MANAGEMENT OF HAIRY CATERPILLAR, EUPROCTIS FRATERNA MOORE OF JUJUBE, *ZIZIPHUS MAURITIANA* LAM.

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ABSTRACT*: Jujube, Ziziphus mauritiana is a very important fruit crop of Pakistan. The fruit contains many type of minerals and vitamins. Hairy cater pillar (HCP), Euproctis fraterna* Moore *(Lepidoptera, Lymantriidae). is one of the major threats to reduce the quality and quantity of fruits, ultimately causing tremendous economic loss to the growers. The current study is the first comprehensive attempt on the management of E. fraterna of Jujube. . The results indicated that the pest had two population, in mid July and September, respectively on Golden Gola variety. Whereas, the population on White Kherol variety crossed the ETL (2.5 E. fraterna 100^{-1} leaves) in the begining of June and then declined after 15^{th} July. The infestation percentage of E. fraterna was recorded from different jujube orchards at Hyderabad, Tando Allahyar, Matiari, T. Muhammad Khan and Mirpur Khas showed the significant variability in the infestation, which was significantly higher at Mirpur Khas the lowest at Matiari district.*

The light trap catches plus application of Neem seed extract (NSE) and lorsban significantly reduced the pest population. Whereas NSE+Dhatura, NLE+Dhatura, Radiant and Laser also found effective against the pest. The pesticides Talstar and Polytrine C were less effective against HCP. It is concluded that installation of light trap, application of Neem seed extract and Lorsban efficiently managed the population of Hairy caterpillar in Jujube orchards. The present research work provides the comprehensive knowledge about jujube Hairy cater pillar management.

INTRODUCTION

Jujube fruit is one of the world's most nutritious plants, provide energy for human consumption and play a important role in the development of the human body [1,2]. In China, it is a famous Chinese fruit used both for its sweet taste and for medicinal value [3].

Ziziphus. mauritiana possess broad genetic diversity and is cultivated nearly every continent of the world. It has ability to grow even an excessive drought and is believe to be the dominant component of the natural vegetation of the India and Pakistan deserts; therefore, it is quote as an example of extremely drought-hardy species of the world [4]. Well-drained sandy loam soils are more preferred for cultivation used of Jujube but it can tolerate many type of soils or even high alkaline soils [5, 6, 7]. It also reported that fruits of many *Ziziphus* species are edible and consumed in various ways. Generally jujubes are eaten as fresh, however, may be dried and made into confectionery, pickled, or extracted juice for drinks can be also be used [8].

Jujube tree is quick growing, early bearing and yields a large production every year. However, a great variability existed in different available varieties for fruit, stone, quality, nutritive value, harvesting period and yield potential [9]. 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 [10]. Among all these insect pests, Hairy caterpillar (*Euproctis fraterna* Moore) is also considered as serious pest of Jujube. [11, 12, 13, 14]. That particular pest is not only causing damage on leaves but also seen on fruits too, its attacks ultimately loosen the vigor of the tree and thus the fruit production is also reduced. Polyphagous hairy caterpillar is a very destructive to Jujube during summer. The caterpillars feed gregariously on the epidermal tissues of the leaves by scraping the chlorophyll content of leaves, resulting in the skeletonization of leaves.[15].

There are several gaps need to be filled in the jujube ecosystem and cultivation technology. However, the major interests related to jujube production are needed to develop management approaches, which are environmentally friendly and may avoid excessive chemical inputs, especially for Hairy caterpillar pest. These interests will only be addressed by continued basic then advanced research to produce reliable planting materials of selected superior germplasm especially with excellent fruit characteristics, adaptation of germplasm to stress conditions, and protecting from major insect pests. In addition, there is a need of applied research to adapt available techniques to planting systems for particular agro ecological and climatic zones.

MATERIALS AND METHODS

Studies on management of Hairy caterpillar of Jujube, was carried out during 2007 and 2008 growing seasons at Department of Plant Protection, Sindh Agriculture University, Pakistan and adjacent fields. The material used and methods followed for different investigations have presented here under.

