Journal of Pure and Applied Agriculture (2022) 7(4): 28-35
ISSN (Print) 2617-8672, ISSN (Online) 2617-8680
http://jpaa.aiou.edu.pk/

Bactrocera dorsalis Hendel (Diptera: tephritidae) egg-laying preferences and larval developmental on five mango varieties of Sindh, Pakistan

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Abstract

The *Bactrocera dorsalis* is crucial agriculturally pest, which causes damage to commercial fruits such as mango. It develops and grows its progeny in the pulp of ripening fruits. Therefore, a study was conducted to observe the egg-laying activities and movements of maggots in common and famous five mango cultivars (Chunsa, Sindhri, Beganpali, Lal Bad shah, and Sonaro) of Sindh, Pakistan. These varieties of mango were examined during a series of experiments in the laboratory under controlled conditions. The infested mangoes were collected from a field and sliced. The larvae were collected from (per fruit) each variety for the rearing of flies and fondness of the host. The fruits were kept in cages for hatching, maggots survived on an artificial diet (sucrose solution 10%) in Laboratory (. Results show that the numbers of larvae were observed significantly different ($df = 2$, $f = 736.9149$, $p<0.05$) from per fruit of five mango varieties. *Bactrocera dorsalis* severely oviposited Chunsa variety (83.5 ± 1.93 larvae, range 81-85), followed by Sindhri (67 ± 4.06 larvae, range 61-64), Beganpali (59.6 ± 3.090 larvae, range 57-61) and Lal Bad Shah (53.9 ± 2.3, range 55-57), and least on Sonaro variety (41.2 ± 2.04 larvae, range 38-40). Sindhri and Beganpali showed no significance with Lal Badshah, but both varieties showed significant differences ($p<0.05$) with Sonaro. There was significant variability among host varieties ($p=0.02$). Maggots' performance was significantly different ($p<0.05$); the maggots performed better in Chunsa cultivar than in the Sonaro variety, because of the high sweetness and firmness in the flesh of Chunsa cultivars. The sex ratio of 3:1 was observed in all varieties of mangoes. The relationship between host preference and survival of maggots showed a strong correlation of determination of 47.4% ($p<0.05$) for varieties, respectively. In pest management it is crucial to explain the host and pest relationship based on an appropriate source of attractiveness for oviposition behaviors and progeny survival.

Keywords: *Bactrocera dorsalis*, Egg laying, Mango varieties, Progeny performances

To cite this article: Amur, A., Memon, N., Sahito, R., & Soomroo, A. N. (2022). *Bactrocera dorsalis* Hendel (Diptera: tephritidae) egg-laying preferences and larval developmental on five mango varieties of Sindh, Pakistan. *Journal of Pure and Applied Agriculture*, *7*(4), 28-35.

Introduction

Bactrocera dorsalis is the present-day alarming pest for fruits all over the world (Bateman, 1972), (Aluja and Mangan, 2008). In entomology, the theory of host and pest association is based on the attractiveness of egg-laying preferences and larval development, and it has been innermost challenging (Thompson, 1988). The egg-laying precedence of *Bactrocera* species, such as oriental fruit fly has been extensively studied in host and pest relations. This behavioral study is the central idea, as the females of *B. dorsalis* attract the most suitable host to oviposit their eggs to ensure the maximum development of their progeny. The larvae are provided with enough essential nutrients.

The determination of the suitable host is mostly attracted by the physical appearance of the fruit, such as fruit softness (ripeness), fruit firmness, odor, color, and size (Akol et al., 2013). The larval development and adult emergence concerning pest preferences, because it has been interconnected with host diet quality and cultivars variation (Mitter et al., 1991). In the population of pests its good heritable variations according to the fondness of the host and tactics of maggots; pest always chooses the best characteristic medium of the host, which prefers to diet for the best maximum survival of progeny Fruit fly. females mostly select the soft pulpy fruits for egg laying and appropriate for the survival of their developmental growth (Rausher, 1984; Thompson, 1988). Pest development, growth, survival, and emergence are depending on the diet medium of a host (Bernays and Graham, 1988). Most theories on the evolution of preference (oviposition) behavior were discussed that females selected those host plant and plant parts individually (varieties, fruits, leaves, basal parts, apical, and medium) where the maximum larval survival and growth occurs,

