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Winter Wheat Yields Depending on Preceding Crops in the Right-Bank Forest-Steppe of Ukraine

Abstract. The article presents the results of research on the specifics of winter wheat yield formation depending on preceding crops. It was established that in the Right-Bank Forest-Steppe, according to the ability to provide winter wheat during the sowing period (0-10 cm soil layer) with available moisture, the preceding crops were arranged as follows: peas – winter rape – sunflower – soybeans – corn for silage. At the time of sowing winter wheat, sufficient reserves of available moisture in the 0-10 cm soil layer were established after peas and winter rape, respectively, 11.5 and 10.9 mm. Soybeans and corn for silage, as predecessors, did not provide sufficient moisture reserves for sowing winter wheat in both the 0-10 cm and 0-30 cm soil layers. The highest yield of winter wheat in 2019-2021 averaged 5.68 t/ha, achieved by planting it after peas. The use of winter rape and soybeans as a precursor reduced its yield by 4.40 and 5.40%, respectively, which in absolute terms amounted to 0.25 and 0.31 t/ha. When winter wheat was cultivated after corn for silage and sunflower, the crop yield decreased by 0.48 and 0.67 t/ha, respectively. The highest quality indices of winter wheat grain – protein content of 13.1 and 13.3% and gluten content of 25.2 and 25.5% – were obtained when it was placed after legumes (peas and soybeans). Winter rape, as a predecessor, provided grain quality indices of 13.0% protein and 24.5%

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gluten. When sown after sunflower and corn for silage, the protein content of winter wheat grain was 12.6% and 12.8%, respectively, and the gluten content was 24.0% and 24.1%

Keywords: winter wheat, predecessor, available moisture reserves, yield

RELEVANCE

The current state of Ukraine's economy demonstrates that the share of agricultural production in its structure is 15-18%, and in the case of state support, it can increase to 25% (Kernes, 2020; Marenych M *et al.*, 2020). The main task of agricultural production is ensuring the food security of the state, which depends to a large extent on the level and growth rate of grain production (Yermolaev *et al.*, 2011; Tanchyk & Babenko, 2015; Petrychenko & Korniychuk, 2018). Winter wheat is ranked among the most valuable grain crops in terms of its high food value. In global agriculture, it is one of the three strategically important agri-food crops (wheat, rice, and corn). Therefore, global food security depends on the state of development of wheat production (Kernes, 2020). The potential of modern adaptive technologies for growing winter wheat is 30-50% increase in its yield from the current level. However, the main obstacle to the growth of wheat production may be climate change, which will result in a deterioration in the moisture supply. Given that moisture reserves determine the agrochemical, agrophysical and biological properties of the soil, they are crucial for plant growth and development, as well as the formation of crop structure elements. One of the determining factors in the formation of the water regime of the soil in winter wheat crops is the optimisation of its placement in crop rotation after various predecessors. The relevance of this issue determined the chosen research topic.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

Achieving the potential productivity level of modern varieties is possible by optimising the placement of crops in the crop rotation after the best preceding crop. This is determined by a number of factors, including the quantity and quality of plant residues left by the crop on the field, the type of root system and its penetration depth, water consumption, impact on phytosanitary conditions, harvesting time, etc. The issue of forming optimal reserves of available moisture in the soil, both at the time of sowing and during the growing season, is particularly acute in the context of climate change (Yeshchenko, 2014; Gamayunova *et al.*, 2016; Panfilova *et al.*, 2019; Petrychenko *et al.*, 2021).

The productivity of winter wheat reaches 50-60% in the autumn period, during which it is important to provide the crop with all the necessary vital factors (moisture, nutrients, heat) in the optimal amount and optimal proportions, which largely depends on the preceding crop (Davydenko, 2012; Tanchyk *et al.*, 2015; Gamayunova *et al.*, 2016). Therefore, sowing after the best preceding crops, namely clean (low moisture zone) and occupied fallow (perennial legumes on one mowing, peas, vetch-oat mixtures) is crucial for the placement of winter cereals (Buzynnyi, 2015; Gamayunova et al, 2019; Andrii Siroshtan *et al.*, 2021). However, the current structure of sown areas shows that the main areas (approximately 80%) of winter cereals in Ukraine are planted after non-pair crops: soybeans, winter and spring rape, corn for silage, buckwheat, cereals, and sunflower. These crops do not provide optimal conditions for the growth and development of winter wheat, which leads to a decrease in available soil moisture, deterioration of nutritional and phytosanitary conditions, and, as a result, a decrease in yield. Therefore, the issue

of placing winter wheat in the crop rotation after the most effective predecessors is relevant.

