Impacts assessment of farmers' knowledge in using pesticides on agricultural productivity in Bugesera District, Rwanda

ABSTRACT

Nowadays, the use of pesticides in modern agriculture has increased due to the heightened strain from insects and weeds on animal and crop health. This study aimed to assess the impacts of farmers' knowledge in using pesticides on agricultural productivity in the Bugesera district, the Eastern Province of Rwanda. Data were collected from the fifteen sectors of the study area using questionnaires, with 399 respondents selected through random and purposive sampling techniques. SPSS software was used for data analysis, which was summarized using contingency tables and graphs. Correlation analysis was done to assess the link between farmers' knowledge of pesticide use and agricultural productivity in across sub-locations.

The study revealed that the level of pesticide use in the Bugesera district was very low, at just 17%, and only 22% of farmers had good level of knowledge about pesticide use. Vegetables were the first crops sprayed by farmers, accounting for 82% of the total crop types to which pesticides were applied in the Bugesera district. Moreover, vegetable yields increased from 9t/ha to 9.475 t/ha following pesticide application. The study found a significant positive correlation between farmers' knowledge of pesticide use and agricultural productivity at the 0.01 level ($r=0.509$, $p<0.01$).

Enhanced farmers' knowledge of pesticide use and the proper application of pesticides can reduce yield loss and boost agricultural productivity. It is recommended that the Bugesera district can provide the incentive scheme to the innovative farmers and encourage them to serve as role models for others.

This would promote the adoption of appropriate pesticide use practices and adherence to sound agricultural principles in chemical pesticide application.

Keywords: Pesticides; Farmer Knowledge; Productivity; Produce Quality; Pests; Good Agricultural Practice

INTRODUCTION

Pesticides are widely used in present-day agriculture and constitute a practical and cost-effective method for improving crop produce quantity and quality, hence maintaining food security for the world's ever-growing population [1]. Pesticides have become an integral part of modern farming, and play a major role in increasing agricultural productivity [2]. Every year, around 2 million tons of insecticides are applied worldwide, with China being the leading contributor, followed by the United States and Argentina, which is quickly expanding [3]. Pesticides serve a crucial role in agricultural productivity, however their use has the potential to harm the environment, consumers, and farmer's health [4]. If improperly used, pesticides can lead to secondary pest outbreaks. The effects of synthetic pesticide poisoning cases in humans worldwide are quite tremendous. Around 385 million cases of unintentional acute pesticide poisoning of farmers and agricultural workers are found every year, and in around 11,000 cases this poisoning is lethal [5]. Lack of knowledge about the harmful effects of pesticide exposure allegedly, has an impact on low rates of adopting preventive measures when using pesticides. Different studies on the knowledge and application of safe pesticide usage have been performed by many researchers in recent years [6]. Inappropriate knowledge of the risks associated with pesticides leads farmers in Iran to handle and apply pesticides improperly. Previous studies have also found that most farmers consider fellow farmers as their main source of information on pesticide usage [7].

Rwanda is promoting agricultural inputs such as insecticides to increase agricultural output for both home and export purpose. Pesticides are also critical for the control of invasive species and noxious weeds [8]. Pest pressure is one of the greatest challenges to crop output in Rwanda, and improving pest control is one strategy to boost food supply. The usage of synthetic pesticides appears to be at both extremes in Rwanda. Some growers do not use pesticides to protect their crops, whereas a tiny percentage of cash crop growers mainly rely on synthetic pesticides. In Rwanda, some farmers applied prohibited pesticides such as endosulfan and benomyl, and 11% used fungicides such as benomyl, mancozeb, and metalaxyl-M to control fall army worm, despite the fact that FAW is not a fungus, as stated by [9]. The different instructions on pesticide labels are written in foreign languages which become the challenge to the farmers. Pesticide residues are not a worry in agricultural products sold in local markets but are a concern in export

