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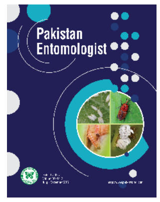

EFFECTS OF ABIOTIC FACTORS ON POPULATION DYNAMICS OF FRUIT FLY (*BACTROCERA DORSALIS* HENDEL) LARVAE AND PUPAE ON CITRUS AND GUAVA FRUITS IN SARGODHA, PAKISTAN

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ABSTRACT

Fruits are very important for human beings to treat many diseases because they are rich source of nutrients. But unfortunately some pests like fruit flies are considered as major damaging organisms for fresh fruit and vegetables. They damage fruits and vegetables by laying eggs under the skin. Fifty plants in five gardens were selected randomly to investigate the population dynamics of *Bactrocera dorsalis* and correlate with abiotic factors. The fallen fruits were collected by an interval of 9-10 days. After 10-12 days of incubation period, the infected fruit samples were exposed in the laboratory and larvae were calculated. One way ANOVA was used to determine relationship between larval and pupal population of fruit flies in citrus and guava fruits. It was concluded that all abiotic factors affect population of fruit flies. Population of *Bactrocera dorsalis* was maximum at higher temperature with low humidity.

Keywords: *Bactrocera dorsalis,* Citrus, Guava fruit, Humidity, Temperature

INTRODUCTION

Pakistan is blessed with vast agricultural resources. According to an estimate the total value of agriculture crops at current factor cost is estimated at Rs.550.268 Billion, divided into major crops Rs.407.623 Billion and minor crops including horticulture Rs.142.645 billions (PHDEB, 2005). Pakistan has ideal climate for growing a wide range of delicious fruits. Pakistan is producing a wide variety of fruits on an area of 743.6 thousands Hectares with a total production of 5712.4 thousand Tons. Out of the said production 354.4 thousands ton of fruit was exported to other countries (Pakistan, 2004).

In international trade citrus fruit is the 1st crop of Pakistan in term of value. Pakistan is the largest producer of a special kind of Reticula Variety (KINNOW) (mandarin) and Orange in world with 2.1 million tons of yield every year. According to an estimate approximately 95% of the total KINNOW produced all over the world is producing in Pakistan (World Bank, 2007). In 2004 the total citrus production acceded to 1670000 tons. Fruits and vegetables are very important for human beings for many diseases (Kader, 2001; Oguntibeju *et al*., 2013). They are rich source of nutrients and minerals, vitamins and enzymes. Moreover, they have high medicinal values (World Bank, 2007). They protect against the cancer of stomach, esophagus, lungs, oral cavity and pharynx, endometrium, pancreas and colon (Donaldson, 2004). Citrus and their products are rich source of vitamins and minerals and dietary fibers. That is essential for normal growth and development and over all nutritional well-being. Citrus is most commonly thought as a good source of vitamin C, essential nutrients including both glycogenic and non-glycogenic, carbohydrate, potassium, foliate, calcium, thiamin, niacin, vitamin B6, phosphorus, magnesium, copper, riboflavin, pantothenic, acid and a variety of phyto chemical. Citrus contain no fat or sodium and no cholesterol (Whitney and Rolfes, 1999). As an antioxidant it can prevent important disease status including cancer, cardiovascular disease & cataract formation (Gershoff, 1993; Harats *et al.*, 1998; Jacques *et al.*, 1997).

Guavas are often marketed as “Super Fruits”, being richer in vitamin A and C if the seeds are eaten too, omega 3 and omega 6 polyunsaturated fatty acids and especially high value of dietary fiber. Guavas contain both carotenoids and Polyphenols/mojorclasses of antioxidant pigments, giving them relatively high dietary antioxidant value among plants

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foods (Jimenez-Escrig *et al.*, 2001; Hassimotto *et al.*, 2005; Mahattanatawee *et al.*, 2006). Consumption of natural antioxidants is associated with a lower risk of cardiovascular disease and cancers (Renaud *et al.*, 1998; Temple, 2000).

