

PHOTOSYNTHETIC ACTIVITY OF WINTER RYE (*SECALE CEREALE* L.) PLANTS IN DEPENDENCE ON CULTIVATION CONDITIONS IN THE NORTHERN STEPPE OF UKRAINE

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Topicality. Today, studying the influence of agrotechnical methods on the photosynthetic activity of plants and the grain productivity of modern winter rye varieties, depending on the predecessors, sowing dates and mineral nutrition, allows us to achieve full biological potential of plants and determine the optimal technological parameters for increasing grain yield in the Northern Steppe of Ukraine. **Purpose.** To conduct investigations on the peculiarities of photosynthetic activity of modern winter rye varieties depending on their predecessors against the background of different sowing dates and the mineral nutrition content in the soil and climatic conditions of the Northern Steppe. **Materials and Methods.** In 2018–2021, the research was conducted on the basis of the Experimental Farm "Dnipro" of the State Enterprise Institute of Grain Crops of NAAS of Ukraine. There were four factors in the experiment. The winter rye varieties Pamiat Khudoierka and Stoir were sown after sunflower and spring barley in the early (5–10 September), optimal (20–25 September) and late (5–10 October) dates. **Results.** Winter rye, sown after spring barley, had a larger leaf area, leaf index and higher values of photosynthetic potential compared to the experimental variants where this crop was sown after sunflower. The maximum values of these parameters were observed in plants of different varieties when sown on 20–25 September with N_{45} applied on frozen-thawed soil after both predecessors. Over the years of research, annual average values of leaf area in the heading stage of plants grown after stubble predecessor for Pamiat Khudoierka variety were 50.4 thousand m^2/ha , Stoir variety – 52.9 thousand m^2/ha , and after sunflower – 46.6 and 48.5 thousand m^2/ha , respectively. These variants also had the highest photosynthetic potential of the crop, which was 2.59 and 2.76 million m^2 -days/ha in Pamiat Khudoierka and Stoir varieties grown after spring barley, and 2.40 and 2.52 million m^2 -days/ha after sunflower, respectively. According to our research results, it was found that the highest yield of Stoir variety was obtained by sowing winter rye after spring barley and sunflower in the most optimal date, namely 20–25 September, and applying nitrogen at the rate of 45 kg a.i./ha in early spring, which was, depending on the predecessor, 6.47 and 5.03 t/ha, respectively. **Conclusions.** Therefore, according to the results of the conducted research, it was found that the maximum leaf surface area (52.9 thousand m^2/ha), leaf index (5.3) and photosynthetic potential (2.76 million m^2 -days/ha) were formed by Stoir variety at sowing on 20–25 September after spring barley and nitrogen fertilisation of 45 kg a.i./ha in early spring on frozen-thawed soil. In addition, the maximum yield level of Stoir variety was achieved under such conditions after spring barley and sunflower, which was 6.47 and 5.03 t/ha, respectively.

Key words: winter rye, variety, predecessor, sowing date, photosynthetic activity of plants, leaf area, photosynthetic potential of crops, yield

Introduction. Winter rye is a promising crop for cultivation in Ukraine and around the world. This is explained primarily by the high value of its grain, which is widely used as a raw material for the bread-baking, alcohol, confectionery, medical and brewing industries [1, 2].

Photosynthetic activity of plants is one of the essential component of the biochemical process in the formation of vegetative and generative organs of winter rye, which determines the crop productivity and depends on many factors. In particular, the photosynthetic intensity is largely conditioned by the leaf assimilation area formed by plants during the growing season.

The size of the leaf assimilation area is determined by the cultivation conditions [3].

For this reason, the formed leaf area and the duration of its activity directly affect the amount and intensity of organic dry matter accumulation by plants.

The study of winter rye varieties listed in the State Register of Plant Varieties Suitable for Dissemination in Ukraine showed that all varieties of both domestic and foreign breeding are highly resistant to abiotic factors. Analysis of these varieties in terms of productivity and a number of other characteristics under various soil and climatic conditions in Ukraine showed

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a diversity of their response to growing conditions [4].

