UNDERSTANDING FARMERS' BAHAVIOUR REGARDING PESTICIDE USE IN VOJVODINA REGION

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ABSTRACT

Requirements to provide high and stable yields and high-quality agricultural products at reasonable prices are hard to meet without any use of pesticides. However, in addition to significant positive effect their application often has adverse effects on human health and environment. This study aims to uncover crop farmers' behaviour regarding pesticide use in Serbia's region of Vojvodina. The research was conducted based on farmers' self-assessment regarding the application of pesticides. The results show that farmers have a serious and responsible approach concerning certain aspects of pesticide use. They generally follow recommendations, particularly concerning the pre-harvest interval, as well as the washing and maintenance of equipment. However, they often neglect other aspects, especially those related to their own safety protection. The study concludes that the mechanisms of appropriate sharing of information and farmers' education should be addressed by decision-makers and that the advisory service should play a strong role in this process.

Introduction

Historically, harvest was the part of agricultural production that was not affected by diseases, pests, and weeds (Roettele et al., 2018). With the development of agriculture, farmers

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have increasingly protected cultivated crops, seeking to preserve as much of their yield as possible. Today, crop protection is one of the most important activities which aims to reduce the dependence of production results on the harmful effects of weeds, diseases, and pests (Aktar et al., 2009). Crop protection will continue to be one of the key issues in agricultural production, which is strongly suggested by projected world population growth (UN, 2019), its resulting growth in food demand (EU, 2019), climate change with the potential to reduce yields (FAO, 2019), and the degradation of arable land (Prăvălie et al., 2021).

The methods of plant protection have changed over time, but today, in most cases, plant protection is carried out using chemical agents generally known as pesticides (Đokić et al., 2018). The worldwide consumption of pesticides is constantly on the increase and this trend is expected to continue in the future (Sharma et al., 2019). However, recent studies show that changes in the management of pesticides could reduce the global consumption of synthetic pesticides by as much as 42% without any serious negative impact on farm productivity and profitability (Lechenet et al., 2017).

Unfortunately, the application of pesticides does not produce only significant positive effects (Cooper, Dobson, 2007), but also numerous negative externalities (Damalas, 2009). Its main adverse effects are exerted on the health and safety of farmers applying pesticides and non-targeted living beings in the ecosystem. It also causes water, air and soil pollution, and poses many health risks for the consumers who eat food with pesticide residues (Syed et al., 2014).

A wrong choice or improper use of pesticides has both economic and ecological implications (Houbraken et al., 2016). Many negative consequences are unintentional, but that does not reduce the damage. According to Ozkan, the unintended consequences of pesticide application are most often caused by their inappropriate use, which occurs primarily due to their users' lack of knowledge and information (Ozkan, 2009).

One of the unintended consequences of pesticide application is the impact on the person who applies them. To avoid such consequences, personal protection is essential, i.e., wearing a mask, long sleeves, trousers, closed footwear, hats, and gloves; adequate cleaning of clothes and frequent handwashing with soap are also crucial (Salvatore et al., 2008; Furlong et al, 2015). The use of pesticides without protective equipment can cause health problems such as headaches, skin irritation, eye irritation, fatigue, muscle aches, cough, sneezing, excessive sweating, dizziness, nausea, abdominal pain, and vomiting (Houbraken et al., 2016; Bhandari et al., 2018). Hazardous practices include mixing pesticides with bare hands, spraying with brushes or twigs, and testing the concentration of pesticide solution by licking it (Dinham, 2003; Macharia et al., 2013). Nicol has proven that not only farmers who handle pesticides are exposed to health risks, but often their family members are at risk too (Nicol, 2003). It is also important to note that pesticide residues can cause nutrient imbalances and reduce the quality of agricultural products (Bourn, Prescott, 2002; Hou, Wu, 2010).

Apart from providing substantial benefits for agriculture, pesticides may also pose a major threat to all living organisms in an agroecosystem if applied improperly (Timprasert et

al., 2014; Houbraken et al., 2016). Although the purpose of pesticide application is to prevent crop diseases and destroy weeds and pests that endanger yields and the quality of crops, many untargeted plant and animal species, including beneficial predators of pests, are often injured or killed (Roca, 2011). It is well documented that exposure to pesticides has adverse effects on plants (John and Shaike, 2015), vertebrates (Zala, Penn, 2004), birds (Giesy et al., 2003; Iwaniuk et al., 2006), soil microorganisms (Adesodun et al., 2005), fish and other aquatic organisms (Oruç, 2010; Grung et al., 2015).

