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EVALUATION OF TECHNOLOGICAL, ECONOMIC AND SOCIAL INDICATORS OF DIFFERENT FARMING PRACTICES IN LITHUANIA

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ABSTRACT. Organic and integrated farming practices contribute to protecting biodiversity, reducing environmental pollution, improving soil quality, and providing high-quality raw material for food industry. The objective of the article is to establish the methodology and evaluate the system of indicators, which enables answering the question which farming practice has more advantages: organic or integrated? Multi-criteria analysis methods were used to achieve this objective. When being compared with between conventional and integrated farming practices, organic farming practice achieves higher profitability and greater energy efficiency. Organic farming reveals to be either superior, or similar to integrated farming practices in environmental terms. Potatoes, fruits and berries under both conventional and integrated farming practices have obtained the same rank (1–2) according to the selected criterions (yield, share of sold product, expenses on plant protection, production cost, price and labour input). Organic farming practice has shown worse rank. Organic farming practice has appeared to be the most suitable for vegetables.

JEL Classification:C44, Q15, Q18

Keywords: integrated farming practices; Lithuania; multi-criteria analysis; organic farming practices.

Introduction

Current trends in agriculture development are focused not only on economic performance, but also on the consequences of corporate activities for the environment and sustainabality (Rajnoha, Lesníkova, 2016; Balas, 2014; Czyżewski, Smędzik-Ambroży, 2015).

In terms of sustainability there are two main farming practices in Lithuania being practiced in recent years: organic and integrated farming. Organic farming encourages the increasing supply of valuable crop production, protecting biodiversity, reducing environmental pollution, and improving soil quality. Integrated farming practice aims to encourage farmers who grow fruits, berries and vegetables, to introduce environmentally friendly production techniques so that to reduce environmental pollution (Rural Development Programme, 2017). Both these farming practices are important for consumers because they provide high-quality raw material for food industry. But both agricultural producers and policy-makers raise the question which of these farming practices is more relevant in terms of sustainability. Thus, a research problem emerges concerning how to evaluate, determine and compare technological, economic and social indicators of organic and integrated farming practices.

The practical relevance of this article is that it is pursuing to adopt research-grounded policy decisions. Therefore, it is essential to develop and apply the assessment methodology based on quantitative and qualitative methods, leading to further assessment of the potential impacts from organic and integrated farming practices.

The objective of this article is to create the methodology and evaluate the system of indicators, which would enable answering the question which farming practice has more advantages: organic or integrated? Intense competition is being currently observed between these sectors in agriculture. It is worth also noting that the economic issues behind comparing the farming practices in Lithuania are yet not explored.

The object of this research is sustainable farming practices.

Referring to the economy of ecosystems and the results of the research, considering agricultural production technologies and the requirements to organic and integrated farming practices, an integrated set of data was compiled, covering technological, economic and environmental indicators. Multi-criteria analysis methods were used to achieve the objective posed in this article.

1. Literature review

Scientific discussion concerning the most appropriate farming practices in terms of sustainability has become significant among policy decision makers and practitioners in recent years. Organic farming practices is well known and considered as a promising option to sustain both agriculture productivity and environment (Delmotte *et al.*, 2016; Jouzi *et al.*, 2016; Kirchmann *et al.*, 2016; Tasca, 2017; Balezentis, 2014). Organic farming offers innovative conservation agriculture principles, including minimal soil disturbance (reduced tillage, no-tillage, green manures), permanent soil cover and long crop rotation mean duration of six years (Peigne *et al.*, 2016). This helps to reduce use of mineral fertilizers, control weeds without the use of herbicides, without losses of yield. Organic farming is more energy efficient compare to conventional almost for all types of crops when expressed on a unit of area. Results are more variable per unit of product because of lower organic yields (Smith *et al.*, 2015). Although organic agriculture produces lower yields than conventional agriculture, it better unites human health, environment and socioeconomic objectives than conventional farming practice (Crowder, Reganold, 2015; Streimikiene, Bilan, 2015).