Integrated pest management of *Euproctis fraterna*

To develop the integrated pest management (IPM) model of major Hairy caterpillar of jujube various field and laboratory experiments conducted at the orchards of Tando Qaiser, Hyderabad and Plant Protection Department, respectively. Different IPM approaches viz, light trap, botanicals and insecticides tested on the major foliage insect-pests of jujube. The result of each experiment conducted is present hereunder:

Light trap

Four light traps per acre at the distance of 70 feet between one trap to another were installed in jujube orchard, and were operated at night to attract the adults of Hairy caterpillar. The height of light trap was 8 feet above the ground level. Data was recorded on daily basis and adult moths of *E. fraterna* were separately counted. The weekly mean and overall

population was recorded in the current experiment. The experiment was repeated during both year of study to confirm the reduction in the infestation percentage of major foliage insect pests.

Evaluation of various botanical extracts

The efficacy trials of four different formulations of Neem (*Azadirachta indica* L.) and Dhatura (*Datura stramonium* L.) for the control of Hairy caterpillar were evaluated at the farmer's fields of Tando Qiaser, District Hyderabad, Sindh.

All experiments conducted on naturally occurring insect pest populations. For each treatment, a row of susceptible variety, Golden Gola with 10 jujube trees was selected and treated thrice (15 May, 15 June and 15th July) in a season. A control row also maintained for the comparison of pest insect population. The observation of different treatment assessed by counting the number of live larvae, Pre-treatment observations were recorded one day before and post-treatment observations after spray on a weekly basis. The detail of each formulation mentioned below:

Neem Leaves Extract (NLE)

Fresh leaves of the neem (1kg Leaves/5 L water) tree were soaked for 24 hours in tap water. On the next days, the solution filtered through fine gauze (muslin cloth) to remove the bigger particles; the filtered solution was then ready for afield application (spraying). Before the spray, 1.0g of detergent powder was added in a solution. The spraying was done in the morning using knapsack and power sprayer.

Neem Seed Extract (NSE)

The spray solution was prepared as a water extract of the kernel of neem fruits at conc. of 50g/1L water. The dry fruits (along with skin coat) of neem were crushed lightly to break them, the seed kernel was then powdered using an electronic blender. The mixture was kept for 24 hours and on the next day, the solution was filtered through fine gauze to remove the bigger particles; the filtered solution was then ready for field application. In the spray solution, 1.0g of detergent powder added in a solution. The spraying was done in the morning using knapsack and a power sprayer.

Dhatura Extract (DE)

The spray solution was prepared as a water extract of dhatura fruits at concentration of 50g/L water. The dry fruits of Dhatura crushed lightly to break them; the seeds were then powdered using an electronic blender. The mixture kept for 24 hours and on the next day, the solution filtered through fine gauze to remove the bigger particles; the filtered solution was then ready for field application. In the spray solution, 1.0g of washing powder has added. The spraying was done in the morning using knapsack and a power sprayer.

Combinations

Two different combinations viz; NLE+Dhatura and NSE+Dhatura were used to test the efficacy against major Hairy caterpillar of jujube. Both extracts were prepared same as explained in section 3.3.6.1 and 3.3.6.3, respectively. In the spray solution, 1.0g of washing powder added. The spraying was done in the morning using knapsack and power sprayer.

Evaluation of various commercial insecticides

The efficacy trials of five different insecticides for the control of the Hairy caterpillar of Jujube were evaluated at the farmer's fields of Tando Qiaser, District Hyderabad, Sindh. All experiments were conducted on naturally occurring insect pest populations. All the insecticides were applied using a knapsack and power sprayers. For each treatment, a row of susceptible variety, Golden Gola with 10 jujube trees was selected and treated thrice (15th May, 15th June and 15th July) in a season. A control row also maintained for the comparison of insect pest population. The observation of treatments was assessed by counting the number of live larvae. Pre-treatment observations were recorded one day before and post-treatment observations after spray on weekly basis.

Efficacy percentage

The efficacy percentage of pesticide was calculated for monthly mean population. The experiment was repeated two times during 2007 and 2008. The efficacy percentage of the insecticides was assessed based on percent population reduction of pests using the formula of Henderson-Tilton as explained in section 3.3.6.4.5.

