



Original Article

Examining the Effectiveness of Chemical Insecticide Active Ingredients in Controlling Insects on Sweet Potato Plants (*Ipomoea batatas* L.)

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Abstract: The study of the effectiveness of several active ingredients of chemical insecticides in controlling insects in sweet potato plants (*Ipomoea batatas* L.) was carried out at the UMT Bukit Kor Agricultural Complex, Marang Trengganu Malaysia from 14 September to 21, 2023—research methods. The design used a randomised group design (RAL) with three treatments and three repeats, namely T0 Control, T1 Sulfoxaflor 1.5 gr/ 2 litres of water, T2 Buprozen + Cartap Hydrochloride 2 g / 2 litres of water. The observation of mortality percentage was carried out until the seventh day, and the result was calculated using the formula $M \ a/b \times 100 \%$. The Brine Shrimp Lethality Test (BSLT) is used to observe compounds' toxicity. The result obtained is calculated as the LC50 (*lethal concentration*) value. The results showed that the toxicity of both insecticide active ingredients used was considered very effective for controlling target insects of the Hemiptera order. The active ingredient Sulfoxaflor obtained an insect mortality percentage of the order Hemiptera by 100%, and the active ingredients Buprozen and Cartap Hydrochloride obtained 100%. However, non-target organisms such as the Araneae order, a natural enemy, namely *Oxyopes javanus*, are also affected by 100% toxicity of the two active ingredients, from calculating the LC50 value from probit analysis after obtaining results. The LC50 value obtained is 47.11 ppm. The LC50 value of these two insecticides has a toxic potential because the value is below 1000 ppm.

Keywords: Sulfoxaflor; Buprozen; Cartap Hydrochloride; Mortality; Toxicity



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1. Introduction

The sweet potato plant (*Ipomoea batatas* L.) is one of the most important crops in Indonesia, both as an alternative staple food during the lean season and as an additional food ingredient for food diversification. As one of the fourth carbohydrate-producing plants after rice, corn, and cassava, sweet potato has a high nutritional content. The beta carotene content is very high compared to other food plants.

Water in sweet potato 64.60–79.59%, ash 0.92–0.98%, starch 17.06–28.19%, protein 1.19–2.07%, sugar 0.38–0.43%, crude fibre 2.16–5.24%, and beta carotene 17.42–51.20%. (Rahayu, 2011). Therefore, sweet potatoes play an essential role in maintaining community food security. Sweet potato production in Indonesia is still low. National level tuber production 2014 was 2.383 million tons, with a harvest area of 0.157 million ha and a productivity of 152 quintals/ha. However, in 2015, production increased to 2.298 million tons, with a harvest area of 0.143 million ha and productivity of 160.53 quintals/ha.

Improvements in sweet potato production are still being carried out. There are several obstacles to developing sweet potatoes, including pests that attack. Insect pests that attack sweet potato plants are included in the main pest category of sweet potatoes. There are 9 main insect pests, namely the sweet potato beetle (*Cylas formicarius*), the stem borer (*Omphisia anastomosis*), the mite (*Eriophyes gastrotrichus*), the turtle leaf beetle (*Aspidomorpha miliaris*), leafroller (*Brachmia convolvuli* Wals), whitefly (*Bemisia tabaci* Genadius), brown ladybug (*Physomerus grossipes*), grub (*Phyllophaga ephilida*), and leaf caterpillar/armyworm (*Spodoptera litura*) (Saleh et al., 2015). Several control methods can be used, one of which is the use of insecticides. Several active insecticide ingredients are toxic to pests on sweet potato plants (*Ipomoea batatas* L.). Among them is Sulfoxaflor. Sulfoxaflor is a nicotinic acetylcholine receptor (nAChR) agonist, similar to neonicotinoids. It has recently been introduced to the global market as a viable alternative to neonicotinoids to manage leaf-sucking pests that cause significant economic losses, such as aphids (*Aphis gossypii*) and whiteflies (*Bemisia tabaci*) (Barrania et al., 2019 and Jiang et al., 2019) with lower residue levels in pollen (< 14.2 µg kg⁻¹) and in nectar (< 0.68 µg kg⁻¹) (Jiang et al., 2020).

