

ECONOMIC IMPORTANCE OF USE OF PESTICIDES IN WHEAT PRODUCTION¹

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Summary

Quality and productivity determined by genotypes and application of scientific farming measure in wheat production. The pesticides are contributing to achieving high yield of wheat which application. The aim of this work is economic analysis of pesticides application in wheat production. For analysis used collected data from 32 wheat producers in rural area of Republic Serbia. The results in included farms in this investigation showed that average area of wheat production was 1.6 ha with achieved average grain yield 3621 kg ha⁻¹ and average costs 563.15 € per hectare. The average use of pesticides active ingredients was 892.5 g. Wheat producers applied the different amount of pesticides active ingredients: 646 g (72.44%) of herbicides, 231.7 g (25.96%) of fungicides and 14.3 g (1.60%) insecticides. The average plant protection costs by used pesticides were 70.30 euros ha⁻¹, which was 12.48% of wheat production. The gain threshold computed was 319.54 kg ha⁻¹. For achieving high economic output in wheat production is necessary apply right dose of pesticide, decrease costs of production and continuously provide education of farmers.

Key words: *wheat, economic analysis, pesticides, toxicity, farm*

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Introduction

Wheat (*Triticum aestivum* L.) is one of the important cereal crops and staple food as well source of proteins for about 70% human population in the world. The weeds, pests, diseases and insects are the major source of crop damage, yield and quality reduction in the world. The economic production of wheat depends from scientific measure of farming which contribute prevention of loses of yield (Knezevic et al., 2015). In wheat

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production the application of pesticides is one of important measure in plant protection of attack of pests and diseases that can cause of yield lose. For production of safe food is very important develop new technology of pesticide application, new pesticides with less hazardous for health (Delcour et al., 2015). Pesticides effects of suppressing pathogens on the plants contribute to the higher yield and quality (Aktar et al., 2009). Behind of use of pesticides, other factors that influence to economic production are genotypes, fertilizer and machines. The control of weeds contributes to prevent losses of yield varied depends of crops from 10% to 50%. The economic impact of insect infestation can be significant which cause serious damage of yield and quality of wheat. The bug (Sunn pest [SP] *Eurygaster* spp.) damaged wheat grain endosperm due to injected proteinase that cause disruption of protein structure and caused reduced flour quality, dough properties low bread volume and texture (Torbica et al., 2007; Dizlek, 2017).

Also, attack of cereal leaf beetles (*Oulema* spp.) cause reduction of assimilation between 10% (attack of the single larva) to 80% (massive attack of larvae) what indicated economic threshold of larva per stem and losses of grain. The intensity of attack of cereal leaf beetles are different depends of season and regions (Tanaskovic et al., 2012). In Serbia, cereal leaf beetles sporadically affected cereals wheat, without significant economic damage. However, in the period 1988-1992, it becomes economically the most important pest in cereals, and up to 28% of cereals were chemical treated. However, during 1992-1998, cereal leaf beetle's populations decreased, and only 2-2.5% of wheat area was sprayed (Stamenković, 2000; Jevtić et al., 2002).

Application of herbicides has economic benefit through yield increasing and decline expenses of labour. For the sustainable rural agriculture is necessary develop technology of crops production with achieving economic profitability, social and economic equity and environmental and food security. In conventional farming, from the period of Green revolution the enormous amount of chemicals were used to protect crop damages due to weed, pests and diseases, control, which connected with environmental pollution as well unsafe food products. However, sustainable agriculture need based by use pesticides with the least toxicity, decreasing of energy expenses and increasing yield and profit (Sexton et al., 2007). Modern handling methods, clean technology, can lead to decline presence of contaminated matter and pest attack to seeds or plants. The very important is choice of right type of pesticides and its application of recommended dose at the right time in prevention of negative effect to production costs, pest resistance to pesticides and ill effect on human and animal health, environment and sustainability of agriculture production (Khan et al., 2010). Another advance of right use of pesticides is suppression and reduction of plant pest and diseases and has key role in increasing agricultural production as well income of farmers due to crop production (Nazarian et al., 2013). In Serbia, pesticides play important role in food security due to limited arable land and requirements of user for improving food security and protecting the environment.

