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Integrated Pest Management (IPM) of Fruit Fly (Diptera: Tephritidea) in Citrus at District Faisalabad

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Abstract: The present research was carried out to meet the integrated pest management of fruit fly (Diptera: Tephritidea) in citrus fruits in the district Faisalabad. Fruit infestation and adult fruit fly were captured in each treatment after weekly intervals. The highest number of flies (188.33/trap/week) were recorded in control one and the lowest number was accounted for at IPM-4 (94.00/trap/week). The highest number of flies (26.00%) were recorded in control one orchards and the lowest number were accounted for at IPM-3(2.00%). This study improved that for the management of fruit fly in citrus adopted the integrated management method which is suitable for the control of citrus fruit fly. It also showed that early eradication of fruit is useful for increasing the yield of citrus crops.

Keywords: Fruit fly, Infestation, Population, Yield and Citrus

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1. Introduction

Fruit fly is belong to family Tephritidae and order Diptera, which cause huge losses in horticultural crops (Cugala, 2011; Biasazin *et al*., 2014). They are polyphagous in nature, fast propagation and widely distributed (Baral *et al*., 2006; Haq *et al*., 2019). Fruit fly lay eggs inside the fruit and larvae also feed inside of fruit (Ndiaye *et al*., 2008). They have more than 5000 species which attack on 75 plant family and more than 400 species of fruits (Uchoa and Nicacio, 2010; Rizk*et al*., 2014; Levi-Zada*et al*., 2020). It is quarantine pest so for more yield and export purpose can be managed with different control measures (Vayssieres, 2009; Doorenweerd *et al*., 2018). Eleven species of the fruit fly have been traced from the Pakistan, the species which are mostly present in the field are *Bactrocra zonata*, *B. curcurbitae* and *B. dorsalis* (Norrbom, 2010) on the guava, apple, ber, snak gourd, bitter gourd musk melon, mango and citrus (Khan *et al*. 2005).

Many farmers in developing countries, mainly rely on synthetic chemical pesticides to control insect pests such as fruit flies. The use (and misuse) of chemical pesticides is often associated with high health and environmental risks (Macharia *et al*., 2008; Kouser and Qaim, 2013). Overuse of chemical pesticides is especially evident in the horticultural industry (Asfaw *et al*., 2010), that has led to several interceptions of horticultural products, including mango fruits, in the international market (Lux *et al*., 2003). In addition, pesticides are expensive and often unaffordable to majority of resource poor farmers.

Both mass trapping and attract-and-kill consist of an attractant, a killing agent and a device such as a trap. The technique is described as attract-and-kill if the devices attract but do not retain flies, and as mass trapping if flies are retained in the device (Navarro-Llopis *et al*., 2013). Recent trials with attract-and-kill devices in Spain in peaches and citrus (Casagrande, 2009) and attractand- kill and mass trapping devices in Tunisia in peach (Hafsi *et al*., 2015) and citrus (Jemaa *et al*., 2010), have shown them to be as effective as conventional bait and cover sprays. Efficacy of mass trapping technique is related to the formulation of the attractant (Mangan, 2009; Epsky *et al*., 2014) and to the target pest population density and geographic isolation of treated crops (El-Sayed *et al*., 2006). Theoretically, modelling expects higher efficiency of mass trapping in case of low population densities of the target pest. In cases of low efficacy of the method, complementary measures, such as increasing trap density or/and bait sprays, usually applied in spots with high pest population densities, are required for acceptable crop protection. The last bait spray treatment is often applied near the harvest, making it difficult to adhere to the pre-harvest safety period. Moreover, despite the important number of bait spray treatments, fruit losses in peach orchards are still high and can reach more than 35% of the fruit production (Bouagga *et al*., 2014; Hafsi *et al*., 2016).

The IPM approaches are economic, ecological and sociological combination of intellect selection (Blake *et al*., 2007; Ekesi *et al*., 2011). Mostly in the world now a days for the control of pest researcher recommended IPM strategy, for fruit flies also IPM control measures are applied (Ekesi and Billah, 2007). Used of IPM strategy the use of chemical insecticides or pesticides are less dependence (Varela *et al*., 2006; Midingoyi *et al*., 2019). In the practical the use of IPM program gives the more profit to the farmers than other control measures. Several control techniques in controlling fruit fly can employed early harvesting, cultural control, use of natural enemies, fruit bagging or wrapping, sterile insect technique, soil disturbance and other chemical based control insecticides techniques (Sarwar, 2015). There is need to address this issue so that fruit flies species specific pest management package can be described. Keeping in view the above facts the present research was carried out to meet the integrated pest management of fruit fly (Diptera: Tephritidea) in citrus fruits at district Faisalabad.

2. Materials and Methods

2.1.Study site

For the management of fruit fly the current experiments were conducted at (Nine square University of Agriculture, Faisalabad, Post-graduate Agriculture Research Station (PARS), 76JB, 129GB and 245RB) areas of Faisalabad citrus growing areas to determine the best control method for the management of fruit fly.Different citrus orchard (Kinnow) was selected for different treatment, the age of the kinnow trees were more than three years. The distance of each orchards were five Km.

2.2. Cultural control

Different cultural exercise were conducted out in the experimental areas which including hoeing, ploughing, sanitation and weeding. For each treatments of cultural control separate citrus orchards were selected and one orchard used as control one where no treatment was applied. Hoeing was done underneath of tree canopy to expose the pupae of fruit fly to natural enemies such as birds. Hoeing was repeated after the 15 days interval and infestation of fruit fly were recorded after weekly interval with citrus fruit infestation. Ploughing was conducted to remove the top unwanted branches after the fifteen days intervals and calculated the infestation and population level after weekly time intervals. Sanitation were conducted to pick up the damage fruit from the tree and ground surface. All unmarketable and infested fruits were destroyed deep inside the soil. The weeding were applied in the citrus orchard to remove the unwanted plant form the orchard and clean it after 15 days intervals. All treatments were compared with control orchards for fruit fly captured and fruit infestation after weekly intervals for two months. The percentage infestation of fruit fly was recorded by following formula (Ashfaq *et al*., 2020);

$$\text{Fruit infestation (\%)} = \frac{\text{No. of infested fruits}}{\text{Total number of fruits}} \text{X } 100$$