The key factors that influence egg laying in any host plant are nutritional value, host external appearance, natural enemies, and nutritional routine (parasitism and grazing) (Thompson and Pellmyr, 1991). Many researchers found a strong relationship between oviposition and larval development (Rausher, 1982). Although some researchers did not found any relationship because natural adversaries had a high rank in the maggots' survival rate as compared to oviposition (Courtney, 1982). In fruits, fruit flies selected those

sites of fruit which is best for the survival of larvae (Verghese et al., 2006). *Bactrocera dorsal* is a polyphagous and major pest for mango; it is suitable for the research work of oviposition and larval development on five susceptible varieties. *B. dorsalis* serious pest of mango 5-10% loss yield (Syed et al., 1970) it is not only economically important but play important role in quarantine techniques (Verghese et al., 2006) *Bactrocera dorsalis* 1-31 % field loss in India and Pakistan infest many varieties of mango such as Dushairy infestation 3.6% to 10% while 80% in Beganpali (Verghese et al., 2006), (Panhwar, 2005). Oriental fruit flies attack many varieties of mango like Khirshapat, Langra, and Fazli. It attacks mango at the time of harvesting when the fruit flies mature because flies have easy to puncture the fruit by ovipositor, and mature fruits are select the best survival medium for their progeny because mango full carbohydrate. Most have not well-known the egg-laying behavior among the mango assortments, which may select energetic comparison for the progress of these performances. This study focused on the behaviors, effects of host variety and various host plant species, pest preferences and performance is an important pre-requisite for developing pest management strategies for this insect pest. The Present study reveals that oviposition preference and performance of progeny were observed in *B. dorsalis* on five common and commercially important mango varieties (Chunsa, Sindhri, Lal Bad shah, Beganpali, and Sonaro varieties). This information will lead to better implementation of the management strategies to control fruit fly infestation in cropping systems.

Materials and Methods

The Five varieties of mango Chunsa, Sindhri, Beganpali, Sonaro, and Lal Bad shah were randomly sampled from Shiekh Barkio, Tandojam, Hattrii, and Dr. MH.Panwar Research Fields of Mango Orchards. The procedure for accumulating, carrying, and nurture of fruit Flies followed by the international Program at the International Center of Insect Physiology and Ecology (*ICIPE*) ((Lux et al., 2003), (Badii et al., 2015). Although sample labeling was done to the procedure described by (Copeland et al., 2002). Fruit flies were harvested from mango orchards, randomly collected 30 mangoes of each variety, observe uncut fruits with any visual marks of fruit fly oviposition punctures were considered unhealthy. Collected fruits were brought to the Zoology Department, University of Sindh, and Jamshoro. Where mangoes were washed and allowed to air dried before being kept in individual rearing cages and provided with an appropriate medium for pupa (Copeland et al., 2002). About 10-12 rearing cages were selected for rearing. Each rearing cage was made-up of plastic glass, one door covered with muslin cloth sleeve, which was facilitating the entrance. The rearing room was 15-14m with one entrance and ventilation hole. The controlled conditions in the laboratory were compared to the conditions outside, but the experiment was protected from the breeze and rainfall. The average temperature was 27±3°c, humidity 55±5%, and the Photo period was maintained at LD 10: 12 h. The Incubation medium was provided by way of placing the mangoes of each variety on plastic trays in an individual cage, on a thin moist layer of sand (sieved and sterilized) for 20 days (but cages were regularly checked) as the third instar larvae moving and enter into the sand for pupation, This sieved sand method followed by(Billah et al., 2008). After one week puparia were picked with the moist camel brush, calculated sited in the petri dishes lined with humid sieve paper, and detained till the appearance of adults. Appeared flies were then transported to holding cages where the fresh fruits means without any ovipositor puncture were provided for oviposition, almost 10 mangoes of each variety were placed individually in a cage each cage was regularly cleaned to maintain a hygienic environment. The tries of oviposition of the female flies were recorded each for 2 h. This trial repeated the double and a combined analysis was made seeing 5 handlings and 10 replications (Rossetto et al., 2006). All the emerged adult flies were calculated by their survival % ratio by the following formula:

Data about germination percentage were recorded after the interval of 24 h up to 8 days. The calculation was made using this formula (Shah et al., 2012):

$$\text{Germination (\%)} = \frac{\text{Total number of adult flies survived}}{\text{Total number of adult flies reared}} \times 100$$

Data analysis

Oviposition preferences of *Bactrocera dorsalis* for mango varieties, its development (life stages) on varieties, and the larval development were assessed with a one-way analysis of variance (ANOVA). Correlation between the parameters was determined by regression analysis using SPSS 21.

