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# Farmer`s Awareness and Acceptance of Biopesticides Application for Pest and Disease Management

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**Abstract:** Pesticides are widely used to boost agricultural production in Malaysia, ensuring high yields and quality produce. The present study aims to investigate Malaysian farmers' pest management practices and their willingness to adopt biopesticides. A nationwide survey was conducted from November 2020 to October 2021 using social media platforms, collecting responses from 268 farmers through a structured questionnaire. Key findings showed that 82% of respondents were aware of biopesticides, and 77% used them for pest management. However, barriers such as high costs (7%), lack of awareness (6%), doubts about effectiveness (5%), and limited market access (3%) has hindered broader adoption. Despite these challenges, 65% of respondents recognized the benefits of biopesticides, particularly their role in reduction of environmental impact and improved human health. The findings highlight significant opportunities to promote biopesticides in Malaysian agriculture by addressing cost, and accessibility concerns through educational initiatives, policy support, and market development support. For instance, tailored educational programs could improve farmer awareness and confidence, while government incentives and streamlined regulatory processes could facilitate market growth. These findings underscores the potential of biopesticides to drive sustainable pest management practices, paving the way for innovative biological solutions in agriculture.

**Keywords:** Biopesticides, chemical pesticides, farmer willingness, pest and disease management, sustainability.

## 1. Introduction

Effective pest and disease management is vital for sustainable agriculture, and biopesticides present a promising, eco-friendly alternative to synthetic pesticides. Integrated Pest Management (IPM) technologies, incorporating biological control agents with sustainable farming practices, have gained attention for their environmental benefits (Ayilara et al., 2023). Biopesticides are derived from natural sources such as microorganisms, animals, and plants, and they target pests through non-toxic mechanisms, making them save for non-target organisms and the environment (Kamarulzaman et al., 2012). Unlike chemical pesticides, biopesticides leave non-hazardous residues can be safely applied even during crop harvesting. These attributes make them an appealing solution to address the growing concerns surrounding synthetic pesticide use, including pest resistance, environmental pollution, and threats to human health (Sivapragasam, 2022).

The over-reliance on chemical pesticides has led to severe environmental and agricultural challenges globally (Fenibo et al., 2021). In Malaysia, where agriculture plays a vital role in the economy, these issues are particularly concerning. Farmers have historically depended on chemical pesticides to achieve high yields and meet market demands, but this practice threatens long-term agricultural sustainability. Biopesticides offer a viable alternative that aligns with Malaysia's sustainability goals, yet their adoption remains limited due to factors such as high costs, limited availability, and low awareness among farmers (Kumar et al., 2021; Nyangau et al., 2020).

Globally, studies highlight the barriers to biopesticide adoption, particularly in developing countires. For instance, research in Kenya and Tanzania revealed low awareness of biopesticides among smallholder farmers, coupled with perceptions of lower efficacy compared to chemical pesticides (Constantine et al., 2020; Kapeleka et al., 2021). Additionally, regulatory frameworks for biopesticides are often complex, with high development and approval costs

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deterring innovation (Fenibo et al., 2021). These findings underscore the need for targeted educational and extension programs to educate farmers on the benefits and proper use of biopesticides. Factors such as cost, availability, perceived efficacy, and access to information and training play a crucial role in shaping farmers' decisions ((Laizer et al., 2019; Singh et al., 2018)).

In the Malaysian context, the adoption of biopesticides is particularly relevant as the country strives to achieves its sustainability goals Malaysia's12th Malaysia Plan (12MP; 2021–2025), launched on September 27, 2021, emphasizes "Advancing Sustainability" as a key theme, promoting sustainable growth while addressing environmental and societal challenges. This aims to create a greener and more resilience economy by encouraging the adoption of eco-friendly practices such as integrated pest management and biopesticides (MOE et al., 2024). Transitioning to biopesticides supports this agenda by reducing environmental impact of agriculture and enhancing food safety. However, the low uptake of biopesticides by Malaysian farmers highlights the need to address barriers to adoption and to promote awareness of their benefits.

The present study seeks to address these gaps by investigating farmers' pest management practices and their willingness to adopt biopesticides usage. The specific objectives of this study were to: (i) document farmers' current pest management practices, (ii) identify the factors influencing pesticide used, and (iii) assess farmers' willingness to integrate biopesticide into their farming systems. By addressing these objectives, the study aims to inform strategies for promoting sustainable pest management practices in Malaysia and contribute to the broader goal of advancing agricultural sustainability.

## 2. Materials and Methods

### 2.1 Sample preparation

The survey employed voluntary response sampling and was distributed online through communication channels such as email, Facebook Messenger, and WhatsApp. While this approach enabled broad outreach during the COVID-19 pandemic, it potentially excluded less tech-savvy farmers who might not have regular internet access or familiarity with social media platforms. To mitigate this limitation, efforts were made to reach farmers indirectly via agricultural extension officers and farming groups. However, the possibility of sample bias toward younger or more tech-literate farmers remains a consideration.

