Vegetable farmers' perception towards the use of bio-pesticide: A case study on the Sooriyawewa Area, Sri Lanka

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ABSTRACT

Vegetables cultivated in Sri Lankan tropical conditions are subjected to severe pest and disease attacks, which lead to yield losses. Farmers adopt the extensive use of chemical pesticides to increase the quality and quantity of yield to gain economic advantages. However, chemical pesticide usage drives several environmental and health problems. Although bio-pesticides can be used as an alternative to chemical pesticides, farmers' perceptions and expectations of these bio-pesticides remain unknown. Therefore, this study aims to find out farmers' perceptions of bio-pesticide usage and provide appropriate marketing strategies. The present study was conducted in the Sooriyawewa Divisional Secretariat (DS) division in the Hambantota District, selecting 75 vegetable farmers randomly. Data were collected through a field survey by using pretested structured questionnaire and analyzed using Wilcoxon signed rank tests, chi square tests, and descriptive analysis. Results indicate that farmers are currently adapted to the use of chemical pesticides rather than bio-pesticides. Farmers' most preferred bio-pesticide attributes include formulation mode, application mode, price, convenience of usage, awareness about bio-pesticides, and their availability in the market. Moreover, farmers prefer to use liquid forms of bio-pesticide as foliar sprays. Farmers' perceived benefits of the bio-pesticides include safety to health, eco-friendliness, reducing production costs, increasing quality and quantity of vegetable yield, ease of handling, and increasing demand for vegetables. Therefore, improving the product attributes, reducing the market price, increasing the availability of the product, and increasing the extension services can increase the farmer's potential to use bio-pesticides. It is required to implement these strategies in collaboration with all the stakeholders involved in bio-pesticide production and usage. As this study found farmers' perceptions, further research needed to be focused on finding other stakeholders' perceptions of bio-pesticides.

Key words: Bio-pesticides, Vegetable Farmers, Perception, Marketing strategies

INTRODUCTION

The cultivation of vegetables has become a pivotal agribusiness in the agriculture sector. This sector provides a significant contribution to the country's economic prosperity while serving as a source of livelihood and promoting food security. The vegetable sector possesses a 12.6% contribution to the agri-output from the 10% contribution of the agriculture sector to the Sri

Lankan GDP in the second quarter of 2022 (Department of Census and Statistics, 2022). South and Southeast Asia produces 53.5 million t of vegetables annually on a land area of 4.65 million ha. However, in the tropics, insect pests and illnesses can severely reduce the output of these vegetables (Srinivasan, 2012). As vegetable production is severely affected by pests and diseases, farmers use pesticides in wider ranges. Since the start of the green revolution, pesticides have been employed to boost agricultural productivity while eliminating pests and diseases. According to the Pretty and Bharucha (2015), Around 5.7 billion pounds of pesticides are used worldwide each year for agricultural purposes. In the last 20 years, the annual consumption of pesticides has increased to 3.5 billion kg, representing a $45 billion business worldwide. The Sri Lankan current usage of synthetic pesticides is estimated at 1700 t of active chemicals, with a total cost of approximately Rs 4.6 billion annually (Rajapakse et al.2016).

Although these pesticides have a positive impact on increasing yield, quality of production, and saving labor and energy, they have a severe negative impact on the environment as well as the health of people. In fact, local farmers frequently overuse pesticides, combining different types and trying to apply them excessively in an effort to get better results, ignorant that doing so might increase toxicity levels and pose higher risks to the environment and human health (World Bank, 2013). According to the Helfrich et al. (2009), numerous terrestrial and aquatic animal and plant species have declined as a result of uncontrolled application of pesticides. A few endangered species' continued existence has also been under danger due to the excessive use of the pesticides. According to the WHO (2021), more than 250,000 people die each year from poisoning, with 150,000 of those fatalities due to pesticides. Moreover, there have been reports of immune suppression, hormone disruption, lowered intelligence, and reproductive abnormalities noted by community health clinics, as well as liver disorders, cancers frequently linked to long-term exposure to pesticides, lung disorders, and skin disorders linked to short-term exposure (Vinson et al., 2011). Therefore, the use of chemical pesticides should be replaced with less harmful, environmentally friendly, and healthy alternatives. Moreover, reducing over usage and educating farmers and other supply chain actors on the correct usage of pesticides can be done.

