Farmers' Attitude, Knowledge, and Awareness of the Risk from Plant Protection Products (PPP) Use: A Case Study in Semani River Catchment, Albania

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Abstract: ***Plant Protection Products have become essential for ensuring food security, but more production endangering the health of farmers, and food safety and may cause environmental pollution. In some countries, the reports on the process of decision-making of farmers in choosing and applying PPPs are often insufficient. A survey of farmers was conducted in the Semani catchment in Albania to explore the level of knowledge and risk awareness on PPPs use along with analyzing the factors that affect certain levels of farmers' behaviors by using multinomial logistic regression. Regarding farmers' knowledge (before PPP application), it was found that more than half of the respondents (57%) have a medium level of knowledge, 66% of them were moderately aware of health risks and 75% of the farmers had a moderate level of awareness about environmental impacts of PPPs. Based on the results of the applied model, a statistically significant relationship between the dependent variable (farmer attitudes) and the independent variable (education* years of experience) was observed. Therefore, developing awareness-raising programs toward PPPs use is highly recommended.***

Keywords: Agriculture, Plant Protection Products (PPPs), food safety, pesticide risk, level of knowledge, multinomial logistic regression and farmers behaviors

1. Introduction

The Global Challenge on food security is to provide food to a world population of approximately 9 billion people by 2050, which would require a raise in food production by some 60 percent (Ngabirano & Birungi 2020). In the food chain, from the producers to consumers, about 35% of production is lost in pre-harvest, due to pests. Therefore, plant protection products (PPPs hereafter) have become essential for ensuring food security (Oerke 2006; Popp, et al., 2013). An ideal PPPs should only be lethal to their target pests, but this is far from reality as non-target organisms are more exposed to PPPs than their target pests (Stanley & Preetha, 2016). PPPs have contaminated almost every part of our environment, e.g., water bodies (de Souza et al., 2020), soil (Sadegh-Zadeh, et al., 2017) biodiversity (Wu, & Chen, 2004), and in the atmosphere (Degrendele et al., 2016). Human exposure to PPPs may occur through professional activities (farmers and farm workers)i.e., acute health effects, or exposure to the general population via contaminated food, water, and air i.e., chronic health effects (Dixit et al., 2019).

European Union (EU) is very strictly regulated and involves a long procedure, including a science-based risk assessment (*Regulation (EC) No 1107/2009,* Regulation (EC) No 396/2005). Pest management decisions are made at the farm level (Möhring et al., 2020). Since 2011, the sustainable use of PPPs has become mandatory for any Member State by implementing National Action Plans with a focus on reducing the risk and impact of pesticide use on human health and the environment (Directive 2009/128/EC. 2009). This directive highlighted the term "Integrated Pest Management" (IPM), where all PPPs users were obliged to follow eight principles of IPM (Barzman et al., 2015). IPM is a well-known approach in developed countries that is centered on the reduction of PPPs use. Yet, an elusive goal in developing countries (Hashemi & Damalas, 2010).

Developing countries have documented more cases of acute poisoning than developed countries, primarily due to poor PPP practices (Dixit et al., 2019). Many reasons might lead to poor plant protection practices, but primarily, due to the lack of knowledge (Akter et al., 2018; Berni et al., 2021) and incorrect perceptions of farmers towards PPP risks. (Hashemi & Damalas 2010; Shammi et al., 2020), adding here the national laws and regulations (van den Berg et al., 2020). This issue is particularly important in countries where agriculture is the predominant income-generating sector, Taking Albania as an example, agriculture plays a substantial role in terms of economic development as it contributes about 20% to the national Gross Domestic Product and about 36% of the Albanian population is employed in the agricultural sector (INSTAT., 2020). Albanian legislation aligns with European directives regulations regarding PPPs in the Albanian market (Law 105/2016) or on plant protection services (Law No. 9362/2005). Presuming that the legislation has regulated the types of PPPs in the Albanian market, their application in the field has been rarely studied so faro the best of our knowledge, there is only one study related to PPP application and it has highlighted the lack of knowledge on PPPs use (Mai et al., 2015). Other studies focused on residues of PPPs in food and the environment have shown that there is already some level of PPP contamination in water (Nuro, et al., 2018), soil (Mukaj et al., 2016) and residues in grapes (Mai et al., 2019), apple (Shahinasi et al., 2019) medicinal and aromatic plants (Brahushi & Kullaj 2014). In a project implemented in Albania using IPM, an overall reduction of 60% of used pesticides was achieved, compared to common practice (Babendreier & Kuhlmann 2014).

