Polish Journal of Agronomy
2020, 43, 34–46

doi: 10.26114/pja.iung.419.2020.43.04

Factors of the development of organic farming in Poland at the voivodship level

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Abstract. The purpose of the research based on the data from the Report on the state of organic farming in Poland in 2015–2016 and environmental conditions, was to determine the impact of natural and economic factors and subsidies from EU programs on the level of organic production and to better understand the diversity of the spatial structure of organic farming within the system of provinces (voivodships). Nineteen structural, socio-economic and financial features, and 3 environmental features that characterize the quality of agricultural production and forms of nature protection for 16 voivodships, were used as assessment criteria. Principal component analysis allowed the basic factors of diversification to be discovered of the set of voivodships contained in the hidden structure defined by the features adopted for analysis. Homogeneous groups – organic farming types by voivodships were distinguished using the k-means method.

The comparative analysis allowed the connections between the structure of organic farming and its place in voivodships to be highlighted in connection with support for organic farming, the number of producers of organic agricultural products, production of feed on arable land, production of cereals and vegetables. The location of organic farms is related to the occurrence of Natura 2000 areas. The first type includes two voivodships, Zachodniopomorskie and Warmińsko-Mazurskie – with the highest level of development of organic farming. In the second type, the following voivodships were concentrated: Lubelskie, Łódzkie, Mazowieckie, Podlaskie and Świętokrzyskie, with a high level of organic farming, where farms smaller in area, that focus on fruit and vegetable production are the predominant type. In the third type, the following voivodships were located in the region of western Poland: Pomorskie and Wielkopolskie with a medium level of organic farming and very diverse in characteristics, including the largest and smaller organic farms with a low level of fruit and vegetable production. The fourth type includes the Małopolskie and Podkarpackie voivodships with a very small farm area and a small number of producers. In the fifth type with the least developed organic farming with a small number of producers and low fruit and vegetable production, three voivodships focused on the average farm area: Śląskie, Opolskie and Kujawsko-Pomorskie.

Keywords: organic farming, Rural Development Program, Principal component analysis – PCA, voivodships, Poland

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INTRODUCTION

Organic farming is a method of farming compatible with the quality of agricultural space and conducting sustainable plant and livestock production within the farm. The use of natural, technologically unprocessed methods makes it possible to produce agricultural products – organic food. Poland has the potential to become a significant player in the European organic food market. It can benefit from the support offered by the European Union as part of the common agricultural and rural policy. Most of the research on organic farming focused on the search for spatial relationships between organic farming and the quality of agricultural production space and protected areas. The most interesting studies are: Stuczyński et al. (2007), Stalenga and Kuś (2007), Makowska et al. (2015). The main factor stimulating the dynamic development of organic farming since 2004 has been the support system under PROW 2004–2006 and 2007–2013 (Kasiczak, Głowacka, 2019; Łuczka, 2013). About half of the land in the European Union is farmed. This makes agriculture very important for the natural environment. Agriculture and nature interact with each other. Thanks to the evolution of agricultural policy, we are seeing more and more environmentally friendly farming and breeding methods. The European Union countries have been implementing the Common Agricultural Policy (CAP) since the 1950s. Currently, the tasks of the CAP are focused on maintaining agriculture throughout the territory, as it shapes the landscape of the rural space and creates tourism value. Agriculture has transformed from the animal and plant producing

sector to the sector of environmental services (Tomczak, 2009b). The evolution of the common agricultural policy is also referred to as the transition from the CAP to the common agricultural and rural policy (CARPE) in recent declarations to the Common Rural Policy (CRP) (Tomczak, 2009a). Environmental initiatives in the European Union policy and the implemented agri-environmental programs supporting the transformation and maintenance of area under organic farming, contributed to the growth of the area of organic farming in Europe. The creators of the Common Agricultural Policy and Rural Policy for Europe (ERP – European Rural Policy) were interested in organic farming because of its benefits for the environment, health and its impact on regional development. This territorial policy aims to reduce prices of agricultural products to the level of world prices, to shift support to stabilize agricultural income, to pay for the provision of the so-called "Environmental services" and to support the sustainability of rural development. This applies not only to crops intended for human consumption, but also to oil and protein crops intended for animal feed. Organic farmers build and maintain soil fertility through a series of practices that mimic the natural ecosystem, rather than supporting the crop by using chemical, fossil fuel-based fertilizers. A hallmark of organic farmers is their strong belief in soil as a wealthy place, an ecosystem of billions of organisms that work together to ensure the circulation of nutrients. Maintaining this living system and the circulation of its nutrients in field crops, vegetables, pastures and farm animals is central to the philosophy of organic farming and is the foundation on which farmers build sustainable systems.

Organic farming is a method of food production defined in many ways in various international documents and legal regulations, for example Codex Alimentarius[1] or European Union law regulations concerning production rules[2], and in Polish statutory regulations[3]. In certain cases, the law provides for a flexible approach to the above-mentioned rules that make it possible to adapt the standards and requirements of organic production to local climatic or geographic conditions, specific farming practices and the degree of development. Standards have been defined and certificates introduced for organic farming. These actions were driven by the concerns of organic farmers that organic standards and principles might be threatened by competing strategies such as Integrated Pest Management (IPM) or Integrated Production (IP), concerns of consumers who wanted protection from the deception and concerns of emerging markets (supermarket chains in particular) expecting certified quality standards (Jacobsson, 2012). In the food markets, organic food represented the first food standards that defined, controlled and certified a specific food production process (traceability), rather than specific product properties (e.g. size or color) (Lampkin et al., 1999). At the end of 2017, the European Council approved new organic farming rules. Thanks to the new regulations, farmers in this field of agriculture will be able to obtain certificates at lower costs and will have easier access to organic seed. Negotiations on the new regulations for organic farming took about 3 years. Now they have yet to be approved by the European Parliament. If this happens, the new regulations will apply from 2021. The aim of the research, conducted using the data from the report on the state of organic farming and environmental conditions in Poland in 2015–2016, was to determine the impact of natural and economic factors and EU subsidies on the level of organic production and to better understand the spatial structure of organic farming in the voivodship system. The study analyzes the interdependence of selected features characterizing organic farming at the voivodship level. Thanks to the application of the main components, the factors determining the structural diversity of the Polish organic farming space were interpreted. The study is an overview and covers many aspects of organic farming in 2016.

