

Utilization Of Betel Leaf (*Piper betle* Linn.) and *Lantana camara* Leaf Extracts As Botanical Insecticides For Armyworm Control (*Spodoptera litura*)

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ABSTRACT

The extensive use of synthetic insecticides has led to environmental contamination, pest resistance, and adverse effects on non-target organisms. Botanical insecticides provide a safer alternative for sustainable pest management. This study evaluated the insecticidal activity of betel leaf (*Piper betle* L.) and *Lantana camara* leaf extracts against armyworm (*Spodoptera litura*). A laboratory bioassay was conducted using three extract concentrations (30%, 40%, and 50%) arranged in a completely randomized design. Larval mortality was recorded daily for seven days after application and analyzed using ANOVA followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level. Both botanical extracts significantly increased larval mortality over time. Mortality began to rise on the second day and increased sharply on the third and fourth days after application. By the fifth day, all extract treatments resulted in nearly 100% mortality, while no mortality occurred in the control. Cumulative mortality patterns indicated that *Lantana camara* induced a faster initial lethal effect, whereas *Piper betle* showed a slightly delayed but equally effective response. No significant differences were observed among concentrations, indicating that a 30% concentration was sufficient for effective control. These results highlight the potential of betel leaf and *Lantana camara* extracts as effective botanical insecticides for armyworm management.

Keywords: botanical insecticide, *Piper betle*, *Lantana camara*, *Spodoptera litura*

INTRODUCTION

Armyworm (*Spodoptera litura* Fabricius) is one of the most destructive polyphagous insect pests affecting a wide range of agricultural crops, including vegetables, legumes, and plantation crops. Larval feeding activity can cause severe defoliation, leading to significant yield losses when infestations are not properly managed (CABI,

2022). In many agricultural systems, control of *S. litura* relies heavily on synthetic insecticides due to their rapid knockdown effect and ease of application.

However, the intensive and continuous use of synthetic insecticides has resulted in several serious problems, such as the development of

insect resistance, resurgence of pest populations, environmental contamination, and negative impacts on non-target organisms and natural enemies (Isman, 2006). These concerns have encouraged the search for alternative pest control strategies that are more environmentally friendly and sustainable (Sparks & Nauen, 2014)

Botanical insecticides derived from plant secondary metabolites have gained increasing attention as potential alternatives to synthetic chemicals. These compounds are generally biodegradable, less persistent in the environment, and often exhibit multiple modes of action, including antifeedant, growth inhibitory, and toxic effects on insects (Isman, 2020). Moreover, botanical insecticides tend to act more slowly, reducing the risk of resistance development compared to single-target synthetic insecticides (Isman, 2008). Essential oils are phytochemicals that occur naturally and serve as secondary metabolites in plants. These complex mixtures of volatile compounds typically consist of twenty to sixty individual compounds in varying concentrations (Zarrad et al., 2015)

Betel leaf (*Piper betle* L.) is a medicinal plant widely distributed in tropical regions and known to contain bioactive compounds such as phenols, eugenol, chavicol, and essential oils with antimicrobial and insecticidal properties (Tripathi

et al., 2009). Several studies have reported that *P. betle* extracts can disrupt insect feeding behavior, respiration, and digestive processes, leading to increased mortality in lepidopteran pests.

Lantana camara is known as a foreign weed that invades land quickly, however *L. camara* is another plant species recognized for its insecticidal potential (Shen et al., 2018). Its leaves contain triterpenoids, alkaloids, and phenolic compounds that exhibit toxic, repellent, and antifeedant effects against various insect pests (Sharma et al., 2007). Previous studies have demonstrated that *L. camara* extracts are effective against larvae of noctuid pests, suggesting their potential use as botanical insecticides. *Lantana camara* extract can also be used to control *Sitophilus zeamais* (Bouda et al., 2001)

Despite the documented insecticidal properties of *P. betle* and *L. camara*, comparative studies evaluating their effectiveness against *S. litura*, particularly in terms of mortality dynamics over time, remain limited. Therefore, this study aimed to evaluate the insecticidal activity of betel leaf (*Piper betle*) and *Lantana camara* leaf extracts at different concentrations against armyworm (*Spodoptera litura*), focusing on cumulative mortality patterns and their potential application as eco-friendly pest control agents.

MATERIALS AND METHODS

Study Site and Time

The study was conducted in field, on Pelemsari region, Kotagede, Indonesia. The bioassay was carried out at room temperature (27 ± 2 °C) and relative humidity of 70–80%. The experiment was conducted from Maret – April 2025, using third instar larvae of *Spodoptera litura*.

