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INCIDENCE AND DISTRIBUTION OF LEMON BUTTERFLY (*Papilio demoleus* L.) LARVA IN CITRUS ORCHARD AND NURSERY IN SYLHET

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Abstract

An attempt was made to explore the incidence of lemon butterfly larva in the orchards and nurseries of Jara lemon, Mandarin and Sweet orange in Jaintapur, Sylhet during May to October 2014. At host plant level, citrus orchards were selected from Citrus Research Station (CRS), Dowdic, Bagerkhal, Lamashampur and Utlarpar village of Jaintapur upazila. In case of orchard, leaf infestation of lemon butterfly larva was recorded from north-facing, south-facing, east-facing, west-facing and central canopy. The maximum leaf infestation was recorded from north-facing canopy of Sweet orange (28.33%), Mandarin (26.56%) and Jara lemon (12.89%). The minimum leaf infestation was recorded from east-facing canopy of Jara lemon (8.47%), Mandarin (20.16%) and Sweet orange (2018%). At landscape level, the highest leaf infestation was recorded in Mandarin (24.69%) and Sweet orange (27.89%) of Bagerkhal village. The lowest leaf infestation (20.16%) was recorded in Mandarin orchard of CRS. Larval infestation on Jara lemon, Mandarin and Sweet orange leaves was low in May and gradually increased up to October. The seasonal fluctuation pattern suggests that pest management measures need to be adopted during new flushes to keep the pest attack below economic injury level. In case of nurseries at CRS only, infested seedlings of Jara lemon, Mandarin and Sweet orange were sampled at 15 days after grafting (DAG), 30 DAG, 45 DAG and 60 DAG from 2.0 m × 2.0 m quadrat. At 60 DAG, the highest infestation was recorded in Jara lemon (57.5%), Mandarin (70.0%) and Sweet orange (82.5%). At 15 DAG, the lowest infestation was recorded in Jara lemon (5.0 %), Mandarin (12.5%) and Sweet orange (20.0%). Seedling infestation rapidly increased up to 30 DAG and gradually increased up to 60 DAG. The larval incidence pattern on seedlings indicates that proper management techniques need to be undertaken at 15 DAG when seedlings are at very early stage and larval attack just starts in the nursery.

Keywords: Jara lemon, Mandarin, sweet orange, host preference.

Introduction

The genus *Citrus* is unique in its diversity of forms and ranked as the third largest production in fruit industry of the world. It occupies 6% of the total area under various fruits (Sarada *et al.,* 2014). It is widely grown in most areas of the world with suitable climates of tropical, subtropical and borderline temperate regions (Kahn *et al.,* 2001). The production of citrus fruits is gradually increasing in Bangladesh over the years. About 155,936 metric tons of citrus fruits were produced in the country during 2016-2017 (BBS, 2017) and the country occupied the 54th position among the citrus producing countries of the world during 2015-2016, sharing around 0.47% of world's total production of citrus (FAO, 2016).

The larva of lemon butterfly, *Papilio demoleus* L. may cause complete defoliation in infested young plants (Butani and Jotwani, 1975). The host preference of *P. demoleus* lies in the order of Sweet orange >Curry leaf >Acid lime (Nandini *et al.,* 2012). It caused 83% leaf defoliation in Sweet orange (Narayanamma *et al.,* 2001). The peak larval activity of *P. demoleus* was noticed during November to February on Kagozi lime in Karnataka, India (Matsumoto, 1996). Matsumoto (1996) also reported that butterfly appears in March and keeps fast breeding during July to September. It has been reported that the larva remains active up to November and thereafter the pupal stage falls in winter season (Nandini *et al.,* 2012). According to Shravan *et al.* (2010), the butterfly incidence was high during June to October in *Citrus limon* in India. The larval population of *P. demoleus* went up to the maximum level (0.13 ± 0.02 larvae branch^{-1})

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during August and February months when temperatures ranged from 28 to 30°C and relative humidity ranged from 82 to 84% (Suwarno, 2010).

The pest attacked mandarin and acid lime plantations almost throughout the year but serious infestation was found during July to August when high relative humidity and low temperatures favored the larval activity of lemon butterfly (Beattie, 2004). The incidence of *P. demoleus* larva was high during August to September in Uttar Pradesh, India (Alturi *et al.*, 2002). Lemon butterfly is a serious pest of various types of citrus plants, but its seasonal abundance and distribution at host plant and landscape levels have not been studied well in Sylhet region. Keeping these viewpoints in mind, the present study was undertaken to find out the abundance and spatiotemporal distribution of lemon butterfly in nurseries as well as in the orchards of Jara lemon, Mandarin and Sweet orange in Sylhet.

