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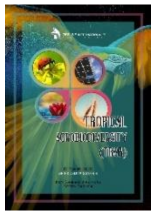

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RESEARCH ARTICLE

OPTIMISING TARO BEETLE MANAGEMENT: COMPARATIVE ANALYSIS OF BIFENTHRIN APPLICATION TECHNIQUES IN PAPUA NEW GUINEA

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ABSTRACT

Taro, *Colocasia esculenta* (L.) Schott is native to Southeast Asia and is widely cultivated and used throughout the world for its edible corms and leaves. In Papua New Guinea (PNG), it is a prized commodity for socio-cultural activities. Despite its many benefits, taro beetles, *Papuana*, and *Eucopidocaulus* species (Coleoptera: Scarabaeidae) were seen as threats to its cultivation. The insecticide "bifenthrin" was recommended, however, the current application method is tedious. Thus, this field experiment was conducted to compare the efficiency of different bifenthrin application methods for the control of taro beetles under field conditions. The treatments studied were the control (no application), measuring beaker (standard practice), knapsack sprayer, and hand sprayer, and were repeated five times using a randomized complete block design (RCBD). The data were subjected to analysis of variance (ANOVA), and the results showed that the knapsack sprayer was more efficient ($p < 0.05$) in terms of application duration, and all three methods were effective ($p < 0.05$) in controlling taro beetles compared to the control. Hence, knapsack sprayers can be used to cover more areas of taro-cultivated land, and any of these methods can effectively control the taro beetles.

KEYWORDS

Beetle infestation, application duration, marketable corm, unmarketable corm, fresh weight, Colocasia esculenta

1. Introduction

Taro, *Colocasia esculenta* (L.) Schott is native to Southeast Asia and is widely cultivated and used worldwide for its edible corms and leaves (Reyad-ul-ferrous, 2015; Pawar, 2018). Corms are primary sources of starch, vitamins, minerals, and essential amino acids such as phenylalanine and leucine, which cannot be synthesized by the human body. Moreover, the leaves are a good source of protein, minerals, and vitamins, and their protein content is higher than that of corms (Matthews, 2010). The entire plant is used in traditional medicine for various purposes, such as antimicrobial, antihepatotoxic, anticancer, and antidiabetic agents, and has also been used to treat various ailments, such as asthma, arthritis, diarrhoea, internal hemorrhage, neurological disorders, and skin disorders (Reyad-ul-ferrous, 2015; Sudhakar, 2020). It is also a source of phytochemicals including flavonoids, alkaloids, and saponins (Sudhakar, 2020).

This plant has also been found to have potential as an alternative energy source for feeding animals (Adejumo, 2013). It is a crop of cultural, social, and economic significance to the people of Pacific Island Countries (PICs). In Papua New Guinea (PNG), it is a prized commodity for socio-cultural activities such as compensation payments, bride price ceremonies, and feasts (Yalu et al., 2009). Despite its many benefits, taro beetles, *Papuana*, and *Eucopidocaulus* species (Coleoptera: Scarabaeidae) were seen as threats to its production and consumption in the South Pacific. This enabled insecticide evaluation in Fiji, Vanuatu, Solomon Islands, and PNG to identify effective controls (Lal, 2008). In PNG, bifenthrin, a pyrethroid insecticide, is used to control taro beetles. The standard application method for this control is usually performed by mixing the insecticide with water in a household bucket and applying the mixture using a measuring beaker around the base of the taro plant.

This method of application is highly effective for taro beetle control; however, it is tedious. On the other hand, the application of pesticides using sprayers is more efficient because of its effectiveness in pest and disease control, reduction in application time and operational cost (Fisher and Deutsch, 1985; Fernando and Wijerathna, 2010; Chen et al., 2019; Jalu et al., 2023). An example of such a sprayer is a lever-operated knapsack sprayer, a manual-operated sprayer normally used by smallholder farmers for controlling weeds, pests, and diseases. According to Fisher and Deutsch, this type of sprayer: 1) is regarded as a versatile tool that, with appropriate fittings, can apply different types of pesticides; 2) can be used almost anywhere as long as the place is suitable for a person to move around, or in areas often inaccessible to larger, motorized sprayers; 3) it is not a high capital cost item relative to other farming equipment; 4) if regularly maintained and not severely misused, it is sturdy enough to endure years of service; and 5) its operation and physical characteristics allow use by persons with a wide range of physiques (Fisher and Deutsch, 1985). There have been limited studies done to control taro beetle using different application equipment since the control has been identified. Thus, this field experiment was conducted to compare the efficiency of different application methods of bifenthrin for the control of taro beetle under field conditions.

