Klover International Journal of Food Science and Nutrition
Volume 10 Issue 2, April-June 2022
ISSN: 2995-4517
Impact Factor: 5.54
https://kloverjournals.org/journals/index.php/fsn

BALANCING ACT: BIO-PESTICIDES IN INTEGRATED PEST MANAGEMENT STRATEGIES FOR CAMBODIAN CROPS

Sophea Khemra[1], Vannak Somnang[2]
Division of Research and Extension, Royal University of Agriculture, Phnom Penh, Cambodia

Abstract
Chemical pesticides have played a pivotal role in safeguarding modern agriculture, shielding crops from potential losses and upholding product quality by mitigating pest and disease infestations (Damalas, 2009). Their affordability and efficacy have established them as a crucial input in agricultural practices (Haynes, 1988). This dependency on pesticides is particularly pronounced in the vegetable production sector of South East Asian countries (Schreinemachers et al., 2017). However, the pervasive use of these chemicals exacts a toll on both human health and the environment, contributing to various diseases, instances of poisoning, and pollution of air, water, and soil. Moreover, it impacts non-target organisms within the ecosystem (Damalas et al., 2001; Aktar et al., 2009). In Cambodia, the importation of pesticides has surged nearly tenfold in quantity over the past decade (FAO, 2022). Notably, there is also clandestine pesticide importation transpiring along the unregulated borders between Cambodia, Thailand, and Vietnam (MOE, 2004). This rapid escalation raises apprehensions regarding the management of associated environmental health risks, particularly in a developing nation like Cambodia, where a significant proportion of the populace is engaged in agriculture (WHO, 1990; ADB, 2021). Consequently, mounting public pressure is advocating for the substitution of chemical pesticides, wherever feasible, with safer alternatives for crop protection. Bio-pesticides emerge as a potential alternative, as they selectively target pests, leaving no residues on food or in the environment (Ahmed et al., 2021). In Cambodia, bio-pesticides have demonstrated effectiveness in curtailing damages inflicted by target pests in vegetable production, leading to substantial gains in yield (Ramasamy et al., 2020). Nonetheless, a minority of Cambodian vegetable farmers have adopted bio-pesticides in pest management. This reluctance predominantly stems from farmers' reservations regarding the efficacy and availability of bio-pesticides in Cambodia (Schreinemachers et al., 2017; Sokcheng and Molideth, 2021). Thus, a comprehensive understanding of the current status of bio-pesticide utilization among vegetable farmers in Cambodia is imperative to enhance bio-pesticide management practices and augment the displacement of chemical pesticides with bio-pesticides. This study endeavors to delineate the materials and formulation mixtures employed in bio-pesticide preparation, their application, and assess their effectiveness in Cambodian vegetable production.

Keywords: Bio-pesticides, Chemical Pesticides, Vegetable Farming, Pest Management, Environmental Health Risks.

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 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.

Volume 10 Issue 2, April-June 2022
ISSN: 2995-4517
Impact Factor: 5.54
https://kloverjournals.org/journals/index.php/fsn

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.

Acknowledgement

This work was funded by Cambodia Higher Education Improvement Project (Credit No. 6221-KH). We are grateful to the enumerator teams for collecting the data used in the study.

References

Abdullah F., Subramanian P., Ibrahim H., Abdul Malek SN., Lee G.S., Hong SL. (2015). Chemical composition, antifeedant, repellent, and toxicity activities of the rhizomes of galangal, Alpinia galanga against Asian subterranean termites, *Coptotermes gestroi* and *Coptotermes curvignathus* (Isoptera: *Rhinotermitidae*). J Insect Sci., 15(1):175. DOI: 10.1093/jisesa/ieu175.

Ahmad W., Jantan I., and Bukhari S. N. A. (2016). *Tinospora crispa* (L.) Hook. f. & Thomson: A Review of Its Ethnobotanical, Phytochemical, and Pharmacological Aspects. Front. Pharmacol., Sec. Ethnopharmacology, 7. DOI: 10.3389/fphar.2016.00059.