Materials and Methods

Study site

The study was carried out in Jaintapur upazila of Sylhet district. Sylhet is located between 23°57' and 25°13', north latitude and between 90°56' and 92°21' east longitudes. In order to determine the leaf infestation (%) in the orchard of Jara lemon, Mandarin and Sweet orange, the study was conducted at five locations of two unions under Jaintapur upazilla in Sylhet district. Citrus Research Station and Dowdic village is located at Nijpat union and three villages like Bagerkhal, Lamashampur and Utlarpar located at Fatehpur union. In order to determine the incidence of lemon butterfly larva (%) in the nursery of Jara lemon, Mandarin and Sweet orange, the study was conducted at Citrus Research Station (CRS), Jaintapur upazilla in Sylhet district.

Selection and tagging of plants in citrus orchard

To determine the leaf infestation (%) in citrus plant, one orchard each of three citrus host plants *viz.*, Jara lemon, Mandarin and Sweet orange was selected from each study location. Then four plants from each type of orchard were randomly selected and tagged for data collection. Since the number of orchards was only one from each study location, no particular design was followed in the experiment.

Incidence of lemon butterfly larva

In order to determine the incidence of lemon butterfly larva at host plant level, horizontal distribution was determined based on data collected from the four tagged plants of each location. The horizontal distribution on Jara lemon, Mandarin and Sweet orange included five canopy directions *viz.*, north canopy, south canopy, east canopy, west canopy and central canopy. These five canopy directions were considered from middle canopy of the plant. Then one twig from each canopy direction was selected randomly. Then the number of infested leaves was counted from fifty leaves of the selected twig at each canopy direction. Besides the above, in order to determine the distribution of lemon butterfly at landscape level, location wide distribution of lemon butterfly was determined based on data collected from the four tagged plants from each of five locations of the study.

Sampling of infested seedlings in citrus nursery

To determine the seedling infestation (%) in citrus nursery, one nursery each of three citrus host plants (i.e., Jara lemon, Mandarin and Sweet orange) was selected for data collection. The size of each nursery was 30 m × 15 m. A quadrat of 2 × 2-m size was placed at random in three locations each of Jara lemon, Mandarin and Sweet orange nurseries to collect data of infested seedlings out of 40 seedlings inside each quadrat. Data on infested seedlings were collected at 15, 30, 45 and 60 days after grafting (DAG). Each date of data collection was considered one treatment and each location of quadrat was considered one replication. The experiment was laid out in a Randomized Completely Block Design (RCBD).

Data analysis

In case of larval distribution of lemon butterfly in citrus orchard, data on the number of infested leaves were transformed to percent leaf infestation using the following formula:

$$\text{Leaf infestation (\%)} = \frac{\text{Number of infested leaves}}{\text{Total leaves}} \times 100$$

Data were analyzed using MS Excel Software and presented in Figures with error bars of one SE for comparison of means.

In case of lemon butterfly larval infestation in the nurseries of Jara lemon, Mandarin and Sweet orange, data on the number of infested seedlings in quadrat were transformed to percent seedling infestation using the following formula:

$$\text{Seedling infestation (\%)} = \frac{\text{Number of infested seedlings}}{\text{Total seedlings}} \times 100$$

In case of infested seedlings of Jara lemon, before analysis percent data were transformed using square root formula and for Mandarin and Sweet orange, original percent data were analyzed. All data were analyzed using R (v3.3.1, R Development Core Team 2016). The analysis of variance (ANOVA) was calculated for interpretation of the results. Treatment means were compared by LSD test.

Results and Discussion

Incidence of lemon butterfly at host plant level

The incidence of lemon butterfly larva on five canopy directions of Jara lemon, Mandarin and Sweet orange plants are presented in Fig. 1. In case of Jara lemon, the maximum percent leaf infestation (12.89%) by lemon butterfly larva was recorded from north-facing canopy, closely followed by west-facing (11.27%) and south-facing (10.18%) canopy. The minimum percent leaf infestation (8.47%) was recorded in east-facing canopy. The moderate level of leaf infestation (9.13%) was observed in the central canopy. In case of Mandarin, the maximum percent leaf infestation (26.56%, 24.42%) was recorded from north-facing and west-facing canopy, respectively. The minimum percent leaf infestations (20.47%, 20.16%, 18.31%) were recorded in central, east-facing and south-facing canopy, respectively. In case of Sweet orange, the maximum percent leaf infestations (28.33%, 25.7%, 24.58%) were recorded from north-facing, west-facing and central canopy, respectively.

