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ORIGINAL ARTICLE

Sustainability conditions of Polish agriculture in the context of the use of plant protection products, as compared to other European Union countries. Economic aspects

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Abstract

Sustainable agriculture is a management system based on the use of agricultural practices that contribute to maintaining the natural environment in good condition. It allows for the rational use of its resources, and minimizing losses for society while maintaining profitability of agricultural production. An important feature of a sustainable agricultural system is the moderate use of industrial agricultural production products, including plant protection products, which in practice should be closely matched to the type and strength of the threat occurring in agricultural crops. The cost of plant protection products per 1 ha of crops is an important indicator of the intensity of agricultural production, which as a result of growing competitive pressure, is still increasing, especially in areas with favorable natural conditions for its development. In this context, it is therefore important to emphasize the strong current aim and readiness of the European Union (EU) to restrict the use of plant protection products in agriculture. This is referred to as the "farm to fork" strategy, which is an important element of the European Green Deal. Currently, the European Commission (EC) is taking a number of legislative steps to reduce the overall use of plant protection products. However, the question arises whether and to what extent Polish agriculture can participate in the ambitious EU goal to reduce them. To try to answer this question, an assessment was made of the amounts and structure of the consumption of chemical plant protection products in Poland, and compared to other EU countries. It was also important to compare the costs of plant protection products per 1 ha of crops on farms in Poland, with similar farms in other European Union countries, while taking into consideration the diverse natural farming conditions in which they operate.

Keywords: costs of plant protection products, plant protection products, sales of plant protection products, sustainable agriculture

Introduction

Sustainable agriculture is a management system that meets one of the basic objectives of the Common Agricultural Policy of the European Union (EU CAP), which concerns the need to achieve a balance in agriculture between ensuring satisfactory agricultural income and providing environmental goods to society in a lasting and stable manner (M'barek *et al.* 2017; Uthes *et al.* 2020). In practice, the system allows for the rational use of natural resources, including soil and the protection of biodiversity and landscape, while maintaining a moderate intensity of agricultural production ensuring satisfactory economic effects. According to

Runowski (2009, 2012), sustainable agriculture is focused on using natural resources in such a way that does not destroy them, but makes it possible to meet the basic needs of society. The above opinion corresponds well with the views of Woś and Zegar (2002), who emphasized that this type of agriculture supports protection and at the same time ensures good quality agricultural production. Matyka (2016) felt that agriculture is distinguished by economic viability, ecological safety, and social approval. In turn, Krasowicz (2009) is convinced that this system should be the dominant farming system in agriculture. It should be emphasized that in general it is thought that sustainable agriculture can effectively implement the 17 global sustainable development goals adopted under the UN resolution entitled *Transforming our world: the 2030 Agenda for Sustainable Development of 2015*, as well as the goals of the European Green Deal strategy of 2019, and its thematic strategies, in particular, the "Farm to Fork" strategy (UN 2015; EC 2019; EC 2020).

Actions aimed at increasing the importance of sustainable agriculture are necessary on a global, European and national level. In economic reality, negative changes in the natural environment, often caused by agriculture, are intensifying (FAO 2020; Gamage *et al.* 2023). The process often results from the progressive intensification of agricultural production related to growing competitive pressure, especially in areas with favorable natural conditions for its production. However, it is worth noting that excessive use of industrial agricultural production products, including chemical plant protection products, causes significant environmental and social damage, for example, reducing the population of insects and thus reducing the amount of food for birds typical of the agricultural landscape (Vickery *et al.* 2009). The circumstances therefore contribute to the reduction of their populations, which are some of the most important biodiversity indicators used in the world, including in the European Union (Gamero *et al.* 2017). A decline in insect populations also contributes to reduced pollination of crop plants, as well as reduced regulation of pests, diseases, and invasive alien species (Potts *et al.* 2010; Schowalter *et al.* 2018). Therefore, as Piwowar (2018) emphasizes, the action of chemical plant protection products negatively affects the quality of the natural environment. Research also indicates a clear statistical relationship between exposure to chemical plant protection products and an increase in the risk of diseases in humans (Żak 2016). Moreover, their ill-considered use in agriculture also results in unjustified additional production costs that are not reflected in the achieved production results. Taking the above into account, it is necessary that their use be strictly adjusted to the type and strength of the threat occurring in agricultural crops.

The European Commission (EC) is currently seeking to limit the use of plant protection products in European Union agriculture. It is currently undertaking a number of legislative actions to reduce their overall use by 50% by 2030. However, the question arises whether and to what extent its member countries, including Poland, are able to participate in the ambitious goal. EU countries differ in their quality of natural farming conditions, production orientation, and economic strength of farms, as well as the intensity of agricultural production. To try to answer the question in the context of Polish agriculture, the aim of this analyses was to assess and compare the volume and structure of the consumption of chemical plant protection products in Poland with other European Union countries. It was also important to determine and compare the level of costs of plant protection products per 1 ha of crops on farms in Poland, and on similar farms in other EU countries. The diverse natural farming conditions in which they operate were also taken into account.

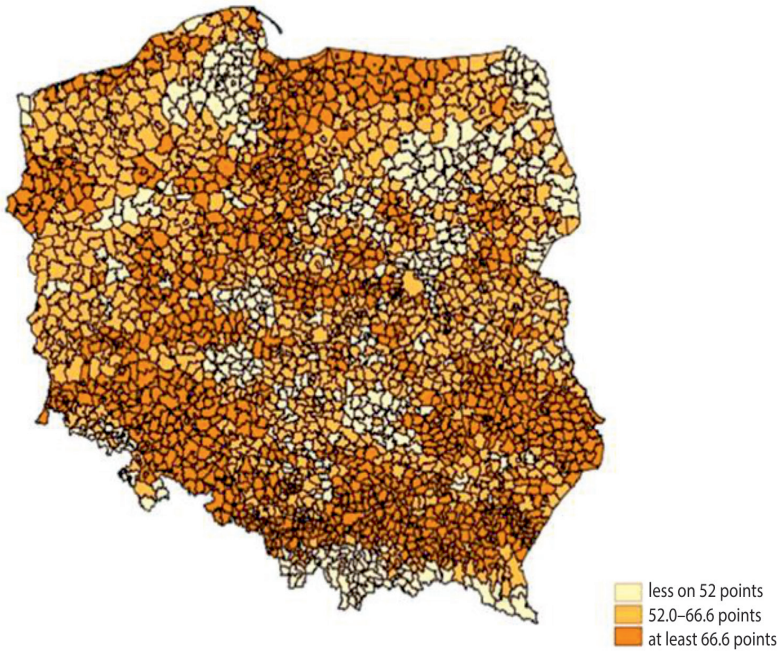
Materials and Methods

To determine changes in the volume and structure of the use of chemical plant protection products in Poland, Statistics Poland data about their sales to domestic agriculture was used. The data included sales by manufacturing companies to domestic customers plus imports. In accordance with Eurostat requirements, sale surveys cover all plant protection products admitted to trading in Poland (since 2005 from producers and importers, and since 2018 from holders of a marketing authorization from the Ministry of Agriculture and Rural Development). In 2010, there were 957 of plant protection products admitted to trading in Poland, in 2015 – 1,405, in 2020 – 2,521, in 2021 – 2,789, and in 2022 – 2,714. It is true that values of the sale of plant protection products and their consumption are not necessarily the same. However, in practice, the vast majority of purchases are used in a given growing season, often immediately after purchase. This is especially true for expensive products since it is usually not profitable for agricultural producers to save money for the purchase of preparations that may not be used or may have expired, which is usually 2 years. Notably, the measure of sales and consumption of plant protection products is also not perfect due to the large variety of chemical compounds used in plant protection. Active substances include those that are used in amounts of a few grams per 1 ha, but also those that are used in amounts of several kilograms. Despite this fact, the tonnage approach is commonly used to measure the consumption of the discussed agrochemicals (Golinowska 2009; Matyjaszczyk 2014).

