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Surveillance on Population Dynamics and Fruits Infestation of Tephritid Fruit Flies (Diptera: Tephritidae) in Mango (*Mangifera indica* L.) Orchards of Faisalabad, Pakistan

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Abstract. Fruit flies (Diptera: Tephritidae) are amongst the world's worst pests of fruits that cause enormous losses in orchards. Due to their economic importance, fruit flies are severe pests of Mango *Mangifera indica* L. fruit, and their monitoring and infestation estimation are essential in order to formulate integrated pest management program. For practical field implementation, two variables such as flies per trap per weak were monitored by installation of Steiner traps hung on tree baited with Methyl eugenol attractant and percent fruit infestation through fruit host samplings. Surveillance for flies per trap was done each week by counting trap catches, recording and removing any flies that have been collected in traps and identifying the species. The percentage of fly infestation for mango fruit was examined by randomly analyzing a total of 100 fruits and observing number of fruits showing fruit fly oviposition or injury marks. The results showed that tephritid fruit fly *Bactrocera zonata* (Saunders) was the predominant species (more frequent and constant) at experimental site. Surveillance of fruit fly populations in mango orchard revealed that peak population of *B. zonata* (40-30 per trap per week) and fruit infestation (9.05-7.45%) were recorded in June, July and August. The availability of host fruit and its productivity were critical factors affecting population fluctuations of the *B. zonata* fly. All of this information gives fruit fly activity in an area, an estimate of the population, species composition, sex, growth stage and determining whether the number of pests are increasing or decreasing to decide implementation of pest control operation.

Keywords: Fruit fly, Host preference, Oviposition, Bactrocera, Fruit, Mango.

1. INTRODUCION

Mango (*Mangifera indica* L.), is one of the most versatile and delicious tropical fruits, and having an outstanding flavor with a range of varieties as a member of the family Anacardiaceae. Mango has a good nutritional value and there is great variation in the form, size, color and quality of the fruits. Mango is an excellent source of vitamin A and C, as well as a good source of potassium, beta-carotene and fiber. Normally, it is produced for human consumption as raw or ripe mango products. During the processing of ripe mango, its peel and seed are generated as waste, which is approximately 40-50% of the total fruit weight. Mango peel is a good source of dietary fiber and its chemical composition may be comparable to that of citrus fiber. The peel has a high value of antioxidant activity and glucose retardation index, while its aroma and flavor are pleasant (Larrauri et al., 1999). Mango canning by-products (seed and peel) together with ensiled mango peel were subjected to analysis, crude protein content in peel, seed and peel silage is 4.68, 4.19 and 5.27%, respectively. As expected, mango seed has a higher fiber content than mango peel and peel silage as indicated by neutral detergent fiber (53.01 vs 25.87 and 27.56%, respectively) and acid detergent fiber (31.02 vs 19.14 and 17.68%, respectively). However, mango seed also has greater gross energy than mango peel and peel silage (4,070 vs 3,827 and 3,984 k cal/ g dry matter, respectively), probably due to its partly high fat content (Sruamsiri and Silman, 2009).

Fruit flies (Diptera: Tephritidae) are considered the most destructive insect pests of fruits and vegetables in the world. The hosts of these flies belong to a wide variety of families of plants, and include many major commercial crops (Vayssieres et al., 2008; Salem and Abd-El- Salam, 2013). Without flies control, direct damage has been reported from 30 to 80% depending on the fruit, variety, location and fruit season (Mwatawala et al., 2006). Mango flowers are visited by bees, flies, wasps, butterflies, moths, beetles, ants

and bugs, seeking for the nectar and some of them transfer the pollens. But, the fruit flies are the greatest and one of the most serious enemies of the mango fruit. Fruit flies often cause serious damage to mango; owing to their attack the highest damage observed in mango was 56.5% (Jose et al., 2013). During recent decades mangoes from Pakistan, are one of the most popular fruits in the world and its production has become increasingly significant as an important food source. Additionally the demand for the fruit is increasing and mango can provide with a valuable source of income to small farmers. Peoples from Pakistan are active in the mango trade including processing and export, they have also gained access to superior export markets and percentage of its export shows a continuous increase. On the other hand, there are stringent regulations of quarantine globally and ban on export can be imposed on any fruit affected by fruit flies, so this restriction can exclude farmers from a profitable market (Riaz and Sarwar, 2013; 2014).

