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SUSTAINABLE DEVELOPMENT OF THE YIELD AND QUALITY OF GRAIN CROPS DEPENDING ON ORGANIC AND MINERAL FERTILIZER SYSTEMS IN THE CONDITIONS OF UNSTABLE MOISTENING IN UKRAINE

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Abstract

The purpose of the article is to establish long-term dynamics and ways to increase the yield and quality of grain products in the conditions of unstable moistening in Ukraine based on the use of modern cost-effective and ecologically safe technologies, which include: scientifically based crop rotations with the effective use of highly productive and competitive varieties and hybrids of grain and leguminous crops, optimal combination of mineral and organic fertilizers with the use of by-products of the predecessors – straw of winter wheat, spring barley and peas, as well as stalks of corn. It was found that during 2016–2022, when applying the organo-mineral fertilization system, there was a rapid increase in yield compared to the control option without fertilizer application: winter wheat and corn for grain – by 17%, peas – by 30%, spring barley – by 32%; increase of all productivity indicators of short crop rotation – by 20–24%. When using an organic fertilization system, an increase in quality indicators is noted: in the grain of winter wheat and peas – protein, in the grain of corn and spring barley –digestible protein and starch. It was determined that the cultivation of highly productive and competitive corn for grain and winter wheat in a short crop rotation, as well as the reduction of costs when applying an organic fertilization system with the introduction of by-products of the predecessors, ensured the highest conditionally net profit – 12.8 thousand UAH/ha, as well as a high level of profitability – 121%.

Key words**:** *sustainable development, grain crops, short crop rotation, yield, grain quality, organic and mineral fertilization, unstable moistening, Ukraine*

INTRODUCTION

The dynamic growth of the global population, which increased more than 3 times during 1950–2022, and in 2050, according to UN forecasts, will increase to 9.7 billion people, is one of the global trends that causes a constant increase in food consumption [15; 19]. At the same time, along with the increase in soil degradation, during 1950–2022, the area of arable land for person decreased by 3 times, and in 2050 it will decrease by another 15% [3; 20]. This will lead to a significant increase in demand for food products, including grain products. Thus, the growth of world grain consumption depends on the increase in the number of the planet's population, and is one of the factors in increasing the volume of its production and export [3; 15]. In particular, during 2008–2022, there is a tendency to increase world grain production by 32% and world grain exports by 76% [15; 20]. In this context, it is important to use the biological potential of varieties and hybrids of grain crops, which is maximally realized thanks to the use of the organic component in innovative technologies [16; 17; 18]. Thus, to increase the yield and quality of grain products, as well as to improve soil processes, grain crops are grown in scientifically based

crop rotations with the introduction of organic matter and nutrients in the form of organic and mineral fertilizers [1; 22; 26; 27]. For extended reproduction and stabilization of the soil fertility level, it is of great importance to use directly in the field the by-products of the predecessors – straw of grain crops and chopped stalks of row crops [10]. The necessity and relevance of the mentioned measures is determined by several circumstances. First of all, the integration of Ukraine into the European space requires the activation of domestic experience in the effective use of the organic component in innovative technologies for growing grain crops. Secondly, the practical significance of the results of scientific research is aimed at revitalizing the domestic market, ensuring a stable export potential, confirming economically profitable and ecologically safe production of high-quality grain products, as well as preserving the environment.

The use of straw of grain crops and chopped stalks of row crops as organic fertilizer in crop rotations is a publicly available, comprehensive and low-costless expensive measure, which is justified by the following factors: it provides the soil with organic matter and reduces the production costs associated with their collection, transportation and storage [10; 29]. When applied to the soil, by-products not only improve its physical and chemical properties [4; 12], and is also an effective means of combating water and wind erosion, improves the structure of the arable layer and reduces moisture evaporation [6; 11; 13; 28]. When by-products are wrapping before growing leguminous crops, nitrogen is additionally accumulated, which can be used by the following crop rotations [5; 7; 8]. With the use of such technologies, the natural fertility of soils and the environment is reproduced [14], the demand of consumers of the world market for high-quality grain products is satisfied [23; 24; 25].

The purpose of the article is to establish long-term dynamics and ways to increase the yield and quality of grain products in the conditions of unstable moistening in Ukraine based on the use of modern cost-effective and ecologically safe technologies, which include: scientifically based crop rotations with the effective use of highly productive and competitive varieties and hybrids of grain and leguminous crops, optimal combination of mineral and organic fertilizers with the use of by-products of the predecessors –straw of winter wheat, spring barley and peas, as well as stalks of corn.