Further, the Sri Lankan Cabinet of Ministers approved restrictions and bans on fertilizer and agrochemicals such as insecticides and herbicide imports on April 27, 2021 (USDA, 2021). This encouraged farmers to use organic, healthy and locally available pesticides for cultivation purposes. It has been suggested that organic farming using bio-pesticides is a viable strategy

for developing integrated and organized farming systems that do not conflict with the advantages of the environment or the economy (Ataei et al., 2021). One of the most well-liked alternative techniques to generate safe, chemical-free food is the use of bio-pesticides (Heredia et al., 2022; Ataei et al., 2021). Biological pesticides, also referred to as bio-pesticides, are made from natural substances including bacteria, plants, animals, and specific minerals (US Environmental Protection Agency Pesticides, 2014). Bio-pesticides are gaining popularity around the world as a safer alternative to traditional chemical pesticides. However, currently, bio-pesticides account for only a small portion of the entire global agricultural pest control business, valued at about $3 billion globally (Olson 2015). The use of bio-fertilizer and bio-pesticides has been a traditional practice adopted by many rural farmers in Sri Lanka to boost soil fertility and all other soil qualities required by crops. Currently, the Sri Lankan pesticide market offers commercial formulations of biochemical pest control agents such as semiochemicals, hormones such ecdysteroids and juvenile hormones, natural plant regulators, and enzymes. However, only a small number of pesticides that meet the criteria for biological pesticides are available for sale in Sri Lanka (Rajapakse et al., 2016). Moreover, Sri Lankan vegetable farmers' perceptions, preferred attributes of bio-pesticides and addressing the concerns of farmers about promoting bio-pesticides remain unexplored yet. Therefore, this study aims to gain insights into the importance attached to different product attributes of bio-pesticides by farmers in order to introduce bio-pesticides as alternatives to chemical pesticides.

- To examine the present status of pest management of vegetable cultivation in Sooriyawewa area.
- To analyze the vegetable farmers perception towards the use of bio-pesticides.
- To identify the farmer's preference towards different product attributes.
- To developed appropriate marketing strategies to promote the bio-pesticide among vegetable farmers.

LITERATURE REVIEW

Pest management techniques in vegetable farming

Although there are many problems associated with vegetable cultivation, Ellis-Jones et al. (2008) stated that the main constraint is the pest problem in Africa. In South Asia and Southeast Asia, where the growing environments are tropical, vegetables are high-value commodities, and chemical pesticide use is extensive due to substantial yield losses caused by insect pests

and diseases (Srinivasan, 2012). In Sri Lanka, the plantation industry takes a more systematic approach to pest management, but horticultural sector faces more challenges because of the number of farmers, crops, and pests involved. Most of the farmers tend to adopt chemical pesticides due to their quick results, despite their negative impacts (Gerken et al., 2001). In Sri Lanka, the use of chemical pesticides has increased recently (Piyasena, 2009). In total, 28,640 metric tons of pesticides were imported into Sri Lanka between 2013 and 2017, with associated expenses of $225 (National Audit Office, 2019). Synthetic pesticides are mostly used to control pests, and in 2012, the total expense of pesticide imports was almost 0.1% of the country's gross domestic product. When pesticides are applied, the environment, consumers, the applicator, and the emergence of pesticide-resistant strains of the target species can all have serious effects (Rajapakse et al., 2016). Further, this causes developing secondary pests and causing health and economic losses to humans (Bandara & Sivayoganathan, 1996).