items. Nevertheless, residues on produce caused by farmers' lack of awareness about pesticide use are one of the most serious food safety problems [10]. Studies conducted on the knowledge and usage of pesticides in several developing countries have shown that farmers' practices are often unsafe and can result in the problems [11] .Some studies indicated that farmers have knowledge which comes from various sources of information related to the use of pesticides associated with various stakeholders including agricultural extension officers, the private sector, farmer groups, and kiosks or pesticide practitioners. However, this knowledge is not sufficient to motivate farmers to change their behavior when practicing GAP for safe pesticide usage. The assessment of farmers' pesticide knowledge on agricultural productivity is very important in applying good agricultural practices specifically pesticide usage.

2. MATERIAL AND METHODS

2.1. The study area

This study was conducted in the Bugesera district which is located in the Eastern Province of Rwanda at Latitude. -2.2346° or 2° 14' 4" south; Longitude. 30.1483° or 30° 8' 54" east; at elevation of 1,438 meters .The district is made up with fifteen sectors and has been exacerbated by extreme poverty, poor coping and mitigating capacity to a changing climate as reported by the Republic of Rwanda Statistical Yearbook 2014 which indicated that agriculture in Bugesera accounts for 46% of family income, followed by labor income (28%), and rentals (10%).Changing climatic conditions has been associated with declining food crop production due to low moisture content. Cassava is the main food and income-generating crop is now a rare commodity; and the production of beans has also been adversely affected by the low soil moisture. There is an emergence of pests and diseases, possibly because of changing environmental conditions, crop pests were reported to have been increased

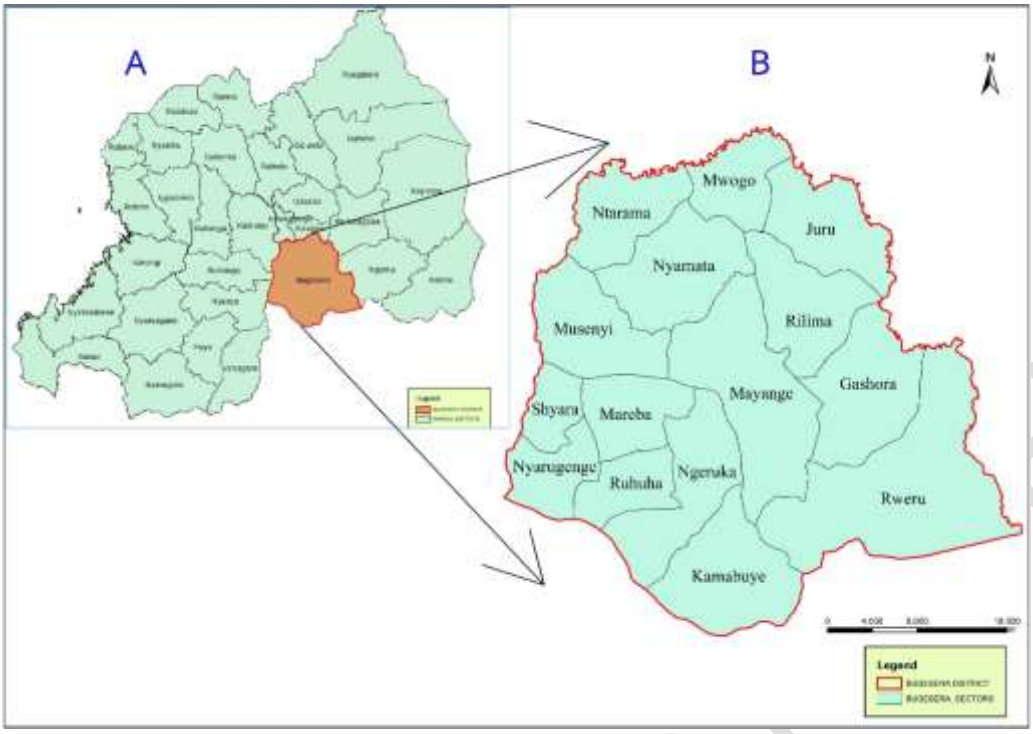

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Figure.1: Map indicates the location of Bugesera district in Rwanda