Table 1. Botanical extracts used to control the foliar jujube Insect pests

Formulation	Botanical name	Plant Part used	Dose L^{-1}
Neem Leaf Extract (NLE)	*Azadirachta indica* L.	Leaves	50g
Neem Seed Extract (NSE)	*Azadirachta indica* L.	Seed with coat	50g
Dathura	*Datura stramonium* L	Seed	50g
NLE+Dhatura	-	-	50g
NSE+Dhatura	-	-	50g

Table 2 Insecticides used to control the foliar jujube pests

Common Name	Trade name	Chemical Group	Manufacturer	Dose
Chloropyriphos	Lorsben- 40 EC	Organo Phosphate (OP)	Dow Agro Science	300ml $200L^{-1}$ water
Dimethoate + Cypermethrin	Laser- 25EC	OP+Pyrethroid	Pak Agro	300ml $200L^{-1}$ water
Spinetoram	Radiant-120 SC	Spinosyn	Dow Agro Science	20 ml $200L^{-1}$ water
Cypermethrin+ Perofenofos	**Polytrine-C 440EC**	OP+Pyrethroid	Syngenta	250ml $200L^{-1}$ water
Bifenthrin	Tal Star-10 EC	Pyrethroid	FMC	200ml $200L^{-1}$ water

RESULTS

Integrated pest management of major Hairy caterpillar in jujube ecosystem

To develop the integrated pest management (IPM) model of major Hairy caterpillar of jujube, various IPM approaches viz, light trap, botanicals and eco-friendly insecticides were tested on Hairy cater pillar of jujube at orchard of Tando Qaiser, Hyderabad. The results achieved therefore are presented here under:

Light trap

The population of *E. fraterna* with light trap during 2007 and 2008 is presented in Figure 1. It is evident from the statistical analysis that maximum mean population of two years was trapped in on 30th August (5.67/acre) and 30th September (5.43/acre) followed by 30th July (3.96/acre), 30th May (3.35/acre) and 30th June (3.23/acre), however, no significant difference was observed for trapping of *E. fraterna* in the months of August and September. The population of *E. fraterna* was lowered in the month of December, January and February of years, 2007 and 2008 (Figure 1). The overall mean number and percentage of two years, 2007 and 2008 for *E. fraterna* is presented in Figure 1. The results indicate that highest number and percentage (84.09; 12% acre^{-1} year $^{-1}$) compared to other major insect pests (Figure 1).

Botanical control

The results obtained on percentage reduction in *E. fraterna* in various botanical extract alone and combinations including Neem Leaf Extract (NLE), Neem Seed Extract (NSE), Dhatura, NLE+Dhatura and NSE+Dhatura are presented in Figure 2. It is evident from the data that efficacy percentage significantly varied between the treatments, however, no significant difference was observed for two experiments conducted during 2007 and 2008. It is obvious from the results that infestation percentage of *E. fraterna* was significantly reduced with NSE followed by NSE+Dhatura and NLE+Dhatur indicates their higher efficacy (62.69, 57.61 and 54.07%), respectively. But against in field conditions after three applications, however, no significant difference was observed in the efficacy of NSE+Dhatura and NLE+Dhatura. The efficacy of Dhatura (45.99%) and NLE (45.46%) was lower with no significant difference compared to others (Figure 2).

