Infestation of mulberry leaves by Leaf roller/webber- (*Diaphaniapulverulentalis*)Hampson and*(Glyphodespyloalis*) Walkerandits management strategies

Abstract

The mulberry is a perennial, fast growing plant mainly cultivated worldwide for rearing of mulberry silkworm, *Bombyxmori*. The *B. mori* which is a monophagous insect feeds only on mulberry leaves for its proper growth and development. The mulberry plant during its growth is susceptible to various diseases *viz.*, leaf spot, powdery mildew, leaf rust etc. and pests*viz.*, leaf roller, Bihar hairy caterpillar, mealy bugs etc. in the field which deteriorates its leaf quality and quantity. Among these pests, defoliators attain significant importance as they cause damage up to 12-25% thereby making mulberry leaves unfit for silkworm rearing. The leaf rollers are major pests currently causing devastation to mulberry plants both in India and other parts of the world. Thus, in this review an attempt has been made regarding new insights aboutthe leaf roller pests and devise more sustainable management of this pest through integrated pest management (IPM) strategy to control it, so that the overall cocoon crop production will be enhanced worldwide.

Keywords: leaf roller, *D.pulverulentalis*, infestation, pest, IPM, mulberry

Introduction

The mulberry (*Morus spp.*) is an important valuable plant and has commercial significance as it is the only sole food source of*B.mori*. Itscontribution is around 38.20% for the successful harvesting of cocoon crop (Miyashita, 1986). It is fast growing plant with deep root system present in order Urticales/Rosales and family Moraceae. The feeding of *B.mori*on good quality mulberry leaves results in its healthy growth and development and eventually enhanced silk production (Islam *et al.*, 2022a, 2022b; Islam *et al.*, 2023;Islam *et al.*,2024). During its growth it also faces many challenges as it is subjected to various kinds of diseases and pests which hampers its leaf production both qualitatively and quantitatively. The leaf roller, *D.pulverulentalis* is a serious pest in Southern India and also is a potential carrier of *Nosemabombycis*, which causes deadly pebrine disease to the silkworms as pebrine spores can get easy entry in the rearing rooms through contaminated mulberry leaves (Ifat*et al.*, 2011). Similarly, Watanabe *et al.* (1988) found leaf roller *G. pyloalis* as the alternate hosts

ofdensoviruses and picornaviruses. The *D.pulverulentalis*was reported from Karnataka in 1995 and then spread to Tamil Nadu,Andhra Pradesh and Kerala and its infestation causes leaf yield loss up to 12.8% having average incidence of 21.77% causing severe damage to sericulture industry (Siddegowda*et al.,* 1995;GeethaBai*et al.,* 1997;Rajaduraiet *al.,* 1999). ManjunathGowda*et al*.(2005) stated that 37parasitoids and 6 predators are knownnaturally controlling the leaf roller infestation at different stages, also 10entomopathogenic fungi were reportedregulating the incidence of leaf rollernaturally (SrinivasaGowda*et al.,* 2000).Around 300 insect and non-insect pest species are known causing attack tomulberry. The insect pests may be sapsuckers, defoliators, borers and residing in soil like termites. The infestation by major insect pests like leaf roller, pink mealy bug and thrips severely reduces nutrient content ofleaves by hampering photosynthesis which eventually reflects in the poor growth of plant (Kotikal*et al.,* 1982; Biradar, 1989;SrinivasaGowda, 2004; Sakthivel*et al.,* 2019).The yield loss caused by major insect pests of mulberry namely Bihar hairy caterpillar (*Spilosomaobliqua*), leaf roller (*D.pulverulentalis*) and mealy bugs (*Maconellicoccushirsutus*) is up to 25-30%, 12-15% and 10-15% respectively (Manjunath*et al*., 2000).Mulberry leaf roller is a major dangerouspest of mulberry plant in India causing heavy infestation in the states of Karnataka, Andhra Pradesh, Tamil Nadu,Kashmir, Assam etc. (Mathur, 1980; Chakraborty, 2005; Dandin and Giridhar, 2010;Illahi*et al*, 2013). Keeping in view the status of this pest the current review elucidated this pest in more detail like its biology, nature of damage, period of occurrence and subsequent management strategies for controlling this pest so that the overall silk production will be increased.

Life cycle and management strategy of *D.pulverulentalis*through IPM

*D.pulverulentalis*is a key seasonal defoliating pest and its maximum population buildupis recorded during September-November and there is a linear relationship between the decrease intemperature and increase in relative humidity resulting in increased pest population (Kumar*et al.,* 2021). The biochemical components in six mulberry varieties*viz.*,M5, Mysore local, MR2,S54, S36 and V1 were analysed infested by*D.pulverulentalis*. It was revealed that the biochemical composition of mulberry leaves was reducedalmost in all the varieties (Mahadeva andNagaveni, 2011).Bhagyamma and VijayaKumari (2022) after carrying out study on three mulberry varieties *viz.*, V1, Mysore local and S36 infested by *D.pulverulentalis*found that the photosynthetic pigments in the leaves like total chlorophyll