### 2.2 Data Collection

The survey was conducted between November 2020 and October 2021 across Malaysia using online social media platforms such as Facebook and WhatsApp. A structured questionnaire was employed, which included close-ended, open-ended, and Likert scale questions. The questionnaire was developed based on available literature and input from relevant stakeholders, including farmers and agricultural officers (Pandey et al., 2020). A Google form link was distributed through online communication and social media platforms, including email, Facebook Messenger, and WhatsApp. Voluntary response sampling was used to gather responses.

The questionnaire was divided into three main sections: **1)** Socio-Demographic Background and Pest Management Practices. This section collected information on age, sex, farming experience, field scale, cultivation techniques, and crops cultivated. It also covered pest management practices, including the types of pesticides used, frequency of pesticide application, and factors influencing the choice of pesticides. These questions were critical to understand the baseline practices and decision-making processes of farmers. **2)** Awareness and Opinions on Biopesticides. This section focused on farmers' awareness levels, opinions regarding biopesticides' environmental safety, satisfaction with their performance, perceived benefits and challenges. These questions aimed to assess the gaps in knowledge and perceptions that could hinder adoption. **3)** Willingness to Use Biopesticides. Respondents were asked to rate their willingness to adopt biopesticides on a Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Most questions were closed-ended with multiple-choice answers, while some open-ended questions allowed respondents to provide suggestions and elaborate on their views about chemical and biopesticides.

### 2.3 Ethical Considerations

Ethical approval for this study was obtained from team leader of this project/ supervisors. Informed consent was ensured by providing respondents with an introductory section in the questionnaire explaining the study's objectives, voluntary participation, and confidentiality of their responses. Participants were required to indicate their consent before proceeding with the survey.

## 2.4 Data Collection and Analysis

Data was collected through a web-based method, requiring respondents to have internet access to complete the questionnaire using their mobile phones or computers (Ebert et al., 2018). Data was statistically analyzed using Microsoft Excel and IBM SPSS (version 27.0) software. A P-value lower than 0.05 was considered statistically significant. For this study, the interpretation of the mean score was done for Section Three (Table 1), while the interpretation of frequency and percentages were done for Sections One and Two.

**Table 1**: **Mean score interpretation**

| Mean Score Range | Interpretation |
|---|---|
| 0.01 – 1.00 | Strongly Disagree |
| 1.01 – 2.00 | Disagree |
| 2.01 – 3.00 | Somewhat Agree |
| 3.01 – 4.00 | Agree |
| 4.01 – 5.00 | Strongly Agree |

## 3. Results and Discussions

## 3.1 Socio-demographic characteristics of farmers

In the current study, a total of 268 respondents were gathered. Table 2 summarizes the characteristics profiles of the farmers. Overall, 79% of respondents were male and 21% were female. Results indicated that most of the farmers in this study were aged ranging from 20 to 30 years old (38.8%). High number of younger respondents might probably because of the nature of the survey which was an online survey that attracts young people compared to age farmers. However, it is still a good sign that the young generation has interested to be involved in vegetable crop farming in Malaysia.

A key finding was the substantial engagement of younger farmers with biopesticides, particularly in the 20-30 year age group. Younger farmers were more likely to adopt sustainable farming practices, including biopesticide use, potentially due to their increased exposure to environmental issues and greater adaptability to innovative agricultural methods. This trend could be leveraged in future programs promoting biopesticides, targeting young, tech-savvy farmers with educational initiatives and training programs. As shown in Table 2, 50% of farmers indicated that they had at least 1 to 2 years of experience in farming. About 51 out of 268 respondents (18%) had experienced 6 years and above, followed by 3 to 4 years (13%), 5 and 6 years (10%), and lastly, the least percentage of respondents had 2 to 3 years of experience in farming (9%). The level of farming experience is important to be observed as they have the knowledge and are familiar with the application of various types of pesticides throughout the years. Thus, this finding indicated that all the respondents in this current study have farming experience and most probably can make a clear judgement in terms of farming practices. Among respondents, the fertigation technique (47%) for cultivating crops become the most favourable technique followed by conventional (25%), hydroponic (21%) and other techniques (8%). The survey also shows field-scale owned by farmers in this study. This variation in experience levels underscores the diversity of knowledge across the farming community, with younger and less experienced farmers potentially more open to trying biopesticides compared to older, more traditional farmers.

Farmers cultivated a wide range of crops and chili was the main plant grown by the farmers, followed by melon, cucumber, pumpkin, tomato, okra and long beans (Figure 1). The largest percentage of farmers were involved in chilli planting, which is 95 (34.88%) respondents. Large involvement of youth in cultivating chilies in Malaysia was mainly due to government support. The government has established the Young Agropreneur Programme aimed at encouraging the involvement of youths' keen on entrepreneurial activities in the agricultural sector by providing guidance, advice, and monitoring youth farmers' progress (Malay Mail, 2020).