The evaluation of the economic and environmental trade-offs between different farming practices revealed that the gross margins of organic farming practices were found to be higher than the corresponding conventional farming practices gross margins. Organic farming practices perform better than integrated farming practices and conventional farming practices with respect to nitrogen losses, pesticide risk, herbaceous plant biodiversity and most of the other environmental indicators. Considering the regional and site-specific soil and

climate conditions on the environmental performances of the farming practices it was observed that on hilly soils, erosion was higher in organic farming practices than in conventional farming practices. The pesticide and the nitrogen indicators showed a similar environmental impact caused by integrated and conventional farming practices (Pacini *et al.*, 2003). For organic farming practice, as a consequence, some production factors are used less efficiently, thus partly negating the advantages of organic farming. Furthermore, the different manure management strategy leads to relatively high nutrient losses in relation to yield. These two points were shown to be the main priorities for the environmental optimisation of organic farming practice (Nemecek *et al.*, 2011).

Escalating production costs, heavy reliance on non-renewable resources, reduced biodiversity, water contamination, chemical residues in food, soil degradation and health risks to farmworkers handling pesticides all bring into question the sustainability of conventional farming practice. The organic farming practises are less efficient, pose greater health risks and produce half the yields of conventional farming practice. Nevertheless, organic farming became one of the fastest growing segments of agriculture in the United States of America and European Union (EU). Integrated farming, using a combination of organic and conventional techniques, has been successfully adopted on a wide scale in Europe (Reiff *et al.*, 2016). Comparative analysis carried out by Reganold *et al.* (2001) on sustainability of organic, conventional and integrated apple production systems gave similar apple yields and showed that organic and integrated practices had higher soil quality and potentially lower negative environmental impact than the conventional farming practice. When compared with the conventional and integrated farming practices, the organic farming practice produced higher profitability and greater energy efficiency. The organic farming practice ranked first in environmental and economic sustainability, the integrated farming practice second and the conventional farming practice last (Reganold *et al.*, 2001).

In the overall assessment organic farming was revealed to be either superior or similar to integrated farming practices in environmental terms. Integrated farming practice, which is the base of the "Environmentally friendly fruits and vegetables cultivation system", according to the scientists within the field of ecology and environment (Kirchmann, Bergstrom, 2008; Posner *et al.*, 2008), is one of the most promising and advisable activities to apply in the agricultural sector.

Organic farming has its main strengths in better resource conservation, since the farming practice relies mainly on farm-internal resources and limits the input of external auxiliary materials. This results in less fossil and mineral resources being consumed. Moreover the greatly restricted use of pesticides makes it possible to markedly reduce ecotoxicity potentials on the one hand, and to achieve a higher biodiversity potential on the other. This overall positive assessment is not valid for all organic products: some products such as potatoes had higher environmental burdens than their counterparts from integrated farming practices (Nemecek *et al.*, 2011). After the literature review, it can be concluded that, all the authors recognizes that both organic and integrated farming practices are appropriate for the policy sustainability goals implementation. However, most authors prefer organic farming.

2. Methodological approach

The methodology for the evaluation of organic and integrated farming practices using technological, economic and social indicators, was created according principles as recommended in the scientific literature (Giupponi *et al.*, 2012; Balana *et al.*, 2011).

Multi-criteria methods have been used for quantitative evaluation of complex phenomena (Zavadskas *et al.*, 2009; Žvirblis, Buračas, 2010; Baležentis, 2016; Baležentis *et*

al., 2017; Craheix *et al.*, 2016; Petit, Aubry, 2016; De Luca *et al.*, 2017; Kamali *et al.*, 2017). Multi-criteria methods integrate the values of the criteria describing a particular process and their weights into a single value. However, all of these methods are based on different logical principles, have different complexity levels and the inherent features. Therefore, it is recommended to use of several methods and average of the values obtained (Krisciukaitiene *et al.*, 2015). SAW, COPRAS, TOPSIS and VIKOR methods were used to fulfil the objective of the article. Multi-criteria methods are based on the matrix $R = \|r_{ij}\|$ of the criteria, explaining the objects A_j $(j = 1,2, \dots, n)$ compared, statistical data and the criteria weights $\omega_i (i = 1,2, \dots, m)$, where m is the number of criteria and n is the number of objects compared. The criteria weights were determined by the authors after the consultations with the experts of the Lithuanian Institute of Agrarian Economics.

SAW (Simple Additive Weighting) method is one of the most widely used methods for multi-criteria evaluation (Hwang, Yoon, 1981; Ustinovičius, Zavadskas, 2004; Rozman *et al.*, 2016; Vico, 2017).

