

PREDECESSOR IS THE BASIS FOR HIGH-YIELDING WITH GOOD TECHNOLOGICAL QUALITIES OF SPRING SOFT WHEAT GRAIN IN THE NORTHERN FOREST-STEPPE OF VOLGA REGION

© 2026 Serzhanov I. M. ✉, Shaykhutdinov F. Sh., Garaev R. I., Serzhanova A. R.,
Nogumanov I. Z.

*Kazan State Agrarian University
(Kazan, Russian Federation)*

✉ igor.serzhanov@mail.ru

Abstract. The study was conducted to identify the response of spring wheat to various precursors in gray forest and chernozem soils of the northern forest-steppe of Volga region, with the aim of improving the region's farming system. The work was carried out from 2018 to 2022 on gray forest soils and leached chernozems. Experimental scheme involved studying the following predecessors: corn, potatoes, sugar beets, peas, barley, a second crop of spring wheat (control) and winter rye after peas. In anticipation of obtaining the planned yield of 3 t/ha of wheat grain, mineral fertilizers were applied before sowing at doses depending on the predecessor ($N_{57...69}P_{21...39}K_{19...56}$). The highest yield of the cultivated crop was observed after peas; on average, the increase over five years compared to the control was equal to 1.01 t/ha. When spring wheat was planted after potatoes on gray forest soils, it was 0.97 t/ha, corn for silage – 0.80, winter rye – 0.78 t/ha. In chernozem soil of Volga region, the yield increase after peas was 1.21 t/ha, after corn for silage – 1.15, after sugar beet – 1.06, and after winter rye – 0.83 t/ha. On gray forest soil, grain grown after peas showed the best yield in terms of key quality indicators, followed by corn for silage and potatoes. When spring wheat was planted after peas, grain vitreousness increased by 13.1%, protein content by 0.9% and gluten by 5.8% compared to the control. On chernozem soil, grain vitreousness increased by 18.5% after peas, while protein and gluten content increased by 0.3% and 3.9%, respectively, after corn.

Key words: predecessor crops, spring wheat (*Triticum aestivum* L.), yield, soil, grain quality.

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ПРЕДШЕСТВЕННИК – ОСНОВА ФОРМИРОВАНИЯ ВЫСОКОГО УРОЖАЯ С ХОРОШИМИ ТЕХНОЛОГИЧЕСКИМИ КАЧЕСТВАМИ ЗЕРНА ЯРОВОЙ МЯГКОЙ ПШЕНИЦЫ В СЕВЕРНОЙ ЧАСТИ ЛЕСОСТЕПИ ПОВОЛЖЬЯ

© 2026 Сержанов И. М. ✉, Шайхутдинов Ф. Ш., Гараев Р. И., Сержанова А. Р.,
Ногуманов И. З.

*Казанский государственный аграрный университет
(г. Казань, Российская Федерация)*

✉ igor.serzhanov@mail.ru

Реферат. Исследования проводили с целью выявления реакции яровой пшеницы на различные предшественники в условиях серых лесных и черноземных почв северной части лесостепи Поволжья для совершенствования системы земледелия региона. Работу выполняли в 2018–2022 годах на серых лесных почвах и выщелоченных черноземах. Схема опыта предполагала изучение следующих предшественников: кукуруза, картофель, сахарная свекла, горох, ячмень, повторный посев яровой пшеницы (контроль) и озимая рожь после гороха. В расчете на получение запланированного урожая 3 т/га зерна пшеницы до посева вносили минеральные удобрения в дозах, в зависимости от предшественника, $N_{57...69}P_{21...39}K_{19...56}$). Наибольшую урожайность выращиваемой культуры отмечали после гороха, в среднем за пять лет прибавка к контролю была равна 1,01 т/га. При размещении яровой пшеницы после картофеля на серых лесных почвах она составила 0,97 т/га, кукурузы на силос – 0,80, озимой ржи – 0,78 т/га. В условиях черноземных почв Предволжья прибавка после гороха составила 1,21 т/га, кукурузы на силос – 1,15, сахарной свеклы – 1,06, озимой ржи – 0,83 т/га. На серой лесной почве лучшим по основным показателям качества было зерно, выращенное по гороху, далее следовали кукуруза на силос и картофель. Стекловидность зерна при размещении яровой пшеницы по гороху увеличивалось, по сравнению с контролем, на 13,1 %, содержание белка – на 0,9%, клейковина – на 5,8%. На черноземной почве повышение стекловидности на 18,5% отмечали после гороха, содержания белка и клейковины (соответственно на 0,3% и 3,9%) – после кукурузы.

Ключевые слова: предшественники, яровая пшеница (*Triticum aestivum* L.), урожай, почва, качество зерна.