Bio-pesticides

Bio-pesticides are a type of pest control substance that is taken from living species such as plants, animals, and microorganisms. It can stop the growth and even eradicate the organisms that damage the plant (Sumartini, 2016). This bio-pesticide ensures environmentally friendly and economically beneficial farming systems with integrated and organized systems. Further, as bio-pesticide have less risk to people, animals and the environment, it is commonly accepted more healthier for environment than the chemical pesticides (Yazdanpanah et al., 2022; Neisi et al., 2020). They frequently have a much less impact on non-target species because they typically only affect the target pest and closely related organisms. The majority of microbial pesticides also have the benefit of reproducing in their target hosts and remaining in the environment due to horizontal as well as vertical transmission, which may result in long-term pest population suppression even if the application is not repeated (Sporleder and Lacey, 2013). In fact, bio-pesticides have the potential to be a useful tool in integrated pest management (IPM). However, there are a number of problems with the production and use of bio-pesticides in agriculture. The development of pesticide resistance in the target organism, dose adjustments, and the identification of new species are a few of the significant problems (Basnet et al., 2022). Challenges associated with the use and usage of bio-pesticides include the need to identify viable bio-pesticides, the expense of production, and the evaluation of the risks to humans and animals (Meshram et al., 2022). Moreover, the development and promotion of bio-pesticides in the majority of the developing world are hampered by a number of issues like the

need to standardize suitable application methods and develop sound formulations and the absence of registration processes (Srinivasan, 2012).

Types of bio-pesticides

Bio-pesticides come in a variety of forms, and they are grouped together based on the methods used for extraction and the molecules or compounds that were employed in their synthesis. They are GMO-Based Bio-pesticides, Microbial Bio-pesticides, and Biochemical Pesticides. (Ruiu, 2018). Microorganisms including bacteria, fungus, and viruses are the source of microbial pesticides. These organisms' active chemicals or substances target particular insect pests or pathogenic nematodes. Biochemical pesticides use naturally occurring substances that manage pests through harmless methods. Depending on how they use pheromones, plant extracts or oils, or naturally occurring insect growth regulators to control insect pest infestations, they are further categorized into various categories (Kumar et al., 2021). When genes are inserted into a plant (Genetically-modified crop), the result is the production of GMO-based biopesticides, which are then utilized to control pests by enabling the production of substances such as the Bt toxin. In the insect intestine, B. thuringiensis's delta endotoxins are divided into smaller toxins that cause cell enlargement, rupture, and ion leakage, which ultimately results in cell death (Gomiero, 2018).

Farmers' preference on bio-pesticides

Adhikari et al (2019) states that the perception of bio-pesticides' advantages for human and environmental health among every relevant group was quite favorable. However, numerous stakeholders must have training and familiarization with all bio-pesticides that are currently available in the market. In contrast, Constantine et al. (2020) study found that apparently about 10% of Kenya's small-scale farmers use licensed bio-pesticides, making their use relatively low. Farmers' perception of bio-pesticides as being ineffective or at least inferior to chemical pesticides is occasionally given as a cause for their poor utilization (Hashemi and Damalas, 2010). Furthermore, Constantine et al. (2020) noted that despite the high willingness to pay for bio-pesticide products, farmers still heavily rely on advice regarding which products to use. Bio-pesticides are also shown to have very low farmer adoption and applicability at the field level. This might be a result of the inherent characteristics of bio-pesticides, which demand greater care in treatment schedules than conventional pesticides, as well as the lack of promotional initiatives such as training farmers and extension personnel (Rajapakse et al.,

2016). As a result, it is crucial to improve the knowledge of those who give advice in addition to making sure that products are locally accessible at reasonable costs.

