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YIELD, PRODUCTIVITY, AND ECONOMIC EFFICIENCY OF WINTER WHEAT CULTIVATION DEPEND ON CROP ROTATION LINK AND FERTILIZER SYSTEMS

Abstract

The yield of agricultural crops is influenced by a complex of natural and agrotechnical factors. The productivity of each crop can only be considered in direct relation to the specific conditions of its cultivation. Among the agrotechnical techniques included in modern technologies, the correct placement of varieties after different predecessors in crop rotation is the most important. The structure of crop rotation and the fertilizer system are the simplest and most accessible agrotechnical measures that ensure high productivity of agricultural crops. The objective application of mineral fertilizers is one of the important elements of winter wheat cultivation technology that can solve the problem of optimizing the crop's fertilization system.

However, for the conditions of the Northern Steppe of Ukraine, these issues remain insufficiently studied. Therefore, research on the influence of the structure, composition, and placement of crops in short rotation crop rotations, the productivity and yield of winter wheat, and their economic justification are quite relevant.

It has been established that the crop rotation factor positively affects the yield of winter wheat when grown after non-steam predecessors and different fertilizer systems. The highest yield level of winter wheat variety Oranta Odeska was observed in the buckwheat–soybean–winter wheat rotation with an organo-mineral fertilizer system, reaching 6.45 t/ha. The yield of winter wheat significantly depended on the use of fertilizer systems in both crop rotation links. The highest yield increments were found in the soybean–soybean–winter wheat rotation with an organo-mineral fertilizer system, reaching 1.94 t/ha.

A significant factorial dependence of winter wheat productivity on crop rotation link was proven under conditions without fertilizers and with a mineral fertilizer system. The highest nutrient uptake index was provided by the organo-mineral fertilizer system – 6.96 t/ha and 7.10 t/ha of grain units, 8.93 t/ha and 9.10 t/ha of feed units, 0.76 t/ha and 0.77 t/ha of digestible protein, respectively, for the soybean–soybean–winter wheat and buckwheat–soybean–winter wheat crop rotation links. The highest yield increments of grain and feed units were obtained with the mineral fertilizer system: 2.14 t/ha (44.3%) and 2.74 t/ha (44.3%), respectively. Additional 45.5% (0.24 t/ha) of digestible protein was formed by winter wheat plants in the soybean–soybean–winter wheat crop rotation link with an organo-mineral fertilizer system.

The highest economic indicators in winter wheat cultivation were found in the variant without fertilizers in the buckwheat–soybean–winter wheat crop rotation link, which allowed for a net profit of 9136 UAH/ha and a profitability of 62.4% with expenses of 14629 UAH/ha.

Key words: *crop rotation links, fertilizer systems, yield, productivity, economic efficiency, winter wheat.*

Introduction. The most important food crop in our country is wheat. Increasing the gross yield of high-quality winter wheat grain is one of the priority directions for the development of agriculture in Ukraine and worldwide, and the variety is one of the most effective methods of increasing productivity.

According to scientific research, the potential of modern varieties of winter wheat is only realized by 30–40% [2; 4; 8; 9].

The yield of agricultural crops is influenced by a complex of natural and agronomic factors. The productivity of each crop can only be considered in direct relation to the specific conditions of its cultivation. The use of individual technologies in the cultivation of modern varieties does not fully realize the biological properties of plants, which ultimately affects the productivity levels [3, 13].

Among the agronomic practices that are part of modern technologies, the most important is the proper placement of varieties after different predecessors in crop rotation. In recent years, winter cereals have been increasingly sown after

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non-traditional predecessors such as spring barley, sunflower, and rapeseed. This has a negative impact on the phytosanitary condition of the fields, moisture supply, nutrient regime of the soil, and leads to a decrease in crop productivity [5; 6; 7].

Structure of crop rotation and fertilization system are the simplest and most accessible agronomic measures that allow forming the soil fertility background, determining the mineral nutrition regime, and ensuring high productivity of agricultural crops. The most environmentally stable fertilization system is one that combines the application of mineral fertilizers with the incorporation of by-products and nutrient-rich cover crops [10; 11; 12; 15].

Recently, the question of applying fertilizer rates and methods to winter wheat crops has become relevant. The scientifically justified use of mineral fertilizers and bio-preparations is one of the important elements of winter wheat cultivation technology that can solve the problem of optimizing the fertilization system for the crop [1; 14].