According to the studies conducted in different parts of the Steppe zone of Ukraine, the assimilation area of modern winter crops should be more than 50 thousand m²/ha to ensure maximum realisation of the productive potential of plants [5–7].

During the cultivation of winter grain crops in the Steppe zone, the plant growth, development and grain productivity are significantly influenced by predecessors, sowing dates and nutrition level [8, 9].

In the experiments conducted at the Synelnykove Breeding and Research Station of the Institute of Grain Crops of NAAS, winter rye plants formed a larger leaf area compared to other winter grain crops when grown both after black fallow and sunflower [10].

According to the research of the Institute of Agriculture in the Carpathian region, winter rye crops formed a leaf area of 64.8 thousand m²/ha, winter wheat – 61.5 thousand m²/ha, winter triticale – 70.2 thousand m²/ha, and crop yields were 5.55–6.32 t/ha, 4.88–5.39 t/ha and 6.45–6.74 t/ha, respectively [11].

In this regard, the purpose of the research was to examine the peculiarities of photosynthetic activity and productivity of winter rye plants depending on the predecessors, sowing dates and level of mineral nutrition in the soil and climatic conditions of the Northern Steppe of Ukraine.

Materials and Methods. The four-factor experiment was conducted at the Experimental Farm Dnipro of the Institute of Grain Crops of the NAAS of Ukraine, and was repeated three times, with plots located sequentially by a systematic method. The area of the elementary plot was 60 m², the registered plot was 40 m².

The soil of the research site is ordinary low-humus slightly eroded chernozem. The humus content in the arable layer was 3.1–3.3 %, nitrate nitrogen content – 18.8–29.0 mg/kg, mobile phosphorus – 125–144 mg/kg, exchangeable potassium – 69–118 mg/kg of absolutely dry soil (according to Chirikov).

After harvesting the predecessors (spring barley and sunflower), the plant residues were chopped and partially incorporated into the soil using disc stubble breakers or heavy disc harrows. The experiments were laid out on the re-

commended fertiliser background (N₆₀P₆₀K₆₀), with mineral fertilisers for both predecessors applied under pre-sowing cultivation.

Winter rye was sown with a SN-16 seeder in three sowing dates: early (5–10 September), optimal (20–25 September) and late (5–10 October). The sowing was conducted using a continuous row seeding method, with a seeding depth of 5–6 cm. The winter rye was harvested by continuous threshing with a Sampo-500 combine harvester at full grain ripeness. The cultivation technology of winter rye was generally accepted for the Northern Steppe region of Ukraine, except for the elements of technology selected for the study.

Experiments and observations were performed in accordance with generally accepted methodological recommendations [12–14].

Results and Discussion. During 2018–2021, the weather conditions were significantly different and were characterised by substantial deviations of certain indicators from the long-term average. For example, with an average long-term precipitation of 514 mm, 533.5 mm fell in 2018/2019, 465.4 and 634 mm in 2019/2020 and 2020/2021, respectively.

During the research period, the variability of hydrothermal regime parameters and their deviation from the normative indicators resulted in the heterogeneous conditions for the formation of leaf area by winter crops. Not only the abiotic factors influenced the leaf surface area, but also significantly depended on the predecessors, sowing dates, level of mineral nutrition and varietal characteristics.

It should be noted that the total leaf area of winter rye crops gradually increased from the beginning of spring growth resumption to the heading phase of plants, absolutely in all experimental plots. Further, in the process of plant maturation, there was a gradual drying out of the leaves of the lower and then upper tiers. In the milky-wax ripeness stage, the leaf area of winter crops was significantly less than in the heading stage. On average, over the years of research, when growing winter rye after spring barley on variants with the application of N₄₅ nitrogen on frozen-thawed soil, the difference in the leaf area for the varieties Pamiat Khudoierka and Stoir at the early sowing date was 28.4 and 27.7 %, at the optimal and late sowing dates – 31.9, 35.6 and 28.3, 27.3 %, respectively.