**Table 2: Farmer characteristics (n=268)**

| Characteristics | Number | Percentage |
|---|---|---|
| *Gender* | | |
| Male | 212 | 79.1 |
| Female | 56 | 20.9 |
| *Age* | | |
| 20 - 30 | 104 | 38.8 |
| 31 - 40 | 68 | 25.4 |
| 41 - 50 | 46 | 17.2 |
| > 51 | 50 | 18.6 |
| *Farming experiences* | | |
| 1 – 2 years | 143 | 50 |
| 2 – 3 years | 26 | 9 |
| 3 – 4 years | 37 | 13 |

*continued*

| | | |
|---|---|---|
| 5 – 6 years | 29 | 10 |
| > 6 years | 51 | 18 |
| *Cultivation technique* | | |
| Fertigation | 127 | 47.4 |
| Hydroponic | 54 | 20.1 |
| Conventional | 66 | 24.6 |
| Others | 21 | 7.8 |
| *Field-scale (plants)* | | |
| 100 - 500 | 92 | 34.8 |
| 501 - 1000 | 49 | 18.6 |
| 1001 - 2000 | 46 | 17.4 |
| 2001 - 3000 | 26 | 9.8 |
| > 3000 | 51 | 19.3 |

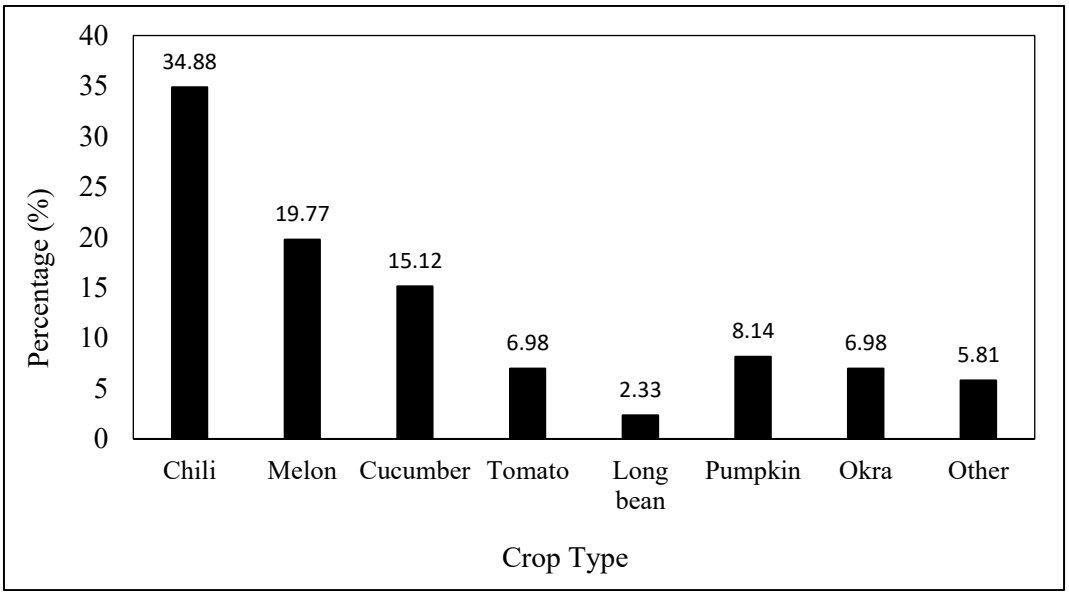


**Fig. 1: Type of crops cultivated by farmers**

## 3.2 Pest and disease

The respondents reported various pests and diseases affecting their crops. The plant diseases mentioned included Downy mildew, powdery mildew, and leaf curl. Based on the survey findings, leaf curl disease primarily impacted chili plants, while powdery mildew was commonly observed on melon and cucumber plants. Furthermore, the farmers identified several insect pests, such as aphids, spider mites, thrips, and whiteflies affecting their crops.

## 3.3 Pesticides used by farmers

Approximately 50% of farmers used chemical pesticides, while 34.3% utilized biopesticides. Despite the relatively small difference, a clear majority of farmers favored chemical pesticides over biopesticides. While chemical pesticides provide numerous benefits for farmers in boosting crop yields to support growing populations, they also carry significant risks. Nevertheless, their perceived effectiveness in controlling pests and diseases has been widely acknowledged and accepted by many farmers. Despite increased awareness of the potential adverse impacts on health and the environment, some farmers may still consider chemical pesticides as their primary pest management strategy.