The criterion of the method S_j was calculated by the formula:

$$S_j = \sum_{i=1}^{m} \omega_i \widetilde{r_{ij}}\,, \qquad (1)$$

where ω_i is the weight of the *i*-th criterion, $\widetilde{r_{ij}}$ is the normalized *i*-th criterion's value for *j*-th alternative.

The criterion of COPRAS (Complex Proportional Assessment) method Z_j was obtained by the formula:

$$Z_j = S_{+j} + \frac{S_{-min} \sum_{j=1}^{n} S_{-j}}{S_{-j} \sum_{j=1}^{n} \frac{S_{-min}}{S_{-j}}}, \qquad (2)$$

where S_{+j} is the sum of maximizing weighted normalized criteria values:

$$S_{+j} = \sum_{i=1}^{m} d_{+ij}\,. \qquad (3)$$

S_{-j} is the sum of minimizing weighted normalized criteria values:

$$S_{-j} = \sum_{i=1}^{m} d_{-ij}\,. \qquad (4)$$

S_{-min} is the minimal S_{-j} value of minimizing criteria of all alternatives.

Using TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) (Hwang, Yoon, 1981; Manos, 2016) method the ideal and negative-ideal solutions were determined by formulas:

$$V^* = \{V_1^*, V_2^*, \dots, V_m^*\} = \left\{\left(\max_j \frac{\omega_i \tilde{r}_{ij}}{i} \in I_1\right), \left(\min_j \frac{\omega_i \tilde{r}_{ij}}{i} \in I_2\right)\right\}, \qquad (5)$$

$$V^- = \{V_1^-, V_2^-, \dots, V_m^-\} = \left\{\left(\min_j \frac{\omega_i \tilde{r}_{ij}}{i} \in I_1\right), \left(\max_j \frac{\omega_i \tilde{r}_{ij}}{i} \in I_2\right)\right\}, \quad (6)$$

where I_1 is associated with benefit criteria, I_2 is associated with cost criteria.

The criterion of the method C_j^* is calculated by the formula:

$$C_j^* = \frac{D_j^-}{D_j^* + D_j^-}, \quad (7)$$

where D_j^* is the separation of each alternative from ideal solution:

$$D_j^* = \sqrt{\sum_{i=1}^{m} (\omega_i \tilde{r}_{ij} - V_i^*)^2}\ . \quad (8)$$

D_j^- is the separation from negative-ideal solution:

$$D_j^- = \sqrt{\sum_{i=1}^{m} (\omega_i \tilde{r}_{ij} - V_i^-)^2}\ . \quad (9)$$

The compromise ranking algorithm VIKOR (serb. *VlseKriterijumska Optimizacija I Kompromisno Resenje*) was calculated by the following steps: 1) determine the ideal f_i^* and negative-ideal f_i^- values of all criterion functions; 2) compute the values $S_j$and R_j for each alternative:

$$S_j = \sum_{i=1}^{n} \frac{\omega_i (f_i^* - f_{ij})}{(f_i^* - f_i^-)}, \quad (10)$$

$$R_j = \max_i [\omega_i (f_i^* - f_{ij}) / (f_i^* - f_i^-)]\ , \quad (11)$$

where ω_i is the weight of the *i*-th criterion; and 3) compute the values Q_j:

$$Q_j = v \frac{S_j - S^*}{S^- - S^*} + (1 - v) \frac{R_j - R^*}{R^- - R^*}, \quad (12)$$

where $S^* = \min_j S_j$, $S^- = \max_j S_j$, $R^* = \min_j R_j$, $R^- = \max_j R_j$, v is the weight of the strategy of "the majority of criteria" (or "the maximum group utility") and usually set to 0.5 (Opricovic, Tzeng, 2004; Manos, 2016).

Conventional, organic and integrated farming practices were used to compare their indicators for those crops: potatoes, vegetables, fruits and berries.

After the literature review the main indicators to compare above mentioned farming practices were selected and outlined in the section below. Three indicators – labour input, hours/ha per year; agricultural production costs, EUR/t; and expenses for plant protection, EUR/ha – were minimizing while yield of agricultural crops, t/ha; purchasing price of

agricultural production, EUR/t; and share of sold production, per cent were maximizing. It is worth to mention, that compensatory payments are very important indicator, but it is not included in to the indicators system, because they compensate additional costs and/or income foregone due to the commitment given and could not influence evaluation results. Data was collected from Eurostat, Statistics Lithuania, Lithuanian Institute of Agrarian Economics, the Ministry of Agriculture of the Republic of Lithuania and Agricultural Information and Rural Business Centre data bases.

