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Response Of Nilaparvata Lugens (Stal.) Hemiptera; Delpacidae To The Application Of Deltamethrin Insecticides At Sublethal Concentrations

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ABSTRACT

The initial population of Nilaparvata lugens was obtained from the field and developed in the entomology and toxicology laboratory of the plant protection department of Halu Oleo University. This study began with mass cultivation of the N. lugens insect pest. This was followed by selecting the LC50 concentration based on mortality at 72 hours after treatment. The results of the probit analysis found an LC50 value 3.16 ml/L for the insecticide deltamethrin. The high recommended concentration found for the insecticide deltamethrin is suspected because it is not recommended for use on N. lugens in rice fields. Increasing the frequency of application at sublethal concentrations (LC10 and LC25) was shown to trigger an increase in the resurgence ratio of 1.50 and 1.70 times, respectively, compared to the control group.

Keywords:, ***Concentration, Mortality, Residual, Resurgence, Toxicity***

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INTRODUCTION

The brown planthopper (BPH), or Nilaparvata lugens (Stal.), has been a major pest attacking rice crops in Indonesia since the 1970s. A significant BPH population explosion occurred in 1978–1979, affecting approximately 750,000 hectares of rice fields and negatively impacting national food security. According to Awaluddin et al. (2024), This insect damages rice plants by sucking the sap from leaf sheaths throughout all stages of growth. In Indonesia, this pest is widespread, from Java, Sumatra, Kalimantan, to Sulawesi. Furthermore, N. lugens also poses a serious threat to rice productivity in various other Asian countries and Australia. (Awaluddin et al. 2024b).

Brown planthopper is not easily controlled with a single control method. This is due to the pest's ability to reproduce rapidly and adapt to environmental changes. To date, BPH remains a pest of great concern to farmers and field workers because it is believed that it can experience a population explosion at any time and cause serious damage to rice crops, leading to crop failure. This concern often prompts farmers to carry out preventive spraying with insecticides considered effective. In implementing integrated pest management (IPM) against BPH in Indonesia, insecticide use should be carried out judiciously. Insecticides are only recommended when other control methods, such as the use of natural enemies and the use of resistant varieties, are no longer able to suppress the increase in BPH populations. (Chelliah dan Heinrichs 1980). However, conditions in the field show that until now many farmers still rely on insecticides to control BPH attacks (Ratna et al. 2009).

In conventional agricultural systems, insecticides are a crucial component in efforts to increase and maintain production yields. While their use offers a number of benefits, continuous and large-scale application of insecticides is not only economically disadvantageous for farmers but also has the potential to cause various negative impacts. Therefore, the selection and use of insecticides in pest management requires careful and judicious use. Adverse impacts of insecticide use include resurgence due to insecticide byproducts and environmental pollution caused by the accumulation of insecticide residues. (Wu et al. 2001). Resurgence is defined as a rapid increase in pest population after insecticide treatment, with population numbers exceeding pre-treatment levels. (Xu et al. 2019).

Deltamethrin, with the chemical name (S)-cyanophenoxybenzyl (1R,3R)-3-(2,2-dibromoethenyl)-2, 2-dimethyl cyclopropane carboxylate and the chemical formula

$C_{22}H_{12}Br_2NO_3$, is a synthetic pyrethroid insecticide. This insecticide is a contact poison that can quickly paralyze insects. (Akre 2016). This insecticide is also known as a broad-spectrum nerve agent (Anitha et al. 2019). This study aims to determine the LC50 concentration based on a toxicity test at 72 hours.

METHODS

This research was conducted at the Entomology and Toxicology Laboratory of the Plant Protection Department, Halu Oleo University. The initial stage involved mass-breeding of BPH pest insects until the desired population target was reached. Once the target was met, the insects were transferred to rice plants in the field for infestation as test subjects. The research process continued by determining the LC50 concentration of the insecticides deltamethrin, which was based on the level of insect mortality 72 hours after treatment application. Approximately 50 gr of Mekongga rice seeds were prepared by washing and soaking them for 24 hours. The seeds were then sown in plastic jars covered with gauze until they germinated. The rice seedlings, seven days after sowing (DSS), were ready to be used as a food source and egg-laying medium for BPH.