MATERIALS AND METHODS

The research was carried out in a long-term field stationary experiment in the conditions of unstable moistening of the Left-Bank Forest-Steppe of Ukraine on the typical low-humus chernozem of the Panfil Research Station of the National Scientific Center «Institute of Agriculture of the National Academy of Agrarian Sciences of Ukraine». During 2016–2022, the effect of various organic and mineral fertilization systems on the yield and quality of production of grain crops grown in a four-field crop rotation was determined: peas – winter wheat – corn for grain – spring barley. In particular, the effectiveness of fertilization systems was determined: 1 – without fertilizers (control), 2 – mineral fertilization system (introduction of $N_{45}P_{55}K_{55}$), 3 – organo-mineral fertilization system (introduction of $N_{45}P_{55}K_{55}$ + by-products of the predecessors), 4 – organic fertilization system (introduction of by-products of the predecessors). The effectiveness of the elements of organic technologies was established: the use as of by-products of the predecessors – straw of winter wheat, spring barley, peas and corn stalks as organic fertilizer; the cultivation of peas in short crop rotation, which improved the soil structure and contributed to the effective accumulation of biological nitrogen.

The experiment was repeated three times. The size of the sowing area is 90 m^2, the accounting area is 40 m^2. Placement of plots is randomized. The technology of growing agricultural crops in the experiment is generally accepted and recommended for conditions of unstable moistening in the Left-Bank Forest-Steppe of Ukraine.

The object of the study is varieties of winter wheat – Kraevyd, spring barley – Image, peas

– Hajduk; corn hybrid – KWS KAVALIER F1. Grain samples were taken according to DSTU 3355-96, DSTU ISO 13690:2003; grain quality was determined according to DSTU 4117:2007, DSTU 3768:2019. Productivity and economic efficiency of various fertilization systems in short crop rotation were determined using an improved methodology developed on the basis of modern methods of calculating productivity and economic efficiency indicators using technological maps [8; 10; 29]. To confirm the reliability of the obtained experimental data, with the help of dispersive analysis the smallest significant difference was determined–SD_{05}.

The climate of the research area is moderately continental. The soils are characterized by a high content of humus – 3.18%, phosphorus – 146 mg/kg of soil and exchangeable potassium – 102 mg/kg of soil, low nitrogen content – 123 mg/kg of soil. The reaction of the soil solution pH-salt is weakly acidic – 5.7, the degree of saturation with bases is high – 85–99%.

The indicators of air temperature and amount of precipitation in the years of the study differed slightly from the average multi-year norm, as well as between years, as a result of which the yield and quality of grain crops changed. According to the observations of the Yagotyn Meteorological Station, the average long-term norms are: air temperature – 7.3°C, precipitation amount – 442 mm. Compared with the average long-term norms, during 2016–2022, the air temperature was higher by 2.4°C, the amount of precipitation was lower by 5 mm. It was found that 2016, 2018 and 2021 were marked by the higher amount of precipitation, where 594, 449 and 555 mm fell, respectively. Precipitation was almost within normal limits in 2020 and 2022 – 439 and 441 mm, respectively. 2017 and 2019 were characterized by a significant moisture deficit, where precipitation was 265 and 319 mm, respectively. In general, during the years of research, weather conditions were favorable for obtaining high yield and quality of grain crops, but with some contrasting periods, that is, rainless and excessively dry periods in the summer months, especially in 2017, 2019 and 2022.

RESULTS AND DISCUSSIONS

Analysis of the structure of world grain production in 2022 shows that the largest share belongs to four leading grain crops: corn – 42%, wheat – 28%, rice – 18%, barley – 6% and other grains – 6% (Fig. 1) [20]. In Ukraine, the largest share of grain production is somewhat consolidated and belongs to three leading grain crops: corn – 49%, wheat – 38%, barley – 10% and other grains – 3% [21].