The purpose of the research is to identify the impact of preceding crops on the formation of winter wheat productivity in the Right-Bank Forest-Steppe of Ukraine.

MATERIALS AND METHODS

The field research was carried out in a stationary field experiment of the Educational and Scientific Innovation Center of Agrotechnologies of LLC "Agrofirma Kolos" in Pustovarivka, Skvyra district, Kyiv region, during 2019-2021. The studied soil is a typical deep, coarse-dusty, medium loamy chernozem with a humus content of 4.5%, hydrolyzednitrogen–184mg/kg,mobilephosphorus – 233 mg/kg, mobile potassium – 95 mg/kg, pH_{KCl} 6.5, and the number of absorbed bases – 85-99%. By its composition and properties, the soil is perfectly suitable for growing all crops recommended for this zone. The experiment included the study of the influence of predecessors for the cultivation of winter wheat: 1. pea (control); 2. winter rape; 3. soybean; 4. sunflower; 5. corn for silage. The size of the sowing plot was 250 m^2, the accounting plot was 180 m^2, the replication of the experiment was four times, and the location of the plots was randomised. Main tillage for wheat (ploughing to a depth of 20-22 cm). The content of available moisture in the soil was determined by the thermostatic-weight method according to DSTU ISO 16586:2005. The harvest was calculated by direct combine harvesting. Crop quality indices were determined by infrared spectroscopy using an infrared analyser NIR Systems 4500 in accordance with DSTU 4117: 2007 Grain and products of its processing.

RESULTS AND DISCUSSION

One of the main criteria for plant growth and development is sufficient soil moisture. Placing winter wheat after various crops rotation creates unequal conditions for its growth and development, primarily due to the different amounts of moisture they leave behind. The research results revealed that the preceding crops had a significant impact on the soil moisture reserves both at the time of sowing winter wheat and during its vegetation. It was found that at the time of sowing, sufficient moisture reserves in the 0-10 cm soil layer were formed when winter wheat was sown after peas and winter rape, respectively, 11.5 and 10.9 mm (Fig.).

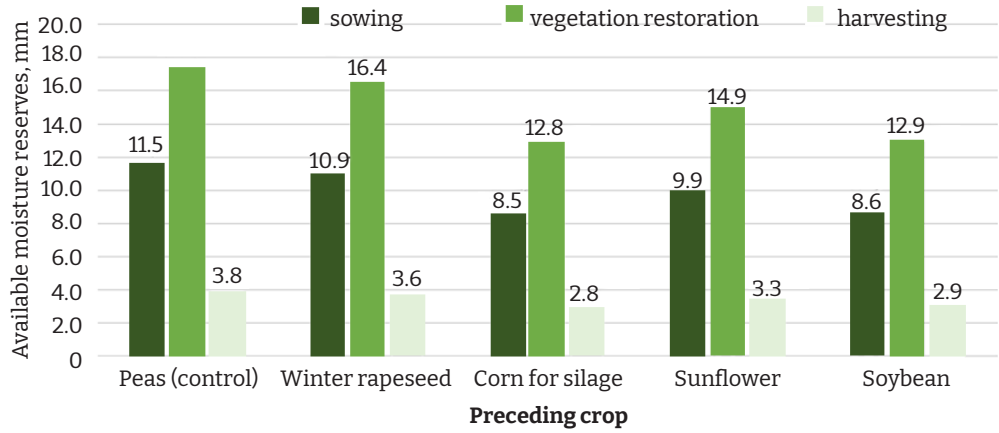

Figure 1. Available moisture reserves in the 0-10 cm soil layer in winter wheat crops depending on the preceding crops in rotation (average for 2019-2021)

Note: LSD_{05} (sowing) = 1.0; LSD_{05} (vegetation restoration) = 1.8; LSD_{05} (harvesting) = 0.8;

It is worth noting that after sunflower, the average moisture reserves in the 0-10 cm soil layer in 2019-2021 were 9.9 mm. And after soybeans and corn for silage, the reserves of available moisture were equivalent and the lowest compared to the studied predecessors, respectively, 8.5 and 8.6 mm. Analysis of the moisture reserves in the one-meter soil layer shows that the difference between the studied preceding crops and the control only increased (Table 1).