To determine differences in the level of consumption of plant protection products in selected crops in Polish agriculture, data was used from a consumption survey conducted in accordance with the methodology specified in the provisions of Regulation (EC) No. 1185/2009 of the European Parliament and of the Council of November 25, 2009 on statistics on pesticides. In Poland, the State Plant Health and Seed Inspection Service in cooperation with the Ministry of Agriculture and Rural Development, Statistics Poland and the Plant Protection Institute, National Research Institute Sośnicowice Branch, are responsible for carrying out the study. Data on the consumption of plant protection products is collected by the State Plant Health and Seed Inspection Service inspectors during direct visits to farms and their acquisition is based on the farmer's records of treatments performed with plant protection products. FAO data on the consumption of plant protection products, including per 1 ha of crops was used to determine differences in consumption among European Union countries.

To compare the level of costs of plant protection products per 1 ha of crops on farms in Poland, with similar farms in other EU countries, data from farms published by the European Commission on its website as part of the FADN – FSDN (Farm Accountancy Data Network – Farm Sustainability Data Network) public information system was used. The most up-to-date data for 2020 was used in the comparative analysis of farms. Appropriate analyses were performed on farms separated according to their production type (field crops, horticultural crops, permanent crops, dairy cows, other grazing animals, granivores, and mixed animals), and based on their economic size expressed as Standard Output (farms with less than EUR 25 thousand SO, EUR 25-50 thousand SO, and at least EUR 50 thousand SO). Data from farms collected as part of the European FADN system is widely treated as the best available data set on agriculture in the EU (Zimmermann and Britz 2016; Uehleke *et al.* 2022). In 2020, the data was representative of approximately 40% of farms operating in the EU (EC 2020).

The aim of the analyses was also to determine the costs of plant protection products per 1 ha of crops on Polish farms conducting agricultural production under various natural conditions. In the authors' opinion, in the context of the discussed issue, it is also important to consider the national specificity of natural management conditions. In Poland, areas with difficult management conditions and with different specificities of the difficulties are of great importance. There are areas with difficulties resulting from low land productivity caused by low soil quality, as well as unfavorable climatic and topographic conditions, as indicated by their low average agricultural production area valorization index (APAV) established by the Institute of Soil Science and Plant Cultivation State Research Institute.[1] (Fig. 1).



Source: own study based on the Institute of Soil Science and Plant Cultivation State Research Institute, State Research Institute data

Fig.1. The value of the valorization of the agricultural production space ratio (points) in communes in Poland

[1]Institute of Soil Science and Plant Cultivation State Research Institute, State Research Institute used the APAV index for the national delimitation of zones with areas facing natural or other specific constraints (ANCs).

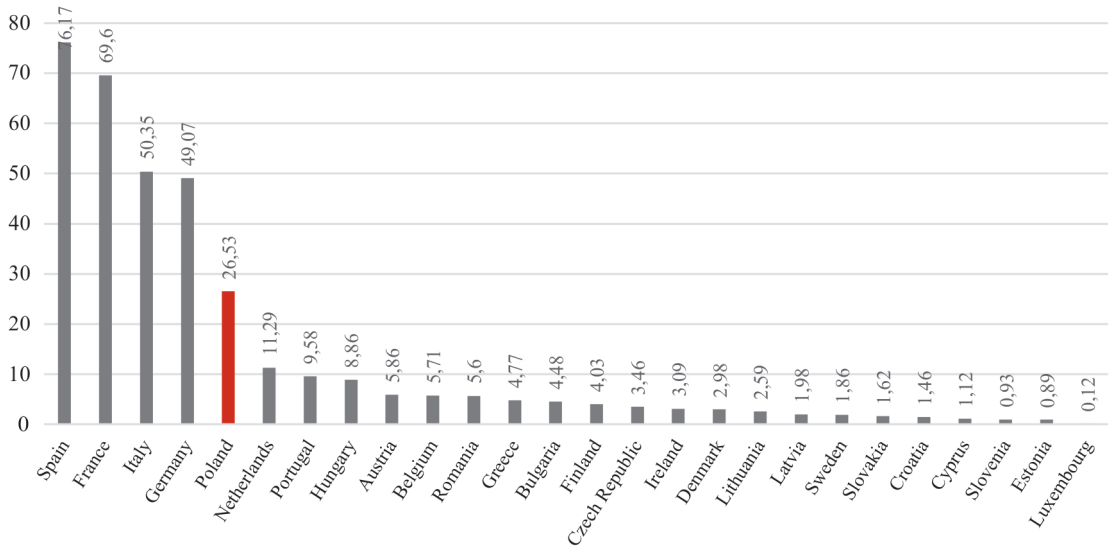
As a result, the analyses determined the costs of plant protection products per 1 ha of crops on farms keeping accounts for the Polish FADN from communes with an average APAV index below the national average, i.e., below 66.6 points per 120 points achievable, as compared to similar farms from other communes. The comparative analyses took into account the production type of farms and their economic size. The analyses were based on the most current data available in the Polish FADN (2021).

Volume of consumption of plant protection products in Poland, as compared to other European Union countries

Most crop protection is based on the use of chemical preparations, which are still considered to be the most effective and modern method of preventing threats to plant yields caused by pests. On the other hand, it is associated with negative side impact on the natural environment. Therefore, it should be emphasized that reducing the use of chemical plant protection products should be one of the priority goals in achieving sustainable agriculture. This would undoubtedly minimize the dangers and threats to human health and nature.

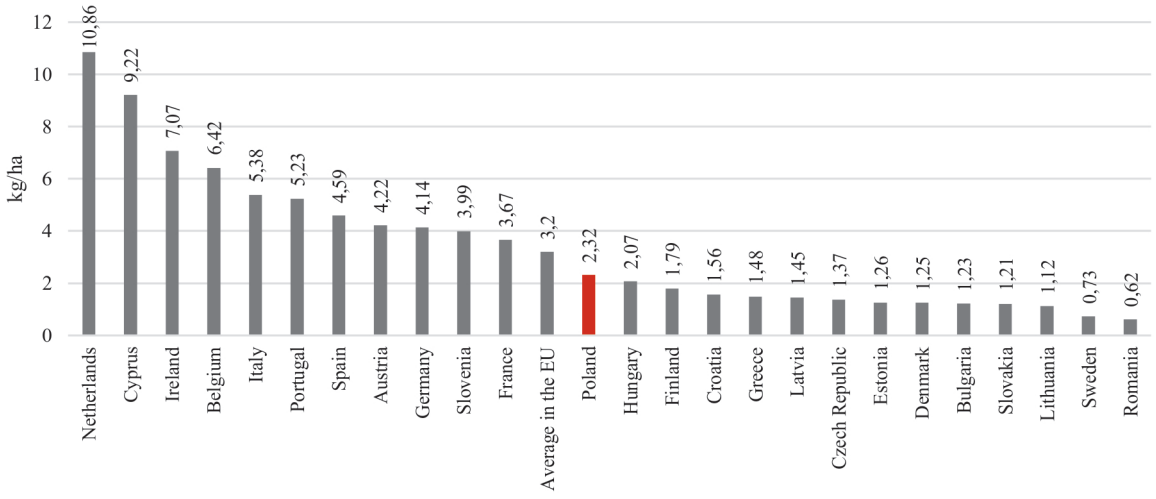
FAO data shows that in 2021 the consumption of active substances contained in plant protection products in European Union agriculture amounted to 354 thousand tons. For comparison, in 2015 the consumption was higher and amounted to 366 thousand tons. The largest amounts of active substances were used in Spain and France – 76.2 thousand tons and 69.6 thousand tons, respectively. In Italy, the consumption of plant protection products amounted to 50.3 thousand tons, in Germany – 49.1 thousand tons, in Poland – 26.5 thousand tons, and in the Netherlands – 11.3 thousand tons. The volume of consumption in other countries did not exceed 10 thousand tons (Fig. 2). The consumption of plant protection products per 1 ha of crops in Polish agriculture in 2021 was 27.5% lower than the average in the European Union. For comparison, in 2015 the difference was larger and amounted to 35%. Some reduction in the disproportions in 2015–2021 resulted from a decrease in consumption in the European Union by an average of 2.4% and an increase in consumption in Poland by 8.9%. An increase in the unit consumption of plant protection products was recorded, e.g., in Bulgaria (almost 3 times), in Austria (by 57.5%), in Estonia (by 43.2%), in Latvia (by 18.9%), in France (by 6.7%), in Germany (by 4.0%), and in the Netherlands (by 2.8%). In turn, a decline in consumption was recorded, e.g., in Greece (by 46.2%), in Croatia (by 37.6%), in Italy (by 23.1%), in the Czech Republic (by 22.2%), Finland (by 18.3%), and Belgium (by 15.6%).

