Nat. Volatiles & Essent. Oils, 2021; 8(6): 1709-1728

NVEO
Natural Volatiles &
Essential Oils

A Durable Semi-Solid Bait Against Bactrocera (Diptera: Tephritidae) Species In Peshawar

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ABSTRACT

Efficacy of liquid and semi-solid form of commercial fruit flies attractant (methyl eugenol) for Bactrocera dorsalis and B. zonata in peach orchard, and raspberry essence for Bactrocera tau and B. cucurbitae in vegetables field were investigated at Agronomy Research Farm, The University of Agriculture, Peshawar in 2017.Treatments in both experiments were arranged randomly (factorial randomized complete block design)withthree replications. A significant difference was observed among the liquid and semi-solid phase of both the methyl eugenol and raspberry essence. The maximum number of fruits flies per trap of B. dorsalis (9.08) and B. zonata (11.19) were recorded in semi-solid phase of methyl eugenol, while minimum number of B. dorsalis (5.06) and B. zonata (7.30) in its liquid phase. Similarly, the semi-solid phase of raspberry essence also attracted significantly more mean the number of B. tau (12.9) and B. cucurbitae (8.08). The semi-solid forms of attractants caught comparatively more mean number of fruit flies over a longer period of time than the liquid forms, therefore semi-solid form of attractant is recommended for further use to reduce the fruit flies incidents.

Key Words: Fruit flies, semi-solid, methyl eugenol, raspberry essence, Peshawar, Bactrocera

INTRODUCTION

Fruit flies (Diptera: Tephritidae) are the world major pests of fruits and vegetables in family Tephritidaethat contain around 4500 species and subspecies compiled in 481 genera

(Agarwal and Sueyoshi, 2005). Fruit flies have several known species across the world but only few have been reported as serious pests in Pakistan due to their heavy losses in fruits and vegetables. Among these, the important ones are Bactrocerazonata,B.dorsalis, B. cucurbitae and B. tau.

Fruit flies attack more than 250 different types of fruits, vegetables and flowers (Khattaket al., 2004) that adversely affect the agricultural production and market access. Among the available species, B. zonata is known to infest several fruits like peach, pear, apricot, plum, guava, mango and citrus fruits. Only in guava the annual losses have been accounted for about 25-50% (Siddiqui et al., 2006) as a result farmers have abandoned kharif guava crop in southern Pakistan. B. dorsalis is known as the most injurious species to almost all types of fleshy fruits and is also widely distributed in Pakistan. Besides, B. dorsalis is also an important pollinator (Tan et al., 2002).

B.cucurbitaehasbeen identified as a serious pest of cucurbits owing to their polyphagous nature and huge economic losses to vegetables varying from 30 to 100% depending upon the crop and season (Dhillon et al. 2005). The pest status of B. tau is also not uncommon in cucurbits and other fruits as well as horticultural crops (Singh et al., 2010) with its devastating status in tomato crops (Sharma et al., 2011). Due to heavy losses to agricultural commodities, fruit flies are economically important pests in Pakistan.

Fruit flies are difficult to control as the developmental stages are unexposed except the adults (Sharma et al., 2011a). In chemical control, contact pesticides fail to treat these immature stages, while the consequences of systemic pesticides usage have far reaching hazardous effects on human health, beneficial organisms as well as on the environment (). Therefore, only the adult fruit flies can be easily controlled using different poison baits containing pheromone along with an insecticide.

Methyl eugenol is a widely used and an effective pheromone based bait attractant for Bactrocerazonata and B. dorsalis (Ullahet al., 2012) since time, employing Male Annihilation Technique in diversified agro-ecosystems, thereby reducing the male fruit flies population to be available for copulation. Contrary to this, raspberry essence also possessesa potential to attractBactrocera species fruit flies primarily the B.cucurbitae(Ullah et al., 2015)and B. tau.

Ordinary liquid baits have always shown limited effects due to their volatile nature and thus bait modification is necessary to tackle this problem and to enhance the durability of the bait attractants. Gelatin, which is obtained from livestock animals and fish, is commercially available as a gelling agent that increases the viscosity of liquid materials. The gelling ability is due to the presence of amino acids in the form of imino acids, proline or hydroxyproline.