Previous studies have shown that the overuse and misuse of chemical pesticides can lead to the development of pesticide resistance, environmental contamination, and negative consequences on human health and non-target organisms (Jothika & Rajasekaran, 2020). Preference of farmers to use chemical pesticides, even when biopesticides are available, may be linked to their unawareness or misconceptions about the efficacy and safety of biopesticides (Constantine et al., 2020). A previous study conducted by Halimatun sadiah et al. (2016) also found a higher number of pesticide usage as compared to biopesticides. Cheaper prices and easy availability may be other key factors influencing farmers' choice of chemical pesticides over biopesticides (Jothika & Rajasekaran, 2020). Practical usage and handling of biopesticides may also be a deterrent for some farmers (Wirasti et al., 2021). Limited shelf life and specific storage conditions required for biopesticides can be challenges for smallholder farmers (Constantine et al., 2020).

The findings indicated that farmers predominantly utilized chemical fungicides, accounting for 72.5% of the pesticides used, while insecticides comprised a smaller portion at 5.88%. This suggests that the primary focus of chemical pesticide application was to address fungal plant diseases, which aligns with the reported prevalence of fungal diseases such as Downy mildew, powdery mildew, and leaf curl among the surveyed crops. The types of plant diseases reported by the farmers in this study were predominantly fungal in nature, encompassing Downy mildew (caused by the pathogen *Peronospora* sp.), powdery mildew, and leaf curl.

As shown in Table 3, the chemical pesticides used by the farmers in this study were categorized by the World Health Organization into four classes based on their toxicity levels. These classes ranged from I (extremely hazardous) to U (unlikely to present an acute hazard). The analysis revealed that six of the pesticides employed by the farmers were classified as either Class III (slightly hazardous) or Class U, suggesting a relatively low level of acute toxicity under normal usage conditions. Mancozeb, also known as manzeb, was the most used chemical fungicide among the respondents. This was followed by other fungicides such as Previcur, Antracol, Topsin, Malathion, and Amistar. Among these, mancozeb and Topsin were classified as having relatively low toxicity levels compared to the other chemical pesticides utsed by the farmers. The findings suggested that the farmers in this study tend to favor pesticides with relatively low toxicity levels.

Obviously 64.7% of respondents chose certain pesticides primarily due to their perceived efficacy. Other influential factors included recommendations from agricultural extension officers, affordability, and peer influence. This suggested that chemical pesticides have been widely accepted as effective strategies for pest and disease management among the surveyed farmers. Previous research has similarly found that most respondents (81.7%) considered conventional pesticides to be efficient (Petrescu-Mag et al., 2019). The effectiveness of pesticides is further dependent on various factors such as formulation, suitability, application equipment, and application techniques.

**Table 3: Type of chemical pesticides used**

| Pesticides type | Pesticides | Active ingredients | % of user | WHO Class |
|---|---|---|---|---|
| Fungicide | Mancozeb | Dithiocarbamate | 25.5 | U |
| | Previcur | Propamocarb | 15.7 | III |
| | Antracol | Propineb | 13.7 | III |
| | Topsin | Thiophanate methyl | 13.7 | U |
| | Amistar | Azoxystrobin & Difenoconazole | 3.9 | III |
| Insecticide | Malathion | Organophosphate | 5.88 | III |
| Unknown | | | 21.6 | |

Table 4 shows the types of biological pesticides being used by farmers in this study. Trichobiome was found to be the most favourable biopesticide used by the farmer. 25% of respondents chose certain types of biopesticides due to its effectiveness. Followed by other factors which are: local produce (22.2%); affordable price (16.7%); suggestions from fellow farmers (13.9%), and suggestions from agriculture officers (8.3%) (Figure 2). Existing research indicated that the primary factor guiding farmers' pesticide selection was the perceived effectiveness of the product, irrespective of whether it is a chemical or biological pesticide. The current findings reinforce that the efficacy of pesticides was the most crucial determinant in farmers' pesticide decision-making. Farmers may be less inclined to use pesticides that are perceived as less effective in managing pests and plant diseases and may instead opt to replace them with more effective alternatives. Conversely, some farmers may prioritize both affordability and efficacy when selecting pesticides to address pest and disease issues. The findings presented aligned with previous research by Sharifzadeh et al. (2018) indicated that pesticide effectiveness in managing pests and diseases is one of the primary considerations for farmers in selecting and utilizing pesticides. Pesticides that demonstrate slow or ineffective results in eliminating pests are likely to be replaced by more effective alternatives.