Among the European Union countries, by far the largest amounts of active substances per 1 hectare of crops were used in the Benelux countries, Cyprus and Ireland – in 2021 it was at least 6 kg. Consumption was also higher than the average in the European Union, among others, in Italy, Germany, Austria, Portugal, and Spain. The group of countries with the lowest level of consumption included Romania and Sweden. Consumption of active substance in the countries in 2021 did not exceed 1 kg/ha of crops (Fig. 3).



Source: FAO data

Fig. 2. Consumption of plant protection products in European Union countries in 2021. (thousand tons of active substance)



Source: FAO data

Fig. 3. Average consumption of plant protection products in the European Union countries in 2021 (kg of active substance/ha of crops)

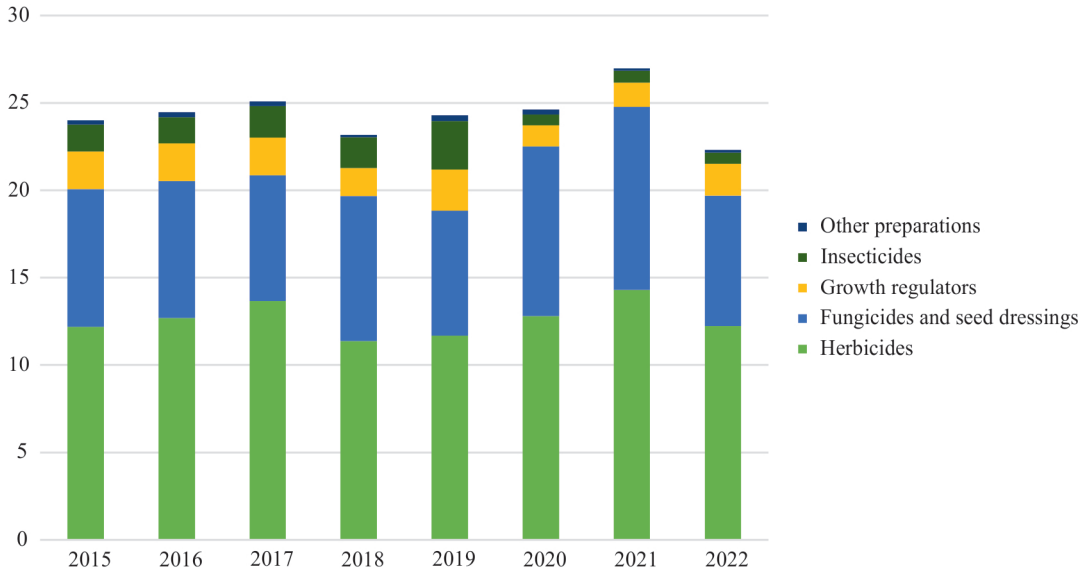
Data from Statistics Poland on the sales of plant protection products in Poland in 2015–2022 indicates, on one hand, an increase in sales expressed as the mass of goods, and on the other hand, a decrease in sales per active substance. It should be emphasized that in terms of maintaining the natural environment in good condition, information about the decline in sales of plant protection products per active substance is of key importance.

The sales of plant protection products per active substance in Polish agriculture decreased from 24.0 thousand tons in 2015–2022 to 22.3 thousand tons. However, in 2021, the sales were higher and amounted to almost 27.0 thousand tons. The following factors contributed to lower sales in 2022 on an annual basis, such as: an unstable and unpredictable situation on agricultural markets, a sudden increase in prices of basic means of production, including mineral fertilizers and energy carriers, farmers' use of stocks from the previous year, as well as a decrease in the number of active substances approved for trading and use (in 2021, there were 2,789 thousand plant protection products admitted for trading in Poland, and in 2022 – 2,714). Changes in the sales volume of individual groups of plant protection products in 2015–2022 per active substance varied. Sales of insecticides decreased by almost 60% to 0.6 thousand tons, growth regulators by 15.6% to 1.8 thousand tons, fungicidal preparations and seed dressings by 5.3% to 7.5 thousand tons, and for herbicides, it increased by 0.4% to 12.2 thousand tons. As a result, for example, the share of insecticidal preparations in the active substance sales structure decreased from 6.4% in 2015 to 2.9% in 2022, and herbicide preparations increased from 50.8% to 54.8% (Fig. 4).

In 2015–2022, the average share of herbicidal preparations in the sales structure of active substances contained in plant protection products in Polish agriculture was 51.8%. During this period, the share of fungicides and seed dressings averaged 33.8%, growth regulators – 7.7%, insecticides – 5.8%, and other preparations (e.g., rodenticides) – 0.9%. Plant protection products sold on the domestic market were mainly imported. In 2022, the share of imported preparations (mainly from Germany and France) amounted to approximately 73% according to Statistics Poland and was at a similar level as in previous years. It should also be emphasized that Poland has been a net importer of plant protection products for many years, both in terms of quantity and value (Zalewski 2023).

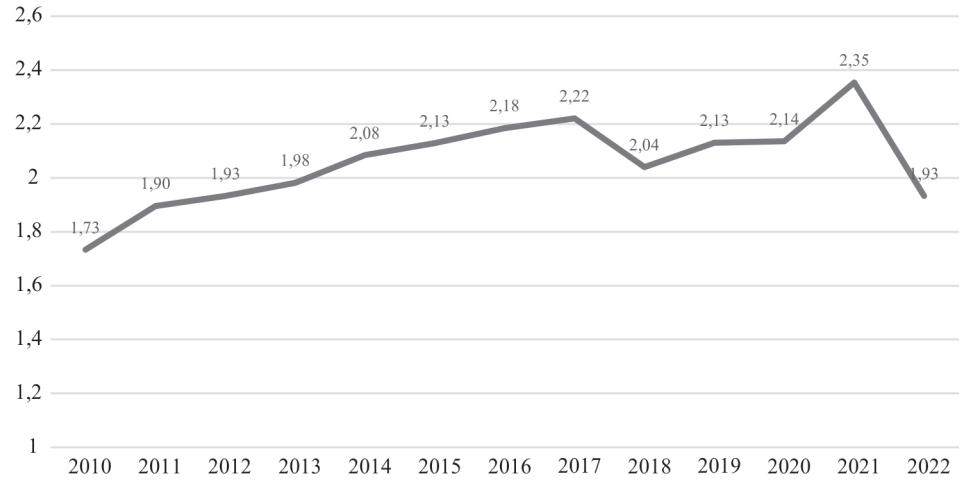
In 2022 in Polish agriculture the consumption of active substances contained in plant protection products per 1 ha of arable land and permanent crops (measured by sales volume) amounted to 1.93 kg. Compared to 2015, it was lower by 9.4%. However, it should be noted that in 2021 it reached a record level of 2.35 kg and, compared to 2015, it was higher by 10.3%. In turn, before 2014, the level of consumption per unit area did not exceed 2.0 kg of active substance. It can therefore be concluded that in 2022 the upward trend in the use of plant protection products ceased (Fig. 5).