In our study, we hypothesized semi-solid form of the baits (methyl eugenol and raspberry essence) to be more effective than its liquid form baits and further investigated the durability of different bait types to obtain an efficient tool for pest management.

Materials and Methods

The research studies were carried out on the efficacy of liquid and semi-solid form of commercial fruit flies attractant methyl eugenol for two species (Bactrocera dorsalis and B. zonata) and raspberry essence for other two species of fruit flies (B. tau and B. cucurbitae) in Agronomy Research Farm at The University of Agriculture, Peshawar during, 2017.

Traps Design

Plastic traps were used in modified cone shaped bottles with four holes for fruit flies entrance and a lid. It also contained a steel wire with took hooks in which the upper meant for hanging trap in trees and lower one for attachment of cotton swab. The height ofeach trap was 11 cm, while distance between the two holes was kept 5.4 cm. A total of 12 traps were used in this study.

Baits Attractants

Thebait types containing methyl eugenol and raspberry essence each with liquid and semi-solid form were prepared by mixing firstly 30ml of either methyl eugenol or raspberry essence in 20 mg already crushed sugar. Another 5 mg of urea and diptrexwere mixed and the whole solution was constantly stirred. From this solution we made liquid phase baits.

For semi-solid forms of the baits, 30mg gelatin was first mixed in 50ml water and then placed on an electric heater at 20 ºC. The mixture was cooled down and incorporated in already prepared liquid solutions. The final material was left for 24 hours. Semi-solid baits of raspberry and methyl eugenol were prepared by dipping foam in these solutions.

Comparison of baits

Two separate experiments were performed each in peaches orchard (April-June) and cucurbit (gourd) field((May-July). Traps of methyl eugenol were placed randomly (factorial randomized completely block setup) in different locations of peach orchard that were replicated three times for each semi-solid(foam filled in 30ml solution) and liquid (30ml solution) bait types. Afterwards, three traps of raspberry essence each in liquid (30ml solution) and semi-solid form(foam filled in 30ml solution) were placed in cucurbits field. Traps were re-baited with fresh solutions after samples collection on weekly intervals. The collected samples were brought in a polythene bag to laboratory in Department of Plant Protection at The University of Agriculture, Peshawar for identification using the keys of Prabhakar et al. (2012).

Durability of baits

For durability of bait types, Two experiments each in peaches orchard (April-June) and cucurbit (gourd) field ((May-July) were conducted. Traps of raspberry essence were randomly arranged(factorial randomized completely block)in three replications in peaches orchard in each semi-solid (foam filled in 30ml solution) and liquid (30ml solution) bait types. Similarly in cucurbits field, another liquid (30ml solution) and semi-solid (foam filled in 30ml solution) raspberry baits were placed. All traps were replicated three times. Specimens were weekly collected from installed traps without re-baiting traps, which were brought in a polythene bag

to Plant Protection Laboratory for identification. Data collectionwas continued for three months each in peaches orchard and cucurbits field.

Statistical Analysis

Data collected for baits comparison and their durability were analysed by using suitable statistical computer software Statistix 8.1. Means and their differences were further compared by applying a Fishers' Least Significance Difference (LSD) test (Steel and Torrie, 1997).

RESULTS

Comparison of baits

Tested baitsfor B. zonatarevealed significant difference and semi-solid form of methyl eugenol placed in traps showed higher mean number of B. zonata followed by its liquid form (Table 1). Results for the weeks studied was significant and maximum number of B. zonata were captured in week 8th (24th May) followed by week 9th (31st May), while minimum number of B.zonata were collected in the 1st week post traps installation (15th March). In the interaction Treatments x Weeks, highest mean B. zonata were recorded in semi-solid form of methyl eugenol in week 8th (24th May) followed by same treatment in week 9th (31st May), while lowest numbers of B. zonata were recorded in liquid form of methyl eugenol in week 1st (5th April).