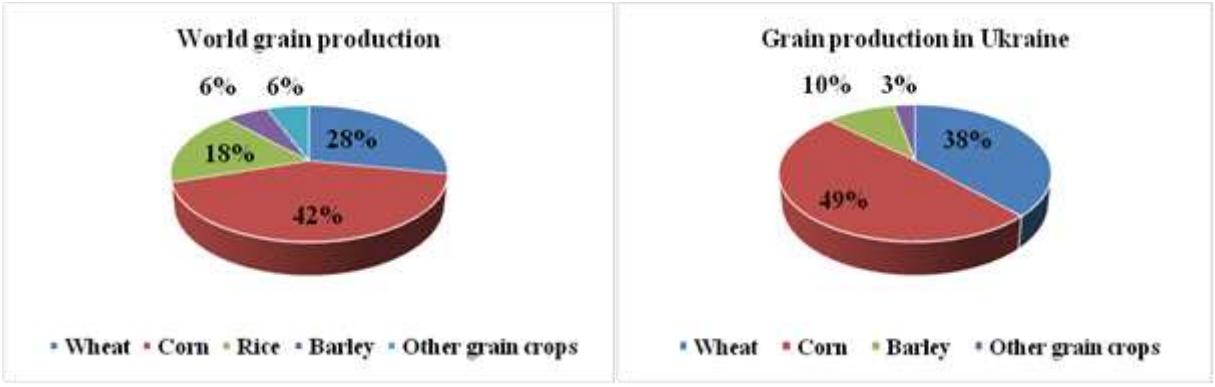

Fig. 1. The structure of world and national grain production, 2022
Source: Own design based on the data from [20; 21].

We will analyze the effectiveness of technologies for growing leading grain crops in a scientifically based short crop rotation depending on different levels of intensification. In particular, on average for 2016–2022, the yield level of winter wheat after peas with the introduction of organic and mineral fertilizers was within 4.81–5.51 t/ha

(Table 1). When using the organo-mineral fertilization system, the highest yield of winter wheat was obtained – 5.51 t/ha, which is higher than the control variant without fertilizer application by 0.85 t/ha. When applying the mineral fertilization system, the yield of winter wheat exceeded the control option by 0.75 t/ha. When introduction only by-products of the predecessor in the form straw of peas, the yield increases of winter wheat amounted to 0.15 t/ha.

Table 1. Yield and grain quality of winter wheat depending on fertilization systems in short crop rotation, 2016–2022

№	Fertilization system of winter wheat	Yield, t/ha	Glassiness, %	Protein, %	Gluten, %
1	No fertilizers (control)	4.66	44	11.1	21.6
2	Mineral ($N_{60}P_{60}K_{60}$)	5.41	46	11.2	21.9
3	Organo-mineral ($N_{60}P_{60}K_{60}$ + by-product of the predecessor – straw of peas)	5.51	56	11.5	26.3
4	Organic (by-product of the predecessor – straw of peas)	4.81	51	11.6	24.8
	SD_{05}	1.23	17	0.7	1.8

Source: authors' own results.

It is of great importance to determine the quality indicators of winter wheat grain, which are conventionally divided into three groups: physical (glassiness), biochemical (protein) and technological (gluten) [9]. When the glassiness of the grain increases, its mechanical strength is ensured [8; 29]; protein-starch processes improve; the content of protein and gluten increases, thanks to which the baking properties and nutritional value of bread improve [2]. On average, in winter wheat grain, the indicated indicators are: glassiness – 40–60%, protein – 11–14%, gluten – 18–28% [29].

During 2016–2022 the effectiveness of the application of fertilization systems with the introduction of by-products of the predecessor in the form straw of peas was established, which contributed to the growth of all winter wheat grain quality indicators. In particular, the application of the organo-mineral fertilization system provided the highest glassiness of winter wheat grain – 56%, which exceeded the control option without fertilizer application by 12%. A high degree of glassiness was obtained when applying an organic fertilizer system – 51%, which exceeded the control option by 7%. At the same time, the glassiness of winter wheat grain decreased to 46% when only mineral fertilizers were applied. This indicator exceeded the control variant by only 2%.

The highest protein content in winter wheat grains was obtained with the application of organic fertilizer in the form straw of peas– 11.6%, which exceeded the control option without fertilizer application by 0.5%. When using the organo-mineral fertilization system, the protein content in winter wheat grains was high and amounted to 11.5%. When only mineral fertilizers were applied, the protein content decreased to 11.2%, which exceeded the control variant by only 0.1%. The high content of gluten in winter wheat grains was provided by the organo-mineral fertilization system – 26.3%, the organic fertilization system – 24.8%. The specified indicators of gluten content exceeded the control option without fertilizers by 3.2–4.7%. When using the mineral fertilizer system, compared to the control option, the gluten content increased by only 0.3%.