Results

Host mango varieties for egg-laying

The number of maggots per fruit was noted on the base of oviposited attempts by oriental fruit fly females in all five varieties of mango, with significantly affected in per fruit (df= 2, f= 736.9149, P> 0.05) (Fig.1). *Bactrocera dorsalis* oviposited Chunsa variety (83.5±1.93 larvae, range 81-85), followed by Sindhri (67±4.06 larvae, range 61-64), Beganpali (59.6±3.090 larvae, range 57-61) and Lal Bad Sha (53.9±2.3, range 55-57), and least on Sonaro variety (41.2±2.04 larvae, range 38-40). Sindhri and Beganpali did not vary expressively with Lal Bad shah, but more significantly (P>0.05) than Sonaro, least susceptible by larval performance (Fig.2). During the laboratory conditions and experimental trials, oviposited attempted fruit fly oviposition attempt were significantly different on over all five varieties of mango (df =2, F=126.9, P>0.05), while on Chunsa (53.2±14.23) followed by Sindhri (36.9±12.50) and Beganpali (38.5±15.89) and Lal Bad shah (30 ±14.41) and least attempting on Sonaro variety (12.4±7.99). Sindhri and Beganpali were not significantly

different (P>0.05), consequently, the five mango varieties formed two discrete groups: Chunsa, Sindhri, Beganpali, and Lal Bad shah were most susceptible to larval and oviposited attempting, While the Sonaro variety was least susceptible by oviposition attempt (Fig. 3).

