Population Density of Foliage Insect Pest on Jujube, *Ziziphus mauritiana* Lam. Ecosystem

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Abstract: Jujube, *Ziziphus mauritiana* L. is the King of arid zone fruits, due to its adaptations to tolerate the biotic and abiotic stresses. However, the occurrence of insect pest is the major threat to reduce the quality and quantity of fruits. The current studies are the first comprehensive evidence on the population density of foliage insect pests evaluated on two different varieties, Golden Gola (susceptible) and White Kherol (resistance) at farmer's field Tando Qaiser, District Hyderabad during 2007 and 2008. A total of 13 different insect pests which were categorized as major (*Ancylis sativa*, *Euproctis fraterna* and *Adoretus pallens*), minor (*Scirtothrips dorsalis*, *Amrasca biguttula biguttula*, *Myllocerus discolor*, *Achaea janata*, *Agrotis biconica* and *Aphis gossypii*) and occasional (*Oxycareous hyalinipennis*, *Dichromorpha viridis*, *Tarucus balkanicus* and *Orgyia postica*) based on overall population of two years. The mean population percentage of insect pests indicates the highest percentage for *E. fraterna* followed by *A. pallens*, *A. biguttula biguttula*, *M. discolor* and *S. dorsalis* on White Kherol, whereas, Golden Gola was severely infested and showed maximum percentage with *A. sativa* followed by *E. fraterna*, *S. dorsalis*, *A. pallens* and *A. biguttula biguttula*. It is concluded that *A. sativa*, *E. fraterna* and *A. pallens* are serious insect pests of jujube. Pest monitoring with direct count and light trap can help to determine the ETL that is most important for the management of various insect pests including these major and minor pest. The present study will hopefully be helpful for management of foliage insect pests of jujube.

Keywords: *Ziziphus mauritiana*, Foliage insect pests, population.

INTRODUCTION

Jujube, *Ziziphus mauritiana* L. is one of the most ancient and important fruit crops of arid and semi arid zones of the world. It is considered as the King of arid zone fruits, due to its adaptations to tolerate the biotic and abiotic stresses prevailing under rain fed conditions [1]. *Z. mauritiana* occur in nearly every continent and is thought to possess great genetic variation. It is an example of an extremely drought hardy species and is a dominant component of the natural vegetation of the Indo -Pak deserts [2]. *Z. mauritiana* is a beautiful evergreen tree and has dark, rounded green leaves, which are very attractive to various foliage pests.

Jujube fruit is one of the world's most nutritious plants, provide energy for human consumption and play a vital role in the development of human body [3, 4]. There is a traditional Chinese proverb that "eating three jujubes a day keeps the doctor away" [5]. It is a good source of protein, sugar, amino acids, calcium, phosphorus, iron, carbohydrates, ascorbic acid, vitamin A & C. The fruits contain between 70 and 165 mg ascorbic acid per 100 g of pulp, which is two to four times higher than the vitamin C content of citrus fruits. The mineral content of calcium, phosphorus and iron in *Z. mauritiana* fruits is also reported as being higher than in apples and even oranges [6, 7].

The production of jujube is known to be greatly influenced by pruning, fertilization, intercropping along with other management practices. However, pruning is essential to maintain vigor in the trees and to maintain fruit productivity, quality and size [8]. Generally pruning of jujube tree after harvesting the crop is more common in almost all jujube growing orchards, especially in Sindh province of Pakistan. However, insect pest infestation and disease may cause huge economic losses in some circumstances. Research reports reveal that numerous insects feed on foliage either by direct destruction of plant tissues or by sucking the plant sap. Jujube is known to attack by 23 different species of insect pests, however, out of these 13 species attack on the foliage right from sprouting to fruit harvest [9]. Among all the foliage insect pests Leaf roller (*Ancylis sativa; Synclera univocalis* Wlk), Hairy caterpillar (*Euproctis fraterna* Moore) and Jujube beetle (*Adoretus pallens* Har) are the serious foliage insect pests [10-15]. These foliage insect pests are not only cause damage on leaves but their attacks ultimately loosen the vigor of the tree and thus the fruit production is also reduced. The available reports on jujube especially the

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documentation of insect pests and their management is rarely known in Pakistan. Sarwar [16] reported the highest population and infestation of fruit fly, however, other insect species attacking jujube tree were certain caterpillars, weevils, beetles, and mite.

The current study was carried to determine the population fluctuation of various foliage insect pests attacking jujube tree. This is the preliminary step for the management of foliage insect pests. After getting the comprehensive knowledge about various pests, grower/researcher will be able to follow the certain management strategies. The analysis was undertaken through different pest scouting methods to achieve the goal of present study.

