

## TOXICITY EVALUATION OF IMIDACLOPRID 17.8% SL AGAINST POPLAR DEFOLIATOR *CLOSTERA CUPREATA* (BUTLER) (LEPIDOPTERA: NOTODONTIDAE)

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### ABSTRACT

Poplar (*P. deltoides*) is a major agroforestry species that plays a significant role in the socio-economic development of farmers in Northwestern India. The poplar leaf defoliator, *Clostera cupreata*, is a major insect pest of poplar, occurring in serious proportions and causing significant growth loss to the trees. In pursuit of chemical management for the poplar defoliator, Imidacloprid 17.8% SL was evaluated for its median lethal toxicity (LC<sub>50</sub>) against *C. cupreata*. The LC<sub>50</sub> was calculated as 0.0017% at 72 hours after treatment (HAT) against third instar *C. cupreata* larvae under laboratory conditions. The screening process for the toxicity of Imidacloprid against *C. cupreata* may provide a crucial step for the development of novel insecticides for managing forestry insect pests.

**Keywords:** Imidacloprid, LC<sub>50</sub>, Lethal concentration, Poplar defoliator, *Clostera cupreata*, Insect pest.

### INTRODUCTION

Poplar, *Populus deltoides* Bartr. Ex Marsh, known as poplar or eastern cottonwood, is a member of the Salicaceae family. It is extensively planted and naturally occurring species across the Northern Hemisphere (Dhillon *et al.*, 2020). *P. deltoides*, introduced to India in 1958 by the Forest Research Institute, Dehradun, is considered one of the most favourable agroforestry species in the country (Kaul and Sharma, 1982), and widely planted in north-western provinces of India viz. Uttar Pradesh, Punjab, Haryana, and the lower foothills of Uttarakhand and Himachal Pradesh (Dhiman *et al.*, 2017; Kumar and Singh 2012). This species has also been grown successfully in Indian subtropical climatic regions, including Assam, Tamil Nadu, Bihar, Andhra Pradesh, and Telangana. Poplar has been widely planted as block plantations, bund plantings, and agroforestry by the farmers, though it has been considered the most suitable fast growing tree species for agroforestry systems. The wood of this species is highly demanded in the wood industry as their raw material for plywood, match sticks, plywood and packing industries, pulp and paper, furniture and the artificial limbs, etc.

(Kumar *et al.*, 2021; Dhillon *et al.*, 2020; Suresh *et al.*, 2018). Additionally, it serves essential functions in the ecosystem such as providing food, shelter, shade, and habitats for variety of fauna and livestock, and helps in protecting soil, water, crops, (Dhillon *et al.*, 2020; Kumar *et al.*, 2021; Pra *et al.*, 2019; Suresh *et al.*, 2018). *P. deltoides* is also utilized for phytoremediation to address heavy metal contamination, soil remediation, and the restoration of fragile ecosystems prone to desertification (Bergante *et al.*, 2015). Approximately 9.6 million hectares dedicated to poplar cultivation world wide as of 2016, with 3.8 million hectares specifically for wood production, while the rest primarily aimed at environmental benefits. Turkey, China, France, and India are leading regions in poplar farming acreage and wood production globally (FAO, 2016; Biselli *et al.*, 2022).

Insect infestations represent a widely documented issue, with numerous invasive species posing significant threats to biodiversity and the functioning of ecosystems globally (Liebhold *et al.*, 2017; Seebens *et al.*, 2018). *P. deltoides* also faces a wide array of threats from insect pests, which notably can hinder plant growth and lead to

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declines in both the quantity and quality of wood biomass (Kumar *et al.*, 2022; Biselli *et al.*, 2022). Noteworthy, about 65 insect pest species reported infesting to *P. deltoides* in northwestern provinces of India (Dalal *et al.*, 2018). Among these insect pests, poplar leaf defoliators (PLD), *Clostera* sp., (Lepidoptera: Notodontidae), are considered the major defoliators of *P. deltoides* due to their wide distribution and regular large-scale defoliation.