In the unfavorable 2017, 2019, and 2022, the yield level of winter wheat decreased somewhat. At the same time, cultivation after the leguminous predecessor, as well as mineral fertilization and application straw of peas as an organic fertilizer, reduced the negative impact of weather conditions and did not affect the quality indicators of winter wheat grain. Therefore, when growing winter wheat in a short crop rotation, the use of organo-mineral and organic fertilization systems using by-products of the predecessor – straw of peas, where the highest yield and

quality indicators of winter wheat grain – glassiness, protein and gluten – were obtained. The efficiency of growing corn for grain in a short crop rotation after winter wheat depended on different levels of intensification. In particular, on average for 2016–2022, when applying organic and mineral fertilizers, the level yield of corn for grain was within 7.19–7.72 t/ha, which is 0.63–1.16 t/ha more than the control variant without fertilizers application (Table 2). The highest yield of corn for grain was obtained when using the organo-mineral fertilization system – 7.72 t/ha, which exceeds the control variant by 18%. A high yield of corn for grain was obtained when applying: mineral fertilizer system – 7.58 t/ha, which ensured a 16% increase; organic fertilizer system – 7.19 t/ha, which contributed to a 10% increase.

Table 2. Yield and grain quality of corn depending on fertilization systems in short crop rotation, 2016–2022

№	Fertilization system of corn for grain	Yield, t/ha	Digestible protein, %	Fat, %	Starch, %
1	No fertilizers (control)	6.56	8.4	4.1	71.9
2	Mineral ($N_{60}P_{60}K_{60}$)	7.58	8.1	4.4	72.2
3	Organo-mineral ($N_{60}P_{60}K_{60}$ +by-product of the predecessor – winter wheat straw)	7.72	8.9	4.3	72.5
4	Organic (by-product of the predecessor – winter wheat straw)	7.19	9.0	4.5	72.6
SD_{05}		1.62	1.3	0.3	1.2

Source: authors' own results.

The analysis of corn grain quality indicators proved the effectiveness of the application of fertilization systems with introduction of by-products of the predecessor as winter wheat straw. In particular, the use of an organic fertilization system provided the highest quality indicators of corn grain: digestible protein – 9.0%, fat – 4.5%, starch – 72.6%. When using the organo-mineral fertilization system, these indicators were high and amounted to: digestible protein – 8.9%, fat – 4.3%, starch – 72.5%. When using the mineral fertilizer system, digestible protein in corn grain decreased to 8.1%, starch to 72.2%, although with some increase in fat to 4.4%.

In the humid 2016, 2018 and 2021, the level yield of corn for grain increased significantly. However, in the unfavorable 2017, 2019 and 2022, a slight decrease in the digestible protein content of corn grain was noted. At the same time, mineral fertilization and the introduction of winter wheat straw as an organic fertilizer reduced the negative impact of weather conditions and did not affect other grain quality indicators. Thus, when growing corn for grain in a short crop rotation, the use of organo-mineral and organic fertilization systems using by-products of the predecessor – winter wheat straw, where the highest yield and quality indicators of corn grain – digestible protein, fat and starch – were obtained.

Different levels of intensification influenced the production efficiency of spring barley, which was grown in a short crop rotation after corn for grain (Table 3).

In particular, on average for 2016–2022, the yield level of spring barley with the application of organic and mineral fertilizers was in the range of 4.02–4.91 t/ha, which is higher than the control variant without the application of fertilizers by 0.34–1.23 t/ha. It should be noted that the highest yield of spring barley was obtained when using the organo-mineral fertilization system – 4.91 t/ha, which exceeds the control variant by 32%. A high yield of spring barley was obtained when the mineral fertilizer system was applied – 4.74 t/ha, which provided a 29% increase.

When applying the organic fertilization system, which involved the introduction of by-products of the predecessor as corn stalks, compared to the control variant, an increase in spring barley yield was ensured by 9%.

Table 3. Yield and grain quality of spring barley depending on fertilization systems in short crop rotation, 2016–2022

№	Fertilization system of spring barley	Yield, t/ha	Protein, %	Cellulose, %	Starch, %
1	No fertilizers (control)	3.68	11.3	4.7	61.1
2	Mineral ($N_{60}P_{60}K_{60}$)	4.74	12.0	4.4	62.2
3	Organo-mineral ($N_{60}P_{60}K_{60}$ + by-product of the predecessor – corn stalks)	4.91	12.1	4.9	62.3
4	Organic (by-product of the predecessor – corn stalks)	4.02	11.9	5.1	62.5
SD_{05}		1.01	0.7	0.5	1.4

Source: authors' own results.