MATERIALS AND METHODS

To determine the population density of foliage insect pests of Jujube, present study was carried out during 2007 and 2008 at the farmer's field Tando Qaiser, District Hyderabad, Sindh, Pakistan. Pest population status in jujube ecosystem was recorded during both years of observation under naturally infestations from freshly grown leaves upto the pruning of Jujube, in the month of March. The material used and methods followed for different investigations are presented here under.

Population Status of Foliage Insect Pest in Jujube

Pest population was counted using following methods:

Direct Counting Method

The observation was taken from randomly selected 100 leaves tree^{-1} under naturally infested conditions on weekly interval from freshly grown leaves of Jujube till the final observation (Figure **1A**).

Sweep Net Method

In this method, a sweep net was used to collect the pest population of selective varieties and was counted on weekly interval until the final observation. A random numbers table was used to identify four rows per acre to be used for sweep net sampling. Ten sweeps were collected in each row from a different starting point each week and number pests species were recorded (Figure **1B**).

Figure 1: Insect pest scouting in the jujube orchards with four different methods during 2007 and 2008.

Note: A = Direct Counting; **B** = Sweep net; **C** = Water pan trap; **D** = Light trap; **E** = Observation under stereoscopic microscope.

Water Pan Trap Method

The determination of pest population through this method was carried out for pest count by using yellow plastic pan traps 85 x 40 cm in diameter. Kerosene oil and tap water was supplied to each pan trap and kept under each sampled tree for observation. Pest found in each trap were identified and counted (Figure **1C**).

Light Trap Method

Light trap have has been reported fairly fast and easy way to (monitor) collect nocturnal, photo/thermo-taxic insects. This technique is generally applied for the monitoring and collection of moths, scarabaeid beetles (Coleoptera, Scarabaeidae), and some Hemiptera and Hymenoptera. In the current study, we also used light trap for the monitoring of jujube beetle. The light trap was installed at the center of jujube orchards, and was operated at night for 8 hours. A light source was fluorescent bulb which was assembled in light trap and the trapped insects were killed with the potassium cynide placed in the mounted glass jar (Figure **1D**). Data was recorded on daily basis and different insect species were indentified.

Identification of Jujube Insect Pests

All the collected species of current study were identified based on their morphological characteristics as mentioned by Atwal [17] and Hashmi [9], and taxonomic keys using various internet databases. These species were also confirmed with the help of Department of Entomology and Plant Protection, Sindh Agriculture University, Tando Jam; Entomology Section of Agricultural Research Institute (ARI), Tando Jam, Pakistan. The broad criteria for classifying the insects were based on the overall two year population percentage as follows: Minor pests: Less than 15 per cent population; Major pests: More than 15 percent populat ion.

Statistical Analysis

The data collected on the population of foliage insect pests were subjected to analysis of variance (ANOVA); to test the superiority of mean values LSD test was applied and all differences described in the text were considered significant at the 5 % level of probability. These analyses were performed using computer software package Statistix 8.1 (Analytical Software 2005). The percentage population was calculated using Microsoft Excel Software 2007.

RESULTS

Population Status of Insect Pests

Diversity of insect pests was observed with Jujube agro-ecosystem analysis (JAESA) at farmer 's field Tando Qaiser, District Hyderabad through different insect scouting methods during 2007 and 2008. Several foliage insect pests were found infesting on

Table 1: Insect Pests Observed through Different Methods of Insects Scouting During 2007 and 2008

Insect Pest	White Kherol				Golden Gola			
	Direct counting	Sweep net	Water pan trap	Light Trap	Direct counting	Sweep net	Water pan trap	Light Trap
Major Pests								
Jujube Leaf roller	87.10	3.00	9.00	22.00	872.90	2.00	11.00	220.00
Jujube Hairy caterpillar	400.80	5.00	11.00	123.00	693.50	4.00	16.00	81.00
Jujube beetle	0.00	2.00	4.00	291.90	0.00	4.00	7.00	469.20
Minor Pest								
Thrip	149.00	12.00	5.00	0.00	503.50	5.00	7.00	0.00
Jassid	247.90	14.00	9.00	0.00	454.50	7.00	11.00	0.00
Jujube Gray weevil	160.40	13.00	5.00	0.00	193.60	13.00	21.00	0.00
Jujube looper	60.20	0.00	5.00	40.00	95.70	0.00	6.00	98.00
Cutworm	46.60	0.00	7.00	26.00	94.90	0.00	17.00	36.00
Aphid	87.50	6.00	0.00	0.00	127.20	14.00	0.00	0.00
Sporadic Pest								
Dusky cotton bug	63.00	7.00	0.00	0.00	145.00	9.00	19.00	0.00
Grasshopper	4.00	1.00	0.00	0.00	9.00	5.00	2.00	0.00
Butterfly	8.00	2.00	0.00	0.00	21.00	7.00	2.00	0.00
Moth	3.00	1.00	0.00	4.00	9.00	5.00	0.00	5.00