Table 1. Available moisture content in the soil by various crops in rotation preceding winter wheat crops, the average for 2019-2021, mm

Preceding Crop	Soil layer, cm	Moisture reserves, mm		
		sowing	restoration of vegetation	harvesting
Peas (control)	0-30	27.4	41.1	9.1
	0-100	150.7	177.8	50.2
Winter rapeseed	0-30	24.8	37.2	8.3
	0-100	94.6	160.8	47.3
Soybean	0-30	21.6	32.4	7.2
	0-100	84.1	155.6	42.1
Sunflower	0-30	25.5	38.3	8.5
	0-100	82.3	152.3	39.2
Corn for silage	0-30	18.2	27.3	6.1
	0-100	88.9	164.5	44.5
LSD_{05} (0-30cm) =		2.4	4.4	1.3
LSD_{05} (0-100cm) =		11.3	18.2	5.0

The highest reserves of available moisture were obtained after peas – 150.7 mm, after rapeseed they were 94.6 mm, and the lowest after sunflower – 82.3 mm, which can be explained by both the harvesting time of the preceding crop and biological characteristics of water consumption. Further monitoring of the available moisture content in the soil shows that even intense autumn and winter precipitation could not compensate for the moisture loss after such predecessors as soybean and sunflower.

In particular, after the winter wheat vegetation resumed, the highest moisture reserves in the one-meter soil layer were observed following peas and corn for silage (177.8 and 164.5 mm, respectively), and the lowest – following soybeans and sunflower (155.6 and 152.3 mm). During the spring and summer vegetation period, moisture reserves decreased by half. The maximum moisture retention in the soil both in the 0-10 cm layer and in the 0-100 cm layer was observed when winter wheat was grown after peas and winter rapeseed.

The yield of a crop is an integral indicator of the performance of its cultivation technology. According to the results of standard studies conducted in 2019-2021 on chernozem, winter wheat yielded the highest after peas (5.68 t/ha) (Fig. 2).

Sowing wheat after winter rape reduced its yield by 4.4%, which in absolute terms amounted to 5.43 t/ha. After soybeans, it amounted to 5.37, and sunflower – 5.20 t/ha. The lowest yield of the crop compared to the control variant (peas) was obtained following corn for silage, where it was 5.01 t/ha.

One of the main indicators of the quality of the product is the protein and gluten content of winter wheat grain. They show the value of the resulting products. It is worth noting that the protein and gluten content of winter wheat grain is not only a genetically determined indicator,

but can also vary depending on growing conditions and technological practices. In particular, the protein content, depending on technological factors, can range from 10-12 to 20-25%.

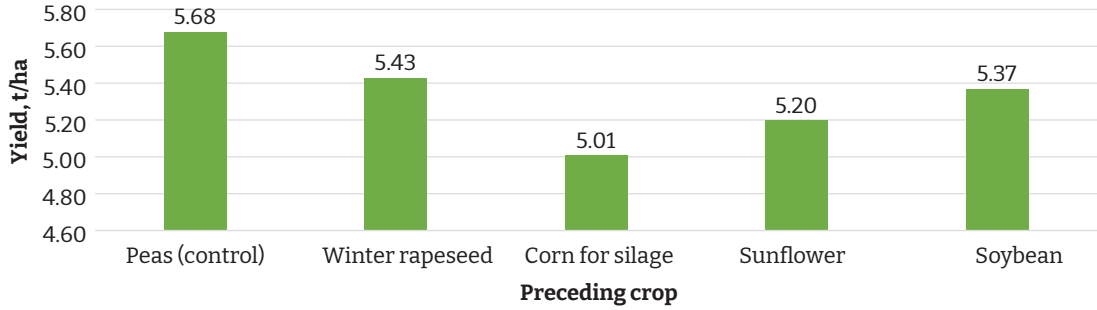

Figure 2. Winter wheat yields depending on preceding crops in rotation (the average for 2019-2021)
Note: LSD_{05} (sowing) = 1.0; LSD_{05} (vegetation restoration) = 1.8; LSD_{05} (harvesting) = 0.8;