In some cases, specific IPM practices are not adopted because farmers' perceptions and preferences are not taken into account. High levels of IPM knowledge have been positively correlated with the adoption level of IPM by farmers (Prudent, et al., 2007). Moreover, farmers' perception ofPPPs' risk to human health, may influence the process of decision-making, regarding their use which can lead to environmental issues. Furthermore, identifying the socio-demographic factors affecting farmers use of PPPs, can be an important step in the design of policies and programs.

The main objective of the current study was to evaluate the level of the farmers' knowledge of PPPs use, and the level of awareness toward the effect of PPPs on human health and the environment. Furthermore, this study aims to identify the factors affecting certain levels of farmers behaviors.

2. Materials and Methods

The Study Area

The Semani River Catchment drains an area of approximately 5, 649 km2 or roughly 23% of Albania's area. Semani catchment is home to 965, 459 people-almost 30% of Albania's population and it has around 40% of the total area occupied by agriculture (MARD, 2018). Field surveys in such large areas are non-representative hence, the Semani catchment was divided into sub-catchments using The Soil and Water Assessment Tool (SWAT) model on ArcGIS 10.3 (Rathjens & Oppelt, 2012). The current study focused on the Thana-Karavasta sub-catchment which covers an area of about 347 km², approximately40% of the surface area of the Lushnje municipality and Divjake together which are considered one of the largest agricultural areas in the country. Thana-Karavasta is bounded, clockwise, by the north between latitudes 40°59'25.2" and 40°79'99''.71 South, and longitudes 19°24'09.3 and19°49'29.7 East (Figure 1.). About 30% of sub-catchment land is a conserved area (National Parks, Special Areas)-about 94 km2-27%. The main land use in the Thana-Karavasta sub-catchment is agriculture about 84% of the land of which 84% is arable land and the rest are permanent crops 13% and heterogeneous agricultural areas 3% (CLC 2018).