ORGANIC FARMING IN THE EU AND IN POLAND

According to Eurostat in the European Union the total area of organic agricultural land in 2017 amounted to 12.6 million hectares, which corresponds to 7% of the agricultural area in the EU and an increase of 25% between 2012 and 2017 (EUROSTAT 2017). Poland, on the other hand, recorded a decrease by almost 25% in this period.

In terms of the size of organic agricultural land, the following stood out: Spain (over 1.9 million ha), Italy (nearly 1.5 million ha), France (over 1.3 million ha) and Germany over 1 million ha (Report 2019). In terms of the area of agricultural land, compared to other countries in 2015 Poland was fifth with 536 579 ha (Puppel at al., 2018). Currently, organic farming in the EU consists of almost 300 000 farms – most of which – 52 600 agricultural producers in Italy, and 22 000 in Poland. This sector is growing faster and faster, as evidenced by the fact that the area of land intended for organic farming in Europe is increasing every year by about 400 thousand. ha.

In Poland, in the years 2015–2016, the largest area under organic farming was occupied by plants for fodder,

1 The Codex Alimentarius was jointly established in 1960 by two agencies of the United Nations: the Food and Agriculture Organization (FAO) and the World Health Organization (WHO). Its purpose was to introduce and promote the definition and requirements for food, facilitating the harmonization of international food circulation.

2 Commission Regulation (EC) No 889/2008 of 5 September 2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labeling of organic products with regard to organic production, labeling and control (Journal UE L 250 of 18 September 2008, item, as amended).

3 Act of 25 June 2009 on organic farming (Journal of Laws of 2015, item 497, as amended). The previous act of June 25, 2009 on organic farming (Journal of Laws No. 116, item 975) was amended by the Act of December 5, 2014 on amending the act on organic farming (Journal of Laws of 2015, item 55), which entered into force on January 28, 2015.

meadows and pastures, and cereals, which in 2015 accounted for 80.2% of the area and 76.7% in 2016 (Raport, 2017). In 2015, the total area of organic agricultural land was 580 730 hectares, of which 86.4% was the agricultural area after the conversion period, and 13.6% during the conversion period. In 2015, along with the decrease in the number of organic agricultural producers, the area of agricultural land decreased by 11.7% compared to 2014 (657 902 ha). The area of organic agricultural land decreased the most in the following voivodships: Zachodniopomorskie, Podlaskie, Podkarpackie and Lubuskie (Raport, 2017).

The largest area where organic production methods were used was still occupied by arable land in the Zachodniopomorskie (114.9 thousand ha) and Warmińsko-Mazurskie (112.8 thousand ha) voivodships. The area of organic agricultural land in these voivodships accounted for 20.4% and 24.7%, respectively, of the total area occupied by organic agricultural land in Poland. The least amount of organic agricultural land is in the Śląskie and Opolskie voivodships – 0.5% and 0.6% respectively (Raport, 2017).

The development of organic farming in Poland is largely related to the financial support obtained from the Rural Development Program funds from the European Agricultural Fund for Rural Development and co-financing from the national budget.

In 2015–2016, payments to organic farming were implemented under RDP 2007–2013 and RDP 2014–2020. In the analyzed years, organic farming has received financial support from RDP 2014–2020 as part of the agri-environment-climate measure (DRŚK) and the continuation of the agri-environmental program (PRŚ) from 2007–2013.

In the DRŚK program, support for organic farming is implemented in the scope of options available as options during the conversion period/after the conversion period. The total funds allocated to the implementation of the Rural Development Program for 2014–2020 amount to EUR 13 513 295 000 (RDP Program for 2014–2020).

The main tool of financial support for the implementation of the tasks set out in the "Framework Action Plan for Organic Food and Farming in Poland for 2014–2020" were funds for the "Organic farming" in the Rural Development Program for 2014–2020.

Under the "Organic farming" RDP 2014–2020, a total of 864 087.5 thousand zlotych was paid out, including 549 818.4 thousand zlotych from EU funds and 314 269.1 thousand zlotych from domestic funds.

The Minister of Agriculture and Rural Development has also implemented other mechanisms supporting organic farming under RDP 2014–2020 through activities such as: "Farm and business development", "Investments in fixed assets", "Quality systems for agricultural products and foodstuffs", "Creation of producer groups and organizations".

Depending on the size of the area on which organic production is carried out, agricultural producers may receive payment at various rates. Full rates are paid to agricultural producers up to 50 ha of the area covered by the financial support program while producers with the cultivation area above 50 ha receive a reduction in payments, so called degressivity of payments (Kondratowicz-Pozorska, 2014).

RESEARCH METHOD

The development of organic farming in Poland and its regional differentiation was analyzed on the basis of production, social and economic features as well as features characterizing the natural environment. In total, 22 features were selected for evaluation and subjected to statistical analysis. They included, between others, the area of organic agricultural land, number of organic producers, size structure of farms, production volume of selected certified agricultural products, financial support and its forms, i.e. realized payments of financial aid paid to organic producers under the agri-environmental program, financed from the RDP 2014–2020 funds[4].

The natural conditions were characterized by the Land Quality Index (WWRPP), constructed as the sum of the point valuations of the most important components of the natural environment for agriculture, soil, topography, water conditions and agroclimate (Table 2) (Witek, Górski, 1977). The research also used a synthetic indicator of the agriculture land suitability for organic farming (SŚWP) – developed on the basis of a number of indicators (Stuczyński et al., 2004, 2007) including index of marginal soils (WGM), grasslands (WTUZ), legally protected areas (WOCH), soil contamination (WZG), soil acidity (WKG) and soil humus (WPG). The third environmental feature expressed the high biodiversity of a natural habitat and referred to the presence of Natura 2000 areas in the production space, and more precisely the share of the total area defined on the basis of the Habitats and Birds Directive (Table 2).

The following statistical measures were used to describe spatial distributions: mean, skewness, kurtosis, boxplot and correlation coefficients.

The accumulated set of variables characterizing organic farming was subjected to the reduction process using the principal components method. Principal component analysis – PCA (Hotelling, 1933; Pearson, 1901) is one of the

4 The RDP Program for 2014-2020 was developed on the basis of European Union regulations, in particular on the basis of Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013 on support for rural development by the European Agricultural Fund for Area Development Rural. Total funds allocated to the implementation of the Rural Development Program for the abovementioned years will amount to over EUR 13.5 billion.

most popular methods of statistical multivariate analysis. It is a statistical method that allows for the study of mutual relations in a set and the detection of hidden conditions that explain the differentiation of the regional structure. In this method, rotations of the primary axes designated by dependent variables are used in such a way that the new axes (so-called principal components, which are linear combinations of primary variables) are orthogonal and explain a lower and lower percentage of variance. The VARIMAX method was used to perform the rotations that ultimately determine the model interpretation.