The main part of the protein is made up of amino acids, of which lysine, tryptophan, methionine, phenylalanine, leucine, isoleucine, threonine, and valine are essential for humans, as they are not synthesised in the human body and must be supplied with food. It has been established that 400-500 g of wheat bread and bakery products cover about a third of a human's daily food needs, half of the carbohydrate needs, a third (40%) of complete proteins, 50-60% of B vitamins, and 80% of vitamin E. Wheat bread almost completely meets human needs for phosphorus and iron, and 40% of calcium. Based on the analysis, the average protein and gluten content in winter wheat grain varied from 12.6% to 13.3% and from 24.0% to 25.5%, respectively, depending on the predecessor (Fig. 3). The highest protein content (13.3%) of winter wheat grain was achieved through sowing it after peas. Rapeseed and soybeans, as predecessors, had an equivalent effect on the protein content of winter wheat grain (13.0-13.1%). The lowest protein content in winter wheat grain was obtained when placed after sunflower and corn for silage, 12.6% and 12.8%, respectively. In terms of gluten content, the general trend of the influence of precursors continued.

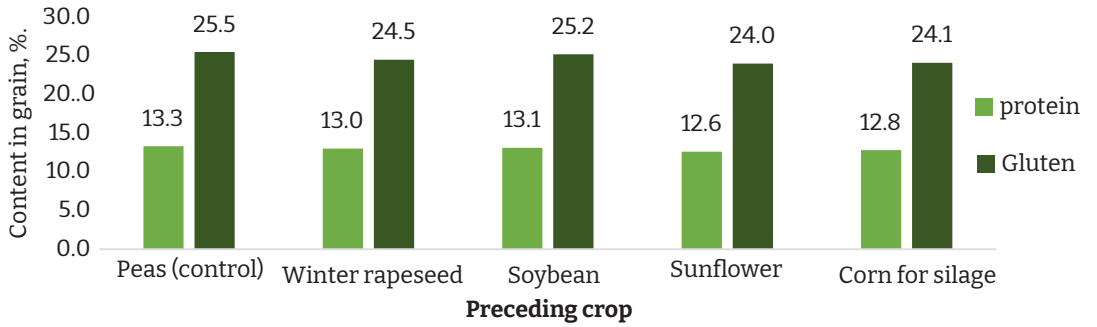

Figure 3. Protein and gluten content in winter wheat grain depending on the preceding crop in rotation (the average for 2019-2021)
Note: LSD_{05} = 0.4 (protein); LSD_{05} = 1.0 (gluten);

CONCLUSIONS

1. During the sowing period of winter wheat, the largest reserves of available moisture in the 0-10 cm soil layer were formed after peas (11.5 mm) and winter rapeseed (10.9 mm). When winter wheat was sown after soybeans and corn for silage, the available moisture reserves were minimal compared to other preceding crops and amounted to 8.6 and 8.5 mm, respectively.

2. In the Right-Bank Forest-Steppe of Ukraine on common chernozems, winter wheat produced the highest yield of 5.43-5.68 t/ha after peas and winter rapeseed. Soybeans, as a predecessor, provided a wheat yield of 5.37 t/ha. When sown after sunflower, the yield of wheat decreased by 8.4% compared to peas, and for corn for silage by 11.8%.

3. The highest values of the protein content of 13.1 and 13.3% and gluten content of 25.2 and 25.5% in winter wheat grain were obtained when sown after legumes (peas and soybeans). Winter rapeseed, as a predecessor, contributed to grain quality indices of 13.0% protein and 24.5% fat. When cultivated after sunflower and corn for silage, the protein content was 12.6% and 12.8%, and the gluten content was 24.0% and 24.1%.

REFERENCES

[1] Andrii Siroshtan, Valerii Kavunets, Oleksandr Derhachov, Serhii Pykalo, Liudmyla Ilchenk, Yield and Sowing Qualities of Winter Bread Wheat Seeds Depending on the Preceding Crops and Sowing Dates in the Forest-Steppe of Ukraine, American Journal of Agriculture and Forestry, 9(2), 2021, pp. 76-82. doi: 10.11648/j.ajaf.20210902.15

[2] Buzynnyy, M.V. (2015). Produktyvnist'' pshenytsi ozymoyi zalezhno vid poperednykiv. Zbirnyk naukovykh prats' NNTS "Instytut zemlerobstva NAAN". Vyp. 2, 106-116.

[3] Davydenko, H.A. (2012). Influence of preceding crops and fertilizers on agrochemical parameters of soil and productivity of winter wheat. Bulletin of Sumy National Agrarian University. Agronomy and Biology Series, 9(24), 37-39.