Results of different tested baits for B. dorsalis showed significant difference where semi-solid form of methyl eugenol placed in traps showed higher number of B. dorsalis followed by captures in liquid form of methyl eugenol (Table 2). Significant differences among the studied weeks for B. dorsalis captures were also observed with maximum number of B. dorsalis trapped in 8th week (24th May) followed by 7thweek (17th April), while minimum numbers of B. dorsalis were trapped in 1stweek (5th April) post traps installation.Interaction (Treatments x Weeks) also showed significant differences with highest mean B. dorsalisrecorded in semi-solid form of methyl eugenol in week 8th (24th May) followed by same treatment in week 7th (17th April), while lowest numbers of B. dorsaliswere recorded in liquid form of methyl eugenol in week 1st (5th April).

Table 1: Mean number of B. zonataper trap per week in liquid and semi-solid form of methyl eugenol.

Treatments	Time interval												Mean
	W1	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W10**	**W11**	**W12**	
	5th April	12th April	19th April	26th April	3rd May	10th May	17th May	24th May	31st May	7th June	14th June	21st June	
Liquid	1.3q	2.67p	4.00o	5.67n	7.67kl	8.67ijk	9.6ghi	13.00cd	11.67ef	9.00hij	8.34jk	6.00mn	7.30b
Semi-solid	3.33op	4.33o	7.00lm	8.67ijk	10.67fg	12.00de	15.67b	18.00a	17.33a	14.00c	13.33c	10.00gh	11.19a
Mean	2.33j	3.50i	5.500h	7.16g	9.16f	10.33e	12.66c	15.0a	14.50b	11.50d	10.8de	8.00g	

LSD for Treatments at P ≤0.05 = 0.3794
LSD for Weeks at P ≤0.05 = 0.9293
LSD for interaction at P ≤0.05 = 1.3143

Table 2: Mean number of B. dorsalis per trap per week (Interaction effect of treatments X time intervals) in liquid and semi-sold form of methyl eugenol.

Treatments	Time interval												Mean
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	
	5th April	12th April	19th April	26th April	3rd May	10th May	17th May	24th May	31st May	7th June	14th June	21st June	
Liquid	0.3q	1.7op	1.7op	2.3no	4.3kl	7.3gh	8.7f	10.7d	9.3ef	6.7hi	5.3jk	3.3lmn	5.06b
Semi-solid	1.7op	2.7mno	3.7lm	5.7ij	9.3ef	12.3bc	14.7a	15.0a	13.3b	12.0c	10.3de	8.3fg	9.08a
Mean	1.00i	1.67i	2.67h	4.0g	6.83e	9.83c	11.7b	12.8a	11.3b	9.3c	7.8d	5.8f	

LSD for treatments at $p \leq 0.05$ = 0.3291

LSD for Weeks at $p \leq 0.05$ = 0.7878

LSD for interaction at $p \leq 0.05$ = 1.1402

Durability of baits

Results for the liquid and semi-solid baited traps of raspberry essence utilized against Bactrocera tau revealed significant differences among the treatments (P<0.001). Among the bait types, semi-solid baited traps of raspberry essence showed significantly higher number of B. tau, while lowest numbers of B. tau were found in liquid form traps (Table 3). Weekly intervals also showed statistically significant differences (P<0.001). Maximum numbers of B. tauwere detected in in week 8th (21st June), however this was not significantly different from trapping in week 9th (28th July), and this was followed by trappings in week 7th (16th July). A minimum mean numbers of B. tau were captured in 1stweek of June.

The data related to interaction of treatments × weeks showed significant differences (Appendix 3). Highest mean number of B. tau were recorded in semi-solid form of raspberry essence in week 8th (21 July) and week 9th (28th July) with mean 21.0 fruit flies per trap respectively, followed by semi-solid form in week 7th (16th July) with 18.67 mean number of fruit flies per trap, while lowest mean numbers of B. tau were recorded in liquid form of raspberry essence at week 1st (2nd May) post trap installation with mean 2.34 fruit flies per trap.