But unfortunately some pests like fruit flies are considered as a major damaging organisms for fresh fruit and vegetables and they have successfully adapted their life cycles to most cultivated fruits resulting in endemic (Kumar, 2011). Fruit flies are among the most serious agricultural pests, having severed economic impact on tropical and sub-tropical agriculture in many parts of world and posing an increase threat of establishment into new areas (Mishra *et al.*, 2012). The true fruit flies comprising over 4000 species distributed over most of this planet, include several of the greatest potential threats. There are 350 to 375 species of genus *Bactrocera*. One of these species is the oriental fruit fly, (*Bactrocera Dorsalis*). It is a very destructive pest of fruit (Weems *et al.*, 2010). Fruit flies are most serious insect pests on horticultural crops throughout the tropical and subtropical regions (Allwood and drew, 1996; Aluja *et al.*, 1996; Amstrong and Jang, 1997; Hasyim *et al.*, 2004; Hasyim *et al.*, 2006). They damage fruit and vegetables by laying eggs under the skin the eggs hatch in to larvae feeding in the decaying flesh of the fruits and vegetables. Infected fruits and vegetables quickly become rotten and inedible crop fell to the ground prematurely, thus causing considerable losses in production (Hollingsworth *et al.,* 1997). The population dynamic of fruit flies has been studies extensively in the tropics and to a lesser extend in temperate areas laying with in the Northern, colder areas of its current geographical distribution (Bateman, 1972; Haris *et al.*, 1993; Hedstrom, 1993; Dhillon *et al.*, 2005).

Three species *Dacus Dorsalis*, *D. Zonatus* and *D. Cucurbitae* are commonly found in Pakistan. *Bactrocera Zonatus* is dominant specie and its population is higher than other two species. *B. Cucurbitae* is in a very small number and does not seem to be a serious pest of fruits. In Indian Sub-Continent there are more than 200 known species of fruits flies but less than 10 species are considered as serious pests. *Bactrocera dorsalis* (Hendel) is dominant on citrus guava and other fruits. It (Hendel) was found very serious for Guava with 46.37 percent damage while *Bacrocera zonata*, *B. cucurbitae* and *C. vexuviana* were at 2nd place and found serious for apple, ber and mango respectively (Khan, 2002). *B. dorsalis* was 1st recorded in 1916 in Bihar, India (Bezzi, 1916) and is now distributed throughout most countries of South East Asia, including Pakistan, India, Nepal, Burma, Thailand, Sri Lanka, Vietnam and China (Wang, 1996; Drew and Raghu, 2002). *B. Dorsalis* is injurious to various types of fruits but especially Guava, Citrus, Mango, Papaya, Jaman. Due to vide occurrence in sub tropical region, it is also called as oriental fruit fly (Kapoor, 1970). Oriental fruit fly attains a destructive status only in sub-tropical habitat (John and Armitage, 1949).

Development from egg to adult under summer conditions requires about sixteen (16) days for the attainment of sexual maturity. Under optimum condition, a female can lay more than 3000 eggs during her life time, but under field conditions from 1200 to 1500 eggs per female (Mau and Matin, 2007; Hungry, 2010). Infestation of 50 to 80% has been recorded in pear, peach, apricot, fig, and other fruits in West Pakistan. This species could rapidly become a very serious pest of citrus and other fruits and vegetables (Weems *et al.*, 2010). The oriental fruit fly, studies have indicated that this species can migrate relatively long distances with a maximum record of 65 km (Steiner *et al.*, 1962; Iwahashi and majima, 1972; Yao *et al.*, 1977).

They damage fruits and vegetables by laying eggs under the skin. The eggs hatch into larvae feeding in decaying flesh of the fruit or vegetables. Infected fruits and vegetables quickly become rotten and inedible or drop to the ground prematurely, thus causing considerable loss in production. The surface feeding characteristic of the fruit fly larvae is significant in that damaged fruit and vegetables can be cut without having to discard the reminder for fear of retaining any developing larvae (Hollingsworth *et al.*, 1997). In general, the yield lost due to fruit fly varies between 30-100% depending on fruit species and season (Dhillon *et al*., 2005). Trimothy *et al.* (2003) formulate that infestation caused by larvae of fruit fly causes the premature fruit drop and reduce fruit quality for olive oil production. Fruit flies can successfully be managed over local areas by fruit begging filed sanitation, protein bait, annihilation technique, growing fly resistant genotypes, augmentation of biological control, and insecticides (Akhtaruzzaman *et al.,* 1999; Sing *et al.,* 2000; Dhillon *et al.,* 2005).

Field sanitation was the most effective method for control of fruit fly. To break the reproduction cycle and population increase, growers' needs to remove all un-harvested fruits or vegetables from a field by completely burying them deep into the soil. Burying damage fruits 0.46 meter deep in the soil prevents adult fly to increase in number (Klungness *et al.,* 2005). The present study aimed to assess the seasonal fluctuations of *B. dorsalis* in citrus and guava in Sargodha, Pakistan. The objectives of the experiment are to assess the population fluctuation of *B. dorsalis* in different seasons, in different field and its correlation with a biotic stresses i.e. temperature and humidity.