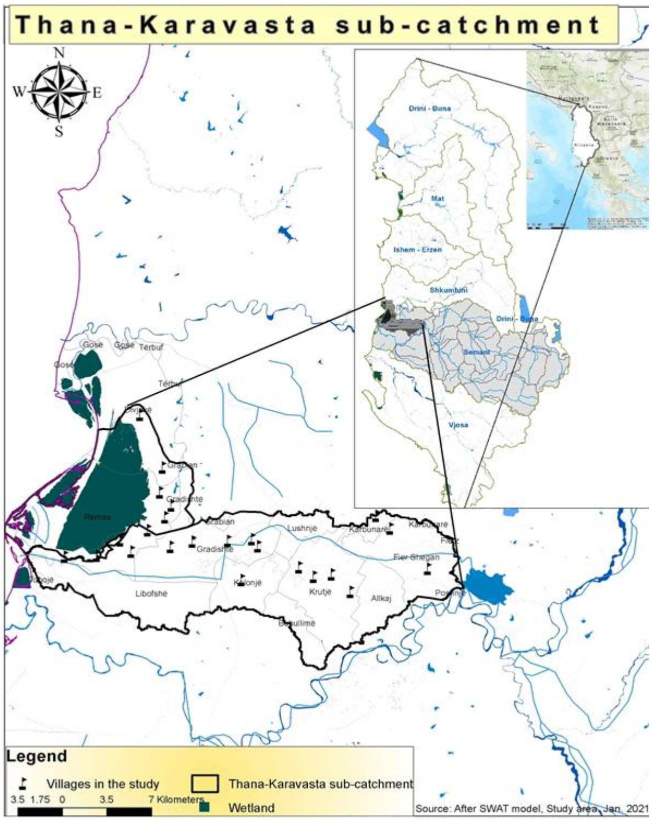

Figure 1: The study area

Sample gathering

The information for this study was gathered from a survey conducted with farmers, which was conducted from June to August 2019, using structured and semi-structured questionnaires. The sample comprised 92 farmers, randomly selected and distributed across 21 villages in the study area. The study combined quantitative and qualitative methods, based on the structured questionnaire. A pilot study with 15 farmers was conducted to test the questionnaire, also made it possible to further refine the close-ended questions to quantify qualitative questions for the subsequent 92 farmers. To test the consistency of the final questionnaire, the Cronbachs alpha test was used. The result of the Cronbachs alpha test was 0.7which indicates the acceptable reliability of the questionnaire.

Questionary design

The questionnaire was divided into three main parts, comprising various types of questions from which the farmers were invited to provide answers. The questionnaire also included socio-demographic information such as gender, age, marital status, educational level, etc. . In all cases, the questions were based on IPM practices, and correct answers were those aligning with IPM principles. The detailed methodology of scoring is found in supplementary materials. The definition of each section of the questionnaire is as follows:

Knowledge section: Included questions to assess farmers knowledge level before applying PPPs. This section of the questionnaire included 6 items, e.g., whether farmers evaluate the state of plants before treatment, if they know the name of PPPs used, if they read the instructions on the PPPs package, if they participated in training on PPPs and plant protection practices, and if they use biocontrol.

Therefore, incorrect answers scored 0, and correct answers could score up to 4 points. The maximum score attainable in this section per farmer was 24 (6 items * 4).

Health Risk Awareness (HRA) section - Included questions to assess farmers awareness levels while and after applying PPPs regarding their health risk. HRA questions included 4 items focusing on practices used by farmers during the spraying of PPPs, and also if they consume food, drink or smoke during PPPs application. Wrong behavior was scored 0 while good behavior was scored 4 with a maximum total score of 16.

Environmental risk awareness (ERA) section-Included questions to test the level of awareness of farmers after applying PPPs regarding environmental concerns. ERA questions included 3 items focusing on the disposal of PPPs containers, where the equipment is washed and the disposal of PPPs leftovers. Wrong behavior was scored 0 while good behavior was scored 4 with a maximum score of 12.

General attitude (Behavior) - is defined in this article as the attitude of the farmers by taking into account their level of knowledge, HRA, and ERA, also quantified as the sum of all the above scores (collected per each section) per each farmer.

Data Analysis

The raw data from the questionnaire survey were reviewed after the interviews and the answers to each question were coded and entered in Excel. Subsequently, data were transferred to an appropriate spreadsheet in SPSS (Version 10) for statistical analysis. After evaluating all questions, a sum of accumulated points is calculated for each farmer. For each group of questions, the average of the scores accumulated by each farmer, the maximum and minimum number of points was determined. Based on the accumulated points per each farmer, each section (Knowledge, HRA, ERA, and also Behavior) was categorized on different levels.

After reviewing the literature, the most appropriate model for the type of our data was multinomial logistic regression. Multinomial logistic regression was used to model nominal outcome variables, in which the log odds of the outcomes are modeled as a linear combination of the predictor variables (SPSS Guide, 2021). Multinomial logistic regression was chosen because the dependent variable has been categorized into three different levels of knowledge. The independent variables were categorical (education) and continuous (age and years of experience).

One of the advantages of this model is similarity to linear regression as well as being easier to be interpreted. But the SPSS program, after running the model, also provides information about the Pearson and deviance chi-square tests for the goodness of fit of the model, the covariance matrix of the parameter estimates, etc.