However, for the conditions of the Northern Steppe region of Ukraine, these issues remain insufficiently studied. Therefore, research on the influence of the structure, composition, and placement of crops in short rotation crop rotations, as well as the productivity and yield of individual crops, is quite relevant.

The aim of the research is to establish the dependence of winter wheat yield levels in different links of short rotation crop rotations on fertilization systems and determine the level of economic efficiency of the investigated factors**.**

The object of the research is crop rotation links and fertilization systems.

Research methodology. The research methods included field and laboratory-field experiments. Field experiments were conducted from 2019 to 2023 in the agriculture laboratory of the Institute of Agriculture of the Steppe, National Academy of Agrarian.

Winter wheat of the Oranta Odessa variety was grown in short rotation crop rotations with different soybean saturation. The crop rotation with up to 60% soybean saturation included the following crop rotation sequence: 1. Soybean; 2. Winter wheat; 3. Soybean; 4. Corn for grain; 5. Soybean. The crop rotation with up to 40% soybean saturation included the following crop rotation sequence: 1. Soybean; 2. Winter wheat; 3. Soybean; 4. Corn for grain; 5. Buckwheat.

Winter wheat sowing was conducted at optimal sowing dates with a recommended seeding rate of 5.0 million seeds/ha, alongside three fertilizer systems: 1. Without fertilizer; 2. Mineral fertilizer system; 3. Organic-mineral fertilizer system. Considering that different crops were grown in the crop rotations, the fertilizer system included the application of scientifically justified norms for the Northern Steppe zone. For crop rotations with up to 60% soybean saturation, the mineral fertilizer system included $N_{50}P_{20}K_{20}$, while for crop rotations with up to 40 % soybean saturation, $N_{70}P_{40}K_{40}$ was applied. However, to maintain an average fertilizer rate of $N_{40}P_{40}K_{40}$ per rotation, the organic-mineral fertilizer system utilized mineral fertilizers similar to the mineral fertilizer system, along with by-products of the preceding crop as organic fertilizers.

The establishment and conduct of the experiments were carried out according to field research methodology.

To achieve high winter wheat yields during the research period, favorable weather conditions were present in 2022 and 2023. Weather conditions in 2021 and particularly in 2019 were not favorable for obtaining high yields of winter cereals, including winter wheat.

The presentation of the main material of the research. It is known that the main components for obtaining high yields of winter wheat are and remain the creation of optimal growing conditions for this crop. By studying the reaction of winter wheat plants to their location in different crop rotations, we have established that on average for 2019–2023, this factor has gained significant importance in variants without fertilizers and under the mineral fertilization system. Growing winter wheat in the crop rotation of buckwheat–soybean–winter wheat has contributed to obtaining reliable yield increases compared to the crop rotation of soybean–soybean–winter wheat, which amounted to 0.46 t/ha without fertilizers and 0.21 t/ha under the mineral fertilization system (Table 1).

Therefore, we have established that the crop rotation factor positively affects the yield of winter wheat when grown on non-steam predecessors in the absence of fertilizers and under the mineral fertilization system, and is neutralized

Table 1. Yield of winter wheat variety Oranta Odeska depending on the crop rotation links and fertilization system (2019–2023)

Crop rotation links, Factor A	Fertilizer system, Factor B	Average for 2019–2023	Difference			
			factor A		factor B	
			t/ha	%	t/ha	%
Soybean–soybean–winter wheat	Without fertilizer	4,39	–	–	–	–
	Mineral $N_{50}P_{20}K_{20}$	5,85	–	–	1,47	33,4
	Organic-mineral $N_{50}P_{20}K_{20}$+By-p.P*	6,33	–	–	1,94	44,3
Buckwheat–soybean–winter	Without fertilizer	4,85	0,46	10,5	–	–
	Mineral $N_{70}P_{40}K_{40}$	6,07	0,21	3,7	1,22	25,2
	Organic-mineral $N_{70}P_{40}K_{40}$+ By-p.P*	6,45	0,12	1,9	1,60	33,1
Average		5,66	–	–	–	–
LSD_{05}		A=0,13	B=0,16		AB=0,22	

Note: By-p.P* – by-product of the previous culture when using the organo-mineral fertilization system. Thus, the research has only shown a tendency to obtain lower yields of the crop when using mineral fertilizers in combination with the by-product of the previous crop as organic fertilizers.

