

Integrated Pest Management of *Leucinodes orbonalis* Guenee: Current Status and Future Prospects

Archana Anokhe¹, Gajendra Singh², Mogili Ramaiah³ and Manoj Kumar Yadav¹

¹ICAR-Directorate of Weed Research, Jabalpur, MP-482004

²Krishi Vigyan Kendra, Amihit, Jaunpur, UP – 222142

³ICAR – Indian Agricultural Research Institute, New Delhi-110012

*Corresponding E. mail: anokhearchana12@gmail.com

Abstract

Brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee.) is the most destructive pest of brinjal, causing damage to tender shoots and fruits, leading to significant yield reduction. Conventional management relies heavily on repeated chemical insecticide applications, which pose serious threats to the environment and human health due to residual toxicity. Integrated Pest Management (IPM) strategies offer a sustainable alternative, combining biological, cultural, mechanical, and need-based chemical approaches. These strategies minimize pest populations while conserving beneficial organisms and maintaining ecological balance. This review emphasizes the importance and effectiveness of IPM approaches in managing *L. orbonalis* in brinjal cultivation.

Keywords: Brinjal Shoot and Fruit borer, insecticides, Integrated Pest management, *Leucinodes orbonalis*.

Introduction

Brinjal (*Solanum melongena* Linnaeus), also known as eggplant, is popularly referred to as the "King of Vegetables" due to its culinary versatility and nutritional value. It is believed to have originated in the Indo-Burma region and has been cultivated in India since ancient times (AVRDC, 2003; Srinivasan, 2009). The major brinjal-producing states in India include Andhra Pradesh, Karnataka, West Bengal, Tamil Nadu, Maharashtra, Odisha, Uttar Pradesh, Bihar, and Rajasthan (Anonymous, 2021). With the development of improved varieties and advanced cultivation technologies, brinjal can now be grown year-round across diverse agro-climatic zones (Fand and Suroshe, 2011). Brinjal is not only a versatile culinary vegetable but also a rich source of bioactive phytochemicals that confer multiple health benefits. The purple skin of brinjal contains nasunin, an anthocyanin with potent antioxidant properties that protect cell membranes from oxidative damage (Noda Y 2000). Another important compound, chlorogenic acid, exhibits antioxidant and anti-inflammatory activities and may help regulate blood sugar levels (Levy, J., 2025). Additionally, saponins and flavonoids present in brinjal support cardiovascular health by aiding cholesterol regulation (de Pascual-Teresa S, 2010). These

phytochemicals contribute to cardiovascular protection, as the vegetable is rich in fiber, potassium, and antioxidants, which can help lower LDL cholesterol and improve blood pressure. Brinjal's low-calorie, high-water, and fiber content make it beneficial for weight management by promoting satiety. Its antioxidants, particularly nasunin and chlorogenic acid, help reduce oxidative stress, potentially lowering the risk of certain cancers (Sharma, M., & Kaushik, P., 2021). The dietary fibre also supports digestive health by improving bowel regularity and nurturing gut microbiota, while nasunin may protect brain cells from free radical damage (Noda Y, 2000). Furthermore, minerals such as manganese, magnesium, and small amounts of calcium contribute to bone health, making brinjal a nutrient-dense vegetable with broad protective effects for overall wellness. In 2022, the global area under eggplant (aubergine) cultivation was approximately 1.8 million hectares, producing around 59.31 million tonnes, which corresponds to an average yield of about 33.0 t/ha (FAOSTAT/FAO). India ranked as the world's second-largest producer, with a production of 12.765 million tonnes. Based on India's average yield of 18.911 t/ha, this translates to a cultivated area of roughly 0.67 million hectares (Helgi Library; FAOSTAT-derived data).