The use of plant protection products in individual crops varies significantly. Generally, the largest amounts of active substances per unit area are used to protect orchards and vegetables. In 2019–2020, the Institute of Plant Protection, National Research Institute, in cooperation with the State Plant Health and Seed Inspection Service and Statistics Poland, examined the use of plant protection products in the cultivation of onions, corn, carrots, potatoes, winter rapeseed, field



Source: Statistics Poland data

Fig. 4. Consumption of plant protection products in Polish agriculture in 2015-2022 (thousand tons of active substance)



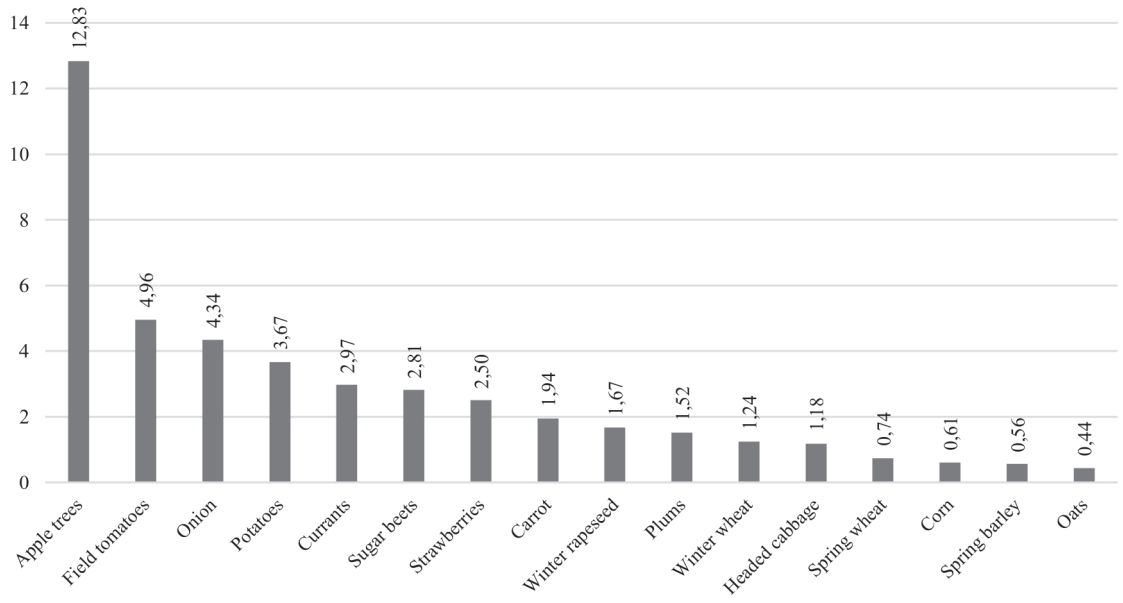
Source: own calculations based on Statistics Poland and Eurostat data

Fig. 5. Consumption of plant protection products in Polish agriculture in 2010-2022 (kg of active substance/ha of arable land and permanent crops)

tomatoes, sugar beets, apples, spring barley, head cabbage, winter wheat, strawberries, oats, spring wheat, plums, and currants. The research results showed that the most agrochemicals were used to protect apples – 12.8 kg, field tomatoes – almost 5.0 kg, and onions – 4.3 kg of active substance per 1 hectare of crops. The smallest amounts of plant protection products were used to protect oats – 0.4 kg and spring barley and corn – 0.6 kg of active substance/ha of crops (Fig. 6).

Costs of plant protection products incurred on farms in Poland, as compared to similar farms in other European Union countries

There are currently 9.1 million farms in the European Union. They are characterized by different production orientations and economic strength. In terms of production type, farms with field crops are the most important. They constitute 34% of the total number of farms. This is followed by mixed farms and farms with



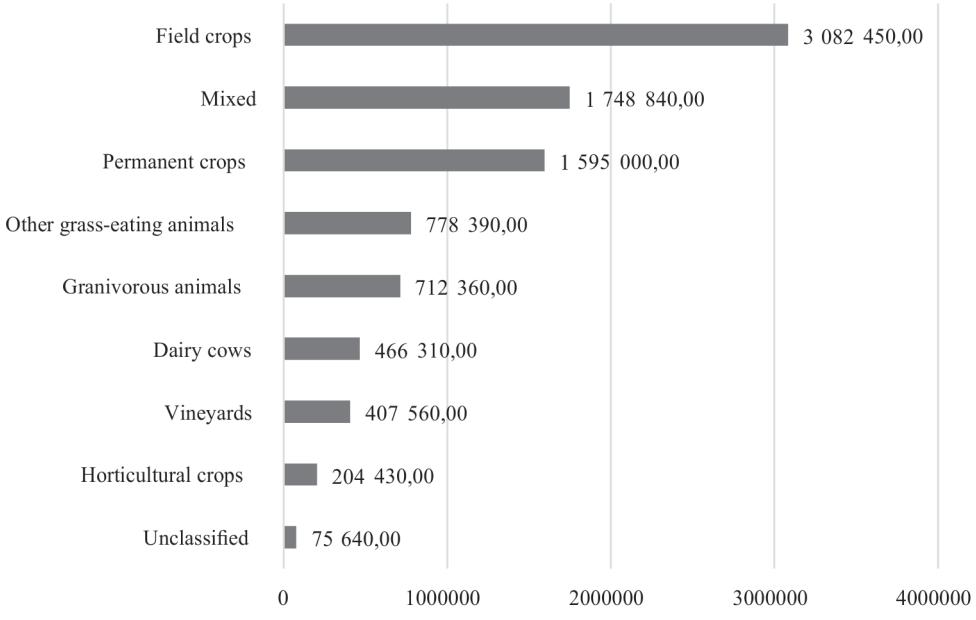
Source: Statistics Poland data prepared by the Plant Protection Institute, National Research Institute Sośnicowice Branch

Fig. 6. Consumption of plant protection products in selected crops in Polish agriculture in 2020 (kg of active substance/ha of crops)

permanent crops, which account for 19.3 and 17.6%, respectively. Farms with field crops are even more important in Poland, where they constitute 58.9% of the total number of farms. Mixed farms and farms with dairy cows are much less important in the country – 21.4 and 6.9%, respectively (Figs. 7 and 8).

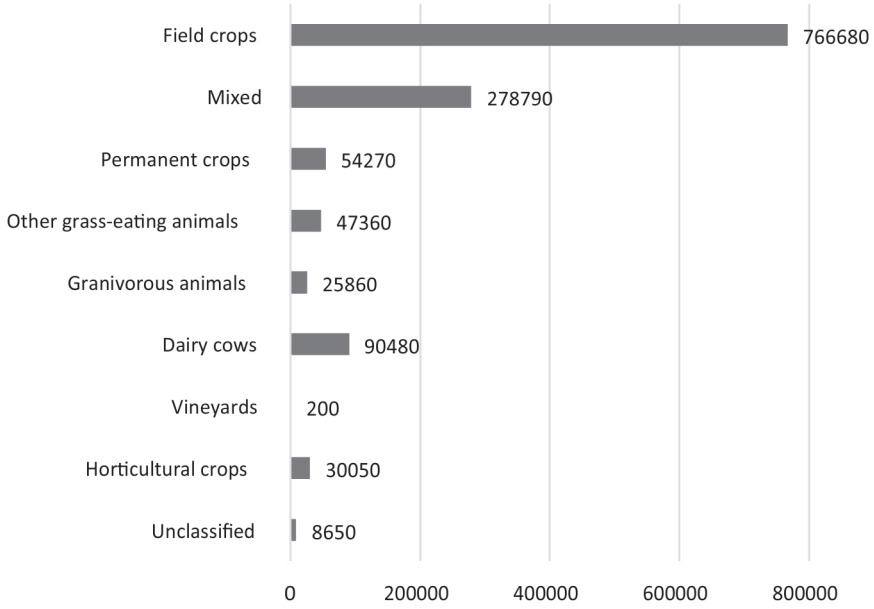
In the European Union, including Poland, in terms of economic size, farms with lower economic strength prevail (up to EUR 25,000 SO) and constitute 80.1 and 84.0% of the total number of farms, respectively. On the other hand, the share of farms with the greatest economic strength (at least EUR 50,000 SO) is 12.9 and 8.0%, respectively (Figs. 9 and 10).