Results for Bactroceracucurbitae trapped in different bait types of raspberry essence presented significant differences (P<0.001). Treatments comparison showed that semi-solid form of raspberry essence trapped significantly higher number of B. cucurbitae, while its liquid form captured lowest mean number of B. cucurbitae(Table 4). The weekly interval captures also displayed significant differences among the B. cucurbitaecatches (P<0.001). On weekly basis, maximum mean B. cucurbitaewere observed in week 8th (21st July), followed by week 7th (16th July), while a minimum mean B. cucurbitae were trapped in week 1st (2nd June).Results for interaction (treatments x weeks) was also found significant (P<0.001). Highest mean B. cucurbitae were recorded in semi-solid form of raspberry essence in week 8th (21rd July) followed by same treatment in week 7th (16th July), while lowest mean B. cucurbitae were recorded in the liquid form of raspberry essence in 1st and 2ndweek of June.

Table 3: Mean number of B.tau per trap per week (Interaction effect of treatments X time intervals) in liquid and semi sold form of raspberry essence

Treatments	Time interval												Mean
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	
	5th May	12th May	19th May	26th May	2nd June	9th June	16th June	23rd June	30th June	7th July	14th July	21st July	
liquid	2.34n	3.67mn	5.0lm	6.67jk	9.67gh	11.6ef	12.67e	16.34c	15.0cd	10.0gh	9.34hi	7.0j	9.1b
Semi-solid	3.67mn	5.34kl	8.0ij	9.67gh	12.67e	15.0cd	18.67b	21.0a	21.0a	15.0cd	14.34d	11.0fg	12.9a
Mean	1.00i	4.50h	6.50g	8.16f	11.16e	13.34c	15.67b	18.66a	18.0a	12.5cd	11.83de	9.0f	

LSD for treatments at $p \leq 0.05 = 0.3914$

LSD for Weeks at $p \leq 0.05 = 0.9587$

LSD for interaction of treatments × Weeks at $p \leq 0.05 = 1.3558$

Table 4. Mean number of B. cucurbitaeper trap per week (Interaction effect of treatments X time intervals) in liquid and semi-solid form of raspberry essence.

Treatments	Time Interval												Mean
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	
	5th May	12th May	19th May	26th May	2nd June	9th June	16th June	23rd June	30th June	7th July	14th July	21st July	
Liquid	0.00p	0.00p	0.67op	1.34no	3.33kl	6.34gh	7.67f	9.67d	8.34ef	5.67hi	4.34jk	2.34l-n	4.13b
Semi-solid	0.67op	1.67mno	2.67lm	4.67ij	8.34ef	11.34bc	13.67a	14.0a	12.34b	11.0c	9.34de	7.34fg	8.08a
Mean	0.33i	0.83i	1.66h	3.00g	5.83e	8.83c	10.66b	11.83a	10.33b	8.33c	6.83d	4.83f	

LSD for treatments at $p \leq 0.05 = 0.3216$

LSD for Weeks at $p \leq 0.05 = 0.7878$

LSD for interaction of treatments × Weeks at $p \leq 0.05 = 1.1141$

Comparison of Different Baits

Cumulative study of the different phases (i.e. liquid phase and semi-solid phase) of bait attractants for the management of different fruit flies is shown in Table (5). Among the different phases of methyl eugenol bait, the semi-solid form of methyl eugenol placed in traps showed a significantly higher mean number of B. zonata (11.19 fruit flies per trap) as compared to the liquid form of methyl eugenol with 7.30 mean B. zonata per trap. In the case of B. dorsalis, the different tested treatments showed that semi-solid form of methyl eugenol placed in traps showed a significantly higher number of B. dorsalis (9.08 fruit flies per trap) when compared with the liquid form of methyl eugenol that entrapped only 5.06 mean numbers of B. dorsalis per trap. Among these species, highest trappings were that of B. zonata as compared to B. dorsalis, however the semi-solid form of treatment bait captured an overall maximum B. zonataas compared to the semi-solid bait for B. dorsalis.

Different bait types of raspberry essence were evaluated against the Bactrocera species (Table 4.5). The semi-solid form of raspberry essence placed in traps showed a significantly higher number of B. tau with mean numbers of 12.9 fruits flies per trap, while lowest numbers of B. tau were found in traps baited with liquid form of raspberry essence with 9.1 mean numbers of fruit flies per trap. For B. cucurbitae, the semi-solid form of raspberry essence placed in traps showed significantly higher numbers of B. cucurbitae with 8.08 mean fruits flies per trap in comparison to the liquid form of raspberry essence capturing lowest number of B. cucurbitae with a mean value of 4.13 fruit flies per trap. Species response to bait types revealed that semi-solid form possess an enhanced effect in capturing B.cucurbitaeas compared to the response of B. tau towards the same bait type of raspberry essence. Further, it was indicated that semi-solid form of the bait, as like in methyl eugenol, showed the same enhanced effect. B. cucurbitae were counted in greater numbers in baited traps as compared to B. tau.