The aim of this investigation was evaluation of economics of pesticide use in wheat production to determine the farm-level economic cost and amount of pesticides used in wheat production for rural development.

Material and methods

In wheat production in 2015 obtained 2418203 tons, approximately. The wheat production realized on 589922 ha approximately, what is the second large area in production among cereal crops in Serbia (source data of statistical office of government of Republic of Serbia). For our study were included 32 wheat farmers in different location of Serbia. The farm was chosen by simple random sampling method. The obtained data in structured questionnaires submitted to farmers were analyzed for farm size and structure, farmers experience and education for agricultural production, area under wheat production, applied quantity and type of pesticides, data of grain yield. By frequency presented characteristics of farmers. Toxicity of pesticides determined according to classification by WHO (2009). Economic cost of pesticides per hectare computed by formula: $EC = Q \times P$

Economic cost = Quantity of active ingredient of pesticide (g ha⁻¹) x Price of pesticide (l €⁻¹)

The gain threshold can be calculated with the following formula:

$$\text{Gain threshold (kg ha}^{-1}\text{)} = \frac{\text{Costs of used pesticides (EUR ha}^{-1}\text{)}}{\text{Average price of wheat (EUR kg}^{-1}\text{)}}$$

Results

The analysis of agricultural properties showed variation of size and structure household, production of agricultural plant species, type of technology of cultivation. Mainly individual farmers are produce for their own consumption and surplus for the market.

In analyzed individual farms, the average size of cultivated area was 5.8 ha of which 27.8% (1.6 ha) used for wheat production (Table 1).

In wheat production, the farmers expressed interest in optimization of technology growing practices in the aim to increase grain yield and make profit.

Table 1. Size of farms and its characteristics

Farm characteristics	Average (ha)	Area under cultivar production	Average (ha)
Farm size - ownership	5.8	Cultivate area	5.8
Irrigated area	-	Wheat area	1.6
Non-irrigated area	5.8	Other crops area production	4.2

Source: Work of author

In this investigation age of the farmers was 56.2 years, which in average 30.6 years were producers of wheat. In included family were 3.8 people, which in average had 8.2 years of education. In average 2.3 people per family are working on crop production (Table 2).

Table 2. Farmer's family characteristics

Personal characteristics	Year	Structure of family	Average
Age of farmers	56.2	Number of people in family	3.8
Experience of farmers	30.6	People in family, working on crop production	2.3
Education of farmers	8.2		

Source: Work of author

Wheat is produced in dry land farming. Pesticides used as integral part of the process for reducing losses of yield caused by weeds, diseases insect pests. The intensive infestation of weeds, particularly are in the early stage of crop development, what require use of herbicides for suppressing weed effect on grain yield i.e. providing economic benefit (Křen et al., 2017).

The knowledge and experience of how to use of pesticides, farmers learn on different way. Farmers for decision of pesticide application have numerous sources as well internet information, information from extension services advices, input dealers and pesticide labels. Mainly, farmers watched special agricultural programs 87.50% (28 farmers) while for needs of agriculture used internet about 18.75% (six farmers). About 65.6% (21) of farmers participated at some special meeting for wheat production, while 25% (eight farmers) participate at the meeting for plant protection. Instruction on the labels for pesticide application read 81.25% of producers (Table 3).

Table 3. Sources of farmers' taking knowledge (specialization)

Source of knowledge	Number of farmers	%
Watching Special agricultural program	28	87.50
Internet data	6	18.75
Participation at the special meeting	21	65.62
Participate at the meeting for plant protection	8	25.00
Instruction on pesticide package	26	81.25

Source: Work of author

The information on the label is very important source of knowledge for the farmers how to safe use and apply pesticides (Waichman et al., 2007).

