

DEVELOPMENT OF THE AGRICULTURAL INNOVATION, TECHNOLOGICAL CHANGES AND BARRIERS OF FAMILY FARMS IN THE PODLASKIE AND PODKARPACKIE VOIVODESHIPS

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The use of innovation in agriculture is part of the trend of sustainable development and playing an important role in modernizing Polish agriculture. Innovative activity is associated with the implementation of changes, dissemination of novelties, and improvement of existing systems to increase the efficiency of production and to reduce its costs. Moreover, from the point of view of adapting Polish agriculture to the EU requirements, it is extremely important to introduce innovations to farms. Therefore, the aim of the present study was to determine innovation types, technological changes and barriers to the development of 590 family-run crop and livestock farms located in two voivodeships from Poland. The study used descriptive and numerical data sourced from questionnaire surveys conducted on family farms. Comparative analyses of data from Polish farms indicated increasing in the innovation changes, especially in animal production. It can be observed that most of the changes introduced required little financial outlays and inventiveness.

Key words: agriculture, changes, farm, innovation, livestock production

Introduction

The global demand for food increases with growing world population and socio-economic improvements in living standards. This trend continues also in Poland despite the negative birth rate. Eurostat (2019) data show Poland as a leader in poultry production with as much as 16.8% of the European Union's production, and in the case of pork, Poland accounts for 8% of the EU's production, placing the national production at the top of the European ranking. Among the European Union countries, Poland also ranks third in terms of the dairy cow population size. Livestock production has a large share in the agricultural gross domestic product (AGDP) while contributing to food production and job creation in rural areas (Ayele et al., 2012). Consequently, agriculture is also responsible for the negative impact on soils, water, biodiversity and climate change (Rodriguez et al., 2004). This situation is compounded by the intensification and maximization of animal and plant production. It should

be noted, however, that the Polish farm structure is dominated by family farms, many of which are small farms that do not produce for the market. Despite the changes and agricultural intensification, farming in Poland is less burdensome on the environment compared to other EU countries.

Innovativeness in agricultural holdings is a prerequisite for the modern market (Dudek and Wrzaszcz, 2020; Faure et al., 2018). Playing an important role in modernizing Polish agriculture, innovative activity is associated with the implementation of changes, dissemination of novelties, and improvement of existing systems to increase the efficiency of production and to reduce its costs. It is necessary to streamline farm operations and modernize farms as a farmer's workplace. Innovation contributes to the development of farms. It is thus one possible option to adapt to the conditions of a market economy. Innovative activity is an indicator of modernity and an important factor for development and modernization of the Polish agriculture, for it is associated with the implementation of changes and dissemination of novelties so as to increase production efficiency, reduce production costs, and achieve higher agricultural incomes. The measurable effects of the innovations are eco-innovation, sustainable production and environmental protection (Dudek and Wrzaszcz, 2020).

With regard to innovative activity, it is necessary to distinguish innovativeness from innovation. Generally, innovativeness is a process (activity), while innovation involves the absorption of novelties or implementing them into economic practice (Roszkowski, 2013). The term "innovation" is broadly understood and refers to all fields of life, from new solutions in economic and social life to new mental and cultural currents (Janasz and Koziół-Nadolna, 2011). Liu et al. (2021) distinguish the following types of agricultural innovation: new technologies and machines in the production process, precise technologies, and agri-environmental technologies.

The most frequently cited definition of innovation was introduced by the Organisation for Economic Cooperation and Development (OECD): "An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations. Innovation activities are all scientific, technological, organisational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations" (OECD, 2005). An innovation can be the introduction of a new production method, the marketing of a new product, the opening of a new market, the acquisition of a new source of raw materials, and the introduction of a new way of organizing work (Wójcik, 2011). A simpler definition was proposed by Barnett (1953), according to whom innovation is "any thought, behavior, or thing that is new because it is qualitatively different from existing forms".

