

EFFECTIVENESS OF PREDECESSORS AT GROWING WINTER RYE (*SECALE CEREALE* L.) IN THE CONDITIONS OF NORTHERN STEPPE OF UKRAINE

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Topicality. Nowadays, the relevant issue is the influence of predecessors on the grain productivity for the modern varieties of winter rye depending on the sowing dates and mineral nutrition, the study of which allows to reveal the biological potential of plants to a fuller extent and to significantly increase the yield of this crop in the Northern Steppe zone of Ukraine. **Purpose.** To study features for formation of grain productivity of modern winter rye varieties depending on the predecessors against the background of different sowing dates and the level of mineral nutrition in the soil and climatic conditions of the Northern Steppe. **Materials and Methods.** In the 2018–2021, the studies were conducted on the basis of Experimental Farm “Dnipro” of State Enterprise Institute of Grain Crops NAAS in four-factor field trial. Winter rye of Pamiat Khudoierka and Stoir varieties were sown after spring barley and sunflower against the background of different levels of mineral nutrition of plants in three terms: early (September 5–10), optimal (September 20–25) and late (October 5–10). **Results.** According to the research results, a significant influence of predecessors on the winter rye yield was established. The highest level of yield was obtained for the Stoir variety, which was sown in the period from 20 to 25 September. At the same time, on average over the years of research, the highest yield was observed in variants with nitrogen feeding plants on freeze-thawed soil: after spring barley – 6.47 t/ha, after sunflower – 5.03 t/ha. The Pamiat Khudoierka variety also provided the highest yield in these variants of the experiment – 6.17 and 4.72 t/ha, respectively. However, the difference in yield between varieties, taking into account the maximum indicator, depending on the predecessors was respectively 0.30 and 0.31 t/ha. **Conclusions.** According to the results of the research, it was found that sowing of winter rye after spring barley and sunflower in the most optimal terms, namely September 20–25, and the applying 45 kg a.i./ha nitrogen in early spring, ensured the formation of the highest yield in the Stoir variety, which was 6.47 and 5.03 t/ha, respectively.

Key words: winter rye, predecessor, varieties, sowing dates, crop feeding, yield

Introduction. Increasing the production of winter rye grain, an essential and extremely valuable crop, is gradually rising in Ukraine and worldwide. At the same time, the recent changes in weather conditions require optimisation of technological methods of winter rye cultivation in the Steppe zone, where it has not been practically carried out, at least not for the past 2–3 decades. The correct selection of the winter rye predecessor with the obligatory consideration of soil and climatic, organisational, economic and agrotechnical conditions is one of the primary tasks. It is known that only scientifically based crop rotations can provide this crop with good predecessors and avoid the wide spread of pests, diseases, weeds and, of course, to get a high grain yield.

Determination of the complex effect of different predecessors to obtain the maximum possible grain productivity of modern winter rye varieties against the background of different

sowing dates and the proper level of mineral nutrition is most appropriate.

Research conducted in different soil and climatic zones of Ukraine has shown that black and bastard fallow are the best predecessors of winter crops. At the same time, changes in the structure of sown areas, which led to an increase in their share of cereals and sunflower, make it impossible to place winter rye crops on high agrophones, according to traditional predecessors. However, winter rye is able to produce quite high grain yields even when placed after non-fallow predecessors [1–4].

In this regard, this study was aimed to investigate the peculiarities of grain productivity formation of modern winter rye varieties depending on their predecessors under different sowing dates and the level of mineral nutrition in the soil and climatic conditions of the Northern Steppe.

Materials and Methods. In 2018–2021,

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the experiments were carried out at the Experimental Farm "Dnipro" of the State Enterprise Institute of Grain Crops of the National Academy of Agrarian Sciences of Ukraine (Dnipropetrovsk region). The soil of the experimental plots is represented by ordinary low-humus low-eroded chernozem. Humus content in the topsoil is 3.1–3.3 %, nitrate nitrogen – 18.8–29.0 mg/kg, mobile phosphorus – 125–144 mg/kg, exchangeable potassium – 69–118 mg/kg of absolutely dry soil (according to Chyrykov).

There were four factors in the field experiment during the research: factor A – predecessor, factor B – sowing date, factor C – variety, factor D – plant nutrition level. We laid out the experiment using the systematic method of sequential plots. The area of the elementary plot was 60 m², the accounting plot was 40 m². The experiment was replicated three times.

Crop residues of the predecessors (sunflower and spring barley) were chopped and partially incorporated into the soil using disc harrows or heavy disc harrows. The trials were laid out on the recommended fertilisation background (N₆₀P₆₀K₆₀), with mineral fertilisers for both predecessors applied under pre-sowing cultivation. Winter rye was sown with a SN-16 seeder in three dates: early (5–10 September), optimal (20–25 September) and late (5–10 October). The sowing method was broadcast-drill sowing, the depth of seed placement was 5–6 cm. Yield accounting was carried out by direct harvesting, followed by weighing and recalculation of the data obtained to standard grain moisture. Statistical data processing was performed by means of analysis of variance according to B. O. Dospikhov (1985).

