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EVALUATION OF METFOD PRODUCTION IN TERMS OF IMPLEMENTATION OF ORGANIC FARMING IN POLAND

Summary

The aim of this paper was to evaluate production technologies in organic farms in terms of the achievement of general and specific objectives of organic farming. The research was conducted in 210 organic farms (which had undergone the conversion period) located in Warminsko-Mazurskie, Lubuskie, Dolnośląskie, Zachodniopomorskie provinces. For the achievement of the objective pursued, crop rotation was evaluated in terms of maintaining good agricultural condition, and also an analysis of the level of fertilization was done and the amount of fertilizer components introduced into the soil was estimated. The amount of nutrients uptake with the yield was evaluated. The crop structure is dominated by crops that reduce erosion and supply nitrogen to the ecosystem, in other words permanent grassland and grasses with small-seed leguminous companion crops. Results of the conducted research indicate that approximately 25% of the studied organic farms carry out livestock production in the conventional system. None of the farms carries out organic livestock production. On arable lands, crop rotation was generally incorrect due to excessive amounts of cereals. Manure fertilization was not applied in the farms with crop and livestock production; the only source of biogens are animal droppings on pastures. In the studied group of organic farms, there is a real risk of permanent decrease in the amount of nutrients in soils.
***Key words**: organic farming, crop production, livestock production, fertilization, balance of elements*

OCENA METOD PRODUKCJI W KONTEKŚCIE REALIZACJI ZAŁOŻEŃ ROLNICTWA EKOLOGICZNEGO W POLSCE

Streszczenie

Celem pracy była ocena technologii produkcji w gospodarstwach ekologicznych w kontekście realizacji ogólnych i szczegółowych celów rolnictwa ekologicznego. Badania przeprowadzono w 210 gospodarstwach ekologicznych, zlokalizowanych w województwach: warmińsko-mazurskim, lubuskim, dolnośląskim zachodniopomorskim, które przeszły okres konwersji. W ramach realizacji założonego celu oceniono płodozmian w kontekście zachowania dobrej kultury rolnej oraz dokonano analizy poziomu nawożenia i oszacowano ilość składników nawozowych wprowadzanych do gleby. Oceniono ilość składników pokarmowych wyprowadzonych z plonem. W strukturze upraw dominują uprawy, ograniczające erozję oraz dostarczające azot do ekosystemu, czyli trwałe użytki zielone oraz trawy z wsiewkami bobowatych drobnonasiennych. Wyniki przeprowadzonych badań wskazują, że koło 25% badanych gospodarstw ekologicznych prowadzi produkcję zwierzęcą w systemie konwencjonalnym. Żadne z gospodarstw nie prowadzi ekologicznej produkcji zwierzęcej, Na ornych płodozmian był generalnie nieprawidłowy ze względu na zbyt dużą ilość zbóż. W gospodarstwach prowadzących produkcję roślinną i zwierzęcą nie stosowano nawożenia naturalnego, a jedynym źródłem biogenów są odchody zwierząt na terenach wypasanych. W badanej grupie gospodarstw ekologicznych istnieje realne zagrożenie permanentnego zmniejszania ilości i składników pokarmowych w glebach.
***Słowa kluczowe**: rolnictwo ekologiczne, produkcja roślinna, produkcja zwierzęca, nawożenie organiczne, bilans pierwiastków*

1. Introduction

Intensification of agriculture is the cause of disturbed circulation of elements in the environment, excessive accumulation of harmful compounds in the biotope and biocenosis, changed landscape of farmlands, as well as decreased biodiversity, not only in agroecosystems but also in adjacent habitats [1, 17, 20]. Agriculture has a great and multi-directional impact on the environment, and it touches large areas. In the second half of the 20th century, the development of agriculture focused on increasing the productivity by constantly increasing the amount of production means. It led to a considerable deterioration of the quality of food produced and degradation of soils over large areas. Intensification of the human impact from agriculture has resulted in the emergence of concepts of alternative production methods. These concepts include, first of all, organic farming and integrated farming [6]. Agricultural production technologies that reduce the negative effect on the environment put emphasis on reducing the use of chemical pesticides and on balanced fertilization, particularly with nitrogen fertilizers [13]. Organic farming is one of the most restrictive methods of food production owing to the fact that it limits the use of external production means. Implementation of this system should ensure rational use of environmental resources. For the purposes of organic production, a sustainable system of farming management ought to be created. This system should take into account the systems and cycles of nature, as well as maintain and improve the health of soil, water, plants and animals, and maintain and improve the balance between them, and also contribute to the increase in biodiversity of habitats. In this system, plants

