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INFLUENCE OF NITROGEN FERTILIZERS AND PREDECESSORS ON THE PRODUCTIVITY OF WINTER WHEAT

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Topicality. *Global warming requires the search for effective predecessors and doses of nitrogen fertilizers to obtain stable yields of high quality winter wheat grain.* ***Purpose.*** *To study the influence of the grain legume predecessor (peas) on the yield of winter wheat (Triticum aestivum L.), and establish the optimal dose of nitrogen fertilizers for the biologization of its cultivation.* ***Methods.*** *Long-term field and analytical.* ***Results.*** *The data of researches on the influence of legume predecessor (peas) and doses of nitrogen fertilizers on the productivity of winter wheat are given. It was found that the legume predecessor (peas) and nitrogen fertilizers significantly increased the yield and quality of winter wheat grain. It was defined that increasing the dose of nitrogen fertilizers for winter wheat from 40 to 80 kg/ha on both predecessors was effective.* ***Conclusions.*** *The application of $N_{80}P_{60}K_{60}$ for winter wheat in the crop rotation link with peas provided the highest grain yield – 5.42 t/ha with an excess to the control without fertilizers by 1.02 t/ha. Under the predecessor (meadow fescue), the application of $N_{80}P_{60}K_{60}$ decreased grain yield by 1.03 t/ha. It was found that an increase in the nitrogen fertilizer dose from 40 to 80 kg/ha for winter wheat was more effective in the peas link – grain yield increased by 0.56 t/ha, while in the meadow fescue link – by 0.38 t/ha. A clear correlation between dose of nitrogen fertilizers and winter wheat grain yield was established: with the coefficient of determination in the meadow fescue link – 0.9999, the peas link – 0.9966. The plowing of pea straw under winter wheat against the background of mineral fertilizers $N_{60}P_{60}K_{60}$ was determined to be effective; the grain yield increased by 0.23 t/ha compared to the application of mineral fertilizers alone, with an absolute indicator of 5.36 t/ha. The application of mineral fertilizers in both links increased the growth of stem mass, ensuring the straw yield in the peas link by 0.4–0.7 t/ha higher than in the meadow fescue link. Under peas as a predecessor, the quality of winter wheat grain has significantly improved. In the control without fertilizers, the protein content in wheat grain after peas was 11.4 %, after meadow fescue – 11.0 %; for the application of a dose of $N_{40}P_{60}K_{60}$ fertilizers – 11.8 % and 11.4 %, respectively; $N_{60}P_{60}K_{60}$ – 12.0 % and 11.5 %, $N_{90}P_{60}K_{60}$ – 12.1 % and 11.7 %. Due to the legume predecessor (peas), the protein content in the grain increased by 0.4–0.5 % compared to the meadow fescue as a predecessor.*

Key words: *nitrogen, predecessor, peas, productivity, winter wheat*

Introduction. Optimization of nitrogen nutrition and selection of effective predecessors are the basis for high and sustainable yields of winter wheat [1, 2]. In the context of global warming, the introduction of legume predecessors into crop rotations plays a significant environmental role, reduces the nitrogen load on the agroecosystem and saves money resources on fertilizer purchases [3, 4].

Due to the acute shortage of manure and the high cost of mineral fertilizers, plant production is being reoriented to maximize the use of internal crop rotation reserves in the crop nutrition system [5, 6]. Soybeans and peas are the most suitable legume crops for modern economic needs and are being widely introduced in Ukraine as the main legume predecessor for winter wheat cultivation. Legumes form a favourable trophic environment in the soil, fill the soil with nitrogen, and promote humification processes, which together ensure the sustainability of winter wheat cultivation and increase its productivity [7, 8]. In the structure of US agricultural production, the share of legumes in crop rotations is 30 %, which reduces the application of nitrogen fertilizers by a third, reduces production costs and contributes to environmentally friendly products [9].

In recent years, organic farming has become increasingly popular in European countries such as Germany, France and the UK. With the increasing aridity of the climate, biologically oriented farming systems serve as an element of sustainability in crop production [10, 11].