There are different techniques for the application of pesticides. The roughest division is into manual and mechanized application, the latter of which can be done from the ground (trucks, tractors with sprayers, self-propelled sprayers) or the air (spraying from airplanes) (Carvalho, 2017). Regardless of the method used, pesticide application can cause pollution of air, soil, and water. Pollution can occur from point or non-point sources (Vischetti et al., 2007). Point sources include pollution resulting from activities such as tank filling, washing, and disposal of packaging waste, or from spills and leaks caused by faulty equipment (Carter, 2000). Non-point sources of pollution refer to the application of pesticides through various mechanisms such as spraying, swelling, and rinsing (Screpanti et al., 2005).

An additional health and environmental risk can be posed by pesticide packaging waste if it is improperly discarded (Mello, Scapini, 2016). Leaking pesticide residues from discarded packaging contaminate soil, surface water and groundwater, and can endanger living organisms if they come into contact with it (Patarasiriwong et al., 2013). Therefore, before disposal, it is necessary to prepare pesticide packaging waste for further safe handling. In 2008, the Food and Agriculture Organization and the World Health Organization created a guide to handling pesticide packaging waste (FAO and WHO, 2008). According to FAO and WHO, the method of triple rinsing of pesticides packaging waste before its disposal, proved to be safe. Rinsing should be performed immediately after emptying the packaging. The washed contents should be returned to the sprayer and used on crops (FAO and WHO, 2008). This enables not only the use of the entire contents of the package but also prevents spot contamination.

Burning and burying pesticide packaging waste is considered a highly undesirable practice that should be prohibited since hazardous components are not destroyed in this way, but are emitted into the environment (FAO and WHO, 2008). The Guide recommends different waste disposal solutions such as reversible distribution (returning emptied packaging to dealers), specialized pesticide packaging waste collection centres, and recycling centres (FAO and WHO, 2008). However, for all these waste disposal options to be suitable, certain preconditions have to be fulfilled: infrastructure construction; regulated legislation; active involvement of all stakeholders in the supply chain; developed information mechanism; and social, environmental, and economic acceptance by a specific local community (Patarasiriwong et al., 2013).

Proper handling of pesticides is crucial for the reduction of environmental and health risks. The expertise of those who handle pesticides is highly important for the

implementation of an adequate strategy to reduce the negative impact of pesticides on human health and the environment (Kien, 2015; Houbraken et al., 2016). On the other hand, it is difficult to monitor how the actual farmers act in the field. Sapbamrer and Thammachai (2020) in their systematic review on pesticide safety practices concluded that the information describing pesticide safety practices appears fairly limited and inconsistent. Therefore, this paper aims to uncover behaviour regarding pesticide use (selection of pesticides, following dosage instructions, application timing, frequency of application, weather conditions, pre-harvest interval, and management of packaging waste) among crop farmers in Vojvodina. The research hypothesis is that undesirable practices among farmers regarding the use of pesticides exist, with consequences for the environment and the health of farmers. The research was conducted based on farmers' self-assessment regarding the application of pesticides.

The remainder of the paper is organized as follows: in the next section, the study area is shortly described and the methodology of collecting empirical data and its analysis are explained; after that, research findings are presented and discussed; and finally, conclusions are drawn, recommendations are given to decision-makers, and research limitations are explained and followed by recommendations for future research.

Materials and methods

To achieve the goal of the research, a survey of 400 farmers from the northern Serbian province Vojvodina was conducted. Due to its sustainable share in total employment and foreign trade exchange, agriculture represents an important sector of Serbian economy and Vojvodina was selected for the study because its agriculture is the backbone of the region's development. Favourable natural conditions for agricultural production (in terms of soil, climate, and hydrology) make Vojvodina the most intensive agricultural area in the country (Despotović et al., 2019). According to the latest Census of Agriculture (SORS, 2012), the province has around 2 million hectares of available land, which is 38 percent of the total available land in the country (without Kosovo and Metohija). However, the province share in the total national utilized agricultural area is 46.81%, while the share in the total arable land is 58.34 percent. An additional reason for the selection of Vojvodina as the study area is the fact that the use of synthetic pesticides is more spread among farmers in this region than in the rest of the country. According to Karapandžin and Rodić (2017), 83.78% of agricultural land in Vojvodina is treated with pesticides, which is significantly higher than the average in the country (61.30%). Hence, understanding pesticide use behaviour among farmers in this region is crucial for the promotion of a shift towards more sustainable agricultural practices.