Apart from that, an insecticide contains the active ingredient Buprofen, previously known as Buprofezin. Buprofezin is an insecticide compound with the IUPAC name 2-tert-butylimino-5-phenyl-3-propan-2-yl-1,3,5-thiadiazinan-4-one with a molecular weight of 305.44 and the molecular formula C₁₆H₂₃N₃O₅. Buprofezin is white crystals with a melting point of 106.1 C, low solubility in water, namely 0.8 mg/l, density (2° C) of 1.18, stable in storage and acid and base solutions (Agricultural and Veterinary Chemicals Australia, 2001; S. Singh et al., 2013). Buprofezin is an insecticide and acaricide. Buprofezin in the IRAC (Insecticide Resistance Action Committee) classification is included in group 16, namely Thiadiazine. Buprofezin is an inhibitor of chitin synthesis, type 1 (in Homoptera), affecting cuticle deposition. Buprofezin inhibits the molting process in nymphs and larvae (Heong & Escalada, 1997; Kiritani, 1979). The active compound buprofezin is used to eradicate pests, especially brown planthoppers. Like other insecticide-active compounds, ibuprofen can also cause environmental damage to soil water, insect resistance, health losses, and so on (Heong & Escalada, 1997; Kiritani, 1979).

Likewise, insecticides with active ingredients such as cartap hydrochloride eradicate pests in the order of Hemiptera. Cartap is an organic nitrogen insecticide first used in Japan in 1967 and then introduced in India in 1988 (Singh et al., 2014). Cartap is marketed as 'AG-Tap', 'Vegetox', 'Padan', 'Thiobel', and 'Kritap' and is available in India in two different formulations (4% granules and 50% powder). Cartap, due to its high insecticidal activity, is used worldwide to control insect pests such as rice, fruit trees, vegetables, tea plants, and sugar cane, and its mode of action is through the stomach (Berg, 2001). Based on the problems above, many orders of Hemiptera attack sweet potato plants, and the control used is an insecticide with the active ingredient Sulfoxaflor and a mixture of Buprofen and Cartap hydrochloride. So, it is necessary to research the toxicity of the above active insecticide ingredients against insects from other orders.

2. Materials and Methods

This study was conducted at the UMT Bukit Kor Agricultural Complex, Marang, Terengganu, Malaysia. The study was carried out from 14 to 21 September 2023. The tools used in this research were a hammer, wooden stakes, neat rope, machete, measuring cup, sprayer, scales, treatment labels, ruler, and writing utensils. Meanwhile, the ingredients used are insects on sweet potato plants, an insecticide with the active ingredient sulfoxaflor, an insecticide with a mixture of ibuprofen and cartap hydrochloride, and water. The research was carried out using a randomised block experimental design (CRD) consisting of 3 treatments and 3 replications: T0 = Control, T1 = Sulfoxaflor 1.5 gr/2 liters of water, and T2 = Buprofen + Cartap Hydrochloride 2 gr/2 liters of water. Observation of the mortality percentage was carried out until the seventh day. Calculated using the formula:

$$M = \frac{a}{b} \times 100 \%$$

Whereas; M = Percentage of insect mortality, a = Number of dead insects and b = number of insects used.

The method used to observe the toxicity of compounds is the Brine Shrimp Lethality Test (BSLT), a simple preliminary/pre-screening test for biological activity to determine the acute toxicity of a compound or extract using the Meyer method. This method is aimed at insect mortality rates caused by the test insecticide. The results obtained are calculated as the LC₅₀ (*lethal concentration*) value of the test extract, namely the number of doses or concentrations that can cause 50% insect death after an application period of 7 days—compounds with LC₅₀ < 1000 ppm can be considered as active compounds based on the Meyer

1982 formula in Lestari et al. (2015). The land used was sweet potato plantation land, made into a plot 5.5 × 5.5 m wide. Then, nine plots were created within it, each 1.5 × 1.5 m wide, with a distance of 50 cm between plots. The materials needed to make the suspension solution are clean water and insecticide suspension, while the tools required are a bucket, stirrer, and sprayer. How to make it: each insecticide suspension that has been weighed (T1, 1.5gr) and (T2, 2gr) is dissolved in 2 litres of water, stirred evenly in the opening sprayer bowl, and then poured with two litres of clean water until all the suspension is dissolved in the water in the sprayer tube—two different sprayers. During the mixing process, avoid being exposed to direct sunlight or shaded. The application is done by spraying an insecticide solution with a sprayer on each predetermined research plot. Observations were made by observing the entire number of insects in the plot and grouping each order. Observations were made before application and on the seventh day after application. The data analysis was carried out by calculating insect mortality and natural enemy mortality after application and then analysing the toxicity of the two active insecticide ingredients based on the calculation of insect mortality that died on a 7-day observation and calculating the *lethal concentration* value of 50% (LC50) by probit analysis with the EPA probit program.