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The purpose of the research was to study the effect of a grain legume predecessor of peas on the yield of winter wheat (*Triticum aestivum* L.) and to establish the optimal rate of nitrogen fertilizer for biologization of its cultivation.

Materials and Methods. The research was conducted in the stationary field trial at the Uladovo-Liulynetska Experimental Breeding Station during 2018–2020. The area of the sowing plot is 100 m^2, the accounting plot is 50 m^2. The variants in the experiments have a systematic sequential arrangement and were repeated four times.

The soil of the experimental field is leached light loamy chernozem, with the following agrochemical and physicochemical characteristics in the 0–30 cm layer: pH of salt – 5.9–6.4; Kappen's Ng – 1.09–1.26 mg-eq. /100 g of soil; the sum of absorbed bases by Kappen–Hilkovits – 23.8–27.2 mg-eq./100 g of soil; humus content by Tiurin – 4.0–4.2 %; alkaline-hydrolyzable nitrogen – 120–127 mg/kg of soil; mobile phosphorus and potassium compounds by Chyrikov – 136–157 and 78–84 mg/kg of soil, respectively.

The research was conducted in two links of crop rotation: 1) maize for grain (*Zea mays*) – meadow fescue (*Lolium pratense*) – winter wheat; 2) maize for grain – peas (*Pisum sativum* L.) – winter wheat. Meadow fescue and peas were grown under fertilizer aftereffect; winter wheat – under direct action of fertilizers. In autumn, nitrogen was applied to winter wheat crops for deep ploughing at a rate of 40, 60 and 80 kg/ha against the background of phosphorus and potassium at a rate of 60 kg/ha. Ammonium nitrate, granular superphosphate and potassium chloride were used for winter wheat, with incorporation of fertilizers to a depth of 0–30 cm. The winter wheat variety is Bohdana. Agricultural practices common to this region.

Winter wheat was harvested in trial sheaves with subsequent weighing and recalculation per 1 ha. The protein content of winter wheat grain was determined by Barnstein; total nitrogen was converted to protein by the coefficient according to DSTU 3768–2004. The research results were analysed using the following methods of analysis of variance and correlation.

Results. According to the results of the research, nitrogen fertilizers and legume predecessors had a significant impact on the winter wheat productivity. The grain yield of winter wheat was significantly higher under the pea as a predecessor than under the meadow fescue. In the control without fertilizers, the grain yield in the pea link was 4.40 t/ha, and in the meadow fescue link – 3.62 t/ha. Biological nitrogen accumulated by peas in the soil created better conditions for nitrogen nutrition of winter wheat, which increased the growth and development rates and grain yield due to the legume component by 0.78 t/ha (Table 1).

The application of nitrogen fertilizers in

Table 1. Yield of winter wheat depending on crop rotation link and fertilizer system, data of Uladovo-Liulynetska Experimental Breeding Station

No.	Link of crop rotation (factor A)	Fertilizer rates for winter wheat (factor B)	Grain yield, t/ha			Average for 2018–2020, t/ha	Straw yield 2018–2020, t/ha
			2018	2019	2020		
1a	maize for grain – meadow fescue – winter wheat	Without fertilizers (control)	3.02	4.30	3.54	3.62	2.9
2a		$N_{40}P_{60}K_{60}$	3.32	4.95	3.76	4.01	3.3
3a		$N_{60}P_{60}K_{60}$	3.50	5.20	3.89	4.20	3.4
4a		$N_{80}P_{60}K_{60}$	3.60	5.50	4.08	4.39	3.5
1	maize for grain – peas – winter wheat	Without fertilizers (control)	4.56	4.60	4.04	4.40	3.4
2		$N_{40}P_{60}K_{60}$	4.98	5.15	4.46	4.86	3.7
3		$N_{60}P_{60}K_{60}$	5.32	5.36	4.72	5.13	4.0
4		$N_{80}P_{60}K_{60}$	5.64	5.62	5.01	5.42	4.2
12		$N_{60}P_{60}K_{60}$ + pea straw	5.70	5.55	4.83	5.36	4.1
LSD_{05} (factor A)			0.19	0.14	0.14	0.15	0.11
LSD_{05} (factor B)			0.13	0.17	0.12	0.17	0.13
LSD_{05} (factor A+B)			0.34	0.31	0.28	0.31	0.23