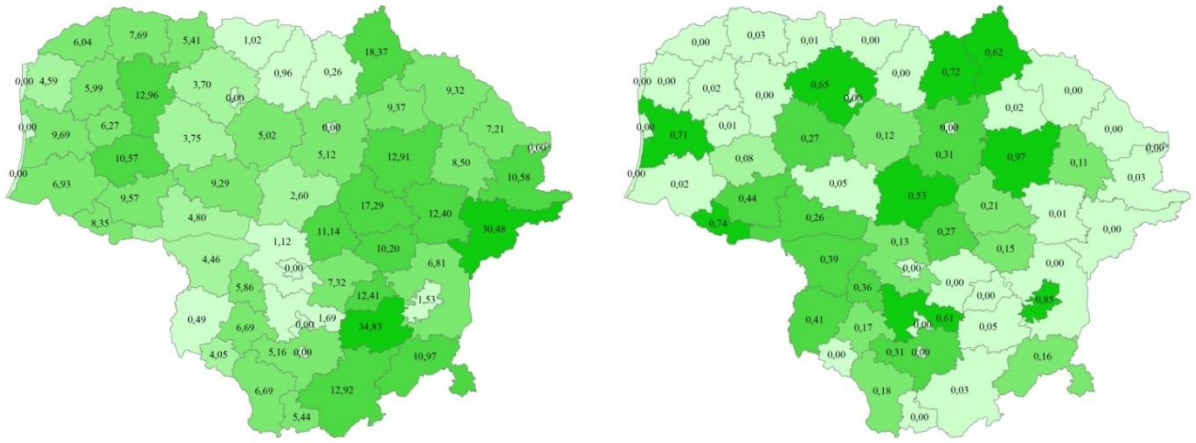
3. Conducted research and results

Rationale and assessment results of technological, economic and social indicators of organic and integrated farming practices are outlined in this section.

3.1. Rationale of organic and integrated farming practices

Organic farming practice occupies an essential place in Lithuania because it started more than two decades ago and has the tendency to increase particularly after the accession to the EU. Utilized agricultural area (UAA) under the organic farming has increased about one third during last five years and reached 214 thous. hectares in 2016. This increase was caused by comparatively high **s**upport under the "Organic farming" measure starting from 2004 to convert or maintain organic farming practices and methods (EU Regulation, 2013). The organic farming practice contributes to the needs in solving problems related to the high quality food supply and sustainable farming practices development (Rural Development Programme, 2017). Support for organic farming also solve the problems related to the negative environmental impact mitigation, biodiversity conservation and ecosystem stability maintenance, because organically farming farmers promote environmentally friendly farming, introduce nature conserving technologies and complies agri-environmental requirements (Rural Development Programme, 2017).

The integrated farming practice aims to preserve the necessary changes to agricultural practices that make a positive contribution to the environment and climate (EU Regulation, 2013). It is relatively new in Lithuania (from 2012), when support under the activity "Environmentally friendly fruits and vegetables cultivation system" was started. Activity implementation results show permanent increase of UAA, doubled during 2012-2016 up to 5 thous. hectares. Implementation of the integrated farming practices is still insufficiently widespread. The results could be much better if more crops (not only vegetables, potatoes, fruits and berries) are involved in to this activity. On the other hand, it would lead to higher demand of financial funds, which are insufficient in recent years.



a) b)

Graph 1. Share of the total utilized agricultural area declared across municipalities under: a) the "Organic farming" measure, b) the activity "Environmentally friendly fruits and vegetables cultivation system" of the measure "Agri-environment payments" in 2016.
Source: composed using data from the Agricultural Information and Rural Business Centre in Lithuania (Informacija, 2016).

The question is which of the farming methods discussed has more advantages: integrated or organic? At the moment competition between these two farming practices is observed. In response to a question, more attention has to be focused on the production levels prediction and monitoring with the purpose to justify the expectations of consumers.