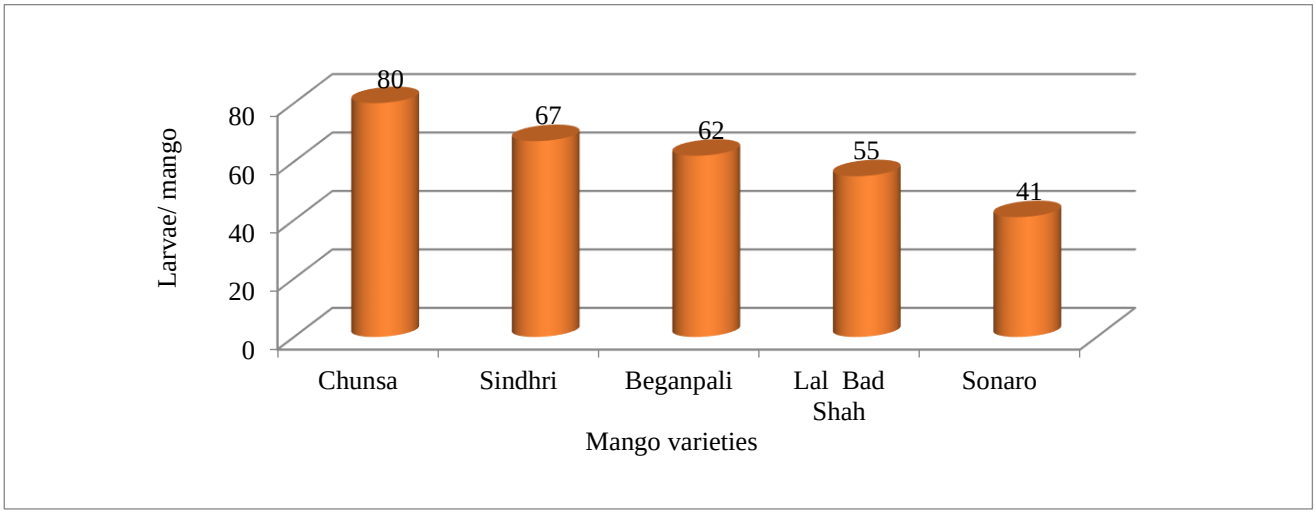

Fig.1 *Bactrocera dorsalis* larvae relative emergence mean ± Sd

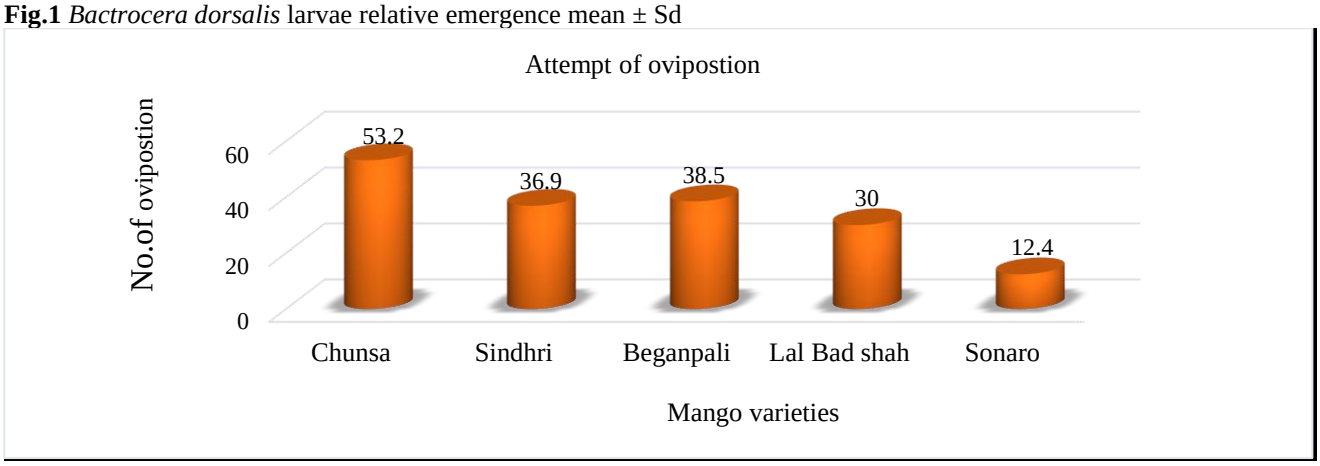

Fig. 2 Attempts of oviposition on four mango varieties

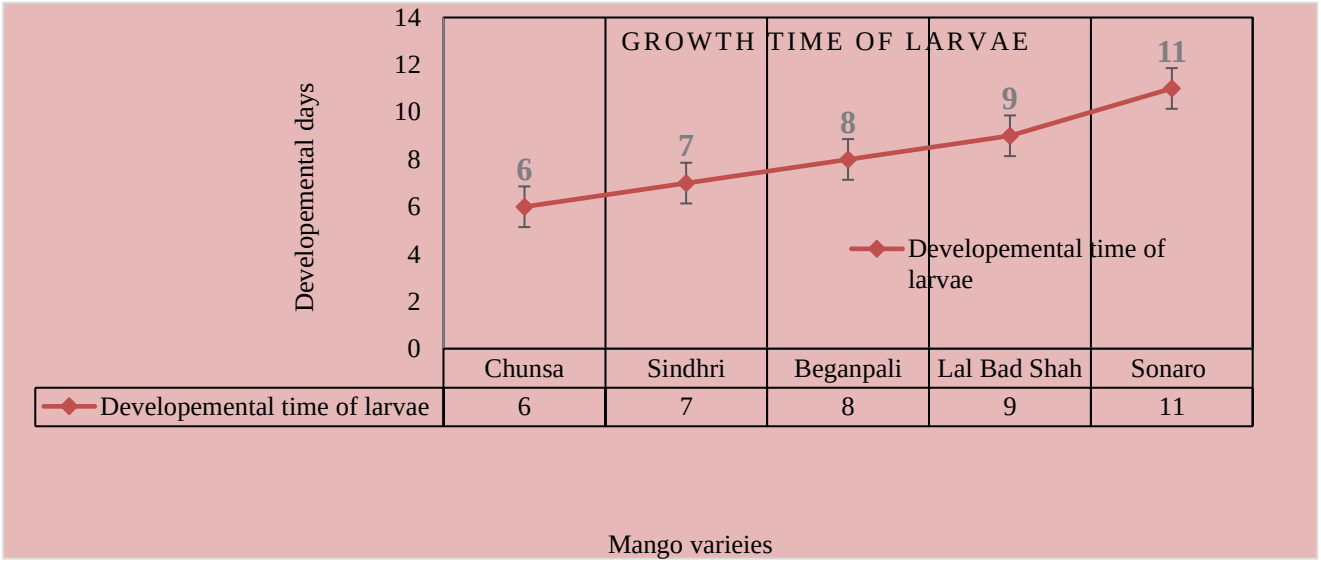

Fig. 3 Proportional with *B.dorsalis larval* development rates on the five host varieties

Pest relation with host

Effect of varieties on larval (maggots) growth

Over maggots growth was significantly affected by mango varieties (f= 167.28, df =1, P>0.05). The extremely vulnerable fruits recorded earlier growth rates (Figure.4). according to experimental work, the developmental time of larvae was most rapid and development occurs within the least days on Chunsa, Sindhri, and Beganpali (4.8±1.54 days, 7.98±1.30 days and 7.79±0.47 days, respectively) while the least development occurred with more days (much development time) on Sonaro and lal Bad shah (9.08 ±1.07, 11.53±1.35, respectively) (Fig.4). Transformation of mature appearance curvature data from maggot's studies resulted in highly important linear relationships among period (accumulative days) and increasing emergence between mango varieties. The transformation of mature fruit flies' curvatures indicates that growth happened significantly faster in the Chunsa variety (64.16±22.05) and least in Sonaro varieties (36.82±16.1). The host species outcome on emergence time showed that increasing developmental was not meaningfully different (P>0.05) among lal bad shah, Sindhri, and Beganpali (47.02±19.37, 49.84±19.22, 40.00±17.17, respectively) (Fig. 4).