Table. 4.5 Cumulative table for liquid and semi-solid phases of methyl eugenol attractant used for Bactrocerazonata and B. dorsalis, and of raspberry essence attractant used for B. cucurbitae and B. tau in baited traps installed at Malakandair Farm, Peshawar during, 2016.

Treatments	Fruit fly Species			
	Bactrocerazonata	**Bactrocera dorsalis**	**Bactroceracucurbitae**	**Bactrocera tau**
Liquid	7.30	5.06	9.1	4.13
Semi-solid	11.19	9.08	12.29	8.08

Durability of Semi-Solid and Liquid Baited Traps of Methyl Eugenol and Raspberry Essence

Semi-solid and Liquid Baits of Raspberry Essence

Different bait types of raspberry essence showed a marked difference in capturing the fruit flies along the studied period of time (Fig 4.1). Initially, the fruit flies captures in semi-solid form of raspberry essence were higher as compared to the liquid form but was not complimentary with a mean number of 1.17 fruit flies per trap in week 1st. The fruit flies capture increased from week 1st to week 9th where highest population of 18.67 fruit flies per trap were noticed in baited traps of semi-solid form of raspberry essence. Onwards from here, the efficacy of semi-solid form decreased with little difference but its durability remained till week 12th with mean numbers of 11.0 fruit flies per trap. In contrast, the liquid form of raspberry essence started with lower captures of fruit flies in week 1st (1.17 fruit flies per trap) and its peak efficacy was achieved in week 8th, where afterwards durability of the liquid form of raspberry essence declined much and only 4.67 fruit flies per trap were detected in week 12th of the study period in liquid baited traps of raspberry essence.

Comparing the efficacy of bait types (Fig 4.1), semi-solid form of raspberry essence exhibited an enhanced durability that remained effective for a longer period of time with greater fruit flies catches, while durability of liquid form of raspberry essence bait remained only for a shorter period of time that diminished after week 8th. An enhanced durability of the semi-solid form of raspberry essence added to the better management of Bactrocera species.

Semi-solid and Liquid Baits of Methyl Eugenol

As like raspberry essence, different bait types of methyl eugenol also displayed a marked difference in capturing the fruit flies (Fig 4.2). Semi-solid form of methyl eugenol captured higher number of fruit flies (2.53 fruit flies per trap) in initial reading when compared with liquid form of the bait. The bait efficacy increased afterwards and a highest captures of fruitflies were attained in week 8th, however the durability of semi-solid form of methyl eugenol remained till week 12th with mean captures of 9.15 fruit flies per trap.