The analysis of spring barley grain quality indicators proved the effectiveness of applying fertilization systems with introduction of by-products of the predecessor as corn stalks. In particular, the introduction of an organo-mineral system of fertilization provided the highest protein content – 12.1%, which exceeds the control variant without fertilization by 0.8%. High levels of cellulose content – 4.9%, starch – 62.3% were also noted. When applying the organic fertilizer system, the highest indicators were obtained: cellulose content – 5.1%, which exceeds the control variant by 0.4%; starch – 62.5%, which exceeds the control variant by 1.4%. A high rate of protein content was noted – 11.9%. When applying the mineral fertilization system, the cellulose content in spring barley grain decreased to 4.4%, starch content to 62.2%, although with some increase in protein content to 12.0%.

A slight decrease in yield and protein content of spring barley grain was established in the unfavorable 2017, 2019 and 2022. However, the application of corn stalks as organic fertilizer along with mineral fertilizer reduced the negative impact of weather conditions and did not affect other grain quality indicators. In humid 2016, 2018 and 2021, the cellulose level in spring barley grain increased. Therefore, when growing spring barley in a short crop rotation, it is of great importance to use organo-mineral and organic fertilization systems using the by-products of the predecessor – corn stalks, where the highest yield and quality indicators of spring barley grain – protein, cellulose and starch – were obtained.

The efficiency of growing peas in a short crop rotation after spring barley depended on different levels of intensification. In particular, on average for 2016–2022, the yield level of peas with the application of organic and mineral fertilizers was in the range of 4.05–4.65 t/ha, which provided an increase compared to the control variant without the application of fertilizers by 0.51–1.11 t/ha (Table 4). It should be noted that the highest yield of peas was obtained when using the organo-mineral fertilization system – 4.65 t/ha, which exceeds the control variant by 31%. A high yield of peas was obtained with the introduction of a mineral fertilizer system – 4.40 t/ha, which provided a 24% increase.

Table 4. Yield and grain quality of peas depending on fertilization systems in short crop rotation, 2016–2022

№	Fertilization system of peas	Yield, t/ha	Protein, %	Digestible protein, %
1	No fertilizers (control)	3.54	19.9	18.6
2	Mineral ($P_{40}K_{40}$)	4.40	20.4	19.3
3	Organo-mineral ($P_{40}K_{40}$ + by-product of the predecessor – spring barley straw)	4.65	20.9	19.5
4	Organic (by-product of the predecessor – spring barley straw)	4.05	20.8	19.4
SD_{05}		1.05	0.5	0.6

Source: authors' own results.

When applying the organic fertilization system, which involved the introduction of by-products of the predecessor as spring barley straw, compared to the control variant, the increase yield of peas was ensured by 14%.

The analysis of peas grain quality indicators proved the effectiveness of the application of fertilization systems with introduction of by-products of the predecessor. In particular, the use of the organo-mineral fertilization system ensured the highest quality indicators of peas grain: protein – 20.9%, digestible protein – 19.5%. The organic fertilization system contributed to obtaining high protein values – 20.8%, digestible protein – 19.4%. When using a mineral fertilizer system, protein in peas grains decreased by 20.4% and digestible protein by 19.3%.

In the humid 2016, 2018 and 2021, the level of peas grain yield increased significantly. Mineral fertilization and introduction of spring barley straw as an organic fertilizer ensured the highest quality indicators. Thus, obtaining the highest yield and quality indicators of peas grain – protein and digestible protein was facilitated by the growing peas in a short crop rotation with the use of by-products of the predecessor – spring barley straw as part of organo-mineral and organic fertilization systems.

It was established that, on average, for 2016–2022, high performance indicators of short crop rotation were ensured thanks to the use of mineral, organo-mineral and organic fertilization systems. In particular, the yield of grain crops was 5.05–5.72 t/ha, including food grain – 1.21–1.43 t/ha, fodder grain – 3.84–4.29 t/ha. Production of grain units was 6.48–7.13 t/ha, fodder units – 8.87–9.77 t/ha, digestible protein – 0.72–0.79 t/ha (Fig. 2).