No segment of the population is completely protected against exposure to pesticides. The high-risk groups exposed to pesticides include production workers, formulators, sprayers, loaders and agricultural workers. Especially, the high-risk groups are people that are in contact with pesticides. Exposure to pesticides linked to negative effect of immune function, liver, intelligence, cardiovascular a respiratory function, reproductive abnormality cancer (Sarwar, 2015). Among them, the farmers belong to the risk group and need take measure of preservation of pesticides toxicity. For the safety is very important method of pesticide application, use of protective equipment and cloths. In this study, the 71.87% of farmers applied pesticides by mechanical spraying and 15.62% of farmers applied manually. Among them about 46.87% of producers, used protective equipment and 25.00% used protective clothing. Most of farmers 87.50% who are prefer use more safe techniques to protect environment during agricultural production (Table 4).

Table 4. Method of application of pesticide

Type of equipment and behavior of farmers	Number of farmers	%
Mechanical spraying	23	71.87
Manual application of pesticides	5	15.62
Use protective equipment	15	46.87
Use protective clothing	8	25.00
Use of safe techniques for environmental protection	28	87.5

Source: Work of author

Plant protection problems such as pests, weeds and diseases are the major factors decreasing wheat production. These pests, weeds and diseases can cause economical losses in wheat crops. The controlling of pests, weeds and diseases can have carried out as mechanical control or by hand. Chemicals which used by adequate techniques are efficient to suppress wheat pests, weeds and disease. About 75.00% of farmers use pesticides against weed, 53.12% against diseases and 18.75% against the insect pests (Table 5).

Table 5. Farmers control of wheat crops by pesticide application

Biotic stress factor	n	%
Weed seed control	24	75.00
Diseases control	17	53.12
Pest control	6	18.75

Source: Work of author

In wheat production applied pesticides which contributed to the growth of crop productivity as well food supply. The pesticides used by the farmers in wheat production presented in table 6. Pesticides were grouped by their toxicity classification and their chemical family (WHO, 2009).

Table 6. Pesticides used in wheat production in research area

Type of pesticides	Trade name of pesticides	Active pesticide ingredient	Toxicity class	No. of farmers	%
Herbicides	Metmark WP	Metsulfuron methyl	U	18	56.25
Herbicides	Stockstar	Tribenuron	U	2	6.25
Herbicides	Lancelot 450 WG	Aminopyralid + Florasulam	U	1	3.12
Herbicides	Duofen plus	Thiophanate-methyl	U	3	9.38
Fungicides	Zantra	Tebuconazole	II	6	18.75
Fungicides	Akord	Tebuconazole	II	11	34.38
Insecticides	Decis Expert 2.5EC	Deltamethrin	II	4	12.5
Insecticides	Tors	Bifenthrin	II	1	3.12
Insecticides	Nurelle D	Chlorpyrifos methyl + Cypermethrin	II +III	1	3.12

Pesticides level of hazardous-classification (WHO, 2009): Ia = Extremely hazardous; Ib = Highly hazardous; II = Moderately hazardous; III = slightly hazardous; U = Unlikely to present acute hazard in normal use; FM = Fumigant, not classified; O = Obsolete as pesticide, not classified.

Source: Work of author

In our study wheat farmers, the nine different types of pesticides were used. Among 32 farmers the four types of herbicides: used in wheat production. Most of the farmers used herbicide Metmark WP which active ingredient is Metsulfuron methyl (56.25%). Some of wheat farmers used active herbicides ingredient Thiophanate-methyl (9.38%), Tribenuron (6.25%), Aminopyralid + Florasulam (3.12%). According to WHO classification the toxicity of all applied herbicides classified in U group (Table 6). Among the 32 wheat farmers the type of fungicide commonly used by the farmers was identified as Tebuconazole, which classified as moderately hazardous (II group of toxicity). The two trade makes (Zantra and Acord) of fungicides were used by 53.13% of the farmers as protection from fungal diseases in wheat production (Table 6).

The insecticides commonly used by the farmers were identified as Deltamethrin (12.5%), Bifenthrin (3.12%) and Chlorpyrifos methyl + Cypermethrin used by 3.12% of the farmers (table 6).