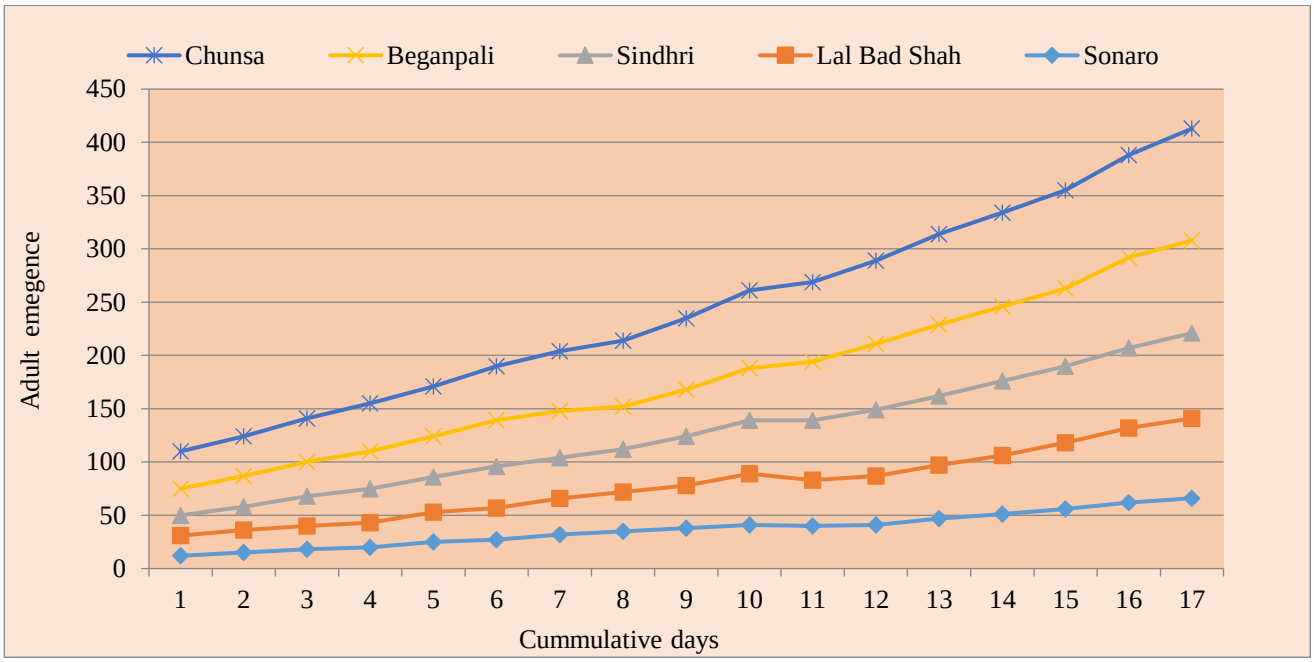

Fig. 4 Emergence curve data on five varieties of mango

Influence of mango varieties on the survival of mature fly

The survival rates of *Bactrocera dorsalis* adult diverse significantly in five varieties of mango (Fig.5). The general, accumulated survival rates of *Bactrocera dorsalis* mature on five varieties differed significantly (P>0.05) (Figure.5), and the highest was on Chunsa variety (45.1±1.79d) followed by the Sindhri (37.4±4.27d) and Beganpali (34±3.33d) and the least survival on Sonara and lal Bad shah (23.4±2.258d, and 26±2.70d, respectively) (Table 1), the Chunsa variety offer significantly prolonged existence to mature Flies than rest of the other cultivars, and least longevity was assessed on Sonaro variety.

Influence of host mango varieties on adult fly mass and gender

Effect of five host varieties on *Bactrocera dorsalis* adult sex ratio no significantly difference (P<0.05) were found, no variation occurs in weight and length, generally the level of sex ratio 1:3 among adult means the female ratio was found more than male during the emergence in mango, but not significantly varied among varieties of mango.