The egg-laying procedure begins by transferring 50–70 pairs of BPH imago from the field to rice seedlings individually. After the eggs hatch, the nymphs are transferred to new jars containing fresh rice seedlings. This transfer is done by placing the old rice seedlings upside down, allowing the newly hatched nymphs to move to the new medium. The rice seedlings are replaced weekly until the nymphs enter the imago stage. The newly emerged imagoes are immediately transferred back to plastic jars containing 7-day-old rice seedlings for the next generation of culture. This cycle is repeated until the BPH reaches the fourth generation, which is then used for the LC50 concentration test.

The test was conducted using a container consisting of two layers of plastic cups with a diameter of 8 cm and a height of 15 cm. The first cup was filled with 5 ml of water, while the second cup was perforated at the bottom diameter 3 mm, lined with tissue paper, then inserted into the first cup. A total of 10 Intani 2 variety rice seedlings aged 7 days after planting were dipped into the insecticide solution for 10 seconds, then water dried for 10 minutes. The treated seedlings were placed in a plastic container and given an identity label. Next, 10 instar-3 BPH nymphs were released into the container covered with gauze. The entire series of treatments was carried out three times. BPH mortality was observed 72 hours after treatment. The data obtained were then analyzed using PoloPlus software to determine the LC50 value. Data analysis continued as long as the mortality rate in the control group did not exceed 10%. The obtained concentrations were then applied to subsequent tests to evaluate the effect of frequency and concentration on BPH population dynamics.

The evaluation of the impact of LC50 concentration on BPH population dynamics began with planting Mekongga rice seedlings in plastic pots measuring 30 cm in diameter and 25 cm in height filled with paddy soil. The planting containers were equipped with transparent plastic mica covers measuring 25 cm in diameter and 70 cm in height, and covered with gauze.. The spray volume for each treatment was 10 ml/pot. In the control, spraying was carried out using only water. Each treatment was repeated three times.

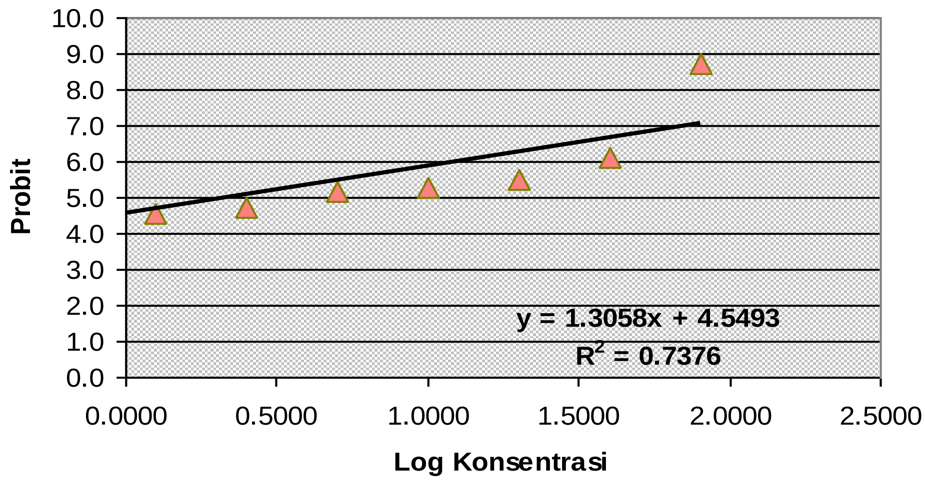
RESULTS AND DISCUSSION

Research Findings

Toxicity testing was conducted in the laboratory with the aim of finding the relationship between deltamethrin insecticide concentration and BPH mortality to determine the LC50 value. (Figure 1).