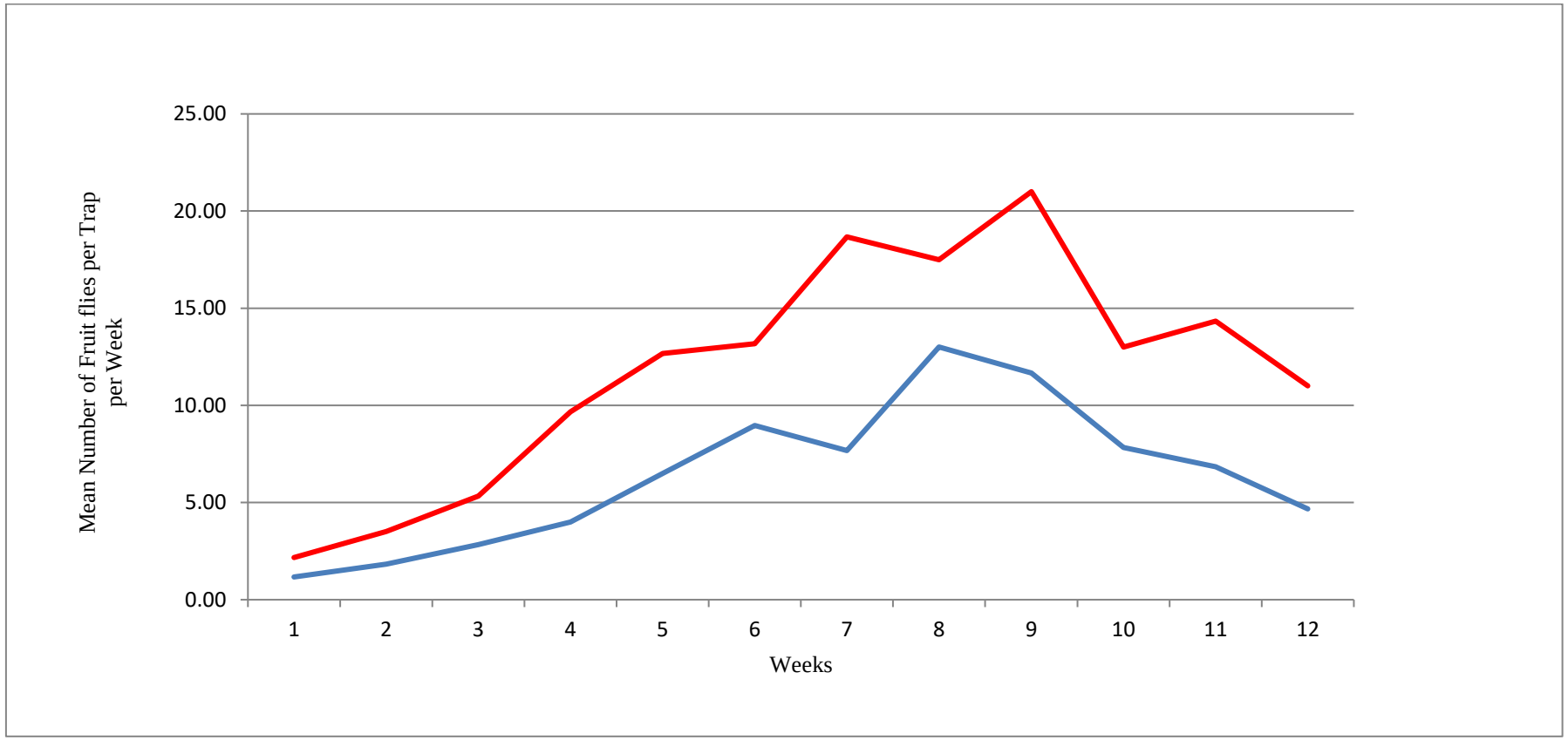

Figure 4.1: Mean number of Bactroceracucurbitae and B. tau where semi-solid form (Red line) captured more number of fruit flies than the liquid form (Blue line) in baited traps of raspberry essence installed in cucurbit field at Peshawar during, 2016.

Contrary to the semi-solid form of methyl eugenol, captures of fruit flies in liquid form were always lower in number. In week 1st, only 0.80 mean numbers of fruit flies per trap were captured in liquid baits of methyl eugenol that were much lower than the semi-solid form and the same fashion continued throughout the study period, whereas peak captures were obtained in week 8th with xxx mean numbers of fruit flies per trap, minimum to those of semi-solid bait captures. Soon afterwards, the captures mean numbers decreased much with no captures of fruit flies obtained in week 12th in liquid form of methyl eugenol baited traps.

Comparative study of the bait types (Fig 4.2) revealed that methyl eugenol in semi-solid form offered an increased durability with longer persistence in comparison to the liquid form, whereby capturing higher numbers of fruit flies. In contrast, the liquid form of methyl eugenol remained durable only for a shorter period that attracted minimal number of fruit flies and its effectiveness further reduced after week 8th however it was completely zero in week 12th of data collection. Therefore, the semi-solid form of raspberry essence offered a better management option in controlling Bactrocera species population with enhanced durability.