In the European Union, farms differ not only in their production orientation and economic strength,



Source: Eurostat data for 2020 (https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farms_and_farmland_in_the_European_Union_-_statistics#Farms_in_2020)

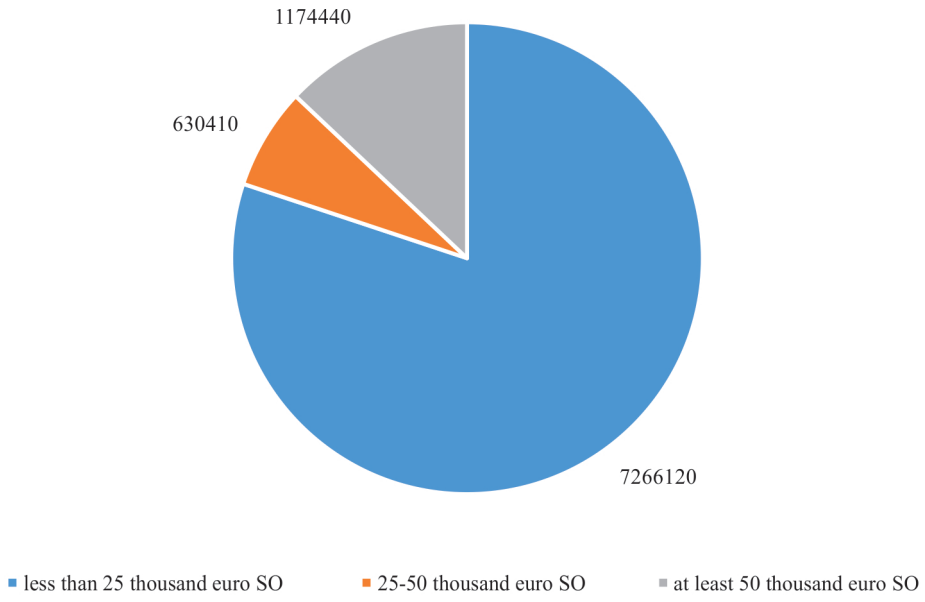
Fig. 7. Number of farms in the EU in 2020, by production type



Source: Eurostat data for 2020 (https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farms_and_farmland_in_the_European_Union_-_statistics#Farms_in_2020)

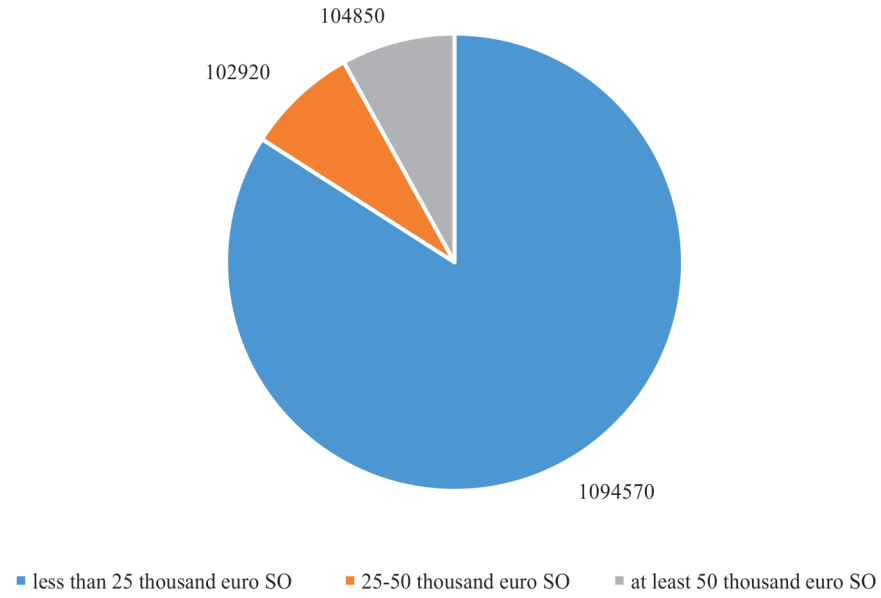
Fig. 8. Number of farms in Poland in 2020, by production type

but also in the level of intensity of agricultural production, expressed in the value of consumption of means of production, including plant protection products, per unit of crop area. Based on European FADN data, it was determined that Polish farms with only permanent crops are in the top 10 (10th place) among the European Union countries in terms of the value of the costs of plant protection products per 1 ha of crops. Domestic



Source: Eurostat data for 2020 (https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farms_and_farmland_in_the_European_Union_-_statistics#Farms_in_2020)

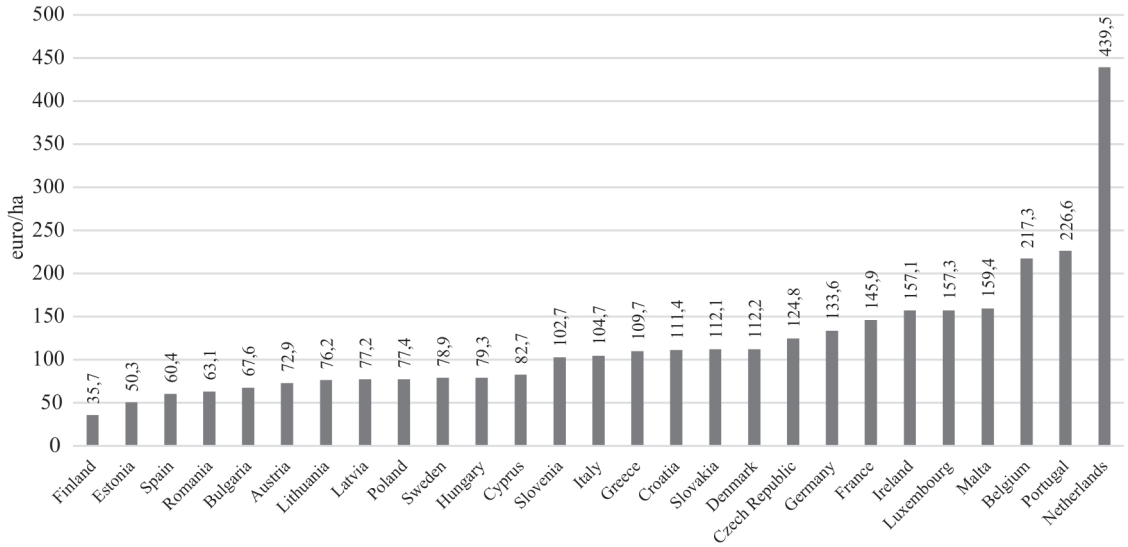
Fig. 9. Number of farms in the EU in 2020, in terms of economic size (SO)



Source: Eurostat data for 2020 (https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farms_and_farmland_in_the_European_Union_-_statistics#Farms_in_2020)

Fig. 10. Number of farms in Poland in 2020, in terms of economic size (SO)

farms specializing in animal production, mixed farms and farms with field crops turned out to be exceptionally extensive in this respect. As to economic size, Polish farms of only medium economic size were placed in the top 10 (10) European Union countries in terms of costs of plant protection products per 1 ha of crops. Farms with low and high economic size were in 13th and 11th place in the community, respectively (Figs. 11–18).