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2. Material and Methods

2.1 Experimental site description

The field experiment was conducted at the National Agricultural Research Institute (NARI) in Keravat (4°20'1.82" S, 152° 1'49.37" E; 21 masl) from December 2022 to June 2023. Keravat is situated on the Gazelle Peninsula, and its climate is described as humid lowland because of its hill and alluvium lowland forest setting (McAlpine et al., 1983). The monthly mean temperature, precipitation, and relative humidity of the trial period were 26.6 °C, 355.6 mm, and 89.9 %, respectively. The soil is characterised by Bleeker as andosol and has a sandy loam texture (Bleeker, 1983). The site used for this experiment was planted with velvet beans (*Mucuna pruriens*) as a fallow strategy for a year before the field experiment.

2.2 Agronomic activities

The land was prepared using primary and secondary tillage methods with a tractor. The ridges were created using a tractor with a spacing of 1 m. The plots were marked and taro suckers were planted at a spacing of 1 m × 1 m. NPK fertilizer (12:12:17) was applied at a rate of 23 g per plant at planting and at 1 and 2 months after planting (MAP). Copper oxychloride was applied at a dosage of 2.5 kg ha^{-1} when leaf blight symptoms were observed by following the 2-week application interval. Taro suckers were plucked from the mother plants at 3 MAP before bifenthrin application to prevent nutrient competition and to ease insecticide application. Weeds were manually managed every month before harvest.

2.3 Treatment, design, and application

The bifenthrin application methods consisted of a control (no application), 500 ml measuring beaker (standard practice) (Figure 1), 15 Litres (L) knapsack sprayer (Figure 2a), and 2 L hand sprayer (Figure 3). The treatments were repeated 5 times using a randomized complete block design (RCBD). Each treatment plot had an area of 14 m^2 (1 m × 14 m), and each block had dimensions of 3 m × 14 m and 1 m spacing between each block. The application of bifenthrin was performed at a rate of 2.5 ml L^{-1}. The standard practice was performed by mixing 25 ml of bifenthrin with 10 L of water in a 10 L household bucket, and 300 ml of the mixture was applied using a 500 ml measuring beaker around the base of the taro plant at planting and 3 MAP. For the knapsack sprayer, 38 ml of bifenthrin was mixed with 15 L of water, and approximately 320 ml of the insecticidal solution was applied within the count of 1 to 14 (or within 4 seconds) for each plant using the modified nozzle (Figure 2b) at full pressure. The application using a hand sprayer was performed by transferring 2 to 2.5 L of the chemical mixture from the household bucket into the hand sprayer, adjusting the nozzle to jet spraying, and applying approximately 320 ml within the count of 1 to 55 (or within 17 s) to each plant at full pressure.

Figure 1: Measuring beaker

Figure 2a: Knapsack sprayer

Figure 2b: Modified nozzle

Figure 3: Hand sprayer

2.4 Data collection

Each treatment plot contained 14 plants, and seven plants were randomly selected and tagged for data collection. The data were collected for the following attributes at harvesting (6 MAP): 1) number of marketable corms, 2) number of unmarketable corms, 3) total fresh marketable corm weight, and 4) total fresh unmarketable corm weight. The number of marketable and unmarketable corms was determined during the sorting stage by counting the non-infested and infested corms for each treatment per plot respectively after harvesting. The values for both parameters were then converted to percentages by dividing the number of either marketable or unmarketable corms by the total harvested plants and multiplying by 100. The total fresh corm weight of either marketable or unmarketable corms was determined by weighing the corms using a table scale.

2.5 Statistical analysis

The data were collated and summary data (average values) were generated for 1) the percentage of marketable corm, 2) the percentage of unmarketable corm, 3) the total fresh marketable corm weight, and 4) the total fresh unmarketable corm weight for each treatment per block using LibreOffice® (version 7.2.0). The bifenthrin application duration, the percentage marketable, the percentage unmarketable corm, and the total fresh unmarketable corm weight were not normally distributed. The bifenthrin application duration and the total fresh unmarketable corm weight were log10 transformed (x + 1) whereas the percentage marketable and unmarketable corm were arcsine transformed [(square root(x/100)] before the summary data were subjected to one-way analysis of variance (ANOVA). When there were significant differences among the treatments, the means were separated using Fisher's protected least significant difference test at the 5% level. All tests were performed using GenStat ® (version 20.1) (VSNI, 2019).