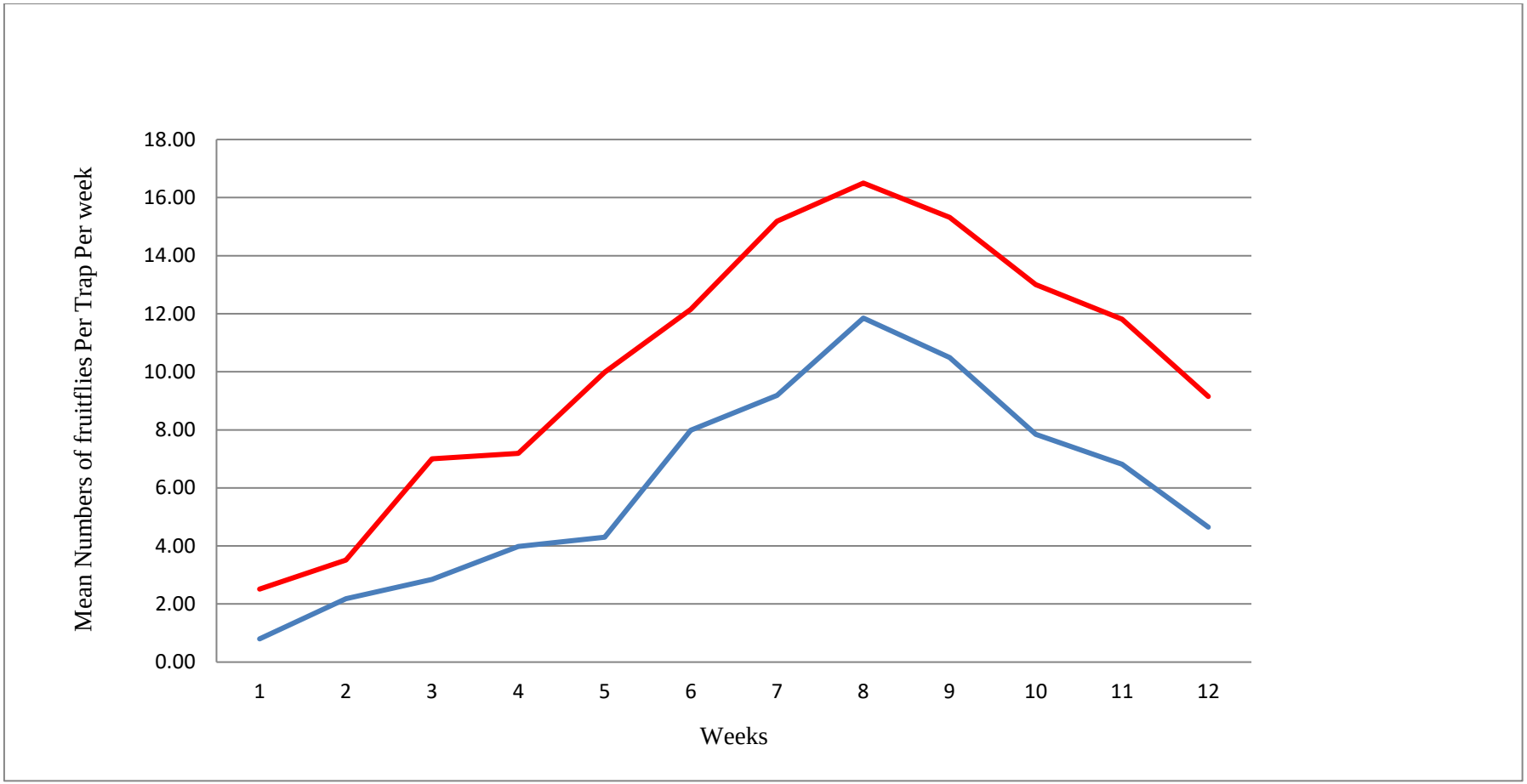

Figure 4.2: Mean number of Bactrocerazonata and B. dorsalis where semi-solid form (Red line) captured more number of fruit flies than the liquid form (Blue line) in baited traps of methyl eugenol installed in peach orchard at Peshawar during, 2016.