MATERIALS AND METHODS

The present study was designed to estimate "population dynamics of fruit fly (larvae and pupae) on different host plants viz. citrus and guava in different gardens in Sargodha region Pakistan. The study was conducted from November 2010 to February 2011. The study was designed on population dynamics of fruit fly (larvae and pupae) in different seasons (autumn, winter, and spring). This research aims to investigate the population dynamics of oriental fruit fly (*Bactrocera dorsalis)* (Hendel) in Sargodha and correlate with temperature as well as humidity. Fifty plants in five gardens were selected randomly in different regions of Sargodha.

Study Area I (Orchards in tail 49)

Tail 49 is a town in south of Sargodha city situated in southern Punjab, Pakistan. It is almost 5 km from the Sargodha city.

Study Area II (Orchards in Chak 86)

Chak 86 is a town in west of Sargodha city situated in southern Punjab, Pakistan. It is situated almost 3 km from the Sargodha city.

Study Area III (Orchards in Chak 87)

Chak 87 is a town in south/west of Sargodha city situated in southern Punjab, Pakistan. It is almost 6 km from the

Sargodha city.

Study Area IV (Orchards in Chak 40)

Chak 40 is a town in east of Sargodha city situated in southern Punjab, Pakistan. It is almost 7 km from the Sargodha city.

Study Area v (Orchards in Chak 39)

Chak 40 is a town in east of Sargodha city situated in southern Punjab, Pakistan. It is almost 6 km from the Sargodha city.

The sampling data was collected from November, 2010 to February, 2011. The samples dropped at ground were collected by an interval of 9-10 days of total study period. The infected fruit samples were taken in plastic bags purchased from Sargodha bazaar to check the population dynamics of fruit fly. These bags were brought in zoological laboratory of department of biological sciences university of Sargodha, Sargodha Pakistan. These samples were shifted into empty boxes filled with sand to facilitate incubation and to provide dark dry place for larvae and pupae in the lab.

After 10-12 days of incubation period, the infected fruit samples of citrus and guava were exposed in the laboratory to remove their outer covers by using a sharp cutter. A magnifying glass was used to examine the naked fleshy material and the number of larvae of *Bactrocera dorsalis* were identified by using identification keys and counted. The larvae were white elongated in shape and were measured up to 7-10 mm in length. These larvae developed into pupae after four to six days. According to our observation, the pupae were cylinder shape with reddish and were measured 6-11 mm in length.

The data regarding temperature and humidity was recorded through thermometer and hygrothermometer in the field. One way ANOVA was used to determine the relationship between larval and pupal population of fruit flies in citrus and guava fruits. After dynamic population study of fruit fly, we observed that there were two types of fruit flies in Sargodha region,1) *Bactrocera Dorsalis* 2) *Bactrocera Zonatus*

The purpose of experiment was to investigate the population dynamics of fruit fly (*Bactrocera Dorsalis*) and to observe the effect of temperature and humidity on the larvae and pupae of fruit fly.

RESULTS

Making observations, the lowest mean fruit fly larval population in citrus and guava fruits (4.06±2.113764 and 4.92±2.403539) respectively was recorded in the same month (February) but in January, we observed the lowest (11.3871°C) mean temperature and highest (62.806%) mean humidity in both gardens, while at the highest mean temperature (21.067°C) and lowest mean humidity(50.3%) both mean larval populations were recorded highest (15.62±1.196662 and 19.32±0.881476) in November from both gardens (Table 1).

It was recorded that the highest mean fruit fly pupal population in citrus and guava fruits (12.74±2.298478 and 15.84±0.882043) respectively was observed in the month of November when there was the highest temperature and humidity in both gardens. In the same gardens at lowest mean temperature and highest mean humidity it was observed that the mean pupal population was lowest in the month of February (15.62±1.196662 and 19.32±0.881476) in citrus sand guava respectively (Table 2).

Table 3 shows that during the whole study period, the mean population of larvae and pupae from both gardens (Citrus and Guava) decreased from November 2010 to February 2011. Overall, the mean larval and pupal population of fruit fly dominates in Guava fruits as compared to Citrus fruits throughout the study period in all the five locations (Figure 1).

