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BIO-PESTICIDE USAGE ANALYSIS IN CAMBODIA: GUARDIANS OF THE GREEN EXPLORED

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Abstract:
The widespread reliance on chemical pesticides in modern agriculture, particularly in South East Asia, has bolstered crop protection but simultaneously raised pressing concerns about its detrimental impact on human health and the environment. Cambodia, in particular, has witnessed a tenfold surge in pesticide imports over the past decade, further exacerbated by illicit border imports. Given the substantial agricultural engagement of its population, this surge amplifies environmental health risks. This escalating concern has driven a growing demand to seek safer alternatives for crop protection. Bio-pesticides, offering targeted pest control with minimal residue and environmental impact, present a viable solution. While bio-pesticides have demonstrated their efficacy in Cambodian vegetable production, their adoption remains limited, largely due to farmer skepticism regarding their effectiveness and availability. In response to this challenge, this study delves into the current state of bio-pesticide use among Cambodian vegetable farmers. By scrutinizing the materials, formulation, application methods, and effectiveness of bio-pesticides, it seeks to provide essential insights for enhancing bio-pesticide management practices. Ultimately, this research aims to facilitate the wider adoption of bio-pesticides as a sustainable alternative to chemical pesticides, addressing both crop protection needs and environmental health concerns.

Keywords: Chemical pesticides, Bio-pesticides, Crop protection, Agricultural sustainability, Cambodia agriculture

1. Introduction

Chemical pesticides play an important role in modern agriculture, protecting crops from potential yield loss and reduction of product quality by minimizing or avoiding pest and disease infestations (Damalas, 2009). Due to effectiveness and low cost, the chemicals are becoming a vital input in the agricultural productions

(Haynes, 1988). The pesticide dependence is heavily on vegetable productions in South East Asia countries (Schreinemachers *et al.,* 2017)**.** However, the chemicals pose several adverse effects on human health and environment, causing several diseases and poisoning; polluting water, air and soil; and affecting non-target organisms in the ecosystem (Damalas *et al.*, 2001; Aktar *et al.*, 2009). In Cambodia, growth in pesticide imports has been estimated about 10 times in quantity over the last ten years (FAO, 2022). In addition, pesticide importation also occurs by active illegal importers along the uncontrolled borders of Cambodia with Thailand and Vietnam (MOE, 2004). The fast rate of this increase causes concerns about how to challenge management of the environmental health risks. Cambodia is a developing country in which the related risks are much greater where a majority of the population is involved in the agriculture (WHO, 1990; ADB, 2021). Consequently, there is an increasing public pressure to replace the chemical pesticides, if possible, with safer alternatives for crop protection. Bio-pesticides may represent an alternative path in crop protection because they destroy especially the target pests, leaving no residue on food or in the environment (Ahmed *et a*l., 2021). In Cambodia, the biopesticides prove to be effective in reducing damages by target pests in vegetable production, leading to significant yield gains (Ramasamy *et al.*, 2020). However, a minority of the Cambodian vegetable farmers have used biopesticide in pest control. This is mainly due to negative thinking of the farmers regarding bio-pesticide effectiveness and availability in Cambodia

(Schreinemachers *et al.*, 2017; Sokcheng and Molideth, 2021). So there is a need for detail information about current status of bio-pesticide use among vegetable farmers in Cambodia in order to improve bio-pesticide management practices and increase substitution of chemical pesticides by the biopesticides. The study therefore aims to describe materials and mixture formulation used in bio-pesticide preparation, application and effectiveness in Cambodian vegetable production.

2. Materials and Methods

The study was conducted in Cambodia's central provinces including Battambang, Siem Reap, Kampong Thom, Kandal, Svay Reang and Takeo. Among the rice farmers, there has been no report about bio-pesticide use (Matsukawa *et al.,* 2016). The vegetable farmers also depend on chemical pesticides in pest control, while only 2% of them have experience in bio-pesticide use (Schreinemachers *et al.,* 2017; Sokcheng and Molideth, 2021). The study design focused on active farmer's families who have culture of farming and long experience with vegetable production in the entire year. Our research team went firstly to ask village chief for the farmer information to reach such targeting farmers. Data was collected through a farm survey by face to face interviews with farmers and older family members across the provinces over a five-month period from July to November, 2022. The interviews, using a list of questions, covered the following topics: experience of botanical pesticide use, material selection, botanical pesticide preparation and use, effectiveness, and current status. A proportion of biomaterial quantity used was simplified into a volume of the mixture solution.