Association between insect Oviposition and larval performance

Oviposition and larval growth rates, long life, and appearance rate were closely significantly associated (Table 1). Fruit preference continuously depends on the durable and significant linear relationship with progeny performance. Adult long life is significantly connected to cultivars preferences, but the sophisticated intercept (18.06) recorded might indicate that there are extra several causes for endurance other than host preferences (Table 2). Emergence and oviposition attempts were also significantly correlated (R2 = 87.1%, P>0.05) (Table 2) MANOVA of the relationship between overall co-efficient of 47.4 % (P>0.05).

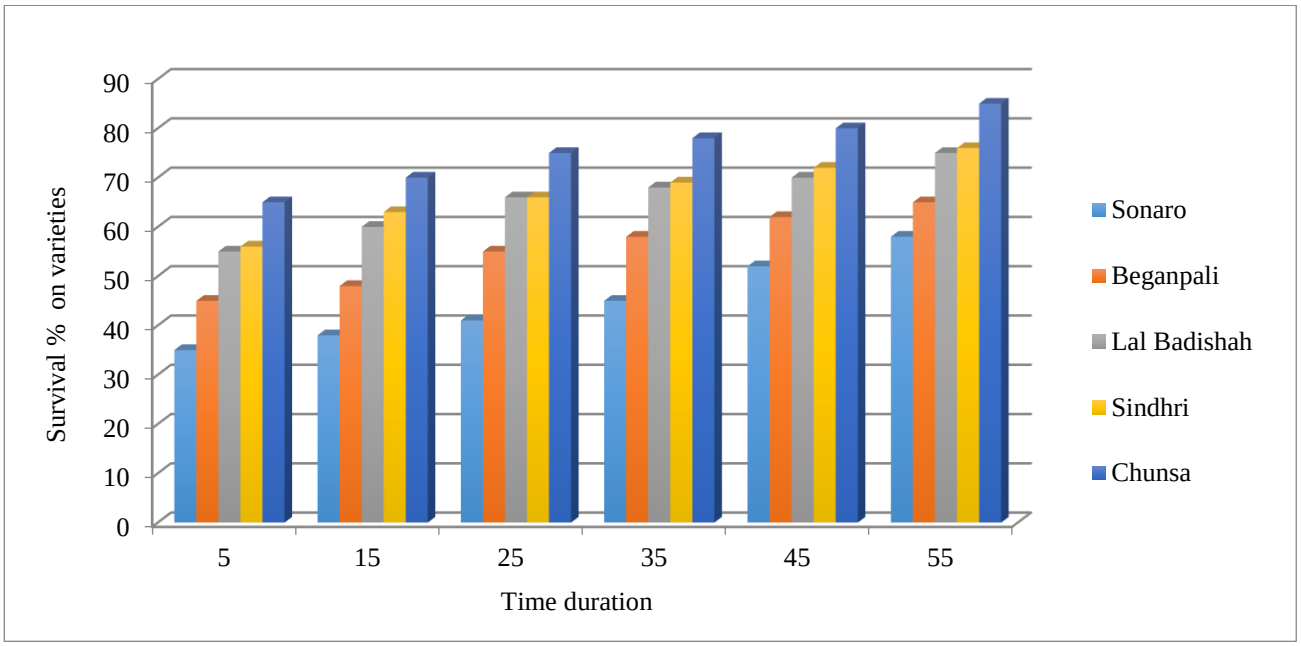

Fig. 5 Survival % on different varieties

Table 1 The effect of five host varieties and mango fruit variety on *Bactrocera dorsalis* adult Longevity (survival).

Varieties name	No. of mangoes	No. of unaffected mangoes	Total infested	Adult survival mean±sd days	Survival % of adult
Chunsa	30	4	26	45.32 ± 1.01	57%
Sindhri	30	7	25	40.34 ± 2.00	48%
Beganpali	30	8	23	34.095 ± 1.70	36%
Lal bad shah	30	12	18	33.06 ± 1.7	30%
Sonaro	30	17	13	28.5 ± 1.8	23%

**** Correlation is significant at P>0.05.

Table 2 Linear-regression between *Bactrocera dorsalis* host preference and offspring performance indicators of five varieties

Varieties	Intercept	R^2	Df	F-value	P (0.05)
Developmental rate	21.42	0.931	1	40.78593	0.00
Survival /longevity	18.06	0.867	1	19.72573	0.02
Emergence	-27.63	0. 871401	1	20.32842	0.02