The classification of voivodships with a similar internal structure of organic farming features (types of organic farming) was determined on the basis of new metatraits called main components using the cluster method – k-means. This method is a statistical technique aimed at comparing and classifying objects described by means of many attributes – including the study of separate principal components. Cluster analysis procedures allow to create classes called clusters – clusters of "the least distant from each other" or "objects most similar to each other", treated as points of a multidimensional space, where the dimension of space is defined by the number of variables on account of which the objects are described (for us separated main components).

In a situation when we have information about voivodships described by specific features, we may be interested in the relationships that exist between them in a spatial system. Before starting the principal components analysis, the basic assumption should be checked to assess the validity of its use, namely, the correlation of the variables – the higher the correlations between the original variables, the more justified the use of this analysis. It should be remembered that the correlation coefficient does not necessarily

Table 1. List of diagnostic features and their statistical characteristics for organic farming by voivodships, 2016.

Economic features and financial support for organic farming in voivodships	Average	Skewness	Kurtosis
1. Area under organic farming in 2015–2016 [ha]	33536	1.51	1.59
2. Number of organic producers of agricultural production	1402	1.15	0.54
Size structure of organic farming by voivodships [%]			
3. The size of organic farms – up to 5 ha [%]	22	0.76	-0.51
4. The size of organic farms – 5–10 ha [%]	21	0.39	-0.92
5. The size of organic farms – 10–20 ha [%]	24	0.79	0.91
6. The size of organic farms – 20–50 ha [%]	20	-0.46	-0.73
7. The size of organic farms – 50–10 ha [%]	10	0.11	-1.81
Production of selected organic crops			
8. Cereal production [t]	10814	0.73	-0.56
9. Potatoes production [t]	1345	1.55	2.37
10. Vegetables production [t]	3393	0.46	-0.69
11. Fruit production [t]	4190	1.61	1.94
12. Cow's milk production [hl]	15127	1.63	2.78
Amounts paid for farms conducting organic production under RDP 2014–2020 in variants (financial support for agriculture)			
13. Agricultural cultivation payments [PLN], Variant 7.1	2035956	1.12	1.61
14. Vegetable crops, payments [PLN], Variant 8.1	913314	1.27	0.15
15. Herbs crops, payments [PLN], Variant 9.1	226690	3.40	12.42
16. Berry crops, payments [PLN], Variant 10.1.2	157176	1.96	4.23
17. Extensive fruit crops, payments [PLN], Variant 10.2	40061	2.63	8.21
18. Forage crops on arable land, payments [PLN], Variant 11.1	844855	2.35	5.40
19. Permanent grassland, payments [PLN], Variant 12.1	291923	1.31	1.10

Based on the report on organic farming in Poland in 2015–2016 (Raport 2017), authors' own calculations using Statistica 12 software

Table 2. List of environmental features and their statistical characteristics for organic farming by voivodship, 2016.

Environmental features of space	Average	Skewness	Kurtosis
1. Land Quality Index (WWRPP)	66.6	0.285	0.664
2. Synthetic indicator of the agriculture land suitability for organic farming (SŚWP)	128.4	-0.865	0.852
3. Natura2000 – division of Natura2000 areas (total participation under the Habitats and Birds Directive)	19.2	0.156	-0.953

Authors' own calculations using Statistica 12

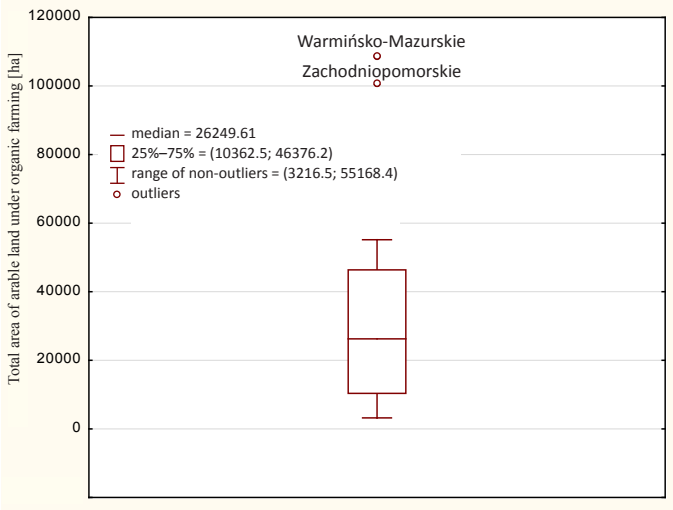

Figure 1. Box plot[5] for the characteristic area of arable land under organic farming in voivodships in 2016.
Source: Authors' own calculations using Statistica 12

mean causation, i.e. a change in one trait does not have to cause a change in the other variable. We can only accept a linear trend between the studied variables. Strongly correlated variables are mutually dependent, and therefore collinear (Ratajczak 2003, Nowak 2004). A 19x19 matrix of correlation relationships was calculated between the examined features.

RESEARCH RESULTS

The results of the research showed that in the group of features such as: area of organic agricultural land, number of certified producers, production of selected organic crops and forms of support according to variants, frequency distribution in the area of trait variability, has an oblique character and a positive skewness (Table 1). This means that most voivodships show low values of a given feature, while the arithmetic mean has a high value, thanks to the few voivodships lying in the upper ranges of variability, which is illustrated by box plots for the studied features (Fig. 1). Kurtosis is a good measure to express the degree of concentration around a central measure (mean or median). A positive value of kurtosis indicates a high degree of trait concentration in the surveyed voivodships, which occurred for the following traits: subsidies for herbal and fodder crops as well as milk production and extensive fruit crops, which was paid to organic farmers only in a few voivodships.

In 2016, the largest organic area of agricultural land was in the Warmińsko-Mazurskie and Zachodniopomorskie voivodships – much larger than in other voivodships (Fig. 1), and their total area in the country decreased by 7.6% compared to 2015.

Decrease in area was recorded in all voivodships, except for the Opolskie voivodship, where the area of organic agricultural land increased by 5.7%.