Marketing strategies of bio-pesticides

Developing stable formulation and delivery systems might accelerate the commercialization of bio-pesticide products. In developing nations, it's crucial to maintain low costs for farmers for a certain product's quality and availability (Koul, 2023). There has been a significant advancement in knowledge and technology about bio-pesticides in recent years in terms of development of formulations, and commercialization, but there are still a number of obstacles to overcome. The key challenges are creating stable formulations, supplying and storing them, standardizing acceptable delivery methods, regulating their use, advertising them, selling them, and creating a market for bio-pesticides that can compete with the market for chemical pesticides (Karamaouna et al., 2013). According to the study done by Sumarwan and Suharto (2023), it is anticipated that performance expectations, effort expectations, social influence, facilitating conditions, price value, perceived need, information publicity, and product promotion will all have an impact on non-users intentions to utilize commercial bio-pesticide products among rice farmers. These key aspects need to be considered when developing strategies for marketing.

Adhikari et al. (2019) argue that the major strategies for increasing the use of bio-pesticides among farmers are the implementation of plant clinics, the provision of duty-free systems for bio-pesticides, encouraging research to extend the shelf life of bio-pesticides, and mass production. Developing quality certification programs for bio-control agents, providing financial support for research and development, practical technological advances, improving rearing and handling practices, and promoting research and education on the use of bio-control agents are some of the crucial strategies for commercializing bio-pesticides. Additionally, it is necessary to provide customer services for location-specific biological control and clear instructions on how to utilize their products (Rajapakse et al., 2016).

METHODOLOGY OF THE STUDY

The present study was conducted in the *Sooriyawewa* Divisional Secretariat (DS) division in the Hambantota District, selecting five vegetable-cultivating Grama Niladari (GN) divisions purposefully. Data were collected through a questionnaire survey from 75 vegetable cultivating farmers selected from 5 GN divisions (*Weniwel ara, Bediganthota, Mahapelessa, Aliolu ara*, and *Viharagala*) through the random sampling method. The sampling framework was all

registered vegetable-growing farmers in these 5 GN divisions, under the Agrarian Service Center. A pre-test was conducted where questionnaires were distributed among 13 farmers in the "Aliolu ara" GN division to improve the content validity. IBM SPSS 0.25 software was used to analyze the data. Data analysis was carried out using Chi-Square, Wilcoxon Sign Rank test, and descriptive analysis. One sample Wilcoxon-signed ranked tests were used to analyze the perceptions, attitudes, and suggestions of the farmers.

RESULTS AND DISCUSSION

Demographic information of the respondents

The majority of farmers belong to the age category > 56 years old; it is 43%, and only 23% of farmers are below 45 years old. That implies the majority of vegetable farmers in this area are old, which may be because the younger generation is reluctant to engage in agricultural activities. When considering the educational background, most of the farmers (69%) have less than ordinary education, and 23% of farmers have an educational background up to the ordinary or advanced level. Further, most of the farmers engage in farming full-time (83%) and they inherited it from the previous generation (69%). The results imply that the majority of the farmers (69%) are receiving income more than Rs. 21000 (Table 1).

Table 01: Demographic information of the farmers

Factor	Category	Percentage (%)
Age	20-35	7
	36-45	16
	46-55	34
	>56	43
Education	No school	12
	Up to grade 5	13
	Grade 6 to 10	44
	O/L and A/l	23
	Other	8
Type of farming	Part time	17
	Full time	83
Descending from an agricultural family	By generation	69
	By marriage	17
	By relatives	0
	Newly started	14
	<5000	0

Monthly income	6000-20000	31
	>21000	69

Source: Survey data

Present status of pest management of vegetable cultivation

Farmers in the Sooriyawewa area are cultivating different types of vegetables, including snake gourds, ridged gourd, bitter gourd, ladies' fingers, brinjal, winged bean, Centella asiatica, string beans, long beans and pumpkin. These vegetables are associated with different pests, and farmers employ several pesticides to control them at present (Table 2).