The two equations of the model are as follow:

$$\ln\frac{P(Atittude = Inadequate)}{P(Atittude = adequate)} = b_{10} + b_{11}([Edu = 2] \times YExp) + b_{12}([Edu = 3] \times YExp) + b_{13}([Edu = 4] \times YExp) + b_{14}([Edu = 5] \times YExp) + b_{15}([Edu = 6] \times YExp) + b_{16}(Age)$$

$$\ln\frac{P(Atittude = Moderatly\ adequate)}{P(Atittude = adequate)} = b_{20} + b_{21}([Edu = 2] \times YExp) + b_{22}([Edu = 3] \times YExp) + b_{23}([Edu = 4] \times YExp) + b_{24}([Edu = 5] \times YExp) + b_{25}([Edu = 6] \times YExp) + b_{26}(Age)$$

Where b ’s are the regression coefficients.

3. Results

Socio-demographic characteristics

The results of the socio-demographic characteristics of the interviewed farmers from the Thana-Karavasta sub-catchment are presented in Table1. Most of the interviewed farmers belonged to the age group of 60-69 followed by the 50-59 age group. 69% interviewed farmers had high school and above educational level, whence 36 % of the participants have been studying agricultural high school. 70% of the participants have been engaged in farming for more than 20 years and 76% of are self-employed on the farm.

Table 1: Socio-demographic characteristics

	Variables	N	%
Age	20-29	1	1%
	30-39	5	5%
	40-49	12	13%
	50-59	33	36%
	60-69	35	38%
	70+	6	7%
Education	Compulsory education	28	31%
	Agricultural High School	34	36%
	General High school	20	22%
	University	10	11%
Experience in Agriculture	1-9 Years	8	9%
	10-19 Years	19	21%
	20-29 Years	26	27%
	30-39 Years	25	27%
	40 +	14	16%
The Main Employment	Employers in the public sector	7	8%
	Employers in the private sector	15	17%
	Self-employed in the non-agricultural sector	0	0%
	Self-employed on the farm	68	76%
	Workers in farm businesses	2	2%

Farmers’ knowledge of PPPs application

Based on the answers from the survey, the farmers’ knowledge of PPPs use was quantified and categorized on three levels, low, medium, and high level of knowledge. These categories are set after defining the average, maximum, and minimum sum of scores gathered by each farmer. The obtained results (Figure 2) show that 57% of farmers had a medium level of knowledge of PPPs application, while 27% of farmers had a low level of

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knowledge. The remaining, 16% of farmers had the proper information for every six items mentioned on material and methods.

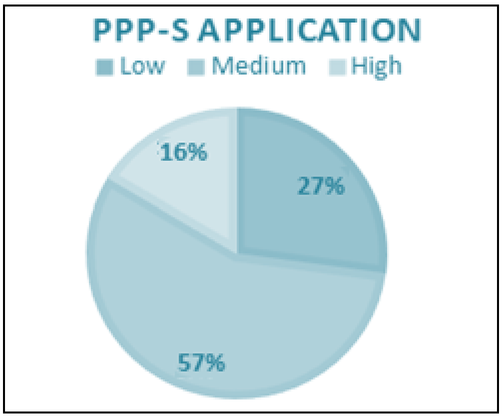

Figure 2: PPPs application

Farmers' health risk awareness from PPPs

The behavioral pattern concerning personal health and hygiene, while handling the PPPs is a great indicator of farmers' awareness of the risk PPPs may cause their health. The findings are presented in the figure below (Figure 3). The results obtained indicate that most of the farmers (66%) had information about protective measures, while the remaining 34%, had a low level of awareness about the issue. Results show an absence of the third category, high levels of awareness of the risk of PPPs.