*Clostera cupreata* (Butler), *C. restituta* (Walker) and *C. fulgurita* (Walker) are well-recognized major defoliators of *P. deltoides* and initially, larvae are gregarious feeder and later instar are solitary in nature and eat away all the tissues of the leaves, leaving only veins (Sangha & Sohi, 2007). The larvae very efficient defoliator lasts for 15 to 20 days and feed the whole leaf very fast and cause complete tree defoliation within few days during July to September. These defoliators regularly cause more than 25% defoliation in the poplar plantation (Gao *et al.*, 1985; Singh 2000; Sangha 2011) and recorded to be loss of about 61.33% of tree growth (Kumar *et al.*, 2022). The large-scale defoliation of *C. cupreata* larvae results in lower plant vigor and increase susceptibility to attack by other pests and diseases; therefore, repeated defoliation in young plants results in tree mortality (Singh and Pandey, 2002).

Numerous research endeavours have concentrated on devising environmentally friendly methods to control insect pests, encompassing bio-pesticides, natural predators, and bio-control as integral elements of integrated pest management strategies (Idrees *et al.*, 2021; Luo *et al.*, 2018; Zhang *et al.*, 2019). While these eco-friendly tactics prove effective against various insect pests, their action tends to be gradual (Veres *et al.*, 2020). Consequently, due to the slower response of these safer control methods, many farmers opt for synthetic insecticides as an immediate measure to manage noxious insect pests. Previously many insecticides such as BHC, DDT, lindane, chlordane, aldrin, parathion, and lead arsenate were recommended for the management of poplar insect pest (Rishi, 1981; Sen-Sharma and Gupta, 1981; Singh and Singh, 1986; Sohi *et al.*, 1987, 1989) but most of these insecticides are banned. Subsequently, the insecticides viz. Quinalphos, Profenofos and Carbaryl were used to keep the population of *C. cupreata* under check (Sangha *et al.*, 2017).

Utilizing innovative synthetic insecticides serves as an efficient emergency measure and could play a crucial role in integrated pest management strategies aimed at addressing the threat of the poplar defoliator *C. cupreata* in India. In the increasing poplar plantation and subsequently increase in insect pest infestation, it is important to screen the effective synthetic insecticides against *C. cupreata* in order to develop efficient insect pest management techniques for poplar farming. Thus, with the aim to evaluate few synthetic insecticides against a major defoliator of poplar trees, present experiment was undertaken.

## MATERIALS AND METHODS

Field survey of poplar was conducted to collection the insect culture of *C. cupreata* in the Haridwar district of

Uttarakhand, during July - August. Egg masses and larval populations of *C. cupreata* were collected and brought to the laboratory for rearing. Insects were transferred to an insect rearing chamber and fresh leaves of *P. deltoides* were provided daily basis for rearing the larval stage. After pupation insects were placed to a in ventilated cages sized 80x60x40 cm for adult emergence. Adult insects were fed with 10% sucrose solution (10 g/l) via a cotton swab. After hatching, the resulting second-generation larvae were moved to fresh poplar leaves for feeding. Third-instar larvae from this second generation were utilized for the bio efficacy study. Both insect rearing and bioassay testing were conducted at room temperature during July and August at Insect Systematics Laboratory, Forest Entomology Discipline, Forest Research Institute, Dehradun, Uttarakhand, India

Imidacloprid 17.8% SL (Manufacturer: Shivalik Crop Science LTD. India) was evaluated against third instar larvae of *C. cupreata*. Five consecutive concentrations viz. 0.1, 0.2, 0.5, 1.0 and 2.0 % prepared through repeated dilution with water. The mode of action of Imidacloprid is acetylcholine receptor stimulation. The toxicity of Imidacloprid insecticides against third instar *C. cupreata* larvae was evaluated using the leaf dip method as outlined in Paramasivam and Selvi, (2017). Leaf discs were prepared of *P. deltoides* measuring 5 cm in diameter and were immersed in a prepared concentration of the insecticide solution for 10 seconds followed and then allowed to dry on a paper towel. Leaf discs used in the control were exposed with distal water. These treated leaves were then placed in Petri dishes (90 mm) lined with moist filter paper, subsequently; a group of ten larvae of third instar of *C. cupreata* were released onto the treated leaves. The each treatment was replicated five times. Larval mortality was observed at intervals of 24, 48, and 72 hours after treatment. Data were subjected to statistical analysis with probit analysis (Finney 1971) statistical method for lethal concentrations (LC<sub>50</sub>), Standard error; 95% confidential limits; Chi-square value ( $\chi^2$ ) and degrees of freedom (df) using SPSS statistical analysis software (IBM SPSS statistical analysis software version 23.0 (Armonk, New York, USA).