2.2. Data collection

In this study, a descriptive survey approach was also used since it was found to be flexible enough to allow for consideration of many facets of an issue under study. The study's population was 47208 farmers registered in the Smart Nkunganire System in Bugesera District for season A 2023.The researcher selected respondents purposefully according to cooperative membership and they were coming from different sectors of Bugesera district. The questionnaire was prepared in national language/Kinyarwanda in order to enable respondents to better understand the content and provide sufficient information. The researcher used the total number of farmers of 47208 (SNS, 2023A) to calculate the sample size by utilizing the formula to estimate a sample size from the study's entire population. Therefore, The Yamane formula was used to calculate sample size n=N/(1+N(e)2) .Where n is the sample size, N is the population size, and e is the level of precision. To minimize the risk that the sample size represented the true population the margin error was fixed at 5%. $\mathbf{n} = \frac{47208}{1+47208(0.05)^2} = 399$

No	Sector name	Total farmers	Sample size
1	Gashora	2002	17
2	Juru	2571	22
3	Kamabuye	3580	30
4	Mareba	3924	33
5	Mayange	2737	23
6	Musenyi	3850	33
7	Mwogo	2201	19
8	Ngeruka	4093	35
9	Ntarama	2137	18
10	Nyamata	2778	23
11	Nyarugenge	1285	11
12	Rilima	1040	9
13	Ruhuha	8925	75
14	Rweru	2950	25
15	Shyara	3135	26
Total population		**47208**	**399**

Table 1: Sample size showing the number of respondents in each sector

The questionnaire for this study was divided into two main pieces. The first portion contained demographic information. The second section focused on analysis of framers' knowledge in using pesticide and agricultural productivity in Bugesera, where the variables of the study were highlighted. A questionnaire which was administered to the respondents. A pre-test of the questionnaire was conducted before embarking on the actual survey to test its validity and suitability for the research study. The questionnaire was addressing the knowledge they have on pesticides use, the practices related to pesticides used against pests and agricultural productivity

3. RESULTS AND DISCUSSION

3.1. Characteristics of farmers

In this research the most respondents were female (58%) compared to male who were 42% and the majority (39%) were aged between 30-40 years while the last class age is about 11%. It is indicated that 16% of the respondents have no schooling; 64% has a primary level of education while 14% of respondents have secondary level education. And it was discovered that 6% of participants had a university education

3.2. Farmers' knowledge and experience in using pesticides

Based on **table .1,** the study showed that 83 % of the respondents have not used pesticides for controlling pests and diseases ,this can affect negatively the agricultural production in Bugesera district, therefore for increasing the agricultural productivity there is a need to use all agro inputs in effective and efficiency manner .The majority of farmers had experience in agriculture where they do not use the agro-inputs and they used to say that the fertilizers in Bugesera is rainfall because this district has been characterized by prolonged drought which affect the crop yield . The smallest number of 17 % has used pesticides in their daily farm activities as shown on **table .1** below

Table .2: The respondents who have used chemical pesticides in their farms

Have you ever used chemical pesticides?		Frequency	Percent
	No	332	83.0
	Yes	67	17.0
	Total	399	100.0

According to the study's outcomes, the rate of using pesticides in Bugesera district is very low. The main causes of this low pesticides use are ignorance of farmers, pesticides that are either not affordable or not accessible in many parts of district and low knowledge on the use of pesticides and its important in increasing agriculture productivity, that findings have the similarity with result of National institute of statistics in Rwanda, where in seasonal agricultural survey of 2021 reported that 22.4 % of farmers applied pesticides in season against 17.9 % of farmers in season B. In addition to that MINAGRI report of 2019 indicated that the national average of pesticide use is less

than 1kg/ha, with the majority of pesticides being fungicides. The ability of farmers to use chemical pesticides can impact the level of agricultural productivity in Bugesera district, as the land becomes scarcity due to the infrastructure, farmers need to improve their skills and use of agro inputs for increasing their crop yield and improved their livelihood