**Table 4: Type of biopesticides used**

| Pesticides type | Pesticides | Active ingredients | % of user |
|---|---|---|---|
| Biofungicide | Trichobiome | *Trichoderma koningii* and multi-Bacillus sp. | 11.11 |
| | Farm clear | Citrus extract, adjuvant & surfactants | 5.56 |
| Biofungicide & biopesticide | Bioguard | | 5.56 |
| | Kitosan | Chitosan | 8.33 |
| Bioinsecticide | Brogard | Extract from herb | 8.33 |

*continued*

| | | |
|---|---|---|
| Biopesticide and biofertilizer | Natural wood vinegar | 11.03 |
| Unknown | | 47.22 |

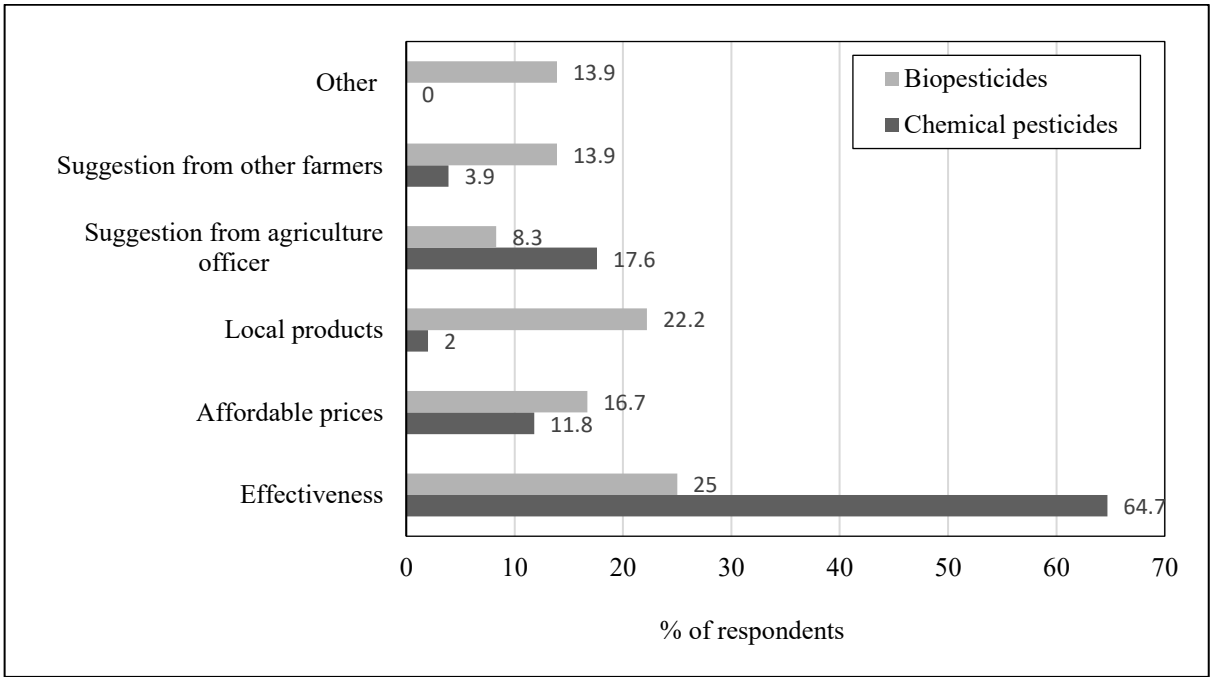


**Fig. 2: Factors influenced the decisions of farmers to use different types of pesticides**

To address these barriers, actionable solutions such as lowering the cost of biopesticides through government subsidies, improving the distribution network, and providing targeted education on their effectiveness are necessary. In contrast, farmers who had prior experience with biopesticides were more likely to report satisfaction with their effectiveness, reinforcing the importance of educating farmers on proper usage and the benefits of biological alternatives. These findings align with similar research conducted globally. For instance, studies in Kenya found that high costs and limited availability were major barriers to the adoption of biopesticides (Muriithi et al., 2020). However, in countries with better access to biopesticides markets, their adoption rates were higher, showing that overcoming logistical challenges can lead to more widespread use of these products.

The frequency of chemical pesticide application varied among the farmers surveyed. Approximately 42% of farmers who used chemical pesticides reported applying them once a week, while 30% applied them twice weekly. Additionally, 8% of farmers frequently applied chemical pesticides three times per week, and 20% sprayed them only once every few weeks. In contrast, farmers who utilized biological pesticides tended to apply them more frequently, as illustrated in Figure 3. More frequent use biopesticides compared to chemical pesticide applications, which may be attributed to the perceived need for consistent pest control or the need for repeated applications to achieve desired effectiveness (Jothika & Rajasekaran, 2020). The frequency of spraying pesticide will depend on its residual time or how long it will persist on the soil. The residual time of biopesticides is generally shorter compared to synthetic pesticides (Jothika & Rajasekaran, 2020). Thus, biopesticides can be easily degraded or lost during the rain or irrigation process, necessitating more frequent application to maintain pest control. Consequently, repeated application may be necessary to sustain the efficacy of biopesticides in managing pests and diseases.