Source: European FADN data for 2020 https://circabc.europa.eu/ui/group/befb6055-ab0c-4305-84fe0c80c1c0553d/library/7c68c459

Fig. 11. Distribution of the costs of plant protection products per 1 ha of crops on farms with field crops in EU countries in 2020

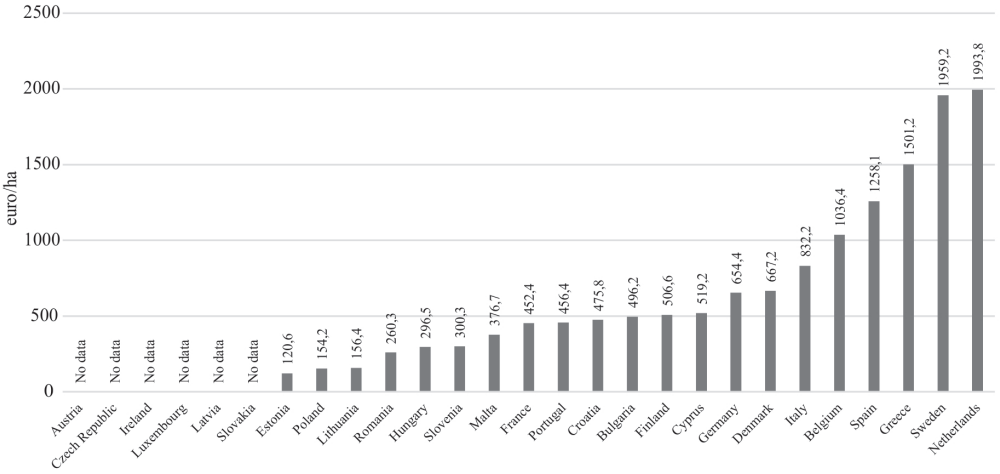


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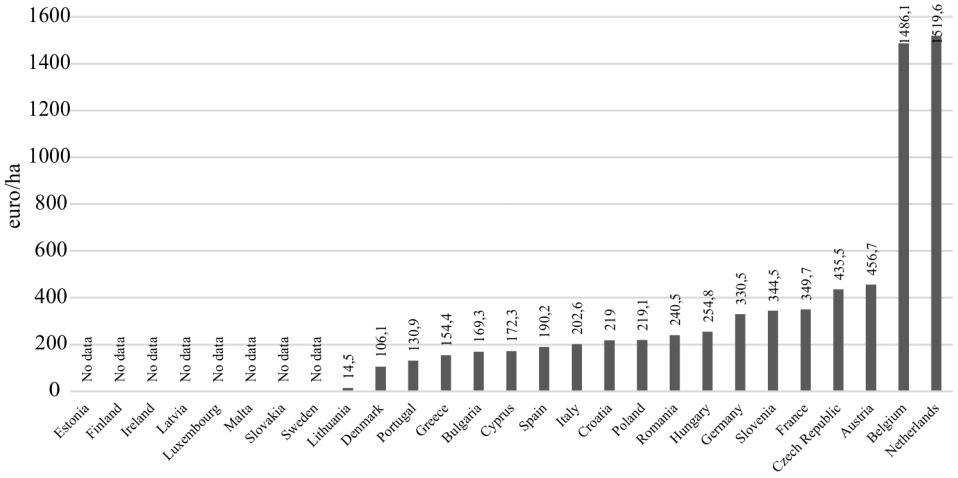
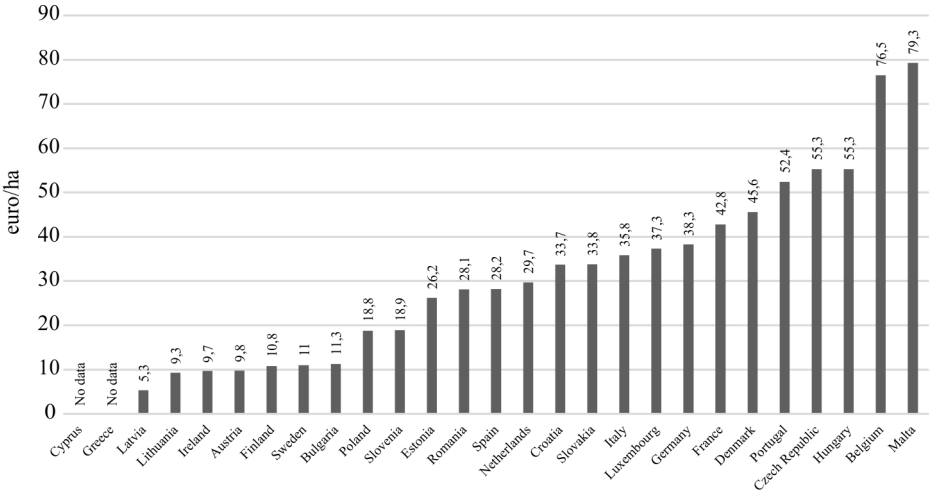
Fig. 12. Distribution of the costs of plant protection products per 1 ha of crops on farms with holiculture crops in EU countries in 2020



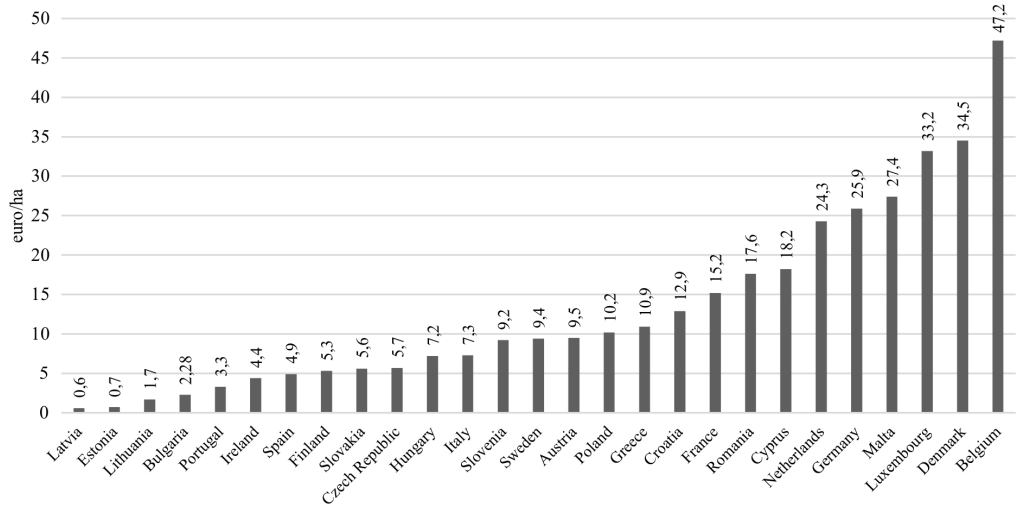
Source: as in Figure 11

Fig. 13. Distribution of the costs of plant protection products per 1 ha of crops on farms with permanent crops in EU countries in 2020



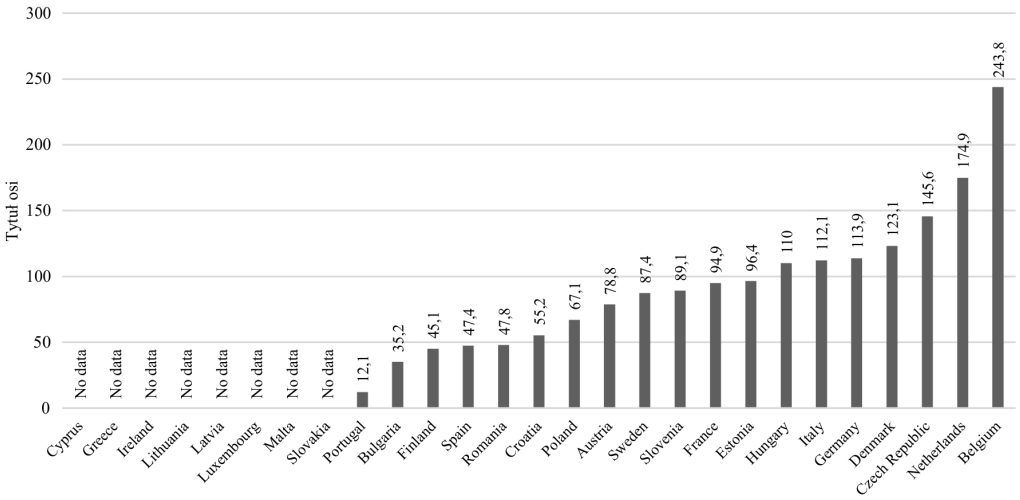
Source: as in Figure 11

Fig. 14. Distribution of the costs of plant protection products per 1 ha of crops on farms with dairy cows in EU countries in 2020



