Research Article

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Homemade Organic Pesticides Based on Local Plant Materials for Pest Control for Strawberry Farming in Rwanda

Abstract

This study aims to investigate homemade organic pesticides formulations and safe use in relation to organic strawberry farming in Rwanda. It is a noble result of the previous baseline study that was about to identify knowledge gaps, needs and priorities of value chain actors for strawberry in Rwanda under the Ecological Organic Agriculture Initiative Project (EOA). Therefore, many gaps on the availability of organic pesticides, appropriate formulations, the pest specific application, the time and frequency application were pointed out in this baseline study. In their traditional agricultural systems, organic farmers usually prepare homemade organic pesticides for both preventive and control measures of pests by using available natural resources without basing on any scientific study or facts. This could be questioned because scientific evidence of their efficacy and safety may not be available or accessible to the users. As this practice is very old and inherited from generation to generation up to now; to come up with scientific evidence, we have conducted a study on different raw materials used in preparing organic pesticides through the laboratory analysis. The plant materials used in this research were locally collected from the gardens of the farmers who grow organic strawberries in Gakenke Districts. These are as follows: Endod (Phytolacca dodecandra), papaya leaves (Carica papaya), marigold (Tagetes erecta), and chilli (Capsicum annuum). The results of the on-farm trials showed that all the organic pesticides produced from the present study contain active ingredients with pesticidal and repellent properties. Therefore, homemade organic pesticides sprayed on strawberry showed their efficacy with great success to control pests and prevent crop damage in the farmers' gardens.

Keywords: Homemade organic pesticides• Indigenous knowledge• Plant materials Strawberry • Genome

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Introduction

Pesticides are defined as any compound or mixture of components intended for preventing, destroying, repelling or mitigating any pest that are responsible for most of the losses related to agriculture crops, either in the field or in the storage. Revealed that traditional pest control methods using organic pesticides for the protection of field crops or during storage are widespread and popular among subsistence farmers [1]. Moreover, the application of homemade organic pesticides in the local farming practices is a very old aged practice in the world and mostly used by subsistence and transitional farmers in low-income countries. The study of Isman (2006) stated that homemade pesticides were already used two millennia back for the control of agricultural pests in ancient China, Egypt, Greece and India. The recent research showed that up to 100% of the farmers in some regions of Zimbabwe and Uganda reported using organic pesticides or have used them [2].

To date, organic pesticides are widely used due to increased environmental awareness and the pollution potential and health hazards from many conventional pesticides, as well as increasing global demand for organically grown food that are actually driving the use of organic pesticides. Homemade organic pesticides are almost free of cost and there is no negative effect on the environment, human health, soil, animals and plants. They tend to be less toxic, ecofriendly

and more targeted to the specific pest. Over the last decades, the efficacy of the organic pesticides used in traditional pest management has been widely investigated in research trials. However, a synthesis of scientific information on homemade organic pesticides used by subsistence farmers is missing. Similarly, the same author reported that a number of research centers around the world are undertaking research aimed at improving techniques for the augmentation and application of organic pesticides, with the objective of improving the commercial feasibility of producing and using organic pesticides.

According to biological control agents or botanical pesticides are often not available and may also be expensive. However, [3] reported that some farmers consider organic pesticides to be a valid alternative option to synthetic pesticides due to their unfordable cost for subsistence and transitional farmers. Furthermore, it was indicated by that some of the organic pesticides that are being used for pest control might lack of active ingredients, which would make their use by farmers a waste of time. Additionally, results may be unpredictable due to varying active ingredient content and concentration in the used plant material, as well as differences in the preparation methods [4].

Materials and Methods

Description of the study area

The District of Gakenke is one of the five districts of the Northern Province. It borders with Rulindo District at its Eastern side, Burera and Musanze Districts at its North, Nyabihu District at its West, at the South by Kamonyi and Muhanga Districts. This District is divided into 19 administrative Sectors made of 97 Cells, 617 Villages. The District spreads over 704.06 Km2, with 345 487 inhabitants, 163,096 (47.2%) male and 182,391 females (52.8%). The density of population in Gakenke District is 473 inhabitants/Km2. In relation to population, 39.1% makes up the total percentage of youth in the district and which is also part of the working class. The climate in Gakenke district is generally the type of humid climate with the average annual temperature varying between 160C and 290C. The humid wind comes from East to West. The rainfalls are relatively abundant with a scale between 1, 100 and 1, 500 mm per year. As it is the case in Northern Province, Gakenke district has four different seasons: the small dry season from January to February, high rain season from March to end May, high dry season that extends from June to end August and finally small rain season from September to December (Intercontinental-Consultants-and-Technocrats-Pvt.-Ltd.-(INDIA) & ALN-Consultants-Ltd-(RWANDA), 2018) **Figure 1.**