should be fed through the soil ecosystem with limited use of non-renewable environmental resources. Properly constructed crop rotation as well as the use of natural or organic fertilizers, and, in special cases, mineral fertilizers obtained from natural minerals, are essential for maintaining soil fertility and the stability of plant Fielding [14]. Realization of the ideology of organic farming requires in-depth knowledge on biological and agrotechnical aspects of crop protection and specific habitat needs of individual plants. Inappropriate approach to the problem of crop protection may lead to weediness and excessive development of pests or fungal diseases [19]. Plant nutrients removed with yield must be replenished in the form of fertilization so as to prevent soil impoverishment, whereas rational management of organic matter resources requires organic fertilization and implementation of cultivation methods that will limit humus mineralization [10]. Because of the difficult economic situation of organic farms that is determined by a limited development of the market for products, using biological and physical crop protection methods as well as mineral fertilization has a marginal dimension. Subventions for agricultural farms certified on compliance with the ecological system are intended to equalize costs incurred for cultivation and for increasing the competitiveness of organic products in the market. Most organic farms in Poland run their businesses only because of the desire to obtain subventions for realization of agricultural-environmental programs. This is the reason why the main emphasis in these farms is put on decreasing the production costs by reducing fertilization and simplifying cultivation techniques. Such actions frequently lead to soil degradation.

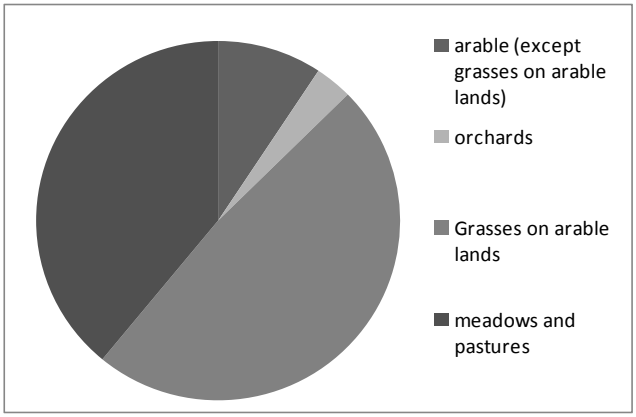
The aim of this paper was to evaluate production technologies in organic farms in terms of the achievement of general and specific objectives of organic farming.

2. Material and Methods

The research was conducted in 210 organic farms which had undergone the conversion period. The farms had been subjected to a system of control and certification of the certification body, and based on the inspections performed in the years 2013- 2015 they met the requirements of the EC regulation No. 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No. 2092/91. Data from three economic years (2012-2015) were used for the research. 116 farms from Warmińsko-Mazurskie province, 20 from Lubuskie province, 35 from Dolnośląskie province, and 39 farms from Zachodniopomorskie province were used in the research. The average area of the studied farms was approx. 30 ha in Warmińsko-Mazurskie province, 25 ha in Dolnośląskie and Lubuskie provinces, and 35 ha in Zachodniopomorskie province. For the achievement of the objective pursued, crop rotation was evaluated in terms of maintaining good agricultural condition, and also an analysis of the level of fertilization was done and the amount of fertilizer components introduced into the soil was estimated. Moreover, the amount of nutrients removed with the yield was evaluated. Calculations were done based on histories of fields included in farm records. The balance of nutrients was computed based on actual yields and average amounts of nutrients [5, 9, 10, 16] (data from the scientific literature). Amounts of nutrients supplied with animal droppings were calculated based on grazing records.