Similarly, in those years, the area of organic agricultural land decreased significantly after the end of the conversion period – by 14.2%. In 2016, a significant 34.1% increase in the area of organic agricultural land was found during the conversion period. The area of arable land increased the most in this period in the following voivodships: Zachodniopomorskie (by 72%), Pomorskie (by 58.5%) and Lubuskie (by 51.2%) (Raport, 2017).

In Poland, as at December 31, 2015, 23 015 organic producers were active in the field of organic farming. The most numerous group among all organic producers were agricultural producers engaged exclusively in plant production. 22 277 entities (ie 96.8% of all organic producers) were active in this area. Analyzing the data on the number of organic producers, 2015 was another year after 2014, when a decrease in the total number of organic producers was recorded, but in 2016 a reverse tendency was noted – an increase of 1.6% was recorded.

Among the 23 015 organic producers, the largest number of companies operated in the following voivodships: Warmińsko-Mazurskie with 4 142 producers, who represented 17.6% of the total number of organic producers in Poland, followed by Podlaskie voivodship with 3 296 producers who represented 14.3%, and 3 072 producers in the

5 The classic "Tukey boxplot" shows measures of central tendency (eg median or mean) and measures of volatility (eg min-max values, quartiles). In this graph, the values of the whiskers are determined by one and a half values of the quartile range (but only on the condition that the minimum and maximum are greater than these values - otherwise we also end up with the minimum and maximum values). All values beyond the above-mentioned quartile range are marked with a dot or an asterisk.

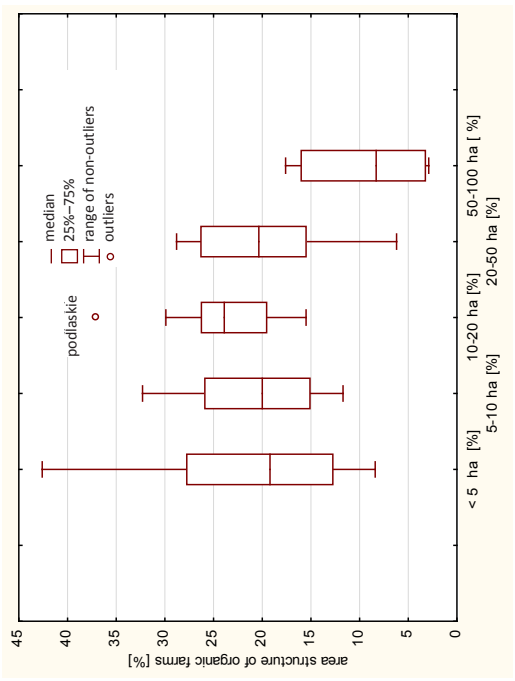

Figure 3. Area structure of organic farms by voivodeship in 2016.
Source: Authors' own calculations using Statistica 12

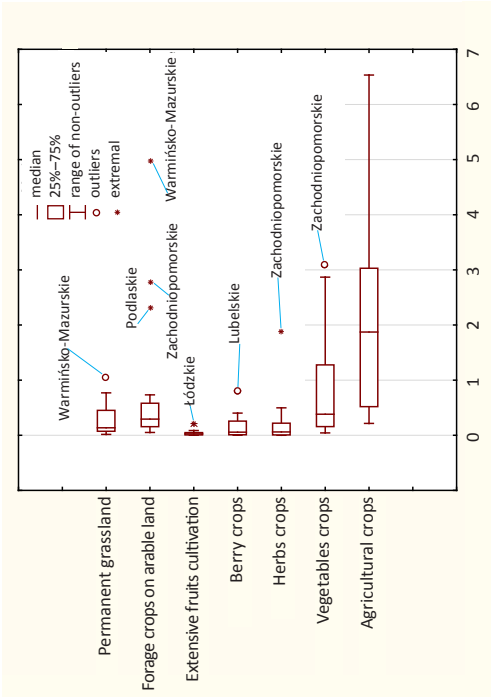

Figure 5. Amounts of support paid [in mln PLN] to farms conducting organic production by voivodship in 2016.
Source: Authors' own calculations using Statistica 12

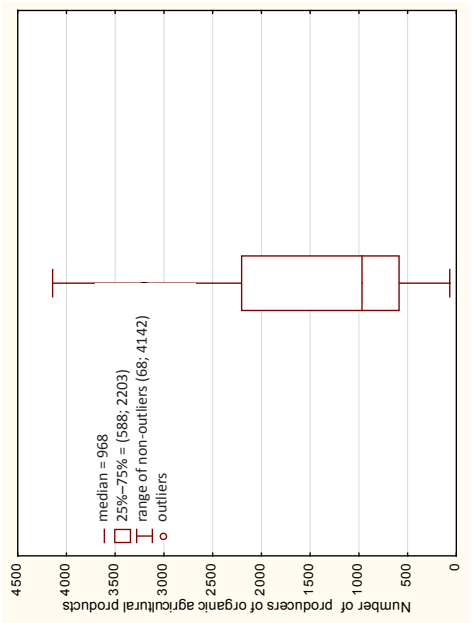

Figure 2. Number of producers of organic agricultural products in voivodeships in 2016.
Source: Authors' own calculations using Statistica 12

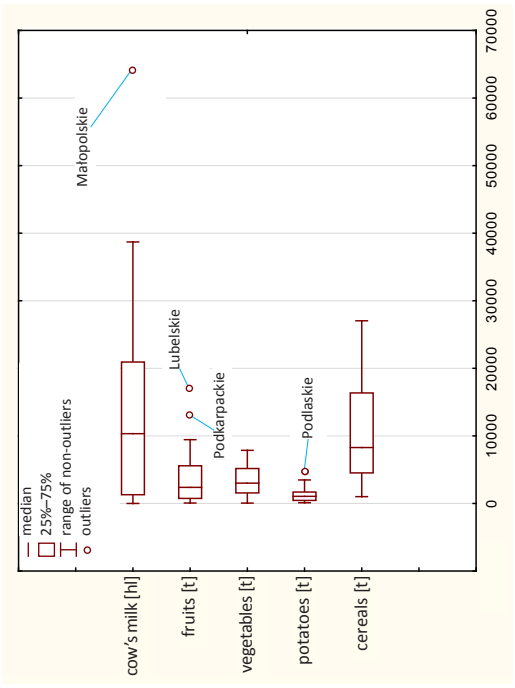

Figure 4. Production of selected organic crops in a ton by voivodeships in 2016.
Source: Authors' own calculations using Statistica 12

Zachodniopomorskie voivodship, who constituted 13.3% of total organic producers (Fig. 2).