It is essential for innovativeness to account for the specific features of agriculture, in particular the biological and spatial nature of agricultural production. This results from the production cycles, the dependence of production on the quality of agricultural production space, as well as the seasonality of production (Kałuza and Rytel, 2010). Launching innovations into agricultural holdings is extremely important in terms of adapting Polish agriculture to European Union requirements and the possibility of achieving higher farm income. Innovativeness is the ability of managers and those managed to develop and implement novel techniques and technologies for production and creation of organizational structures,

to create sets of factors of production that give optimum benefits, and to use rational methods and techniques for management and for problem solving (Górka and Ruda, 2012).

Socio-economic factors and production and economic considerations have been identified as determinants of the process of implementing innovation in agricultural holdings. The attitude of farmers towards innovation also results from the knowledge they have. Innovative activities in agriculture encounter many barriers, including fragmented agricultural structure, low awareness level by farmers, insufficient means of production, as well as the lack of clarity on the farm's future (Wójcicki, 2000). Therefore, the aim of the present study was to determine innovation types, technological changes and barriers to the development of family farms located in two regions from Poland in 2017, 2018 and 2019.

Material and methods

Selection of farms intended for research was purposeful. The choice of criterium was the specialization identified by the value share of milk and animal production with a respect to the production value of a given farm. The part of the main production branch accounted for 65% of the final production structure. Most of the farms were recommended by Agricultural Advisory Centre from given region.

The study was conducted in 590 family-run crop and livestock farms located in the Podkarpackie and Podlaskie voivodeships:

- 269 dairy farms,
- 154 sheep farms,
- 167 pig farms.

The objective of the study was accomplished using a survey questionnaire, which served to collect information to identify innovative activities in agricultural holdings. The questionnaire included open and closed questions with multiple choice option. Collected data referred to a general characteristics of farms (respondent's particulars), revenues, production cost and the kind of innovations implemented to improve effectiveness of functioning in crop and animal farms.

Direct interviews were performed in 2017, 2018 and 2019. The present results form part of our broader study on innovativeness of agricultural holdings in Poland. The presented results are arithmetic means, calculated on the basis of data from individual farms. The collected data are presented using the descriptive and tabular method, which allows for observing certain phenomena on the farms and formulating valuable conclusions.

Results

Selected information about the researched farms

The average utilized agricultural area of pig farm was almost 29.0 ha in the Podkarpackie voivodeship and 40.5 ha in the Podlaskie voivodeship. The area of the analysed farms was greater than the national average. Arable land prevailed in terms of the type of activity,

accounting for an average of almost 86% of total farm area. In all farms, owned land occupied a greater area than rented land. In the Podkarpackie voivodeship, average sow number in the analysed farms was 11.8 head. In the second region (Podlaskie voivodeship), the number of animals in all the years was 30.4 sows.

In the case of sheep production, the number of ewes per farm in the Podkarpackie voivodeship was 82.7, almost half that in the Podlaskie voivodeship (162.6 ewes). Largest farms were located in the Podlaskie voivodeship (43.5 ha on average) and smallest in the Podkarpackie voivodeship (36.5 ha on average). Most of the farm area in the Podkarpackie voivodeship was occupied by arable land, which accounted for a fairly high proportion of the land use structure (over 56%). The same voivodeship also had the largest percentage of the land rented by farmers (around 18%). The highest proportion of grassland was characteristic of the Podlaskie voivodeship (almost 46%).

Milk production farms had an average of 40.8 cows while the total number of cattle averaged 76.3 head. The average size of the cow population in the farms was similar in all the regions under analysis. On average, smallest farms were located in the Podlaskie voivodeship (45.3 ha). In the Podkarpackie voivodeship, total farm area averaged 63.8 ha. Grassland in this region accounted for 43.4%. The same voivodeship also had the highest proportion of land rented by farmers (around 38.3%).

Identification of innovative activities in agricultural farms

In the sheep, pig and dairy cattle farms selected for the study, technological and organizational changes mainly concerned crop production, livestock production and the economics and organization of production (Table 1). In general, the highest proportion of changes made to the farms was noted in pig farms.