*** Correlation is significant at P>0.05.

Discussion

This study observes the oviposition and larval development of fruit fly *Bactrocera dorsalis* in different varieties by its polyphagous nature and expected positive co-relation between adult oviposition (preferences) and larval development (offspring) in susceptible varieties of mango. This research showed that fruit host preference by *Bactrocera dorsalis* was observed by the oviposition attempt and the number of larvae. Our study showed that the highest number of larvae was found in the Chunsa variety 83.5±1.93 larvae followed by Sindhri, Beganpali, and Lal Bad shah but the least number of larvae was found in the Sonaro variety 41.2±2.04 larvae. The number of larvae was significantly different between the Sonaro and other varieties (P<0.05). The same findings were discovered by (Akol et al., 2013) on the five fruits and different varieties of mango. The highest attempts of oviposition were found after different trials of experiment on Beganpali followed by Chunsa and Sindhri variety (53.2 ±14.23, 36.9±12.50, and 38.5±15.89, respectively), but the least attempts were observed on the Lal bad shah and Sonaro variety (30 ±14.41 and 12.4±7.99) the

attempting of oviposition in varieties was highly significant (P>0.05), related results were found by (Díaz-Fleischer and Aluja, 2003) on mango by *Anastrepha Ludens* fruit flies, by the measurement and number of clutches on ripened and unripe mangoes. The same results were observed (Bateman, 1972, Akol et al., 2013) oviposition attempts by *Bactrocera invadens* on different mango varieties such as (Glen mango fruit =57.8±23.7) followed by (Biire= 43.1±5.5) and (Kate=37.1±8.3), and least on (Zillatte=13.3 ±5.2) and (Tommy =12.0±4.8).

In choice and no choice experiments, findings of Alfa had an average of (9.2±4.36) attempts of oviposition whereas (Tommy Atkins 38.3±23.52) (Rossetto et al., 2006). Oviposition attempts significantly different were declared the susceptibility of varieties. The larval developmental time was significantly different on mango varieties our results show that the most susceptible varieties have a faster developmental time of life stages *Bactrocera dorsalis* on mango varieties rapidly survival on Chunsa variety in the least days (4.8±1.54 days), followed by the Sindhri (7.98 ±1.30 days) and Beganpali (7.79 ±0.47) but the much time takes in development was on Lal Bad shah (9.08 ±1.07), and Sonara variety (11.53 ±1.35), significantly different time duration has occurred in larval development same results were found by (Kalia, 2015) larval development of *Bactrocera dorsalis* on different fruits Papaya, Guava, Sapatu and banana, and mango varieties. (Ambele et al., 2012) worked on susceptible varieties of mango, according to him most susceptible varieties were highly attacked by female oviposition based on their physical appearance and their larval development was faster on the susceptible varieties and the highest emergence occurred. Our results are almost related to this hypothesis, because the highest attacks of oviposition and larval development on the most susceptible varieties Chunsa, Sindhri, Beganpali and lal bad shah but the least attempts of oviposition have occurred on the Sonaro variety and the developmental rate was also slow. Adult emergence occurred from the Chunsa variety (64.16 ±22.05) and the least from the Sonaro variety (36.82±16.1). There is no significant difference between the Sindhri and Lal Bad shah in the emergence of flies (47.02±19.37, 49.84±19.22, 40.00 ±17.17, respectively). The same work was done on different varieties of mango by (Akol et al., 2013).