Table 3 . Responses of farmers on using pesticide and personal protective equipments

	N	Mean	Std. Deviation
The same pesticide can not be used to control pests and diseases in the same field	67	2.2239	1.49566
Misuse of pesticides affect negatively crops	67	1.8209	1.20511
Personal protective equipments are very important for pesticide users	67	2.2090	1.60998
Valid N (listwise)	67		

By considering the (**table .2)**, all respondents strongly disagree and disagree with each of the three statements related to pesticide and personal protective equipment use, as presented by a very weak overall mean of 1.82 and homogeneity standard deviation. From the observation, researcher found that in Bugesera district farmers have poor level of knowledge in using pesticides and protecting themselves, when they are using chemicals in fields. The farmers did not use full PPE because the PPE is considered to disturb the farmers'activities in working and the farmers were not free to move and had difficulty in breathing as reported by [12] in their study of Pesticide Poisoning and the Use of Personal Protective Equipment (PPE) in Indonesian Farmers. The unwillingness of farmers to not pursue preventive behavior may be due in part to the highly inconvenient of PPE or high cost of PPE for small scale farmers in the study area as confirmed by previous research [13]

Table. 4: The real time to spray a chemical pesticide to the crops

Which is the best time to apply a chemical pesticide to the crops?	Frequency	Percent
Morning	56	83
Afternoon	7	11
Evening	4	6
Total	67	100.0

Source: Primary Data, 2023

Table .3: As it is indicated 83% respondents of this study applied chemical pesticides in the morning, the majority respondents of this study applied the chemical in early morning while11% used pesticides afternoon since 6% of respondents used pesticides at the evenings. Spraying in the morning is crucial for a number of reasons, including the fact that plants absorb pesticides more effectively and the air is stiller than it is at other times of the day. For applications to work effectively and for personal safety, still air is essential. Wind disperses spray aimed towards shrubs, endangering people and animals who are in its path. Early morning and early evening are the best times to apply.

Table 5: Reasons for adherence to recommended pesticide dosages in Bugesera District

What have you based on for using pesticide?	**Frequency**	**Percent**
On economic injury level	20	30
On type of pests and diseases	7	10
On my own farm experience	32	48
On economic Threshold	8	12
Total	67	100.0

By considering the factors that influence farmers to take decision for spraying based on type of pest, referred to the **(table .4)** which indicates different factors which can push farmers to use pesticides therefore farmers were given those factors and then they chose among them, out of 67 respondents 30 % are aware that they should consider the economic injury level, where farmers should take decision based on the cost used to control pests and diseases while 10% were based on type of pests and

diseases for spraying the chemicals, 48% of respondents referring to their farm experience for pesticide application and 12% know that they should apply chemicals based on economic threshold. Therefore, results indicated above **(table 4)** revealed that the most farmers applied chemicals when the cost of application is justified by the outcome in order to increase agricultural productivity, therefore farmers should have good level of knowledge related to pesticides application for increase the produce in terms of quality and quantity

Table 6: The color marks the most dangerous pesticide

Which color marks the most dangerous pesticide?		Frequency	Percent
	Red color	35	52
	Yellow Color	20	30
	Blue Color	8	12
	Green Color	4	6
	Total	67	100.0

Source: Primary Data, 2023

Considering the findings of the present study on farmers' knowledge about the colors mark of pesticides, **in Table .5** the out of 67 respondents 52 % were aware that the color which indicates more dangerous pesticides is red since the 30% of respondents said that yellow color indicates the high degree of poisonous of pesticides, while 12% said that blue color mark on pesticides shows how the pesticide is dangerous , and 6% of respondents replied that green color is mostly indicates the dangerous chemical pesticides. toxic pesticide, whereas (8%) said blue color code, (11%) yellow color code, and (5%) green color code. The current study's findings demonstrate that the majority of farmers who used pesticides to manage pests and diseases are aware of the description that signifies the most toxic insecticides.