rates of 40, 60 and 80 kg/ha against the phosphorus and potassium background in 60 kg/ha in the link with meadow fescue provided grain yield of 4.01, 4.20 and 4.39 t/ha, respectively, with an increase to the control without fertilizers by 0.39, 0.58 and 0.77 t/ha. In the link with peas, the application of mineral fertilizers at $N_{40}P_{60}K_{60}$ provided a winter wheat grain yield of 4.86 t/ha, $N_{60}P_{60}K_{60}$ – 5.13 t/ha, $N_{80}P_{60}K_{60}$ – 5.42 t/ha. An increase in the rate of nitrogen fertilizers from 40 to 80 kg/ha in the link with peas increased grain yield by 0.46–1.02 compared to the control without fertilizers. Nitrogen fertilizers for winter wheat cultivation after legume predecessor increased grain yield more significantly than for its cultivation after the grain predecessor of meadow fescue.

It was found that the introduction of pea straw under winter wheat on the background of mineral fertilizers was effective. When $N_{60}P_{60}K_{60}$ and pea straw were applied under winter wheat, the grain yield was 5.36 t/ha, which is 0.23 t/ha higher than in the variants with the application of mineral fertilizers alone.

It was found that the incorporation of $N_{40}P_{60}K_{60}$ in the link with peas increased the yield of winter wheat grain compared to the link with meadow fescue – by 0.85 t/ha, $N_{60}P_{60}K_{60}$ – by 0.93 t/ha, $N_{80}P_{60}K_{60}$ – by 1.03 t/ha. The effect of legume predecessor and mineral fertilizers on the yield of winter wheat in the experiment was comparable: due to the pea predecessor, the yield increased by 0.85–1.03 t/ha, due to fertilizers – by 0.46–1.02 t/ha.

A clear correlation between the nitrogen fertilizer rate and the grain yield of winter wheat was established: with a determination coefficient in the meadow fescue link of 0.9999, and in the pea link of 0.9966 (Fig.1).

The application of mineral fertilizers in

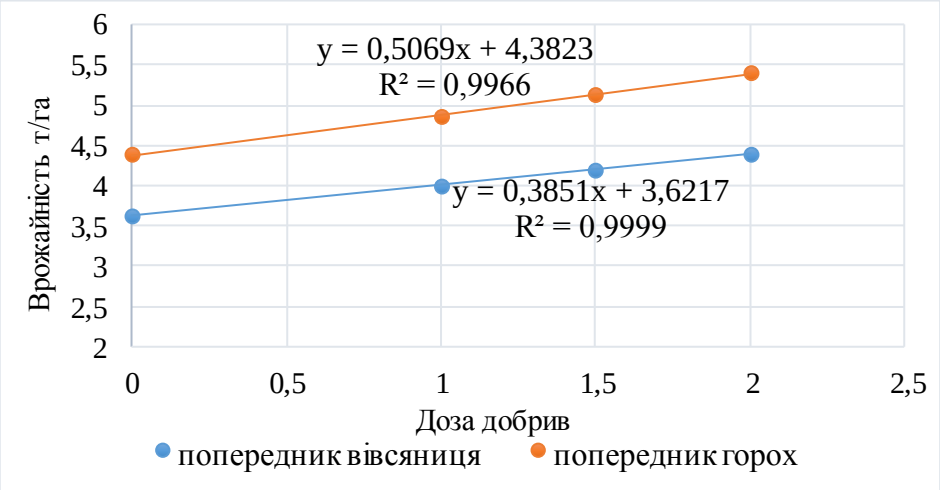

Fig. 1. Correlation between nitrogen fertilizer rate and winter wheat yield, Uladovo-Liulynetska Experimental Breeding Station, average 2018–2020; single rate of nitrogen fertilizer – 40 kg/ha.

both links of the crop rotation contributed to a more intensive growth of stem mass. Thus, in the link with meadow fescue, the straw yield of winter wheat increased by 0.4 t/ha, $N_{40}P_{60}K_{60}$ – by 0.5 t/ha, $N_{80}P_{60}K_{60}$ – by 0.6 t/ha, compared to the control without fertilizers; in the link with peas – by 0.3, 0.6 and 0.8 t/ha, respectively. At the same time, the straw yield in the pea link was higher than in the meadow fescue link by 0.4–0.7 t/ha.

