique (BAT) for fruit flies on Mango, Guava and Peach during 2019

Treatments	Treatments details	Mean of trapped adult fruit flies on Mango	Mean of trapped adult fruit flies on Guava	Mean of trapped adult fruit flies on Peach
T1	Cue- lure + wooden block	171.67 (2.24e)	185.00 (2.27d)	140.33 (2.15ef)
T2	Cue- lure+ absorbent plastic	88.00 (1.95i)	96.33 (1.99g)	64.67 (1.81i)
T3	Protein hydrolyzate + wooden block	109.00 (2.04h)	124.00 (2.10f)	78.33 (1.90hi)
T4	Protein hydrolyzate + absorbent plastic	212.67 (2.33d)	230.00 (2.36c)	174.33 (2.24de)
T5	Mineral bottle traps (ME+ wooden block+ malathion)	290.33 (2.46b)	309.00 (2.49b)	245.33 (2.39bc)
T6	Mineral bottle traps (ME+ absorbent plastic + Spinosad)	241.33 (2.38c)	258.33 (2.41c)	203.00 (2.31cd)
T7	Fish meal + Diazinon	129.67 (2.11g)	146.67 (2.17e)	96.67 (1.99gh)
T8	Meshed banana +malathion	152.00 (2.18f)	168.00 (2.23d)	118.67 (2.08fg)
T9	Commercially available traps Green Valley fruit fly traps	359.00 (2.56a)	375.33 (2.57a)	329.67 (2.52a)
T10	Commercially available traps PCI	317.33 (2.50b)	330.00 (2.52b)	283.00 (2.45ab)
F-value		520.76	332.09	120.17
(P-value)		*P*<0.01	*P*<0.01	*P*<0.01

Note: Figures in parentheses are logarithmic "log(x+0.5)
Tukey HSD test, Treatments with the same letters are not significantly different (*P*<0.05).

Table 2: Refinement of Male Annihilation Technique (MAT) and Bait Attractant Technique (BAT) for fruit flies on Mango, Guava and Peach during 2020

Treatments	Treatments details	Mean of trapped adult fruit flies on Mango	Mean of trapped adult fruit flies on Guava	Mean of trapped adult fruit flies on Peach
T1	Cue- lure + wooden block	184.67 (2.27d)	176.00 (2.25c)	139.67 (2.14de)
T2	Cue- lure+ absorbent plastic	91.33 (1.96f)	105.33 (2.02e)	68.00 (1.82h)
T3	Protein hydrolyzate + wooden block	105.33 (2.02f)	118.67 (2.07de)	84.00 (1.92gh)
T4	Protein hydrolyzate + absorbent plastic	220.67 (2.34c)	224.00 (2.35b)	170.00 (2.22cd)
T5	Mineral bottle traps (ME+ wooden block+ malathion)	311.33 (2.49b)	318.67 (2.50a)	234.00 (2.37b)
T6	Mineral bottle traps (ME+ absorbent plastic + Spinosad)	253.33 (2.40c)	251.00 (2.40b)	210.00 (2.32bc)
T7	Fish meal + Diazinon	129.67 (2.11e)	141.67 (2.15cd)	102.33 (2.01fg)
T8	Meshed banana +malathion	152.00 (2.18e)	172.00 (2.23c)	125.00 (2.09ef)
T9	Commercially available traps Green Valley fruit fly traps	384.00 (2.58a)	381.67 (2.58a)	310.00 (2.49a)
T10	Commercially available traps PCI	332.67 (2.52ab)	338.00 (2.53a)	270.00 (2.43ab)
F-value		225.72	108.41	90.36
(P-value)		*P*<0.01	*P*<0.01	*P*<0.01

Note: Figures in parentheses are logarithmic "log(x+0.5)
Tukey HSD test, Treatments with the same letters are not significantly different (*P*<0.05).

Table 3: Pooled data on refinement of Male Annihilation Technique (MAT) and Bait Attractant Technique (BAT) for fruit flies during 2019 and 2020

Treatments	Treatments details	Mean of trapped adult fruit flies on Mango	Mean of trapped adult fruit flies on Guava	Mean of trapped adult fruit flies on Peach
T1	Cue- lure + wooden block	178.17 (2.25e)	180.50 (2.26d)	140.00 (2.15e)
T2	Cue- lure+ absorbent plastic	89.67 (1.95i)	100.83 (2.01g)	66.33 (1.82h)
T3	Protein hydrolyzate + wooden block	107.17 (2.03h)	121.33 (2.09f)	81.17 (1.91g)
T4	Protein hydrolyzate + absorbent plastic	216.67 (2.34d)	227.00 (2.36c)	172.17 (2.24d)
T5	Mineral bottle traps (ME+ wooden block+ malathion)	300.83 (2.48b)	313.83 (2.49b)	239.67 (2.38b)
T6	Mineral bottle traps (ME+ absorbent plastic + Spinosad)	247.33 (2.39c)	254.67 (2.41c)	206.50 (2.32c)
T7	Fish meal + Diazinon	129.67 (2.11g)	144.17 (2.16e)	99.50 (1.99f)
T8	Meshed banana +malathion	152.00 (2.18f)	170.00 (2.23d)	121.83 (2.09e)
T9	Commercially available traps Green Valley fruit fly traps	371.50 (2.57a)	378.50 (2.58a)	319.83 (2.51a)
T10	Commercially available traps PCI	325.00 (2.51b)	334.00 (2.52ab)	276.50 (2.44b)
F-value (P-value)		752.93 *P*<0.01	414.61 *P*<0.01	446.94 *P*<0.01

Note: Figures in parentheses are logarithmic "log(x+0.5)
Tukey HSD test, Treatments with the same letters are not significantly different (*P*<0.05).

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