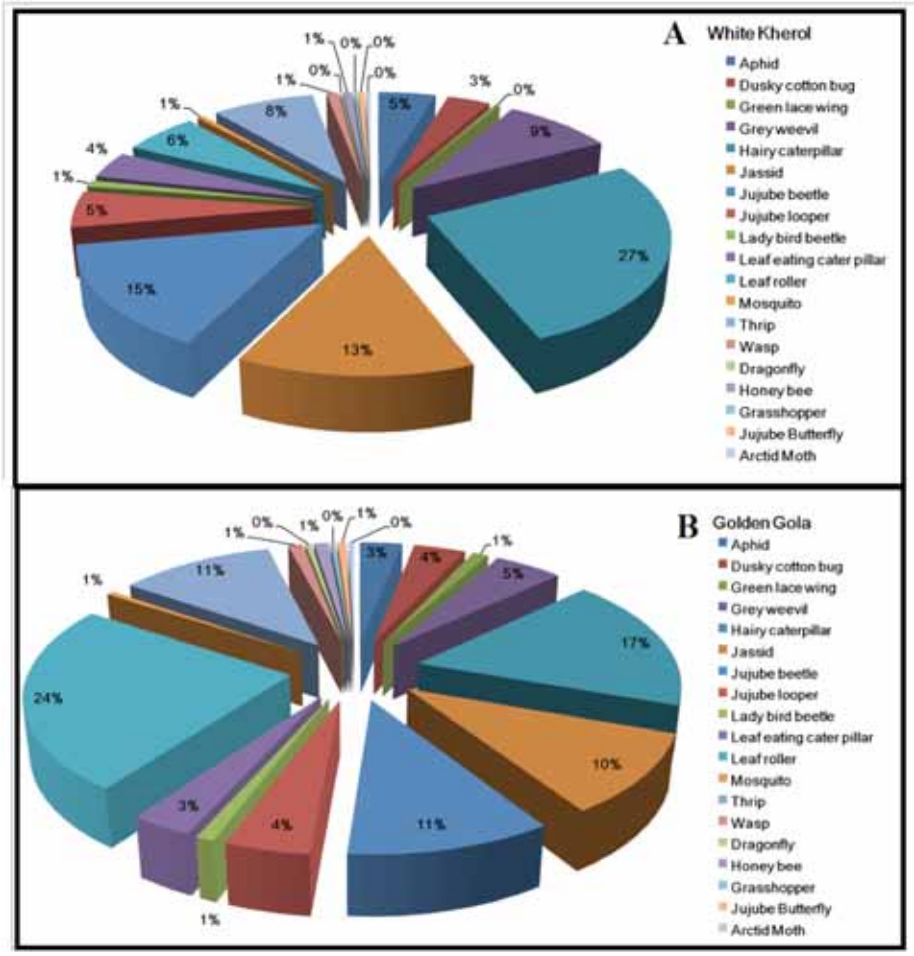

Figure 2. Mean population of insect pests observed on White Kherol (**A**) and Golden Gola **(B**) through different insects scouting methods during 2007 and 2008.

Table 2: Taxonomical Position and Nature of Various Insects Observed During 2007 and 2008

S. No	Common Name	Technical Name	Family	Order
Major Pests				
1.	Jujube Leaf roller	*Ancylis sativa* Liu	Tortricidae	Lepidoptera
2.	Jujube Hairy caterpillar	*Euproctis fraterna* Moore	Lymentriidae	Lepidoptera
3.	Jujube beetle	*Adoretus pallens* Blanchard	Scarabaeidae	Coleoptera
Minor Pests				
4.	Cutworm	*Agrotis biconica* Kollar, 1844	Notuidae	Lepidoptera
5.	Thrip	*Scirtothrips dorsalis* Hood	Rambutanae	Thysanoptera
6.	Jujube looper	*Achaea janata* Linn.	Notuidae	Lepidoptera
7.	Jassid	*Amrasca biguttula biguttula* Ishida	Cicadilidae	
8.	Aphid	*Aphis gossipie* Glover	Aphididae	Hemiptera
9.	Jujube Gray weevil	*Myllocerus discolor* Boheman	Curculionidae	Coleoptera
Sporadic Pest				
10.	Dusky cotton bug	*Oxycareous hyalinipennis* Costa	Lygaediae:	Hemiptera
11.	Green Grasshopper	*Dichromorpha viridis* Scudder	Acrididae	Orthoptera
12.	Jujube Butter fly	*Tarucus balkanicus* Freyer, 1844	Lycaenidae	Lepidoptera
13.	Moth	*Orgyia postica* Wlk	Lymantriidae	Lepidoptera