Results of this research show that, the average usage of pesticides is 892.5 g per hectare as an active ingredient in the wheat production. The average amount of active ingredient of herbicides usages per hectare was 646.5 g, of fungicides 231.7 g and insecticides 14.3 g.

Data of study in villages of in West Mediterranean region of Turkey, showed that average usage of pesticides were 1103.5 g per hectare as an active ingredient in the wheat production. Precisely, average amount per hectare of active ingredient 48.0 g of insecticides, 146.0 g of fungicides and 908.9 g of herbicides were used (Yilmaz et al., 2016). In addition, they reported that in another similar study in 2001 year were established that average usage per hectare as active ingredient of pesticides variate depends of region. Therefore, active ingredient of herbicides was 595.90 g (in Polatli, Ankara, Turkey) while 887.3 g (in Konya, Turkey), and active ingredient of fungicides was 78.3 g (in Polatli, Ankara, Turkey) and 40.60 g (in Konya, Turkey).

The differences of used amount of pesticides affected by weather, season, pest pressure, price of pesticides and technical equipment. Therefore, in Serbia cereal leaf beetle sprayed 28% of wheat area in period 1988-1992, while only 2-2.5% of wheat area was sprayed in period 1992-1998 (Stamenkovic, 2000).

In Serbia wheat grown on about six hundred thousand hectares per annum with total production over the 2.0 million tons. According to official report in Serbia realized the average wheat grain yield 3400 kg ha⁻¹ with expenses for application of pesticides in average 92.0 € ha⁻¹. The amount of pesticides use in wheat production in Serbia is not significant different in comparison to European Union countries. However, in Serbia, EU and all over the world there are concerns about negative influences of pesticides on human health, food safety and environment in some regions.

Table 7. Pesticides used in wheat production in research area

Type of pesticides	Used amount of active ingredient of pesticides		Recommended amount (g; ml) ha ⁻¹	Pesticide + Pesticide application cost	
	(g; ml) ha ⁻¹	%		(€ ha ⁻¹)	%
Herbicides	646.5	72.44	600	10.10	14.37
Fungicides	231.7	25.96	250	30.80	43.81
Insecticides	14.3	1.60	10	29.40	41.82
Total amount	892.5	100.00	860	70.30	100.00

Source: Work of author

In wheat production in this investigation the highest share of used pesticides had herbicides 72.44% of total weight of active ingredients, then fungicides 25.96% and insecticides 1.60%. The economic costs were 70.30 € per hectare. The share in this price was 43.81%, of fungicides, 41.82% of insecticides and 14.37% of herbicides (Table 7).

By analysis were established that farmers use herbicides and insecticides more than the recommended, fungicides less than the recommended dosages extension services advices, instruction of pesticide labels. The application of inadequate amounts of pesticides (increased or decreased) can lead to inefficient, crop and economic losses and environmental hazards.

In this investigation the average costs of wheat production were established to be 563.15 euros per hectare, with share of pesticides cost 70.3 € per hectare, with portion of 12.48% of average production cost. The average yield included farms in this study, was 3621.0 kg ha⁻¹. In this study were computed that cost of pesticide per kilogram amounted to 0.019 € and the cost of production per kilogram 0.155 € (Table 8).

Table 8. Cost of wheat protection and production in research area

Average grain yield kg ha ⁻¹	Average costs of applied pesticides (€ ha ⁻¹)	Proportion of pesticides cost and grain yield (€ kg ⁻¹)	Average production costs (€ ha ⁻¹)	Average costs production of wheat (€ kg ⁻¹)	Proportion of plant protection costs in average production costs (%)
3621	70.3	0.019	563.15	0.155	12.48

Source: Work of author

For decision of use pesticides, the producers conduct estimation of level of pest infestation. On the base of gain threshold can estimate does pesticide treatment economically justified. Gain thresholds are a simple way to determine the relationship between the pesticide and pesticide application costs and the value of the harvested crop. In this study in wheat production the average pesticide costs was 70.30 € and price of harvested wheat grain was 0.22 €. The gain threshold computed was 319.54 kg ha⁻¹ and it was 8.82% of wheat production per hectare. This mean that increase of grain yield has to be 319.54 kg ha⁻¹ for economically justified pesticide application.