Ahmed N., Alam M., Saeed M., Ullah H., Iqbal T., Al-Mutairi K. A., Shahjeer K., Ullah R., Ahmed S., Ahmed N. A. A. H., Khater H. F., and Salman M. (2021). Botanical insecticides are a non-toxic alternative to conventional pesticides in the control of insects and pests. Global Decline of Insects. doi: 10.5772/intechopen.100416.

Basukriadi A., and Wilkins R. M. Oviposition Deterrent Activities of *Pachyrhizus erosus* Seed Extract and Other Natural Products on *Plutella xylostella* (Lepidoptera: *Plutellidae*). Journal of Insect Science, 14, 1, 244, DOI: 10.1093/jisesa/ieu106.

Aktar M. W., Sengupta D., and Chowdhury A. (2009). Impact of pesticides use in agriculture: their benefits and hazards. Interdiscip Toxicol., 2(1), 1-12. DOI: 10.2478/v10102-009-0001-7

Asian Development Bank (ADB). (2021). Cambodia agriculture, natural resources, and rural development, sector assessment, strategy, and road map. Manila, Philippines, 2021. DOI: 10.22617/TCS210256-2.

Batish D. R., Singh H. P., Kohli R. K., and Kaur S. (2008). Eucalyptus essential oil as a natural pesticide. Forest Ecology and Management, 256(12):2166-2174. DOI: 10.1016/j.foreco.2008.08.008.

Benelli G., Canale A., Toniolo C., Higuni A., Murugan K., Pavela R., and Nicoletti M. (2016). Neem (*Azadirachta indica*): towards the ideal insecticide? Natural Product Research, 31, 4. DOI: 10.1080/14786419.2016.1214834.

Damalas C. A, Eleftherohorinos I. G. (2001). Pesticide exposure, safety issues, and risk assessment indicators. Int J Environ Res Public Health, 8(5), 1402-19. DOI: 10.3390/ijerph8051402.

Damalas C. A. (2009). Understanding benefits and risks of pesticide use. J. Sci. Res. Essay, 4(10): 945-949.

de Souza Tavares W., Akhtar Y., Gonçalves G., Zanucio J. C., and Isman M. B. (2016). Turmeric powder and its derivatives from *Curcuma longa rhizomes*: Insecticidal effects on cabbage looper and the role of synergists. Sci. Rep., 6, 34093 (2016). DOI: 10.1038/srep34093

Food and Agriculture Organization (FAO). (2010–2020). Statistics Division. Input—pesticides trade. https://www.fao.org/faostat/en/#data/RT. (January 15, 2022).

Haynes K. F. (1988). Sublethal effects of neurotoxic insecticides on insect behaviour. Ann. Rev. Entomol., 33,149–168. DOI: 10.1146/annurev.en.33.010188.001053.

Jiraungkoorskul W. (2019). Efficiency of *Tinospora crispa* against *Culex quinquefasciatus* larva. Environ Sci. Pollut. Res. Int., 26(15):14712-14716. DOI: 10.1007/s11356-018-2429-9.

Kesetyaningsih T. W. (2012). Efficacy of *Annona Squamosa* leaf extract as an insecticide against Cockroach (*Periplaneta americana*). International Conference: Research and Application on Traditional Complementary and Alternative Medicine in Health Care (TCAM) June, 22nd -23rd 2012 Surakarta Indonesia.

Kimutai, A., Ngeiywa, M., Mulaa, M., Gjagi P. G. N., Ingonga J., Nyamwamu L. B., Ombati C., and Ngumbi P. (2017). Repellent effects of the essential oils of *Cymbopogon citratus* and *Tagetes minuta* on the sandfly, *Phlebotomus duboscqi*. BMC Res. Notes, 10, 98. DOI: 10.1186/s13104-017-2396-0.