The enhanced nitrogen nutrition of winter wheat plants produced by the application of nitrogen fertilizers and the legume predecessor had a positive effect on grain quality. The grain protein content was significantly higher under the pea as a predecessor than under the meadow fescue. Thus, in the control without fertilizers, the protein content in wheat grain after peas was 11.4 %, meadow fescue – 11.0 %; with the application of $N_{40}P_{60}K_{60}$ – 11.8% and 11.4 %, respectively; $N_{60}P_{60}K_{60}$ – 12.0 % and 11.5%, $N_{90}P_{60}K_{60}$ – 12.1 % and 11.7 %. The cultivation of winter wheat after peas was characterized by an increase in the protein content in the grain compared to the meadow fescue as a predecessor – by 0.4–0.5 % (Fig. 2).

The increased rates of nitrogen fertilizer applied under both predecessors had a positive effect on winter wheat.

The grain protein content in winter wheat increased by 0.4–0.7 % in both links due to mineral nitrogen fertilizer applied at a rate of 40–80 kg/ha

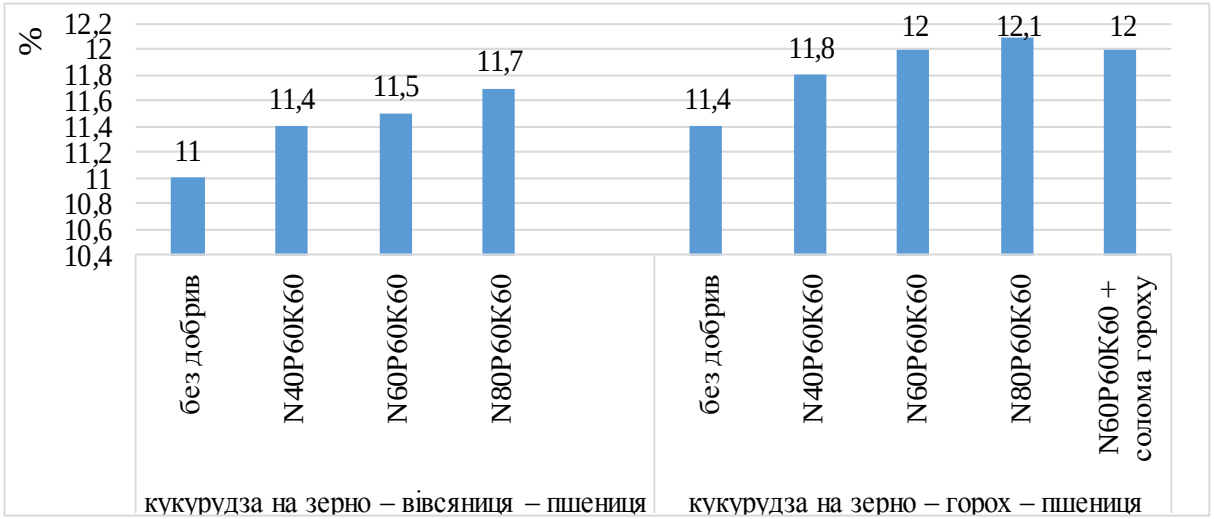

Fig. 2. Protein content in winter wheat grain depending on the crop rotation link and fertilizer system, Uladovo-Liulynetska Experimental Breeding Station, average 2018–2020, %.

compared to the control without fertilizers.

The best grain quality indicators were obtained when winter wheat was grown after peas with application of $N_{80}P_{60}K_{60}$: the protein content in the grain was 12.1 %, exceeding the control without fertilizers by 0.7 %.