Insect Rearing

Larvae of *Spodoptera litura* were collected from infested host plants in agricultural fields and reared in the laboratory until the third instar. Larvae were maintained in plastic containers and fed fresh leaves of their host plant daily. Only healthy and active larvae of uniform size were used for the bioassay to minimize variability.

Preparation of Plant Extracts

Fresh leaves of betel (*Piper betle* L.) and *Lantana camara* were collected, washed with distilled water, and air-dried at room temperature. The dried leaves were ground into fine powder using a blender.

Plant extracts were prepared by maceration. Leaf powder was soaked in distilled water for 24 hours at room temperature and filtered using filter paper. The filtrate was considered as the stock solution. Working solutions were prepared by diluting the stock solution to obtain concentrations of 30%, 40%, and 50% (v/v).

Bioassay Procedure

The experiment was arranged in a completely randomized design (CRD) with two plant extracts and three concentrations (30%, 40%, and 50%), along with a control (distilled water only). Each treatment was replicated 5 times, and each replicate consisted of 20 larvae.

Fresh host plant leaves were dipped into the respective extract solutions for approximately 30 seconds, air-dried, and then placed into plastic containers. Larvae were introduced into each container and allowed to feed freely. Control larvae were fed leaves treated with distilled water only.

Larval mortality was recorded daily for seven days after application. Larvae were

considered dead when no movement was observed after gentle probing.

Data Analysis

Larval mortality was expressed as a percentage and subjected to analysis of variance (ANOVA). When significant differences were detected, means were separated using Duncan’s Multiple Range Test (DMRT) at a 5% significance level. Statistical analyses were performed using SPSS . Cumulative mortality was calculated to describe mortality dynamics over the observation period.

RESULTS AND DISCUSSION

Larval Mortality of *Spodoptera litura*

The application of botanical insecticides significantly affected the mortality of *Spodoptera litura* larvae. No larval mortality was observed on the first day after application in all treatments, indicating that both plant extracts did not cause

immediate lethal effects. Mortality began to increase on the second day and showed a sharp rise on the third and fourth days after application (Table 1)

Table 1. Mortality of armyworm (*Spodoptera litura*) after application of botanical insecticides (%)

Extract	Concentration	Day-1	Day-2	Day-3	Day-4	Day-5	Day-6	Day-7	Mean (%)
<i>Piper betle</i>	30%	0.00b	23.3 ab	53.3ab	86.7 a	100.0 a	100.0 a	100.0 a	66.2 a
	40%	0.0 b	20.0 ab	46.7 a	93.3 a	100.0 a	100.0 a	100.0 a	65.7 a
	50%	0.0 b	36.7 a	43.3 a	96.7 a	100.0a	100.0 a	100.0 a	68.1 a
<i>Lantana camara</i>	30%	0.0 b	20.0 ab	56.7 b	70.0 b	96.7 a	100.0a	100.0 a	63.3 a
	40%	0.00b	13.3 b	63.3 b	83.3 ab	100.0 a	100.0 a	100.0 a	65.7 a
	50%	0.0 b	25.0ab	60.0 b	100.0 a	100.0 a	100.00 a	100.00 a	69.3 a
Control	–	0.00 b	0.00 b	0.00 c	0.00 c	0.00 c	0.00 c	0.00 c	0.00 c
Mean (day)	–	0.00 b	19.7 e	46.2 d	75.7 c	85.2 a	85.7 a	85.7 a	–

Note:

Values followed by the same letter in the same column are not significantly different according to DMRT at 5% significance level.

Cumulative mortality curves clearly demonstrated a time-dependent toxic effect of the botanical insecticides (Figure 1).

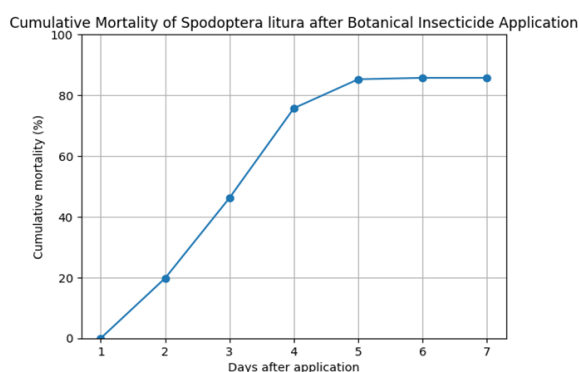


Figure 1. Cumulative mortality of *Spodoptera litura* larvae after botanical insecticide application

Mortality increased gradually during the early observation period and reached a steep increase between the third and fourth days after application. After the fifth day, the mortality curves tended to plateau, indicating that most larvae had already been affected.