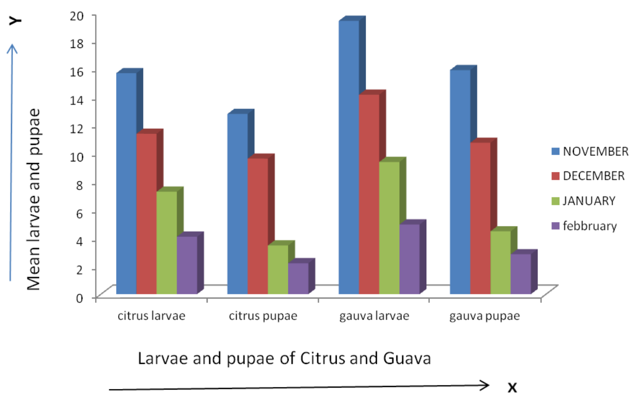

Fig. 1

Comparative analyses of fruit flies larvae and pupae in citrus and guava gardens during study period (Monthly data)

DISCUSSION

The comparative population dynamic study of fruit fly (larvae and Pupae) was conducted on citrus and guava gardens in Sargodha region. We observed maximum population of fruit fly in month of November and it decreased from December, 2010 through February, 2011.

Population of fruit fly Larvae and pupae in citrus and guava host fruits

The mean larval population was recorded highest (n=11.55) in citrus host fruits from citrus garden no. 1 Tail 49 in month of November because of higher temperature and lowest (n=8.45) was observed from garden no. 4 Chak 86 (Mr.Aftab) in month of February while the observed mean larval population was highest (n=12.45) in guava host fruits collected from garden no. 4 Chak 86 (Mr. Aftab) in month of November and lowest (n=11.525) in guava from garden no. 1 tail 49 in month of February because of decrease in temperature.

Same like larval population the mean pupal population was evaluated lowest (n=5.775) in citrus host fruits from garden no. 5 Chak 87 and highest (n=8.525) was recorded from garden no. 1 tail 49 while the highest mean pupal population (n=9.25) was recorded in host fruit from guava garden no. 1 tail 49and was lowest (n=7.95) in garden no. 5 Chak 87 (Mr. Munawar).

The similar results were recorded by Drew and Hooper in 2004. They observed that population of fruit flies increased during summer and rainy days while decreased by the decrease in temperature and rainfall in autumn. Ye and Liu (2007) also evaluated the same findings that population of fruit fly remained at the lower level from November to February. Vayssieres *et al.* (2009) reported the average fruit loss varies from 10 to 50% in the beginning of April to end of

June for all species together. They reported that the best suitable temperature for the development and reproduction of *Bactrocera Dorsalis* was between 15°C to 34°C, while the optimum temperature ranges between 18°C to 30°C. Mostly, larvae and adult die when temperature become higher than 34°C or lowers than 15°C and when temperature lowers down from threshold temperature which is 18°C than larvae and pupae prolong their development and hence emergence ratio of adults lower down. Saleh and Hamalawii (2004) said that the population of fruit fly *C. Capitata* was higher from mid of September to December and after it started decreasing till March as the temperature was not suitable. Chen *et al*. (2006) said that fruit fly population was lowest from November to January whereas in October it was highest. Nboyine *et al.* (2013) concluded that fruit fly population is highest from May to November. The damage of fruit in this period is too high as compared to other months.

Khan (2002) concluded low population of fruit flies that was found on apple in Murree hills in August to October. In guava field maximum infestation (11.38 to 15.36%) was shown in the month of August and September. Kannan *et al.* (2006) reported the high activity of fruit fly that was recorded during the last week of May that gradually increases till the fourth week of June. Effect of abiotic factor was also being studied on population of fruit flies. Maximum and minimum range of temperature was also recorded during experiment. The mean values of maximum and minimum temperature of 21.2°C and 9.9°C respectively. We observed that with the increase in temperature population of *B. dorsalis* also increase but at a certain threshold level. It shows that the population of fruit flies has a positive correlation with maximum temperature.

More likely Zhang and Hou (2005) explained same kind of result that *B. Dorsalis* infestation occurs seasonally, mostly appearing when temperature is high, from late spring to mid-autumn. More over Kannan *et al.* (2006) discuss similar correlation studies showed significant positive relationship with minimum and maximum temperature. They said that the monthly minimum temperature, maximum temperature and monthly rainy days were the major climatic factors that effected population of fruit flies. Chen *et al.* (2006) and Abu and Srivastava (2006) recorded that Bactrocera species has a significant correlation with temperature.

Dhillon *et al*. (2005) worked on the melon fruit flies. He said that population of Cucurbit species increases when the temperature falls below 32°C and relative humidity ranges between 60 to 70%. Humidity also effects the population of fruit flies. Mustafa *et al.* (2011) concluded that humidity is significantly correlated with the population of fruit flies. But humidity and temperature was negatively correlated, because when temperature increases the humidity decrease and vice versa.