3. Results and Discussion

Organic farming meets the expectations of a specific group of consumers who look for products produced using a technology that limits the negative effect on the environment [4]. This primarily concerns elimination of chemical synthesis-derived agents from production, fertilization optimization, and supplying plants with nutrients. It is very important to design agricultural engineering so as to reduce energy consumption of production and to use renewable energy sources to the highest degree. In addition, chemical composition and technological parameters of organic products ought to be of high quality [12]. Achievement of general and specific objectives of organic farming with respect to crop production requires implementation of a series of actions connected with maintaining good agricultural condition of the habitat, limiting the risk of pest development, and supplying plants properly with necessary nutrients. Proper management of fertilizing elements at a field and farm level is the fundamental principle of sustainable agriculture. Fertilization should be designed based on the balance of elements. The balance covers income from all sources of nutrients, and expenditure expressed by the quantity of elements taken out with yield. Fertilization should be comprehensive and cover all elements taken up by plants, both macroelements and microelements [3, 18, 22]. A negative balance is indicative of a deficiency of nutrients and may contribute to a reduction of their soil resources or incompletely used potential of soil productivity and plant production capacity. A positive balance may lead to diffusion of unused elements in the environment, which worsens the economics of production and has a negative effect on the environment [8, 11].



Source: own work / Źródło: opracowanie własne

Fig. 1. Structure of agricultural land use in the studied farms in the years 2013-2015 [%]

Rys. 1 Struktura użytkowania gruntów rolnych w badanych gospodarstwach w latach 2013-2015 [%]

The largest area in the studied group of farms belonged to grasslands (their area was 39% of total area of the studied farms) and grasses on arable lands (their area constituted almost 50% of all crops) [Fig. 1]. The group of farms from Warmińsko-Mazurskie and Zachodniopomorskie provinces have the largest amount of permanent grasslands. The area of permanent meadows in farms from these provinces constituted approximately 50% of all crops. In Dolnośląskie and Lubuskie provinces, grasses on arable lands cover the largest area (47.5% and 67.3%, respective-

ly) [Tab. 1]. On arable lands (except grass crops), cereals occupied the largest area in farms from all the provinces. Their area was from 24.5% of the area of arable lands in Zachodniopomorskie province to 90% in farms from Lubuskie Province [Tab. 2]. One of the fundamental principles of organic farming is designing a good crop rotation, which will allow to limit pest development, decrease the level of erosion, and increase the microbiological activity and biodiversity. Results of the conducted research indicate that most of the studied area is covered by permanent grassland and grasses on arable lands that limit erosion. Their area was more than 80% of cultivated area in farms in Warmińsko-Mazurskie and Lubuskie provinces, and approximately 90% of crops in farms in Dolnośląskie and Zachodniopomorskie provinces. Maintenance of permanent grasslands is in line with the principles of organic farming because it maintains natural ecosystems. However, maintenance of permanent grasslands under ecological management conditions poses the risk of adverse changes in plant composition [21], which is caused by a reduction of the amount of nitrogen and other elements introduced into the ecosystem. In a long-term perspective this may lead to a reduction of primary production and deterioration of quality of fodder obtained from such areas, which is caused by a disturbance in quantitative relationships between individual elements [15]. In cultivation of grasses on arable lands, small-seed leguminous companion crops were applied in most cases, which is beneficial from the point of view of enriching agroecosystems with nitrogen and increasing biodiversity. Approximately 30% of the area of arable lands with annual plants is covered with crops that enrich the ecosystem in nitrogen, with the exception of a group of farms located in Dolnośląskie province, where there were no crops enriching the ecosystem with nitrogen. Cereal crops constituted approximately 40% of the area of arable lands in Warmińsko-Mazurskie and Lubuskie provinces, 90% in Dolnośląskie province, and approximately 24% in Zachodniopomorskie province. Results of the conducted research point to improper crop rotation in areas with cereal crops. In the three-year research period, no plants enriching the ecosystem with nitrogen were cultivated in these areas, with the exception of 9 ha in Warmińsko-Mazurskie province. Improper crop rotation is one of the most important factors that lead to soil degradation in organic farming [2]. Crop structure in the studied farms was determined by the system of subventions and by the principles of the agricultural-environmental program which do not allow changes in the use of permanent meadows, whereas cultivation of grasses with small-seed papilionaceous plants under conditions of organic farming does not cause technological problems.