Comparison between extracts showed that *Lantana camara* induced higher cumulative mortality at an earlier stage, whereas *Piper betle* exhibited a slightly delayed but equally strong

lethal effect. This difference suggests variation in the mode of action and speed of toxicity between the two plant extracts (Figure 2)

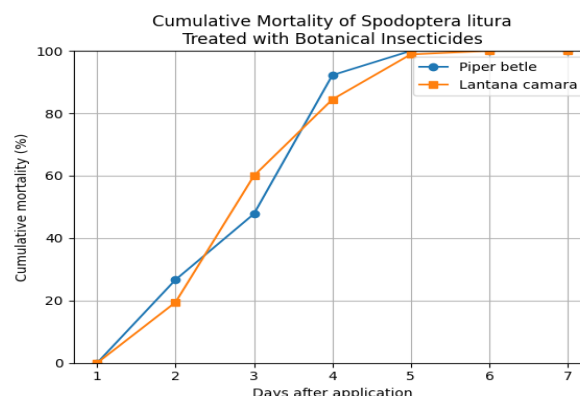


Figure 2. Cumulative mortality of *Spodoptera litura* treated with botanical insecticide

On the third day (Table 2), larval mortality ranged from 43.33% to 63.33% across treatments. Extracts of *Lantana camara* tended to produce higher mortality compared to betel leaf (*Piper betle*), although differences among concentrations were not statistically significant. This result suggests that *L. camara* may exert a faster initial toxic effect on *S. litura* larvae.

Table 2. Larval mortality (%) on the third day after application

Extract	Concentration			Mean
	30%	40 %	50%	
<i>Piper betle</i>	53.33ab	46.67a	43.33a	47.78a
<i>Lantana camara</i>	56.67b	63.33b	60.00ab	60.00a
Mean	55.00a	55.00a	51.67a	(-)

By the fourth day after application, mortality increased markedly in all treatments, reaching 70–100%. Both extracts at all concentrations resulted in significantly higher mortality compared to the control. The highest mortality was observed at a concentration of 50%,

although statistically it did not differ from lower concentrations. From the fifth to the seventh day, almost all treated larvae died, resulting in cumulative mortality close to 100%, while no mortality was recorded in the control (Table 3)

Table 3. Larval mortality (%) on the fourth day after application

Extract	Concentration			Mean
	30%	40%	50%	
<i>Piper betle</i>	86.67a	93.33a	96.67a	92.22a
<i>Lantana camara</i>	70.00b	83.33ab	100.00a	84.44a
Mean	78.33a	88.33a	98.33a	(-)

Cumulative Mortality Pattern

Cumulative mortality curves clearly demonstrated a time-dependent toxic effect of the botanical insecticides. Mortality increased gradually during the early observation period and reached a steep increase between the third and fourth days after application. After the fifth day, the mortality curves tended to plateau, indicating that most larvae had already been affected.

Comparison between extracts showed that *Lantana camara* induced higher cumulative mortality at an earlier stage, whereas *Piper betle* exhibited a slightly delayed but equally strong lethal effect. This difference suggests variation in the mode of action and speed of toxicity between the two plant extracts.

Effect of Extract Type and Concentration

Statistical analysis revealed no significant differences among concentrations (30%, 40%, and 50%) for both plant extracts, indicating that even the lowest concentration tested was sufficient to cause high larval mortality. This finding is particularly important from a practical perspective, as lower concentrations may reduce production costs and minimize potential impacts on non-target organisms. Similarly, no significant difference was observed between the two plant extracts in terms of overall mortality. Both *Piper betle* and *Lantana camara* demonstrated strong insecticidal activity against *S. litura*, confirming their potential as effective botanical insecticides.