3. Results and Discussions

3.1 Efficiency of bifenthrin application methods

Taro beetles, *Papuana*, and *Eucopidocaulus* species (Coleoptera: Scarabaeidae) are a threat to taro production in PICs as these pests can cause up to 95% yield reduction and that rendered application of control measures (Yalu et al., 2009). The study showed that the application of bifenthrin using a knapsack sprayer was more efficient ($p < 0.05$) in terms of application duration, that is, the time taken to cover all the taro plants per treatment. It took an average of 18.5 minutes to cover 70 taro plants in an area of 70 m^2, compared with the measuring beaker (standard practice) and hand sprayer, $F(2, 3) = 49.3$, $p = 0.005$, (Table 1). Knapsack sprayers are more efficient in the application of small or large amounts of pesticidal solutions to areas, strips, spots, or individual targets (Fisher and Deutsch, 1985). The application of insecticides using different types of sprayers has been shown to increase operational efficiency, reduce equipment and energy costs, and reduce the risk of pesticide exposure to workers (Zhu et al., 2011; Chen et al., 2019; Xiao et al., 2020). The application of bifenthrin using a knapsack sprayer also reduced workers' exposure to body aching by carrying the bucket around. Taro beetles are predominant in PNG, and efficient methods for their control can ease the work involved in the application of control measures (Lal, 2008).

Table 1: Efficiency of treatments

Treatment (application method)	Application duration (minutes)[1]
Measuring beaker	43.0 [a]
Knapsack sprayer	18.5 [b]
Hand sprayer	63.0 [c]
p-value	0.005
SED	4.49
$LSD_{0.05}$	14.29
CV (%)	10.8

The data represent the means of two application rounds. Means with similar superscripts are not significantly different, according to Fisher's test. [1]Analysis of variance was done on log10 transformed data.

3.2 Effectiveness of bifenthrin application methods

The application of bifenthrin using different methods for taro beetle control showed that the application methods had similar effects ($p > 0.05$) on the percentage of marketable and unmarketable, and total fresh weight of the taro corm (Table 2). However, their effects were significantly different ($p < 0.05$) from the control. The measuring beaker, knapsack sprayer, and hand sprayer had the highest percentage, $F(4, 15) = 726.0$, p = < 0.001, and total fresh weight of marketable corm, $F(4, 15) = 81.0$, p = < 0.001, compared to the control, and the control had the highest percentage, $F(4, 15) = 726.0$, p = < 0.001, and total fresh weight of unmarketable corm, $F(4, 15) = 121.1$, p = < 0.001, compared to the three application methods. Bifenthrin has been shown to effectively control taro beetles under field conditions in four PICs (Lal, 2008). These pests usually kill young plants and reduce the corm quality of mature taro plants by burrowing them in the soil and creating pathways for secondary infections, such as corm rot, which further deteriorates corm quality. The application of bifenthrin is paramount for sustaining taro production in PICs including New Guinea Islands (NGIs). Taro is an ancient staple crop of socio-cultural and economic importance in the NGIs and the presence of taro beetles is one of the issues that caused a decreasing trend in taro production (Bourke, 2012). Moreover, no resistant cultivars are found in PNG, which makes farmers' varieties more vulnerable to genetic erosion.

Table 2: Effectiveness of treatments

Treatment (application method)	% marketable corm[2]	% unmarketable corm[2]	Total fresh marketable corm weight (kg)	Total fresh unmarketable corm weight (kg)[1]
Control	5.7 [a]	94.1 [a]	0.2 [a]	4.2 [a]
Measuring beaker	100.0 [b]	0.0 [b]	4.7 [b]	0.0 [b]
Knapsack sprayer	100.0 [b]	0.0 [b]	4.4 [b]	0.0 [b]
Hand sprayer	100.0 [b]	0.0 [b]	4.2 [b]	0.0 [b]
p-value	< 0.001	< 0.001	< 0.001	< 0.001
SED	2.47	2.47	0.33	0.27
$LSD_{0.05}$	5.39	5.39	0.72	0.59
CV (%)	5.1	16.6	15.4	40.6

The data represent the means of five replicates. Means with similar superscripts are not significantly different by Fisher's test. [1, 2] Analysis of variance was performed on log10 and arcsine transformed data, respectively.

Thus, the introduction of efficient application methods of bifenthrin can enable producers to expand the acreage of land, promote the trade of taro corms, and maintain its socio-cultural significance.

4. Conclusion

The application of bifenthrin using a measuring beaker (standard practice), knapsack sprayer, and hand sprayer has shown the knapsack sprayer to be more efficient in application duration. Moreover, these application methods have been shown to effectively control taro beetles compared to the control. Hence, knapsack sprayers can be used to cover more areas of taro-cultivated land, and any of these methods can be used to effectively control taro beetles. Other application methods are also available, and future studies should examine the effectiveness of above- and below-ground drip or jet applications of bifenthrin using pipes and assess taro beetle infestation in flooded taro cultivation.

Author's Contribution

Junias Sogra, Lux Jimmy, Kenndy Kamik, and Alex Galus planned the research, experimented, collected data, and prepared the manuscript. Alex Galus analyzed the data, critically revised it, and did the finalization of the manuscript.

Conflict of Interest

The authors declare no conflicts of interest regarding the publication of this article.

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