For Gakenke District, the mean size of land cultivated per household is 0.62 ha, which is above the national average (0.59 ha), rural average (0.6 ha) and urban average (0.46 ha). Gakenke District also has 80.5% of households cultivating under 0.9 ha of land. The proportion of cultivating households with under 0.3 ha land by district and shows that these households represent 43.1% in Gakenke District. Exports crops are coffee and flowers. The percentage of households raising livestock is 84.5% of all households in Gakenke District making it the first on this indicator country-wide. Gakenke district is characterized, in general, by high inclined hills separated by rivers and marshlands. The relief seems to comprise two distinctive regions with the high altitude region with mountains attaining at least 2 648 m (Mont Kabuye) and another region characterized by lowly inclined hills of 1,700 m of altitude which in one way or another traduces soil-erosion. Marshlands occupy an area representing 361 Hectares **Table 1.** These marshlands are generally exploited during the dry season (May-September). In relation to education, the net enrolment rate in primary school is 95.7% above the national average of 91.7% and secondary enrolment rate 26.5% which is above the national average around 21%. These percentages rank the district at the first position in the Northern Province. The same survey revealed that the computer literacy rate for persons of 15 years and older stands at 3% which is below the national average 5.3% [5].

Plant material collection and extraction method

The selection of botanicals was based on their recommendation developed in the existing literature references documenting the efficacy of homemade botanical pesticides and pest management in organic farming systems. Thus, the selection of plant materials used in the present study was founded on previously reported pesticidal properties of the plants against many insect pests [6]. The botanical pesticides used in the present study were endod (Phytolacca dodecandra), papaya leaves (Carica papaya), marigold (Tagetes erecta), chilli (Capsicum annuum), and water. The plant materials, were

collected from strawberry farmer's gardens in Gakenke District. The plant materials were randomly collected from five different farmers' gardens **Figure 2.**

Maceration and decoction processes

Preceding to organic pesticides production, the plant materials were subjected to sorting, washing with water, then blending. Two different types of organic pesticides were produced; the pesticide made through maceration with cold water and pesticide made through decoction with boiled water. A mixture of 0.6 kilogram of endod (Phytolacca dodecandra), 0.6 kilogram of papaya leaves (Carica papaya), 0.6 kilogram of marigold (Tagetes erecta), and 0.2 kilogram of chilli (Capsicum annuum) were used to make 5 liters of organic pesticide through maceration, coded, UTAB-MOP, whereas a mixture of 0.3 kilogram of endod (Phytolacca dodecandra), 0.3 kilogram of papaya leaves (Carica papaya), 0.3 kilogram of marigold (Tagetes erecta), and 0.14 kilogram of chilli (Capsicum annuum) were used to make 5 liters of organic pesticide through decoction, coded UTAB-DOP. The extract produced through maceration was incubated for 160 hours