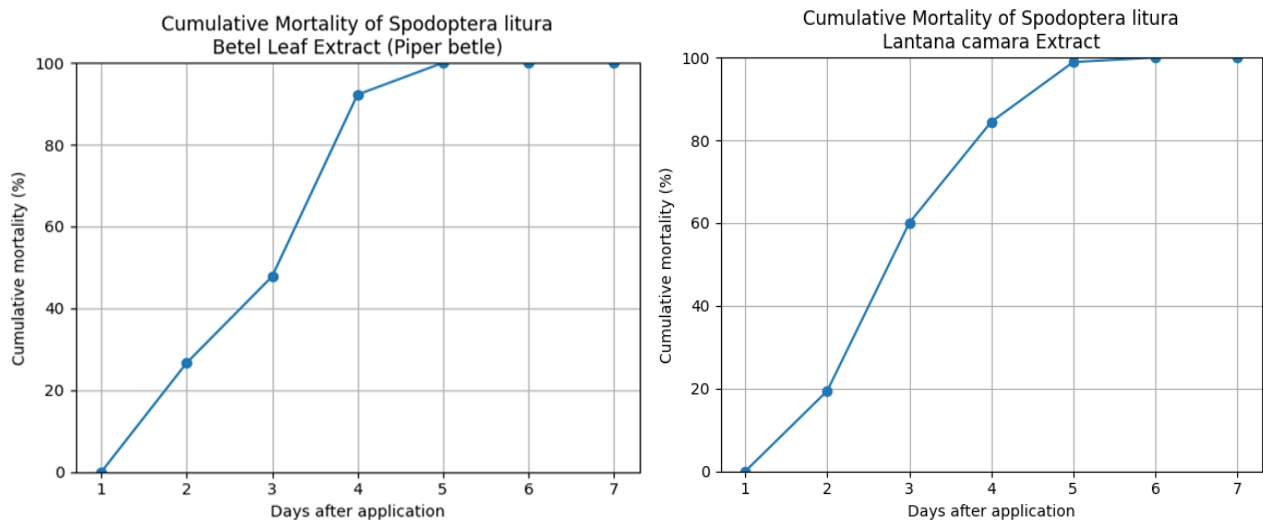


Figure 3. Cumulative mortality of *S. litura* from *Piper betle* and *Lantana camara*

Mode of Action and Biological Implications

The delayed mortality pattern observed in this study is characteristic of botanical insecticides, which generally act as slow-acting toxins rather than fast-acting contact poisons. The insecticidal activity of *Piper betle* has been attributed to phenolic compounds and essential oils, such as

eugenol, which can disrupt respiratory function and digestive processes in insects. Betel leaf extract (100%) demonstrates efficacy in eliminating *Aedes aegypti* larvae (Susanto & Setiyorini, 2017). Betel leaf extract at various concentrations can also control house flies (Anisah & Sukesu, 2018). Betel

leaf extract also has repellent and antifeedant properties for cockroaches (Thavara et al., 2007).

In contrast, *Lantana camara* contains triterpenoids and alkaloids that exhibit antifeedant and toxic effects, leading to reduced feeding activity and eventual larval death. Cumulative mortality increased steadily over time and approached 100% by the fifth day after application. *Lantana camara* extract caused a faster initial increase in mortality compared to betel leaf extract, indicating a quicker toxic response (Figure 4)

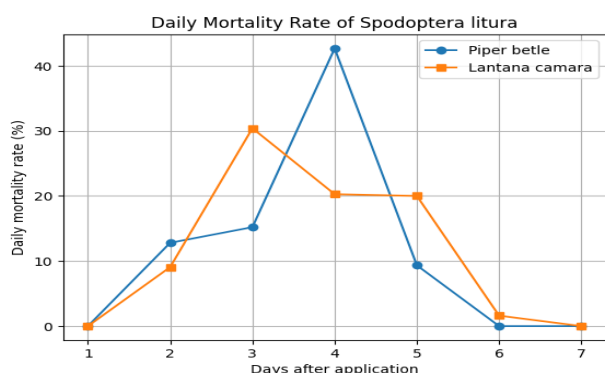


Figure 4. Daily mortality death of *Spodoptera litura*

The gradual increase in mortality over time suggests that larvae were exposed continuously to bioactive compounds through treated foliage,

CONCLUSION

Both betel leaf (*Piper betle*) and *Lantana camara* extracts exhibited strong insecticidal activity against *Spodoptera litura* larvae under laboratory conditions. Larval mortality increased over time, reaching nearly 100% by the fifth day after application. *Lantana camara* induced a faster initial lethal effect, while betel leaf extract showed a slightly delayed response; however, both extracts

resulting in cumulative toxic effects. Such a mode of action is advantageous for resistance management, as it involves multiple physiological targets and reduces selection pressure compared to single-mode synthetic insecticides. The delayed mortality pattern observed reflects the slow-acting nature of botanical insecticides, which disrupt feeding behavior and physiological processes. The presence of multiple bioactive compounds may reduce the risk of resistance development and supports their suitability for integrated pest management programs.

Implications for Sustainable Pest Management

The high mortality of *S. litura* larvae observed in this study highlights the potential of betel leaf and *Lantana camara* extracts as environmentally friendly alternatives to synthetic insecticides. Their effectiveness at relatively low concentrations and delayed mode of action make them suitable candidates for incorporation into integrated pest management (IPM) programs. Further studies under field conditions are recommended to evaluate their efficacy in more complex environments and to assess potential effects on non-target organisms and natural enemies.

were equally effective overall. Concentration levels did not significantly affect mortality, indicating that lower concentrations can be efficiently utilized. These findings demonstrate the potential of betel leaf and *Lantana camara* extracts as environmentally friendly botanical insecticides and support their application in sustainable pest management strategies.

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