Figure 1. Deltamethrin toxicity test against BPH

Within 72 Hours



Information :

1) The number of test insects for each treatment was 10.

2) Each treatment was divided into three replications.

The BPH mortality rate within 72 hours was evaluated using probit analysis through the Probit 5 program. The test results showed an LC50 value of 3.00 ppm/L, LC25 of 1.50 ppm/L, and LC10 of 0.75 ppm/L, which were then used as a reference for sublethal concentrations in population development studies.

The high LC50 concentration value found when compared to the recommended dose in controlling aphids and rice hopper pests of 0.2 – 1 mL/L of water, is because the deltamethrin insecticide is not recommended for controlling BPH pests in rice plants, but in reality in the field farmers still use this insecticide to control other pests in rice plants.

Development of BPH Resurgence with deltamethrin

The calculated values for LC50 (3.00 ppm), LC25 (1.50 ppm), and LC10 (0.75 ppm/L), derived from the probit analysis (Figure 1), were subsequently employed to evaluate the impact of application frequency and sublethal insecticide concentrations on population growth, as detailed in Table 1

Table 1. Effect of sublethal application of deltamethrin insecticide on the success of BPH nymphs becoming adults in the Intani 2 varieties.

Sublethal concentration (ppm)	Frequency		Number (x tails)		
	Application (Times)	Nymph Age (Days)	Nymph	Mortality	Imago
LC_{10} 750	1	5	100	23.67	76.33
	2	5 & 10	100	33.00	67.00
	3	5,10 & 15	100	36.67	63.33
LC_{25} 1500	1	5	100	41.33	58.67
	2	5 & 10	100	33.00	67.00
	3	5,10 & 15	100	65.33	34.67
LC_{50} 3000	1	5	100	50.33	49.67
	2	5 & 10	100	70.33	29.67
	3	5,10 & 15	100	76.00	24.00
Control	0	0	100	12.33	87.67

Description:

• x (Average value of three repetitions)

Observations on the survival of adults from the 1st instar nymph phase to day 19 showed that the highest mortality was found in the LC50 treatment with a three-time application frequency, namely 228 individuals (remaining 72 adults). Conversely, the lowest mortality was recorded in the control group with a mortality rate of 37 individuals (remaining 263 adults). In addition, in the LC10 and LC25 treatments, the mortality rate tended to increase proportionally with increasing frequency of deltamethrin application at concentrations of 0.75, 1.50, and 3.00 ppm/L.

The test results showed that the highest population increase in the first generation (F1) was found in the LC10 treatment with three applications. In this group, the number of first-instar nymphs that hatched reached 19,035 (hatchability 93.45%) from a total of 19,437 eggs. This achievement was higher than the control group which produced 18,385 nymphs (hatchability 96.56%) from 19,040 eggs. Meanwhile, the LC25 treatment with one application resulted in 17,659 nymphs that hatched with a hatching percentage recorded at 104.2% of the total 18,308 eggs laid.

The population growth rate showed an increasing trend consistent with the increasing frequency of application at the LC10 concentration (0.75 ppm/L). Based on observations, applications of 1, 2, and 3 times resulted in population growth of 11,764, 13,155, and 19,035 individuals, respectively. Egg hatching success was recorded at 95.98%, 94.95%, and 97.93% of the total eggs laid (12,257, 13,855, and 19,437 eggs, respectively). In addition, the degree of resurgence compared to the control increased gradually with values of ± 0.64, 0.72, until it reached 1.04.