Conclusions:

1. The application of $N_{80}P_{60}K_{60}$ under winter wheat in the link with peas provided the highest grain yield – 5.42 t/ha exceeding the control without fertilizers by 1.02 t/ha. The application of $N_{80}P_{60}K_{60}$ under winter wheat with meadow fescue as a predecessor was resulted in a decrease in grain yield by 1.03 t/ha. Increasing the nitrogen fertilizer rate for winter wheat from 40 to 80 kg/ha in the link with peas was determined to be more effective – grain yield increased by 0.56 t/ha, while in the link with meadow fescue – by 0.38 t/ha.

2. The incorporation of pea straw under winter wheat with a mineral fertilizer rate of $N_{60}P_{60}K_{60}$ was found to be effective – the grain yield increased by 0.23 t/ha with an absolute value of 5.36 t/ha compared to the application of mineral fertilizers alone.

3. Enhanced nitrogen nutrition, which was created by the legume predecessor pea and nitrogen fertilizers, significantly improved the quality of winter wheat grain. The highest protein content in winter wheat grain was obtained when winter wheat was grown after peas with the application of $N_{80}P_{60}K_{60}$: the protein content in the grain was 12.1 %, exceeding the control without fertilizers by 0.7 %.

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Іваніна В. В., Коротенко І. М. Вплив азотних добрив і попередників на продуктивність пшениці озимої. *Зернові культури. 2022. 6 (2). 92–96.*

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Актуальність досліджень полягає у встановленні ефективних попередників та доз внесення азотних добрив для отримання стабільних врожаїв високої якості зерна пшениці озимої в умовах зростаючого потепління клімату. **Мета.** Вивчити вплив зернобобового попередника гороху на врожайність пшениці озимої (Triticum aestivum L.) та встановити оптимальну дозу азотних добрив за біологізації її вирощування. **Методи.** Довготривалий польовий та аналітичний. **Результати.** Наведено дані досліджень щодо впливу бобового попередника гороху та доз внесення азотних добрив на продуктивність пшениці озимої. Установлено, що бобовий попередник горох та азотні добрива істотно підвищили врожайність та якість зерна пшениці озимої. З'ясовано, що збільшення дози внесення азотних добрив під пшеницю озиму з 40 до 80 кг/га за обох попередників було ефективним. **Висновки.** Застосування під пшеницю озиму у ланці з горохом $N_{80}P_{60}K_{60}$ забезпечило найвищу врожайність зерна – 5,42 т/га з перевищенням до контролю без добрив на 1,02 т/га. За попередника вівсяниці внесення $N_{80}P_{60}K_{60}$ супроводжувалось зменшенням урожайності зерна на 1,03 т/га. Збільшення дози азотних добрив під пшеницю озиму з 40 до 80 кг/га ефективнішим визначено у ланці з горохом – врожайність зерна зросла на 0,56 т/га, тоді як у ланці з вівсяницею – на 0,38 т/га. Встановлено чітку кореляційну залежність між дозою внесення азотних добрив і врожайністю зерна пшениці озимої: з коефіцієнтом детермінації у ланці з вівсяницею – 0,9999, ланці з горохом – 0,9966. Ефективним визначено заорювання соломи гороху під пшеницю озиму на фоні дози мінеральних добрив $N_{60}P_{60}K_{60}$ – врожайність зерна порівняно з внесенням лише мінеральних добрив підвищилась на 0,23 т/га за абсолютного показника 5,36 т/га. Внесення мінеральних добрив в обох ланках посилило наростання стеблової маси, забезпечивши врожайність соломи у ланці з горохом на 0,4–0,7 т/га вищою, ніж у ланці з вівсяницею. За попередника гороху істотно покращилась якість зерна пшениці озимої. На контролі без добрив вміст білка в зерні пшениці після гороху становив 11,4 %, вівсяниці – 11,0 %; за внесення дози добрив $N_{40}P_{60}K_{60}$ – відповідно 11,8 % та 11,4 %; $N_{60}P_{60}K_{60}$ – 12,0 % та 11,5 %, $N_{90}P_{60}K_{60}$ – 12,1 % та 11,7 %. За рахунок бобового попередника гороху вміст білка в зерні порівняно з попередником вівсяницею підвищився на 0,4–0,5 %.

Ключові слова*: азот, попередники, горох, продуктивність, пшениця озима*