The difference in these winter rye varieties sown after sunflower, under the specified mineral nutrition regime with sowing date of 5–10 September, was 32.6 and 31.6 %, 35.9 and 38.2 %, 20–25 September, and 33.1 and 36.8 %, respectively, and 5–10 October, respectively.

A similar pattern was observed in the control experimental variants without additional nitrogen fertilisation. In the plots after spring barley, the leaf area in the milky-wax ripeness stage of winter rye was lower than in the heading stage, in particular, at sowing on 5–10 September in Pamiat Khudoierka variety – by 21.3 %, Stoir variety – by 22.1 %, at sowing on 20–25 September – by 31.9 and 35.6 %, and on 5–10 October – by 28.3 and 27.3 %, respectively. On winter rye crops after sunflower, this difference was 24.8 and 30.3 % for sowing in the first ten days of September, 31.5 and 34.6 % for varie-

ties sown in the optimal time, and 26.9 and 29.2 % for varieties sown in the first ten days of October. The results of the research showed that the formation of the leaf area of plants was significantly influenced not only by a set of technological practices, but also by individual elements of agricultural technology. Therefore, the predecessors of winter rye significantly influenced the size of the assimilation surface formed by the crops by creating heterogeneous conditions of moisture supply and nutritional regime. The leaf area of winter rye, which was sown after spring barley, was larger in size compared to crops sown after sunflower. On average, in 2019–2021, this indicator in the heading stage of plants grown after the stubble predecessor ranged from 43.1–52.9 thousand m²/ha, while in crops sown after sunflower it was 39.6–48.5 thousand m²/ha (Table 1).

Table 1. Leaf area of winter rye plants depending on growing conditions, thousand m²/ha, (2019–2021)

Stage of plant development	Variety*	Sowing date					
		5–10 September		20–25 September		5–10 October	
		control (no fertilisers)	N ₄₅ on frozen-thawed soil	control (no fertilisers)	N ₄₅ on frozen-thawed soil	control (no fertilisers)	N ₄₅ on frozen-thawed soil
Predecessor – spring barley							
Spring tillering	1	21.2	22.8	16.6	17.9	11.9	13.0
	2	22.3	23.1	17.5	18.8	12.7	13.6
Stem elongation	1	32.1	35.5	31.0	34.2	30.4	33.1
	2	32.3	35.7	33.7	36.8	31.0	34.2
Heading	1	43.2	47.5	46.7	50.4	43.1	46.7
	2	44.1	48.0	48.9	52.9	44.0	47.1
Milky-wax ripeness	1	35.6	37.0	36.5	38.2	35.3	36.4
	2	36.1	37.6	37.0	39.0	35.7	37.0
Predecessor – sunflower							
Spring tillering	1	19.7	20.9	15.2	16.1	10.1	11.2
	2	20.2	21.0	16.0	16.9	10.9	11.8
Stem elongation	1	29.4	32.7	29.0	32.2	28.2	31.6
	2	30.5	34.0	31.0	34.1	29.4	32.1
Heading	1	39.7	43.9	42.6	46.6	39.6	43.4
	2	42.1	44.1	44.7	48.5	41.2	45.0
Milky-wax ripeness	1	31.8	33.1	32.4	34.3	31.2	32.6
	2	32.3	33.5	33.2	35.1	31.9	32.9

Notes: * 1 – Pamiat Khudoierka variety; 2 – Stoir variety.