Spatial analysis shows that integrated farming is concentrated in central part of Lithuania, where farming conditions are better, but only in few municipalities (*Graph 1*). In contrary, organic farming is cultivated in all the municipalities and occupies larger share of UAA compare to integrated farming. The problem arises that organic farming is spread in those areas with low land quality and is not able to produce sufficient yields. The main reasons of this disproportionate distribution are different economic conditions (public support and production cost) for organic and integrated farming.

3.2. Assessment of technological, economic and social indicators

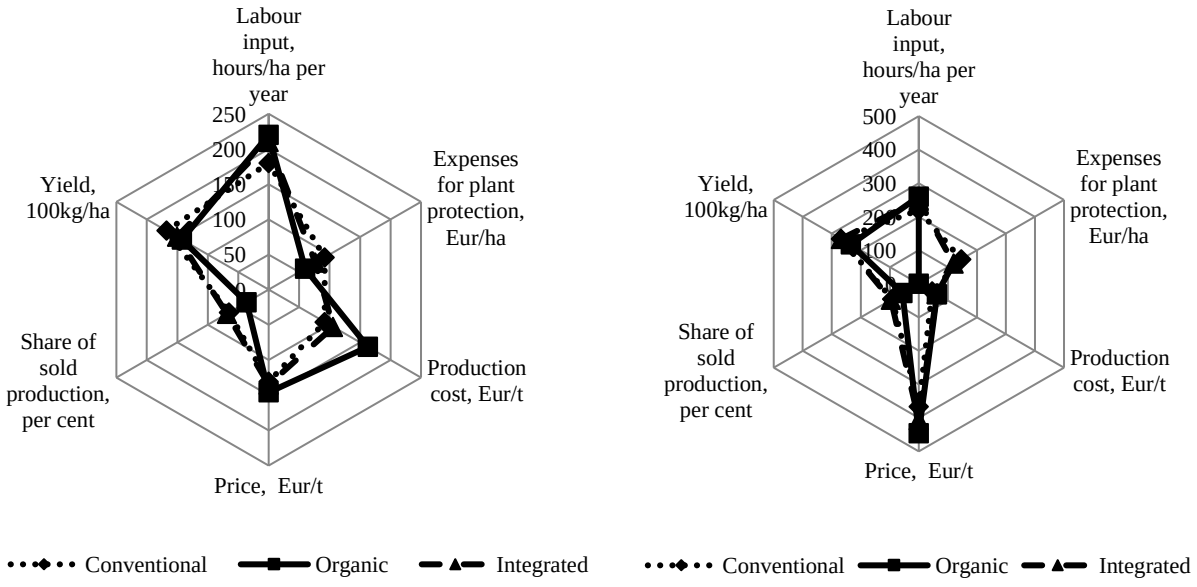
Evaluating of organic and integrated farming practices according to scientific literature technological, economic and social indicators were chosen. The following indicators were included into multi-criteria analysis: technological (yield, share of sold production) (Balana *et al*., 2011; Uthes *et al*., 2011; Sauer *et al*., 2012; Dzikowski, 2013), environmental (expenses for plant protection) (Kriščiukaitienė *et al.*, 2013); economic (production cost, price) (Blanco Fonseca, 2007; Acs *et al*., 2010; Udagawa *et al.*, 2014); and social (labour input) (Blanco Fonseca, 2007).

Traditionally, potatoes, vegetables and orchards are cultivated under the conventional farming practices: area occupies 98, 95 and 90 percent of total UAA respectively. In contrary, berry plantations mostly are cultivated under the organic farming practices, area occupies 48 percent of total UAA, followed by integrated (28 percent) and conventional (24 percent) farming practices. The reasons are mainly related to higher profitability farming conventionally.