The winter rye was harvested by continuous threshing of the entire plot area with a Sam-

po-500 combine at full grain ripeness. The techpo-500 combine at full grain ripeness. The technology of winter crops cultivation, except for the technological elements studied, was generally accepted for the northern part of the Steppe of Ukraine.

The research was based on generally accepted methods and recommendations [5, 6].

Results and Discussion. The weather conditions during the research were characterised by high variability. With an average long-term precipitation of 514 mm, 107.7 % of the average long-term norm fell in the 2018/2019 growing season, and 90.5 % and 123.3 % in the 2019/2020 and 2020/2021 growing seasons, respectively. At the same time, the distribution of precipitation by months and seasons was quite uneven, which certainly affected the timeliness of germination, growth and development of plants in the autumn and spring-summer periods and, accordingly, resulted in the formation of unequal grain yield.

As is well known, the harvesting dates of previous crops determine the amount of productive moisture reserves in the sowing layer of the soil, as the moisture accumulation occurs from their harvesting to the sowing of winter rye due to precipitation during this period.

On average, over the years of research, the longest pre-sowing period was observed after harvesting spring barley, which was 61 days for sowing on 5–10 September, 81 days for sowing on 20–25 September, and 91 days for sowing on 5–10 October. In terms of the years of research, it was the shortest in 2020 – according to the sowing time of 58, 78 and 88 days, and the longest in 2018 – 63, 83 and 93 days. After harvesting sunflower, the pre-sowing period was less extended and averaged from 5 to 35 days in 2018–2020 (Table 1).

Table 1. Productive moisture reserves (mm) in the soil layer of 0–100 cm depending on the predecessors and the pre-sowing period length of winter rye (2018–2020)

Sowing dates	Pre-sowing period length, days				Productive moisture reserves at harvesting the predecessor, mm			
	2018	2019	2020	average	2018	2019	2020	average
Predecessor – spring barley								
5–10 September	63	62	58	61	19.3	17.2	21.2	19.2
20–25 September	83	82	78	81				
5–10 October	93	92	88	91				
Predecessor – sunflower								
5–10 September	5	6	3	5	7.2	6.4	9.1	7.6
20–25 September	25	26	23	25				
5–10 October	35	36	33	35				

The productive moisture reserves in the one-metre soil layer of winter rye predecessors also differed significantly. Thus, on average, over the years of research, after harvesting spring barley, they were 152.6 % higher than after sunflower and amounted to 19.2 mm. It should also be noted that the productive moisture reserves in the soil after sunflower in the soil layer 60–100 cm were almost absent, as this crop had a more developed and deeply located root system. However, both after sunflower and spring barley, at the harvesting date, the moisture reserves in the upper layer of the soil profile (0–10 cm) were very low.

The shorter pre-sowing period and significantly lower residual reserves of productive

moisture in the soil after sunflower, respectively, negatively affected the further growing season of winter rye in autumn, spring and summer.

On average over the years of research, productive moisture reserves for both predecessors were not always sufficient for timely emergence of friendly seedlings. More favourable conditions were after spring barley and less suitable after sunflower. For example, during sowing on 5–10 September, the productive moisture reserves in the sowing layer of soil after spring barley were 2.8 mm, which was 86.7 % higher than after sunflower during this period. A similar trend was observed at other sowing dates (Table 2).

When sowing on 20–25 September, the

Table 2. Influence of predecessors on productive moisture reserves in the soil and initial development of winter rye in the autumn growing season (average for 2018–2020)

Sowing dates	Variety	Productive moisture reserves in the soil layer 0–10 cm, mm	Time period of sowing – full seedlings, days	Field germination of seed, %
Predecessor – spring barley				
5–10 September	Pamiat Khudoierka	2.8	12	83
	Stoir		11	85
20–25 September	Pamiat Khudoierka	5.5	9	85
	Stoir		8	87
5–10 October	Pamiat Khudoierka	6.1	11	83
	Stoir		10	84
Predecessor – sunflower				
5–10 September	Pamiat Khudoierka	1.5	12	81
	Stoir		11	82
20–25 September	Pamiat Khudoierka	2.6	10	83
	Stoir		9	84
5–10 October	Pamiat Khudoierka	4.5	11	81
	Stoir		10	82

difference in the initial soil moisture reserves between the predecessors was 111.5 %, and on 5–10 October – 35.6 %. It was found that the seedlings of Stoir variety emerged 1 day earlier than those of Pamiat Khudoierka due to higher seed vigour after all the predecessors and for sowing dates. The productive moisture reserves in the soil positively influenced the field germination of winter rye varieties studied in the experiments. So, over the years of research, the highest field germination was in Stoir variety, which was grown after spring barley; when sown on 5–10 September and 20–25 September, the values of field germination of seeds were 2 % higher than the corresponding values of Pamiat Khudoierka variety. A similar trend was

observed in other variants.