The sample contains different municipalities, in proportion to their participation in the total number of registered farms larger than 10 ha in the province (SORS, 2012). The survey was conducted from April 2017 to January 2018. The selection of farmers within each municipality is random, and their participation is voluntary and anonymous. According to the Code of Academic Integrity of the University of Novi Sad (adopted

on January 30, 2020) which defines the conditions of scientific research work with respondents, for voluntary and anonymous research it is not necessary to obtain a special permit.

The survey questionnaire consists of several parts and is rather complex and extensive (Karapandžin, 2019). For this paper, only a part of the collected data related to pesticide handling was used. Of the total number of surveyed agricultural producers, 15 did not provide answers to all questions of interest for this research. Therefore, they were excluded from further analysis, so the final sample covered 385 subjects. Descriptive statistical methods were used to process the collected data.

Results and Discussion

Basic characteristics of the surveyed farmers and farms are shown in *Table 1*. The data show that the sample is dominated by male farmers with a high school diploma whose only source of income is agriculture. The respondents' average age is 41.59, with an average of 20.95 years of experience in agriculture. Only 34% of the surveyed farmers have a matching education, i.e., some kind of degree in the field of agriculture (*Table 1*). The average farm size is 51.89 ha. A substantial deviation from the average values shows that the sample is heterogeneous regarding the farm size. A smaller number of farms are engaged exclusively in field crop production (40.3%), while other farms carry out mixed field crops and livestock production (*Table 1*). The surveyed population's cooperation with the extension service is at a relatively low level as only 57.4% of the respondents have reported frequent cooperation with it (several times a year).

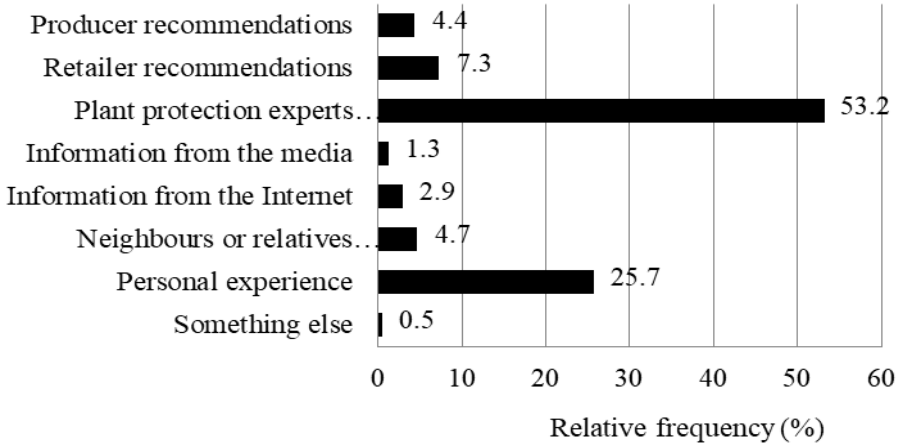
Table 1. Basic characteristics of surveyed farmers and their farms.

Variables	Min-Max/Relative Frequency %	Mean	SD
Gender	female (=0) =2.1 male (=1) =97.9	0.97	n.a.*
Age	20-82	41.59	12.64
Education	elementary (=0) 11.2 secondary (=1) 73.0 tertiary (=2) 15.8	1.05	0.52
Experience in agriculture	2-64	20.95	11.52
Formal education in agriculture	no (=0) =66.0 yes (=1) =34.0	0.34	n.a.
Farm size	10-200 ha	51.89	40.63
Livestock production	no (=0) =40.3 yes (=1) =59.7	0.59	n.a.
Contact with extension service	rarely or never (=0) = 42.6	0.57	n.a.
	frequently (=1)= 57.4		
*n.a. – not applicable			

Source: Authors calculations

The survey results show that the majority of respondents (53.2%) make responsible decisions on the type of pesticides to be applied; i.e., their selection is predominantly based on recommendations by plant protection experts (*Figure 1*). If experts are familiar with the farm's specific features, then the selection of pesticides based on experts' recommendations is to be the advised practice.