Golden Gola (susceptible) and White Kherol (resistance) jujube trees. The results of present studies revealed that highest population density was determined when insect scouting was done through direct count method. Other scouting methods were also remained useful for specific insect species such as light trap for nocturnal (moth of jujube leaf roller) (Table **1**). There was also variability in the population percentage of different insect pests for White Kherol and Golden Gola varieties (Table **1**, Figure **2A** and **2B**). However, mean population percentage of insect pests during 2007 and 2008 indicates the highest percentage for Hairy caterpillar followed by Jujube beetle, Jassid, Gray weevil and Thrips on White Kherol, whereas, Golden Gola was severely infested and showed maximum percentage with Leaf roller followed by Hairy caterpillar, Thrips, Jujube beetle and Jassid (Figure **2A** and **2B**).

Identification of Jujube Insect Pests

A total of 13 different insects pest invading the jujube tree were observed during the both year of study, 2007 and 2008 (Table **2**) when pest scouting was made through different methods. The taxonomical positions of all observed insects are described in Table **2**. Based on the overall population of two year, three insect pests (Jujube Leaf roller, Jujube Hairy caterpillar and Jujube beetle) were categorized as major insect pest due to their highest population than other insect pests (Figure **3**). The minor pests observed in the current study were Thrips, Jassid, Jujube Gray weevil, Jujube looper, Cutworm and Aphid. There were also some other insect pests which were sporadically found on the jujube trees are Dusky cotton bug, Grasshopper, Jujube Butterfly and Arctiid Moth (Table **2**).

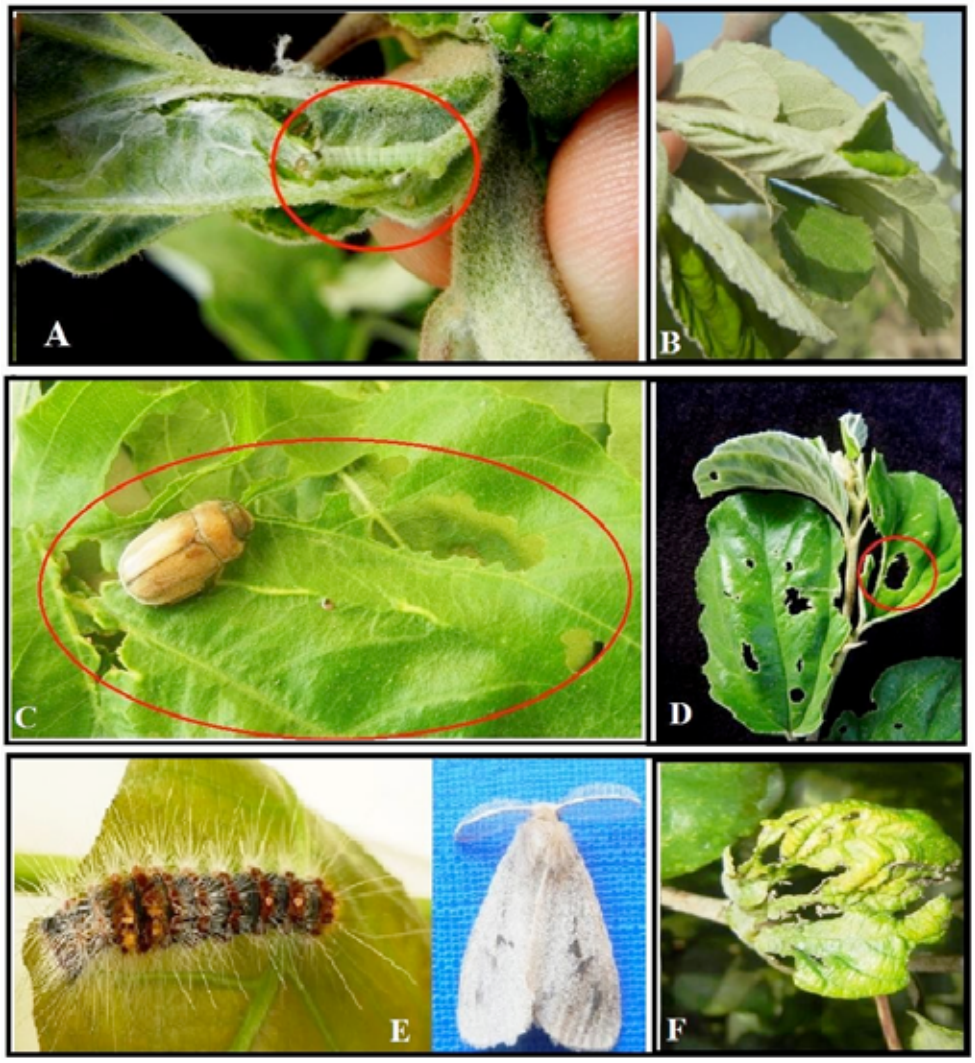

Figure 3: Morphological characteristics of major insect pest and their infestation on jujube foliage.