3. Results and Discussion

The results showed that 183 farmer families with multiple vegetable farming and reliance of agricultural production as the main source of income were selected for interview, but 112 farmers were returned valid meaning that these farmers had experience in bio-pesticide preparation and use. Most farmers 83(74%) were trained by agriculture extension officers or NGO staff in support of sustainable agriculture program which promotes safety and quality of food and life, use of renewable resources, and reduction of hazardous chemical pesticides and environmental health risks. While other farmers 29 (26%) received training from the neighbors or relatives. 17 plants shown in table 1, cow urine, wood ash and white sake were used in pesticide preparation. These materials are local natural resource products in the farmer ecosystems. Chili pepper, lemongrass, turmeric, ginger and galangal are known by the Cambodians as condimental crops for Cambodian food plates. Papaya and sugar apple are fruit crops and widely cultivated in Cambodia. Yam bean is also important tuber crop in Cambodian market. Bitter vine is medicinal plant for traditional medicine in Cambodia, while tropical yam and strychnine trees are wild plants in Cambodia and known as poisonous plants to the humans. Tobacco is an industrial crop in Cambodia as well as other countries in the world. *Chromolaena odorata*, *Datura metel*, Neem, and Eucalyptus are wild plants and weeds in Cambodia. These plant tissues were used in bio-pesticide preparation due to insecticidal effects (Baidoo and Mochiah, 2016; Kimutai *et al.*, 2017; Tavares *et al.*, 2016; Madreseh-Ghahfarokhi *et al.*, 2018; Abdullah *et al.*, 2015; Nagata *et al.*, 2017; Selvaraj *et al.*, 2017; Kesetyaningsih, 2012; Rahayu *et al.*, 2020; Ahmad *et al.*, 2016; Jiraungkoorskul, 2019; Basukriadi and Wilkins, 2014; Udebuani *et al.*, 2015; Kuganathan and Ganeshalingam, 2010; Benelli *et al.*, 2016; Batish *et al.,* 2008; Wuryantini *et al.*, 2020). White sake, wood ash and cow urine were considered as toxicant components in combination with plant materials. 29 botanical pesticides were found and prepared with 2 to 6 materials (Table 2). Most pesticides were made with 2 and 3 materials, of which chilli pepper, tobacco and neem were predominantly used by the farmers 50% (56), 43% (48) and 36.6% (41), respectively. Farmers used different mixture formulation as seen in the table 2. Ingredient weight in the mixture varied with formulation, number of the ingredients and the farmers. Sun cured tobaccos were used, while other plant parts were fresh. The bio-pesticide preparation consisted of trituration of botanical materials, materials soaking in water for 2-4 days and pesticide solution extraction. On an average, 1liter of the prepared pesticides was mixed with 15L of water for farm spraying. The pesticide use aimed to kill insects in the vegetable productions, of which the effectiveness ranged from 50 % to 100 % varying with insect types and densities according to the farmers. The farmers reported that the pesticides were less effective against insect miners, borers and leaf rollers. Furthermore, most farmers paid high cost and faced availability limit of the

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materials. These findings suggest that the plant materials for bio-pesticide production should be secured by increase in the agricultural production to fulfill the demand and decrease in the cost. On the same way, the bio-pesticide effectiveness should be increased by optimization of material selection, mixture, formulation, and preparation.