2.3. Physical approach

Different physical treatments were applied to check the effectiveness of physical control measures. The physical approaches were consisted of methyl eugenol traps (T1), Protein hydrolysate bait traps (T2), Bagging by cloth bag (T3), Bagging by Polythene bag (T4), Bagging by double-layer brown paper bag (T5) and Untreated control (T6). The methyl eugenol traps were installed in citrus orchard eight per acre at the suitable height. These traps were consist of only with methyl eugenol which were applied on the cotton soak hanged middle of trap and refreshed the traps after 7 days intervals. After week intervals when the traps were refreshed the fruit fly population collected and recorded. The cloth bags were applied to cover the full developed fruit of citrus. These bags were removed at the time of picking up fruit. One orchard of guava was consider as control treatment where no physical approach was applied. After seven intervals the population and fruit infestations were recorded and compared with treatment which have more effective against fruit fly. The percentage infestation of fruit fly was record following formula (Ashfaq *et al*., 2020);

$$\text{Fruit infestation (\%)} = \frac{\text{No. of infested fruits}}{\text{Total number of fruits}} \text{X } 100$$

2.4. Chemical approach

Seven insecticides which showed in table No. 1 were purchased from the local pesticides market of Faisalabad. The field recommended dose of these pesticides were applied at citrus orchards after the intervals of 15 days with the help jacto sprayer (PJH HD400) and one orchard control where only water applied. After the fifteen days interval the infestation rate of fruit fly were recorded with the help of infestation rate formula which described as above.

Table No. 1. Details of pesticides evaluated against citrus fruit fly at citrus orchards

Sr. #	Chemical name	Trade name	Company
1	Abamectin	Cure 1.8%EC	Sayaban Group
2	Acetamiprid	Acelan 20 SL	FMC
3	Bifenthrin	Tender 10EC	Suncrop
4	Emamactin benzoate	Proclaim 1.9EC	Sygenta
5	Imidacloprid	Confidor 350SC	Bayer
6	Indoxacarb	Steward 150EC	FMC
7	Trichlorfon	Dipterex 80SP	ICI Pakistan Ltd.

2.5. Biological control

For the management of female fruit fly in citrus orchards spinosad was applied in the citrus orchards. The recommended dose of spionsad were applied after fifteen days intervals. Three replication was used for the period of two months of data collection. The fruit fly population per trap and percent infestation was recorded.

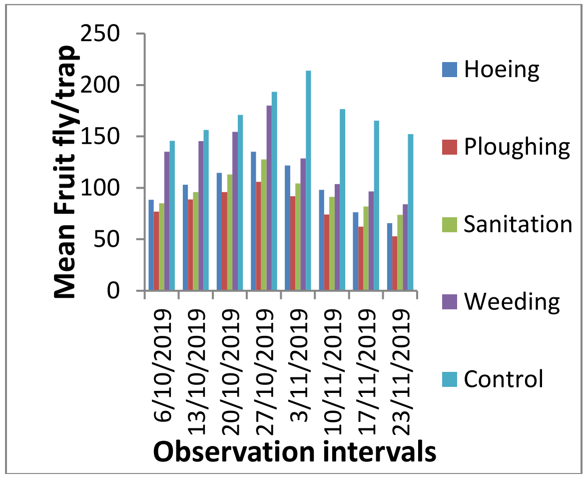

Figure 1. Mean fruit fly per trap per week comparison between different observation intervals and cultural approaches at District Faisalabad on citrus orchards

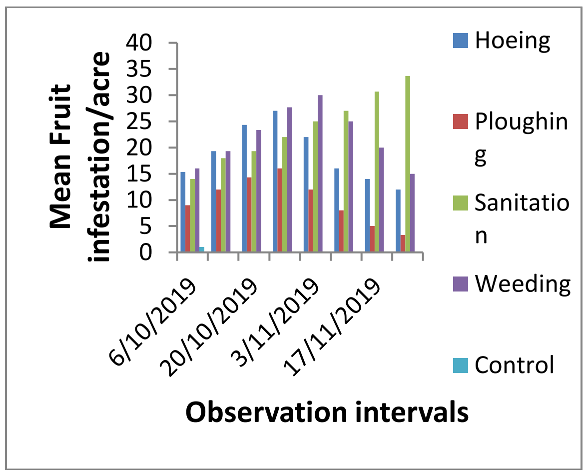

Figure 2. Fruit infestation (%) per acre recorded between different observation intervals and cultural approaches at District Faisalabad on citrus orchards

The infestation was calculated by above formula.For the management of male fruit fly pheromone traps were used for the collection of male fly.The methyl eugenol was soaked in the cotton and put into the trapswhich mixed with insecticides. Eight traps were installed per acre orchards.

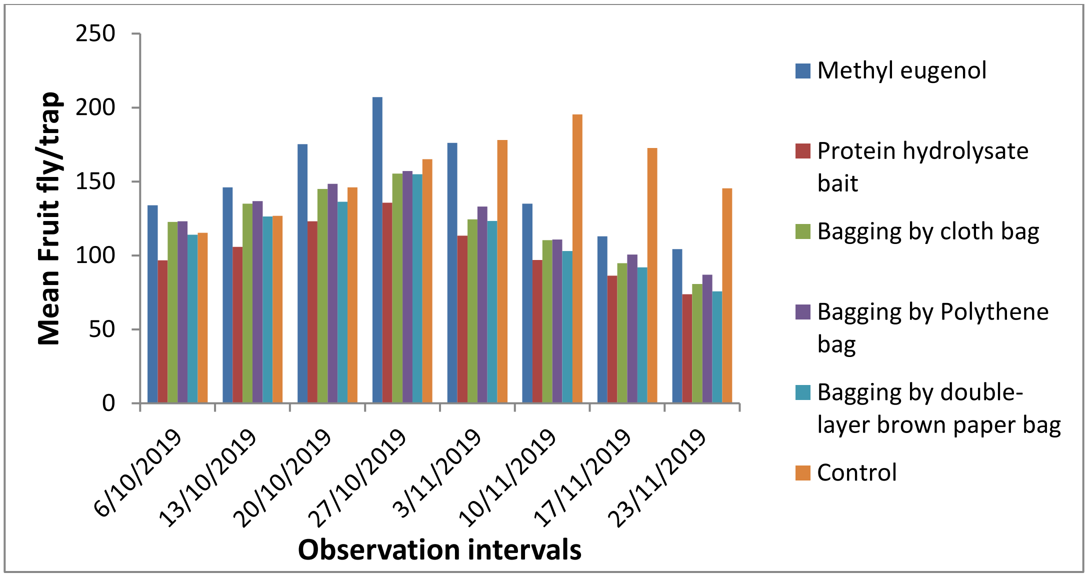

Figure 3. Fruit infestation (%) per acre recorded between different observation intervals and physical approaches at District Faisalabad on citrus orchards