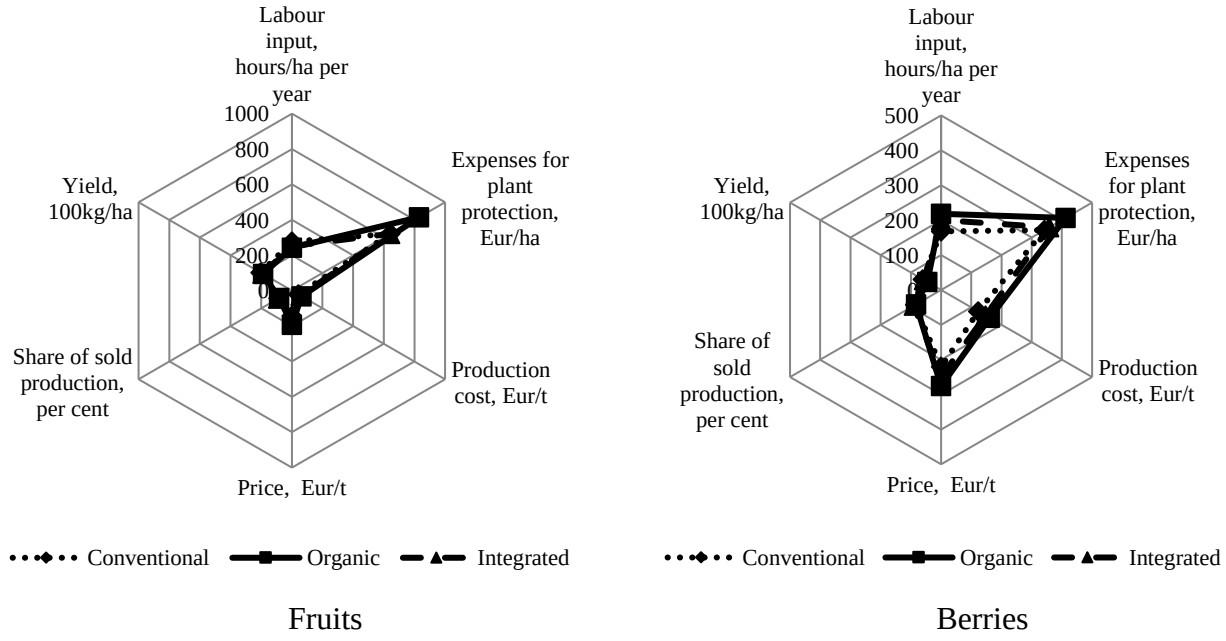
Analysing separate indicators it is worth to conclude that technological indicators yields are highest for all analysed products under conventional farming practices. However,

share of sold production is slightly higher under integrated farming practices (*Graph 2*). Environmental indicator – expenses for plant protection – differs depending on the product: the lowest expenses for potatoes are observed in organic farming, while highest – in conventional. There are no expenses for plant protection for organic vegetables, while conventional and integrated farming shows similar expenses. In opposite, for organic fruits and berries expenses for plant protection are higher than for conventional and integrated, because plant protection means allowed in organic farming for fruits and berries are more expensive, but also are more environment friendly. The question which farming practices supply more safe products could be answered by technological research.

Potatoes profitability without support is the highest (42 percent) and differs from integrated by 14 percentage points. Organic farming appears unprofitable without support for many years. The economic situation with support is observed slightly different: the most profitable becomes integrated potatoes farming and organic potatoes' farming becomes profitable too; however with the lowest profitability among the practices analysed. Profitability of the vegetables differs insignificantly under all the practices – organic shows the lowest ratio. On the other hand, organic vegetable farming is the most environment friendly and supply safe products, because does not use chemical plant protection means. Fruit profitability without support also is highest under the conventional farming. If compared the conventional, organic and integrated farming practices with support profitability differs insignificantly. Profitability without support of the berries differs insignificantly under all the practices, however with support becomes highest under the organic farming due to higher prices and lower costs in comparison with conventional and integrated farming practices.



Potatoes Vegetables



Graph 2. Comparison of production, economic and social indicators for different farming practices in Lithuania
Source: composed using data from the Lithuanian Institute of Agrarian Economics (Kriščiukaitienė, 2013), Statistics Lithuania (Lietuvos žemės, 2016), and Eurostat (2017).

Economic indicators such as production costs are observed highest for all products under the organic farming practice and lowest under conventional, while prices show opposite means. Social indicator, such as labour input for potatoes, vegetables and berries is highest under the organic farming practice because of additional labour needs for weed control. Only for organic fruits production labour input is lowest due to lower yields. Such a differences in separate indicators evaluation highly demands for multi-criteria analysis in terms of sustainability. For this purpose as suggested in scientific literature few multi-criteria analysis methods were used: SAW, COPRAS, TOPSIS and VIKOR. Practical benefit, on the one hand, is for policy makers to improve agri-environmental measures and, on the other hand, for farmers to understand and to decide when choosing farming practices to adapt.