Note: A and **B** = Jujube Leaf roller (*Ancylis sativa*); **C** and **D** = Jujube Hairy caterpillar (*Euproctis fraterna*); E and F= Jujube beetle (Adoretus pallens).

Table 3: Analysis of Varience for Population Denisty of Major Insect Pest Obsevred During 2007 and 2008

Source	DF	Leaf roller		Hairy catterpillar		Jujube Beetle	
		MS	P	MS	P	MS	P
Year	1	2.501	0.4352	0.2375	0.5957	0.2503	0.2816
week	23	110.446	0.0000	82.6977	0.0000	27.6676	0.0000
Tree	4	15.204	0.0053	4.9345	0.0001	0.0281	0.9714
Year*week	23	0.294	1.0000	0.0942	1.0000	0.0723	0.9987
Error	908	4.103		0.8431		0.2156	
Total	959						
CV		161.78		67.90		58.56	

Population Fluctuation of Major Foliage Insect Pests

The data recorded specifically on different insect pests showed the difference in the population. The mean population density 100^{-1} leaves of leaf roller (*Ancylis sativa*) on White Kherol and Golden Gola was significantly varied for varieties, however, no significant difference was observed for two year of observations (Table **3**).

The population of *Ancylis sativa* was gradually increased from April and then declined in the month of October for year, 2007 and 2008. It was reached to the ETL (3.3 *Ancylis sativa* 100^{-1} leaves) on Golden Gola variety after 15th May and continued up to the 15th September. However, the population density was remained below the ETL in White Kherol variety indicates complete resistant during both year of research. The overall population of leaf roller on both varieties during two year of observation showed

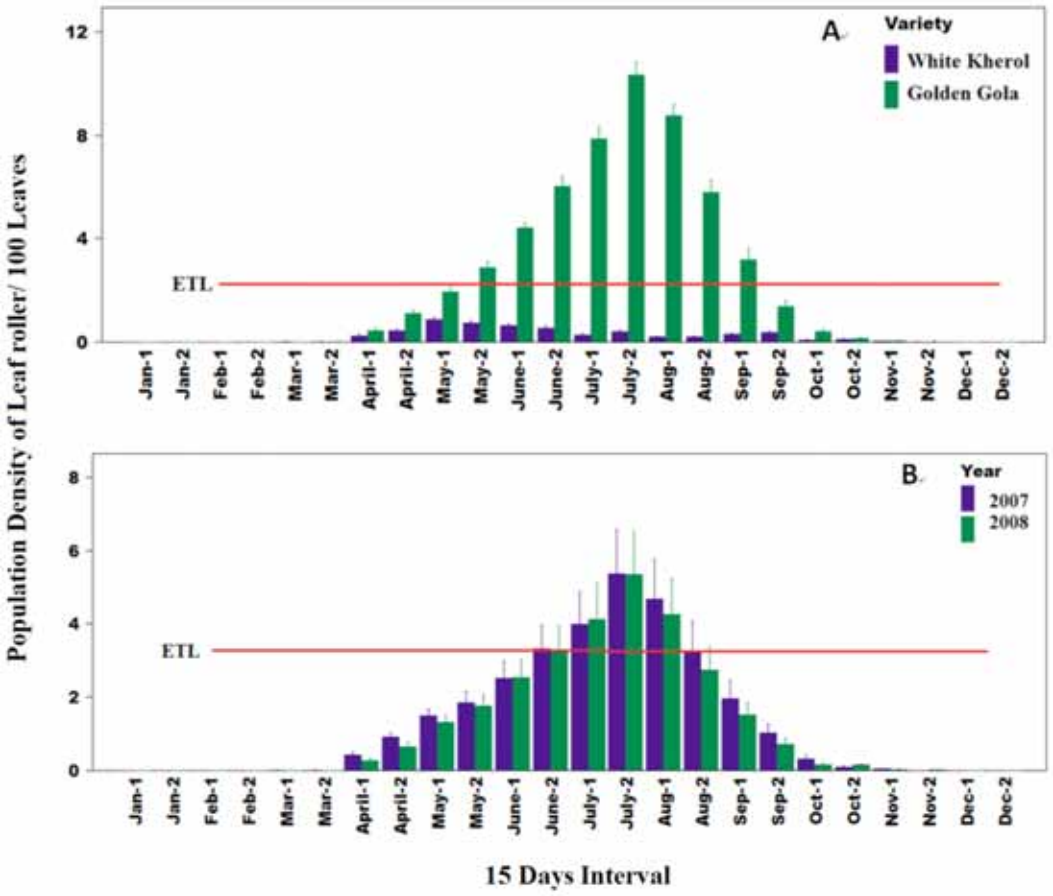

Figure 4: Population density of leaf roller in resistant and susceptible varieties (**A**) of *Z. mauritiana* during 2007 and 2008 (**B**).