Sowing dates also significantly influenced the formation of the winter rye leaf area. So, after both predecessors, the maximum values of this indicator were observed at sowing on 20–25 September. On average, over the research years, when the plants were grown after spring

barley, the leaf assimilation area of Pamiat Khudoierka variety in plots without feeding was 46.7 thousand m²/ha, with the application of N₄₅ on frozen-thawed soil – 50.4 thousand m²/ha, the leaf assimilation area of Stor variety – 48.9 and 52.9 thousand m²/ha, respectively. In the expe-

rimental variants sown in the early September, the leaf area of Pamiat Khudoierka variety was 8.1 and 6.1 % less, and in the early October – 8.4 and 7.9 % less. A larger difference in the size of the formed leaf area between winter rye crops sown on 20–25 September and 5–10 September was observed in the Stoir variety, which was 10.9 % in the control variant of the experiment (without feeding) and 10.2 % in the plots with N₄₅ application on frozen-thawed soil. In the heading stage, the assimilation area of Stoir variety crops sown on 20–25 September was 11.1 % larger than that of winter crops sown on 5–10 October in variants without feeding (control), and 12.3 % larger with nitrogen feeding of N₄₅ on frozen-thawed soil.

As noted above, the largest leaf area was on the plots of winter rye after sunflower, at sowing on 20–25 September. In the heading stage, it was 44.7 thousand m²/ha in the control variant of the experiment, 48.5 thousand m²/ha in the variant with nitrogen feeding in the Stoir variety, and 42.6 and 46.6 thousand m²/ha in the Pamiat Khudoierka variety, respectively.

For sowing on 5–10 September, this indicator was lower compared to sowing on 20–25 September by 6.2 and 10.0 % in Stoir variety, respectively, and by 7.3 and 6.2 % in Pamiat Khudoierka variety.

On average, over the years of research, the total leaf area during the specified period of development of winter crops sown on 5–10 October was less than that sown on 20–25 September. In the Stoir variety, this difference in variants without nitrogen feeding (control) was 8.5 %, with the application of N₄₅ on frozen-thawed soil – 7.8 %, in the Pamiat Khudoierka variety – by 7.6 and 7.4 %, respectively.

Varietal characteristics of winter rye also influenced the formation of leaf area of plants. Thus, during the entire research period, almost at all stages of development, plants of the Stoir variety were characterised by higher values of this indicator compared to the Pamiat Khudoierka variety.

As is known, the coefficient of land area use by crops is determined by the calculation of the leaf area index, the values of which differed significantly in the studies, depending on the cultivation conditions of winter rye (Table 2).

The largest leaf area index was observed in the heading stage of winter rye plants after

both spring barley and sunflower, when the leaf area reached its maximum. It should be noted that regardless of the level of mineral nutrition, the highest leaf area index was observed in crops after the stubble predecessor. The value of this index was also significantly influenced by the sowing date. On average, over the years of research, on plots of winter rye sown after spring barley, the leaf area index was highest in variants where winter rye was sown on 20–25 September, and subsequently nitrogen fertilisation of plants with N₄₅ was carried out on frozen-thawed soil. For the varieties Stoir and Pamiat Khudoierka, it was 5.3 and 5.0, respectively, and for the control variants of the experiment – 4.9 and 4.7.

The maximum values of the leaf area index were also observed in winter rye crops sown on 20–25 September after sunflower. In the varieties Pamiat Khudoierka and Stoir, it was 4.3 and 4.5 in plots without nitrogen feeding, and 4.7 and 4.9, respectively, with the introduction of N₄₅ on frozen-thawed soil.

The highest leaf area index among the studied varieties was observed in rye crops of Stoir variety, when sown on 20–25 September after spring barley with the application of N₄₅ on frozen-thawed soil exceeded the values of the Pamiat Khudoierka variety by 6 %, and without fertilisation by 4.3 %. When winter crops were placed after sunflower, the difference in the leaf area index between the varieties was 4.3 and 4.7 %, respectively.

The results of the research have established a reliable relationship between the photosynthetic potential formed during the spring-summer growing season and the yield of winter rye. The obtained results suggest that the value of photosynthetic potential of the crop was significantly influenced not only by the predecessors, sowing dates, level of mineral nutrition and varietal characteristics of plants, but also by abiotic factors, in particular, hydrothermal conditions in winter rye crops during the entire growing season.