Table 1. Areas of innovation on the farms (%)

Voivodeship	Years	Crop production (%)	Animal production (%)	Economics and organization of production (%)
Podkarpackie	average	71.2	69.9	65.0
	2017	68.7	69.7	64.7
	2018	71.6	70.1	62.6
	2019	73.4	69.8	68.1
Podlaskie	average	75.6	63.1	52.6
	2017	73.9	62.4	49.9
	2018	76.1	61.1	54.1
	2019	76.7	65.9	53.7

As regards “innovation” in crop production, most activities were related to the introduction of new machinery and equipment for crop production (57 farms) as well as new plant protection products and fertilizers (58 farms). Agricultural producers used mainly working capital loans to buy new protection products and fertilizers as they are aware that this is crucial to crop performance. Despite financial difficulties, it is worth noting the activities associated with the purchase of machinery and equipment for crop production (57 farms) (Table 2).

Table 2. Type of technological changes related to crop production on the farms (%)

Voivodeship	Years	New comprehensive technologies in crop production	New fertilizers	New plant protection chemicals	New machinery and equipment for crop production	Change of cropping pattern	New plant species and varieties	Other
Podkarpackie	average	9.5	10.9	21.9	19.0	14.6	22.6	1.5
	2017	6.3	14.6	27.1	16.7	14.6	20.7	0.0
	2018	10.6	10.6	21.3	23.5	10.6	23.4	0.0
	2019	11.9	7.1	16.7	16.7	19.0	23.8	4.8
Podlaskie	average	8.3	9.0	15.0	29.0	9.0	29.7	0.0
	2017	12.8	7.7	10.3	35.9	5.1	28.2	0.0
	2018	8.9	9.9	17.8	26.8	8.9	27.7	0.0
	2019	6.8	6.8	9.1	34.1	9.1	34.1	0.0

Table 3. Type of technological changes related to animal production on the farms (%)

Voivodeship	Years	Increasing livestock numbers (main approach)	Increasing the numbers of other animals	Modernization of livestock buildings	Conservation of own feeds	Purchase of milking machine or cooler	New hygiene products	Construction of livestock buildings	Improvement of animal welfare	Installation of new machinery and equipment	Introduction of new species and breeds of animals	Introduction of changes in animal nutrition	Purchase of breeding animals	Other
Podkarpackie	average	10.1	1.4	18.1	4.5	1.5	7.2	4.3	18.1	8.7	5.8	15.2	5.1	0.0
	2017	14.9	0.0	21.3	4.3	2.1	2.1	4.3	14.9	8.5	10.6	10.6	6.4	0.0
	2018	7.8	2.0	19.7	5.9	0.0	9.8	5.9	17.6	7.8	2.0	17.6	3.9	0.0
	2019	7.5	2.5	12.5	2.5	2.5	10.0	2.5	22.5	10.0	5.0	17.5	5.0	0.0
Podlaskie	average	7.7	1.9	6.4	3.2	0.0	10.9	1.9	14.2	14.7	11.5	16.7	10.3	0.6
	2017	9.5	0.0	7.2	7.2	0.0	11.9	2.4	9.5	19.0	19.0	9.5	4.8	0.0
	2018	6.9	2.0	7.8	3.9	0.0	10.8	2.9	14.7	12.7	14.7	11.8	11.8	0.0
	2019	9.3	1.9	3.7	1.9	0.0	11.1	0.0	13.1	18.5	5.6	25.6	7.4	1.9

The type of changes associated with livestock production largely involved the improvement of animal welfare and the introduction of changes in animal nutrition through the use of new concentrate feeds and mineral additives (Table 3). Investments such as modernization of machinery (14.7% – Podlaskie voivodeship) and modernization of agricultural production facilities (18.1% – Podkarpackie voivodeship) were noted in larger-sized farms. Research showed the following regularities. A much larger number of farms indicated the introduction of changes in animal nutrition (on average 16% from both voivodeships).

As Table 4 shows, the highest numbers of farms used different types of renewable energy sources, especially in the Podkarpackie voivodeship. Farms located in the Podlaskie voivodeship did not apply any technology changes to environmental protection in 2019. The most popular innovation in farms from the eastern Polish area was an efficient use of water resources and photovoltaic cells.