The predecessors significantly influenced the formation of tillers of winter rye plants in the experiments. For example, at sowing on 20–25 September after spring barley, winter rye plants of Stoir variety had a tillering coefficient of 4.2 before overwintering, while at the same sowing date after sunflower, this indicator was 27.3 % lower and amounted to 3.3 (Table 3).

A similar dependence was observed at other sowing dates for both varieties. It should also be noted that the Stoir variety was formed a greater number of tillers compared to the Pamiat Khudoierka variety. According to the results of the research, predecessors had a significant influence on the rate of aboveground mass accu-

Table 3. Characteristics of winter rye development in the autumn growing season depending on growing conditions (average for 2018–2020)

Sowing dates	Variety	Predecessors	
		spring barley	sunflower
Plant tillering coefficient			
5–10 September	Pamiat Khudoierka	4.3	3.6
	Stoir	4.5	3.7
20–25 September	Pamiat Khudoierka	4.1	3.2
	Stoir	4.2	3.3
5–10 October	Pamiat Khudoierka	2.8	2.3
	Stoir	2.9	2.4
Absolute dry weight of 100 plants, g			
5–10 September	Pamiat Khudoierka	37.4	29.5
	Stoir	38.2	29.9
20–25 September	Pamiat Khudoierka	32.5	25.9
	Stoir	33.3	26.7
5–10 October	Pamiat Khudoierka	21.6	16.3
	Stoir	22.2	16.8

mulation by rye plants, since they had the greatest impact on the soil nutrient status and the moisture supply of plants. Thus, at sowing on 20–25 September after spring barley, the absolutely dry weight per 100 winter rye plants of Stoir variety at the end of the autumn growing season was 24.7 % higher than after sunflower and amounted to 33.3 g.

It should be noted that the predecessors significantly influenced the accumulation of aboveground mass by plants during the spring-summer growing season. Higher values of this indicator were observed in winter rye varieties

after stubble predecessor, and relatively lower values – after sunflower. Thus, in the heading phase, the maximum absolute dry weight of 100 winter rye plants (797.3 g) were observed in the Stoir variety, which was grown after spring barley and sown in early terms (September 5–10) and fertilised with nitrogen (N₄₅) on frozen-thawed soil. For comparison, the absolutely dry weight of 100 winter rye plants of this variety after sunflower under similar conditions was 10.7 % less, and at sowing on 20–25 September this difference was 10.3 %, on 5–10 October – 14 % (Table 4).

Table 4. Characteristics of winter rye development in the spring and summer growing season (average for 2019–2021)

Sowing dates	Predecessor	Variety*	Absolute dry weight of 100 plants in heading stage, g		Plant height at full grain ripeness, cm	
			control (without feeding)	N ₄₅ on frozen-thawed soil	control (without feeding)	N ₄₅ on frozen-thawed soil
5–10 September	spring barley	1	702.3	773.2	122.7	126.9
		2	711.4	797.3	124.5	128.4
	sunflower	1	690.2	711.5	119.8	123.0
		2	699.5	720.4	120.5	124.2
20–25 September	spring barley	1	627.4	651.7	120.6	123.5
		2	638.0	662.5	121.4	125.8
	sunflower	1	561.2	594.1	116.7	121.7
		2	578.5	600.5	117.4	122.4
5–10 October	spring barley	1	467.6	480.3	117.1	120.8
		2	473.1	498.2	118.2	121.4
	sunflower	1	407.1	429.1	115.3	119.1
		2	412.3	437.2	116.0	120.2

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

Note that in the trials without fertilisation, for Stoir variety sown in early September, this difference was 1.7 %, on 20–25 September – 10.3 %, and on 5–10 October – 14.7 %. The absolutely dry weight of 100 winter rye plants of Pamiat Khudoierka variety sown after spring barley was higher than after sunflower by 1.8, 11.8 and 14.9 %, respectively.

We also found out the influence of predecessors on plant height depending on growing conditions. The winter rye plants, growing after spring barley, were generally taller than those sown after sunflower. For example, in the control variant of the trial, without nitrogen fertilisation, this difference was 1.8–4.0 cm depending on the sowing date, and 1.2–4.2 cm in the plots with N₄₅ applied to the frozen-thawed soil.