In these experiments, the value of photosynthetic potential significantly depended on the factors studied. Its highest values were observed in crops placed after spring barley. So, depending on the level of mineral nutrition and sowing dates, the photosynthetic potential of Stoir variety ranged from 2.31 to 2.76 milli-

Table 2. Leaf area index of different varieties of winter rye depending on the predecessors, sowing dates and mineral nutrition level (average for 2019–2021)

Sowing date	Variety	Predecessor			
		Spring barley		sunflower	
		Mineral nutrition level			
		control*	N ₄₅ on FTS**	control*	N ₄₅ on FTS**
Spring tillering stage					
5–10 September	Pamiat Khudoierka	2.1	2.3	2.0	2.1
	Stoir	2.2	2.3	2.0	2.1
20–25 September	Pamiat Khudoierka	1.7	1.8	1.5	1.6
	Stoir	1.8	1.9	1.6	1.7
5–10 October	Pamiat Khudoierka	1.2	1.3	1.0	1.1
	Stoir	1.3	1.4	1.1	1.2
Stem elongation					
5–10 September	Pamiat Khudoierka	3.2	3.6	2.9	3.3
	Stoir	3.2	3.6	3.1	3.4
20–25 September	Pamiat Khudoierka	3.1	3.4	2.9	3.2
	Stoir	3.4	3.7	3.1	3.4
5–10 October	Pamiat Khudoierka	3.0	3.3	2.8	3.2
	Stoir	3.1	3.4	2.9	3.2
Heading stage					
5–10 September	Pamiat Khudoierka	4.3	4.8	4.0	4.4
	Stoir	4.4	4.8	4.1	4.4
20–25 September	Pamiat Khudoierka	4.7	5.0	4.3	4.7
	Stoir	4.9	5.3	4.5	4.9
5–10 October	Pamiat Khudoierka	4.3	4.7	4.0	4.3
	Stoir	4.4	4.7	4.1	4.5

Notes: * – no fertilisers; ** – feeding on frozen-thawed soil (FTS).

on m²-days/ha, and of Pamiat Khudoierka variety – from 2.25 to 2.66 million m²-days/ha, and in case of sowing after sunflower – from 2.14 to 2.52 and from 2.05 to 2.44 million m²-days/ha, respectively.

On average, over the years of research, the highest photosynthetic potential of crops for both varieties and predecessors was observed when winter rye was sown on 20–25 September,

followed by nitrogen feeding of N₄₅ on frozen-thawed soil.

Under these conditions, the Pamiat Khudoierka and Stoir varieties, which were grown after spring barley, had a photosynthetic potential of 2.59 and 2.76 million m²-days/ha, for cultivation after sunflower – 2.40 and 2.52 million m²-days/ha, respectively (Table 3).

Research results revealed a significant in-

Table 3. Photosynthetic potential of winter rye crops during the spring and summer growing season, million m²-days/ha (average for 2019–2021)

Sowing date	Variety	Mineral nutrition level	
		control*	N ₄₅ on FTS**
Predecessor – spring barley			
5–10 September	Pamiat Khudoierka	2.37	2.66
	Stoir	2.41	2.68
20–25 September	Pamiat Khudoierka	2.36	2.59
	Stoir	2.52	2.76
5–10 October	Pamiat Khudoierka	2.25	2.47
	Stoir	2.31	2.53
Predecessor – sunflower			
5–10 September	Pamiat Khudoierka	2.20	2.44
	Stoir	2.30	2.49
20–25 September	Pamiat Khudoierka	2.19	2.40
	Stoir	2.32	2.52
5–10 October	Pamiat Khudoierka	2.05	2.29
	Stoir	2.14	2.35

Notes: * – no fertilisers; ** – feeding on frozen-thawed soil (FTS).

fluence of predecessors, sowing dates and nutrition level on the yield of the studied winter rye varieties. In general, the highest yield was obtained when winter rye was sown after spring barley. After this predecessor, Stoir variety sown on 20–25 September and fertilised with N₄₅ on frozen-thawed soil was more productive with a yield of 6.47 t/ha, and under similar growing conditions after sunflower – 5.03 t/ha. Grain productivity of Pamiat Khudoierka variety in these experimental variants was also the highest, but slightly inferior to Stoir variety and amounted to 6.17 and 4.72 t/ha, respectively

(Table 4).