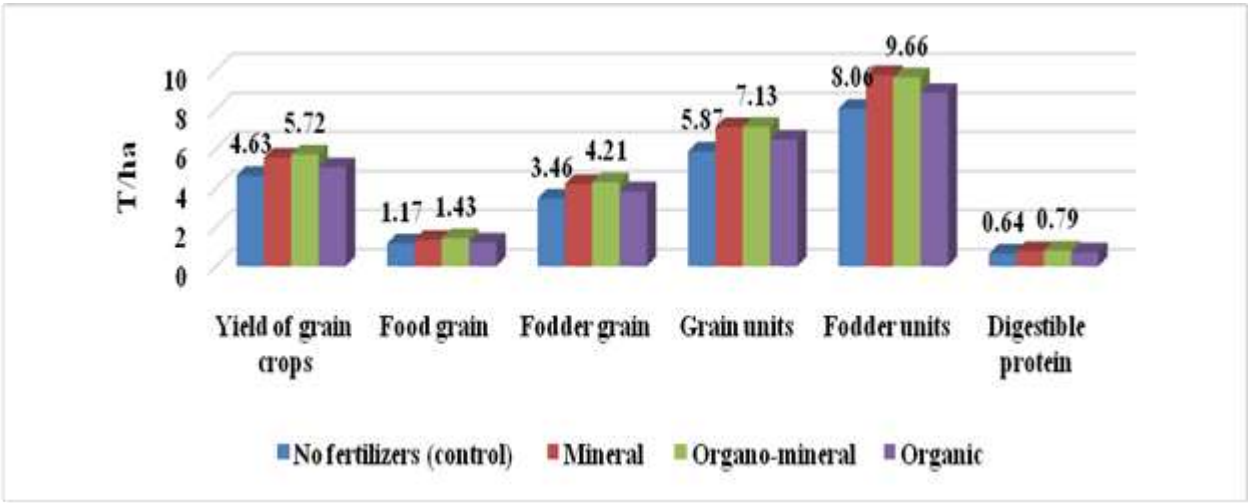

Fig. 2. Productivity of short crop rotation depending on fertilization systems, 2016–2022
Source: authors' own results.

The highest indicators of short crop rotation productivity were obtained with the introduction of the organo-mineral fertilization system: the yield of grain crops was 5.72 t/ha, including food grain – 1.43 t/ha, fodder grain – 4.29 t/ha. The collection of grain units was 7.13 t/ha, fodder units – 9.66 t/ha, digestible protein – 0.79 t/ha. When applying the mineral fertilization system, productivity indicators decreased slightly: the yield of grain crops – up to 5.56 t/ha, including food grain –up to 1.35 t/ha, fodder grain –up to 4.21 t/ha. The collection of grain units was 7.11 t/ha, fodder units – 9.77 t/ha, digestible protein – 0.78 t/ha. When applying the organic fertilization system in short crop rotation with introduction of by-products of the predecessors, high productivity indicators were noted: the yield of grain crops – 5.05 t/ha, including food grain – 1.21 t/ha, fodder grain – 3.84 t/ha. Harvest of grain units was 6.48 t/ha, fodder units – 8.87 t/ha, digestible protein – 0.72 t/ha.

In the unfavorable 2017, 2019 and 2022, a slight decrease in all productivity indicators of

short crop rotation was noted, while mineral fertilization and introduction of by-products of the predecessors as organic fertilizer reduced the negative impact of weather conditions. In the humid 2016, 2018 and 2021, productivity indicators of short crop rotation increased significantly.

On average, for 2016–2022, the economic indicators of short crop rotation depended significantly on the cultivation of highly productive and competitive winter wheat and corn for grain, the fertilization systems, and weather conditions. Thus, the highest conditionally net profit, which amounted to 12.8 thousand UAH/ha, was obtained when applying the organic fertilization system with the introduction of by-products of the predecessors (Fig. 3).