## 3.4 Awareness of farmers on biopesticides products

A significant 82% of respondents were aware of biopesticides, but only 77.0% actually used them, reflecting a gap between awareness and adoption. This gap was particularly pronounced in older farmers, who cited concerns about the effectiveness and availability of biopesticides. The respondents also expressed various purposes for using biopesticides, as detailed in Table 5. The findings revealed that many farmers were drawn to using biological-based products in their farming, which have similar potential to conventional chemical-based products. However, among the 23.0% of respondents who do not use biopesticides, 7.0% cited the price as the reason, while 6.0% indicated a lack of awareness about the availability of biopesticide products in the market. Approximately 5.0% of the respondents expressed uncertainty regarding the effectiveness of biopesticides on their crops. Additionally, 3.0% of the respondents cited the

difficulty in accessing biopesticide products in the market. Finally, 2.0% of the respondents indicated that biopesticides did not provide satisfactory results for large-scale farming operations.

Although a small proportion of farmers do not utilize biopesticides, the reasons behind their decision are worth exploring. Addressing these concerns through targeted awareness campaigns and demonstrating the practical benefits of biopesticides, such as long-term environmental sustainability, could increase adoption rates. One key factor that led to the preference for chemical pesticides over biopesticides was price. It is a well-established fact that biopesticides are typically more expensive than their chemical counterparts (Mishra et al., 2020; Nyangau et al., 2020). While some chemical pesticides may be equally or even more costly, their quick-acting nature and persistence in the environment enable them to be applied in smaller quantities and at lower frequencies, ultimately resulting in more cost-effective usage compared to biopesticides, which often require more frequent reapplication (Bharti & Ibrahim, 2020; Liu et al., 2019). To facilitate greater adoption of biopesticides, a more effective strategy could involve implementing subsidies for biopesticide products and enabling biopesticide companies to establish a stronger market position, thereby enhancing their ability to compete with chemical pesticide alternatives (Chappell et al., 2023).

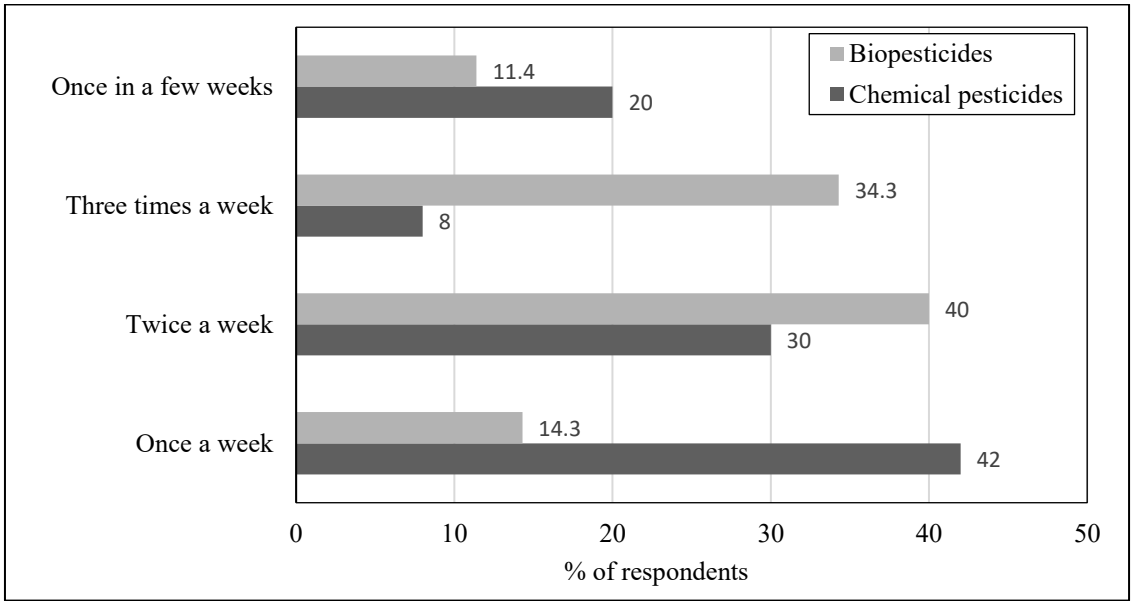


**Fig. 3: Frequency of pesticide spraying**

Farmers may perceive biopesticides as less effective in pest management. The high specificity of biopesticides in targeting certain pests means they can only control the specific pests present in the treated area, leaving other pests unaffected. The other pests that are present in the treated area will be able to survive and continue to cause damage to plants (Harper, 2023). Moreover, biopesticides, in general, have a shorter lifetime and persistence compared to chemical pesticides (Ayilara et al., 2023; Kumar et al., 2021). Thus, biopesticides can be easily degraded or lost during the rain or irrigation process hence repeated application is needed (McGrath et al., 2010). The frequency of application of pesticides depends on its residual time to be degraded in the surroundings (Menzie, 1972). A previous study found that biopesticides react slowly to control pests and diseases compared to chemical pesticides. Hence, it required more time to be effective in controlling pests. Unlike chemical pesticides, biopesticides take a longer time as they involve living organisms. Most probably, this is one of the underlying causes that make biopesticides seem less efficient than chemical pesticides (Bharti & Ibrahim, 2020; Kumar et al., 2021).