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Introduction. Spring wheat is a leading food crop. Annually 23-25% of arable land of the Republic of Tatarstan is allocated to its cultivation. Spring wheat grain production has increased significantly as a result of major measures to implement government agricultural decisions, the gross grain harvest amounted to 2.5 million tons [1, 2, 3].

In recent years (2018-2022) the average yield of this valuable crop increased by 0.63 t/ha, reaching 2.63 t/ha in the Republic of Tatarstan [4, 5, 6].

In 2023-2024, despite dry weather conditions, an average of 2.53 t/ha of spring wheat grain was harvested [7, 8, 9].

Many researchers recommend planting spring wheat after good predecessors, particularly row crops and peas [10, 11].

A significant number of scientific papers have been devoted to the issue of spring wheat predecessors. However, this issue remains relevant in recent years [12, 13, 14].

According to some researchers, spring wheat should be planted after such predecessors as alfalfa and silage corn [15, 16, 17].

The aim of this study was to identify the response of spring wheat to various predecessors in the gray forest and chernozem soil of northern Volga forest-steppe region to improve the region's farming systems.

Conditions, materials and methods. Work was carried out in 2018-2022 on various soil types in the Republic of Tatarstan: gray forest soil (Predkamye (Cis-Kama region)) and leached chernozem (Predvolzhye (Cis-Volga region)). Field and laboratory research was conducted at Agrobiotechnopark of Kazan State Agrarian University, where gray forest soil in the 0-20 cm layer had a near-neutral pH (pHsol. – 6.5), was characterized by an average humus content of 3.4–3.6% (according to Tyurin), a high supply of mobile phosphorus (210-250 mg/kg according to Kirsanov) and an increased supply of mobile potassium (123-169 mg/kg of soil).

Agrochemical characteristics of leached chernozem at Avangard LLC, where the experiments were conducted, were as follows: humus content in the arable soil layer (0...30 cm) - 7.0...8.1% (according to Tyurin), available phosphorus - 180...242, available potassium - 153...187 mg/kg (according to Kirsanov), pHsol - 5.7...5.8 units.

Experimental studies were conducted using the following scheme to identify the specific effect of precursors and their impact on spring wheat: re-seeding of spring wheat (control); winter rye after occupied fallow (peas); barley; corn for silage; peas; potatoes; sugar beet. The experiment was replicated 4 times with a systematic arrangement of variants. The plot area was 60 m².

Spring wheat cultivation practices are

generally accepted according to the zonal farming system of the Republic of Tatarstan. Nutrient background of N_{57...69}P_{21...39}K_{19...56} was applied before sowing in the form of ammophoska, ammonium nitrate and potassium salt (calculated doses for 3 tons of grain per 1 ha for spring wheat).

Spring wheat of Burlak variety was bred domestically (originated by Ulyanovsk Research Institute of Agriculture). Field trials, observations, evaluation and records were conducted in accordance with the guidelines of B.A. Dospekhov [18]. Phenological observations of growth and development, yield records and other related studies were conducted according to State Variety Testing methodology [19]. Crop structure was assessed using test sheaves taken from 0.33 m² plots (in three locations within the plot, in four replicates).

Spring wheat grain yield was determined by plot threshing, followed by conversion to standard moisture content (14%) and absolute purity (100%).

Technological qualities of grain were determined in accordance with current State standards (GOST): grain weight – according to GOST 10840.64 (drop weight threshing); grain vitreousness – according to GOST 10987-86; grain protein content – according to GOST 10846-91; and grain gluten content – according to GOST R 544478-2011.

Harvesting was carried out at the full grain maturity stage using a combine harvester.

Weather data during the experiments were based on indicators of meteorological stations from Laishevskiy and Buinskiy districts of the Republic of Tatarstan. The beginning of spring wheat growing season (May) in the years of study, with the exception of 2022, was accompanied by dry weather on both soil types. This phenomenon is not uncommon for Cis-Kama and Cis-Volga regions of the Republic. 21.8-24.0 mm of precipitation fell in May 2018, which is 55.9-60.5% of the norm, in June - 34.4-37.6 mm (60.7-70.5%) and in total for the growing season - 112-134 mm. The hydrothermal coefficient (HTC) for the growing season was 0.82-0.94. Precipitation in May and June in total in 2019 amounted to only 58-61% of the norm. In July, the amount of precipitation was 49.8-52.0 mm or 83-87% of the norm. The hydrothermal coefficient for the growing season is 0.96...0.99. The beginning of May 2020 was characterized by high temperatures, exceeding the average values by 3.2...4.1°C. Precipitation in May amounted to 27.0...24.3 mm or 79...72% of the norm, in June - 29.0...33.6 mm (51.0...56.0% of the average values), the hydrothermal coefficient is 0.87...0.91. Agrometeorological data for 2021 were extreme due to high

temperatures and insignificant amounts of precipitation, both in May and June – 15.0...18.0 mm (36.5...38.5%) and 9...19 mm (15.0...31.0% of the norm). The hydrothermal coefficient for the growing season is 0.29...0.36. At the beginning of 2022 growing season favorable conditions for a high spring wheat yield were achieved. Precipitation in May ranged from 78 to 62 mm (190.2 to 165.0% of the norm), while in June it ranged from 19 to 28 mm, or 30.1 to 45.0% of the average.