3.3. Agricultural productivity resulted from pesticides application

Good agricultural practices regarding pesticide application is essential element for increasing crop yield, it must be done principally to prevent or reduce agricultural losses due to pests and diseases, and this may lead to food availability at reasonable

price, all year round. In response to high pest and disease pressure, farmers use several control measures to reduce yield-including the application of pesticides .As reported by [14].The assessment of agricultural productivity due to pesticides use requires getting the information of how farmers are knowledgeable and their daily practices regarding to pesticide

Table 7: Types of crops which have been applied to chemical pesticides

To which crop have you applied to chemical pesticides?	Frequency	Percent
Vegetables	55	82
Maize	8	12
Rice	4	6
Total	67	100.0

The table .6 indicates that 82% of respondents applied chemical pesticides to vegetable crops, while 12% of respondents applied the pesticides to the maize since 6% used pesticides for controlling pests and diseases on rice crop. The findings show that majority of farmers who used pesticides they apply it to vegetable crops. The vegetables are grown three times in year and are more susceptible to diseases and pets while other two remained crops are planted in two cropping seasons. This indicated why most farmers apply pesticides in vegetable fields and they need more knowledge in using pesticides so that they can increase agricultural productivity in Bugesera district

4.3. Increased crop yields due to pesticide application

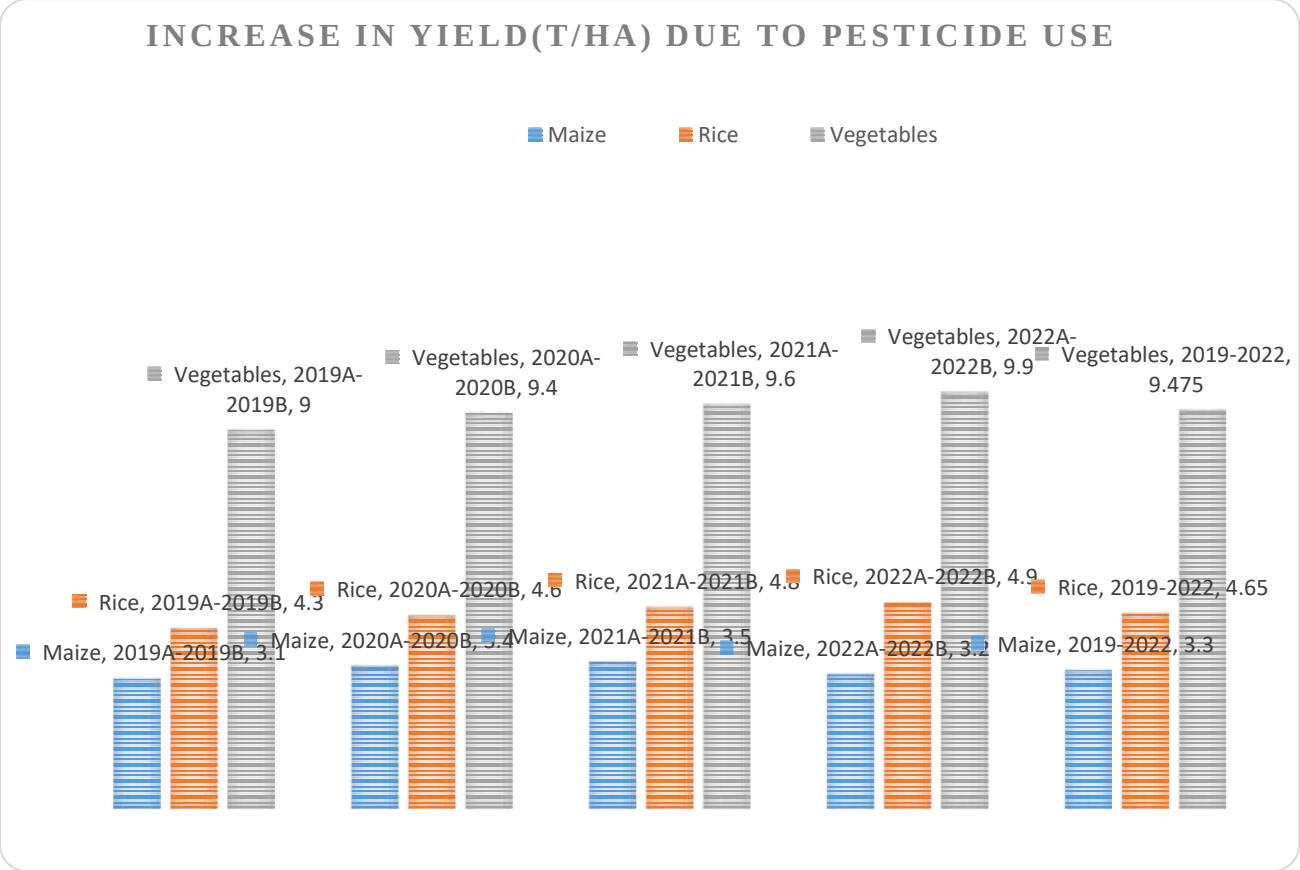

Figure2: Increasing crop yield in Bugesera District from 2019-2022

The figure 2 shows the increasing of maize, vegetables and rice crop yield for the respondents who have used the chemical pesticides for controlling pests and diseases in their fields, the increase in production on the above figure started from season A 2019 to season B 2022.For those who have applied the agro chemical pesticides, their yield has increased in the following sequence for maize crop yield was 3.1 t/ha to 3.3t/ha, for the rice yield has increased from 4.3t/ha to 4.65t/ha, while the yield for vegetables has