## RESULTS AND DISCUSSION

The toxicity results revealed that imidacloprid exhibited a concentration of 0.072% at 24 hours after treatment (HAT), while concentrations of 0.012% and 0.0017% were observed against third instar larvae of *C. cupreata* at 48 and 72 HAT, respectively (Table 1). This study represents the first toxicity evaluation of Imidacloprid 17.8% SL against *C. cupreata*. Though, Sangha *et al.* (2017) determined the lethal concentrations of quinalphos, profenofos, and carbaryl against *C. cupreata* in this field. However, Imidacloprid 17.8% SL was previously applied in soybean fields and was found to be most effective against tobacco caterpillar *Spodoptera litura*, green semilooper, and soybean blue beetle (Bhardwaj *et al.*, 2018). Additionally, the results revealed that the maximum reduction in population was observed with imidacloprid 17.8% SL

against rice brown plant hopper *Nilaparvata lugens* (Priyadharshini, 2023). Justin *et al.* (2015) also reported a significant reduction in the population of *Aphis craccivora*

Koch, leafhopper *Empoasca kerri* Pruthi, defoliator *Spodoptera litura* (Fab.), and pod borer *Helicoverpa armigera* (Hub.) in black gram.

**Table 1.** Toxicity of Imidacloprid 17.8% SL against third instar larvae of poplar defoliator, *C. cupreata*.

| Insecticide | LC50 (95% CL) <sup>b</sup> (mg L <sup>-1</sup> ) | Regression equation | Slope ±SE <sup>a</sup> | χ <sup>2</sup> (df) <sup>c</sup> |
|-------------|--------------------------------------------------|---------------------|------------------------|----------------------------------|
| 24HAT       | 0.726 (0.329-1.60)                               | y=1.106X + 5.18     | 1.06±0.17              | 0.84 (3)                         |
| 48 HAT      | 0.125 (0.064-0.243)                              | y=1.372X + 6.24     | 1.42±0.14              | 0.90 (3)                         |
| 72 HAT      | 0.017 (0.004-0.071)                              | y=0.33X + 6.65      | 1.02±0.31              | 0.67 (3)                         |

<sup>a</sup> Standard error; <sup>b</sup> 95% confidential limits'Chi-square value (χ<sup>2</sup>) and <sup>c</sup> degrees of freedom (df) as calculated by probit analysis of SPSS version 23.0; The LC<sub>50</sub> values of each tested insecticide corresponding 95% confidence limits (P < 0.05).

The chemical method stands out as the most rapid, successful, and widely used approach for controlling insect pests through the application of appropriate concentrations of insecticides. Priyadharshini (2023) reported resistance in *Nilaparvata lugens* against Imidacloprid, thus recommending the rotation of different insecticides to manage resistance in insect pests effectively. Continuously screening new insecticidal molecules against targeted insect pests is essential for ensuring bio-efficacy and incorporating newer molecules into pest management programs. However, there is limited research conducted on screening insecticides for forestry insect pests, despite *Populus deltoides* being widely planted over 2.7 lakh hectares in Northwestern states of India. The use of higher discriminating concentrations of imidacloprid 17.8% SL notably increased cumulative larval mortality among early instar *C. cupreata*. This study underscores a significant increase in early instar larval mortality with escalating concentrations of these insecticides.

## CONCLUSIONS

Due to the limited number of recommended insecticides for managing the poplar defoliator *C. cupreata*, it is crucial to use imidacloprid 17.8% SL with caution and prudence in management strategies to ensure its long-term efficacy. Furthermore, after conducting additional field investigations to confirm its effectiveness, this insecticide could be deployed on an emergency basis at recommended doses against *C. cupreata* larvae. The findings of this research provide valuable insights for selecting alternative insecticides for poplar defoliator management. However, further research is needed to validate these laboratory findings under field conditions.

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