Due to the major fly pests of mango; all varieties can be infested by the fruit flies excluding some varieties which are less preferred, such as those with bitter skin. The levels of fruit fly infestation depend on the surrounding host plants and. agro-ecological conditions of the locality. A little damage can be caused to host when the female with its ovipositor stings to the fruit to lay eggs. As soon as this occurs, latex leaks from the punctured wounds and can be observed on the skin of fruit. The females fruit fly usually choose only maturing or mature fruits to lay their eggs, on the other hand in certain cases, some immature young fruits are also attacked, which may fall to ground from the host tree. The most severe injure is caused by the larvae (maggots or worms) by inside feeding on the fruit pulp causing softening of the fruit, internal discoloration, off-flavors, fruit-fall and finally general spoilage. After the larvae emerge from the fruit to pupate in soil, they create an outlet opening in the skin of fruit, then bacteria and fungi penetrate in the host through these openings and cause fruit rotting. Besides direct fatalities, indirect losses as a result of enormous quarantine restrictions are imposed by mango importing countries (Sarwar, 2006; Domingos and Serafina, 2009; Sarwar et al., 2013). Prior to orchard treatment, pest identity information, together with pest infestation information is needed to decide on the plant management measures by mango producers to have benefits from increased yields and improved fruit quality. An important element of integrated pest management is study of pest surveillance and incidence which are crucial to keep the fly populations in check and significantly increase the quality of fruit that restrict movement of fruits from infested areas (Mirani, 2007; Ghafoor et al., 2010). For the definition of pest status, several activities can be conducted, including surveillance and identification of fruit flies diversity, and quantification of pest status and damage caused by key fruit fly species in mango orchard.

2. MATERIALS AND METHODS

2.1. Experimental site

For practical field implementation, fly monitoring and fruit infestation estimation were recorded during the two experimental seasons 2011 and 2012 at the Post-Graduate Agriculture Research Station (PARS), that is a model farm of University of Agriculture, Faisalabad. The experimental area was comprised about 3 acres (three replicates) of Mango *M. indica* orchard grown with variety "Langra", and field tests were conducted from January to December 2011-12. This region is cultivated mainly with guava, citrus, dates and miscellaneous crops. The region has very good climatic conditions for growing mango trees. The chosen orchard area has a high degree of isolation from other orchards. The culture control practices and ground spray applications using chemical insecticides methods are usually used for controlling fruit flies in the locality.

2.2. Surveillance of fruit fly populations

Surveillance of fruit fly populations was undertaken by installation of Steiner traps baited with sex attractant (lure Methyl eugenol) and pesticide used as a killer, and counting trap catches to examine the relative seasonal abundance of pest. The traps made of plastic material and hung in tree were distributed in a completely randomized block design in three replications. In each replicate, 1 trap was used and each replicate containing one trap comprised similar sex attractant or bait trap. The distance between each replicate was about 50 meters and the direction of the traps was south and north sides. All the traps were hanged at about 3 m height in a shady place of the mango trees. For indicating the population fluctuation trends of the tephritid fly species, the average number of flies per trap every one week were counted and recorded during the whole experimental season. The captured adult flies were counted and recorded separately for each Methyl eugenol trap. The adults of fruit flies collected were preserved in 75% alcohol in vials for later identification and the samples were identified at the Entomology Laboratory of this Institute.

2.3. Assessing of fruit fly infestations

The samples of mango fruit were collected weekly for checking pest infestation symptoms and noting fruit fly infestation. The percentage fly infestation for mango fruit was examined randomly by analyzing a total of 100 fruits, and numbers of healthy fruits and fruits showing fruit fly oviposition marks (damaged and undamaged fruits) were counted. For host fruit species, 10 trees were randomly selected and from each tree, 10 fruits were examined. Any fruit was considered damaged if fly ovipuncture mark was in evidence or if when fruits were fallen on ground and is difficult to observe the oviposition puncture, fruits were opened slightly to check the presence of larvae. By following this procedure, when at least one fruit fly larva was observed inside the fruit, it was considered damaged. For assessing fruit fly infestations, from total numbers of fruits observed subtracted the numbers of infested fruits counted and then percent infestation was calculated.

2.4. Statistical analysis

Data obtained on fly monitoring and fruit infestation estimation were statistically analyzed by using the Statistix 8.1 software. The data means were compared according to ANOVA and subjected to LSD test at $P \leq 5.0$.

3. RESULTS

Peach fruit fly species, *B. zonata* was frequently recovered from the traps and fruits collected, and recorded as the most abundant species and accounted maximum of total emerged pests. The obtained data as shown in Table 1, indicated that fly adults showed different response of population and infestation trends during the experimental season as indicated by number of flies captured by traps. However, overall there were statistical differences among the parameters of the means of fly captured in traps and fruit infestation.