increased from 9t/ha to 9.475 t/ha. Based on the study findings, the vegetable crops were the most responding to pesticides application because most pests and diseases damage this crop compared to others in this study. Farmers testified that their level agricultural production has increased after pesticides application. Their difference in yield can be caused by many factors including the level of knowledge in pesticide use. However the yield can be decreased due to natural disasters such drought, flood, storms and snow in Bugesera district. This result is in line with the findings of study on Agriculture Development, Pesticide Application and Its Impact on the Environment by [8].Where they reported that without the use of pesticides, there would be a 78% loss of fruit production, a 54% loss of vegetable production, and a 32% loss of cereal production .Consequently, pesticides play a critical role in reducing diseases and increasing crop yields worldwide. It has been noted that loss of crops due to weeds are much more and followed by loss due to pests and insects accounting for the total loss of nearly 50% of crop yield revenues

3.4. The relationship between farmers' knowledge in using pesticides and agricultural productivity

Farmers' Knowledge in using pesticides is understanding or awareness of information related to pesticides use. This knowledge refers to the information, facts, skills and wisdom acquired through learning in agriculture sector. Farmers gain knowledge through experiments, observation, and discovery with research. Hence, farmers' knowledge in using pesticides comes into practice in their farming activities and it guides to certain goal of increasing agricultural productivity. In increasing crop yield in terms of quantity and quality famers need to combine knowledge and skills in using pesticides, so there should be relationship between the famers' knowledge in using pesticides and their agricultural produce. The results from this study suggested that, the pesticide application in appropriate way helps in minimizing pest, disease, and weed burdens

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Table .8 Relationship between farmers'knoweledge in using pesticides and agricultural productivity in Bugesera District

			Farmers 'knowledge in using pesticides
Farmers' knowledge in using pesticides	Pearson Correlation	1	.509
	Sig. (2-tailed)		.000
	N	67	67
Agricultural productivity	Pearson Correlation	. 509	1
	Sig. (2-tailed)	.000	
	N	67	67