Livestock production is fundamental for production management in organic farms because it is a source of organic matter and nutrients. Using natural fertilizers contributes to the improvement of soil properties [9]. Of all the studied farms, 54 of them carry out livestock production (40 farms are located in Warmińsko-Mazurskie province, 6 in Zachodniopomorskie province, 5 in Lubuskie province, and 3 in Dolnośląskie province). In most cases, organic farms keep beef cattle, less often dairy cattle. Horses were kept on five farms. On none of the farms were animals kept in organic system. Lack of interest in organic animal production results from economic considerations.

Manure was the only source of fertilizer components in farms that carry out livestock production.

Tab.1. Structure of agricultural land use in the studied farms in individual provinces in the years 2013-2015 [%]
Tab.1. Struktura użytkowania gruntów rolnych w badanych gospodarstwach w poszczególnych województwach w latach 2013-2015 [%]

Type of the Crop	Province			
	Warmińsko-Mazurskie	Dolnośląskie	Lubuskie	Zachodnio-pomorskie
Arable (except grasses on arable lands)	14.6	11.5	6.5	4.6
Orchards	1.5	4.5	3.4	3.9
Grasses on arable lands	36.0	47.5	67.3	42.6
Meadows and pastures	47.9	36.5	22.8	49.0

Source: own work / Źródło: opracowanie własne

Tab. 2. Structure of arable land use in the studied farms in individual provinces in the years 2013-2015 [ha]
Tab. 2. Struktura użytkowania gruntów ornych w badanych gospodarstwach w poszczególnych województwach w latach 2013-2015 [ha]

Type of the Crop	Province			
	Warmińsko-Mazurskie	Dolnośląskie	Lubuskie	Zachodnio-pomorskie
Cereals	239.0	41.5	51.2	26.0
Leguminous	154.0	19.5	0.0	21.6
Others	98.1	5.7	5.7	17.0

Source: own work / Źródło: opracowanie własne

Tab. 3. Mean level of fertilization in farms that keep animals in individual provinces
Tab. 3. Średni poziom nawożenia w gospodarstwach utrzymujących zwierzęta w poszczególnych województwach

Specification	Province			
	Warmińsko-Mazurskie	Lubuskie	Dolnośląskie	Zachodnio-pomorskie
Avarage area of a farm [ha]	48.6	36.5	42.13	59.65
The number of animals [LU ·ha^{-1}]	0.86	1.21	0.99	0.44
Nitrogen production N [kg]	3552	3723	3538	2229
Nitrogen dose [kg N · ha^{-1}]	21.3	16.5	17.8	13.7
Phosphorus production P_2O_5 [kg]	1671	1766	1668	1048
Phosphorus dose [kg · P_2O_5 ha^{-1}]	10.0	7.8	8.4	6.4
Potassium production kg K_2O	2916	3091	2919	1835
Potassium dose K_2O [kg · ha^{-1}]	17.5	13.6	14.7	11.2

Source: own work / Źródło: opracowanie własne

Tab. 4. Mean amounts of nutrients removed with the yield from individual groups of crops (from years 2013-2015)
Tab. 4. Średnie z lat 2013-2015 ilości składników wyniesionych z plonem z poszczególnych grup upraw

Type of crop	Average yield [kg · ha^{-1}]	Amount of nutrients removed with plant yield [kg · ha^{-1}]		
		Nitrogen [N]	Phosphorus [P_2O_5]	Potassium [K_2O]
Cereals	2010	39.4	29.33	21.57
Permanent grasslands	3500	35.7	12.83	75.07
Grasses on arable lands	4200	51.7	17.41	86.03