Note: SE = 0.4529; LSD (0.05%) = 0.8889.

increase above the ETL after 15th June, which continued up to the 15th August. The highest peak of *Ancylis sativa* was seen after 15th July and then gradually decreasing (Figure **4A**). The result presented in Figure **4B** indicates the population of *Ancylis sativa* during 2007 and 2008. The peak population of *Ancylis sativa* was recorded in the second 15 days of July 2007 and 2008 (Figure **4B**).

The population density 100^{-1} leaves of Hairy caterpillar (*Euproctis fraterna*) on the foliage of White Kherol and Golden Gola jujube trees was fluctuating during the period of observation. Similar to leaf roller signification difference was observed for two varieties, however, no significant difference was observed for years of observations, 2007 and 2008. The increase in the population of *Euproctis fraterna* was seen from the month of April and which crossed the ETL (2.5 *Euproctis fraterna* 100^{-1} leaves) in the beginning of June and then declined in the month of October on Golden Gola variety. Results further indicates that the population showed decline below the ETL only after 15th August to 15th September, however, in the rest of the months (April to October) it was remained above the ETL. The results regarding the Kherol variety, the ETL was crossed in the beginning of June and then declined after 15th July. The highest peak of *Euproctis fraterna* was seen after 15th July and then declined. The second peak of *Euproctis fraterna* was noticed after 15th September and the gradually declined (Figure **5A**). The results presented in Figure **5B** indicate the population of *Euproctis fraterna* during 2007 and 2008. The peak population of *Euproctis fraterna* was recorded in the first 15 days of July 2007. During 2008, the boosting time of *Euproctis fraterna* was also same, however, the population density was little lower compared to 2007 (Figure **5B**, Table **3**).

The result presented in the Figure **6A** and **6B** showing the population density of *Adoretus pallen* which significantly varied between susceptible and resistant varieties. It was fluctuating from April to October on both varieties during 2007 and 2008. The population density 100^{-1} leaves on the foliage of White