Brinjal cultivation is severely constrained by several insect pests that attack the crop from seedling to harvest. Among these, the brinjal shoot and fruit borer (*Leucinodes orbonalis* Guen.) is the most serious pest, causing significant yield and quality losses (Regupathy *et al.*, 1997; Alam *et al.*, 2003). This pest is considered a major limiting factor in brinjal cultivation across South and Southeast Asia (Srinivasan, 2008; Patial and Mehta, 2008), and has been reported from several countries, including India, Sri Lanka, Germany, Myanmar, and the USA (Alam *et al.*, 2003; Rashid *et al.*, 2003). *L. orbonalis*, commonly known as the Brinjal Shoot and Fruit Borer (BSFB), is a major pest of eggplant. *Leucinodes orbonalis*, was first described by Guenée in 1854 and designated as the type species of the genus *Leucinodes* by Walker in 1859. The pest infests the crop throughout its growth stages, boring into tender shoots during the vegetative stage and later damaging developing fruits. Damage from *Leucinodes* can lead to yield losses ranging from 70% to 92%, and in the absence of control measures, complete crop loss is possible (Krishnaiah and Vijay, 1975; Rahman, 2007). Mall *et al.*, (1992) observed higher shoot infestation during the vegetative phase, while Singh *et al.*, (2000) noted that larval activity shifts from shoots to flowers and fruits as the crop matures. The larvae bore into tender plant tissues, causing wilting and death of shoots, and infested fruits show holes plugged with frass, making them unmarketable and reducing consumer appeal (CABI, 2007; Alam *et al.*, 2006). Infestation also leads to a decline in vitamin C content in fruits (Mamun, 2014). The eggs are creamy white, laid singly or in small groups on the underside of leaves, while the larvae are initially dull white and turn light pink as they mature, reaching 15–18 mm in length. Pupation occurs in a boat-shaped silken cocoon on the plant or in the soil, and the adult moth is greyish-brown with pale whitish wings marked by pinkish-brown spots and fringed with fine hairs (TNAU, 2024). The larvae bore into tender shoots during early crop stages, causing wilting, drying, and reduced branching, while in later stages they attack flower buds and fruits, making them unmarketable due to internal damage and frass contamination (AVRDC, 2003; CABI, 2007; Alam *et al.*, 2006; Sandanayake & Edirisinghe, 1992; Singh *et al.*, 2000). The female moth lays about 40 eggs on leaf undersides, which hatch in 4–5 days; the larval period lasts 15–20 days, and pupation takes 6–8 days, completing the life cycle in 21–45 days depending on environmental conditions (Talekar, 2002; Hussain *et*

al., 1937). Development includes six larval instars and a total duration of 19–28 days from egg to adult, with adults living for 1–3 days and females surviving slightly longer, indicating the pest's high reproductive potential and rapid population turnover (Allam *et al.*, 1982; Mehto *et al.*, 1983). The larvae have also been observed feeding on *Solanum nigrum* and *Solanum tuberosum*, both members of the family Solanaceae, causing less damage comparable to that on brinjal. In addition, *Lycopersicon esculentum*, *Abelmoschus esculentus*, *Cynodon dactylon*, *Ocimum basilicum*, and *Solanum indicum* have been identified as alternate hosts of this pest (Ardez *et al.*, 2008).

Effect of Abiotic Factors on Population Dynamics of Brinjal Fruit and Shoot Borer

Temperature and relative humidity play a crucial role in assessing the pest status and its natural enemies, which is essential for developing eco-friendly pest management strategies against *L. orbonalis* (Georghia and Taylor, 1978). Mall *et al.*, (1992) observed that temperatures between 20–25°C and relative humidity levels of 50–72% favored the development of the pest, while rainfall had a suppressive effect on its multiplication. Patil and Mehta (2008) studied the insect pest complex and their seasonal succession in Palampur, Himachal Pradesh, during 2003 and 2004. *L. orbonalis* appeared in the third week of July and the end of June in the respective years, peaking on 22nd September (97 larvae/30 plants) and 11th August (95 larvae/30 plants). It was identified as the predominant pest, with other insect species classified as moderately damaging. Singh *et al.* (2009a) reported that initial infestation occurred in the fourth week of August (47 days after transplanting), with peak incidence observed in the second week of September (114 days after transplanting). The infestation gradually declined as temperatures increased. They found no significant correlation between shoot damage and weather parameters. In another field experiment, Singh *et al.*, (2009b) found peak shoot infestation in the second week of June 2003 (25.8%) and the third week of May 2004 (31.4%). Masarrat-Haseeb *et al.*, (2009) recorded a peak infestation of 42.47% in the third week of November, which declined to zero by the second week of January with the onset of winter.