Table 4. Type of technological changes related to environmental protection on the farms (%)

Voivodeship	Years	Improved efficiency of the water resources	Improved efficiency of the wind energy	Improved efficiency of energy use on the photovoltaic cells	Improved efficiency of energy use on the biomass energy	Other
Podkarpackie	average	41.4	20.7	27.6	6.9	3.4
	2017	100.0	0.0	0.0	0.0	0.0
	2018	10.0	40.0	20.0	20.0	10.0
	2019	42.9	14.2	42.9	0.0	0.0
Podlaskie	average	45.5	9.1	27.3	0.0	18.1
	2017	40.0	20.0	0.0	0.0	40.0
	2018	45.5	9.01	27.3	0.0	18.1
	2019	0.0	0.0	0.0	0.0	0.0

As regards the economics and organization of production in the farms selected for the study, the changes made concerned mainly the keeping of records of costs and revenues. On average, “bookkeeping” was introduced in almost 20% of the farms in the Podkarpackie voivodeship and in almost 16% in the Podlaskie voivodeship (Table 5). It is worth noting that the surveyed lamb producers in the Podlasie region did not keep any records of costs and revenues on computer, unlike in most of the farms under study. The low interest shown by the farmers in expanding the acreage by buying arable land was attributed to the lack of sufficient funds to finance the investment. Farm area was increased through the lease of land in 39 farms and through the purchase of land in 21 farms. Mainly live pig producers resorted to the lease of land.

Table 5. Type of changes related to the organization of production on the farms (%)

Voivodeship	Years	Increasing farm area through purchase of agricultural land	Increasing farm area through lease of agricultural land	Construction or modernization of livestock buildings	Purchase of agricultural machinery and equipment	Purchase of tractors	Keeping of records of costs and revenues on the farm	Introduction of computer techniques	Use of credits for investment purposes	New forms of work organization on the farm	Searching for new sources of income	Integration of farms into groups of agricultural producers	Improved marketing of agricultural products	Collective purchase of means of production
Podkarpackie	average	7.2	10.9	12.3	18.1	5.1	19.7	4.3	7.2	2.2	5.1	3.6	1.4	2.9
	2017	9.3	16.2	11.6	14.0	4.7	16.2	4.7	4.7	4.7	6.9	4.7	0.0	2.3
	2018	6.1	6.1	14.4	20.4	6.1	20.4	2.0	8.2	0.0	6.1	4.1	2.0	4.1
	2019	6.5	10.9	10.9	19.6	4.3	21.6	6.5	8.7	2.2	2.2	2.2	2.2	2.2
Podlaskie	average	6.0	7.5	4.5	27.8	3.0	15.8	4.5	3.8	6.0	4.5	2.3	3.8	10.5
	2017	0.0	0.0	0.0	46.8	3.1	12.5	6.3	3.1	6.3	3.1	3.1	6.3	9.4
	2018	1.2	4.7	5.9	37.6	4.7	15.3	4.7	5.9	7.1	1.2	3.5	2.4	5.8
	2019	14.6	12.5	2.1	10.4	0.0	16.7	4.1	0.0	4.1	10.4	0.0	6.3	18.8

Based on the analysis of the investment projects in the studied agricultural holdings, it can be stated that most of the changes and investments, small as they were, were financed out of own resources. A large share (31.5% – Podkarpackie voivodeship and 22.4% – Podlaskie voivodeship) of the sources of financing technological changes in the farms was provided by funds from aid schemes. Less than 10% of the projects were financed from credits, mainly commercial credits (Table 6).

Table 6. The main sources of funding for technological changes on the farms (%)

Voivodeship	Years	Own funds	Credit	EU funds	Other
Podkarpackie	average	36.2	7.7	31.5	24.6
	2017	55.6	11.1	33.3	0.0
	2018	34.9	9.3	46.5	9.3
	2019	23.6	3.9	17.6	54.9
Podlaskie	average	49.4	9.4	22.4	18.8
	2017	53.8	11.6	34.7	0.0
	2018	52.2	17.4	26.1	4.3
	2019	44.4	2.8	11.1	41.7

In the present study, the farmers defined their attitudes towards the implementation of changes and novelties (Table 7). It is concluded based on the information obtained that most of the surveyed farmers approached the changes with reserve but were favourably inclined towards them. Innovations were willingly introduced to the farms by almost 29% of the farm owners in the Podlaskie voivodeship and by around 23% of the farmers in the Podkarpackie voivodeship.