Table 1: Population Dynamics and Fruits Infestation of Tephritid Fruit Flies in Mango (*Mangifera indica* L.) Orchards

Month	Fruit fly population per trap per week	Fruit infestation (%)
January	0.41 h	0.00 g
February	0.10 h	0.00 g
March	0.83 h	0.00 g
April	2.50 g	2.43 f
May	27.33 d	3.70 e
June	40.06 b	9.05 b
July	42.66 a	10.99 a
August	30.00 c	7.45 c
September	13.25 e	5.36 d
October	7.50 f	0.00 g
November	3.50 g	0.00 g
December	0.83 h	0.00 g
S. Error	0.758	0.311
LSD Value	1.573	0.646

Means of fruit fly captured and percent infestation within columns followed by the different letter are significantly different ($P \leq 5.0$).

3.1. Surveillance of fruit fly populations

As clearly illustrated in the Table 1, the natural populations of *B. zonata* fly adults during the whole season in field test as indicated by number of flies captured by traps showed greater fluctuations. Concerning for the attraction of fly adults in traps, the traps installed in July attracted the highest number of adults *B. zonata* with a mean of 42.66 flies per trap per week by way of significant difference in study year. The total mean of *B. zonata* flies captured by attractant traps in June were more (40.06 adults) than the mean captured counted in August (30.00 adults) followed by May (27.33 adults) per trap per week. Based on population fluctuation levels the fly number of adults obtained and counted from attractant traps were negligible in October, November and April (7.50, 3.50 and 2.50 per trap per week, respectively). The lowest numbers of fly captured were observed in February installation trap with 0.10 adults, followed by March and December traps, 0.83 adults, than the last one in January, 0.41 adults per week with no significantly differences (Figure 1).

3. 2. Fruit fly infestations

Comparing the mango infestation form Table 1, it represents the overall a serious fruit production impediment of economic importance by *B. zonata*, however, overall there were statistical differences among this parameter. The highest amount of fruit infestation was recorded from mango taken in July (10.99%) than June (9.05%) followed by 7.45% in August, all with significant differences. While, mango

fruit represented significantly less preferable to *B. zonata* fly adults and recorded a low level of attractiveness in April, May and September (2.43, 3.70 and 5.36% infestation, respectively) with significant differences with other periods of fruit setting. It is clearly seen that the natural fruit infestation in October, November, December, January, February and March was zero due to non-availability of fruit host when compared with the other months of year representing non-significant differences among rest of the months (Figure 1).

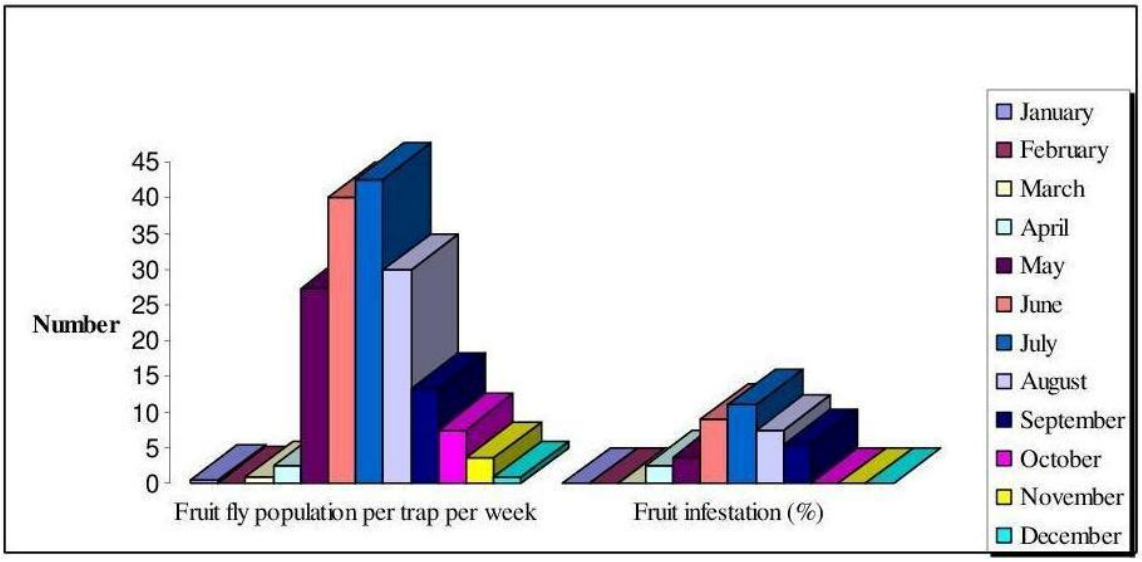

Fig. 1: Gross Results Showing the Population Dynamics and Fruits Infestation of Tephritid Fruit in Mango (*Mangifera indica* L.) Orchards