Table 1: Used materials

English names	Scientific names	Family name	Khmer names	Parts used in 10L (kg)
Chinese yam	*Dioscorea hispida*	Dioscoreaceae	[illegible]	Tubers (3-4)
Neem	*Azadirachta indica*	Meliaceae	[illegible]	Leaves (3-4)
Bitter vine	*Tinospora crispa Miers*	Menispermaceae	[illegible]	Aerial parts (3-4)
Lemongrass	*Cymbopogon citratus*	Panicoideae	[illegible]	Aerial parts (3-4)
Strychnine tree	*Strychnos nux-vomica*	Loganiaceae	[illegible]	Leaves + fruits (2-3)
Datura metel	*Datura metel*	Solanaceae	[illegible]	Fruits + leaves (3-4)
Tobacco	*Nicotiana tabacum*	Solanaceae	[illegible]	Leaves (0.5-1)
Chili pepper	*Capsicum annuum*	Solanaceae	[illegible]	Fruits (1-2)
Eucalyptus	*Eucalyptus tereticornis*	Myrtaceae	[illegible]	Leaves (3-4)
Papaya	*Carica papaya*	Caricaceae	[illegible]	Leaves (3-4)
Sugar-apple	*Annona squamosal*	Annonaceae	[illegible]	Leaves (3-4)
Galangal	*Alpinia galangal*	Zingiberaceae	[illegible]	Tibers (2-3)
Turmeric	*Curcuma longa*	Zingiberaceae	[illegible]	Tibers (2-3)
Ginger	*Zingiber officinale*	Zingiberaceae	[illegible]	Tibers (2-3)
Chromolaena odorata	*Eupatorium odoratum*	Asteraceae	[illegible]	Leaves (3-4)
Yam bean	*Pachyrhizus erosus*	Fabaceae	[illegible]	Seeds (2-2.5)
White sake	-	-	-	(1-2)
Wood ash	-	-	-	(1-2)
Cow urine	-	-	-	(1-2)

Table 2: Bio-pesticide formulation

Material mixture	N	%	Trainers
Tobacco + galangal	2	1.78	NGO / government officers
Tobacco + neem + galangal + Chinese yam	1	0.89	NGO / government officers
Tobacco + neem + Chinese yam	8	7.15	NGO / government officers
Tobacco + neem	5	4.46	Neighbors / relatives
Tobacco + turmeric + white sake	2	1.78	NGO / government officers
Tobacco + sugar-apple + oil			NGO / government officers
Tobacco + chili pepper + neem + Datura metel + Chinese yam + galangal	1	0.89	NGO / government officers
Tobacco + chili pepper + eucalyptus + strychnine tree	5	4.46	NGO / government officers

Tobacco + chili pepper + white sake	11	9.82	Neighbors / relatives
Tobacco + chili pepper + ginger	3	2.68	NGO / government officers
Tobacco + chili pepper + lemongrass	5	4.46	NGO / government officers
Tobacco + chili pepper + cow urine	3	2.68	Neighbors / relatives
Tobacco + chili pepper + wood ash	2	1.78	Neighbors / relatives
Chinese yam + chili pepper + strychnine tree	6	5.38	NGO / government officers
Chinese yam + chili pepper + turmeric	2	1.78	NGO / government officers
Chinese yam + chili pepper + wood ash	5	4.46	NGO / government officers
Wood ash + chili pepper + white sake	3	2.68	Neighbors / relatives
Sugar-apple + chili pepper + yam bean	3	2.68	NGO / government officers
Datura metel + chili pepper + galangal	1	0.89	NGO / government officers
Neem + chili pepper + ginger	3	2.68	NGO / government officers
Neem + chili pepper + strychnine tree	3	2.68	NGO / government officers
Neem + wood ash	5	4.46	Neighbors / relatives
Neem + bitter vine	3	2.68	NGO / government officers
Neem + bitter vine + galangal	6	5.38	NGO / government officers
Neem + chromolaena odorata + galangal	4	3.57	NGO / government officers
Neem + papaya + strychnine tree	10	8.93	NGO / government officers
Chinese yam + papaya	5	4.46	NGO / government officers
Sugar-apple + eucalyptus	2	1.78	NGO / government officers
Datura metel + eucalyptus	3	2.68	NGO / government officers

(NGO = non-government organization)

4. Conclusion

From the study it was event that the use of the bio-pesticides was limited due to cost and availability of the materials, and effectiveness. Hence, the suggestion is that the bio-pesticide use should be significantly improved through effectiveness optimization and increase in agricultural production of the preparatory materials.

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