As it is shown by the (**table .7**) there is a high positive correlation between framer's knowledge in using pesticides and the agricultural productivity, the farmers who have high level of knowledge in using pesticides are more likely to increase their agricultural produce both quantity or quality. Referring to the above (**figure 2)** shows how there increase in yield is different among farmers who applied chemical pesticides, this is linked to their level of knowledge on pesticides use. The knowledge and practices allowing farmers to follow the instructions and taking the right decision in right time as it indicated by yield harvest by different farmers of the same district. The respondents who used the pesticides in proper way by applying good agricultural practices have benefited from the use of these chemical pesticides where the study shows that the high positive correlation at the 0.01 level ($r=0.509$, $p<0.01$). This result means that the lower level of farmers' knowledge in using pesticides, the lower level of agricultural produce in terms of quality and quantity. The farmers with a high level of knowledge in using pesticides harvest more and good yield. The knowledge in using pesticides allows farmers to use chemical pesticides in effective and efficiency way so that they can improve their crop yield and livelihood

Table 9 Farmer household's earned incomes due to pesticides use

Responses	Frequency	Percent
Before using pesticide		
Strongly agree	3	4
Agree	2	3
Neutral	0	0
Strongly disagree	30	45
Disagree	32	48
Total	67	100.0
After using pesticide		
Strongly agree	36	54
Agree	25	37
Neutral	1	1
Strongly disagree	2	3
Disagree	3	4
Total	67	100.0

Source: Primary Data, 2023

The results presented in the **table .8** is indicating that 45% of all questioned respondents strongly agreed that they did not earn more money incomes before they use pesticides in agricultural activities while 48% of respondents agreed that did not earn enough incomes before using pesticides .After using pesticides 54% of all questioned respondents strongly agreed they earned money incomes from pesticides use while 37% of respondents agreed that farmers earn incomes from pesticide

application and 3% of respondents strongly disagreed with the assertion stating that they earned incomes after pesticides use., farmers did not generate incomes from pesticide application because they were not able to use required knowledge in using agro chemicals which in turns impacted them to earn the incomes due to lower farming productions they harvested .Therefore, it seems that the majority of all questioned respondents agreed and strongly agreed with the assertion because pesticide application increases farm products and makes farmers get incomes through selling their harvests to market for revenues. Those incomes came from the productions they got due to adopting pesticide application

CONCLUSION

This study was intended to assess the impacts of farmers' knowledge in using pesticides on agricultural productivity in Eastern province. It was conducted in Bugesera district for the period which started from 2019 to 2022.The following conclusions were based on the three objectives; analyzing the farmers' knowledge and experience in using pesticides, assessing agricultural productivity resulted from pesticides application and evaluation of the relationship between farmers' knowledge in using pesticides and agricultural productivity. It was conclusively found that a great number of farmers do not use pesticides in their field, to protect the crops from pests and diseases damage. The importance of the pesticide use in increasing agricultural productivity is acting as quick, easy, and inexpensive solution for controlling weeds and insect pests in rural areas. In addition, the famers have low level of knowledge in using pesticide, which negatively affect the pesticides use in effective and efficiency manner. On the other hand, a small number of farmers who spray pesticides in their field for controlling pesticides with proper practices were able to increase their crop yield. Because the poor management of pests and diseases cause the significant yield loss

Finally, it is clear that farmers in Bugesera district have inadequate knowledge in using pesticides, which affect expected crop yield, and this could be due to ignorance or carelessness of those farmers.

There should be a sequence of training events with participatory approaches to enhance and enrich farmers' knowledge and skills, to change farmers' attitudes, and to encourage them to put their knowledge into practice for increasing agricultural productivity.

References

1. Sharma, A., Kumar, V., Shahzad, B. et al. (2019). Worldwide pesticide usage and its impacts on ecosystem. SN Appl. Sci. 1, 1446 https://doi.org/10.1007/s42452-019-1485-1

Rahaman, M.M., Islam, K.S., Jahan, M., (2018). Rice Farmers' knowledge of the risks of pesticide use in Bangladesh. J. Health Pollut. 8 (20).