4. DISCUSSIONS

As shown in current studies, fruit fly *B. zonata* became the most predominant pest in mango orchards and it was the only species that occurred in all studied fruits host due to multiple infestations and high numbers of trap catches. The observed dominating nature of fruit fly species reveals its greater polyphagy and competitive abilities. This ability may indicated by two possible displacement mechanism of other flies due to this pest, explicitly (1) larvae competition for the same food resource in the same fruit; and (2) adult aggressive behavior that do not leave females of other fruit flies species to lay eggs in the same fruits (Ekesi et al., 2009). Currently, *B. zonata* was considered the major pest, dominant species ad more frequent at experimental site. This can be attributed because of its polyphagous and destructive nature, rapid spread and invasiveness nature, and prevalence and predominance in attacked hosts. Aluja and Mangan (2008) had stated the similar opinion that the diversity of fruit trees in a natural afforest increases the likelihood of occurrence of monophagous species of fruit flies. The study of Mwatawala et al., (2006) confirmed that the invasive fruit fly is well established in the study area where it occurs at high densities and is becoming the most abundant species over the native fruit flies species in attacked fruits.

Additionally, as a result of the experimental work carried out on surveillance of fruit fly populations in mango orchard by installation of traps revealed that peak population of *B. zonata* and fruit infestation were recorded in May, June, July and August. This is because the mango fruits ripened during the month of July and August. Present results endorse the findings of Anjum et al., (2000) who observed peak population of *B. zonata* in the first week of July and the population of *B. zonata* was higher than of *B. dorsalis*. This was also confirmed by Khalid and Mishkatullah (2007) in Northern Punjab that the fruit flies showed a low population level from November to February, and increased level from March to August. The population peak appeared in July and August and maximum declined was observed in October depending on the host fruit maturity, temperature and rainfall. Availability of host fruits was another essential factor affecting population fluctuation. Therefore, the fruiting period and productivity exerted essential effects on the fly population fluctuations.

Pest populations were low during most of the year, but the peak number of fruit flies captured and infestation trends were linked to the fruiting peaks of their major mango host or pest activity increased when fruit reached maturity (May-August). Other population fluctuation studies in other states of world have also demonstrated this tendency. Plant susceptibility to insects depends on the phenological

synchrony between pest and host. Knowledge about fruit fly species and their respective seasonality related to host plant phenology is crucial to understand the population dynamics of these insects (Souza-Filho et al., 2009). Fruit infestation is influenced by its degree of maturation during the fruit fly oviposition period (Messina and Jones, 1990). The population peak in the orchard in the period without fruits, vegetative stage and beginning of flowering, demonstrates that the pest fly population exploited the site to obtain food and shelter (Hendrichs and Hendrichs, 1990). Present findings represented a level of fruit fly damaged fruits ranged from 2.43-10.99%, whereas, the percentage of fruit damage observed was 56.50% on mango in other localities of world (Mwatawala et al., 2006). Average fruits damage varied from 10% (beginning of April) to 50% (June) for all species together in other regions (Jean-François et al., 2005). From these data obtained it is clearly illustrated that peach fruit fly adults recorded showed different degrees of preferability to food stage. The climatic conditions may have also an influence on the mean captures of fly adults and the pest preferred to attract to mature host more than other younger fruits or food.

5. CONCLUSION

Fruit flies of quarantine concern constitute an important barrier to the export of fresh fruit products, thereby limiting the trade potential of fruit producing countries. Pakistani mango is exported to large number of countries, but due to increased concerns on sanitary requirements in developed countries, the mango export can face quarantine requirements. For protecting mango harvests, the pest flies can be controlled with integrated pest management measures in environmentally friendly way. As a part of this venture, population monitoring is important to identify the presence of pest and determine when and where it appears that is essential for managing fruit fly pests. Therefore, the knowledge of mango host plant gained on population dynamics and damage incidence become important in development and implementation of *B. zonata* integrated management program. The research studies carried out on fruit fly can accomplish a number of things and insure timely implementation of appropriate pest control measures. The occurrence of *B. zonata* at high population densities in the study sites is associated with the highest severity level of damage infestation, and the availability of host fruit leading to high economic losses. Fruit fly and fruit sampling procedures are needed to be further developing and incorporate into bait station research protocols for standard quality fruit production to increase economic of the commercial sector, but also the sources of livelihood, and income security to the household sector in the country.

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