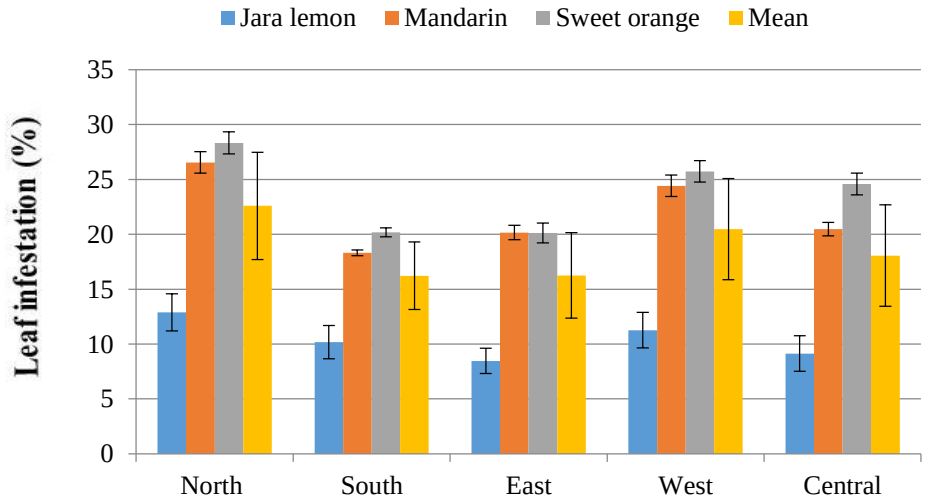

Fig. 1. Leaf infestation (%) of lemon butterfly larva on five canopy directions of three citrus host plants at Jaintapur in Sylhet at host plant level from May to October 2014. Error bars indicate one SE

The minimum percent leaf infestations (20.13%, 20.18%) were recorded in south-facing and east-facing canopy, respectively. The percent leaf infestation of all five canopy directions did not vary among the three host plants, suggesting that canopy structures of the host plants were more or less similar in receiving light intensity. The variation of leaf infestation among the canopy directions may be due to the variation in entrance of light intensity on five different canopy directions. The maximum infestation was found in both north and west canopies possibly due to the prevalence of higher temperature at day times when sunlight was more intense. It is often true that the growth and development of insect population increases with the increase of temperature in any ecosystem (Pedigo, 1996). It is most likely that the temperature of south and east canopy positions remained low due to incidence of lower intense light conditions at early part of the day. Thus the lower incidence of butterfly in these two directions is logical. In the same reason, the moderate level of infestation was found in the central canopy where the temperature and light entrance was moderate due to lower sunlight entrance from surrounding canopy directions. Nonetheless, the microclimatic variations in respect to temperature and relative humidity among the different canopy directions were not recorded during the study. It is thus suggested that future researchers may ascertain the above speculation providing data on microclimatic conditions at host plant level.

Distribution of lemon butterfly larva at landscape level

The incidence of lemon butterfly larva on five locations of Jara lemon, Mandarin and Sweet orange host plants are presented in Fig. 2. In case of Jara lemon, percent leaf infestation of the three host plants did not differ statistically with infestation range of 9.73 to 10.58%. In case of Mandarin, the highest percent leaf infestation (24.69%) was found in

Bagerkhal village, followed by Lamashampur (22.22%), Utlarpar (21.36%) and Dowdic (21.49%) villages. Whereas, the lowest percent leaf infestation (20.16%) was found in Citrus Research Station (CRS). In case of Sweet orange, highest percent leaf infestation (27.89%) was also found in Bagerkhal village. Regardless of the three host plants, significantly the highest percent leaf infestation (21.35%) was noticed in Bagerkhal village. The results clearly showed the rate of leaf infestation by lemon butterfly larva was always markedly higher in Bagerkhal village of Jaintapur. The local citrus farmers of this village are not much aware of the pest attack. Even they do not have adequate knowledge about the incidence and management of lemon butterfly, especially because they have inadequate knowledge about how and when to manage the pest. The results also showed that the rate of leaf infestation was lower in CRS of Jaintapur. It is mentioned here that the citrus farmers who live adjacent to CRS have better understanding and close contacts with the researchers of CRS. They very often receive hands-on training about the management techniques of citrus pests including lemon butterfly. The reason of lower incidence of lemon butterfly larval in CRS could be due to good knowledge and easy access of the local farmers to the scientists of CRS in Jaintapur, Sylhet. The results indicated that hands-on training on pest management techniques of citrus pests could be useful to reduce the lemon butterfly attack in the Sylhet region.