Duyck *et al.* (2004) reported that lower level of humidity as between 30-50% has very important effect on survival of fruit fly species. Chen and Hui (2007) studied aboitic factors and reported that increase in temperature is the basic factor of maximum fruit fly population while lowest humidity also increases the number of fruit fly population. Chen and Ye Hue (2006) reported that the monthly mean temperature fell within the ranges of the temperatures suitable for development and reproduction of the fly. But the monthly mean minimum temperatures from November to January seemed to be lower and were suggested to be responsible for the low populations in this period.

While observing humidity (%) Broufus *et al.* (2009) said that the egg population and development was high at 5-75% humidity but declined at 94%. But Imura and Nakakia (1984) said contrary that the relative humidity did not marked effect on the period or hatchability and the larval and pupae show development at all the humidity ranges between 0.85% equally. In the same way Vayssieres *et al.* (2009) gave contrary vision contrary that *Bactrocera invaders* behaves contrary as its population was low in dry season and becomes high in the rainy season as humidity increases till the end of rainy season in June.

On the basis of these results it was observed that development time of the eggs, larvae and pupa significantly decrease with an increasing in temperature from 18°C to 33°C. The developmental rate of the pre ovi-position stage reached physiological maximum at the higher temperature (36°C). Survival rate reached maximum at 24 – 33° C and decrease at higher or lower temperature (Liu *et al.*, 2009). A positive and highly significant correlation of rain fall and rainy days was observed with fruits flies. Temperature also correlated positively and significantly with the number of fruits flies. It suggested that during high rain fall and high temperature in July, formers should pay extra attention to sanitation (Mahmood *et al.*, 2002). A possible confirmation was found that mean developmental time required for eggs to hatch decreased with increasing temperature from 18°C up to 33°C ranging from 26.5 to 66.75 h. At larval stage, the trend was similar to egg stage. The developmental time decreasing from 17.56 days at 18°C to 7.56 days at 33°C and then increased to 7.96 days and 36° C (Liu *et al.*, 2009).

The temperature regimen of 18.3°C to 35°C resulted in delayed egg maturation and reduced production of mature eggs compared with the control temperature regimen. Egg maturation was possible at the higher temperature (Xin *et al.*, 2009).

CONCLUSION

Population of fruit flies was depending upon the sources of food (citrus & guava) and climatic factors. There was a population fluctuation of fruit flies that was occurred in different sources of food which may be citrus or guava. In this study period we observed that in guava fruits there were a significantly high population of fruit fly larvae and pupae as compared to citrus fruits. When temperature was increases, population of fruit flies was also increases but at a certain threshold level of temperature. In this study it was observed that the maximum population of fruit fly (*Bactrocera* Dorsalis) in both the fruits was observed in the month of November at minimum humidity and maximum temperature and minimum population in both fruits was observed in the month of February. Population of fruit flies and temperature were significant positive correlated. When humidity was decrease population of fruit flies was increase but at a certain threshold level of humidity.

Table 1

Comparative analysis of population of larvae of fruit flies in Citrus and Guava gardens during study period.

S.No.	Month	Mean larval population in Citrus fruits	Mean larval population in Guava fruits	Mean Temperature° C	Mean Humidity%
1	November	15.62±1.2	19.32±0.88	21.07	50.3
2	December	11.34±2.14	14.1±1.42	14.19	55
3	January	7.24±1.05	9.34±0.38	11.39	62.81
4	February	4.06±2.11	4.92±2.4	15.96	60.86

Table 2.

Comparative analyses of population of pupae of fruit flies in Citrus gardens during study period.

S.no.	Month	Mean pupal population in Citrus fruits	Mean pupal population in Guava fruits	Mean Temperature° C	Mean Humidity%
1	November	12.74±2.3	15.84±0.88	21.07	50.3
2	December	9.58±1.96	10.7±1.32	14.19	55
3	January	3.44±0.5	4.44±1.04	11.39	62.81
4	February	2.19±0.64	2.82±0.88	15.96	60.86

Table 3.

Comparative analyses of population of larvae and pupae of fruit flies (*B. dorsalis*) in Citrus and Guava gardens during study period (Monthly data).

Mean	November	December	January	February
Mean Citrus larvae	15.62	11.34	7.24	4.06
Mean Citrus pupae	12.74	9.58	3.44	2.186
Mean Guava larvae	19.32	14.1	9.34	4.92
Mean Guava pupae	15.84	10.7	4.44	2.82

AUTHORS' CONTRIBUTION

M. Mudassar Shahzad conducted research work, collected data and compile results. Irfan Mustafa planed the research work and provide the facilities for research. Syed Makhdom Hussain and M. Asrar helped in data analysis and writing of manuscript. Syed Zakir Hussain Shah helped in data manipulation and improvement of manuscript. M. Furqan and M. Zubair-ul-Hassan Arsa;an provided help in revision of manuscript and data collection.

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