Table 7. Willingness of the farm owners to implement changes (%)

Voivodeship	Years	Hard to say	High	Low
Podkarpackie	average	58.5	23.0	18.5
	2017	57.1	35.7	7.2
	2018	52.0	28.0	20.0
	2019	65.4	11.5	23.1
Podlaskie	average	49.3	28.6	22.1
	2017	50.0	29.2	20.8
	2018	41.3	34.8	23.9
	2019	61.2	19.4	19.4

According to the owners of the surveyed farms, the low selling prices for agricultural products are an impediment to the development of the farms (Table 8). The other restraining factors on farm development, indicated by animal raw material producers, included low profitability of production and difficulties to sell animal raw materials.

Table 8. Factors restraining the development of farms (%)

Voivodeship	Years	Lack of cultural funds	High interest rates on agricultural credits and difficulties in obtaining credit	Low selling prices for agricultural products	Risk due to high fluctuations in selling prices	High prices for means of production	Difficulties in selling agricultural products	Competitive imports	Adverse weather conditions	High cost of agricultural services	No restraining factors
Podkarpackie	average	7.9	4.3	24.5	20.9	23.7	2.3	5.0	8.6	1.4	1.4
	2017	28.6	0.0	71.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2018	9.7	6.9	23.6	19.4	26.4	2.8	5.6	4.2	1.4	0.0
	2019	6.0	1.4	25.4	22.4	20.9	1.5	4.5	13.4	1.5	3.0
Podlaskie	average	13.3	0.0	26.7	34.2	4.2	4.2	5.8	9.2	1.6	0.8
	2017	15.5	0.0	28.9	35.6	2.2	4.4	6.7	6.7	0.0	0.0
	2018	15.5	0.0	28.9	35.6	2.2	4.4	6.7	6.7	0.0	0.0
	2019	12.0	0.0	25.3	33.3	5.3	4.0	5.3	10.7	2.8	1.3

Table 9. Factors conducive to the development of farms (%)

Voivodeship	Years	Possibility of using EU funds	Preferential credits	Possibility of exporting agricultural products and preparations thereof	Favorable prices for agricultural products sold	Agricultural procurement agreements	Insurance reducing the risk of carrying on agricultural activities	Lack of conducive factors	Other
Podkarpackie	average	48.4	6.3	0.0	6.3	9.4	7.7	18.8	3.1
	2017	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2018	62.1	3.4	0.0	3.5	6.9	6.9	13.8	3.4
	2019	37.1	8.6	0.0	8.6	11.4	8.6	22.9	2.8
Podlaskie	average	45.7	7.1	12.9	1.4	0.0	0.0	32.9	0.0
	2017	55.6	11.1	0.0	3.7	0.0	0.0	29.6	0.0
	2018	55.6	11.1	0.0	3.7	0.0	0.0	29.6	0.0
	2019	39.5	4.7	20.9	0.0	0.0	0.0	34.9	0.0

The owners of agricultural holdings showed EU funds as the major factor contributing to farm development (Table 9). However, almost 33% of the farmers from the Podlaskie voivodeship and 19% farmers from the Podkarpackie voivodeship indicated the lack of factors conducive to technical and technological changes as well as the presence of obstacles to the development of the farms. Despite the benefits of introducing innovative solutions in agriculture, there are many factors that make them less efficient. As regards the impediments to the implementation of new solutions, farm owners from the Podkarpackie voivodeship considered that their operations are most adversely affected by the low selling prices for agricultural products (24.5%), the high prices for the means of agricultural production (almost 24%), and the risk of considerable selling price fluctuations (almost 21%). According to the farmers, the development of agricultural holdings is also negatively influenced by adverse weather conditions.