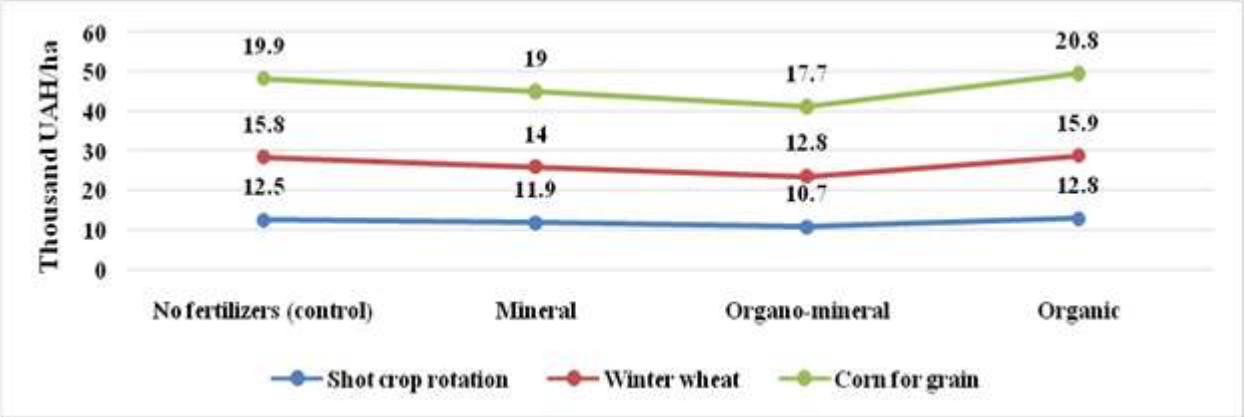

Fig. 3. Conditionally net profit of growing corn for grain, winter wheat and in general in short crop rotation depending on fertilization systems, 2016–2022
Source: authors' own results.

Thanks to a significant reduction in total costs to 10.6 thousand UAH and the cost of grain to 2.09 thousand UAH/t, even with a decrease in yield to 5.05 t/ha and the total cost of gross production to 23.4 thousand UAH, received a high the level of profitability – 121% (Figs. 4 and 5). When using the mineral component in organo-mineral and mineral fertilizer systems, the total costs increased by 3.2–5.2 thousand UAH and the cost of grain by 0.39–0.67 thousand UAH/t, which led to a conditional decrease net profit by 0.9–2.1 thousand UAH/ha and the level of profitability – by 35–53%, although even at the highest level of yield of grain crops – 5.56–5.72 t/ha and the total cost of gross production – 25.7–26.5 thousand UAH.

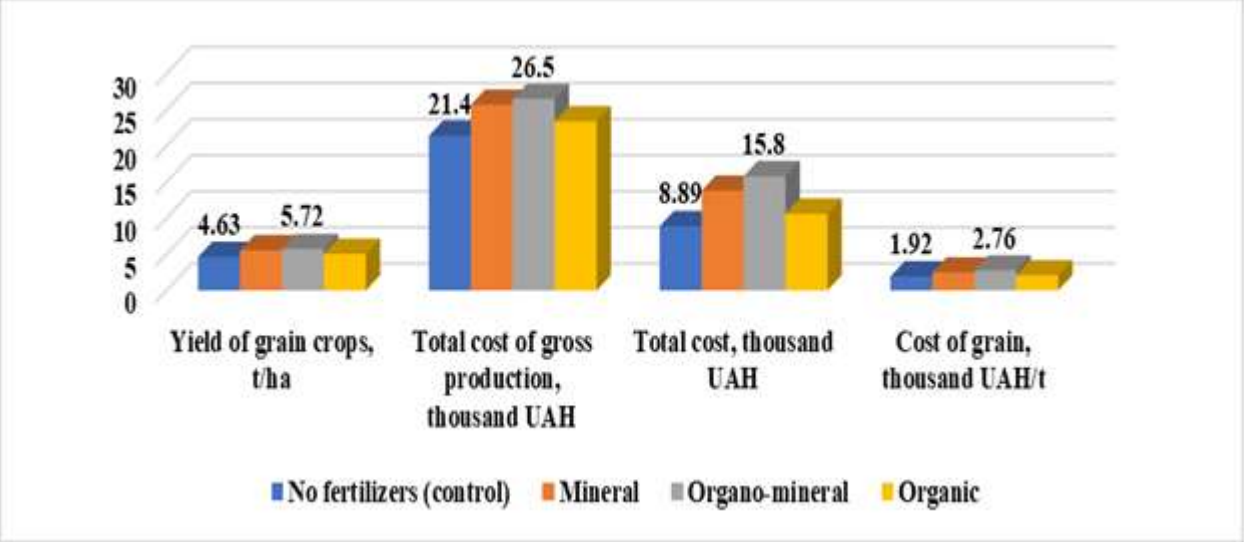

Fig. 4. Economic efficiency of fertilization systems in short crop rotation, 2016–2022
Source: authors' own results