These voivodships were also the leaders in terms of the number of organic farms: Warmińsko-Mazurskie (4 041), Podlaskie (3 273) and Zachodniopomorskie (3 043), which accounted for almost a half (46.5%) of all organic farms in Poland in 2015. In 2016 the largest share in the structure of farms was held by farms with an area of 10–20 ha of organic farming (26.5%) (Fig. 3). In 2016, compared to 2015, the number of the smallest farms with an area of up to 5 ha increased significantly, the share of which increased to 20.3%, at the expense of other farms, the shares of which decreased – farms with an area of 5–10 ha (20.4%), 10–20 ha (26.5%), 20–50 ha (20.8%), 50–100 ha (8.4%).

The production of cow's milk in 2015 amounted to 238 557 hectoliters and was 12.7% lower than in 2014. In 2016, compared to 2015, it increased by 1.5% and amounted to 242 032 hectoliters. The highest was found in the Małopolskie voivodship (63 967 hectoliters), which accounted for 26.4% of domestic production (Fig. 4). In the Opolskie voivodship, as the only one in Poland, no cow's milk with an organic farming certificate was produced.

The highest fruit production, in accordance with the certificate of conformity, comes from the following voivodships: Lubelskie 16 998 tonnes and Podkarpackie 13 178 tonnes, and the lowest – from Śląskie – 146 tonnes (Fig. 4).

The vegetable production volume is 54 291 tonnes, with an average of 3 393 tonnes per voivodship.

The potato production, in accordance with the certificate of conformity, includes the Podlaskie voivodship – 4 652 tonnes, with an average of 1 345 tonnes per voivodship (Fig. 4).

The production of grain in accordance with the certificate of conformity in Poland is 173 031 tonnes, with an average of 10 814 tonnes per voivodship. The least grain is produced in the Opolskie voivodship – 1 014 tonnes, and the most in the Zachodniopomorskie voivodship – 27 036 tonnes (Fig. 4).

The driving force behind the development of organic farms are subsidies for organic farming. This is confirmed by numerous reports and studies (Clock, 2018). The highest subsidies in 2016 for permanent grassland, in accordance with the certificate of compliance, in variant 12.1 were obtained by farmers in the Warmińsko-Mazurskie voivodship – PLN 1 051 072, which constituted 22.5% of subsidies in this variant nationwide (Fig. 5).

The highest payments made for fodder crops on arable land, in accordance with the certificate of compliance, in variant 11.1 were received by farmers from the following voivodships: Warmińsko-Mazurskie – PLN 4 990 306, Zachodniopomorskie – PLN 2 774 194 and Podlaskie – PLN 2 322 233 PLN, and the least from Łódzkie – 51 196 PLN.

The largest number of subsidies for extensive fruit cultivation, in accordance with the certificate of conformity, in variant 10.2 was for crops located in the Łódzkie voivodship – PLN 208 172 (32.4% nationwide). The amounts of subsidies for berry crops according to the certificate of conformity were small. The leader here is the Lubelskie voivodship, from which farmers received co-financing in the amount of PLN 795 822 (31.6% nationwide) (Fig. 5).

Herbal crops, in accordance with the certificate of conformity, received the highest subsidies in the Zachodniopomorskie voivodship – PLN 1 885 110, in this package there was no co-financing for the Śląskie and Opolskie voivodships (Fig. 5).

The highest co-financing for vegetable crops in variant 8.1 in accordance with the certificate of conformity was also received by farmers in the Zachodniopomorskie voivodship – PLN 3 090 440.

The amounts paid for agricultural crops complying with the certificate of conformity option 7.1 were the highest of all agri-environmental payments. The average value of co-financing per voivodship amounted to PLN 2 035 959, and the median was PLN 1 872 836. The highest amount of co-financing was for farmers from the Zachodniopomorskie voivodship – PLN 6 533 431, and the lowest for the Opolskie voivodship – PLN 214 896 (Fig. 5).

Agriculture is very important to our natural environment. Agriculture and nature interact with each other, i.e. favorable natural conditions may favor organic production and vice versa. The conducted analysis indicates a very low share of organic farming in the Śląskie voivodship, which may result from the low suitability of agricultural land for the purposes of organic production and the

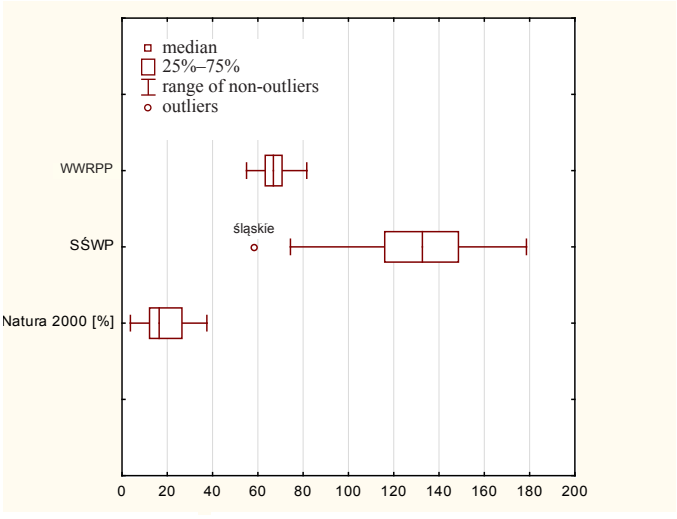

Figure 6. Variability of natural conditions, i.e. share of Natura 2000, the synthetic indicator of the agriculture land suitability for organic farming (SŚWP) and Land Quality Index (WWRPP) by voivodship.
Source: Authors' own calculations using Statistica 12

Table 3. Assessment of principal components – eigenvalues.

Number of principal components	Eigenvalues	% of explained variance	% of cumulative variance
1	8.63	39.24	39.24
2	4.74	21.56	60.80
3	2.30	10.49	71.30
4	1.95	8.86	80.16
5	1.30	5.94	86.10
6	0.77	3.52	89.62
7	0.59	2.70	92.32
8	0.52	2.37	94.70
9	0.39	1.80	96.49
10	0.32	1.48	97.98
11	0.20	0.91	98.89
12	0.12	0.56	99.45
13	0.07	0.35	99.80
14	0.03	0.17	99.97
15	0.00	0.02	100.00

Source: Authors' own calculations using Statistica 12

risk of soil contaminated with trace metals in this area (Stuczyński et al. 2004). The regional variability of selected environmental indicators is presented in Figure 6.