Overall, in the five study years, with the

exception of 2022, moisture availability in Cis-Kama and Cis-Volga regions of the Republic of Tatarstan was below the long-term average, indicating a consistent trend of decreasing precipitation during the first half of spring wheat growing season in recent years.

Statistical analysis of the study results was performed using analysis of variance [18].

Results and discussion. Predecessors, while exerting a certain influence on soil fertility factors, ultimately impacted spring wheat productivity (table 1).

Table 1 – Grain yield of spring wheat of Burlak variety depending on predecessors (average for 2018-2022)

Таблица 1 – Урожай зерна яровой пшеницы сорта Бурлак в зависимости от предшественников (среднее за 2018–2022 годы)

Predecessor	Gray forest soil		Leached chernozem	
	yield, t/ha	increase over control, %	yield, t/ha	increase over control, %
Silage corn	2.78	40.4	3.40	51.1
Potatoes	2.95	49.0	-	-
Sugar beet	-	-	3.31	47.1
Peas	2.99	51.0	3.46	53.8
Barley	2.23	12.6	2.60	15.6
Spring wheat (control)	1.98	-	2.25	-
Rye after peas	2.76	39.4	3.08	36.9
HCP ₀₅	0.5		0.2	

The average spring wheat yield for 2018-2022 on gray forest soil was: peas – 2.99 t/ha, exceeding the control by 1.01 t, and potatoes – 2.95 t/ha, an increase over the control by 0.97 t. Peas and potatoes proved to be the best precursors on gray forest soil, providing yield increases of 49.0-51.0% relative to the control.

Overall wheat yield is significantly higher on leached chernozem. However, peas even proved to be the best predecessor, providing an additional 1.20 tons of wheat grain per hectare compared to the control. Spring wheat responded well to corn and sugar beets, increasing the productivity by 47.1–51.1% compared to the control, in the western Volga regions of the republic. The importance of peas as the best predecessor for spring wheat is noted in the scientific works of A. A. Ziganshin, 2001 [20]. The content of available nitrogen in the soil increases after growing peas and other leguminous crops due to their ability to enter into

symbiotic relationships with nodule bacteria of *Rhizobium* genus. Peas are capable of assimilating up to 55% of its nitrogen requirements from the air under conditions that ensure active nitrogen fixation. The peculiarity of mineral nutrition of peas is that by flowering, plants absorb 46-50% of the total nitrogen input during the growing season, reducing soil nitrogen depletion. The amount of readily hydrolyzable nitrogen increases, improving the agrophysical condition of soil, ultimately creating favorable conditions for plant growth and development. Results from determining the yield structure show that the increase in wheat grain yield from peas and row crops is due to higher ear grain content and increased 1.000-kernel weight.

Spring wheat produces grain with high technological qualities with good agricultural practices. Grain quality varied significantly depending on the preceding crops (table 2).

Table 2 – Effect of predecessors on technological quality of spring wheat grain (2018–2022)

Таблица 2 – Влияние предшественников на технологические качества зерна яровой пшеницы (2018–2022 годы)

Predecessor	Gray forest soil			Leached chernozem		
	vitreousness, %	protein content, %	gluten, %	vitreousness, %	protein content, %	gluten, %
Silage corn	51.5	13.5	22.2	52.0	13.3	25.2
Potatoes	46.2	12.8	22.8	-	-	-
Sugar beet	-	-	-	46.0	13.1	22.1
Peas	53.9	13.5	23.4	59.6	13.2	22.9
Barley	33.9	12.6	20.5	41.5	13.0	22.0
Spring wheat (control)	40.8	12.6	17.6	41.1	13.0	21.3
Rye after peas	48.0	12.1	21.0	50.7	13.1	22.3
HCP ₀₅	0.2	0.2	0.1	0.9	0.4	0.4

On average, over 5 years on gray forest soil, wheat grown after peas and row crops demonstrated the best grain quality across key parameters. The increase, compared to the control, after peas in vitreousness was 13.1%, protein content – 0.9%, gluten – 5.8%. On leached chernozem, peas also proved to be the best precursor for spring wheat. The vitreousness index was 18.5% higher than the control variant, and the protein content was 0.2% and gluten content was 0.8%. After corn, the excess over the control in vitreousness was 10.5%, protein – 0.3% and gluten – 3.9%.