Chemical control

The results on the effect of various commercial insecticides used against the *E. fraterna* are presented in Figure 3. It is obvious from the data that the pre-treatment *E. fraterna* population on jujube foliage 100^{-1} leaves varied from 1.3 to 4.74, which was above the ETL level. After different treatments of insecticides that population was reduced in all the treatments with three different applications of sprays viz; 15th May, 15th June and 15th July, respectively. After the first spray (15th May), the population of *E. fraterna* reduced below the ETL (2.5 *E. fraterna* 100^{-1} leaves) with Lorsben followed by Radiant, Laser, Polytrine-C and Talstar (0.22, 0.23, 0.73, 1.73 and 2.23 *E. fraterna* 100^{-1} leaves), respectively, compared to control plot (3.14 *E. fraterna* 100^{-1} leaves). The maximum reduction of *E. fraterna* 100^{-1} leaves was obtained with Radiant, Lorsben and Laser (0.90, 0.96 and 0.97/100 leaves) after third spray on 15th July compared to control plot (4.62 *E. fraterna* 100^{-1} leaves), however, no significant difference was observed for the efficacy of Radiant, Lorsben and Laser against *E. fraterna*. Whereas, the population of *E. fraterna* 100^{-1} leaves crossed the ETL (2.9) after three spray of Talstar indicates its lower efficacy against *E. fraterna*. The mean reduction after three sprays indicates the significant difference among the treatments. The efficacy of Radiant (0.51) and Lorsben (0.55) followed by Laser (1.05), Polytrine-C (2.05) and Talstar (2.55) were remained more effective, which reduced *E. fraterna* population below the ETL. In the control plot the population *E. fraterna* 100^{-1} leaves was remained higher (3.88) during both years of experiments (Figure 3)

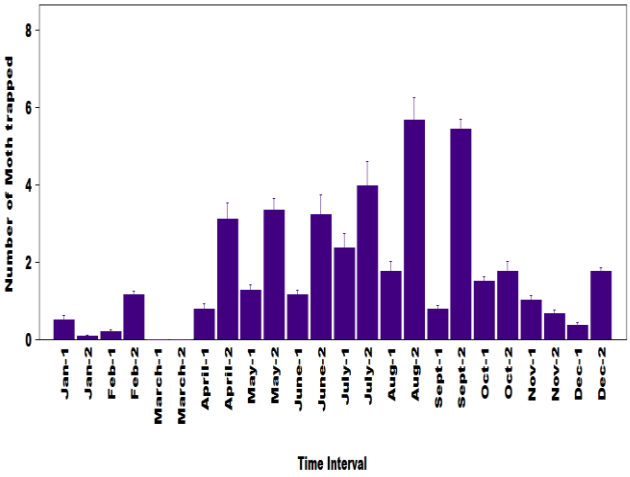

Figure 1 Light trapped mean population of Hairy caterpillar (*E. fraterna*) moth recorded during 2007 and 2008.

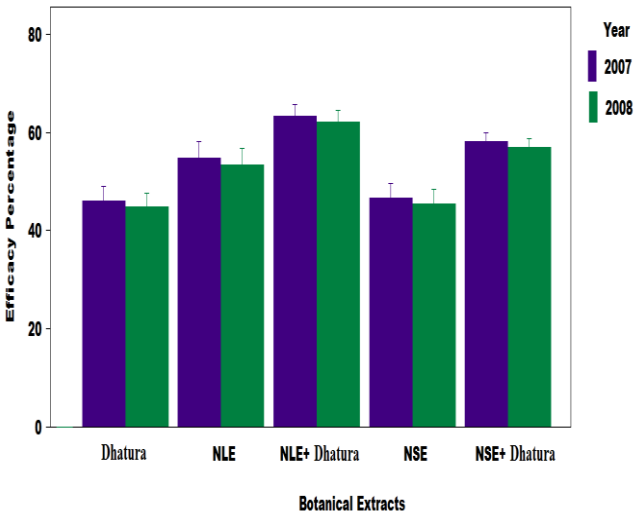

Figure 2 Efficacy of different botanical extracts (Mean ± SE) against *E. fraterna* in field conditions of jujube.
Note. NLE = Neem Leaf Extract; NSE = Neem Seed Extract