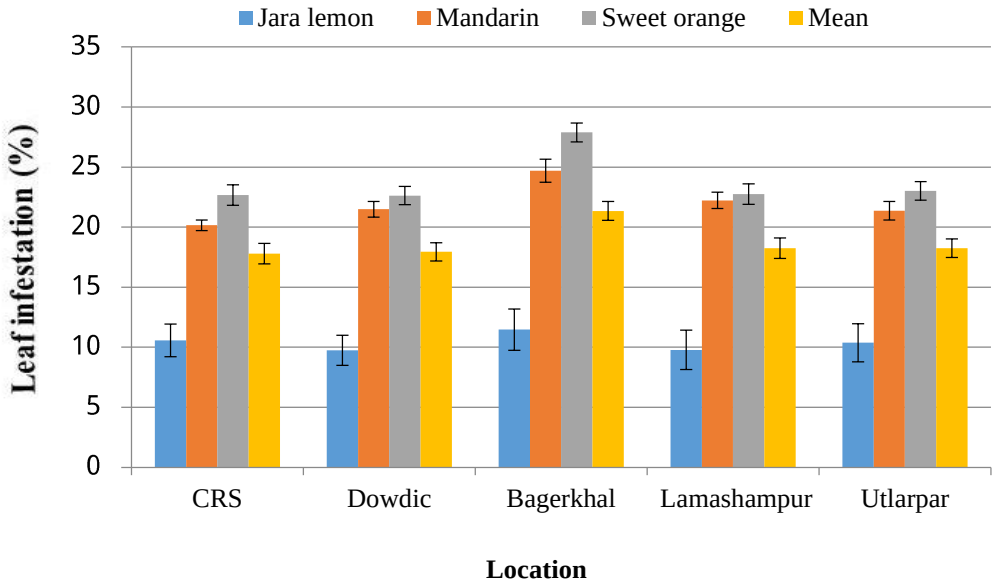

Fig. 2. Leaf infestation (%) of lemon butterfly larva on three citrus host plants of five locations at Jaintapur in Sylhet at landscape level from May to October 2014. Error bars indicate one SE

Seasonal incidence of lemon butterfly larva on Jara lemon, Mandarin and Sweet orange

The incidence of larval leaf infestation on Jara lemon, Mandarin and Sweet orange host plants during the period from May to October is shown in Fig. 3. The results revealed that the infestation was lower in May which increased slowly to June. Afterwards, the infestation gradually increased to the month of October with a consistent increment. The results revealed that the infestation was lower in May which slowly reached a peak in August. After the month of August the infestation again started to decrease slowly, reaching down to a level which is equivalent to the starting month of May. The results showed that the infestation was lower in May and gradually increased to a higher level in October, with no major peak in any subsequent months.

In Bangladesh, there are usually four or five flushes of new leaf on citrus trees each year and the larva of lemon butterfly attacks only the younger and tender leaves mostly at the time of new flushes of leaf and thus infestation remains higher during new leaf formation. The present results indicated that the management techniques against lemon butterfly larva need to be undertaken when new flushes of citrus leaf take place.

