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An Insight into bio-ecology and Management Strategies of Citrus Leaf Miner (*Phyllocnistis citrella* Stainton, Lepidptera: Gracillariidae), a Potentially Serious Pest of Darjeeling Mandarin

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Abstract—*The citrus leaf miner, Phyllocnistis citrella Stainton (Lepidptera: Gracillariidae), is a serious pest of Darjeeling mandarin. This pest was first reported from Calcutta, India. But this pest now occurs in almost all citrus growing regions of the world. Citrus (oranges, mandarins, lemons, limes, grapefruit etc.) is the most important host crop of this pest although some other plants of rutaceae family have also been recorded as host. The larva causes severe damage of newly emerged young leaves in nursery and in newly planted in orchard. The attack of this pest increases the susceptibility of leaves to citrus bacterial canker caused by Xanthomonas axonopodis pv. Citri. Depending on foliage flushing cycles and weather conditions 6 to 13 generations per year can be expected. Chemical control and biological control are the two key tools for management of this pest. Sometimes chemical control is difficult because the larva is protected by leaf cuticle and the pupa is protected by rolled leaf margins. However, there are some chemicals which may effectively check the infestation of this pest. The bio-ecology, distribution, host range and management strategies have been reviewed in this paper.*

Keywords*: Citrus leaf miner, Darjeeling mandarin, Host range, Biological control.*

1. INTRODUCTION

The genus *Citrus* belongs to family Rutaceae consisting of large number of species and variety. The world citrus is dominated by sweet orange followed by mandarins, limes and lemons and grapefruits. Citrus is the third most important fruit crop of India with production of 11.14 million tonnes (2013-14) from 1.07 million hectares [1]. The productivity of citrus in India is lower than the productivity of many other citrus growing countries like China, Brazil and USA. In India, the North Eastern region is one of the major centres of diversity of citrus with several local cultivars and the *Darjeeling mandarin* is a popular cultivar widely grown in Darjeeling hills. The unique topography and agro-climatic conditions of Darjeeling hills have made it possible to grow mandarin orange having unique taste and flavour. Cultivation Darjeeling Mandarin is one of the major sources of livelihood for the farmers of this region. But farmers have been facing variety of problems resulting low productivity. Of the several problems faced by the farmers, citrus decline is a major threat for mandarin cultivation and virtually plagued citrus plantations in Darjeeling region of West Bengal. It is a complex problem of citrus resulting from both biotic and abiotic factors. Among biotic factors, insect pests contribute significantly towards citrus decline. The common insect pests damaging mandarin orange in Darjeeling are trunk borer, fruit fly, leaf miner, lemon butterfly, mealy bug, aphid, shoot borer and bark eating caterpillar. It is well accepted fact that citrus leafminer (*Phyllocnistis citrella* Stainton) (Lepidoptera: Gracillariidae), is a serious pest of citrus and related species of the plant family Rutaceae [2,3,4] particularly in nursery and in newly planted orchard. Keeping in view the importance of this pest, an attempt has been made to review the bio-ecology and management strategies of this pest.

2. DISTRIBUTION

CLM was first described from Calcutta, India, in 1856 [5]. But this pest is widespread in most of the citrus growing regions of the world and considered one of the major citrus pests globally [6,7,8].This pest has also been confirmed from citrus-growing regions of Asia, Australia, Africa and in many other parts of the world.

3. HOST RANGE

CLM is serious pest of citrus and related Rutaceae and some related ornamental plants [9,10]. (Beattie 1989, Clausen 1933). The most important host crop is citrus (oranges,

mandarins, lemons, limes, grapefruit, and other varieties). It also infests some other plants of rutaceae family *viz., Aegle marmelos* (L.) Corr. Serv. [11] and *Poncirus trifoliata* (L.) Raf. in India and *Atalantia* sp. in the Philippines [12]. It was also found to infest *Jasminum sambac* (L.) Aiton (Oleaceae) [11],*Pongamia pinnata* Pierre (Leguminosae) and *Alseodaphne semecarpifolia* Nees (Lauraceae) in India [13]. There are some host in which larva do not complete their life cycle viz., *Murraya koenigii* L. Sprengel (Rutaceae [11], *Dalbergia sissoo* Roxb. ex DC (Leguminosae) (Latif and Yunus 1951) and *Grewia asiatica* L. (Tiliaceae) in India [13].

4. BIOLOGY

The eggs are flat, slightly oval and about 0.3 mm long. They are translucent but appear light green because of the leaf surface. The adults are small, delicate moths with narrow paired forewings and hindwings fringed with long hairs. The upper surface of each forewing has a black dot at the tip. The length of the wings is about 2 mm at rest. In flight, their wingspan is about 4.5 mm. Early instar larva is pale green in colour whereas the fourth instar (prepupa) is yellowish-brown and resembles the third instar. The pupae are yellowish-brown in colour and are aboutn 2.5 mm in length.