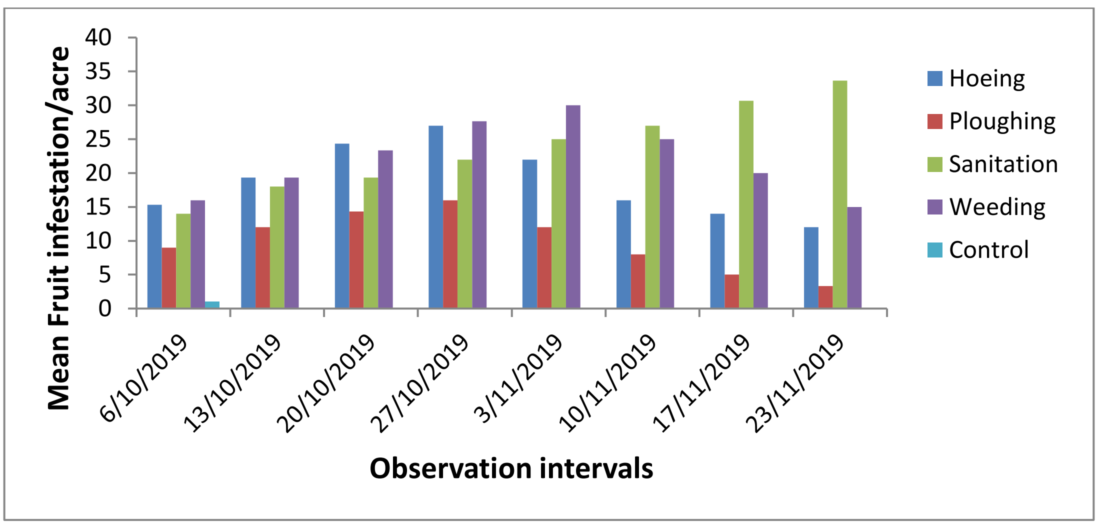

Figure 4. Fruit infestation (%) per acre recorded between different observation intervals and cultural approaches at District Faisalabad on citrus orchards

The traps were refreshed after the intervals of seven days for the period of two months during 2019.

2.6. Integrated Pest Management (IPM)

For the effectiveness of different control approaches with combination different measures were applied at once time in the citrus filed. IPM-1 was consist of (Hoeing, methyl eugenol and abamectin), IPM-2 (Ploughing, protein hydrolysate bait traps and imidacloprid), IPM-3 (Sanitation, sticky trap and trichlorfon) and IPM-4 (Weeding, light trap and indoxacarb). One orchards where no applicationof anything was applied consider as control treatment. Fruit infestation and adult's fruit fly were captured in each treatments after weekly intervals (Ashfaq *et al*., 2020).

2.7. Statistical analysis

For the experiment of cultural, chemical, biological control and IPM the design was used are Randomized Complete Block Design (RCBD) under two way factorial arrangement with three replication were used. The collected data were analyzed by ANOVA technique using STATISTICA. Means were separated by Tukey's honestly significant difference (HSD) test at probability level of 5%.

3. Results and Discussion

The highest number of flies (214.00/trap/week) were recorded in control treatment on 03-11-2019 which were significant different from all other approaches and data observation intervals. The lowest number were accounted at ploughing treatment (63.67/trap/week) on 23-11-2019 which was non-significant from ploghing treatment (53.00/trap/week) on 23-11-2019 which were significantly different from all other intervals and approaches which showed in (Figure No. 1).

The maximum fruit fly infestation (33.67%) was recorded in control treatment on 27-11-2019 which were non-significant different from ploughing (18.00%) on 27-10-2019 and weeding (17.33%) on 27-10-2019 which were significant different from all other approaches and data observation intervals. The lowest fruit fly infestation was accounted at sanitation treatment (1.33%) on 23-11-2019 which have non-significant difference from same treatment on 17-11-2019 (2.00%) which were significantly different from all other intervals and approaches which showed in (Figure No. 2).

The highest number of flies (207.00/trap/week) were recorded in methyl eugenol treatment on 23-11-2019 which were significantly different from control one (195.33/trap/week) on 17-11-2019 and control one (178.00/trap/week) on 03-11-2019. The lowest number were accounted at protein hydrolysate (73.63/trap/week) on 23-11-2019 which was non-significant from double-layer brown paper bag (75.67/trap/week) on 23-11-2019 which were significantly different from all other intervals and physical approaches which showed in (Figure No. 3).

The maximum fruit fly infestation (33.67%) was recorded in control treatment on 27-11-2019 which were non-significant different from ploughing (18.00%) on 27-10-2019 and weeding (17.33%) on 27-10-2019 which were significant different from all other approaches and data observation intervals.

The lowest fruit fly infestation was accounted at sanitation treatment (1.33%) on 23-11-2019 which have non-significant difference from same treatment on 17-11-2019 (2.00%) which were significantly different from all other intervals and approaches which showed in (Figure No. 4).

The highest number of flies (253.67/trap/week) were recorded in trichlorfon application on 03-11-2019 which were significant different from all other approaches and data observation intervals. The lowest number fruit fly population were accounted at acetamiprid (65.67/trap/week) on 23-11-2019 which were significantly different from all other intervals and insecticides which showed in (Figure No. 5).

The maximum fruit fly infestation (24.33%) was recorded in control treatment on 17-11-2019 which were non-significant different from also control one (22.00%) on 03-11-2019 and (21.67%) on 10-11-2019 which were significant different from all other approaches and data observation intervals. The lowest fruit fly infestation was accounted at abamectin treated orchards (0.67%) on 23-11-2019 which were significantly different from all other intervals and insecticides which showed in (Figure No. 4.6).

The maximum fruit fly population was recorded (202.00/trap/week) was recorded in male annihilation technique on 27-10-2019 which were significant different from second one and data observation intervals. The lowest fruit fly infestation was accounted at bait application technique (77.33/trap/week) on 23-11-2019 which were significantly different from all other intervals and insecticides which showed in (Figure No. 4.7).