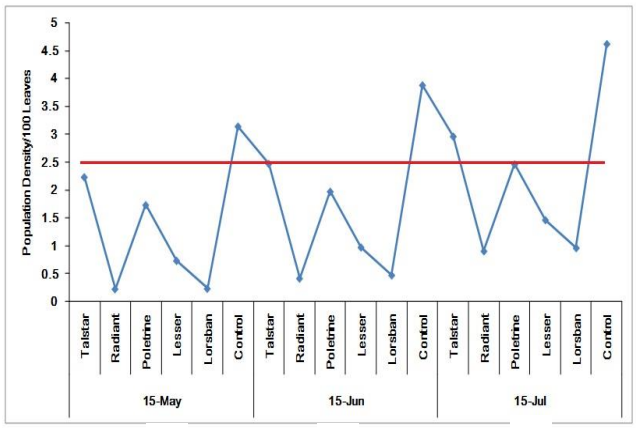

Figure 3 Effi[illegible] of different [illegible] mercial insecticides (Mean ± SE) against *E. fraterna* in field conditions of jujube.
Note. The red colored line showing the ETL (2.5 *E. fraterna* 100^{-1} leaves) of *E. fraterna*

DISCUSSION

Jujube, *Ziziphus mauritiana* is one of the most important fruit, consumed worldwide for its nutritional and medicinal purpose [1,2]. However, the literature available on *Z. mauritiana* especially in Pakistan indicates very negligible work has reported over this important fruit tree, especially on plant protection side for Hairy caterpillar pest. There are only two reports available in the literature for the insect pests of jujube in Pakistan. Firstly, it is mentioned that about 23 different species of insect pests, however, out of these 13 species attack on the foliage right from sprouting to fruit harvest of the jujube tree [10]. In the second report, the infestation of fruit fly and lower infestation of caterpillars, weevils, beetles, and mite on a jujube tree was reported by [16]. However, no any further details are reported in this study that can be used as indicators for insect pest management. The current study is the first comprehensive study on the population density of *Euproctis fraterna*, that is main threats for this most important fruit tree. In addition, integrated approaches for the *E. fraterna* management is also highlighted here by [17]. Similarly, [18] reported twenty-seven species of insects were feeding on *Ziziphus mauritiana*; however, the main pests were *Euproctis fraterna* and *Synclera univocalis*.[19] reported seven main pests of Indian jujube such as *Ansylis sativa, Adoretus spp, Panonychus citri, Inderbela tetraonis, Amrasca devastans, Taucus theophrastus, and Porthesia Taiwan, Euproctis fraterna*. In addition to these lines, [20, 21, 22] and [23] reported that Jujube leaf roller as serious insect pests in India. Jujube beetle and Hairy cater pillar are reported to be active during summer (May-August) by [10] reported that Jujube beetle which is commonly called as Chafer beetle or ber beetle or leaf chafer, and there are various species of Jujube beetles (*Adoretus decanus, A. kanarensis, A. stoliezkae, A. pallens, A. versutus*) (Coleoptera: Scarabaeidae) mainly devour the foliage during the night time. However, there was no any comprehensive study reported about these major and minor insect pests. The current study documented all these major and minor insect pest as well sporadic pests and natural enemies along with pictorial illustration that can be used as manual for future references.

Light trap

The light is one of best tool the monitoring of insect, simultaneously, an easiest way for the capturing of nocturnal insect pest. The moth population of *A. sativa* with light trap revealed the maximum mean light trapped in beginning of September followed by July, however, no significant difference was observed for trapping of moth in these months. The moth population was lowered in the month of December, January and February of years, 2007 and 2008. The population of *E. fraterna* with light trap during 2007 and 2008 revealed maximum mean number was trapped on 30th August and September followed by July, and June/acre, however, no significant difference was observed for trapping of *E. fraterna* in the months of August and September. The overall mean number and percentage of two years, 2007 and 2008 for *E. fraterna* indicate highest number and percentage. It is obvious from the statistical analysis that maximum mean population of *A. pallens* was trapped on 30th June and 30th May with no significant difference followed by 30th September, 15th June and 30th August. The population of *A. pallens* was observed lower in the month of December, January and February of years, 2007 and 2008. The overall mean number and percentage of two years, 2007 and 2008 through light trap for *A. sativa* moths was highest compared to *E. fraternal* and *A. pallens*. Similarly, [24] reported that beetles were captured through light trap.