By comparison with the variants of the experiment without application of nitrogen fertilizers in spring, nitrogen feeding on frozen-thawed soil of plants sown on 20–25 September after spring barley provided an increase in the yield of Stoir variety of 11.2 % and Pamiat Khudoierka variety of 11.6 %.

Under similar growing conditions after sunflower, nitrogen feeding increased the yield, depending on the variety, by 39.7 and 36.0 %, respectively.

Conclusions. Consequently, based on the

Table 4. Yield of different varieties of winter rye depending on growing conditions, t/ha (average for 2019–2021)

Sowing date (factor B)	Variety (factor C)	Yield, t/ha	
		Plant nutrition level (factor D)	
		control (no fertilisers)	N ₄₅ on frozen-thawed soil
Predecessor – spring barley (factor A)			
5–10 September	Pamiat Khudoierka	5.00	6.05
	Stoir	5.40	6.19
20–25 September	Pamiat Khudoierka	5.53	6.17
	Stoir	5.82	6.47
5–10 October	Pamiat Khudoierka	5.21	5.40
	Stoir	5.42	5.53
Predecessor – sunflower			
5–10 September	Pamiat Khudoierka	3.01	4.42
	Stoir	3.26	4.53
20–25 September	Pamiat Khudoierka	3.47	4.72
	Stoir	3.60	5.03
5–10 October	Pamiat Khudoierka	3.00	4.16
	Stoir	3.10	4.25
LSD ₀₅ , t/ha: predecessor (factor A) – 0.11–0.13; sowing date (factor B) – 0.09–0.11; variety (factor C) – 0.10–0.12; plant nutrition level (factor D) – 0.12–0.15; interaction AB – 0.11–0.14; AC – 0.12–0.14; AD – 0.13–0.16; BC – 0.13–0.15; BD – 0.15–0.18; CD – 0.13–0.16; ABCD – 0.18–0.21			

results of the research, we found that the maximum leaf area and the highest photosynthetic potential were observed in winter rye crops sown after spring barley and sunflower in the most optimal terms, namely on 20–25 September, followed by nitrogen feeding in early spring

on frozen-thawed soil at the rate of 45 kg a.i./ha. Under these conditions, we achieved the best indicators of photosynthetic activity of winter rye plants, as well as the highest yield of Stoir variety, which was 6.47 t/ha after spring barley and 5.03 t/ha after sunflower.

References

- Fadeev, L. V. (2021). Rye returns. *AgroOne* [Agricultural magazine], 2 (63), 14–17. [in Ukrainian].
- Hospodarenko, G. M., Ptashnyk, M. M. (2013). The content of protein and starch in the grain of winter rye depending on the types, norms and terms of fertilization. *Novitni tehnologii*. [Newest technologies], 1 (1). 5–10. [in Ukrainian]. [https://doi.org/10.21498/na.1\(1\).2013.119316](https://doi.org/10.21498/na.1(1).2013.119316).
- Nichiporovich, A. A. (1963). On ways to increase the productivity of plant photosynthesis in crops. *Fotosintez i voprosi produktivnosti rasteniy* [Photosynthesis and questions of plant productivity]. Moscow: Izdatelstvo AN SSSR, 5–36 [in Russian].
- Sabluk, V. T., Kienko, Z. B., Dimitrov, S. G. (2018). Varietal resources of sowing rye (*Secale cereale* L.) in the State Register of Plant Varieties of Ukraine. *Plant Varieties Studying and Protection* [Plant Varieties Studying and Protection], 14 (4). 431–439. [in Ukrainian]. <https://doi.org/10.21498/2518-1017.14.4.2018.151914>.