Studying the factor of fertilizer systems, it was established that its effect was greater compared to the crop rotation factor, especially when growing winter wheat preceded by soybean replanting. It was found that in the specified crop rotation sequence, the yield increase in the mineral fertilization system was 1.47 t/ha or 33.4%, and in the organo-mineral system it was 1.94 t/ha or 44.3%. Considering that the yield of winter wheat in the crop rotation sequence buckwheat–soybean–winter wheat was higher than in the sequence soybean-soybean-winter wheat, and the difference between the fertilizer treatments was smaller, we also obtained significant but smaller yield increases for the fertilizer systems in the buckwheat–soybean–winter wheat link. According to the data in Table 1, it was found that the yield increase due to the mineral fertilization system was 1.22 t/ha or 25.2%, and for the organo-mineral system it was 1.60 t/ha or 33.1%.

Thus, the results of our research demonstrate that on average for the years 2019–2023, the yield of winter wheat depended on the use of fertilizer systems in both crop rotations links. The highest yield increases were observed when using the organo-mineral fertilizer system in the crop rotation sequence soybean–soybean–winter wheat, reaching 1.94 t/ha. However, the highest yield of winter wheat was obtained when grown in the buckwheat–soybean–winter wheat link with the organo-mineral fertilizer system, reaching 6.45 t/ha.

One of the important criteria for evaluating the effectiveness of crop cultivation is its productivity level. To some extent, the negative impact of the external environment can be reduced by using crop rotation and enriching crop rotations with additional sources of nutrients. We have found that the crop rotation factor and different fertilizer systems had a significant impact on the productivity of winter wheat.

So, in our study, the highest yield of grain units from the winter wheat crop of the Oranta Odeska variety was in the crop rotation chain of buckwheat–soybean–winter wheat. Due to the effect of only the crop rotation factor, this indicator increased by 0.51 t/ha (10.5%) and reached 5.33 t/ha, compared to the link of soybean–soybean–winter wheat – 4.83 t/ha.

A significant increase in grain unit yield was achieved by applying mineral fertilizers – 0.24 t/ha for LSD_{05}=0.14 t/ha. Despite the fact that the highest level of productivity for this indicator was in the organo-mineral fertilizer system – 7.10 t/ha, the influence of the crop rotation factor in this variant was not significant – 0.13 for LSD_{05}=0.14 t/ha (Table 2).

Table 2. Yield of grain units from the winter wheat crop of the Oranta Odeska variety depending on the crop rotation chain and fertilizer system (2019–2023)

Crop rotation links, Factor A	Fertilizer system, Factor B	Average for 2019–2023	Difference			
			factor A		factor B	
			t/ha	%	t/ha	%
Soybean–soybean–winter wheat	Without fertilizer	4,83	–	–	–	–
	Mineral $N_{50}P_{20}K_{20}$	6,44	–	–	1,61	33,4
	Organic-mineral $N_{50}P_{20}K_{20}$+By-p.P*	6,96	–	–	2,14	44,3
Buckwheat–soybean–winter	Without fertilizer	5,33	0,51	10,5	–	–
	Mineral $N_{70}P_{40}K_{40}$	6,68	0,24	3,7	1,34	25,2
	Organic-mineral $N_{70}P_{40}K_{40}$+ By-p.P *	7,10	0,13	1,9	1,76	33,1
Average		6.22	–	–	–	–
LSD_{05}		A=0,14	B=0,17		AB=0,24	

Note: By-p.P * – by-product of the previous culture

A significantly larger share of the influence on winter wheat productivity in different crop rotation links was attributed to the fertilizer system. In the mineral fertilizer system, the highest additional yield of grain units from the winter wheat crop of the Oranta Odeska variety was obtained in the soybean-soybean-winter wheat link – 1.61 t/ha or 33.4%. In the buckwheat-soybean-winter wheat link, this indicator was slightly lower – +1.34 t/ha or +25.2%, but still significantly exceeded the smallest significant difference.

In the organo-mineral fertilizer system, the yield of grain units from the winter wheat crop was highest – 6.69 t/ha in the soybean-soybean-winter wheat link and 7.10 t/ha in the buckwheat-soybean-winter wheat link. However, it should be noted that growing winter wheat after repeated soybean plantings had the most effective impact on plant productivity, with an additional yield of grain units at 2.14 t/ha, which exceeded the variant without fertilizer application by 44.3%.