The results of the research on the correlation allow conclusions to be drawn about the spatial structure of organic farming. The area of organic agricultural land is positively and strongly correlated with the number of agricultural producers (r = 0.87), production of cereals (r = 0.87), payments made for agricultural crops (r = 0.86), vegetable crops (r = 0.89) and forage crops on arable land (r = 0.91) and payments for permanent grassland (r = 0.89).

In practical applications of principal components, the principal components with the largest variances (with the highest eigenvalues) are considered the most important. The number of principal components identified for the study was determined (Table 3). The following criteria are most often used for this purpose: self-worth and scree (Nowak, 2004; Rozmus and Trzęsiok, 2018). The analysis leaves those components for which eigenvalues are greater than 1 (Kaiser criterion), because eigenvalues less than 1 are not more useful than individual variables.

The resulting principal component, as a linear combination of primitive variables, should explain more variability than a single variable. It turned out that for the four main components the calculated eigenvalues are greater than 1 and meet the criterion of a sufficient proportion – the degree of explained variance of the original variables must be at least 75%, so these components were distinguished. From the results given in Table 3, it can be read that the first component explains 39.2% of the total variability. The second component explains 21.5%, the third 10.4% and the fourth 8.8%, which gives a total of more than 80.1% of the total variability (Table 3).

The scree plot is consistent with the results of the principal component analysis (Fig. 7). The correct interpretation is to find the place from which, to the right, there is a gentle decline in eigenvalues. There should not be more factors than those to the left of this point. As a result of the conducted analysis, four eigenvalues were selected, which together express 80.2% of the total variability of all the analyzed factors of organic farming, which meets the criterion of a sufficient proportion (Fig. 7, Table 3). We get the result, i.e. a set of new variables V_1, V_2, V_3, V_4. The obtained components can be treated as the main metatraits of the structural dimension of the organic farming space in Poland in 2016. As it has already been written, the transformation of 19 socio-economic and financial, and 3 natural features characterizing the quality of agricultural production space and forms of nature protection for 16 voivodships into main components was carried out taking into account the initial features and the use of correlation matrices. The first component explains 39.2% of the set of original features, the second 21.5%, the third 10.4% and the fourth 8.8%.

The results obtained as a result of the presented research procedure allow for the formulation of the following conclusions: The first component (V_1) is composed of eight primary features and shows the highest loads with a correlation coefficient above 0.90 and a strong relationship with the total area of organic farming land, permanent grassland (permanent grassland), and the number of organic agricultural producers (Table 4). Farms characterized by the V_1 component are also strongly associated with the cultivation of fodder on arable land, the production of cereals, agricultural crops and the cultivation of vegetables. The

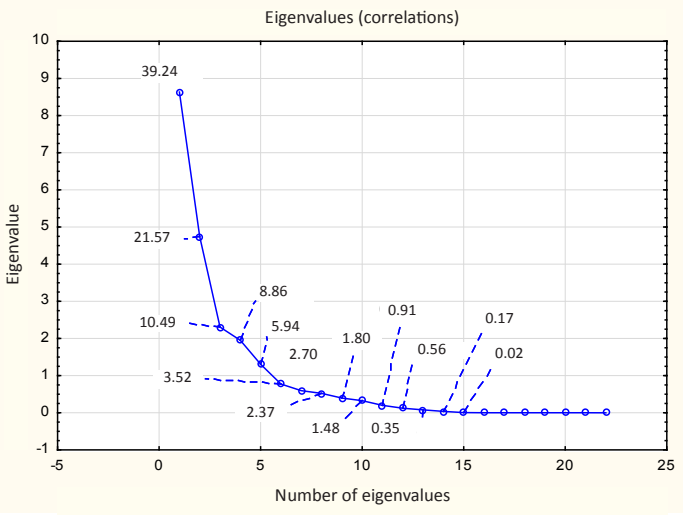

Figure 7. Scree-designate successive eigenvalues.
Source: Authors' own calculations using Statistica 12

Table 4. The main components and correlation coefficients obtained as a result of the analysis.

Features	Extracted main components Marked loads >0.7			
	V_1	V_2	V_3	V_4
The first component: area under organic farming and organic operators				
Total area under organic farming [ha]	**0.94**	0.24	0.13	0.03
Permanent grassland, payments [PLN], Variant 12.1	**0.93**	-0.03	-0.07	-0.03
Number of organic operators	**0.91**	-0.16	0.17	0.22
Forage crops on arable land, payments [PLN], Variant 11.1	**0.90**	0.09	-0.03	0.09
Cereals production [in tonnes]	**0.86**	0.23	0.15	0.21
Agricultural crops, payments [PLN], Variant 7.1	**0.79**	0.38	0.29	0.02
Vegetables crops, payments [PLN], Variant 8.1	**0.78**	0.37	0.06	-0.05
Natura2000 – division of Natura2000 areas (total participation under the Habitats and Birds Directive [%]	**0.76**	0.06	0.02	-0.21
The second component: areas of organic farms				
50–100 ha [%]	-0.05	**0.89**	-0.26	-0.23
20–50 ha [%]	0.33	**0.86**	-0.20	0.09
5–10 ha [%]	-0.18	**-0.83**	0.11	0.08
Up to 5 ha [%]	-0.28	**-0.76**	0.24	-0.29
Third component: subsidies for berry crops and fruit and vegetable production				
Berry crops, payments [PLN], Variant 10.1.2	0.20	-0.21	**0.90**	-0.00
Fruits production [t]	-0.05	-0.44	**0.84**	0.09
Vegetables production [t]	0.57	-0.05	0.69	-0.07
The synthetic indicator of the agriculture land suitability for organic farming (SŚWP)	0.33	0.30	0.46	-0.06
Land quality index (WWRPP)	-0.39	0.16	0.32	-0.53
Fourth component: average area of organic farms				
10–20 ha [%]	0.50	-0.03	0.02	**0.78**
Extensive fruits cultivation, payments [PLN], Variant 10.2	-0.19	-0.09	0.42	**0.54**
Potatoes production [t]	0.68	-0.53	-0.06	**0.34**
Cow's milk production [hl]	0.37	-0.61	-0.08	**-0.59**
Herbs crops, payments [PLN], Variant 9.1	0.57	0.43	0.20	**-0.32**

Source: authors' own calculations using Statistica 12

location of organic farms is related to the occurrence of Natura 2000 areas, the correlation coefficient is 0.76 (Table 4). Linking organic farming with Natura 2000 sites may have a positive impact on the quality of production and additionally contribute to the protection of natural values, and in certain cases even strengthen them. An important role in this group of farms is played by the area of permanent grasslands, for which the correlation coefficient is 0.93 (Table 4).