The improvement of scientific farming measure can contribute profitability of wheat production which can estimate on the base of yield value (Pretty and Bharucha, 2014).

Benefits of use of pesticides

The need of use of pesticides is to ensure and improve the yield and quality of products and industrial processes in function to provide safe food and high standard of health in society. Numerous pesticides provide protection against dangerous pest and diseases or their vectors. Some pesticides are used to preserve the perishability of the product during storage i.e., to protect the time usability of goods, food, products. Without use of targeted pesticides, many products (coating, sealants) cannot be use for consumers, but products enable placing on market without or with low content of pesticides to protect environment. The use of pesticides requires assessment of the economic feasibility and safety for human health and environment, social consciousness and International cooperation and competitiveness (Sexton et al., 2007). In recent time, political measured and demands of numerous professional and public associations directed to carefully examine impact of pesticides on environmental and human health as well pesticide benefits, risks and their application in accordance with hygienic standards.

The very important is knowledge about benefits and risks of pesticides and their rational application with the motto “as much as necessary, and as little as possible.” This way of application giving to benefits of pesticides through achieve optimal results and long-term efficacy of the treatment, reducing potential risks to health and environment, well targeted manner uses in intended fields. In European Union developed action for sustainable use of pesticides for plant protection products in the aim of harmonized social environmental and economic impact (Directive 2009/128/EC). The ecological basis needs to be put in balanced proportion to socio-economic aspects. For sustainable use of pesticides is necessary conduct education for safety data of pesticide application, poisoning incidents with provable health damage, control of tools and machine and best practice of pesticides application, monitoring of risk and benefits of appropriate use of pesticides, rules of disposal of pesticides products after their use phase and of their packaging.

Crop production and protection from the losses

The significant attention in agriculture has production of crops which are major in food of human population. Among them the three crops (wheat, rice, maize) spread in production on about 40% of total cropland and are important essential resources of proteins, carbohydrates, lipids, vitamins, microelements in human nutrition all over the world. Also, soybean, cotton, sunflower, barley, rye, out, sorghum take significant place in agricultural production for the food of human and animals. The aims of agricultural production are increasing yield and quality of crops and reducing losses (Knezevic et al., 2017). Improved crop management based on selection of high yielding genotypes, improved soil fertility by application of fertilizers, irrigation, application pesticide contributed to increasing of yield in agricultural crops (Paunovic et al. 2009; Kondic et al., 2012). However, in diverse agro-ecosystems the crop production conducted under pressure of biotic and abiotic limited factors (pests, insects, rodents, drought, frost, high and low temperature air, etc.) which cause reduced yield and quality.

Among crops the loss potential of pests worldwide varied depends of crops and in barley can achieve below 50% in sugar beet and cotton more than 80%, On the beginning of 21st century losses in wheat, barley, soybean, sugar beet and cotton are estimated at 26-30%, while for maize-35%, potatoes-39% and rice-40%, respectively (Oerke and Dehne, 2004).

The very important for wheat producers is how to recognize the economic ceiling i.e. the maximum yields that make economic sense, given by the relative prices of input and outputs, risk and other factors (Sumberg 2012). Similar in study of Loyce et al. (2012) found that agronomic optimum could differ depends to the soil-weather conditions and crop management practices but also by the degree of risk. The greater potential of costs optimization is in crop protection compared to costs of crop nutrition.

Pesticides have been a major contributor to the growth of crop productivity and food supply (Sexton et al., 2007). The weeds had the highest loss potential (32%) while the less effect have animal pests (18%) and pathogens (15%). In addition, due to viruses estimated serious problems in potatoes and sugar beets in some areas in average 6-7% and in other crops about 1-3% (Oerke and Dehne, 2004).