Table 2. Effect of sublethal deltamethrin application on the population growth of BPH in the first generation (F1)

Sublethal concentration (ppm)	Application (times)	Imago	Egg	Nymph	Hatching (%)	Average number of nymphs /adults	Frequency ratio (Times)
LC_{10} 700	1	229	12257	11764	95.98	51.18^{ab}	0.73
	2	201	13855	13155	94.95	67.88^{ab}	0.97
	3	190	19437	19035	97.93	104.74^{a}	1.50
LC_{25} 1500	1	176	18308	17659	96.46	104.53^{a}	1.49
	2	201	10499	9863	93.94	63.82^{ab}	0.91
	3	104	9497	8380	88.24	119.03^{a}	1.70
LC_{50} 3000	1	149	9890	9242	93.45	61.16^{ab}	0.87

	2	89	4360	3845	88.19	50.90[ab]	0.73
	3	72	2920	2171	74.35	28.06[b]	0.40
Control	0	263	19040	18385	96.56	69.95[ab]	1.00

Description :

a. Number of three replicates
b. Fecundity ratio (the average number of eggs produced/adults for each treatment divided by the control)
c. Mean values followed by the same letter in the same row are not significantly different based on the LSD at the 5% level.

In contrast to LC10, the population growth rate in the first generation (F1) for the LC25 and LC50 treatments showed a decreasing trend as the frequency of insecticide application increased. At LC25 concentration (1.50 ppm), the population decreased successively from 17,659 to 8,380 individuals with egg hatchability ranging from 96.46% to 88.24% and a declining resurgence value from 0.96 to 0.46. A similar pattern was found at LC50 (3.00 ppm), where the population decreased significantly from 9,242 to 2,171 individuals with a weakened egg hatching percentage (93.45% to 74.35%) and a low degree of resurgence (0.50 to 0.15) after 1, 2, and 3 applications (Table 2).

Based on statistical analysis, the LC10 treatment with three applications and the LC25 with one application showed no significant differences compared to the control. However, both treatments were significantly different from LC10 (applications 1 and 2), LC25 (applications 2 and 3), and all application levels at LC50. From the results of this first study, the two treatments that produced the highest first-generation (F1) population growth rates—namely LC10 0.75 ppm (3 applications) and LC25 1.50 ppm (1 application)—were selected for the next stage of research. This stage aims to further evaluate the effect of the frequency of sublethal deltamethrin applications on the fitness level, fertilization, and viability of Increasing the frequency of insecticide application at sublethal concentrations has been shown to stimulate increased egg fertilization and viability of first-generation (F1) female brown planthopper (BPH) imagoes. Due to these negative impacts, the use of insecticides containing deltamethrin in rice paddy ecosystems is not recommended, regardless of whether BPH is a target pest or not. eggs.

The phenomenon of increased reproduction in the LC10 (3x application) and LC25 (1x application) groups is thought to occur because BPH increases the intensity of nutrient absorption from the host as an adaptive response to the decline in plant quality due to the sublethal effects of insecticides. On the other hand, a more efficient detoxification mechanism allows deltamethrin compounds to be broken down into free proteins instead of binding to target receptors. The additional energy from these proteins supports the formation of female imagos with larger morphology and superior fertility and fecundity capacities (Li et al. 2023). In addition to the side effects of pesticides, additional energy support in the form of macronutrients, particularly protein, is also obtained from the plant variety itself. This protein intake contributes to the development of female adults with larger body morphology and superior fertility and fecundity (Bhavanam 2016, ; Leyria et al. 2025 end Leather 2018)

In general, the results of this study indicate a significant positive effect of the sublethal application of deltamethrin insecticide on the biological parameters of BPH. Treatments at concentrations of 0.75 ppm and 1.5 ppm/L of water significantly increased the fecundity and viability (hatchability) of brown planthopper eggs in the first generation (F1). In addition to the direct effect of the insecticide, the results of this study also indicate a significant effect of the 'Intani 2' rice variety used as a test medium for BPH. This is evident from the high average egg fertilization and viability per pair of adults in the control group (without treatment) in the first generation (F1).

CONCLUSION AND IMPLICATIONS

Increasing the frequency of insecticide application at sublethal concentrations has been shown to stimulate increased egg fertilization and viability of first-generation (F1) female brown planthopper (BPH) imagoes. Due to these negative impacts, the use of insecticides containing deltamethrin in rice paddy ecosystems is not recommended, regardless of whether BPH is a target pest or not.

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