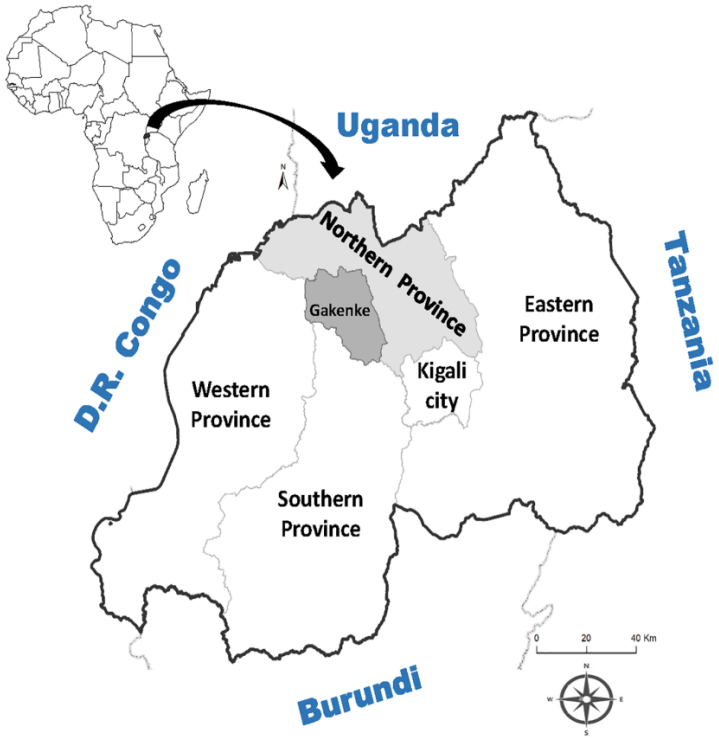


Fig 1. Administrative map of Gakenke District

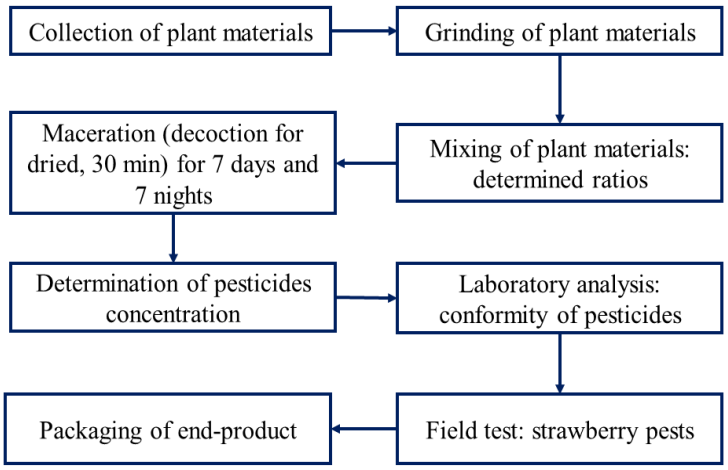
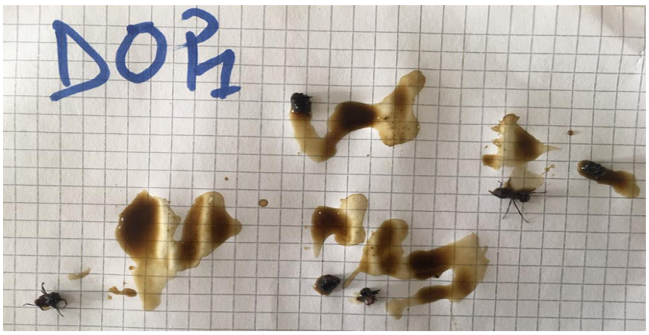


Fig 2. Maceration and Decoction processes

Strawberry garden attacked by ants (*Formica rufa*)

Ants (*Formica rufa*) collected from strawberry garden



Ants (*Formica rufa*) spread with UTAB-DOP

Ants (*Formica rufa*) spread with UTAB-MOP

Pests in strawberry garden: before spray of organic pesticide solutions

Strawberry garden after treatment with organic pesticide solutions

Fig 3. Strawberry Garden in different Solutions

Table 1. Efficacy of organic pesticide against strawberry pests

Extraction method	Lethal concentration	Crop	Pests	Efficacy (%) in comparison with negative control	
				Parameter	Organic pesticide
Decoction	21.45 g/L	Strawberry	Formica rufa	Pest mortality	100
			Aphids	Pest mortality	100
			Mites	Pest mortality	100
	10.725 g/L	Strawberry	Formica rufa	Pest mortality	82
			Aphids	Pest mortality	80
			Mites	Pest mortality	81
	5.3625 g/L	Strawberry	Formica rufa	Pest mortality	72
			Aphids	Pest mortality	71
			Mites	Pest mortality	70
	3.575 g/L	Strawberry	Formica rufa	Pest mortality	61
			Aphids	Pest mortality	60
			Mites	Pest mortality	60
Maceration	9.35 g/L	Strawberry	Formica rufa	Pest mortality	85
			Aphids	Pest mortality	80
			Mites	Pest mortality	81
	4.675 g/L	Strawberry	Formica rufa	Pest mortality	71
			Aphids	Pest mortality	70
			Mites	Pest mortality	69
	2.3375 g/L	Strawberry	Formica rufa	Pest mortality	62
			Aphids	Pest mortality	61
			Mites	Pest mortality	61
	1.559 g/L	Strawberry	Formica rufa	Pest mortality	50
			Aphids	Pest mortality	42
			Mites	Pest mortality	41

at room temperature to allow for extraction of phytochemicals, on the other hand, the extract produced through decoction was boiled for 20 minutes to allow for phytochemicals extraction **Figure 3.**

Vis-à-vis the harvesting process, the extracts both from maceration and decoction techniques were subjected to a mechanical filtration process in order to separate the liquid concentrate from solid plant materials. By measuring the weight of equal volume of water and the liquid organic pesticides, the mass concentration of the pesticides was calculated, using the following equation:

$$\text{Mass concentration} = \frac{(m_{\text{organic pesticide}} - m_{\text{water}}) \times 1000\ \text{mL/L}}{V_{\text{sample (in mL)}}}$$

Where, m is the mass, V is the volume and L is liter

Prior to storage of the liquid organic pesticides, the product from maceration was boiled at 75 degree Celsius for 30 minutes in order to kill spoiling microorganisms and extend the shelf life of the liquid organic pesticide.