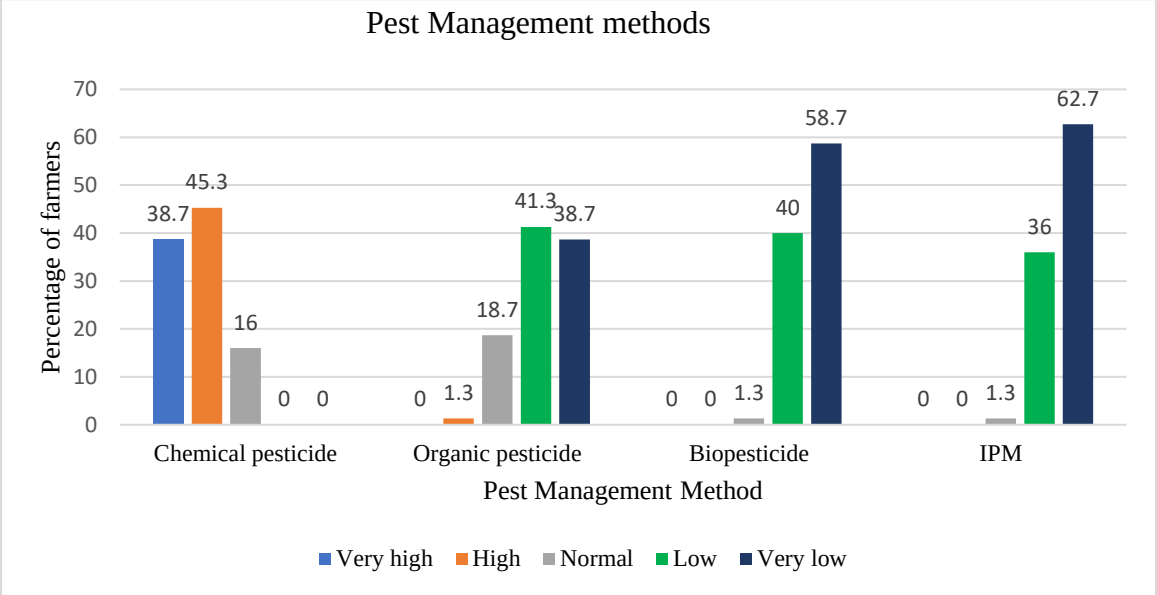
Table 2: Types of vegetable cultivated, common pests and chemical pesticide

Type of vegetable	Name of pests	Trade name of pesticide
Snake gourd	Mite, fruit fly, stem borer, root borer, Leaf miner	Coragen , Azeta acetamiprid , piuru dan
Ridged gourd	Mite, fruit fly, stem borer, root borer, Leaf miner	Coragen , Azeta acetamiprid , piuru dan
Bitter gourd	Mite, fruit fly, stem borer, root borer, Leaf miner	Coragen , Azeta acetamiprid , piuru dan
Ladies' fingers	Scale insect, Red bug, pod borer	Virtako 40WG , Coragen
Brinjal	Red mite, stem borer, leaf miner	Admire, Provado, Lebasite, Coragen
Winged bean	Lower stage of insects	Virtako
centella asiatica	Lower stage of insects, lady bird (golden)	Virtako
String beans, Long Beans	Lower stage of insects, aphid, caterpillar, pod borer	Coragen, Virtako
Pumpkin	fruit fly, Lower stage of insects, melon fly	Success, Lagrobet

Farmers are using four main types of methods used to control pests, such as chemical pesticides, organic pesticides, bio-pesticides, and integrated pest management (IPM) methods. The usage of organic pesticides, bio-pesticides, and integrated pest management (IPM) methods for pest control either absent or at a low level. However, chemical pesticide usage is high (45.3%) and very high (38.7%) in the farming community (Figure 1). The use of chemicals has become very popular due to their high potential to kill pests and quick action against the pest population in a wide range of ecological conditions. Similar results have been discovered by past scholars. According to Constantine et al. (2020), smallholder farmers in Kenya employ a high proportion of conventional chemical pesticides and a low proportion of bio-pesticide

products in the survey areas. Chemical pesticide treatment is still the main technique used to protect crops against yield loss, despite the fact that chemical pesticides have a harmful impact on both human health and the environment (Sharma et al., 2019). In contrast, bio-pesticides have either less or no impact on living things while having good availability and working in a variety of ways (Thakur et al., 2020). Therefore, it is essential to use fewer chemical pesticides and more bio-pesticides (Ruiu, 2018)

Figure 1: Pest Management Methods



Source: Survey data

Table 3: Relationship between education level and the applying pest method.