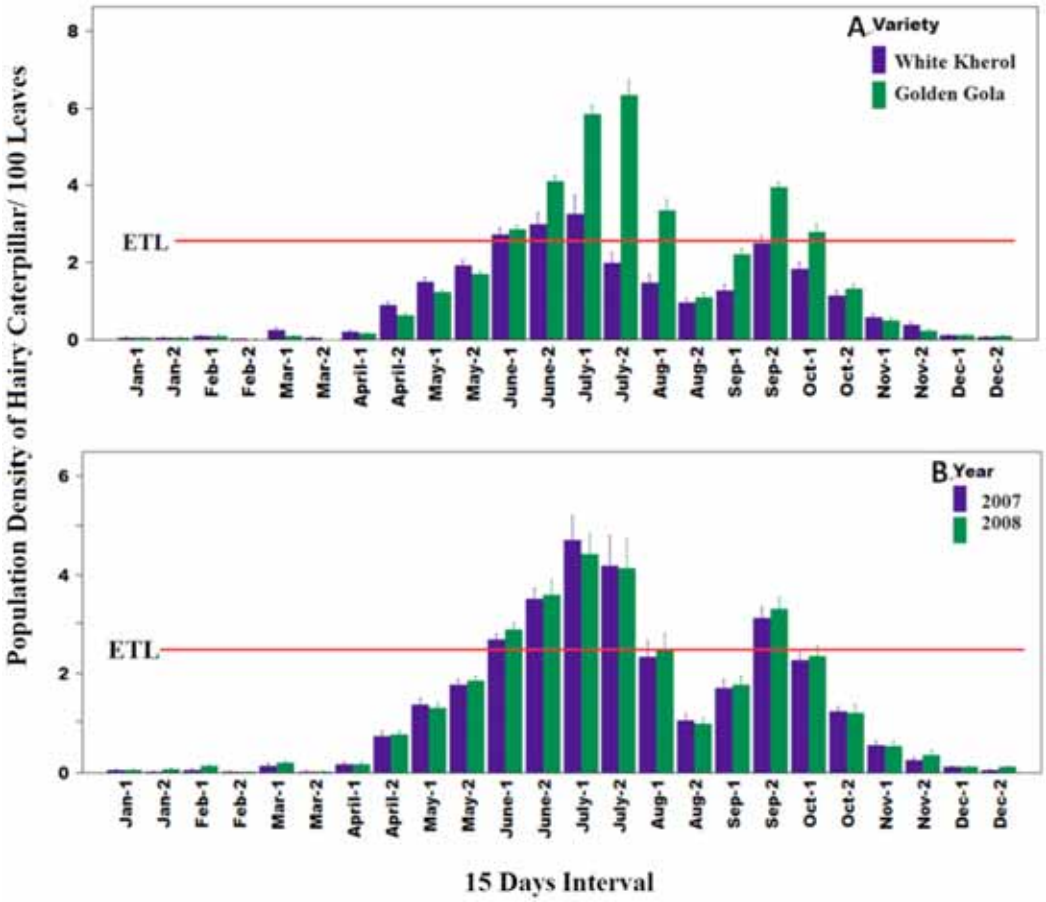

Figure 5: Population density of Hairy caterpillar on resistant and susceptible varieties (**A**) of *Zizyphus mauritiana* during 2007and 2008 (**B**).

Note: SE= 0.2053; LSD (0.05%) = 0.4030.

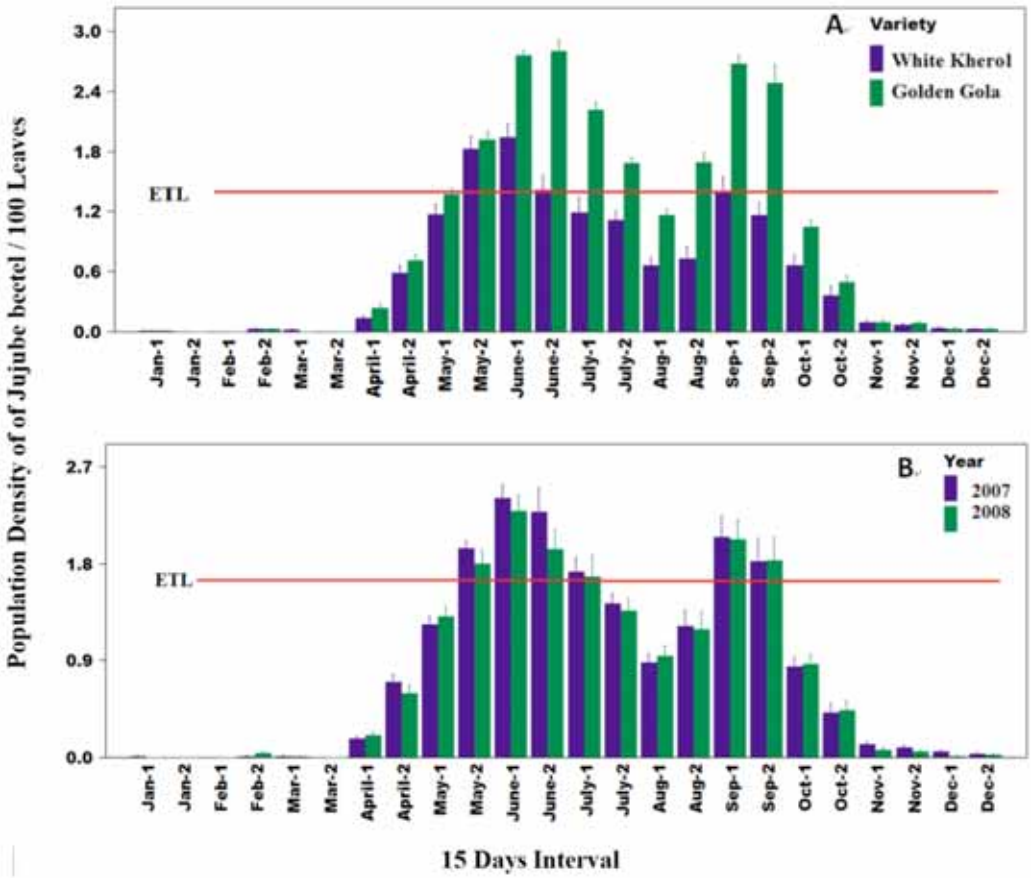

Figure 6: Population density of Jujube beetle on resistant and susceptible varieties (**A**) of *Zizyphus mauritiana* during 2007and 2008 (**B**).

Note: SE =0.0300; LSD (0.05%) = 0.058.

Kherol and Golden Gola jujube trees crossed the ETL (1.3 *Adoretus pallens* 100^{-1} leaves) after 15th May, which continued above the ETL on Golden Gola variety up to the end of September. However, on the White Kherol the population declined below the ETL after 15th June, which continued below ETL throughout the year. The first highest peak of *Adoretus pallens* was seen after 15th July and then declined. The second peak of *Adoretus pallens* was noticed in the beginning of September and the gradually declined (Figure **6A**). The Figure **6B** showed the population density of *Adoretus pallens* 100^{-1} leaves for 2007 and 2008. There was a significant difference for two year of observation; however, on overall basis the population of *Adoretus pallens* 100^{-1} leaves was higher during 2007 compared to 2008 (Figure **6**).