Effect of Biotic Factors on Population Build-up of Brinjal Fruit and Shoot Borer

Several natural enemies, including predators, parasitoids, and entomopathogens, have been reported against *L. orbonalis* in South and Southeast Asia

(Waterhouse, 1998). However, their role in maintaining the pest population below economic threshold levels remains limited (Srivastava and Butani, 1998). Among parasitoids, *Trathala flavoorbitalis* appears promising for biological control, though its potential remains underexplored. Other parasitoids, such as *Goryphus nursei* (Ichneumonidae: Hymenoptera) have been recorded in Uttar Pradesh. In Thailand, *Pristomerus testaceus*, *Elasmus corbetti*, and *Euagathis spp.* have been observed, but *T. flavoorbitalis* remains dominant. The egg parasitoid *Trichogramma chilonis* has also shown efficacy against *L. orbonalis* (Raja et al., 1997). The parasitoid *Eriborus sinicus* also shows promise. However, mechanical methods remain the most reliable non-chemical approach (AVRDC).

Integrated Management of *L. orbonalis*

Management of *L. orbonalis* continues to rely heavily on synthetic insecticides, which offer immediate control but contribute to environmental contamination, pesticide resistance, and residue problems (Sharma and Kaushik, 2010; Mandal et al., 2018). Reports indicate that pest populations in several regions have developed resistance to conventional insecticides, warranting the exploration of safer alternatives (Yadav et al., 2015; Singh et al., 2021). Consequently, there is an urgent need to develop and implement Integrated Pest Management (IPM) strategies involving bio-rational pesticides, botanicals, sex pheromone traps, and other ecological tools that reduce dependence on chemicals while maintaining pest control efficacy (Talekar et al., 2003; Kalawate et al., 2006). Extension agencies, research institutions, and local governments have undertaken collaborative efforts to evaluate various eco-friendly strategies through field trials and training programs for farmers (Srinivasan, 2009; Tripua et al., 2017).

Biological Control

The brinjal fruit and shoot borer, *Leucinodes orbonalis* Guenée, is one of the most destructive pests of eggplant in South and Southeast Asia. Biological control forms an important component of Integrated Pest Management (IPM) strategies aimed at reducing reliance on chemical insecticides and minimizing environmental and health risks. A diverse complex of natural enemies, including parasitoids, predators, and entomopathogens, has been reported against *L. orbonalis*. Among these, larval parasitoids play a dominant role. *Trathala flavoorbitalis* (Ichneumonidae: Hymenoptera) is the most widely reported and dominant parasitoid across India and Southeast Asia,

although its natural parasitism levels are often insufficient to maintain pest populations below the economic threshold. Other larval parasitoids such as *Goryphus nursei*, *Pristomerus testaceus*, *Eriborus spp.*, *Diadegma apostata*, *Phanerotoma spp.*, and dipteran parasitoids like *Pseudoperichaeta sp.* have also been recorded, indicating a rich parasitoid complex.

Cultural Control

Cultural methods include removing infested shoots and branches during early stages to disrupt feeding and reproduction. Field sanitation before, during, and after the cropping season, and removal of alternate host plants such as *Solanum nigrum*, *S. indicum*, *S. torvum*, tomato, and potato, is essential for managing the pest (Fletcher, 1916; Menon, 1962; Nair, 1967). Organic amendments and botanicals are environmentally safe and non-phytotoxic, with minimal risk of resistance development (Urs, 1987). Mehto and Lall (1981) noted that excessive nitrogen led to succulent growth, making plants more vulnerable to pest attack. Neem cake application reduced infestation significantly (Sudhakar et al., 1998; Varma, 1994; Krishnamoorthy & Krishnakumar, 2001). Sreenivasa Murthy et al., (2001) also observed that neem cake (250 kg/ha) lowered infestation to 8% and increased yield by 68%. Godase and Patel (2003) recorded the lowest fruit borer incidence (6.08%) using neem cake at 1700 kg/ha.