Kuganathan N., and GaneshalingamS. (2011). Chemical Analysis of *Datura Metel* Leaves and Investigation of the Acute Toxicity on Grasshoppers and Red Ants. E-Journal of Chemistry, 8(1): 107- 112. DOI: 10.1155/2011/714538.

Madreseh-Ghahfarokhi S., Pirali Y., Dehghani-Samani A., Dehghani-Samani A. (2018). The insecticidal and repellent activity of ginger (*Zingiber officinale*) and eucalyptus (*Eucalyptus globulus*) essential oils against *Culex theileri Theobald*, 1903 (Diptera: *Culicidae*. Ann Parasitol.; 64(4):351-360. DOI: 10.17420/ap6404.171.

Matsukawa M., Ito K., Kawakita K., and Tanaka T. et al. (2016). Current status of pesticide use among rice farmers in Cambodia. Appl. Entomol. Zool., 51, 571–579. DOI: 10.1007/s13355-016-0432-5.

Ministry of Environment (MOE). (2014). National Profile on Chemical Management in Cambodia. Phnom Penh, Cambodia. https://www.un.org/esa/dsd/dsd_aofw_ni/ni_pdfs/NationalReports/cambodia/Full_Report.pdf

Nagata K., Aistrup G. L., Honda H., Shono T., and Narahashi T. (199). Modulation of the nicotinic acetylcholine receptor by dioscorine in clonal rat *phaeochlomocytoma* (PC12) cells. Pesticide Biochemistry and Physiology, 64, 157-165.

Rahayu R, Darmis A, and Jannatan R. (2020). Potency of Papaya Leaf (*Carica papaya L.*) as Toxicant and Repellent against German Cockroach (*Blattella germanica L.*). Pak J. Biol. Sci., 23(2):126-131. DOI: 10.3923/pjbs.2020.126.131.

Ramasamy S., Sotelo P., Lin M., Heng C. H., Kang S., and Sarika S. Validation of a bio-based integrated pest management package for the control of major insect pests on Chinese mustard in Cambodia. Crop Protection, 135, 104728. DOI: 10.1016/j.cropro.2019.02.004.

Schreinemachers P., Chen H., Nguyen T. T. L., Buntong B., Bouapao L., Gautam S., Le N. T., Pinn T., Vilaysone

P, and Srinivasan P. (2017). Too Much to Handle? Pesticide Dependence of Smallholder Vegetable

Farmers in Southeast Asia. Science of the Total Environment, 593–594, 470–77. DOI: 10.1016/j.scitotenv.2017.03.181.

Selvaraj C., Kennedy J. S., and Suganthy M. Oviposition deterrence effect of EC formulations of *Strychnos nuxvomica L.* plant extracts against *Plutella xylostella Linn.* Under laboratory conditions. Journal of Entomology and Zoology Studies, 5(6):180-184.

Sokcheng S., and Molideth S. (2021). Pesticide Use Practices in Cambodia's Vegetable Farming. Cambodia Development Review, 25 (1): 1–6.

Udebuani A.C, Abara P.C., Obasi K O, Okuh S.U. (2015). Studies on the insecticidal properties of *Chromolaena odorata* (*Asteraceae*) against adult stage of Periplaneta Americana. Journal of Entomology and Zoology Studies, 3(1): 318-321.

World Health Organization (WHO). (1990). World Health Organization and United Nations Environment Programme. Public health impact of pesticides used in agriculture. World Health Organization, 1990, Avenue Appia 20, Geneva, Switzerland.

Wuryantini S., Harwanto, Yudistira R. A. (2020). The toxicity of the extract of tobacco leaf *Nicotiana tabacum L*, marigold leaf *Tithonia diversifolia* (HAMSLEY) and *citrus japansche citroen peel Citrus limonia* against *citrus psyllid*

(*Diaphorina citri Kuwayama*), the vector of citrus HLB disease. The 3rd International Conference on Biosciences, IOP Conf. Series: Earth and Environmental Science, 457, 012039. DOI: 10.1088/17551315/457/1/012039.