5. Cherenkov, A. V., Kozechko, V. I. (2014). Photosynthetic activity of plants of various varieties of winter wheat, depending on the technological methods of cultivation in the conditions of the northern Steppe of Ukraine. *Tavriyskiy naukoviy visnik* [Taurida Scientific Herald], 61. 38–40. [in Ukrainian].
6. Zheliazkov, O. I., Samoilenko, O. A., Pedash, O. O., Bondarenko, A. S., Boiko, O. V., Romanenko, O. L. (2012). Photosynthetic activity of winter wheat plants depending on the technological methods of cultivation in the Sivash region. *Bulletin Institutu silskoho hospodarstva stepovoi zony UAAS* [Bulletin of Institute of Agriculture of the Steppe Zone of the UAAS], 2. 103–106. [in Ukrainian].
7. Cherenkov, A. V., Zheliazkov, O. I., Khorishko, S. O., Kozelskyi, O. M. (2015). Photosynthetic activity of winter wheat plants depending on the technological methods of cultivation in the northern Steppe of Ukraine. *Bulletin Institutu silskoho hospodarstva stepovoi zony UAAS* [Bulletin of Institute of Agriculture of the Steppe Zone of the UAAS], 8. 73–77. [in Ukrainian].
8. Solodushko, M. M. (2015). Productivity of winter cereal crops depending on predecessors and seeding dates in the Steppe zone. *Buletin institutu zernovogo gospodarstva UAAS* [Bulletin of Institute of grain farming of the UAAS], 8, 91–94. [in Ukrainian].
9. Solodushko, M. M., Gasanova, I. I., Pedash, O. O., Yaroshenko, S. S., Drumova, O. M., Astakhova, Ya. V., Yerashova, M. V., Bezsusidnia, Yu. V., Zavalypich, N. O. (2021). Effect of mineral nutrition on winter wheat yield after sunflower in Ukrainian steppe zone. *Ukrainian Journal of Ecology*, 11 (7). 179–184.
10. Gladka, A. V. (2012). *Osoblivosti vyroshchuvannya ta vplyv agrotehnicnykh zakhodiv na produktyvnist ozimykh kolosovykh kultur v umovakh pivnichnoho Stepu Ukraini* [Features of cultivation and the impact of agrotechnical measures on the productivity of winter cereal crops in the conditions of the northern Steppe of Ukraine]. (Cand. Agric. Sci. Diss.). Institut zernovogo gospodarstva UAAN, Dnipropetrovsk. Ukraine. [in Ukrainian].
11. Voloshchuk, O. P., Voloshchuk, I. S., Konyk, H. S., Dzyubailo, A. H., Hlyva, V. V., Vorobyova, Y. V., Hereshko, H.S., Sluchak, O.M. (2023). Comparative evaluation of the productivity of winter crops (Wheat [*Triticum aestivum* L.], Rye [*Secale cereale* L.], Triticale [*Triticosecale witt.*]) in the western forest-steppe of Ukraine. *Journal of Agricultural Sciences (Belgrade)*, 68 (1). 81–96. <https://doi.org/10.2298/JAS2301081V>.
12. Dospikhov, B. A. (1985). *Metodika polevogo opyta s osnovami statisticheskoy obrabotki rezultatov issledovaniy* [Methodology of field experience with the basics of statistical processing of research results] (5th ed. rev.). Moscow: Ahropromizdat. [in Russian].
13. Tsykov, V. S., Pickush, G. R. (1983). *Metodicheskie rekomendacii po provedeniyu polevykh opytov s zernovymi, zernobobovymi i kormovymi kulturami* [Methodical recommendations on caring out the field tests with cereals, legumes and feed crops]. Dnepropetrovsk: N. p. [in Russian].
14. Vovkodav, V. V. (2001). *Metodika derzhavnoho sortovyprobuvannya silskogospodarskikh kultur* [Methodology for state variety testing of agricultural crops]. (2nd ed.). V. V. Vovkodav (Ed.). Kyiv: N. p. [in Ukrainian].