Methods	Chi-Square value	*P* value *
Chemical Pesticide	6.693	0.570
Organic pesticide	11.848	0.458
Bio-pesticide	**19.368**	**0.013***
IPM	4.880	0.770

Source: Survey data

A chi-square test was applied to test the relationship between a farmer's education level and the utilization of different pest management methods. Accordingly, there is a significant (p=0.013) relationship between a farmer's education level and the application of bio-pesticides. This implies that educated farmers tend to use bio-pesticides to control pests. Therefore, there is potential to enhance bio-pesticide usage by providing better knowledge about bio-pesticides to farmers (Table 3).

Perception of bio- pesticide application

Results of the Wilcoxon-Sing rank test ($p < 0.05$) revealed that farmers perceived bio-pesticides as less effective compared to chemical fertilizers, and availability was an issue for them to buy the product. However, they perceived bio-pesticides as an alternative that had fewer health effects on humans (Table 4). In their survey done in Nepal, Adhikari et al. (2009) also discovered that the majority of the participants believed that bio-pesticides are safe for both human health and environmental health, and they believe that there is less availability on the market.

Table 4: Results of Wilcoxon-sing rank test; Perception of bio-pesticides

Statement	Mean value	Standardized test value	*P* value **
Practiced only for vegetables	2.65	0.725	0.468
Can't control pests without chemical	4.28	7.480	0.000
It is not easy to find bio-pesticides in market	3.04	4.860	0.000
Easy to obtain information	2.68	1.093	0.275
Bio-pesticides promote good health.	4.35	7.687	0.000
More profitable than using chemical pesticides.	2.45	-.574	0.566
I am happy to continues application of bio-pesticide	2.43	-.704	0.481

Wilcoxon sign rank test, **Significant at $p < 0.05$ level

Scale 1 = very low and 5 = very high

Source: Survey data

Attributes of bio-pesticides preferred by the vegetable farmers

The results of Wilcoxon sign rank test showed that formulation mode, application mode, price, convenience of usage, awareness about bio-pesticides, and their availability in the market are significant attributes ($p < 0.05$) of bio-pesticides when introducing it into the market. Mean value analysis revealed that farmers are highly considered all the above factors when selecting bio pesticides. (Table 5). All these attributes needed to be considered when developing marketing strategies.

Table 5: Attributes of bio-pesticides preferred by the vegetable farmers

Statement	Mean value	Test value *	*P* value **
Formulation mode	4.11	7.273	0.000
Application mode	4.08	7.053	0.000
Reduce product Price	4.08	7.169	0.000
Convenience of usage	4.07	7.118	0.000
Awareness about bio pesticides	4.05	7.292	0.000
Availability in the market	4.16	7.643	0.000

Wilcoxon sign rank test, **Significant at $p < 0.05$ level

Scale: 1 = very low and 5 = very high

Source: Survey data

Further, the farmer's preference level for formulation mode and application mode is identified, where the majority of the farmers (99%) prefer liquid form and all the farmers (100%) prefer applying it as a foliar spray (Table 6 and 7).

Table 6: Farmer's preference level of Formulation mode

	Very high (%)	High (%)	Normal (%)	Low (%)
Dry	99	1	0	0
Liquid	40	23	20	17

Source: Survey data

Table 7: Farmer's preference level of Application mode

	Very high (%)	High (%)	Normal (%)	Low (%)
Foliar spray	100	0	0	0
Seed treatment	16	64	20	0
Soil treatment	31	45	24	0
Post-harvest	0	19	76	5

Source: Survey data

Additionally, this study found farmers' attitudes toward the perceived benefits of bio-pesticides. Accordingly, safety to health, eco-friendliness, increasing quality and quantity of vegetable yield, ease of handling, and increasing demand for vegetables are significant ($p < 0.05$) benefits of using bio-pesticides (Table 8). This implies that farmers agree with the stated benefits of the bio-pesticides. According to Coulibaly et al. (2008), factors such as maintained human health,

bio-pesticide ease of application, and good yield from bio-pesticides were identified in surveys in Benin that affected farmers' willingness to pay for a new bio-pesticide for vegetables.