Mechanical Control

Regular removal and destruction of infested shoots and fruits are effective for managing BSFB (Rahman et al., 2002; Talekar, 2002; Arida et al., 2003). Pruning during the early crop stages and continuing this practice throughout the growing season is beneficial, particularly when implemented on a community-wide scale.

Use of sex Pheromones

Sex pheromones are crucial for IPM and are used for mass trapping of males. Attygalle et al., (1988) identified 11-hexadecen-1-ol as an attractant. Chatterjee (2009) reported that deploying 75 pheromone traps/ha significantly reduced BSFB infestation. Rani (2013) evaluated four trap heights in Bangalore rural district and found them effective in attracting BSFB moths.

Impact of IPM on Brinjal Fruit and Shoot Borer

Sumathi et al., (2018) demonstrated IPM strategies across 10 farmer fields during 2014–15 and 2015–16. Fruit damage was significantly lower in IPM fields compared to conventional ones. Srinivasan and Huang (2009) emphasized that pruning and timely

removal of infested shoots are key components of effective IPM strategies against *L. orbonalis*.

Effect of Biopesticides and Botanicals

Biopesticides are known for their high target selectivity, environmental safety, cost-effectiveness, and novel modes of action. They are considered a sustainable and rational approach for long-term pest management due to their compatibility with beneficial organisms and the ecosystem. Puranik *et al.*, (2002) evaluated various formulations of *Bacillus thuringiensis* (Bt) in comparison with neem-based and chemical insecticides against brinjal shoot and fruit borer (*Leucinodes orbonalis*). Among the treatments, five sprays of Dipel 8L at 0.2% concentration, applied at 10-day intervals, resulted in the lowest levels of both shoot and fruit infestation. Similarly, Yin (1993) reported that spraying Bt significantly reduced infestation by *L. orbonalis* compared to the untreated control. Kasyapa (1998), reporting from Medak district in Andhra Pradesh, noted that local farmers frequently used chilli + garlic extract and neem seed kernel extract (NSKE) sprays as part of their traditional pest management practices. Krishnakumar and Krishnamurthy (1998) from the Indian Institute of Horticultural Research (IIHR) found that NSKE at 5% concentration was effective in managing *L. orbonalis*. Sasikala *et al.*, (1999) also observed that Bt var. *kurstaki* (Btk) at 0.15% concentration significantly reduced shoot and fruit infestation while increasing yield. The next most effective treatments included the release of the egg parasitoid *Trichogramma japonicum* (Ashmead) and combinations of neem oil + Bt, as well as neem oil + carbaryl.

Efficacy of Insecticides Against BSFB (*Leucinodes orbonalis*)

Singh *et al.*, (2018) evaluated insecticides against *L. orbonalis* and reported the lowest infestation and highest fruit yield in treated plots, particularly with Flubendiamide 480 SC and Novaluron 10 EC. Yousofi *et al.*, (2015) also observed significant reductions in shoot and fruit infestations across all treatments compared to the control. Misra (2008) tested

Rynaxypyr 20 SC and Flubendiamide in Bhubaneswar during winter 2007 and summer 2008. Rynaxypyr 20 SC, applied at 40 and 50 g a.i./ha, resulted in 95–97% reduction in shoot damage and 87–90% reduction in fruit damage. Sharma (2010) reported the lowest infestation (8.26%) with Fipronil, compared to 18.89% in the untreated control. Panda *et al.*, (2005) demonstrated that a combination of Fipronil, Triazophos, and Cartap hydrochloride resulted in 11.89% shoot infestation. Bhargava *et al.*, (2003) observed the lowest pest population with the application of Imidacloprid, which also yielded the highest production of healthy fruits (170.2 q/ha) in brinjal.