Conclusions. The best predecessors to spring wheat in crop rotation, providing higher yield increases, are peas (1.01 t/ha) and potatoes (0.97 t/ha) on gray forest soil, and peas (1.20 t/ha), corn (1.15 t/ha) and sugar beet (1.06 t/ha) on leached chernozem.

On both soil types, predecessors such as peas and row crops significantly improved spring wheat grain quality compared to the control (repeat sowing of spring wheat): grain vitreousness by 10.7-18.5%, protein content by 0.2-0.9% and gluten content by 1.6-5.8%.

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Authors:

Serzhanov Igor Mikhailovich – Doctor of Agricultural Sciences, Professor of Plant Growing and Horticulture Department, Director of Institute of Agrobiotechnology and Land Management Kazan State Agrarian University (65 Karl Marx Street, Kazan, 420015, Russian Federation), e-mail: igor.serzhanov@mail.ru, ORCID 0000-0003-1758-0622

Shaykhutdinov Farit Sharipovich – Doctor of Agricultural Sciences, Professor of Plant Growing and Horticulture Department Kazan State Agrarian University (65 Karl Marx Street, Kazan, 420015, Russian Federation), e-mail: faritshay@kazgau.com, ORCID 0009-0006-1423-4846

Garaev Razil Ilisurovich – Ph.D. of Agricultural Sciences, Associate Professor of Plant Growing and Horticulture Department Kazan State Agrarian University (65 Karl Marx Street, Kazan, 420015, Russian Federation), e-mail: rass112@mail.ru, ORCID 0009-0004-7774-6553

Serzhanova Albina Rafailevna – Ph.D. of Agricultural Sciences, Associate Professor of Agrochemistry and Soil Science Department Kazan State Agrarian University (65 Karl Marx Street, Kazan, 420015, Russian Federation), e-mail: serzhanovaalbina@mail.ru, ORCID 0009-0001-7468-5423

Nogumanov Ilyas Zakhitovich – post-graduate student Kazan State Agrarian University (65 Karl Marx Street, Kazan, 420015, Russian Federation), e-mail: zakhitovich99@mail.ru

Contribution of the authors:

I.M. Serzhanov – Validation, Curation of data, Writing – review and editing, Scientific supervision;
F.Sh. Shaykhutdinov – Conceptualization, Methodology, Writing – initial draft of the text, Visualization, Project management;

R.I. Garaev – Field and laboratory research, Data collection and processing;

A.R. Serzhanova – Review of literary sources, Data collection, Methodological testing;

I.Z. Nogumanov – Field and laboratory research, Data collection and processing.

The authors have reviewed and approved the final manuscript.

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Сведения об авторах:

Сержанов Игорь Михайлович – доктор сельскохозяйственных наук, профессор кафедры растениеводства и плодовоовощеводства, директор Института агробиотехнологии и землепользования Казанского государственного аграрного университета (420015, Российская Федерация, г. Казань, ул. Карла Маркса, 65), e-mail: igor.serzhanov@mail.ru, ORCID 0000-0003-1758-0622

Шайхутдинов Фарит Шарипович – доктор сельскохозяйственных наук, профессор кафедры растениеводства и плодовоовощеводства Казанского государственного аграрного университета (420015, Российская Федерация, г. Казань, ул. Карла Маркса, 65), e-mail: faritshay@kazgau.com, ORCID 0009-0006-1423-4846

Гараев Разиль Ильсурович – кандидат сельскохозяйственных наук, доцент кафедры растениеводства и плодовоовощеводства Казанского государственного аграрного университета (420015, Российская Федерация, г. Казань, ул. Карла Маркса, 65), e-mail: rass112@mail.ru, ORCID 0009-0004-7774-6553

Сержанова Альбина Рафаиловна – кандидат сельскохозяйственных наук, доцент кафедры агрохимии и почвоведения Казанского государственного аграрного университета (420015, Российская Федерация, г. Казань, ул. Карла Маркса, 65), e-mail: serzhanovaalbina@mail.ru, ORCID 0009-0001-7468-5423

Ногуманов Ильяс Захитович – аспирант кафедры растениеводства и плодовоовощеводства Казанского государственного аграрного университета (420015, Российская Федерация, г. Казань, ул. Карла Маркса, 65), e-mail: zakhitovich99@mail.ru

Вклад авторов:

I.M. Serzhanov – валидация, курирование данных, написание – рецензирование и редактирование, научное руководство;

F.Sh. Шайхутдинов – концептуализация, методология, написание – первоначальный вариант текста, визуализация, управление проектом;

R.I. Garaev – проведение полевых и лабораторных исследований, сбор и обработка данных;

A.R. Сержанова – анализ литературных источников, сбор данных, апробация методик;

I.Z. Ногуманов – проведение полевых и лабораторных исследований, сбор и обработка данных.

Все авторы ознакомились и одобрили окончательный вариант рукописи.

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