The measures of protection showed the highest efficacy at 53-68% and lower between 43-50% of protection in food crops. The protection depends from agro-ecological region and highest coefficient of efficacy in wheat was 28%. The control of weed can conduct by mechanical removal and herbicides and efficiency of weed control is higher (68%) than control of animal pests (39%) and diseases (32%) by using of pesticides (Oerke and Dehne, 2004). The increasing of quantity of crop production and food is possible through increasing productivity per unit area. This is possible on the base intensification of pest control in various crops. When the pest problem is managed at the proper time it improves the crop productivity. Therefore, use of pesticide of appropriate dose and time contributes to improving the crop productivity and quality (Khan et al., 2010). Using of pesticides than the recommended dose can decline protection efficacy. Considering the task of preventing negative effects on the environment the prevention of losses in crop production can achieve by integrated pest management.

Conclusion

Application of pesticides can prevent losses caused by pests in agricultural production and can improve quantity and quality of the produce. In this study showed that average area of wheat production was 1.6 hectare with average yield 3621.0 kg ha⁻¹ and with average cost of wheat production was 563.15€. In average use of pesticides active ingredient was 892.5 g ha⁻¹ with costs 70.30 € what is 12.48% of wheat production costs. In analysis of use of pesticides in wheat production in the individual farms in Serbia showed that the gain threshold was 319.54 kg ha⁻¹ what is 8.80% of wheat production per hectare, what is economically justified.

In study was found that the farmers applied herbicides and insecticides more than recommended amount and insecticides less than recommended amount, what leads

losses of yield, increase of costs, economic loss and negative effect on environment. This require intensive education of the farmers related to pesticide application (methodology, legislation, equipment) to achieve the maximum benefits at minimum human, environmental and economic costs.

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EKONOMSKI ZNAČAJ UPOTREBE PESTICIDA U PROIZVODNJI PŠENICE

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Rezime

Genotip i tehnologija gajenja determinišu kvalitet i produktivnost pšenice. Izbor genotipa pšenice sa visokim potencijalom za prinose i kvalitet i visoku adaptivnost na biotičke i abiotičke faktore stresa, doprinosi ekonomskoj proizvodnji kroz smanjenje upotrebe hemikalija i đubriva u toku gajenja. Takođe, vrlo je važno optimizovati dozu pesticida za primenu za zaštitu biljaka od štetočina i bolesti. Cilj ovog rada je ekonomska analiza primene pesticida u proizvodnji pšenice. Za analizu su korišćeni podaci prikupljeni od 32 proizvođača pšenice u ruralnom području Republike Srbije. Rezultati ovih istraživanja kod ispitivanih poljoprivrednika su pokazali da je prosečna površina za proizvodnju pšenice bila 1,6 hektara sa ostvarenim prosečnim prinosom zrna od 3621,0 kg ha⁻¹ i prosečnim troškovima 563,15 evra po hektaru. Uporebljena prosečna količina aktivne materije pesticida iznosila je 892,5 g. Primenjene su različite količine aktivne materije korišćenih pesticida. Ova analiza je pokazala da su proizvođači pšenice koristili 646 g (72,44%) hemijski aktivne materije herbicida, 231,7 g (25,96%) hemijski aktivne materije fungicida i 14,3 g (1,60%) hemijski aktivne materije insekticida. Na bazi primenjene doze pesticida prosečni troškovi za zaštitu bilja su izračunati i iznosili su 70,30 evra po hektaru, što je 12,48% troškova proizvodnje pšenice. Prag dobiti upotrebe pesticida je povećanje prinosa od 319,54 kg ha⁻¹. Pesticidi doprinose postizanju visokih prinosa pšenice čija primena treba da se optimizuje u cilju smanjenja rizika pri njihovom korišćenju, zaštite životne sredine, obezbeđenja hrane i održivosti ruralnog razvoja. Ovo se može postići kroz programe edukacije poljoprivrednika, razvoj novih tehnologija primene pesticida, kao i ponudom i kreiranjem novih manje toksičnih pesticida.

Ključne reči: pšenica, ekonomska analiza, pesticidi, toksičnost, farma

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