The formation of other indicators of winter wheat productivity in our study followed a similar trend. In the soybean-soybean-winter wheat link, the yield of feed units was the lowest at 6.19 t/ha (Table 3).

Replacing one field of soybeans with buckwheat in the crop rotation resulted in an increase in this indicator by 0.65 t/ha (10.5%) and allowed for a yield of 6.84 t/ha of this product.

The use of different fertilizer systems had a more effective impact on crop productivity. In the organo-mineral fertilizer system, the yield of feed units was the highest – 8.93 t/ha for growing winter wheat after repeated soybean plantings and 9.10 t/ha in the buckwheat-soybean-winter wheat link. In the mineral fertilizer system, this productivity

Table 3. Yield of feed units from the winter wheat crop of the Oranta Odeska variety depending on the crop rotation chain and fertilizer system (2019–2023)

Crop rotation links, Factor A	**Fertilizer system, Factor B**	**Average for 2019–2023**	**Difference**			
			factor A		**factor B**	
			t/ha	**%**	**t/ha**	**%**
Soybean–soybean–winter wheat	Without fertilizer	6,19	–	–	–	–
	Mineral $N_{50}P_{20}K_{20}$	8,25	–	–	2,07	33,4
	Organic-mineral $N_{50}P_{20}K_{20}$+By-p.P*	8,93	–	–	2,74	44,3
Buckwheat–soybean–winter	Without fertilizer	6,84	0,65	10,5	–	–
	Mineral $N_{70}P_{40}K_{40}$	8,56	0,30	3,7	1,72	25,2
	Organic-mineral $N_{70}P_{40}K_{40}$+ By-p.P *	9,10	0,17	1,9	2,26	33,1
Average		7,98	–	–	–	–
LSD_{05}		A=0,18	B=0,22		AB=0,31	

Note: By-p.P * – by-product of the previous culture

indicator was lower – 8.25 t/ha and 8.56 t/ha respectively, but it increased significantly for growing winter wheat in the soybean-soybean-winter wheat link, obtaining an additional 2.74 t/ha (44.3%) of feed units compared to the control without fertilizers.

A higher collection of digestible protein was observed in both crop rotation links when using the organo-mineral fertilizer system, 0.76 t/ha and 0.77 t/ha respectively, but the effect of the crop rotation factor in this variant was not significant, LSD_{05}=0.01 t/ha. The crop rotation without fertilizer application had a significant impact on this productivity indicator – 0.52 t/ha and 0.58 t/ha, meaning that introducing buckwheat into the crop rotation chain resulted in an increase in protein yield by 0.06 t/ha or 11.4% (Table 4).

Table 4. Yield of digestible protein units from the winter wheat crop of the Oranta Odeska variety depending on the crop rotation chain and fertilizer system (2019–2023)

Crop rotation links, Factor A	Fertilizer system, Factor B	Average for 2019–2023	Difference			
			factor A		factor B	
			t/ha	%	t/ha	%
Soybean–soybean–winter wheat	Without fertilizer	0,52	–	–	–	–
	Mineral $N_{50}P_{20}K_{20}$	0,70	–	–	0,18	34,5
	Organic-mineral $N_{50}P_{20}K_{20}$+By-p.P*	0,76	–	–	0,24	45,5
Buckwheat–soybean–winter	Without fertilizer	0,58	0,06	11,4	–	–
	Mineral $N_{70}P_{40}K_{40}$	0,73	0,03	3,7	0,15	25,2
	Organic-mineral $N_{70}P_{40}K_{40}$+ By-p.P*	0,77	0,01	1,9	0,19	33,1
Average		0,68	–	–	–	–
LSD_{05}		A=0,01	B=0,02		AB=0,02	

Note: By-p.P * – by-product of the previous culture

Unlike the yield of grain and feed units, the collection of digestible protein was more effectively influenced by the organo-mineral fertilizer system, and the highest increase was obtained for growing winter wheat in the soybean–soybean–winter wheat link – 0.24 t/ha (45.5%). In addition, the crop rotation factor determined active protein accumulation for all fertilizer systems.