The ranks of the farming practices of four different crops are presented by four above mentioned methods differ insignificantly (*Table 1*).

Table 1. Assessment results of farming practices of different crops in 2015.

Farming practices	SAW		COPRAS		TOPSIS		VIKOR		Final rank
	Value	Rank	Value	Rank	Value	Rank	Value	Rank	
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Potatoes									
Conventional	.900	1	.349	2	.638	2	.500	2	2
Organic	.786	3	.300	3	.349	3	.000	3	3
Integrated	.890	2	.352	1	.729	1	.957	1	1
Vegetables									
Conventional	.756	2	.303	3	.282	3	.500	2	3
Organic	.836	1	.386	1	.703	1	.000	3	1
Integrated	.720	3	.311	2	.326	2	.699	1	2

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Fruits									
Conventional	.997	1	.343	1	.600	1	.413	2	1
Organic	.926	3	.320	3	.394	3	.000	3	3
Integrated	.983	2	.337	2	.521	2	1.000	1	2
Berries									
Conventional	.992	1	.350	1	.625	1	.500	2	1
Organic	.889	3	.314	3	.365	3	.000	3	3
Integrated	.956	2	.336	2	.532	2	.954	1	2

Source: own calculations.

Three of for multi-criteria analysis methods show, that for potatoes mostly suits integrated farming practice. The second choice according the results obtained could be conventional farming practices. The organic farming becomes attractive for the farmers when potatoes yields and quality will increase and consumers will be able and agree to pay higher price for organic potatoes.

Concerning the vegetables according all the methods with exception of VIKOR due to the first place belongs to organic farming practice. The second place belongs to integrated farming practice and the last one for the conventional farming practices. Such results were obtained because of organic farms manage to get enough high yields and consumers prefer to purchase organic vegetables.

The production of fruits and berries occupy the same places according all farming practices analysed: the first place belongs to conventional farming practice. The second place belongs to integrated farming practice and the last one for the organic farming practices. Such situation is caused by higher production costs for the organic fruits and berries, which are inadequate for prices received.

It is important to pay attention that support is not included in to multi-criteria analysis as a criterion. It is made not by coincidence, but on purpose to reveal real picture of the performance of different farming practices analyzed. In order to achieve the goals, policy makers could to project the need for support and strategically direct it to stimulate development of desirable farming practices. Moreover research results are useful if support will be abolished.

Summarising it is worth to say that three methods (SAW, COPRAS and TOPSIS) present almost the same ranks for farming practices. VIKOR method presents almost different means due to methodological issues concerning the compromise solution, based on mutual concessions.

According to the selected criterions (yield, share of sold production, expenses for plant protection, production cost, price and labour input) potatoes, fruits and berries both conventional and integrated farming practices has obtained the same rank (1-2) in Lithuania. Organic farming practice has shown worse rank. However, detailed analysis shows that organic farming practices only for vegetables is the most suitable. One can conclude, that the prices of organic production are comparatively too low. Their changes would influence changes in ranks.

Conclusion

Theoretically, organic and integrated farming practices had potentially higher positive influence to soil quality and lower negative environmental impact than the conventional farming practice. When comparing with the conventional and integrated farming practices, the

organic farming practice achieves higher profitability and greater energy efficiency. Organic farming reveals to be either superior or similar to integrated farming practice in environmental terms.

Scientific literature suggests the methodology for the evaluation of organic and integrated farming practices using technological, economic and social indicators has to be created according multi-criteria analysis methods. Almost the same ranks obtained for farming practices of three methods (SAW, COPRAS and TOPSIS) ensure reliable results of this paper.

Traditionally, potatoes, vegetables and orchards are mostly cultivated under the conventional farming practice. In contrary, half of berry plantations are cultivated under the organic farming practice. The reasons are mainly related to higher profitability farming conventionally.

Comparatively new (starting 2012) integrated farming practice covers only potatoes, vegetables, fruits and berries, because of lack of financial funds for all other crops.

Potatoes, fruits and berries under both conventional and integrated farming practices has obtained the same rank (1-2) according to the selected criterions (yield, share of sold production, expenses for plant protection, production cost, price and labour input). Organic farming practice has shown worse rank. Organic farming practice has appeared the most suitable for vegetables. Prices of organic production are comparatively too low. Their changes would influence changes in ranks.

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