Table 8: Farmers' attitudes toward the perceived benefits of bio-pesticides

Statement	Mean value	Standardized Test value	*P* value **
Safe to health	4.11	7.273	0.000
Eco friendly	4.12	7.327	0.000
Have a good Yield	4.11	7.273	0.000
Quality of yield	4.07	7.196	0.000
Easy handle	4.16	7.317	0.000
High demand for vegetable	4.11	7.273	0.000

Wilcoxon sign rank test, **Significant at $p < 0.05$ level

Source: Survey data

Appropriate marketing strategies

The main marketing pillars, such as product, price, place, and promotion, were considered to provide marketing strategies. Under the product factor, there are about seven suggestions, including increasing the product quality, increasing the types of products, increasing the durability, increasing the efficiency of the product, applying with chemical pesticides, and reducing the negative impact and harmful effects of familiar pests. The majority of the farmers agreed with them. Further, reducing the market price, increasing the availability of the product, and increasing the extension services through farmer organizations according to price, place, and promotion factors were suggested, and most farmers agreed with those suggestions (Table 9).

Table 9: Marketing strategies

Considerable factor	Suggestions	Mean value
Product	Increase product quality	4.08
	Increase the type of products	3.00
	Increase the durability	4.19
	Increase the efficiency of the product	4.24
	Apply with chemical pesticide	2.76
	Reduce the negative impact and harmful effect for familiar pests	4.35
Price	Reduce the market price	3.04

Place	Increase the availability of the product	4.07
Promotion	Increase the extension services	4.39

Scale: 1 = strongly disagreed and 5 = strongly agreed

Source: Survey data

CONCLUSION

Most farmers are currently adapting to the use of chemical pesticides rather than bio-pesticides, even though chemical pesticides can harm human health as well as the environment. Although farmers perceive that bio-pesticides promote good health, they still hold the belief that pests are unable to be controlled without chemicals, and it is not easy to find bio-pesticides in the market. Therefore, farmers are aware of the benefits of bio-pesticides. However, there are some factors, such as availability, price, and effectiveness that prevent them from using it. Farmers will consider attributes such as formulation mode, application mode, price, convenience of usage, awareness about bio-pesticides and their availability in the market when introducing bio-pesticides to the market. Further, farmers prefer to use liquid forms of bio-pesticide as foliar spray. Farmers' perceived benefits of the bio-pesticides include safety to health, eco-friendliness, increasing quality and quantity of vegetable yield, ease of handling, and increasing demand for vegetables. Therefore, improving the product attributes, reducing the market price, increasing the availability of the product, and increasing the extension services can increase the farmer's potential to use bio-pesticides.

Required actions should be taken to implement these strategies in collaboration with all the stakeholders involved in bio-pesticide production and usage, and it is important to establish careful planning and collaboration among farmers, bio-pesticides manufacturers, government agencies, agriculture extension services, and other relevant parties. Establishing clear communication channels is required to prepare a platform to raise the voice of farmers' requirements. This can be done through farmer associations, conducting regular surveys and feedback, and the selection of farmer representatives, which can help transmit farmer demand. Moreover, information campaigns, mobile apps, workshops, and organizational meetings can be effectively used to promote dialogue and network building. These methods transmit relevant information to bio-pesticides producers, and they should adhere to farmers' requirements and demand while making efforts to reduce product costs, offer competitive prices, increase their availability in the market, and conduct proper marketing campaigns. On the other hand,

agriculture extension services and government bodies should conduct educational programs, raise awareness about, and provide the required training to adopt bio-pesticides in order to eliminate their misperceptions.

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