Field trials of organic pesticides

Farm trials of both organic pesticides produced during this study, UTAB-MOP and UTAB-DOP, were conducted at Gakenke district. The pesticides were spread on strawberries crops attacked by various pests in order to evaluate their respective potential. A randomized complete block design (RCBD) with seven treatments and three replications was used in this study. The treatments consisted of 6 doses and two controls as follow: three dilutions with water, 1:0, 1:2, and 1:4 volume per volume (w/v) of pesticide extracted through maceration and three dilutions with water, 1:0, 1:2, and 1:4 volume per volume (w/v) of pesticide extracted through decoction, and two control, T1, spread with tap water and T2, without any spray. The repellent and pesticidal capacity evaluation were tested on ants (Formica rufa), aphids, mites, blight, moth, caterpillars that were found to attack strawberry crops. The spread with organic pesticides was made periodically three times per week for about 3 weeks. Both pesticides showed repellent and pesticidal capacity where the pesticidal capacity increases with increase of the dose of the pesticide.

Results and Discussion

This research was conducted in the Laboratory

of the Faculty of Agriculture, Environment Management and Renewable Energy at University of Technology and Arts of Byumba (UTAB). The process of extraction of organic pesticide through maceration was completed within approximatively seven days, whereas the extraction of pesticide through decoction took twenty minutes. Subsequently, the organic pesticides were harvested by the means of mechanical filtration. In line with previous research, this practice is similar to the statement in their study on the effect of extraction method of Tithonia diversifolia leaves against Spodoptera frugiperda larvae. To them, there are various extraction methods to obtain compounds derived from plants. The extraction methods ranging from simple to complicated extractions to those that require equipment to obtain compounds contained in the leaves of Tithonia diversifolia, the use of improper extraction methods can eliminate the bioactive compounds contained in the plant material which results in a reduced toxicity/biological effect on the target. A total of 4.1 liters of the concentrate for UTAB-MOP, equivalent to 82% yield (v/v) from the total volume, were collected; whereas 4.3 liters of the concentrate for UTAB-DOP, equivalent to 86% yield (v/v), were collected. The mass concentration of organic pesticides was calculated. The organic pesticide made through decoction, UTAB-DOP, was found to have the highest mass concentration of 21.45 g/L, while the pesticide made through maceration, UTAB-MOP has 9.35 g/L. The highest mass concentration of pesticide from decoction is due to the fact that extraction of phytochemical increases with temperature [7]. The efficacy of extracted pesticides was compared by observing the percentage proportions at which the mortality and repellent rate from maceration trials differed from those of decoction trials. Therefore, results from the field application of both UTAB-DOP and UTAB-MOP solutions revealed repellent and insecticidal activities depending on the concentration of the pesticide, as for the lowest concentration, 1:4 dilution, the dead pests were not found on ground whereas the insecticidal properties were revealed by the spray of higher concentrations, 1:2 and 1:0 dilutions. This activity might be due to different phytochemicals found in plant materials used for making the organic pesticides that exhibit insecticidal properties as it was indicated by a number of authors in the similar studies, such as capsaicin from Capsicum annuum having repellent and insecticidal activity against hemipterans. Sitotroga cerealella, Alfalfa weevil, Myzus persicae, Bemisia tabaci and alkaloid carpaine from Papaya leaves that contain insecticidal activity against Spodoptera litura; alilanisol, anetol, and limonene from Tagetes erecta that exhibit insecticidal properties against hemipteran pests [8]. Coleopteran pests lepidopteran pests mites, nematodes, bacteria, fungi, viruses and mosquitoes indicates that other compound may contribute to the insecticidal activity of preparations based on chili peppers.

Findings corroborate with other researchers [9]. Who stated in their study that there was a significant effect of *T. diversifolia* leaves crude extract obtained at different method in influencing mortality of *S. frugiperda* larvae. They concluded that the extraction method also might affect the content of toxic substances that can be absorbed and taken from *T. diversifolia* leaf extract [10].

Conclusion

Organic agricultural inputs consist of the key prominence in integrated agriculture with well-adjusted use of fertilizers for sustainable soil fertility. During this study, two organic pesticides were made, UTAB-DOP and UTAB-MOP solutions. The mass concentration of both UTAB-DOP and UTAB-MOP solutions were calculated. UTAB-DOP was found to have the highest mass concentration of 21.45 g/L. The organic pesticides were on-farm tried in strawberry gardens. The results from the field showed that both UTAB-DOP and UTAB-MOP solutions possess repellents and insecticidal properties. However, the insecticidal activity increases with the increase in dosage of the pesticide. Both pesticide solutions were effective to various ants such as Formica rufa and aphids, mites, blight, moth, and caterpillars. The organic pesticides produced from the present study showed to be a prominent alternative to synthetic pesticide and in turn could contribute to sustainable ecological agriculture.

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