Moreover, the availability of biopesticide in the local market is a critical factor that can influence the adoption and use of biopesticides by farmers. The inconvenience of accessing biopesticide can discourage farmers from using them, even if they are aware of the benefits of these products. To address this, efforts should be made to improve the distribution and availability of biopesticides in rural areas, ensuring that farmers can easily obtain the products they need. The regulatory challenges associated with biopesticides also play a significant role in their adoption. Compared to chemical pesticides, the registration and approval processes for biopesticides are more complex and time-consuming, often taking several years to complete. This can lead to a limited number of biopesticide products being available in the market, thereby restricting the choices for farmers. To overcome this barrier, policymakers and regulatory authorities should streamline the registration process for biopesticides, making it more efficient and less burdensome for biopesticide manufacturers and developers.

Farmers identified several barriers to adopting biopesticides, including cost, availability, and knowledge gaps. These barriers are consistent with findings from previous studies which highlighted those high costs and limited availability hindered the adoption of biopesticides in other regions (Constantine et al., 2020). Furthermore, the retailer

also does not want to take the risk to stock up the biopesticides which are known to have a short shelf life if there is low demand from the farmers. Studies by Adhikari et al. (2019) also revealed that there are low demands from farmers for biopesticides and this makes agriculture suppliers feel discouraged to shift their trade of chemical pesticides to biopesticides. The characteristics of biopesticides that are highly selective in controlling pests or diseases are good for the environment by not harming natural enemies and wildlife (Ayilara et al., 2023; Kumar et al., 2021). To facilitate greater adoption, solutions such as price subsidies, improved access through local agro-dealers, and public-private partnerships could be explored. Additionally, addressing farmers' misconceptions about biopesticides' efficacy through demonstration projects and training could help bridge the knowledge gap.

However, biopesticides are specialized products catering to a particular market segment. As such, they may have lower profit margins compared to chemical pesticides, which have a broader market appeal (Chappell et al., 2023; Kumar et al., 2021). As such, the limited availability and accessibility of biopesticides pose significant barriers to their widespread adoption among Malaysian farmers. The findings suggested that most farmers exhibited heightened awareness regarding the environmental and health impacts of the agricultural products they utilized in the long run. This indicates a high level of familiarity with the safety considerations and features of these products. Additionally, a substantial proportion of farmers expressed satisfaction with the effectiveness of biopesticides, demonstrating that the use of these biological pest control agents has been beneficial in managing their farming operations, controlling pests, and promoting healthy plant growth. In summary, most farmers demonstrate awareness of the biopesticides available in the market. This presents an opportunity for the development and commercialization of new biological products in the Malaysian agricultural sector. However, ensuring that the price of biopesticides is lower than chemical pesticides remain a challenge, which depends on the technology and substances utilized, despite the effectiveness of these products.

**Table 5: Farmer's awareness of biopesticides**

| Item | Category | Percentage (%) |
|---|---|---|
| Do you know about biopesticides on the market for agricultural purposes? | Yes | 82 |
| | No | 18 |
| Do you use biopesticides? | Yes | 77 |
| | No | 23 |
| If yes. For what purpose are you using biopesticides? | Control insects | 17.0 |
| | Control weeds | 1.0 |
| | Control pests | 24.0 |
| | Others | 35.0 |
| | Not related | 32.0 |
| If not. What are the reasons for you to not using biopesticides? | Difficult to find in the local market | 3 |
| | Prices are more expensive than chemical pesticides | 7 |
| | Not sure of the effectiveness | 5 |
| | Don't know about biopesticides | 6 |
| | Others | 2 |
| | Not related | 77 |
| Are you aware of the effects of the product used now against the environment for the long term? | Yes | 88 |
| | No | 12 |
| Are you aware of the effects of the products used now on personal health for the long term? | Yes | 89 |
| | No | 11 |
| Are you satisfied with the effectiveness of the biopesticides used? | Yes | 80 |
| | No | 20 |

## 3.5 Farmers' willingness to use biology-based products

This section delves into farmers' willingness to use biological based products in their agricultural activities by analyzing mean scores. Before providing their insights on biofungicides, farmers watched a video explaining the benefits of a biofungicide product called Lyses$^{TM}$ a product from Universiti Putra Malaysia, that able to suppress the pathogen infestation on crops like melons and cucumbers. Post-video watching, farmers were asked about their willingness to use such products. This finding is encouraging, especially considering the growing concerns about the long-term environmental and health risks associated with chemical pesticides. Table 6 presents data showing farmers' willingness to incorporate biological products into their practices. Higher mean values indicated greater receptiveness. Notably, all

five items scored above 3.0, indicating broad agreement with the use of bio-based products. The overall mean score of 4.29 reflects a high degree of willingness and openness among farmers towards biopesticides.