2. Jallow MF, Awadh DG, Albaho MS, Devi VY, Thomas BM.(2017) Pesticide Knowledge and Safety Practices among Farm Workers in Kuwait: Results of a Survey. Int J Environ Res Public Health. doi: 10.3390/ijerph14040340. PMID: 28338612; PMCID: PMC5409541

3.Anket S, Vinod K, Babar S et al (2019) Worldwide pesticide usage and its impacts on ecosystem. SN Appl Sci 1:1–16

4.Ben Khadda Z, Fagroud M,El Karmoudi Y, Ezrari S, Berni I, De Broe M, Behl T, Bungau SG,SqalliHoussainiT(2021). Farmers' Knowledge, Attitudes, and Perceptions Regarding. Carcinogenic Pesticides in Fez Meknes Region (Morocco). Int J Environ:Res Public Health 16;18(20):10879.benefitsandhazards.Interdisc. Toxicol., Vol.2, No. 1, pp. 1-12

5. Boedeker, W., Watts, M., Clausing, P., Marquez, E.,(2020). The global distribution of acute unintentional pesticide poisoning: estimations based on a systematic review. BMC Publ. Health 20 (1875).

6. Mubushar, M., Aldosari, F.O., Baig, M.B., Alotaibi, B.M., Khan, A.Q., 2019. Assessment of farmers on their knowledge regarding pesticide usage and biosafety. Saudi J. Biol. Sci. 26 (7), 1903–1910.

7.Diemer, N., Staudacher, P., Atuhaire, A., Fuhrimann, S., Inauen, J., 2020. Smallholder farmers' information behavior differs for organic versus conventional pest management strategies: a qualitative study in Uganda. J. Clean. Prod. 257, 120465

8.Tudi, Muyesaier, Huada Daniel Ruan, Li Wang, Jia Lyu, Ross Sadler, Des Connell, Cordia Chu, and Dung Tri Phung. (2021). "Agriculture Development, Pesticide Application and Its Impact on the Environment" International Journal of Environmental Research and Public Health 18, no. 3: 1112. https://doi.org/10.3390/ijerph18031112

9. Jean, S., Emmanuel, F., Edouard, A.N. and Brownlinda, S. (2019) Farmers' Knowledge, Attitude and Practices on Pesticide Safety: A Case Study of Vegetable Farmers in Mount-Bamboutos Agricultural Area, Cameroon. Agricultural Sciences, 10, 1039-1055. https://doi.org/10.4236/as.2019.108079

10.Tambo, J. A., Kansiime, M. K., Rwomushana, I., Mugambi, I., Nunda, W., Mloza Banda, C., Nyamutukwa, S., & Day, R. (2021). Impact of fall armyworm invasion on household income and food security in Zimbabwe. Food and Energy Security, 10(2), 299–312

11. Kumela, T., Simiyu, J., Sisay, B., Likhayo, P., Mendesil, E., Gohole, L., Tefera, T., (2018).Farmers' knowledge, perceptions, and management practices of the new invasive pest, fall armyworm (Spodoptera frugiperda) in Ethiopia and Kenya. Int. J. Pest Manag. 65 (1), 1–9.

12. Mohammad Sharif Sharifzadeh, Gholamhossein Abdollahzadeh, Christos A. Damalas

13. Tri Joko, Nikie A. Y Dewanti, Hanan L. Dangiran,(2020). "Pesticide Poisoning and the Use of Personal Protective Equipment (PPE) in Indonesian Farmers", Journal of Environmental and Public Health, vol. 2020, Article ID 5379619, 7 pages, 2020.
https://doi.org/10.1155/2020/5379619

14. Okonya, J. S., Petsakos, A., Suarez, V., Nduwayezu, A., Kantungeko, D., Blomme, G., Legg, J. P., & Kroschel, J. (2019). Pesticide use practices in root, tuber, and banana crops by smallholder farmers in Rwanda and Burundi. International journal of environmental research and public health, 16(3), 400.https://doi.org/10.3390/ijerph16030400