The second main component (V_2) shows very strong positive relationships with farms with larger areas, ranging from 50–100 ha and 20–50 ha (Table 4). On the other hand, small farms with an area of 5–10 ha and up to 5 ha are negatively correlated, the correlation coefficient is respectively -0.83 and -0.76, which means that they do not benefit from financial support for organic farming or use it in to a small extent (Table 4).

In the third main component (V_3), the highest loads were recorded for the variable characterizing berry crops and soft fruit production, the correlation coefficient is 0.90 and 0.84, respectively (Table 4). Vegetable crops have a load lower than the adopted threshold (0.70). In this group of farms, there are relationships between organic farming and natural conditions expressed in the form of a synthetic indicator of the agriculture land suitability for organic farming (SŚWP) and a land quality index (WWRPP), which favor organic production. The correlation coefficients for both of these indicators are 0.46 and 0.32, respectively (Table 4) and prove that the specificity of organic farming is related to favorable conditions for organic production. The largest role in the V_4 component is played by farms with an area of 10–20 ha, cultivating extensive fruit crops, and to a lesser extent by farms involved in potato cultivation. The negative value of the correlation coefficient for milk production (-0.59) and herbal crops (-0.32) proves that this category of farms was not involved in extensive horticulture (Table 4). The results of the analysis indicate a weak relationship between organic farming and the conditions favoring organic production with high indexes SŚWP in the case of the V_1 component (correlation coefficient 0.33),

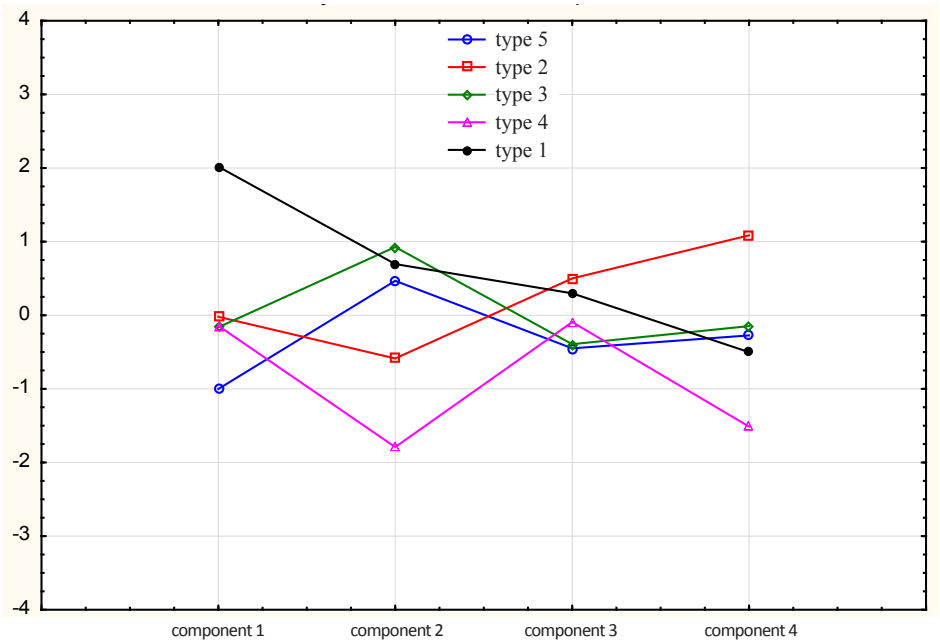

Figure 8. Average component values for types of organic farms.

Table 5. The main components of the organic farming structure of voivodships.

Voivodship	Components			
	V_1	V_2	V_3	V_4
Dolnośląskie	-0.13672	0.98095	-0.28097	-0.16694
Kujawsko-Pomorskie	-0.74172	0.17881	0.18072	-0.41293
Lubelskie	-0.33321	-0.28275	2.82474	0.55056
Lubuskie	0.03763	1.07437	-0.54491	-0.14485
Łódzkie	-1.09236	-0.13541	0.24794	1.84910
Małopolskie	-0.00137	-2.21966	-1.16633	-1.73359
Mazowieckie	0.36707	-0.55928	0.60481	0.46827
Opolskie	-1.26563	0.89900	-0.25325	-0.53543
Podkarpackie	-0.28295	-1.36060	0.98367	-1.28970
Podlaskie	1.34743	-0.97980	-1.10770	2.03655
Pomorskie	-0.20593	0.75235	-0.64564	-0.06554
Śląskie	-0.99513	0.32829	-1.27394	0.12852
Świętokrzyskie	-0.39005	-0.97254	-0.06758	0.52573
Warmińsko-Mazurskie	2.15712	0.20208	-0.10932	0.16887
Wielkopolskie	-0.34473	0.90433	-0.09922	-0.20963
Zachodniopomorskie	1.88054	1.18987	0.70698	-1.16900

Source: author's own calculations using Statistica 12

which connects the areas with the highest share of organic areas. Considering the strength of the main components with the analyzed features, it may be tempting to give them the following names: first component V_1 – organic farmland and producers, component V_2 – larger organic farms; component V_3 – production of fruit and vegetables; fourth component V_4 – smaller organic farms.

Based on the generated new metatraits, called main components and the applied k-means cluster method, five types of voivodships were distinguished with a similar internal structure of organic farming features in Poland (Fig. 8, Table 5).

The results of the performed classification of voivodships using the k-means method for the types of organic farming characterized by an internal similarity of the analyzed principal components seem to be in line with reality. When analyzing the interregional differentiation of or-

Table 6. Types of organic farms by voivodships.