During the data observation intervals the highest number of flies (17.00%) were recorded on 27-10-2019 which were significant different from all others intervals. Non-significant different were observed between (15.33%) on 20-10-2019 and (13.67%) on 13-10-2019. On 06-10-2019 the fruit fly population was recorded (11.00%) which was significantly different from all other intervals. On 10-11-2019 the fruit fly population was recorded (11.00%) which was significantly different from all other intervals. The fruit fly infestation was observed on 17-10-2019 (5.33%) which also significant different from remaining one. The lowest fruit fly population per trap (03.00/%) were recorded on 23-11-2019 and significantly from all other data intervals showed in (Figure No. 4.8).

The highest number of flies (188.33/trap/week) were recorded in control one on 03-11-2019 which were significant different from all other approaches and data observation intervals. The lowest number were accounted at IPM-4 (94.00/trap/week) on 17-11-2019 which significantly different from all other intervals and approaches which showed in (Figure No. 4.9).

The highest number of flies (26.00%) were recorded in control one orchards on 03-11-2019 which were significant different from all other approaches and data observation intervals. The lowest number were accounted at IPM-3(2.00%) on 23-11-2019 which significantly different from all other intervals and approaches which showed in (Figure No. 4.10).

Our results are in line with Asadullah *et al.* (2012) who conducted an experiment under field conditions in Kunduz province, Afghanistan to evaluate the efficacy of different control measures. Results revealed that the maximum infestation was recorded in control (23.00) and minimum in diptrex (6.17). Control one showed high percent of infestation of fruit fly then other one. The finding also match with also supported by Sarwar, (2015) who concluded that cultural management strategies to complement crop hygiene or sanitation include, production during periods of relatively low fruit fly activity, growing of less susceptible varieties, early harvesting of fruits and fruit bagging practices that can be effectively employed to manage fruit fly infestations in fruit and vegetable crops.Our results are co-related with Dias *et al.* (2018) who performed a systematic review of research which showed that quarantine treatments control the fruit fly up to 17%.

These results in line with Leblanc *et al.* (2011) who evaluated the efficacy of cue-lure, methyl eugenol solid lure with insecticides dispensers for the management of fruit fly in Tahiti. Results indicate that mallet MC showed maximum result when compare to methyl eugenol and cue-lure was apply separately. Results also in line with Navarro-Llopis *et al*. (2015) used the traps in pest management strategies to reduce Mediterranean fruit fly populations has proved to be efficient. Direct field observations have revealed that fruit damage is higher in trees with traps than in trees without them. When traps were baited with protein hydrolysate, fruit damage was even higher than in trees without traps. However, fruit damage was significantly diminished when efficient bait station devices were used. Results also matched with El-Salam *et al.* (2019) who tested the yellow sticky and plastic McPhail-type traps in integrated pest program for controlling the olive fruit fly, *Bactrocera oleae* in Egyptian. The Yellow sticky traps captured significantly more flies than McPhail traps.

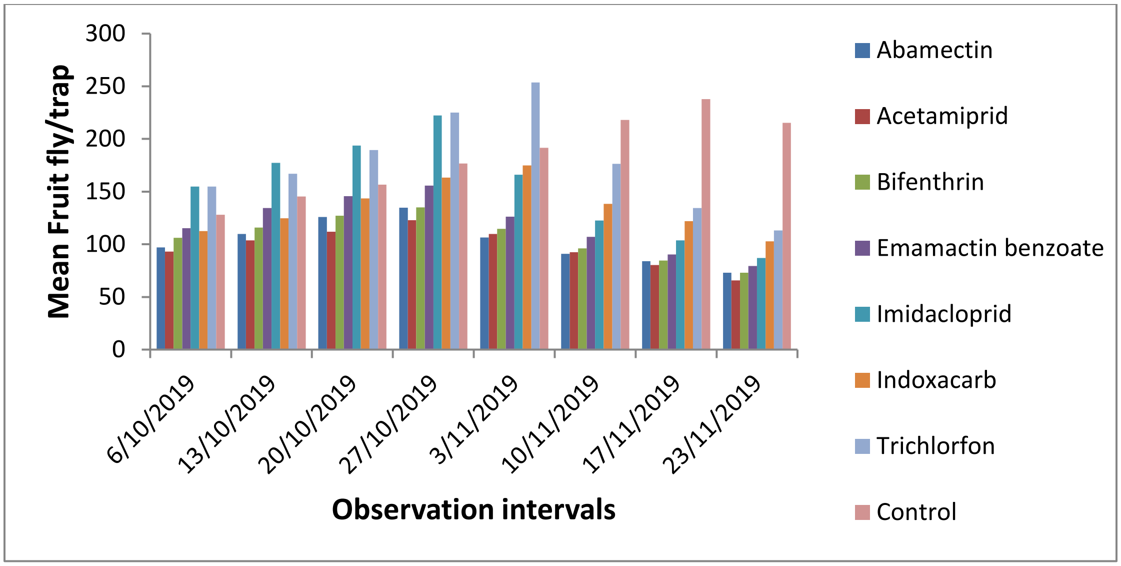

Figure 5. Mean fruit fly per trap per week comparison between different observation intervals and insecticides at District Faisalabad on citrus orchards