The gravid adult female lays eggs singly on the ventral side of the host leaves. The newly emerged and young leaves, particularly along the mid vein, are the preferred sites for egg-laying. Egg period is 2 to 10 days. The neonate larvae immediately begin feeding in the leaf and initially produce tiny, nearly invisible, mines. Larvae are protected within the leaf during their feeding cycle. As the larva grows, its serpentine path of mines becomes more prominent. The larvae molt 4 times over a 5-20 days period as they develop. Pupation takes place inside the curled leaf edge of the infested leaf. The pupal stage lasts from 1 to 3 weeks. A small opening is made at the anterior end of the pupal chamber and the pupae force themselves partially through the openings. The adults then emerge at dawn and are active in the morning; other activity is at dusk or night. Females lay eggs evenings and at night [6,9].The length of the entire life cycle varies with temperature. Under favourable condition the entire life cycle takes about 14-17 days.

5. DAMAGE.

The newly emerged larva mines into the tender leaf tissues making zig - zag galleries causing them to curl and look distorted. Due to air and condensed water vapour inside the gallaries, a characteristic silvery, serpentine mine develops with a raised parchment-like skin lined centrally with dark excreta. Epidermis of infested leaves appear as a silvery film over leaf mines. Severe infestation reduces photosynthetic surface area of leaves and increases the susceptibility of leaves to citrus bacterial canker, *Xanthomonas axonopodis* pv. *citri* [14,15] leading to reduction in vigour and plant growth [16].The pest damages new leaf flushes and adversely affects plant health and fruit development. Older leaves that have hardened off are generally not susceptible unless extremely high populations are present. Mature trees (more than 4 years old) having a dense canopy of older foliage can tolerate damage on new leaves to some extent. On the other hand growth may be retarded in case of heavy and prolonged infestation in young trees in the nursery or newly planted trees in orchards.

6. MANAGEMENT.

Cultural Practices

Citrus leaf miner moths are attracted to the newly emerged flush of citrus trees. Once the leaves harden, the pest will not be attracted to mine those matured leaves. So care should be taken to make flushing period uniform and short. Pruning of infested leaves are normally not recommended as because undamaged parts of infested leaves continue to produce food for the tree. Nitrogen fertilizer should not be applied at times of the year when leaf miner populations are high.

Water sprouts often develop on branches and above the graft union on the trunk of mature trees. These shoots grow rapidly and produce new leaves for a prolonged period of time. Where citrus leaf miner is a problem, water sprouts should be removed because that might act as a site for egg laying. Suckers, the vigorous shoots which grow from the trunk below the graft union, should always be removed since they originate from the root stock and do not usually produce desirable fruit.

Mechanical control

Pheromone traps are a useful tool for detecting leaf miners. It helps in monitoring the population of leaf miner and thereby helps in timing insecticide applications. It only attracts male moths. However, they do not catch enough of the population to be used for control. Manufacturer's recommendations for maintaining the trap have to be followed for effective attraction of the pest. Ando *et al.* (1985)[15] in Japan have developed a pheromone, (7Z, 11Z)7, 11hexadecadienal, to attract males of CLM.

Biological Control

Biological control of CLM is one of the key tools for management of this pest. However information on biological control of CLM infesting Darjeeling mandarin is scanty. Citrus leaf miners are controlled by various parasites and predators, including some naturally occurring wasps such as *Cirrospilus sp* and *Pnigalio sp*.Almost 39 species of parasitoids (mostly chalcidoidea) have been reported from Southeastern Asia, Japan, and Australia.Thirteen parasitoids of CLM have been reported from Honshu (Japan) by Ujiye [17]. Quilici *et al.* [18] reported 4 parasitoid species in France. *Ageniaspis citricola* is another important parasitoid of *P.*

citrella and it causes 8.2–28.6% mortality[19]. Yingfang Xiao [20] reported *Phytoseiulus persimilis*, *Galendromus occidentalis*, and *Neoseiulus californicus* as potential biological control agents of CLM in Alabama and *Zagrammosoma multilineatum* is the most important parasitoid in Mexico causing nearly 70% parasitisation [21] and up to 60% in Florida. Four spider species viz., *Chiracantium inclusum, hibana velox, Trachelas volutes and Hentzia palmarum* in Florida indicating that spiders are the major mortality factors of CLM [22].

Chemical control

CLM larvae rarely cause severe damage on matured mandarin plants and it can also tolerate the damage to an extent. Therefore management is generally limited to practices that limit succulent growth and protect natural enemies. Young trees in nursery and newly planted trees in orchards are more vulnerable to injury and insecticide treatment may occasionally be justified. Effective chemical control of CLM is difficult because the larva is protected by leaf cuticle and the pupa is protected by rolled leaf margins. Selection of insecticides is crucial to manage this pest because some insecticides are not very effective and many products leave residues that kill natural enemies, aggravating problems. Frequent uses of broad-spectrum insecticides are never recommended because that may disrupt natural enemies population. If very young trees are infested, insecticides can be applied to the new foliage or to the soil in advance of new flush growth. As the information on chemical control of CLM on Darjeeling mandarin is scanty, efforts have been made to present the information on citrus in general. Insecticide products that contain azadirachtin or spinosad show some efficacy against larvae and are comparatively safe for natural enemies. Imidacloprid may be applied once a year. Imidacloprid applications should be timed to protect periods of leaf flushing. It should be applied as soon as new flush begins to appear. Application of imidacloprid during the period 1 month prior to or during bloom should be avoided to protect bees. Imidacloprid (0.005%), fenvalerate(0.005%) and thiodicarb (0.075%) are effective treatments against CLM in acid lime and sweet orange respectively [23,24,25].

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