3. Results

Table 1 shows the insect mortality results obtained after insecticide application in the T0 treatment of insects of the orthoptera, Hemiptera, Diptera, Coleoptera, Araneae, and Hymenoptera orders experienced an average mortality of 49.82 or 50% of the initial insect data before insecticide application. In treatment T2, there was 100% mortality in all insect orders. Meanwhile, in the T3 treatment, the total percentage of total mortality was 86.65%. For the orders Hemiptera, Araneae, and Hymenoptera, the mortality rate was 100%.

Table 1. Insect Mortality After Application

Treatment	% Insect Mortality					
	Orthoptera	Hemiptera	Diptera	Coleoptera	Araneae	Hymenoptera
T0	47.61	45.83	66.66	60	25	53.84
T1	100	100	100	100	100	100
T2	89.29	100	80	50	100	100

Table 1. Insect Mortality After Application (Cont'd)

Treatment	Total	Average
T0	298,94	49,82
T1	600	100
T2	519,29	86,54

Table 1 indicates that the insect population on sweet potato plants has decreased. It means that the insecticides tested work effectively to eradicate all insects. Besides that, all insects affected by insecticides die, including the natural enemies of insect pests. It is essential to pay attention to this to maintain the ecosystem. The use of insecticides is considered adequate and fast in controlling insect pests. Subandi et al. (2016) stated that using insecticides at doses that are not recommended and used continuously with the same active ingredient or mode of action can cause insect pest resistance. It is feared that the continuous use of insecticides with the same active ingredient can cause various serious problems. It is due to the nature of pests that insecticide resistance can develop. The issue of pest resistance to insecticides can occur if farmers continuously use the same active ingredients so that the dose and frequency of use increase (Udiarto and Setiawati 2007). According to Baehaki (2012), insecticide application helps in insect selection, thereby encouraging the development of resistant individuals from generation to generation and ultimately producing a population dominated by resistant individuals. The higher the frequency of insecticide application, the faster the process of selecting and developing insects to become resistant.

Table 2. Mortalities of Natural Enemies of *Oxyopes javanus* (Araneae)

Treatment	Number of Dead Insects	Total Insects	% Mortality
Control	1	4	25
Sulfoxafloflor	5	5	100

Treatment	Number of Dead Insects	Total Insects	% Mortality
Buprozen + Cartap Hydrochloride	3	3	100

The results of the mortality analysis showed that this insecticide's application greatly influenced *Oxyopes javanus* mortality at 7 DAS. *Oxyopes javanus* mortality in the 2 insecticides tested was 100%, with the highest mortality at application time T1, 100%, and T2, 100%. The lowest mortality of 25% was shown at application time T0 (Table 2). The difference in mortality of *Oxyopes javanus* from insecticides T1 and T2 versus T0 was 75%. Therefore, it is recommended that selective insecticides be applied to reduce the risk of death of *Oxyopes javanus*. T1 and T2 treatments had a negative impact on the survival of *Oxyopes javanus*. Based on these results, it can be stated that the application of this insecticide active ingredient resulted in the death of *Oxyopes javanus* caused by direct contact with plant poison on natural enemies. In contrast, the death of *Oxyopes javanus* at T0 was caused by the presence of residual effects of the insecticide active ingredient, and this is by Flint et al. (1991), which suggests that pesticides not only cause direct poisoning of non-target organisms but can also result in simplification of food webs in ecosystems.

Many facts show that the unwise use of insecticides increases the population of insect pests due to a decrease in the population of their natural enemies (Higley & Wintersteen, 1992; Smilanick et al., 1996; Thakore, 2006; Tillman, 2006; Vandekerhove & De Clercq, 2004). The control interaction with both types of chemical insecticides showed the presence of a mortal parasitoid bag on the seventh day, namely T0 (25%) (Table 2). It proves that there are factors that cause natural parasitoid death, which may be caused by environmental influences and the parasitoid's age or not due to the impact of the application of vegetable insecticides. Broad-spectrum insecticides can have negative impacts on natural enemies in the environment. Natural enemies are organisms that naturally help control pest populations by preying on or infecting them. The effect of broad-spectrum insecticides on natural enemies can include several, such as Direct Death, Reproductive Disruption, and Behavioral Disorders. Insecticides can influence the behaviour of natural enemies, such as changing diet or prey-seeking habits, Loss of Habitat and Food Sources, and Bioaccumulation (accumulation of chemical substances in organism tissues).