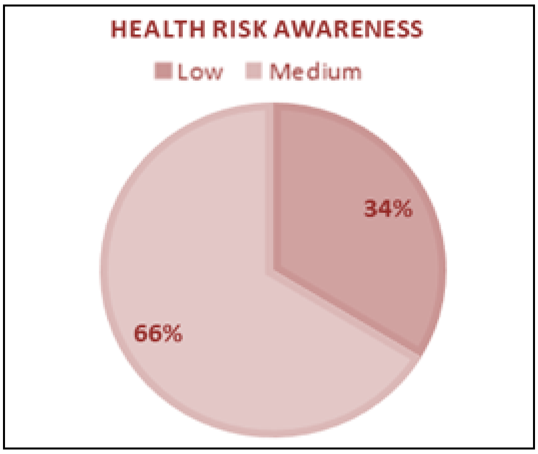

Figure 3: Health risk awareness

Farmers' environmental risk awareness from PPPs

This section sought at determining farmers' level of knowledge about the environmental consequences of PPPs misapplication. In the questions addressed to farmers, the main focus was on three aspects: what was done with the pesticides after they were used, the machinery used to remove them, and where these chemicals were stored. The obtained results (Figure 4) show that 75% of farmers have a medium level of knowledge about the environmental impact of PPPs and 25% have a low level of knowledge on this issue.

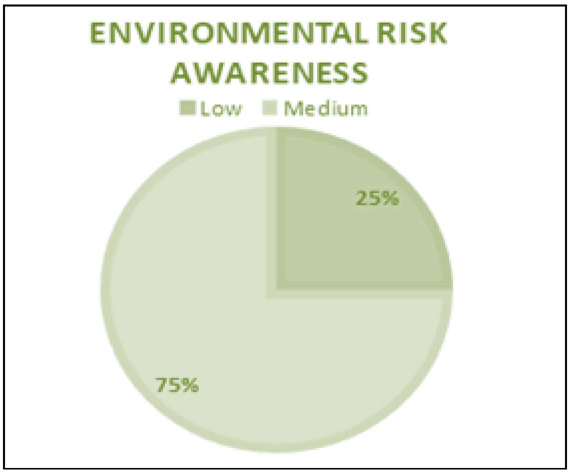

Figure 4: Environmental risk awareness

Farmers' general attitudes toward PPPs use

Following the same method of determining the level of knowledge, health, and environmental risk awareness in the previous sections, this section presents the total score data of farmers' behavior toward PPPs use. The obtained findings are shown as their attitudes in Figure 5. The majority of farmers (63%) have shown a moderately adequate attitude. 27% of them have an inadequate attitude and only 10% of farmers have shown an adequate attitude toward PPPs use.

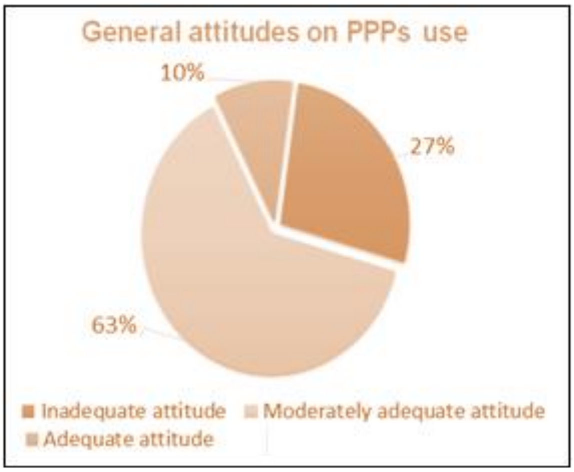

Figure 5: Farmers' general attitudes on PPPs use

Factors affecting farmers' attitudes toward pesticide use

The results of the correlation between factors affecting farmers' attitudes are shown in Table 2. The correlation between farmers' attitudes and education was positive and significant ($r=0.426$, $\rho<0.05$). Also, the correlation between farmers' age and years of experience ($r=0.708$, $\rho<0.01$). However, the correlation of years of experience and education was negative and significant. Looking through the results of the correlation analysis, it was considered logical to combine education and years of experience as a single variable to observe the interaction between them. The results of the regression will be presented in the following part.