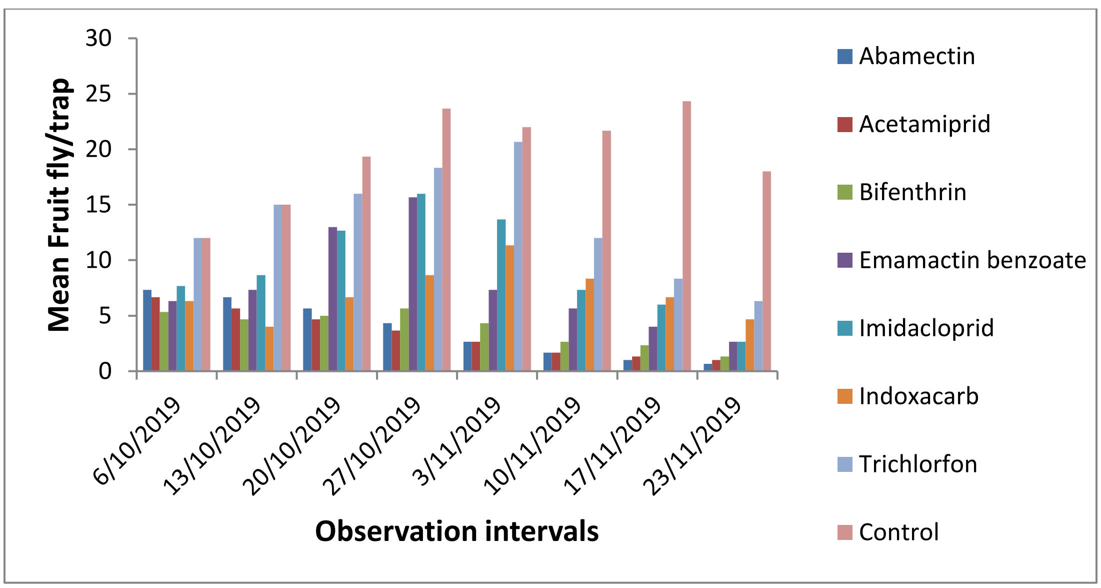

Figure 6. Fruit infestation (%) per acre recorded between different observation intervals and insecticides at District Faisalabad on citrus orchards

Our results support by Braham *et al*. (2007) who conducted field experiments to tested the efficacy of spinosad, kaolin and malathionin the orange, *Citrus sinensis* (L.) Osbeck, in Sidi Bouali, in Tunisia. Results indicated that male flies were detected no significant differences between treatments. Fruit spoil (number of fallen fruits and fallen punctured fruits) were in lesser on kaolin-treated trees than spinosad, malathion, and untreated trees. Chuang and Hou (2007) also calculated the methyl eugenol with neonicotinoid insecticides against melon fly in laboratory and field trials.

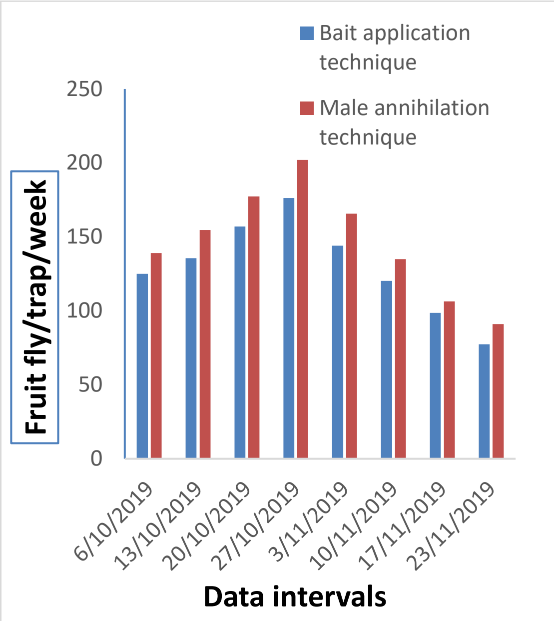

Figure 7. Mean fruit fly per trapper week captured between interaction during different observation intervals and biological control at District Faisalabad on citrus orchards

Results showed that naled was kill fruit fly 98.3%-100% at 24-74 houre after treatment in laboratory, in neonicotinoid insecticides imidacloprid and acetamipid kill 60-80% fruit fly at 24-74 hour after treatment. The residual effect of naled and persistent 96 week and persistent of imidacloprid or acetamiprid was 150 week, mortality rate 38.9 and 61.2 % respectively. The mortality rate of clothiamidin and other neonicotinoid insecticides nearly 80% after 24 hour treatment and residual effect were 28 week and after 72 hour of exposure the result of imidacloprid was upto 91.8% i.e the mortality rate of fruit fly. The attractiveness methyl eugenol alone or incorporated with naled or neonicotnoid insecticides were same in field trials. The addition of imidacloprid or acetamiprid kills 40.1 or 64.3% respectively. When assayed once every 2 week from traps to 42 week without changing the poison.

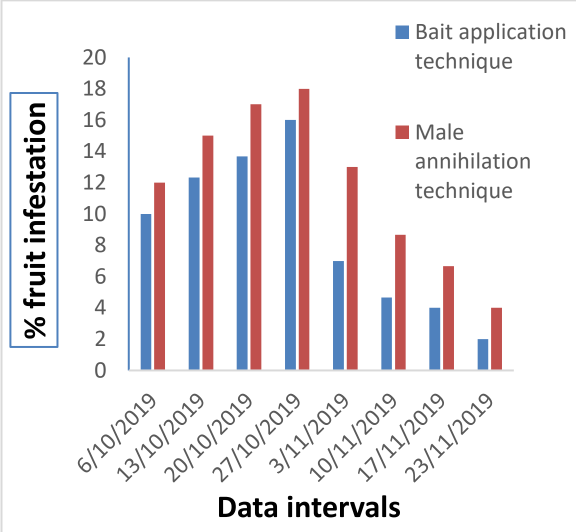

Figure 8. Fruit infestation (%) during different observation intervals at District Faisalabad on citrus orchards where biological controlapplied

The result of naled was high 98% after 34 week and 80% after 42week. It was also observe that neonicotnoid insecticides used as broad spectrum for fruit fly control.Chueca *et al*. (2007) also evaluated the efficacy of different insecticides against*Ceratitis capitata* (Wiedemann) in Spain. Results revealed that the field experimental demonstrated that 0.1% Spintor 480 SC®0.5, 5% Spintor Cebo®, percentage Nu-lure, and 0.5% malafin 50®0.5percentage Nu-lure condensed *C.*

capitata adults likewise and secluded fruit from *C. capitata* harm to a similar amount.Ghanim *et al*. (2010) also studied the effectiveness of compound products of naled, lambada, fenthion (Lebaycid), fenitrothion (Sumithion), malathion and dimethoate (mixed with methyl eugenol in the ratio of 1:4), in addition to commercial malathion (57% EC mixed with methyl eugenol in two ratios of 1:2 and 2:3) evaluated under field conditions as male annihilation technique (lure and kill) of *Bactrocera zonata* (Saunders) (Diptera: Tiphritidae). The obtain results exposed that naled mixture was significantly greater to all other mixtures regard less area inspection. Naled mixture blocks were comparatively effective for up to 8 weeks while others efficiency did not go over 4 weeks. Commercial malathion (1:2), technical malathion, dimethoate was the significance. It was optional that naled mixture can be used successfully in *B. zonata* male annihilation technique and renewed every two month. Lambada, lebaycid, sumithion, commercial malathion (2:3) mixtures used with monthly new beginning.