Survival of the *Bactrocera dorsalis* was significantly varied highest survival rate on the Chunsa (45.1±1.79d) followed by Sindhri (37.4±4.27d) and Beganpali (34 ±3.33d) and least survival on Lal Bad Shah and Sonara (23.4 ±2.258d, and 26±2.70d, respectively).The same finding was discovered by (Akol et al., 2013) on different mango varieties such as (Biire, 36.347 ±2.00) followed by (Glen, 34.095 ±1.85d), (Kate 33.97 ±1.70) and least on (Tommy= 23.580±1.8 d) and (Apple =23.609). The sex ratio of *Bactrocera dorsalis* was almost the same in all varieties of mango 3:1 same findings by (Kalia and Yadav, 2005) on different fruits and different varieties. This research work strongly supports the (PPH) with a general coefficient of determination of 47.4% (Table II). According to the preference and performance hypotheses, females select those habitats for distributed progeny, where maximum survival of offspring occurs (Scriber, 1983, Valladares and Lawton, 1991, Nufio and Papaj, 2004, Akol et al., 2013), worked on the different varieties of mango according to his findings that *Bactrocera invadens* offspring best survive on the different varieties of mango. While the adults did not significantly correlate with oviposition. Our results showed that the larval development and oviposition correlated, but the emergence and the oviposition were not correlated. Same findings by (Akol et al., 2013) offspring performance of *Bactrocera invadens* is Outstanding on mango cultivars as specified by the high co-efficient of 65% and mature flies' mean survival time (R2=65%, P=0.003) while adult growth rate did not show basic affiliation with egg laying. The perfect association between host precedence and different developmental growth cycle of maggots species that females maximize offspring suitability by selecting High-quality hosts for feeding to enhance the survival rate of their progeny. These results show the findings of *B. dorsalis* have the most favorable host varieties for adult activities such as Chunsa, Sindhri, and Beganpali mangoes, which indicates that there is no large adjustment between mass appropriateness for grown and descendant's performance. Most cultivars are finest for pest egg laying but the same host plants are not always good for adult survival or growth due to their nutritional values. Habitually in the field, the vitreous gardens are always mixed; in the same field multiple host plants are available, additionally less diverse pests usually abundant in these mixed gardens when fittingness is morphologically not influenced. Therefore host priority is less suitable for adults during the egg laying performance. Oviposition choices depend on natural selection; which decreases the tradeoff of host quality, this is against the intra-specific race (Aluja and Mangan, 2008). Host preference is not only concerned with mango cultivars but it is significantly correlated with host suitability at the mean survival time. During the artificial experiments, it should be possible that the time off host favorites and progeny survival could have been procedurally limited in terms of mango host. Mostly the suitable results of host preference were found in the natural Field as compared to the artificial medium (Åhman, 1985, Aluja and Mangan, 2008, Stanton, 1982) reported natural and artificial affection in recommendations of mango varieties, according to the discussion of natural fondness, it cannot be determined in the field because there will be no all plants with equal abundances and availability. It should be possible that a positive correlation may have been concealed and conformation with artificial (laboratory) trials (Karban and Courtney, 1987, Courtney, 1990, Horner & Abrahamson, 1992, Larsson & Ekbom, 1995, Scheirs et al., 2003).

These results among multiple host species are exceptional. Fruit flies adults may not have a natural advantage conditional on a given mango variety. It may be well corresponding to trade with ordinary adversaries with specific varieties (Lill et al., 2002, Forister, 2004) the larval morphs slower to progress as the adults, that condition has been found in every group (Forister, 2004, Thompson, 1988); It is the communal

occurrence, when predictable things are not constantly in preferred varieties in concluded time, or when conflicting variety enormities stop fascination of the genetic factor, it leading a specific favorite (Rausher, 1984). According to these replicas, pests offer their progeny food by egg laying in or on hosts. The reserve is accessible to their descendants, and also may affect the sex ratio (Wiklund, 1981). Oviposition and larval developmental performance of herbivorous insects is determined by the nutritional content of the host plants selected by the female. In the study of *P. polytes*, females preferred to oviposit the most on *C.reticulata* compared to other host plants; *M. koenigii* was the least preferred host. In several earlier studies, the host plants which had higher nitrogen content were shown to be the most preferred hosts (Hwang and Feng, 2001, Udayagiri and Mason, 1995, Wheeler, 2003, Chen et al., 2004, Moreau et al., 2006).

Conclusion

In pest management, it is important to explain the host and pest relationship based on the appropriate source of attractiveness for oviposition behaviors and progeny survival. The indispensable consciousness of this study; is as the females of *B. dorsalis* attract the most suitable host (fruits or vegetables) for oviposition to ensure the maximum development of their progeny. The determination of the suitable host is mostly attracted by the physical (external) appearance of the fruit, such as fruit softness (ripeness), fruit firmness, odor, color, and size; but for the survival of progeny it is important for pest to determine the nutritional value of host appearance, natural enemies and nutritious routine (parasitism and grazing), this is the significant mechanisms for oviposition behavior in any host plant, The larvae is provided with enough essential nutrients. During the present study, the reason for appropriateness was found and differences in appropriateness by the host in varieties were observed. It is a very significant technique to find out the reasons for oviposition and survival of progeny, the results based on the favorite appearance, the host preferences, and offspring survival among mango cultivars. This research work suggested nutrition, oviposition, and developmental growth (maggot survival) of the host. Most have not well known about the egg-laying behavior among the mango assortments, which may select energetic comparison for the progress of these performances. Focused on the behaviors, effects of host variety and various host plant species, pest preferences, and performance is an important prerequisite for developing pest management strategies for this insect pest.

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