Table 2: Results of the correlation analysis

Correlations				
	General attitude	Years of experience	Education	Age
General attitude	1			
Years of experience	-.140	1		
Education	.416**	-.210*	1	
Age	-.101	.708**	-.186	1
Valid N (listwise)	92			
**. Correlation is significant at the 0.01 level (2-tailed).				
*. Correlation is significant at the 0.05 level (2-tailed).				

The model fitness was assessed using the Chi-Square statistic. The chi-square value was 32.127 and the p-value was less than 0.05. This proves that there is a significant relationship between the dependent variable (farmer attitudes) and independent variables in the final model. The chi-square statistic Education * Years of experience were significant (126.991, p<0.05), indicating that this interaction had a significant effect on the attitude of farmers.

The Pearson (118.270) and Deviance (125.605) statistic test proves that the model is fit. Since the tests are not statistically significant, that is the p-value is greater than 0.05.

The Pseudo R-Square measures are Cox and Snell (0.295), Nagelkerke (0.357), and McFadden (0.20). The model accounts for 20% to 35.7% of the variance is explained by the independent variables.

Table 3: Results of multinomial logistic regression and interpretation

	Effect (s)	Model Fitting Criteria	Effect Selection Tests		
		-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Model Summary	Intercept	128.631	1.641	2	.440
	Age	128.020	1.029	2	.598
	Education * Years of experience	158.093	31.102	10	.001
Final Model		126.991	32.127	12	.001
Goodness-of-Fit		Pearson	118.270	162	.996
		Deviance	125.605	162	.985
Pseudo R-Square		Nagelkerke			.357

The likelihood ratio test proves that the independent variable like the age of farmers was not statistically significant (p-value = 0.598 >0.05). This proves that the age of farmers does not affect their attitude. While the predictor Education * Years of experience was statistically significant (ρ value=0.00 1<0.05). Thus, in this case, the null hypothesis was rejected and the alternative hypothesis was accepted.

The probability of the respondents whose years of experience increased and who had completed compulsory education that belonged to the inadequate attitude group was likely to increase by 4.759 times compared to farmers that have shown adequate attitude. This coefficient was statistically significant. For the farmers that had inadequate attitudes, the probability that the attitudes will ameliorate compared to those with adequate attitude levels is 4.795 times if farmers have completed compulsory education and have experience in agriculture.

The likelihood that respondents with more years of experience and who have completed agriculture high school belong to the inadequate attitude category was likely to increase by 1.160 times compared to farmers that belong to the adequate attitude group. For the Moderately adequate attitude category, the probability that the level of attitudes increases compared to the adequate attitude category is 1.174 times if farmers have completed agriculture high school and had farming experience.

4. Discussion

In the current study, are assessed farmers' attitudes, knowledge, and risk awareness regarding their health and environment regarding the use of PPPs. The mean age of 92 participated farmers in the study was 57 ± 10.1 years and 80% of the farmers were over 50 years. Age is an important factor in the risk awareness of farmers about the application of PPPs. Based on obtained results of the logistic regression model, age does not affect farmers' attitudes about the use of PPPs, but there are other studies (Tijani & Sofoluwe 2012), which demonstrate that older farmers may not be aware of pesticide application due to their low level of knowledge.

Farmers' level of attitudes about PPPs is linked with their educational status. When we looked at the educational status of the farmers included in the study, it was identified that 31.5% were elementary school graduates, 57.6% were high school graduates and 10.9% were university graduates. According to correlation analysis, there is a relationship between farmers' education and their attitudes. Farmers in our region have important know-how to practice farming when 36% of them are specially educated in agriculture. Educated farmers may read publications and access information through the Internet, which reduces the lack of information (Tijani & Sofoluwe 2012).