Thus, the results of five years of data prove that the productivity of winter wheat depended on the use of fertilizer systems in both crop rotation links. The highest nutrient collection indicators for the Oranta Odeska variety were provided by the organo-mineral fertilizer system – 6.96 t/ha and 7.10 t/ha of grain units, 8.93 t/ha and 9.10 t/ha of feed units, 0.76 t/ha and 0.77 t/ha of digestible protein for growing winter wheat in the soybean–soybean–winter wheat and buckwheat–soybean–winter wheat links, respectively. However, the highest increases in grain and feed unit yields were obtained with the mineral fertilizer system: 2.14 t/ha (44.3%) and 2.74 t/ha (44.3%), respectively. Additional 45.5% (0.24 t/ha) of digestible protein were formed by winter wheat plants in the soybean–soybean–winter wheat link using the organo-mineral fertilizer system.

The instability in prices for agricultural products, energy carriers, plant protection agents, fuel, and mineral fertilizers led to an increase in the costs of growing winter wheat, which has lower grain quality in 2023 due to unfavorable weather conditions and reduced profit. Prices established on August 17, 2023 were used for calculating the economic efficiency of growing winter wheat.

The lowest costs for growing winter wheat were in the variants without fertilizers in both crop rotation links and amounted to 14,430 UAH/ha and 14,629 UAH/ha, respectively (Table 5). The most profitable option turned out to be the variant without fertilizers in the buckwheat-soybean-winter wheat crop rotation chain, where obtaining a higher yield played a decisive role, resulting in a net profit of 9,136 UAH/ha with the highest profitability of 62.4%.

Table 5. Economic efficiency of growing winter wheat variety Oranta Odeska depending on the crop rotation chain and fertilizer system (2019–2023)

Crop rotation links, Factor A	Fertilizer system, Factor B	Yield, t/ha (average for 2019–2023)	Production costs, UAH/ha	Gross output value, UAH/ha	Net profit, UAH/ha	Profitability, %
Soybean–soybean–winter wheat	Without fertilizer	4,39	14430	21511	7081	49,1
	Mineral $N_{50}P_{20}K_{20}$	5,85	22711	28665	5954	26,2
	Organic-mineral $N_{50}P_{20}K_{20}$+By-p.P*	6,33	22919	31017	8098	35,3
Buckwheat–soybean–winter	Without fertilizer	4,85	14629	23765	9136	62,4
	Mineral $N_{70}P_{40}K_{40}$	6,07	27357	29743	2386	8,7
	Organic-mineral $N_{70}P_{40}K_{40}$+ By-p.P*	6,45	27522	31605	4083	14,8

Note: By-p.P * – by-product of the previous culture

In the organo-mineral fertilization system in the crop rotation of buckwheat–soybean–winter wheat, the highest yield of winter wheat (at the level of 6.45 t/ha) was obtained compared to the soybean–soybean–winter wheat rotation, where 20 kg/ha less mineral fertilizers were applied. Scientifically justified recommendations for the application of mineral fertilizers were taken into account individually according to the needs of each crop, with an average of $N_{40}P_{40}K_{40}$ per hectare of crop rotation area. However, due to the high price of mineral fertilizers, the production costs of winter wheat increased significantly.

Therefore, the application of mineral and organic fertilizers is necessary and an integral part of the technology for growing winter wheat, which contributes to achieving the highest level of yield. However, at the same time, high prices for mineral fertilizers lead to an increase in production costs from 22,711 UAH/ha to 27,522 UAH/ha, which does not allow for a net profit of more than 2,386–5,954 UAH/ha. The most profitable option in today's conditions is the cultivation of winter wheat without fertilizers in the buckwheat–soybean–winter wheat crop rotation chain, which allows for a net profit of 9,136 UAH/ha with expenses of 14,629 UAH/ha.

Conclusions. Crop rotation positively influenced the yield of winter wheat when grown after non-steam predecessors in the absence of fertilizers and with a mineral fertilizer system, and this effect was neutralized when using an organo-mineral fertilizer system. The highest yield of winter wheat variety Oranta Odeska was obtained when grown in the buckwheat-soybean-winter wheat rotation link with an organo-mineral fertilizer system, reaching 6.45 t/ha.

The yield of winter wheat significantly depended on the fertilizer systems used in both crop rotations. The highest yield increase was observed when using an organo-mineral fertilizer system in the soybean-soybean-winter wheat rotation link, with an increase of 1.94 t/ha.