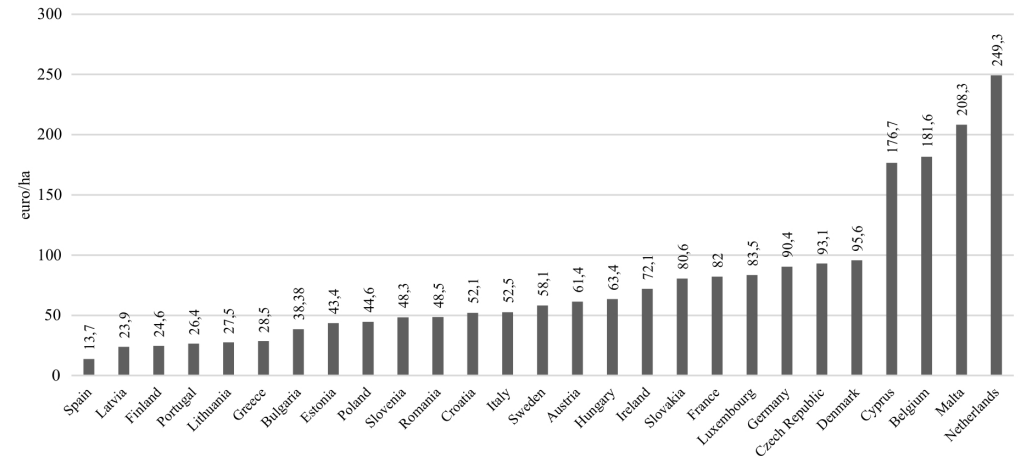
Source: as in Figure 11

Fig. 15. Distribution of the costs of plant protection products per 1 ha of crops on farms with other grass-eating animals in EU countries in 2020



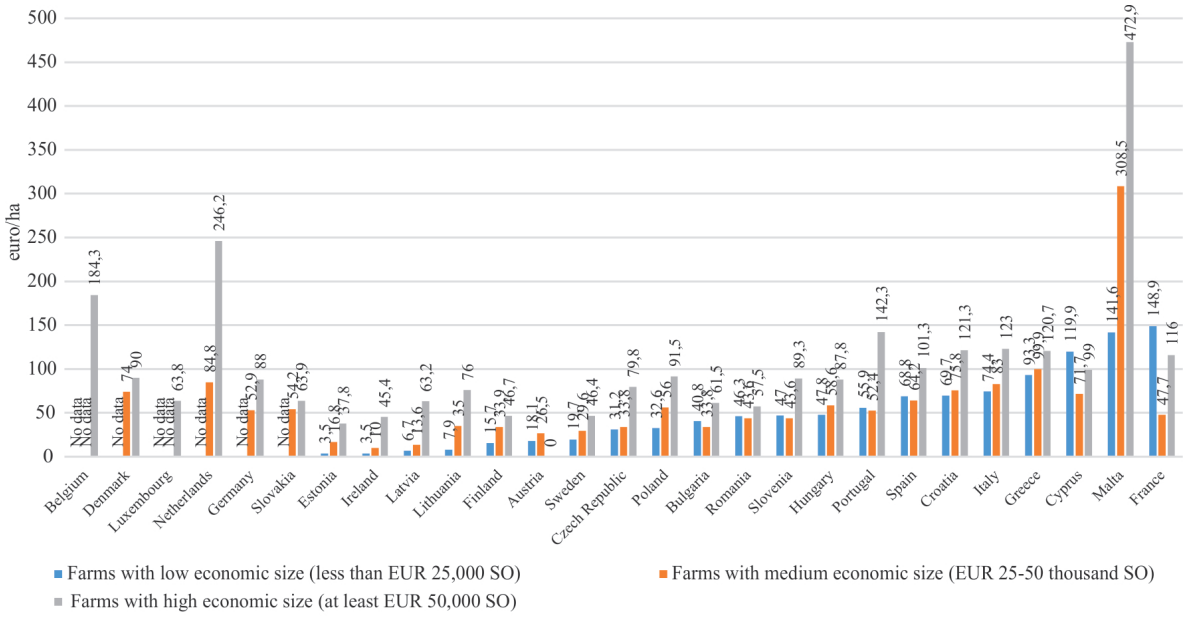
Source: as in Figure 11

Fig. 16. Distribution of the costs of plant protection per 1 ha of crops on farms with granivores in EU countries in 2020



Source: as in Figure 11

Fig. 17. Distribution of the costs of plant protection per 1 ha of crops on mixed farms in EU countries in 2020



Source: as in Figure 11

Fig. 18. Distribution of the costs of plant protection per 1 ha of crops on farms with low, medium and high economic size in EU countries in 2020

Costs of plant protection products incurred on farms operating under various natural farming conditions in Poland

Based on the numbers contained in the previous chapters, it should be noted that in Poland limiting the use of plant protection products in agriculture, including the possibility of meeting the EU-wide target of their reduction by 50% in 2030 should be approached with great caution. It is also significant that to a large extent, the situation results from the natural conditions of Polish agriculture, which are characterized by spatial variability and a large share of areas with natural difficulties in agricultural production, as evidenced by their low value of the APAV index. Such areas naturally limit the possibility of conducting intensive agricultural production, especially in the context of using plant protection products. This in turn makes them highly predisposed to successfully implement the assumptions of sustainable agriculture. In this context, their great advantage is often a diverse and valuable landscape. Furthermore, many agricultural implementing institutional environmental measures can be found under the EU CAP, i.e., agri-environment-climate, organic and afforestation measures.

In Poland, the scale of difficult natural conditions for agriculture is large. Nearly every fifth commune (18.2%) is characterized by particularly difficult natural conditions, with an average APAV index below 52 points. In 2021, there were 201.4 thousand farms whose share in the total number of farms was approximately 15.9%, and their use accounted for approximately 13.2% of the total agricultural area. Moreover, in communes with an APAV index ranging from 52.0 to 66.6 points, 40% of the total number of farms operated and used 39.9% of the total agricultural area in Poland. On the other hand, in Poland there are 42.5% of communes in which the average APAV index is at least equal to the national average (66.6 points). In 2021, there were 559.6 thousand farms in the communes, with a total area of 6,674.1 thousand ha. Their share in the total agricultural area was approximately 46.9% (Table 1).

In Polish communes with an average APAV index below the national average farms often operate with extensive organization of agricultural production (Zieliński and Jadczyszyn 2022). Moreover, as mentioned above, these communes are much more likely to have farms implementing institutional environmental measures under the EU CAP. These features of farms from areas with natural handicaps lead to the opinion that they often have limited expenditure on industrial means of agricultural production, including plant protection products (Table 2, Fig. 19).

Based on the Polish FADN data for 2021, agricultural farms, regardless of their production type and economic size, from communes with an average APAV index below the national average, incurred significantly lower costs of plant protection products per 1 ha of crops than analogous farms from other communes. It should be emphasized that the lowest costs of plant

Table 1. Selected characteristics for agriculture from communes with different average values of the valorization of the agricultural production space ratio in Poland in 2021