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Солодушко М. М., Безсусідня Ю. В. Фотосинтетична діяльність рослин жита озимого (*Secale cereale* L.) залежно від умов вирощування в Північному Степу України.

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Актуальність. Визначення впливу технологічних прийомів вирощування на фотосинтетичну діяльність та рівень зернової продуктивності жита озимого є актуальним. Оскільки проведення цих досліджень дозволяє у більш повній мірі розкрити біологічний потенціал рослин, визначити оптимальні технологічні параметри за яких суттєво підвищується врожайність жита озимого при його вирощуванні в зоні Північного Степу України. **Мета** проведених досліджень полягала у вивченні особливостей фотосинтетичної діяльності рослин сучасних сортів жита озимого залежно від попередників на фоні різних строків сівби та рівня мінерального живлення в ґрунтово-кліматичних умовах Північного Степу. **Матеріали і методи.** Дослідження проводилися впродовж 2018–2021 рр. на базі дослідного господарства «Дніпро» ДУ Інститут зернових культур НААН України. Кількість факторів у досліді – чотири. Сорти жита озимого Пам'ять Худоєрка та Стоір висівалися після соняшнику та ячменю ярого у ранній (5–10 вересня), оптимальний (20–25 вересня) та пізній (5–10 жовтня) строки. **Результати.** Жито озиме, розміщене після ячменю ярого, мало більшу за розмірами площу листків, листковий індекс та вищі значення фотосинтетичного потенціалу, порівняно з варіантами досліді, де ця зернова культура висівалася після соняшнику. При вирощуванні після обох попередників максимальні значення цих показників відмічали у рослин різних сортів за сівби 20–25 вересня за внесення N_{45} по мерзлоталому ґрунті. В середньому за роки досліджень, у фазі колосіння площа листової поверхні рослин у сорту Пам'ять Худоєрка, який вирощувався після стерньового попередника на зазначених ділянках становила 50,4 тис.м²/га, у сорту Стоір – 52,9 тис.м²/га, після соняшнику – 46,6 та 48,5 тис.м²/га відповідно. Найвищі показники фотосинтетичного потенціалу посіву також відмічалися на зазначених варіантах і становили у сортів Пам'ять Худоєрка та Стоір, які вирощувалися після ячменю ярого – 2,59 та 2,76 млн м²-днів/га, а після соняшнику – 2,40 та 2,52 млн м²-днів/га відповідно. За результатами досліджень встановлено, що сівба жита озимого після ячменю ярого і

соняшнику в найбільш оптимальні строки, а саме 20–25 вересня, та застосування азоту ранньою весною із розрахунку 45 кг/га д. р., забезпечували формування найвищої врожайності у сорту Стоір, яка складала відповідно до попередника 6,47 і 5,03 т/га. **Висновок.** Таким чином, за результатами проведених досліджень встановлено, що максимальну площу листової поверхні (52,9 тис.м²/га), листовий індекс (5,3) та фотосинтетичний потенціал (2,76 млн м²-днів/га) формував сорт Стоір за сівби 20–25 вересня після ячменю ярого та проведення підживлення рослин азотом ранньою весною по мерзлоталому ґрунті із розрахунку 45 кг/га д.р. До речі, за таких умов було одержано і максимальний рівень врожайності у сорту Стоір, який за вирощування після ячменю ярого та соняшнику склав 6,47 та 5,03 т/га відповідно.

Ключові слова: жито озиме, сорт, попередник, строк сівби, фотосинтетична діяльність рослин, площа листової поверхні, фотосинтетичний потенціал посівів, урожайність