DISCUSSION

Jujube, *Ziziphus mauritiana* is one of the most important fruit, consumed worldwide for its nutritional and medicinal purpose [3, 4]. Beside its economic value, several biotic and abiotic factors are influencing on the production. However, the literature available on *Z. mauritiana* especially in Pakistan indicates very negligible work has been done over this important fruit tree. The infestation of fruit fly and lower infestation of caterpillars, weevils, beetles, and mite on jujube tree has also been reported [16]. However, no any further details are reported in this study that can be used as indicators for pest management. The occurrence of insect pest is the major threat to reduce the quality and quantity of fruits, ultimately causing tremendous economic loss to the growers. It is also reported that some time these insect pest may reduce up to the 100 percentage of crop yield.

The current study is the first comprehensive study on the population density of foliage insect pests, which are the main threats for this most important fruit tree. The resistant and susceptibility of jujube variety has been decided based on the population density of foliage insect pests. On the basis of overall population percentage, Kherol variety was observed as resistant and Golden Gola as susceptible against almost all insect. The major insect pests such leaf roller, hairy

caterpillar and jujube beetle found infesting on the both variety. However, White Kherol showed the complete resistance against leaf roller compared to hairy caterpillar and jujube beetle. This may be due to the plant metabolites available in the leaf of white Kherol that developed the resistant against leaf roller. The population density of jujube leaf roller on Golden Gola was observed higher that indicates the susceptibility in this variety. It has also been reported that jujube leaf roller is serious pest in India and Pakistan; larvae feed from lower surface of the freshly grown leaves, rolling up leaves from the edges to midrib and feed on leaf tissues [17, 18]. In the current study, similar evidence was observed for jujube leaf roller. However, no any detailed evidence is available pertaining to the population density of this major pest. Current study determined the population fluctuation throughout the year, and found the highest peak of *Ancylis sativa* after 15th July and which was gradually decreased in the later months. This may be due to the jujube phrenology and environmental condition of the jujube area. Generally primary shoots are developing in the month of March and April, and the secondary shoots are growing in the month of May to July, that are tender and soft, respectively, supporting the growth and development of jujube leaf roller. It was observed that the older leaves were not supporting the growth and development of this pest. Another species of jujube leaf roller, *Synclera univocalis* reported by Singh and Mann [18] which is also main pest webbing the leaves of jujube in the Indian Punjab. In the previous studies, even for both species, there was no any decided ETL that may be kept under consideration before managing the pest. Here, we formulated the ETL i.e 3.3 *Ancylis sativa* 100^{-1} leaves of susceptible jujube tree based on the population.

Similarly, hairy caterpillar is widely distributed in India and Pakistan [19]. This is polyphagous in nature and is reported as destructive pest to Jujube especially during summer season [20]. In the current study, Hairy caterpillar (*Euproctis fraterna*) was major and second most important insect pest infesting on both, White Kherol and Golden Gola. Two peaks of *Euproctis fraterna* were noted, first after 15th July, then declined and second peak after 15th September and the gradually declined. The population of *Euproctis fraterna* crossed the ETL (2.5 *E. fraterna* 100^{-1} leaves) in the beginning of June and then declined in the month of October, however, in Kherol variety; population crossed the ETL in the beginning of June and then declined after 15th July. This variability maybe due to the varietal response as well as due to the influence of a biotic factor on the pest population. The third major insect pest of current study was jujube beetle, which was observed with high population on both varieties that crossed the ETL (1.3 *Adoretus pallens* 100^{-1} leaves) after 15th May. In the previous studies jujube beetle is reported as serious foliage pest and has been active during summer (May-August) [9, 21].

With reference to pest scouting methods, direct counts, though it was laborious, resulted high population, however, some nocturnal insect are difficult to observe. To cope the situation light trap was used for the monitoring of nocturnal insect pest. As result we become able to present the data of jujube beetle which showed high population through light trapping and also some moths which were captured in light trap which was assembled in iron stand with glass jar. The source of light was mercury bulb that emitted fluorescent light. It also reported that this technique is generally applied for the collection of moths, scarabaeid beetles (Lepidoptera, Scarabaeidae), and some Hemiptera and Hymenoptera. The beetles have been reported to be trapped by using any source of light [8].

It is concluded from the present study that Leaf roller (*Ancylis sativa*), Hairy caterpillar (*Euproctis fraterna* Moore) and Jujube beetle (*Adoretus pallens* Blanchard) are serious insect pests and can cause heavy economic loss in case of improper management. During two years of studies, highest population density was recorded for these three major pests. Pest monitoring with direct count and light trap can help to determine the ETL that is most important for the management of various insects.

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