Table 3. Result of Probit Analysis

Concentration	Number of Insects Die in a Day		Number of Insects	Mortality	Average	Probit Value	Concentration Log
	3	7					
750	19	19	75	25,33	7,6	4,33	2,88
1000	65	66	66	100	26,2	7,33	3
1000	68	71	76	93,42	27,8	0,48	3

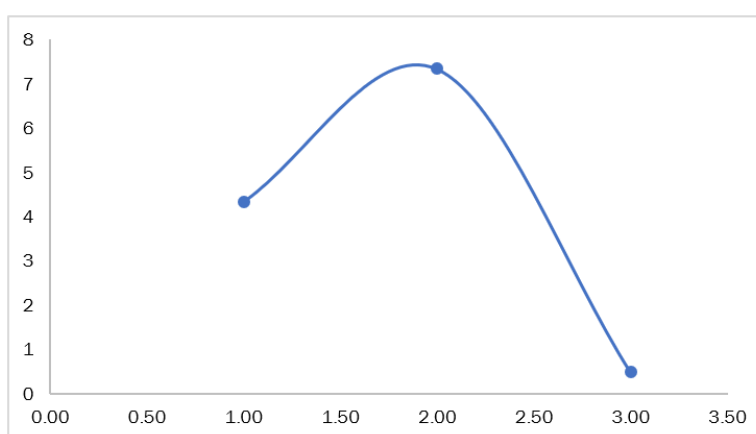


Figure 1. Lethal Concentration Analysis

$$y = 5$$

$$a = 1,04$$

$$b = 3,26$$

$$y = a x + b$$

$$5 = 1,04x + 3,26$$
$$x = 1,67$$

LC50 = antilog 1,67
LC50 = 47,11 ppm

Data analysis was based on calculating the mortality of insects that died during 7 days of observation and calculating the *lethal concentration* 50% (LC50) value by probit analysis with the EPA probit program. The regression value obtained from the method is $y = 1.04x + 3.26$. In the LC50 calculation, the y value entered is 5. The value 5 represents the LC50 value to obtain the concentration of LC50 obtained from the research results. The LC50 calculation results obtained were 47.11 ppm. An LC50 value of less than 1000 ppm (<1000 ppm) has strong toxic activity. The smaller the concentration produced, the higher the toxic properties of insects. LC50 values of more than 1000 ppm (>1000 ppm) do not have poisonous activity (Lestari et al., 2015). The results of LC50 calculations using graphic equations obtained a value of 47.11 ppm, so it can be concluded that these two insecticides can potentially kill all insects in this study. A potential outcome of frequent broad-spectrum pesticide use is the emergence of pests not controlled by pesticides but benefiting from reduced mortality from natural enemies or competitive release, commonly known as secondary pests (Hill et al., 2017).

4. Conclusions

This study concludes that the toxicity of the two active insecticide ingredients used is considered very effective for controlling target insects of the Hemiptera order. The active ingredient Sulfoxaflor obtained a % mortality percentage of insects of the Hemiptera order 100%, and the active ingredients Buprofen and Cartap Hydrochloride obtained 100%. However, non-target organisms such as the Araneae order, a natural enemy, namely *Oxyopes javanus*, are also affected by 100% toxicity from the two active ingredients. (3) After obtaining the results, calculate the LC50 value from probit analysis. The LC50 value obtained was 47.11 ppm. The LC50 value of these two insecticides has toxic potential because the value is below 1000 ppm. Behind their effectiveness in eradicating target insects, these two active ingredients also have a serious impact on the order of other beneficial insects, such as natural enemies and pollinating insects, so it can be concluded that the active ingredients Sulphoxaflor, as well as Buprofen and Cartap Hydrochloride, have a broad spectrum. Therefore, insecticides with the active ingredients Sulphoxaflor Buprofen, and Cartap Hydrochloride must pay attention to the dosage, method of use, and application time to maintain the ecosystem's perfect sustainability.

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