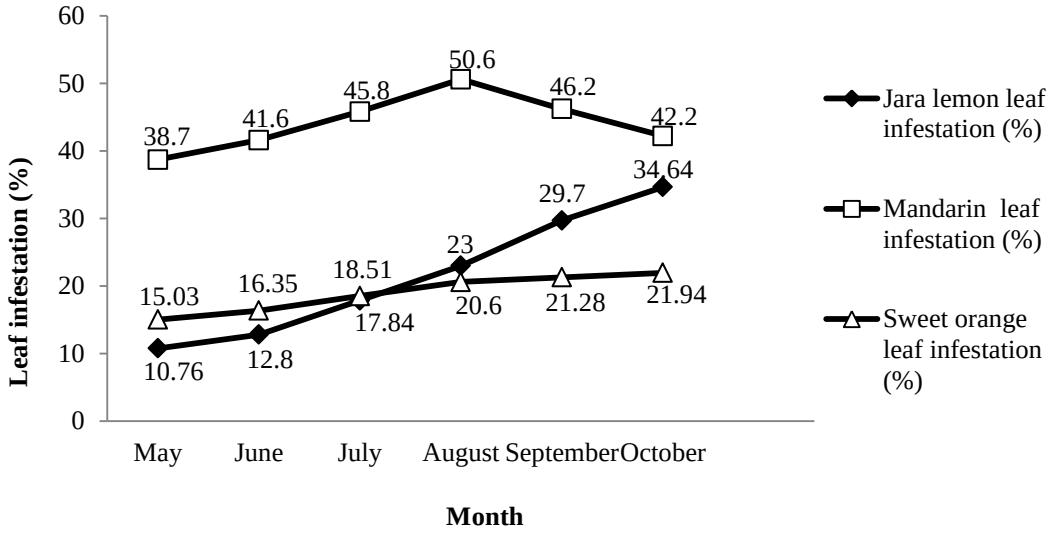

Fig. 3. Seasonal incidence of lemon butterfly larva in Jara lemon, Mandarin and Sweet orange at Jaintapur, Sylhet from May to October, 2014

Incidence of lemon butterfly larva in citrus nursery

The seedling infestation in the nursery of Jara lemon, Mandarin and Sweet orange host plants is shown in Table 1. In case of Jara lemon nursery, the lowest seedling infestation (5%) was found at 15 Days after grafting (DAG) and the maximum seedling infestations were 55.0% at 45 DAG and 57.5% at 60 DAG.

The intermediate level of seedling infestation (32.5%) was found at 30 DAG. In case of Mandarin nursery, the lowest seedling infestation (12.5%) was found at 15 DAG and the maximum seedling infestations were 67.5% at 45 DAG and 70.0% at 60 DAG. The intermediate level of seedling infestation (37.5%) was found at 30 DAG. In case of Sweet orange nursery, the lowest seedling infestation (20.0%) was found at 15 DAG and the highest seedling infestation (82.5%) was recorded at 60 DAG, followed by moderate rates of seedling infestation were 42.5% at 30 DAG and 65.0% at 45DAG. The results indicated that the larval infestation sharply increased up to 30 DAG and then gradually increased up to 60 DAG. It may be mentioned that the percent seedling infestation was calculated on the basis of infested seedlings (i.e. infested either one leaf or more than one leaf of any seedling was considered infested seedling), thus the rate of seedling infestation rapidly spread over the nursery only at early seedling stage. In contrast, when the leaf became mature and less palatable to larva at 45 DAG and 60 DAG, the infestation remained static. The larva of *P. demoleus* may cause complete (100%) defoliation of infested young seedlings (Butani and Jotwani, 1975). The larvae are serious pest of citrus nursery stock (trees 1-2 feet in height) and other young citrus trees in Asia and the Middle East, where they are capable of defoliating entire nursery groves (Bindra, 1957). Almost 83% defoliation was occurred in Sweet orange plants in Andhra Pradesh, India (Narayanamma *et al*., 2001). Butani and Jotwani (1975) reported that larvae may utilize young leaf of mature trees as well. More than 40% defoliation was occurred in acid lime gardens in Tamil Nadu region during October to January (Usharani *et al.,* 2012). The present and previous results indicate that the larval infestation of lemon butterfly is very serious particularly for the seedlings in the citrus nurseries of Bangladesh and India where higher temperature and relative humidity exist. As a result, proper management techniques must be undertaken at very early seedling stage in the citrus nurseries to keep the pest attack below economic injury level.

Thus the checking of larval incidence on nursery seedlings would ensure healthy growing of citrus plants in the main citrus orchards in the Sylhet region and possibly for other citrus growing regions in the country or even in the world where lemon butterfly prevails as a big threat to citrus production and marketing.

Table 1. Incidence of lemon butterfly larva in the nursery of Jara lemon, Mandarin and Sweet orange at Citrus Research Station, Jaintapur, Sylhet

Seedling age at DAG	Number of selected seedlings	Infested seedlings (%)		
		Jara lemon	Mandarin	Sweet orange
15	40	5.0 (2.10) c	12.5 c	20.0 d
30	40	32.5 (5.70) b	37.5 b	42.5 c
45	40	55.0 (7.43) ab	67.5 a	65.0 b
60	40	57.5 (7.60) a	70.0 a	82.5 a
LSD	-	1.80	14.70	8.28
CV (%)	-	15.79	15.70	7.90

DAG = Days after grafting; Values are average of nine observations; Square root transformed values are shown in the parenthesis. Columns with different letters are significantly different ($p<0.01$).

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