and carotenoids decreased by 40.17% and 40.85% respectively. Further, the biomolecule components like proteins,carbohydrates and starch decreased by 24.62%, 47.09% and 16.09% respectively. However, the phenol content increased by 57.39% than control.**Life Cycle:** The eggs of*D.pulverulentalis*(Order-Lepidoptera, Family-Pyralidae)are pale yellow in colour laid singly on the lower surface along the leaf vein of the mulberry leaves havingfecundity around 80-150. The egg period lasts for 3-4 days. The total larval period is12-15 dayshaving 5 larval instars.The first larval instar is minute andis fluorescent yellow in colour. The second larval instar is light yellowish orange in colour having small sub-median black spots enclosed by white patches. The third larval instar is deep orange in colour and itsdorsal, mid dorsal lines and spots are clearly visible. The fourth larval instar is dark greenish brown incolour and the fifth larval instar is dark pinkish brown in colour. The pupalperiod lasts for 7-9 days and are dark brown in colour andpupates in dried leaves/soil. The adults are yellowish grey in colour having longevity of 8 and 11 days for male and female respectively. The total lifecycle iscompleted in 17-24 days(Mahadeva, 2018).**Symptoms:**The early instar larvae occupy the apical parts of the mulberry shoot and feed on the young, tender leaves. The larvae reside on the leaves by forming web and fold the leaves and thereby makingshelter for itself. The leaf margins of apical leaves are rolled and tied by the larval web wherein they live. Occasionally 1 or 2 leaves are rolled into cup shape with the web secreted from the larvae which remains inside and hence this pest is called as leaf roller/leaf webber. The lower leaves of the infested plants become soiled due to faecal matter of larva.

IPM of *D.pulverulentalis*:(a) Mechanicalcontrol:The infested portions are trimmed and collected in a polythene bag and then destroyed by burning.Flood irrigation and deep ploughing helps in killing of pupae of the pest residing in the soil.Light traps can be used to attract and kill adults of pest.**(b)Chemicalcontrol:**Foliar application of 0.076% DDVP 76% EC (one ml in one litre of water) 10 days after pruning/leaf harvest is helpful. If the infestation continues then further 2-3 sprays are needed. The leaf for silkworm rearing can be used after 7 days of DDVP application. The commercial neem pesticide (0.03% AZ) 0.05% can be sprayed having safe periodof10 days. **(c)Biological control:** The release of eggparasitoid, *Trichogrammachilonis*@ 1 lakh adults/acre in 4 split doses, larval parasitoid,*Braconbrevicornis* @ 200 adult wasps and ectopupalparasitoid,*Tetrastichushowardii* @ 1 pouch /acreis effective for controlling leaf roller*D.pulverulentalis*(Sakthivel*et al.,* 2019; Kumar *et al.,* 2024). The *Apanteles sp*. and

Chelonus sp. are also reported to be parasitic on leaf roller (GeethaBai*et al.*,1997; SrinivasaGowda*et al.*, 2001), also the *Calosoma sp.*which is a larval predatorpredateson leaf webber larvae(Annon., 1997).Furthermore, the aqueous leaf extracts of *Catharanthus**roseus, Piper betle, Ocimum sanctum, Tagetes**patula*and*Menthapiperita* are found to be effective against leaf rollerlarva.The insecticidal properties of various medicinal plants *viz.,Lantana camara, Allium sativum, Zingiberofficinale, Azadirachtaindica* and *Vitexnegundo* was studied against*D.pulverulentalis* and among these, lantana extract at lower concentration of 11% was found to be most effective against leaf roller (Maheswari and Govindaiah, 2017, 2018).

Life cycle and management strategy of *G.pyloalis*through IPM

The *G.pyloalis*(lesser mulberry pyralid) is a serious pest of mulberry in India, China, Japan, Malaysia, Pakistan, Uzbekistan, Burma and Korea (Madyarov*et al.*, 2006).Borgohain*et al.* (2015) carried out study on mulberry leaves infested by *G.pyloalis* and revealed that early first and second instar larvaefed by scraping green tissues andmesophyll layer leaving behind only transparent epidermis layer. The larvae (first and second instar) damaged up to 0.11-0.33 cm^2 area and full-grown larvae damaged up to 0.69-1.75 cm^2 area of mulberry leaf. **Life Cycle:***G.pyloalis*(Order-Lepidoptera, Family-Pyralidae)is a holometabolic insect consisting ofegg, larva, pupa and adult stages having much similarity to silkworm.The moth is nocturnal (Khosravia and Sendi., 2010) andlays around 200 eggs under side of leaf, the egg is pale yellow in colour, roundand its size measures about 0.2mm. The eggs hatch within 5-6 days into larva. The larvae measure around 0.2-2cm in length and are slender,fusiform and segmented. Each larva has 3 pair of forelegs, 4 pairs of hind legs and a pair of caudal legs and then mature,transforminginto brown pupae and then into moth. The whole life cycle takes about a month to complete.**Symptoms:**Under Kashmirclimatic conditions, infestation is observed around July-October. After hatchingthe larva spin fine silky net of threads around themselves and eat leaves leaving behind transparent cuticular layer. The larval excreta are held in between fine silky threads, thus making leaves unsuitable for silkworms. After the pest damage,the nutrients in the leaves are lost and this in turninhibits the growth of plants. Mainly,much damage is caused by 4th and 5^{th} instar larva. The larvae feed inside the leaves after webbing the leaves together. The larvae skeletonise the mulberry leaf after eating all thegreen portions. The infested part of the leaf becomes dark brown in colour and is devoid of chlorophyll, moisture content, proteins, sugarsetc. (Hassanand Mir., 2018). **IPM of *G.pyloalis*:(a) Mechanical control:**Hand pick the larval stages of pest anddestroy it. Ensure deep ploughing andweeding in order to destroy the hibernating larva.Burn the diseased and