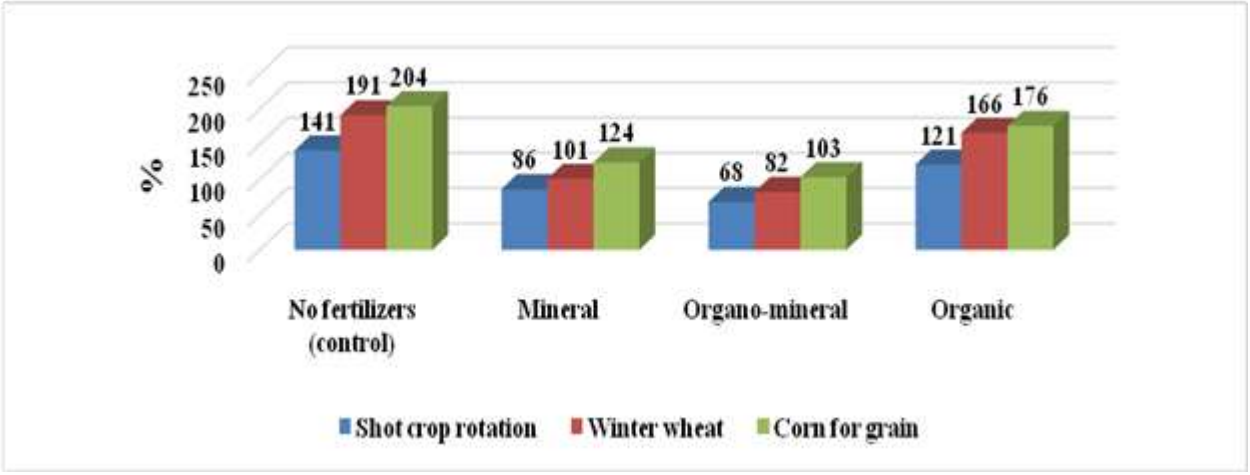

Fig. 5. The level of profitability of growing corn for grain, winter wheat and in general in short crop rotation depending on fertilization systems, 2016–2022
Source: authors' own results.

The most profitable was the cultivation of highly productive and competitive winter wheat after peas and corn for grain after winter wheat in a short crop rotation, where an organic fertilization system was used with the introduction of predecessor straw.

In particular, received the highest conditional net profit of 15.9–20.8 thousand UAH/ha and a high level of profitability – 166–176% due to a significant reduction in total costs and cost of grain.

When using the mineral component in organo-mineral and mineral fertilization systems, the total costs and cost of grain increased significantly, which led to a decrease in conditional net profit by 1.8–3.1 thousand UAH/ha and the level of profitability – by 52–84%.In the unfavorable 2017, 2019 and 2022, a slight decrease in all indicators of economic efficiency in short crop rotation was noted, at the same time, mineral fertilization and introduction of by-products of predecessors as organic fertilizer reduced the negative impact of weather conditions. In the humid 2016, 2018 and 2021, indicators of economic efficiency in short crop rotation increased significantly.

CONCLUSIONS

It was established that, on average, for 2016–2022, the growing highly productive and competitive varieties and hybrids of grain crops in short crop rotation, the use of by-products of predecessors as part of organo-mineral and organic fertilization systems, contributed to obtaining the highest yield and quality indicators of grain of winter wheat, spring barley, peas and corn, especially in conditions of unstable moistening in Ukraine.

In particular, when using the organo-mineral fertilization system, there is a rapid increase in yield compared to the control variant without fertilizer application: winter wheat and corn for grain – by 17%, peas – by 30%, spring barley – by 32%, in short crop rotation – by 24%. With the application of organo-mineral and organic fertilization systems, winter wheat grain increased: glassiness by 7–12%, protein – by 0.4–0.5%, gluten – by 3.2–4.7%. In corn grain, digestible protein increased by 0.5–0.6%, fat by 0.2–0.4%, starch by 0.6–0.7%. In spring barley grains, the following increased: protein by 0.6–0.8%, cellulose– by 0.2–0.4%, starch – by 1.2–1.4%. In peas for grain, protein increased by 0.9–1.0%, digestible protein by 0.8–0.9%.

The highest productivity indicators were obtained when using the organo-mineral fertilization system, which increased by 20–24% compared to the control variant without fertilizer application. Cultivation in a short crop rotation of highly productive and competitive corn for grain and winter wheat, as well as reducing costs when applying an organic fertilization system with the introduction of by-products of the predecessors, ensured the highest conditional net profit – 12.8 thousand UAH/ha, as well as a high level of profitability – 121%. At the

same time, a significant increase in the cost of applying mineral fertilizers led to a decrease in these indicators by 7–16% and 35–53%, respectively. In years with unfavorable weather conditions, the scientifically based rotation of crops in short crop rotation, the optimal combination of mineral fertilizers and by-products of the predecessors as organic fertilizers, reduced the negative impact of unstable moistening.

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