Experience in agriculture is an important factor in gaining new skills. The farmers who participated in our study had been engaged in farming for a mean duration of 25.6 ±11.7 years and it is expected that they have already experienced plant protection use and management. Correlation analysis indicates that there is no relationship between experience in agriculture and farmers' attitude. But experience and education together have a significant effect on the farmers' attitude toward PPPs use.

Regarding farmers' knowledge about PPPs application, it was found from the survey that more than half of the respondents (57%) have a medium level of knowledge. Meanwhile, 16% of the farmers belonged to a high level of knowledge and only 27% had a low level of knowledge about PPPs application. This result is in line with the study conducted by (Mai et al., 2015) in Albania, where 47% of respondents had received information about the safe use of PPPs.

The next two sections of the survey were specifically designed to highlight farmers' risk awareness about health and the environment when they use PPPs. The obtained data show that 66% of the farmers moderately answered about risk they face when they are using PPPs and 34% of them had a low level of awareness. The conducted study by (Mai S., et al., 2015) in Albania has found that 38% of farmers do not use any PPE, whereas our data show that only 25% of farmers do not use PPE, and 65% of them use PPE with 1 to 3 items (Gloves, mask, or long-sleeves shirts) which leaves them exposed to the risk of PPPs on their health. The main reason for this lack of PPE use is the high price of PPE. Having insufficient knowledge about protective equipment and not knowing the benefits to avoid pesticide exposure can lead to a direct effect on the health of the operators. Especially in developing countries, the application risk of pesticides and the unsafe disposal of pesticide containers not only harm the health of farmers but also cause serious damage to the environment and public health (Sarkar et al., 2021). In the current study, it was found that 75% of the farmers had a moderate level of awareness about the environmental impacts of PPPs use and the rest had a low level of the issue. The fact that farmers are more aware of the risk that PPPs have to the environment than to their health can be explained by the presence in the media on such topics and also the background of the surveyor is more related to the environment and it may have influenced their response.

The obtained results of the multinomial logistic regression of the 92 observations are presented in Table 2. The goodness of fit of the model shows an acceptable pseudo-R-square of 0.36 and is significant at the 5% level, suggesting that 36% of the variability in perception can be explained by sets of variables selected in the regression model. The model focused on the variables that influence farmers' attitudes when using PPPs. Age (AGE) was negative and insignificant at 1% and 5% alpha levels respectively to understand farmers' attitudes about PPPs use. The negative sign of the variable (AGE) indicates that the majority of the farmers interviewed are seniors, with a mean age of 57 years, and that their principal activity is farming. These farmers, although aware of the risk of PPPs and still very limited because of their low education levels. This can be explained by the fact that nearly 30% of the respondents had attended compulsory education. The significant association of the variable (education* years of experience) in the level of farmers' attitudes toward PPPs use shows that a high level of education combined with farming experience explains not only farmers' behaviors but also their good farming practices.

5. Conclusions

The survey conducted in the Semani catchment area of Albania revealed that farmers have a moderate level of knowledge about Plant Protection Products (PPPs) before their application and are not always aware of the risk that PPPs pose to their health during application. The study identified a statistically significant relationship between farmer attitudes and the independent variable of education* years of experience, highlighting the importance of knowledge acquisition in shaping farmers' behaviors. Further, the obtained results demonstrate that farmers in study area have shown a moderately adequate attitude toward the use of PPPs. Inadequate attitudes toward PPPs use among farmers in Albania (about 30%) are serious threats to sustainable food security, food safety, farmers' health, and the environment. Therefore, the survey highlights the need for an awareness-raising program on Plant Protection Products (PPPs). The program should focus on providing comprehensive information, promoting good agricultural practices, emphasizing health risks and safety measures, introducing alternative pest management strategies, tailoring education to different backgrounds, encouraging knowledge sharing, fostering collaboration, monitoring and evaluating the program's impact, and offering incentives for sustainable practices. Implementing these recommendations will enhance farmers' knowledge and attitudes toward responsible PPP use, contributing to the preservation of human health and the environment.

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