fallen leaves in September-October. Ensure straw banding of trees and light trapping for moths to control this pest.**(b)Chemicalcontrol:**Spraying of 0.04% DDVPon leaves can significantly reduce the infestation level of the pest.**(c) Biological control:**The *G.pyloalis* was reported as the most predominant defoliator pest and itsnatural enemies likehymenopteran parasitoids*viz.,Apantelesobliquae*, Ichneumonid wasp, *Chelonus carbonator*and the coccinellid predator,*Cheilomenessexmaculata*proved to be active natural enemies against it (Sultana*et al.,* 2023)(Table 1& 2).Nighat*et al.*(2002) recorded twobraconid larval parasitoids*viz., Apantelesglomeratus* and *Chelonus sp.* parasitizing the larvae of *G. pyloalis,* further parasitoidsnamely*Habrobaconhebetor*, *C. carbonator*, *Glyptapanteles sp*., *Pristomerus sulci*, *Xanthopimpla sp*., *Perilampus sp*., *Campoletis sp.* and *Brachymerialasus*could be used for the control of*G. pyloalis* under temperate conditions of Kashmir(Mittal*et al.*,2011, 2016) (Table3). In a recent finding *G.pyloalis*was found as a host of *P. sulci* (Bhat*et al.*, 2020).

Table 1: Natural enemies present on mulberry

Natural enemies	Order	Family
***Apantelesobliquae* Wilkinson**	Hymenoptera	Braconidae
***Chelonus carbonator* Marshall**	Hymenoptera	Braconidae
Megaseliascalaris	Diptera	Phoridae
Cheilomenessexmaculata	Coleoptera	Coccinellidae
***Disophrys*sp.**	Hymenoptera	Braconidae
Tachinid fly	Diptera	Tachinidae
Ichneumonid wasp	Hymenoptera	Ichneumonidae
Spider	Araneae	Salticidae

Table 2: Defoliator pests present on mulberry

Common name	Scientific name	Order	Family
Mulberry leaf roller	*Glyphodespyloalis*Walker	Lepidoptera	Pyralidae
Common cutworm	*Spodopteralitura*Fabricius	Lepidoptera	Noctuidae
Tussock caterpillar	*Euproctisfraterna* Moore	Lepidoptera	Erebidae
Spanworm	*Hemerophillaatrilineata* Butler	Lepidoptera	Geometridae
Green weevil	*Myllocerusviridanus*Fabricius	Coleoptera	Curculionidae

Source:**Sultana *et al.*,**

Table 3:Parasitoids of *G. pyloalis*

Name	Family	Order	Stage attacked	Period of activity
***Apantelesobliquae* Wilkinson**	Braconidae	Hymenoptera	Larval instars	July - Oct.
***Braconhebetor* Say**	Braconidae	Hymenoptera	Larval instars	Sept.
***Chelonus carbonator* Marshall**	Braconidae	Hymenoptera	Late instars	July - Oct.
***Pristomerus sulci* M. & K.**	Ichneumonidae	Hymenoptera	Late instars / Pupae	Aug.
Xanthopimpla sp.	Ichneumonidae	Hymenoptera	Late instars / Pupae	Aug.
Campoletis sp.	Ichneumonidae	Hymenoptera	Late larval instars / Pupae	Aug. - Sept.
***Brachymerialasus*(Walker)**	Chalcididae	Hymenoptera	Pupal	July - Aug.

Source:**Mittal *et al.*,**

Conclusion

The incidence of pests poses a great threat to mulberry plants and deteriorates its leaf quality and eventually results in poor cocoon production. The outbreak of pest attack like defoliators on mulberry plants incur heavy losses to silkworm farmers and in turn it becomes imperative to design sustainable management strategies to control it through IPM. As the wide use of chemicals is not a long-term solution to control pests as they harm the environment by leaving more residues, so utilising biological means like its natural enemies is best for naturally maintaining the balance in the mulberry ecosystem. So, in order to check the leaf roller population like *D.pulverulentalis*and *G.pyloalis,*multipronged approach using IPM should be followed for better efficiency to boost the silk industry.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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