Figure 1. Selection of pesticides



Source: Authors calculations

However, it is worrying that as many as a quarter of respondents (25.7%) make their decisions solely based on personal experience. Excessive reliance of Vietnamese farmers on previous experience in creating crop protection strategies of pesticide selection was noticed by Haubraken and associates (Houbraken et al., 2016). They concluded that such practices are not sustainable in the long term and can affect production results, cause pest resistance, and pollute natural resources (Houbraken et al., 2016). Another group of authors noted that negative effects often result from farmers' bad habits (Huang et al., 2020). Considering the surveyed farmers in Vojvodina, it is important to observe the share of farmers who choose pesticides based on partly reliable sources, such as the Internet, the media, and recommendations by neighbours or relatives (*Figure 1*). All this shows that farmers need professional help in choosing pesticides. The easiest way to facilitate this is to further develop an agricultural extension service that offers free expert advice. Such a service already exists in Vojvodina, but it cannot reach every farmer since its capacities are very limited.

Once the pesticides have been selected, farmers should prepare and apply them to their plots. There are several steps in these phases that farmers must perform carefully and conscientiously. *Table 2* shows the results of the farmers' self-evaluation of their adherence to recommendations regarding different elements of pesticide handling.

Table 2. Self-assessment of adherence to pesticide handling recommendations

	NR*	MDR	NRNDR	MR	AFR	Mean	SD
Pre-harvest interval	0.0	0.0	0.5	1.6	97.9	4.97	0.2
Frequency of application	0.0	0.0	1.8	3.1	95.1	4.93	0.32
Washing and maintenance of equipment	0.3	1.0	0.8	5.2	92.7	4.89	0.46
Dosage	1.3	0.8	1.6	9.6	86.8	4.80	0.63
Application timing	0.3	0.0	2.1	17.4	80.3	4.77	0.50
Weather conditions	0.3	0.5	2.3	22.6	74.3	4.70	0.57
Packaging waste management	13.2	1.6	5.2	8.6	71.4	4.23	1.40
Personal safety protection	32.2	14.5	27.0	12.7	13.5	2.61	1.40

*NR - I do not respect at all; MDR – I mostly disrespect; NRNDR - I neither respect nor disrespect; MR - I mostly respect; AFR - I always fully respect

Source: Authors calculations

Over 95% of the respondents claim that they mostly or always follow the recommendations regarding the pre-harvest interval, frequency of application, recommended dosage, application timing, and weather conditions for the application of pesticides. Also, the vast majority of them consider that the way they wash and maintain equipment is in accordance with recommendations. It is dubious, however, how familiar farmers are with the latest recommendations, so such results should be interpreted with caution.

Unfortunately, a certain number of the respondents state that they do not act in accordance with the recommendations, which means that they consciously ignore them. In addition, the results of the research show that the respondents insufficiently adhere to recommendations regarding personal safety protection when handling pesticides. Only 26.2% of the farmers generally or always adopt such recommendations, while 46.7% do not. The fact that they do not use personal protective equipment (gloves, masks, clothing that covers most of the skin, appropriate footwear, hats) is usually justified by experiencing discomfort such as feeling hot (due to long legs and sleeves and wearing a hat), difficult breathing (under a mask), and limited manipulative abilities (due to wearing gloves). These results do not differ significantly from the results obtained in other similar studies which showed that farmers often fail to apply appropriate safety measures when handling pesticides, most often due to discomfort and unavailability of appropriate equipment (Blanco-Munoz, Lacasana, 2011; Bhandari et al., 2018; Sharif Sharifzadeh et al., 2019; Berni et al., 2020; Lari et al., 2020).

The vast majority of farmers (80%) claim that they mostly or always follow the recommendations regarding the handling of packaging waste from pesticides (*Table 2*). However, a closer look at the way packaging waste is handled indicates problems in this regard (*Table 3*). The data in *Table 3* show that only 17.1% of the surveyed farmers properly dispose of pesticide packaging waste, i.e., hand it over to competent subjects after appropriate pre-treatment. The most common way of managing used pesticide packaging includes pre-treatment in the form of triple rinsing, drilling of packaging,

and disposal, together with household waste (29.9%). This type of management of pesticide packaging waste, which belongs to hazardous waste by its characteristics, is not adequate. However, due to a lack of information[5] or practically non-existent options for proper managing of pesticide packaging waste (due to a lack of infrastructure), the conclusion might be that the respondents act conscientiously and in the best possible manner in the given circumstances. Criticism for this should be directed at those who are supposed to provide farmers with the necessary knowledge and information and create infrastructural preconditions for desirable behaviour.