Socio-economic Impact and Prospects of BSFB (*Leucinodes orbonalis*) Management

Alam *et al.*, (2003) reported a significant increase in brinjal production area with a simultaneous reduction in pesticide usage and labour inputs due to the adoption of IPM practices. In West Bengal, IPM-adopting farmers reduced pesticide spraying and labour costs while expanding their cultivation area. Recognizing the success of IPM strategies, the AVRDC – The World Vegetable Centre is working to extend BSFB IPM programs to other South and Southeast Asian countries, including Bangladesh, India, Nepal, and the Philippines. In addition to scaling up IPM technologies, partnerships are being developed with national IPM programs to strengthen regional implementation capacity.

Conclusion

The brinjal shoot and fruit borer damages both the terminal shoots of young plants and the developing fruits, leading to significant yield loss. Farmers often rely heavily on chemical insecticides, which may be ineffective and pose risks to beneficial insect populations. The adoption of an Integrated Pest Management (IPM) approach offers a sustainable solution by reducing reliance on chemical control, preserving natural enemies (predators and parasitoids), and maintaining ecological balance in the brinjal cropping system.

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Table1: List of natural enemies of brinjal fruit and shoot borers

Natural Enemy	Family / Group	Stage Attacked	Country	Region / Remarks	Reference
<i>Trathala flavoorbitalis</i>	Ichneumonidae, Hymenoptera	Larva	South & Southeast Asia	Most dominant and promising parasitoid in South and Southeast Asia; potential underexplored	Tewari & Sardana (1987)
<i>Goryphus nursei</i>	Ichneumonidae, Hymenoptera	Larva	India (Uttar Pradesh)	Recorded from Uttar Pradesh, India	Krishnamoorthy & Mani (1998)
<i>Pristomerus testaceus</i>	Ichneumonidae, Hymenoptera	Larva	Thailand	Reported from Thailand; less dominant	Patel <i>et al.</i> , (1971); Tewari & Moorthy (1984)
<i>Elasmus corbetti</i>	Eulophidae, Hymenoptera	Larva / Pupa	Thailand	Observed in Thailand	Navasero (1983)
<i>Euagathis</i> spp.	Braconidae, Hymenoptera	Larva	Southeast Asia	Southeast Asia; minor role	Patel <i>et al.</i> , (1971)
<i>Eriborus sinicus</i>	Ichneumonidae, Hymenoptera	Larva	Asia	Shows promise as a biological control agent	Raja <i>et al.</i> , (1997)
<i>Eriborus argenteopilosus</i>	Ichneumonidae, Hymenoptera	Larva	India	Demonstrated effectiveness under field conditions	Yang (1982)

<i>Diadegma apostata</i>	Ichneumonidae, Hymenoptera	Larva	India	Natural predation reported but impact limited	Kadam <i>et al.</i> , (2006)
<i>Phanerotoma</i> sp.	Braconidae, Hymenoptera	Larva	India	Natural occurrence reported; field impact limited	Kadam <i>et al.</i> , (2006)
<i>Apanteles</i> sp.	Braconidae, Hymenoptera	Larva	Philippines	Most reliable non-chemical method under field conditions	Waterhouse (1998)
<i>Pseudoperichaeta</i> sp.	Tachinidae, Diptera	Larva	India	Dipteran larval parasitoid	Waterhouse (1998)
<i>Trichogramma chilonis</i>	Trichogrammatidae, Hymenoptera	Egg	India	Effective under field conditions	Tewari & Sardana (1987)
<i>Chrysopa kulingensis</i>	Chrysopidae, Neuroptera	Eggs / Larva	China	Predatory lacewing	Krishnamoorthy & Mani (1998)
<i>Coccinella septempunctata</i>	Coccinellidae, Coleoptera	Eggs / Larva	India	Generalist predator	Patel <i>et al.</i> , (1971); Tewari & Moorthy (1984)
<i>Brumoides suturalis</i>	Coccinellidae, Coleoptera	Eggs / Larva	India	Generalist predator	Navasero (1983)
Spiders, ants, ladybird beetles	Arthropod predators	Eggs / Larva	Asia	Natural predation; impact limited	Patel <i>et al.</i> , (1971)

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