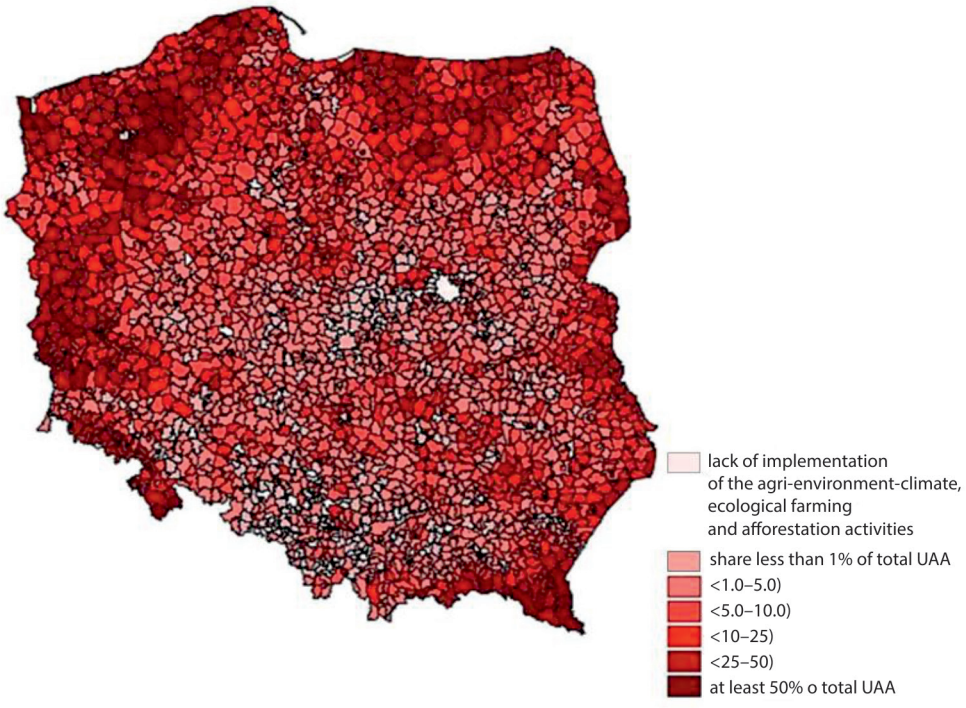
Variable	Communes with an average valorization of the agricultural production space ratio value:		
	below 52 points	52–66.6 points	at least 66.6 points
Number of communes	452	972	1053
Share of LFA areas in total agricultural land (%)	98.6	88.9	18.8
Number of farms (thousands)	201.4	508.5	559.6
Area of agricultural land (thousand ha)	1 883.7	5 660.5	6 674.1

Source: own study based on Agency for Restructuring and Modernization of Agriculture data

Table 2. Natural values and the contribution of agriculture to the protection of the natural environment in communes with different average values of the valorization of the agricultural production space ratio in 2021

Variable	Communes with an average valorization of the agricultural production space ratio value:		
	below 52 points	52–66.6 points	at least 66.6 points
Share of Natura 2000 areas in the total area (%)	34.0	24.7	15.5
Share of HNVf agricultural land in total agricultural land with:			
– exceptionally high natural value (%)	24.2	14.6	7.6
– high natural value (%)	29.7	18.3	9.7
– average natural value (%)	49.0	30.8	16.7
Share of agri-environment-climate, organic and afforestation measures under the EU CAP in total arable land (%)	18.4	14.2	7.8

Source: own study based on data from the Agency for Restructuring and Modernization of Agriculture, Institute of Soil Science and Plant Cultivation State Research Institute, State Research Institute, Zieliński, Jadczyszyn (2022)



Source: own study based on data from the Agency for Restructuring and Modernization of Agriculture

Fig. 19. Share of the area of agri-environment-climate, organic farming and afforestation measures implemented under the EU CAP in the total area of agricultural land in communes in Poland in 2021

protection products were borne by farms with the lowest economic size, and from communes with difficult farming conditions (Tables 3 and 4).

Taking the above into account, it should be emphasized that farms from communes with difficult natural conditions in terms of the costs of plant protection products per 1 ha of crops generally conduct more extensive agricultural production. In their case, however, the use of these means of production at the current level is absolutely justified due to the need to maintain production that ensures satisfactory agricultural income under the difficult conditions. Moreover, it is often dictated by the frequent proximity of ecological compensation facilities that are valuable in terms of the environment, but burdensome due to the risk of increased weed infestation (forests, unused permanent grasslands, field balks, etc.). However, there are also areas in Poland where favorable natural conditions support intensive agricultural production, which is reflected in higher costs of plant protection products per 1 ha of crops. These are areas where farms usually achieve much higher income.

Conclusions

This study tried to compare the state of sustainability of Polish agriculture in the context of the use of plant protection products, with other European Union countries. The analysis primarily considered its economic aspects.

It was established that:

- Polish agriculture, in comparison to many other European Union countries, is characterized by moderate and stable consumption of plant protection products per 1 ha of crops. Therefore, it can be assumed that in

Table 3. Costs of plant protection products per 1 ha of crops (PLN · ha^{-1}) on farms separated in terms of their production type and economic size and conducting agricultural production in various natural management conditions determined by the agricultural production area valorization index

Production type	Farms from communes with the valorization of the agricultural production area valorization index, below 66.6 points and economic size			Farms from communes with the valorization of the agricultural production area valorization index, of at least 66.6 points and economic size		
	less than 25 thousand euro SO	25–50 thousand euro SO	at least 50 thousand euro SO	less than 25 thousand euro SO	25–50 thousand euro SO	at least 50 thousand euro SO
Field crops	125.7	233.9	340.9	325.7	428.3	537.0
Horticultural crops	308.4	370.7	771.1	830.9	1230.6	1853.6
Permanent crops	857.1	917.8	962.8	948.8	1213.1	1893.6
Dairy cows	34.1	57.2	97.8	68.6	119.1	175.1
Grass-eating animals	26.6	39.9	77.9	54.8	91.4	195.3
Granivorous animals	98.9	147.3	255.0	229.6	226.9	394.9
Mixed	68.1	123.3	260.5	162.8	233.8	397.9

Source: own study based on Polish FADN data for 2021

Table 4. Increase in % of incurred costs of plant protection products per ha of crops for farms from communes with an average APAV of at least 66.6 points compared to similar farms from communes with an average APAV of less than 66.6 points in Poland in 2021

Production type	Economic size of farms		
	less than 25 thousand euro SO	25–50 thousand euro SO	at least 50 thousand euro SO
Field crops	159.1	83.1	57.5
Horticultural crops	169.4	232.0	140.4
Permanent crops	10.7	32.2	96.7
Dairy cows	101.2	108.2	79.0
Grass-eating animals	106.0	129.1	150.7
Granivorous animals	132.2	54.0	54.9
Mixed	139.1	89.6	52.7

Source: own study based on Polish FADN data for 2021

this respect it has a limited negative impact on the surrounding natural environment. In 2015–2021, the consumption of active substances contained in plant protection products per 1 ha of crops in Poland was 27.5% to 35% lower than the average in the European Union. In countries such as the Netherlands, Cyprus, and Ireland, the consumption of plant protection products per 1 ha of crops was at least three times higher than Poland, while in Belgium, Italy, Portugal and Spain it exceeded the level of consumption in Poland by more than two times. In this context, the possibility of limiting the use of plant protection products in Polish agriculture should be approached with caution.

- In Poland, the level of consumption of plant protection products per 1 ha varies significantly between individual crops. By far the largest amounts of active substances are used to protect apples, while the smallest amounts are used in cereal crops, including those grown on the poorest soils (e.g., oats).
- In Poland, there are large disproportions in the costs of plant protection products on farms, regardless of the type of production and economic size, and in areas with worse or favorable natural conditions for farming. It was found that the costs are lower on farms from communes with an average APAV index less than 66.6 points. This situation confirms that the possibilities of reducing the use of plant protection products in these areas in Poland are limited. The possibility of limiting usage of plant protection products should be largely associated with further encouraging farmers to undertake environmental measures under the EU CAP, as well as avoiding a situation in which some farms discontinue these measures after the end of the statutory implementation period.
- In Poland, apart from areas with difficult farming conditions, there are also areas where the natural conditions support intensive agricultural production. The ambition to care for the natural environment should not be treated as superior to the need to maintain its competitiveness in relation to agriculture from other European Union countries. There are areas with an average APAV index at least equal to the national average (66.6 points) where plant protection products are often used to a greater extent. This practice is justified because agriculture should primarily perform a production and market function. It is primarily responsible for ensuring Polish food self-sufficiency and the possibility of exporting domestic agri-food products, especially in Poland's current international situation. There is no doubt that in areas convenient for agricultural production there are certain opportunities to reduce the use of plant protection products without compromising the production results, including technological progress using precision farming techniques.

Taking the above into account, there are significant indications that Polish agriculture, especially in areas with poor natural conditions for farming, as compared to agriculture in other European Union countries in terms of the use of plant protection products, is characterized by a high degree of sustainable agricultural production. As a result, it is absolutely justified to adopt Poland's cautious position with respect to the possibility of implementing the EU goal of reducing the use of plant protection products at the assumed level under national conditions by 2030, which would probably limit the possibilities of survival and development of many farms in the growing competitive pressure on the international scene.

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