Results also matched with El-Aw *et al*. (2008) determined the efficacy of malathion, methomyl and spinosad *Bactrocera zonata* (Diptera: Tephritidae) in Egypt. Results indicated that the carbamate insecticides, methomyl were affect more flies than the neonicotinoid insecticides, actara, biorational insecticides, spinosad and the OP-insecticide, malathion in feeding assay under the laboratory. Spinosad was more powerful than the fruit fly recommended insecticide, malathion. Mosleh *et al*. (2011) also checked the efficacy of different insecticides against the peach fly, *Bactrocera zonata* (Saunders) (Diptera: Tephritidae), in laboratory condition. Results showed that diazinon was the majority toxic with the tested compounds followed by malathion,methoxyfenozide and lufenuron to *Bactrocera zonata* at 24 hour after treatment, the individual LC_{50} doze for males were 0.20 ppm, 0.48 ppm, 8.97 ppm, and 9.73 ppm and for females 0.26 ppm, 0.91 ppm, 11.26 ppm, and 14.12 ppm. After 48 hour treatment diazinon did malathion, methoxyfenozide and lufenuron follow the mainly toxic to *Bactrocera zonata*, LC_{50} values were 0.09ppm, 0.34 ppm, 1.60 ppm, and 1.88 ppm for males and 0.14 ppm, 0.44 ppm, 1.68 ppm and 2.17 ppm for female's flies. After 72 hour treatment diazinon was the most toxic follow by malathion, lufenuron and methoxyfenozide to *Bactrocera zonata*, LC_{50} values were 0.02 ppm, 0.13 ppm, 0.22 ppm and 0.51 ppm for males and 0.07 ppm, 0.16ppm, 0.55 ppm and 0.62 ppm for female's flies. LC_{50} values

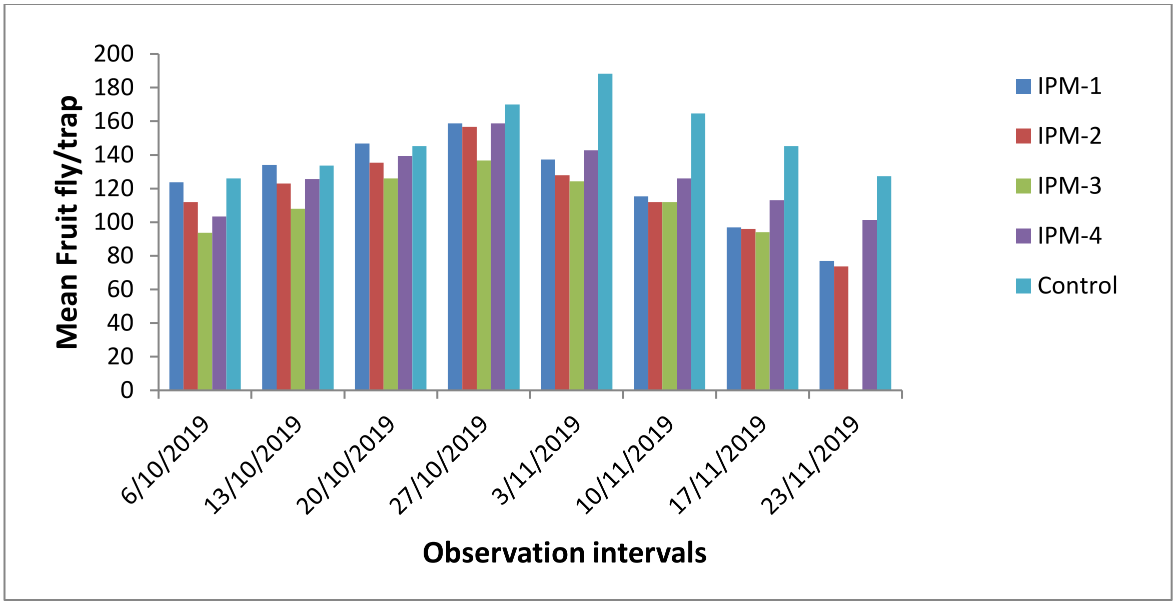

Figure 9. Mean fruit fly per trap per week comparison between different observation intervalsand integrated pest management approaches at District Faisalabad on citrus orchards

were treated for adult females increased more than in the treated adult males at 24, 48 and 72 hours after management. The results were so as to the adult male additional susceptible in the direction of the experienced insecticides than adult females flies.Juan-Blasco *et al*. (2013) determine the effect of eight different insecticides against fruit fly in citrus fruits. Results indicated that highest mortalities was found in chlorpyrifos and spinosad respectively. Reynolds *et al*. (2017) also investigated the alternative in-field chemical controls against *Bactrocera tryoni* (Froggatt). Infested fruit treated with acetamiprid, fenthion, and thiacloprid produced no/very few offspring. Alpha-cypermethrin demonstrated good field efficacy against adults (one day post treatment: 97.2% mortality, five day post treatment: 98.8% mortality) and subsequent offspring (100% across one and five day post treatments), comparable to that of fenthion (full-label rate) (100% mortality for offspring and adults across both post treatments).

Our results regarding the bait application technique match with Heath *et al.* (2008) who tested the efficacy of bait stations containing spinosad, avermectin, phloxine B and methomyl carried out laboratory bioassays with the Caribbean fruit fly, *Anastrepha suspensa* (Loew). Results exposed that the field cage studies confirmed that important mortality occurred with either1 %(w/v) spinosad or one %(w/v) methomyl bait stations against pesticide-free bait posting. Bait position were uncovered to environmental