Botanical control

The use of plants and plant part extracts is also cheapest and safest way of insect pest control. The use of neem tree for the control of insect pests and other disease is well documented. Here we used a different formulation of neem and Dhatura alone (Neem Leaf Extract, NLE; Neem Seed Extract, NSE; Dhatura) and in combination (NLE+Dhatura and NSE+Dhatura) to reduce the infestation. Reduction in the percentage of *E. fraterna* was achieved with NSE+Dhatura and NLE+Dhatura followed by NSE indicates their higher efficacy. It is also reported that *Pongamia glabra* leaf extract contains fatty acid which is responsible for blocking the pores of the cellular membrane of the alimentary canal of *Euproctis fraterna* and reduction of growth and growth rates. The application of neem seed kernel extract (NSKE @ 5%) is also reported as an effective against *Euproctis fraterna* larvae.

Chemical control

The use of pesticides is no doubt dangerous for the agro-ecosystem as we all as for human and animal health. These injurious pesticides also suppressing the population of beneficial; however, some time it is necessary to use these pesticides to reduce the insect pest population below the economic injury level as crop can be saved from huge economic losses. In the current study, we used some commercially available pesticides against *E. fraterna*. Similarly, the efficacy of Radiant and Lorsben followed by Laser, Polytrine-C and Talstar were remained more effective, which reduced *E. fraterna* population below the ETL. Maximum reduction in the population was achieved with Lorsben and Radiant followed by Talstar and Laser,

respectively, compared to control plot. However, Lorsben followed by Radiant had the lower population compared to Talstar and Laser. The efficacy of Talstar, Laser and Polytrine-C was observed poor in which the population of *A. pallens* after third spray was observed above the ETL. Several lines of research reports are available for the management of Hairy caterpillar of jujube with pesticides. [25] reported that spraying a mixed solution of fertilizers and pesticides before flowering secures a control of 85-96% for *Ancylis sativa*. *Ceroplastes japonicus* was controlled either by the application of 500-800x solution of 50% Carbaryl reported by [22,23]. *Chihuo zao, Carposina niponensis* and *Synclera univocalis* were also successfully controlled on jujube either by 3 applications of 1500x solution of 25% Chlorbenzuron [22, 23]. The best control of *Amrasca devastans* and *Q. pakistanica* on jujube was achieved by Cyhalothrin, Carbaryl, Methomyl and Fastac is also reported by [13]. Similarly, the young stages of hairy caterpillars were controlled with 10% BHC when dusted, however, BHC, Endrin, Aldrin, Endosulfan, Trichlorphon and Carbaryl proved best pesticides for the control of all instars *of Euproctis fraterna* is mentioned by [26,27, 28] in another study successfully controlled *Pagyda traducalis, Ancylis lutescens* and *Limnaecia* sp. on jujube by the use of Quinalphos, Phosalone and Fenitrothion. [17] obtained the most effective control of 3rd to 6th instars larvae of *Euproctis fraterna* with different insecticides, including Cypermethrin, Deltamethrin, Fluvalinat) and Fenvalerate. [28] was found most effective control on hairy caterpillars with the spray of 0.05 % Monocrotophos and 0.2 % Carbaryl (Killex carbaryl 50WP). Similarly, the spray of 0.2% Carbaryl (50WP) and 0.05% Monocrotophos effectively control the Jujube beetle [28].

CONCLUSIONS

Current study was the first comprehensive research on the "Management of Hairy caterpillar, *Euproctis fraterna* moore of Jujube, Z*iziphus mauritiana* Lam'' which is the main threat for this important fruit crops. In addition, documentation of Hairy caterpillar and integrated approaches for the foliage insect pests management are also highlighted. Two peaks of *E. fraterna* were noted, on 15th July, then declined and second peak on 15th September and the gradually declined. The maximum population of *E. fraterna* captured with light trap was recorded in August and 15th of September; however, it was lowered in the month of December, January and February of years, 2007 and 2008. Reduction in the infestation *E. fraterna* was obtained with NSE=Dhatura and NLE+Dhatura followed by NSE indicates their higher efficacy. Lorsben followed by Radiant and Laser was remained more effective, which reduced *E. fraterna* population below the ETL, whereas, the efficacy of Talstar and Polytrine-C was observed less effective.

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