Types of ecological agriculture and classified voivodships	Component 1 share of organic agricultural land and number of producers	Component 2 share of larger organic farms	Component 3 share of fruit and vegetable production	Component 4 share of smaller organic farms
TYPE 1: Warmińsko-Mazurskie, Zachodniopomorskie	max	high	high	low
TYPE 2: Lubelskie, Łódzkie, Mazowieckie, Podlaskie, Świętokrzyskie	high	low	max	max
TYPE 3: Dolnośląskie, Lubuskie, Pomorskie, Wielkopolskie	average	max	low	high
TYPE 4: Małopolskie, Podkarpackie	low	min.	average	min.
TYPE 5: Kujawsko-Pomorskie, Opolskie, Śląskie	min.	average	min.	average

Source: Authors' own calculations using Statistica 12

ganic farming, five types were distinguished according to voivodships, which should be considered the most similar in terms of main components.

The first type includes two voivodships, Zachodniopomorskie and Warmińsko-Mazurskie, with the highest (max) value of the first component (V_1), high value of the second (V_2) and third (V_3) component and low value of the fourth component (V_4) (Fig. 8, Table 6). These voivodships have similar and the highest shares of organic farming area and shares of permanent grasslands and a large share of Natura 2000 areas. Within these voivodships there is the highest number of organic farming producers, and the production of cereals and vegetable crops.

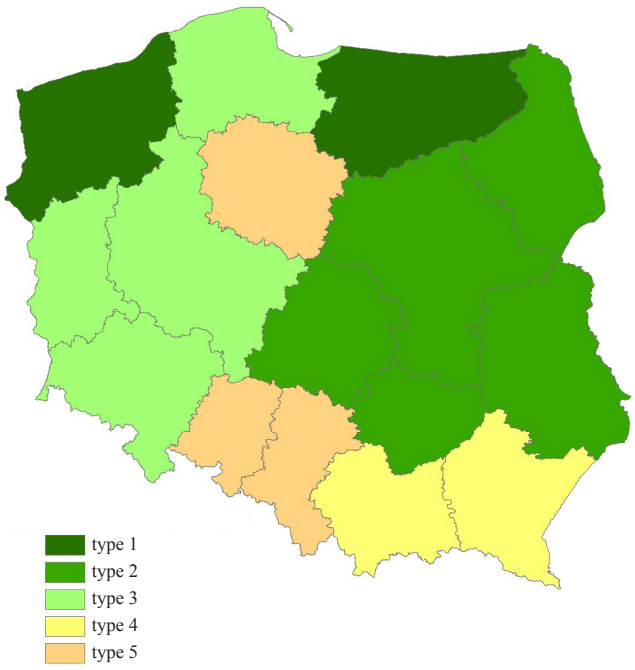

Figure 1. Map of organic farms types by voivodship.

The second type of organic farming includes five voivodships: Lubelskie, Łódzkie, Mazowieckie, Podlaskie and Świętokrzyskie (Fig. 8) with a high value of the first component (V_1), low value of the second component (V_2), maximum value of the third component (V_3) and fourth component (V_4) (Table 6). In these voivodships there is a high share of organic area, a low share of larger farms in the range of 50–100 and 20–50 ha, the highest share of berry and soft fruit crops and the maximum share of farms with an area of 10–20 ha and the highest share of extensive fruit crops (Table 6).

In the third type, there were voivodships located in the region of western Poland: Dolnośląskie, Lubuskie, Pomorskie and Wielkopolskie (Fig. 8). They are characterized by an average value of the first component (V_1), a maximum value of the V_2 component, a low value of the V_3 component and a high value of V_4. These voivodships have an average area of permanent grasslands, a small area of berry crops and a low fruit production.

The fourth type includes two voivodships: Małopolskie and Podkarpackie, which are characterized by a low value of the V_1 component, minimum value of the V_2 component, average value of the V_3 component and minimum value of the V_4 component (Table 6). In these voivodships there was a small share of the area used for organic farming, the lowest share of larger farms, the average share of berry crops and fruit production, and a minimum share of farms with an area of 10–20 ha (Table 6).

The voivodships: Śląskie, Opolskie and Kujawsko-Pomorskie were included in the fifth type of organic farming, with the smallest share of the area used for organic farming, the average share of farms larger than 50–100 ha. Type 1 and 2 organic farming, with the largest acreage of organic farming, largely coincides with the High Nature Value farmland (HNVf) areas with low agricultural production efficiency in Poland (Jadczyszyn, Zieliński 2020). Such a coincidence is not noticed in the case of the Małopolskie

and Podkarpackie voivodships, where farmers are much less interested in organic production.

SUMMARY

The performed classification of voivodships in terms of organic farming features is difficult to interpret. This is largely due to the need to make many arbitrary (subjective) decisions regarding the choice of variables and the research method used. It seems that the applied principal components method translated well from the statistical dependencies into cause and effect relationships. This method made it possible to reduce the dimensionality, reduce the number of primary variables and introduce a smaller number of new variables (metatraits) that, with sufficient accuracy, characterize the structure of organic farming in the country. The final classification of new variables (principal components) using the k-means method led to the identification of voivodships by types of organic farming. The obtained research results showed the relationship between the structure of organic farming and its place in voivodships with the implemented policy of subsidies for organic farming. The highest dynamics of the development of organic farming was found in the voivodships of northern Poland (Zachodniopomorskie and Warmińsko-Mazurskie), where farms are the largest in area and the largest amounts are paid per farm. It can be concluded that in these regions organic farming is the most profitable for farmers. In terms of area, smaller farms in the Małopolskie and Podkarpackie voivodships, with a structure of up to 5 and 5–10 ha, make very little use of the funds allocated for this purpose. The relationship between organic farming and the most favorable conditions for its development on the national scale is at a low level, the correlation coefficient with the synthetic indicator of the agriculture land suitability for organic farming (SŚWP) for the separated main components (V_1, V_2, V_3 and V_4) is in the range from -0.06 to 0.46. Only the Warmińsko-Mazurskie voivodship, belonging to type 1, with the most developed organic farming, is characterized by the highest index (SŚWP). Farmers in the Podkarpackie voivodship, where there are also very favorable conditions for the development of organic farming, are not interested in subsidies under this measure. The Śląskie voivodship and the western part of the Małopolskie voivodship, belonging to the Olkusz poviat, in which organic farming is currently developing to a lesser extent deserve attention. Due to the local soil contamination with trace metals occurring in this region, it is necessary to take very careful decisions on the development of this type of agricultural activity, after a careful diagnosis of the degree of contamination. It seems that increasing the share of organic farming in areas with a fragmented structure and most useful for its development is possible through appropriate financial support under the agricultural policy and the implementation of the RDP program.

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received – 9 March 2020
revised – 19 May 2020
accepted – 17 August 2020