Crop rotation significantly influenced the productivity of winter wheat, both in the absence of fertilizers and with a mineral fertilizer system. The highest nutrient uptake was observed with the organo-mineral fertilizer system, reaching 6.96 t/ha and 7.10 t/ha of grain units, 8.93 t/ha and 9.10 t/ha of feed units, and 0.76 t/ha and 0.77 t/ha of digestible protein in the soybean-soybean-winter wheat and buckwheat–soybean–winter wheat rotations, respectively.

The highest increases in grain and feed units were obtained with the mineral fertilizer system, with additional gains of 2.14 t/ha (44.3%) and 2.74 t/ha (44.3%), respectively. Additional 45.5% (0.24 t/ha) of digestible protein was formed by winter wheat plants in the soybean–soybean–winter wheat rotation with an organo-mineral fertilizer system.

The highest economic indicators were achieved when growing winter wheat without fertilizers in the buckwheat–soybean–winter wheat rotation, resulting in a net profit of 9136 UAH/ t/ha and a profitability of 62.4 % with expenses of 14629 UAH/ t/ha.

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УРОЖАЙНІСТЬ, ПРОДУКТИВНІСТЬ ТА ЕКОНОМІЧНА ЕФЕКТИВНІСТЬ ВИРОЩУВАННЯ ПШЕНИЦІ ОЗИМОЇ ЗАЛЕЖНО ВІД ЛАНКИ СІВОЗМІН І СИСТЕМ УДОБРЕННЯ

Анотація

Урожайність сільськогосподарських культур формується під впливом комплексу природних та агротехнічних факторів. Продуктивність посівів кожної культури може розглядатися лише в безпосередньому зв'язку з конкретними умовами її вирощування. Серед агротехнічних прийомів, що входять до складу сучасних технологій, найбільш важливим є правильне розміщення сортів після різних попередників у сівозміні. Структура сівозмін та система удобрення є найпростішими та найдоступнішими агротехнічними заходами, які забезпечують високу продуктивність сільськогосподарських культур. Об'єктивне застосування мінеральних добрив є одними з важливих елементів технології вирощування пшениці озимої, що може вирішити проблему оптимізації системи удобрення культури.

Однак для умов Північного Степу України ці питання залишаються ще недостатньо вивченими, тому дослідження щодо впливу структури, набору та розміщення культур у сівозмінах короткої ротації, продуктивності та врожайності пшениці озимої та їх економічного обґрунтування є досить актуальними.

Встановлено, що сівозмінний фактор позитивно впливає на урожайність пшениці озимої за її вирощування по непарових попередниках і різних системах удобрення. Найбільший рівень врожайності пшениці озимої Сорту Оранта одеська був у ланці гречка – соя – пшениця озима на фоні органо-мінеральної системи удобрення і становив 6,45 т/га. Урожайність пшениці озимої істотно залежала від використання систем удобрення в обох ланках сівозмін. Найбільші прибавки врожайності встановлені за органо-мінеральної системи удобрення у ланці сівозміни соя–соя–пшениця озима (1,94 т/га).

Доведено істотну факторіальну залежність продуктивності пшениці озимої від ланки сівозміни на фонах без добрив та мінеральної системи удобрення. Найвищі показники збору поживних речовин забезпечувала органо-мінеральна система удобрення – 6,96 т/га та 7,10 т/га зернових одиниць, 8,93 т/га та 9,10 т/га кормових одиниць, 0,76 т/га та 0,77 т/га перетравного протеїну, відповідно до ланок сівозмін соя – соя – пшениця озима та гречка – соя – пшениця озима. Найбільші при-

бавки виходу зернових та кормових одиниць отримували за мінеральної системи удобрення: 2,14 т/га (44,3%) та 2,74 т/га (44,3%) відповідно. Додаткові 45,5% (0,24 т/га) перетравного протеїну формували рослини пшениці озимої в ланці сівозміни соя – соя – пшениця за органо-мінеральної системи удобрення.

Найвищі економічні показники при вирощуванні пшениці озимої встановлено у варіанті без добрив у ланці сівозміни гречка – соя – пшениця озима, що дозволило отримати умовно чистий прибуток на рівні 9136 грн/га, рентабельності 62,4% за витрат 14629 грн/га.

Ключові слова: *ланки сівозмін, системи удобрень, урожайність, продуктивність, економічна ефективність, пшениця озима.*

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