DISCUSSION

Fruit flies can infest wide range of commercial and native vegetables and fruits. Due to its heavy infestation causes 200 million dollar losses annually in Pakistan (Stonehouseet al., 1998). The uses of lures for attracting fruit flies are common because in short time large number of flies traps. Male fruit flies of many species are attract to the chemicals referred to as Para-pheromones (Lawson et al., 2003). The lures attract fruit flies from large distances. Methyl eugenol is one of the male attractant widely used for Bactroceraspp. (Dominiaket al., 2011). Due to strong attractant properties, methyl eugenol has been used for trapping fruit flies and for pest controls (Yong 1990), while raspberry is itself an attractant (Metcalf et al., 1983). The addition of food essence increases the effectiveness of attractant traps (John et al., 2001). These lures and food essence are mainly used in liquid form that consume time and also increases the risk to human health (Vargas et al., 2009). Consequently, there is considerable interest in the development and adoption of semi-solid dispensers for Bactrocera species detection that minimize handling time and exposure risk and, in fact, a number of recent studies (Vargas et al., 2009; Leblanc et al., 2011).

In current studies liquid and semi-solid form of Methyl eugenol were used in fruit flies trap to find out the population abundance of Bactrocerazonata and Bactrocera dorsalis in peach orchard. The number of fruit flies (B. zonata and B. dorsalis) was statistically higher in semi-solid phase of methyl eugenol as compared to its liquid form. These finding are agreed with [Shelly, 2010; Leblanc et al., 2011; Shelly et al., 2011a, b; Wee and Shelly, 2013) who concluded that semi-solid phase of attractant are longer lasting and capture more Bactrocera spp. as compared to liquid form of attractant.

In time intervals, peak population of fruit flies (B. zonata and B. dorsalis) per trap were captured on fourth week of May, while minimum mean numbers of fruit flies (B. zonata and B. dorsalis) per trap were captured in 1st week of April. Similar results were found by (Chen and Ye, 2007; Ullahet al., 2015) who reported that B. zonata and B. dorsalis start their activity in 1st week of April. B. zonatawere found in higher number than B.dorsalis (Ullahet al., 2015). The population of fruit flies then increased till the last week of May (Chen et al., 2006). In June, there is decline in fruit flies, due to high temperature and rain fall (Mahmood and Mishkatullah, 2007). Thus the population increases from 1st week of April till May where it then decreases till the end of June (Ye and Liu, 2007).

In the recent experiment, liquid and semi-solid form of raspberry essence was used in fruit flies traps to find out the population abundance of Bactrocera tau and Bactroceracucurbitacae in vegetables. A significant difference was observed among the tested treatments. The population of fruit flies captured in semi-solid phase of raspberry was significantly higher than in the liquid form. These finding are in line with (Leblanc et al. 2011; Shelly et al. 2011a, b; Wee and Shelly 2013) who demonstrated that due to long effect of semi-solid phase it attract more male flies as compared to liquid formulation and declared semi-solid form of attractant safe for human life.

In over all time intervals the population started from June, reached to peak till last week of July and then started decline till the experiment end last week of August. Similar findings are reported by

(Vargas et al., 2008; Ullahet al., 2012) population of B. tau and B. Cucurbitacae in same pattern from June till end of August. These results are also inconformity with (Samaloet al., 1991; Gupta, 1989) who concluded that B. cucurbitacae is more attracted to cucumbers and B. tau is more attracted to bitter gourd after tomato.

CONCLUSION AND RECOMENDATONS

The collected information revealed to conclude;

1. The semi-solid phase of methyl eugenol and raspberry attract more number of fruit flies as compared to liquid phase of both the treatments.
2. In peach orchard, the number of Bactrocerazonata was recorded more in numbers as compared to B. dorsalis.
3. The peak population of both B. zonata and B. doralis were recorded in last week of May while that of B. cucurbitae and B. tau was recorded in last week of June.
4. In vegetable field, the semi-solid phase of raspberry attracted more B. cucurbitae than B.tau.

RECOMENDATONS

Based on our research study, we recommend the followings;

- The use of semi-solid form of attractant for the fruit flies is more reliable because of its long lasting properties therefore,
- It is recommended for farmers to use the semi-solid form of attractant in traps for the management of fruit flies in the fields, which will save time and will minimize the risk of exposure to liquid toxicants**.**

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