The findings revelased farmers were open to explore alternative pest management approaches despite acknowledging certain limitations, such as uncertainties about biopesticide effectiveness and perceptions of higher costs and accessibility issues in the local market. Addressing these concerns is crucial for promoting the adoption of biopesticides. Understanding farmers' behaviors and approaches provides valuable insights into pest and disease management practices. This knowledge can help develop effective strategies for promoting sustainable pesticide usage in the future. Although the market growth of local biopesticides appears slow, the farmers' experimentation with non-chemical alternatives suggests promising market potential for these products. However, there's a need for enhanced and targeted education on using biopesticides as viable pest and disease control strategies, considering existing practices and other relevant findings.

**Table 6 Mean scores of the willingness of farmers to use biological-based products.**

| Statement | Mean | Standard deviation | Percentage (%) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 |
| 1. Do you agree on the use of biological-based products for agriculture after watching the video? | 4.30 | 0.835 | 1.0 | 1.0 | 15.0 | 33.0 | 50.0 |
| 2. If you are given a biological-based product sample for the crop, are you going to use it? | 4.44 | 0.808 | 1.0 | 1.0 | 11.0 | 27.0 | 60.0 |
| 3. If the sample given can give a better effect than the product which you are using now, are you willing to replace it in the future? | 4.43 | 0.868 | 1.0 | 1.0 | 16.0 | 18.0 | 64.0 |
| 4. Do you agree to use the product if the price of a biologically based product is slightly more expensive than the chemical-based product if proven effective as well as reducing the use of chemical poison? | 3.93 | 1.066 | 4.0 | 2.0 | 30.0 | 25.0 | 39.0 |
| 5. Would you recommend biologically based products to other people in the future? | 4.37 | 0.837 | 1.0 | 1.0 | 14.0 | 28.0 | 56.0 |
| The total average mean value | 4.29 | | | | | | |

1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree

## 4. Prospects of utilization of biopesticides in Malaysia

The prospects for biopesticides in Malaysia are promising, but their adoption remains hindered by various technical, institutional, social, and economic barriers. To promote their use, it is essential to focus on farmer education, policy support, and market development (Nyangau et al., 2020; Singh et al., 2018). While some farmers are aware of biopesticides, their understanding of the benefits and proper application of these products is limited (Constantine et al., 2020; Singh et al., 2018). Improving Malaysian farmers' perceptions of biopesticides can be achieved through educational programs that highlight the advantages, such as reduced environmental impact, better human health, and potential long-term cost savings. Government initiatives can further support the production, distribution, and accessibility of biopesticides, addressing barriers faced by farmers.

By identifying the key factors influencing farmers' decisions regarding pest management strategies, policymakers, researchers, and extension agents can develop more effective strategies to promote the adoption of biopesticides and other integrated pest management approaches. This may include improving the regulatory framework, investing in research and development, and strengthening extension services to provide farmers with the necessary knowledge and support (Constantine et al., 2020). Economic viability is another crucial factor influencing their adoption. Farmers may hesitate to invest in biopesticides if they perceive them as more expensive or less effective than chemical pesticides. Therefore, it is vital to develop cost-effective, easy-to-use biopesticides that provide reliable pest control.

Limited adoption of biopesticides can also be attributed to factors such as product availability and accessibility, cost-effectiveness compared to synthetic pesticides, and the level of trust and confidence farmers have in these alternative strategies (Laizer et al., 2019). To promote the widespread adoption of biopesticides, a multi-faceted approach is required. This should include efforts to raise awareness, build farmer capacity through training and extension services, and address the regulatory and institutional barriers that hinder the development and deployment of these technologies (Singh et al., 2018; Constantine et al., 2020). Collaboration between researchers, policymakers, and industry stakeholders will be crucial in overcoming these challenges and unlocking the full potential of biopesticides for sustainable agriculture (Glare et al., 2016).

## 5. Conclusion

This research presented farmers' awareness of biopesticides practices in pest management which later give an impact on the farmer's willingness to use biological pesticides application. Over the years, the use of biological products in agriculture has become a standard practice for organic farming, which offers low levels of toxicity or improve the safety of the environment. The current study shows most farmers are aware of the application of biopesticides as one of the strategies in pest and disease management. Most farmers demonstrate a high level of willingness in using biopesticides in the future. The data obtained indicate that farmers have a good perception and certainty of biological-based products for their farming activities. This will create an opportunity for biobased product industry makers to promote their developed technology to farmers. To facilitate adoption, policymakers and industry leaders should focus on reducing biopesticides costs through subsidies and public-private partnerships. Hence, much support from the industrial sectors, especially in biological-based industries, is important for the continuous contribution toward better farming practices as agriculture activities end up as a source of food for humankind. Additionally, future research should explore the long-term impacts of biopesticides adoption on crop yield, soil health, and ecosystem sustainability to inform future agricultural practices and policies. This effort is important to provide safe and healthy food to ensure people can get enough nutrients without compromising on their health and harming the environment.

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## Conflict of Interest

The authors declare no conflicts of interest.

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