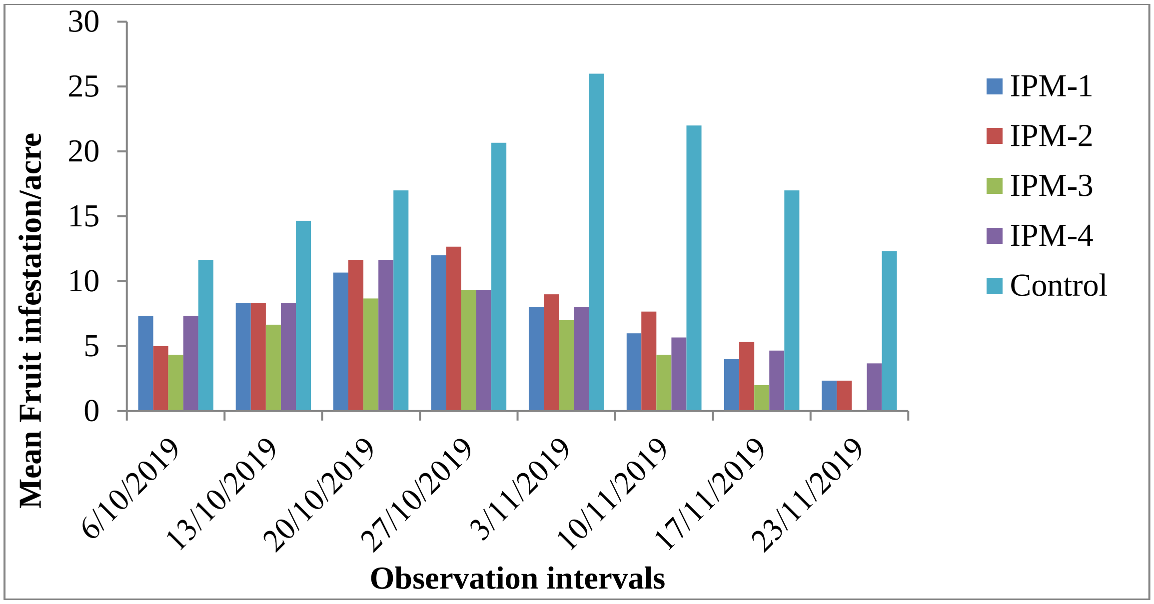

Figure 10. Mean fruit infestation (%) per acre between interaction where using different integrated pest management at District Faisalabad on citrus orchards

circumstances through introduction them during trees on the ARS station in Miami, Florida, flanked by tests.

The results also supported by Pinero *et al.* (2009) who tested the efficacy of GF-120NF against fruit fly. Results revealed that the plot, which apply high and moderate application, have fewer fruit flies than the control one. Result indicate the foliar application of GF-120NF were effective to control the fruit fly population.Ali *et al.* (2010) also checked the effectiveness of different control practices against the fruit fly which including the cultural control measures, MAT and BAT during 2007 at district Peshawar. The data showed that the best control measured was MAT application which control more fruit fly, eco-friendly and economically reasonable for the farmer. After MAT technique the second best was BAT and least or less cultural control measures. Hence, it was concluded that the MAT application technique was best for fruit fly management.

The results also correlated with Vargas *et al.* (2008) who evaluated the specialized pheromone and lure application technology (SPLAT) by means of methyl eugenol and cue-lure contains the spinosad making sprayable formulation of oriental fly *Bactrocera dorsalis* and melon fly *Bactrocera cucubitae*. The experiment was conducting field with three different dispanser (Min-U-Gel, Acti-Gel, and SPLAT) and two different insecticides like naled and spinosad. The result of SPLAT methyl eugenol by means of spinosad was equivalent to standard Min-U-Gel methyl eugenol by means of naled within 12 week. The evaluation of SPLAT cue-lure by means of spinosad was same to standard Min-U-Gel cue-lure with naled during 7-12 week, but not same 1-6 week. In the other work the SPLAT methyl eugenol by spinosad give effective result then Min-U-Gel methyl eugenol through naled throughout 1-6 week and was superior during 7-12 week on papaya and guava orchards. In an open weathering test, cur-lure dispensers (SPLAT with spinosad, SPLAT with naled and Min-U-Gel with naled) were more effective up to 70 day.Lloyd *et al*. (2010) also conducted an experiment for the management of *Bactrocera tryoni* in citrus and other fruit crops at Queensland central District of Australia during four years from 2003 to 2007. Different IPM approaches was applied such as bait spry, insecticides and MAT application to reduce the infestation of fruit fly in the areas. The results showed that farmers which used AWM programs was reduced the infestation of fruit fly from 60.8 to 21.8%. Our results showed that more profit return from the crop where we applied the AWM than untreated orchards.Leblanc *et al.* (2011) also evaluated the efficacy of cue-lure, methyl eugenol solid lure with insecticides dispensers for the management of fruit fly in Tahiti. Results indicate that mallet MC showed maximum result when compare to methyl eugenol and cue-lure was apply separately. Mallet can be used in the IPM program for fruit fly because it was environmentally friendly. Navarro-Llopis *et al*. (2013) also carried out the field trials in two citrus areas to test the efficacy of attract-and-kill devices against mass trapping and spinosad plus bait treatments. The results indicated that The Magnet® MED attract-and-kill device, Spintor® treatments and mass trapping achieved good control of *C. capitata* populations, confirmed by low percentages of damaged fruit in the harvest assessments. Conversely, the fly population levels on plots treated with another attract-and-kill prototype device increased three times more than the populations recorded in other treated plots. The same was observed for fruit damage, with from six to eight times less damage with Magnet® MED and spinosad treatments, respectively, vs. the attract-and-kill prototype devices.Demirel and Akyol (2017) also evaluated the mass trapping for the control of Medfly in Satsuma mandarin in Hatay province of Turkey. In the first year, a total of 8968 medfly adults were caught by traps. The largest mean of catches per trap were recorded on 31 October (64.21), followed by 24 October (31.29), 17 October (22.48), 7 November (20.64), 3 October (17.60) and 10 October (16.71). In the second year, a total of 1307 medfly adults were caught by traps. The largest mean of the catches per trap were recorded on 25 September (7.35), followed by 13 November (5.83), 6 November (5.52), 18 September (5.43) and 30 October (4.26), respectively. The percentages of damage rates of medfly observed in both years. The damage rates of Medfly were 10.91 and 8.56 % in 2011 and 2012, respectively. In conclusion, the population density of medfly on satsuma mandarin increased in September and October due to high temperature. The mass trapping was not enough to control medfly on satsuma mandarin. Therefore, the mass trapping should be used with pesticides to decrease the population density of medfly during September and October in Hatay province of Turkey.