At the stage of full grain ripeness, the highest height was in winter rye plants at early sowing, with nitrogen fertilisation of crops. In these plots, the plant height of Stoir variety was 128.4 cm, and the plant height of Pamiat

Khudoierka variety was 126.9 cm. At the same time, due to early spring nitrogen fertilisation, the minimum plant height of these varieties was observed in the plots at late sowing dates and was 120.2 and 119.1 cm, respectively.

According to the results of the research, a significant influence of predecessors on the winter rye yield was found. In particular, the crop cultivation after the stubble predecessor ensured the formation of higher grain crop yield compared to the crops sown after sunflower. Under such conditions, the maximum yield was provided by Stoir variety, which was sown from 20 to 25 September. At the same time, on average over the years of research, a higher yield was observed in variants with nitrogen fertilisation on frozen-thawed soil (N₄₅): on crops after spring barley – 6.47 t/ha, after sunflower – 5.03 t/ha. The Pamiat Khudoierka variety also provided the highest yield in the indicated variants of the experiment – 6.17 and 4.72 t/ha, respectively (Table 5).

Increase of 11.2 % in winter rye yield of

Table 5. Yield of different varieties of winter rye depending on the growing conditions (t/ha) (average for 2019–2021)

Sowing dates (factor B)	Variety (factor C)	Yield, t/ha	
		plant nutrition level (factor D)	
		control (without feeding)	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, for: predecessor (factor A) – 0.11–0.13; sowing dates (factor B) – 0.09–0.11; varieties (factor C) – 0.10–0.12; plant nutrition level (factor D) – 0.12–0.15; interactions of 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			

Stoir variety grown after spring barley and 39.7 % – after sunflower confirms the effectiveness of fertilisation of winter rye crops at the optimal sowing date (20–25 September), compared to the variants without fertilisation in early spring, and only background fertiliser was applied, which was provided for by the

experimental scheme.

Our experimental data indicate that winter rye plants grown after sunflower had a significant deficit of agronomically valuable moisture required at almost all development stages, which undoubtedly affected the overall yield level, which was significantly lower than

that of winter crops grown after spring barley.

Conclusions

The results of the research have shown that the difference between the predecessors of winter rye such as spring barley and sunflower lies in different conditions for germination and plant development in the autumn and spring-summer growing seasons, which affected their productivity and the quantitative indicators of yield. Sowing winter crops after spring barley had a positive effect on the formation of bio-

metric parameters of plants during the entire growing season and resulted in a higher grain yield of winter rye after stubble predecessor than after sunflower.

Generally, sowing winter rye after spring barley and sunflower in the most optimal terms, namely 20–25 September, and the application of nitrogen fertiliser at the rate of 45 kg a.i./ha in early spring, provided the highest yield of Stoir variety, which was 6.47 and 5.03 t/ha, depending on the predecessor.

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Безсусідня Ю. В. Ефективність попередників при вирощуванні жита озимого (*Secale Cereale* L.) в умовах Північного Степу України. *Зернові культури*. 2022. 6 (2). 111–116.

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Актуальність. Визначення впливу попередників на рівень зернової продуктивності сучасних сортів жита озимого залежно від строків сівби та мінерального живлення є доволі актуальним, оскільки дозволяє у більш повній мірі розкрити біологічний потенціал рослин, суттєво підвищити врожайність цієї зернової культури в зоні Північного Степу України. **Мета** наших досліджень полягала у вивченні особливостей формування зернової продуктивності 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 проводили на базі дослідного господарства «Дніпро» ДУ ІЗК НААН в польовому чотирьохфакторному досліді впродовж 2018–2021 рр. Сорти жита озимого Пам'ять Худоєрка та Стоір висівали по попередниках ячмінь ярий та соняшник у три строки: ранній (5–10 вересня), оптимальний (20–25 вересня) та пізній (5–10 жовтня) на фоні різного рівня мінерального живлення рослин. **Результати.** За результатами досліджень встановлено вагомий вплив попередників на урожайність жита озимого. Максимальний рівень врожайності було одержано за вирощування сорту Стоір, сівба якого проводилася в період з 20 по 25 вересня. При цьому, в середньому за роки досліджень, найбільшу врожайність відмічали у варіантах із проведенням азотного підживлення рослин по мерзлоталому ґрунту: на посівах після ячменю ярого – 6,47 т/га, після соняшнику – 5,03 т/га. Сорт Пам'ять Худоєрка найвищий рівень врожайності також забезпечував у зазначених варіантах дослідів – 6,17 та 4,72 т/га відповідно. Разом з тим, різниця в урожайності між сортами, якщо брати до уваги максимальні величини даного показника, залежно від попередників становила відповідно 0,30 і 0,31 т/га. **Висновки.** 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.

Ключові слова: жито озиме, попередники, сорти, строки сівби, підживлення посівів, урожайність