Discussion

New technologies and processes, as well as extensive scientific knowledge in agronomy and crop science facilitate the introduction of innovation in the form of innovative solutions which may be either simple or more complex (Pisante et al., 2012). According to Rotz et al. (2019) innovative solutions are the effect of farmer involvement but also result from political actions and the context in which the farm operates.

Production activity in agriculture has a significant environmental impact and can negatively affect the soil, air, and surface and ground waters. A key environmental issue is the fact that livestock metabolize feed and deposit many nutrients into the environment in the form of excreta. Improper use of the industrial means of production, chemical fertilizers and plant protection chemicals may adversely affect many ecosystems. Agriculture uses natural resources directly in the production processes. On the other hand, farmers operating in a market economy must produce in accordance with social needs and, at the same time, maximize their goal functions through production and economic effects under conditions of competition. The achievement of microeconomic goals in agriculture is not always commensurate with environmental and social objectives. Environmental protection becomes a priority and at the same time one of the most important challenges of many European Union policies (Góral and Rembisz, 2017). As regards “innovations” introduced into production to protect the environment, most activities focused on improving efficient use of on-farm water resources. Examples included coverage of arable land with vegetation during winter or contribution of mixtures with small-seeded and coarse-grained legumes to the cropping system. The main factor to prevent water loss and ensure water use efficiency is the application of sustainable management practices. According to Pisante et al. (2012), the use of improved varieties of drought-resistant crops makes water use more efficient under sprinkling irrigation conditions. Good management combined with reuse of final water favours the protection of water on a farm.

The European Union’s recent activities promote using renewable energy and increasing energy efficiency (Nándor and Vántus, 2015). These measures also have an

impact on agriculture, as evidenced by the results of our own research which revealed that the technological change favouring environmental protection in the analyzed farms was an increased use of renewable energy sources.

Our results showed that Polish farms introduce changes related to the improvement of animal welfare. By raising the level of animal welfare, which is an extremely broad topic, in addition to ethical benefits, financial benefits can also be obtained. This reflects growing public awareness as well as the involvement of the public sector, as evidenced by numerous publications and reports, also legal acts and certificates (Buller et al., 2020).

In conclusion, comparative analyses of data from Polish farms indicated increasing in the innovation changes, especially in animal production. We could observe changes in the improvement of animal welfare, which is consistent with the Green Deal strategy. It can be observed that most of the changes introduced required little financial outlays and inventiveness. It should be highlighted that for most of the large farms, the changes made are more intense and the farmers understand the need to introduce these changes and show pro-innovative attitudes. The introduction of changes in agricultural holdings is difficult because it often entails a change in farmer's mentality and is specific to agricultural production. It can be observed that livestock farm owners realize that the implementation of new technological solutions and new ideas provides an opportunity to improve farm organization and management. Thus it can contribute to improving the economic situation and increasing the income.

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Innowacje rolnicze, zmiany technologiczne i bariery gospodarstw rodzinnych w województwach podlaskim i podkarpackim

STRESZCZENIE

Działalność innowacyjna jest niezwykle ważna przy modernizacji polskiego rolnictwa, wiąże się z wprowadzaniem zmian, upowszechnianiem wszelkich nowości, udoskonaleniem stanów już istniejących w celu zwiększenia wydajności produkcji, a także obniżenia jej kosztów. Niezbędne jest unowocześnienie i usprawnienie gospodarstw rolniczych jako warsztatu pracy rolnika. Wprowadzanie innowacji przyczynia się do rozwoju gospodarstw rolnych. Jest to więc jeden z możliwych sposobów dostosowawczych do warunków gospodarki rynkowej. Dlatego celem przedstawionych badań było określenie rodzaju innowacji, zmian technologicznych oraz barier związanych z rozwojem rodzinnych gospodarstw rolnych zlokalizowanych w dwóch województwach Polski. Materiał źródłowy do analizy stanowiły informacje pozyskane metodą wywiadu kwestionariuszowego w 590 gospodarstwach rodzinnych utrzymujących zwierzęta gospodarskie.

Słowa kluczowe: rolnictwo, innowacje, zmiany, produkcja zwierzęca