Source: own work / Źródło: opracowanie własne

The number of animals in the studied farms with animal production varied between provinces. In Warmińsko-Mazurskie and Dolnośląskie provinces, this value was at a level of 0.86 and 0.99 LU·ha^{-1}, respectively, in Lubuskie province – 1.21, and in Zachodniopomorskie province – 0.44 LU·ha^{-1} [Tab. 3]. The mean amount of nitrogen introduced with organic fertilization in the farms from Warmińsko-Mazurskie, Lubuskie, Dolnośląskie and Zachodniopomorskie provinces was 21.3; 16.5; 17.8 and 13.7 kg N· ha^{-1}, respectively [Tab. 3]. For phosphorus, these value are 10.0; 7.8; 8.4 and 6.4 kg P_2O_5· ha^{-1}; whereas for potassium they are 17.6; 13.6; 14.7 and 11.2 kg K_2O · ha^{-1}, respectively [Tab. 3]. Manure production resulting from the number of animals should meet plant demand for nutrients and maintain the ecosystem in ecological balance. All the studied farms which carry out livestock production did not have ecological arable lands with crops cultivated in ecological system. In none of the studied farms were natural fertilizers used for fertilization of organic crops. In all cases, produced natural fertilizers were applied on conventionally used lands. Animal droppings left during grazing were the only source of fertilizing elements on ecological lands. Estimated amounts of fertilizer components do not meet plant demand, and in a longer time perspective the deficit of elements in soil will increase. In organic farming, maintaining good soil condition requires organic fertilization in quantities according to plant demand and the production capacity of the ecosystem. In each case nutrients should be balanced, and fertilizer components (whose amount in organic fertilizers is insufficient) should be replenished in other forms [19, 10]. In farms which do not have balanced nutrient management policy, meeting plant demand by using only natural fertilizers is difficult to achieve [7]. There is a risk of deteriorating quality of soils in organic farms in Poland. That is why it is important to conduct permanent monitoring of both soil and plants produced in organic farms.

Based on our own data (unpublished) on the content of individual macroelements in biomass and on the amount of yield for crops which have the highest share in the crop structure, the mean annual amount of nutrients removed with plant yield in the studied organic farms was computed. The mean amount of nitrogen removed with cereal yield in the years 2013-2015 was 39.4 kg N · ha^{-1}, with the yield of permanent meadow sward – 35.7 kg N · ha^{-1}, whereas from grass crops on arable lands – as much as 51.7 kg N · ha^{-1} [Tab. 4]. Amounts of phosphorus removed with yield are, respectively, 29,33 kg P_2O_5 · ha^{-1}; 12,83 kg P_2O_5 · ha^{-1} and 17.41 kg P_2O_5 · ha^{-1}. Amounts of potassium removed with yield are, respectively, 21.57 kg K_2O · ha^{-1}; 75.07 kg K_2O · ha^{-1} and 86.03 kg K_2O · ha^{-1} [Tab. 4]. Results of the conducted research point to too low fertilization in relation to plant demands. The computed amounts of elements removed with yield point to the risk a permanent decrease in the quantity of nutrients in the soil. Yields obtained in the studied farms are very low, which can be caused by nutrient deficiency resulting from long-term cultivation in the organic farming system. In organically managed soils, a phosphorus deficiency can be usually observed. Management of this nutrient under organic production conditions is difficult due to the lack of readily assimilable fertilizers which are allowed to be used in organic farming. Phosphorus deficiencies also lead to an impairment of the ability to bind atmospheric nitrogen by symbiotic and free-living bacteria [16, 23].

There is real risk of a permanent decrease in the amount of organic matter and nutrients in organically managed soils [5]. That is why, in order to realize the philosophy of organ-

ic farming, the development of farms which carry out crop production in conjunction with animal production should be supported.

4. Conclusions

1. The crop structure is dominated by crops that reduce erosion and supply nitrogen to the ecosystem, in other words permanent grassland and grasses with small-seed leguminous companion crops.
2. Approximately 25% of the studied organic farms carry out livestock production in the conventional system. None of the farms carries out organic livestock production.
3. On lands with cereal crops, crop rotation was generally incorrect from the point of view of achievement of general and specific objectives of organic farming.
4. Manure fertilization was not applied in the farms with crop and livestock production; the only source of myogens are animal droppings after grazing.
5. In the studied group of organic farms, there is a real risk of permanent decrease in the amount of nutrients in soils.
6. In order to realize the philosophy of organic farming, the development of farms which carry out crop production in conjunction with organic animal production should be supported; this forces the use of natural fertilization on farmers' own lands.

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