Results also match with Farman *et al*. (2015) who carried the experiment for the management of melon fruit fly with different control practices. The treatment including the use of bagging, bait traps, insecticides and methyl eugenol. The results revealed that population was decrease 61.38 to 76.84% in the treatment where we bait application and insecticides respectively. Hence it's concluded that the bait application was best control measured compared to other treatment for melon fruit fly.Allahyari *et al*. (2016) also surveyed to analyze the factors determining adoption of IPM practices for the control of *Bactrocera oleae* in Roudbar county of Guilan province, Iran. Twelve variables were found to be strongly correlated with adoption of IPM practices for olive fruit fly control. Discriminant analysis was used to identify the variables with the greatest power of classifying growers in three groups of IPM adopters (low, medium, and high level of adoption). The variable: farming experience and especially the olive farming experience along with the variables: family size and extension activities gave an overall classification accuracy of 72.1%, implying a strong capability of correctly differentiating growers in the IPM groups. Understanding growers' characteristics and behavior concerning the adoption of IPM can be a first major step for boosting adoption rates among olive growers of the study area or among growers of other areas with a similar profile. To this end, government policies should strengthen growers' technical knowledge of IPM concerning olive fruit fly through extension services and community involvement, particularly among inexperienced small-scale growers.Muriithi *et al*. (2016) checked the effectiveness of IPM program against the fruit fly in mango orchards. Results exhibited that the farmers used IPM programs produced more yield and higher income in profit return. The farmer used the IPM management programs less damage to mango orchards compared to untreated orchards. Hence, it was proofed that the IPM program was best for the management of fruit fly in mango orchards. Demirel and Akyol (2017) also evaluated mass trapping for the control of Medfly in Satsuma mandarin in Hatay province of Turkey. The studies were conducted in 2011-2012. In the first year, a total of 8968 medfly adults were caught by traps. The largest mean of catches per trap were recorded on 31 October (64.21), followed by 24 October (31.29), 17 October (22.48), 7 November (20.64), 3 October (17.60) and 10 October (16.71). In the second year, a total of 1307 medfly adults were caught by traps. The largest mean of the catches per trap were recorded on 25 September (7.35), followed by 13 November (5.83), 6 November (5.52), 18 September (5.43) and 30 October (4.26), respectively. The percentages of damage rates of medfly observed in both years. The damage rates of Medfly were 10.91 and 8.56 % in 2011 and 2012, respectively. In conclusion, the population density of medfly on satsuma mandarin increased in September and October due to high temperature. Ashfaq *et al*. (2020) also assess the losses of fruit in three citrus varieties from four different locations of each research site during 2015-16. Male Annilation Technique (MAT) and Bait Application Technique (BAT) with insecticides and sanitation measures (Collection of infested fruit and buried deep in soil) were applied in the form of three IPM models to monitor the infestation rate. The results show that maximum loss of fruit (14.95%) was computed after 60 days of observation among three citrus varieties whereas the minimum fruit loss (6.87%) was measured at 15 days interval. Among varieties, maximum loss (18.92%) was observed in *Citrus reticulata* during both years followed by *C. sinensis* and *C. paradisi* with the highest loss in district Faisalabad (14.66% & 12.26%) as compared to district Sargodha (8.91% & 7.67%), respectively. Among IPM models, the highest infestation was observed in IPM-1 (6.90%), followed by IPM-2 (4.31%). Minimum infestation was recorded by IPM-3 (3.10%). The above findings indicated that the integrated management of *B. zonata* using MAT and BAT techniques has significant effect over control on the fruit fly infestation in the citrus orchards of the study area.

Elekcioglu *et al*. (2020) also studied the effectiveness of the integrated pest management (IPM), mass trapping and chemical control were compared in an orange orchard in Tarsus (Mersin) during 2015 and 2016. The highest number of flies was detected in the control plot as 404 flies/trap/week in 2015 and in chemical control plot as 429 flies/trap/week in 2016. No statistical difference was found between the applications regarding the number of male flies weekly captured and number of infected fruits. However, it was determined that the ratio of infected fruits in the IPM plot was lower than that of other plots (1.57% in 2015 and 0.89% in 2016) at harvest, followed by Biolure, Trimedlure and Spinosad, respectively. It was concluded that IPM, which included the application of several methods, was the most effective control practice for *C. capitata*.

The IPM results alos matched with Mwungu *et al*. (2020) who examined the impact of an IPM strategy developed to control mango fruit flies on humans and the environment. The results indicate that the adoption of the IPM strategy reduced pesticide use and pesticide toxicity. Policy efforts therefore should focus on promoting and disseminating fruit fly IPM to improve the livelihoods of rural mango farmers, but also reduce human health and environmental threats as a result of pesticide use. Yazid *et al*. (2020) also carried out in commercial clementine orchards (*Citrus clementina* variety Fina Berkane) in three localities of Moulouya Perimeter (Lamriss, Reggada and Slimania) to assess the effectiveness of introducing this technique in phytosanitary management programs against Medfly. Our finding showed that plots that had undergone systematic chemical spray every seven days recorded an average rate of fruit infestation of 2.35%, and those with the Grower's conduct recorded a rate of 4.75%. Therefore, mass trapping, applied alone, did not reduce significantly the rate of fruit infestations by Medfly (3.66%), but once included in an integrated pest management program, it significantly reduced the rate of infested clementine fruits, to achieve a rate of 1.46%. Xia *et al*. (2020) also investigate the species, the abundance of tephritid fruit flies in the orchards, as well as the efficacy of the selected lure traps to these flies. Four lure traps or devices, *i.e*. methyl eugenol + Steiner trap (ST), cuelure + ST, ammonium acetate + putrescine + ST, and sticky spheres, were deployed from June to November 2017 and April to October 2018. Six economically significant Dacini pests were trapped during the period. These flies are *B. dorsalis*, the melon fruit fly, *Zeugodacus cucurbitae,* the pumpkin fruit fly, *Z. tau*, the Malaysian fruit fly, *B. latifrons*, andother two species - *B. rubigina* and *Z. scutellatus*. *B. dorsalis* was the most abundant, accounting for more than 50% of the capture, followed by *Z. cucurbitae*. The remaining four species accounted for less than 2% of the total capture. *B. minax* and *B. tsuneonis*, two destructive citrus damaging tephritid fruit flies in China, were not found during the trapping period. Methyl eugenol trapped the highest number of fruit flies, followed by cuelure.

4. Conclusions

This study improved that for the management of fruit fly in citrus adopted the integrated management method which are suitable for control of citrus fruit fly. It also showed that early eradication of fruit useful for increased the yield of citrus crop.

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