Table 3. Ways of handling pesticide waste packaging (N = 385)

Ways of handling		%
After I wash it three times, I take it to the retailers or someone else who is in charge of its safe disposal.	I also drill it	17.1
	I don't drill it	9.1
After rinsing it three times, I throw it away with household waste.	I also drill it	29.9
	I don't drill it	9.9
After washing it three times, I take it to the landfill near the settlement.	I also drill it	7.5
	I don't drill it	0.5
Without prior preparation, I take it to the retailers or someone else who is in charge of its safe disposal.		1.0
Without prior preparation, I throw it away with household waste.		2.9
Without prior preparation, I take it to the landfill near the settlement.		1.6
Without prior preparation, I throw it in a field or a ditch.		0.5
I burn it.		19.2
I store it on the farm until it is taken away.		0.3
None of the above		0.5
Total		100.0

Source: Authors calculations

It is worrying that as many as 19.2% of the sample respondents burn pesticide packaging waste. This way of handling pesticide packaging waste has been observed by researchers in other populations, for example, among farmers in Vietnam (Houbraken et al., 2016) and in Iran (Bagheri et al., 2018). This is a practice that is dangerous for both the environment and the person involved in the process. Farmers are often aware that this practice is not an adequate way of disposing waste, but they justify this procedure by saying that it is impossible to do it in another way. The share of producers who dispose of pesticide packaging waste in a completely unacceptable way (throwing it in a ditch or a field; on landfills; with municipal waste without prior preparation; or keeping it on the farm) is relatively small. However, this represents an additional indication that there is still a lack of information among farmers about the practices they are not allowed to implement or about those they can and must implement to avoid the negative consequences discussed above.

5 As many as 90.6% of the respondents are not sure where and how they should properly dispose of their pesticide packaging waste.

The vast majority of the respondents, as many as 80.8%, claim that there are people who throw pesticide packaging waste in places that are not intended for that purpose. However, only 29.6% of the sample respondents would report someone doing that. Most often, the reason why they decide not to report such practices is either that they do not know those who do it or, if they do know them, they wish to avoid offending them.

Conclusion

The results of the research suggest that the vast majority of the surveyed farmers assess their handling of pesticides as mainly adequate, i.e., in accordance with recommendations. This refers to the compliance with pre-harvest intervals, dosage, application timing, frequency of application and weather conditions during application, and washing and maintaining the equipment used.

However, a large percentage of farmers stated that they mostly or never follow the recommendations regarding personal safety protection when handling pesticides. Although they are aware of harmful effects of pesticides on their own health, they do not apply protective equipment (gloves, long socks and sleeves, hats, masks) because they feel uncomfortable and restrained. Besides, the majority of the surveyed farmers do not know how to manage pesticide packaging waste properly. Most frequently, the farmers dispose of pesticide packaging waste together with their household waste (with or without prior treatment) simply because they do not know how to do it in a better way. Unfortunately, some farmers carry out dangerous procedures when managing packaging waste, such as burning, disposal on plots and in ditches, or storage on the farm. All these problems are largely caused by insufficient knowledge and information on the proper handling of pesticides, which supports the research hypothesis and clearly indicates that some institutional improvements are needed in this area.

Therefore, the education of farmers regarding the use of pesticides, in the form of various types of formal and informal education, may be recommended to decision-makers. In this process, the extension service should play a significant role. That is why it is important to encourage farmers to cooperate more with this service. Adequately informing farmers is also important, not only by using labels and pictograms on pesticide packaging that farmers often do not even understand, but also through various media channels where farmers will be offered information in ways they can comprehend.

The contribution of this study is in providing empirical data on and practical knowledge of Serbian farmers' behaviour regarding pesticide use. This material could support successful planning and policy-making in this area. Although this research cannot be considered a novelty in the EU, it is innovative in the context of the Western Balkan countries' reality. The obtained results are relevant and essential for policy intervention aimed at the promotion of safer pesticide use thus contributing to the advancement of environmental management in this region.

Like many others, this study is not exempted from limitations that should be noted. First, the study was based on a convenience sample, which means that the application

of its findings to the entire population of Serbian farmers is limited. Second, this research is based on farmers' assessment of their procedures in handling pesticides. Their perception does not necessarily have to correspond to reality since self-reporting studies are often limited by problems related to social desirability bias, consistency, and connection with actual behaviour. A better insight would definitely be gained by using the method of direct observation of farmers. However, at the moment, such research is not feasible due to its high cost.

Although we believe that the study has achieved its aims, there are many questions which should be answered in future research applying this survey's data. For example, one of them is the matter of differences in pesticide use behaviour among farmers regarding their gender, age, level of education, experience in agriculture, farm size, and farm type. Therefore, the final recommendation is that future studies should focus on the influence of demographic and farm characteristics on pesticide use behaviour among farmers.

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Conflict of interests

The authors declare no conflict of interest.

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