[4] Hamayunova Valentyna *et al.* Znachenye optymyzatsyy pytanyya v stabyl'nosty formyrovanyya urozhaynosty zernovykh kul'tur v zone yuha Ukrayny. Stiinta agricola, [S.l.], 2, 24-29, jan. 2019. ISSN 2587-3202.

[5] Hamayunova, V.V., Lytovchenko, A.A., & Muzyka, N.N. (2016). Produktyvnost' ozymykh zernovykh kul'tur pod vlyyanyem tekhnolohyy ykh vozdelyvanyya v uslovyyakh yuzhnoy Stepy Ukrayny. Vestnyk Prykaspyya, 3(14), 13-17.

[6] Hamayunova, V.V., Lytovchenko, A.O., & Muzyka, N.M. (2016). Znachennya poperednyka u formuvanni zernovoyi produktyvnosti ozymykh kul'tur v umovakh Stepu Ukrayiny. Visnyk ZHNEAU, 1(53), 80-87.

[7] Kernesyuk YU.V. Hlobal'nyy rynok pshenytsi: kon'yunktura i trendy. Ahrobiznes s'ohodni. Rezhym dostupu do statti: http://agro-business.com.ua/agro/ekonomichnyi-hektar/item/19645-hlobalnyi-rynok-pshenytsi-koniunktura-i-trendy.html.

[8] Marenych M., Kaminsky V.F., Bulygin C.Yu., Hanhur V.V., Korotkova I.V., Yurchenko S.O., Bahan, A.V., Taranenko S.V., & Liashenko V.V. (2020). Optimization of factors of managing productive processes of winter wheat in the Forest-Steppe. Agricultural Science and Practice, 7(2), 44-54. doi: 10.15407/agrisp7.02.

[9] Panfilova, A. V., Hamayunova, V.V., & Drobit'ko, A.V. (2019). Urozhaynist' pshenytsi ozymoyi zalezhno vid poperednyka ta biodestruktora sterni. Visnyk Poltavs'koyi derzhavnoyi ahrarnoyi akademiyi, (3), 18-25. doi: 10.31210/visnyk2019.03.02

[10] Petrychenko V.F., & Korniychuk O.V. (2018) Faktory stabilizatsiyi vyrobnytstva zerna pshenytsi ozymoyi v Lisostepu Pravoberezhnomu. Visnyk ahrarnoyi nauky. 2, 17-23.
[11] Petrychenko, V.F., Lykhochvor, V.V., Korniichuk, O.V. & Olifir, Y.M. (2021). The yield of winter wheat depending on sowing terms. Ukrainian Journal of Ecology Ukrainian Journal of Ecology, 11(3), 161-166, doi: 10.15421/2021_158
[12] Tanchyk S.P. & Babenko A.I. (2015) Produktyvnist' pshenytsi ozymoyi zalezhno vid poperednykiv u pravoberezhnomu lisostepu. Mizhvidomchyy tematychnyy naukovyy zbirnyk "Zemlerobstvo". K.: VP "Edel'veys" Vyp. 1, S. 19-22.
[13] Tanchyk S.P., & Palamarchuk O. M. (2014) Vplyv poperednykiv na urozhaynist' ta yakist' zerna pshenytsi ozymoyi na urozhaynist' v Pravoberezhnomu Lisostepu Ukrayiny: [elektronnyy resurs]. Naukovi dopovidi Natsional'noho universytetu bioresursiv i pryrodokorystuvannya Ukrayiny. 49. Rezhym dostupu do statti: http://nd.nubip.edu.ua/2014_7/17.pdf.
[14] Tanchyk, S.P., Pavlov, O.S., & Palamarchuk, O.M. (2015). Vplyv poperednykiv ta norm vysivu nasinnya na aktual'nu zabur'yanenist' i vrozhaynist' pshenytsi ozymoyi v Pravoberezhnomu Lisostepu Ukrayiny. Zbirnyk naukovykh prats' Instytutu bioenerhetychnykh kul'tur i tsukrovykh buryakiv. 2015. Vyp. 23. 133-139.
[15] Yermolayev M. M., Litvinov D. V., Yermolayeva T. M., ta in. (2011) Produktyvnist' pshenytsi ozymoyi u korotkorotatsiynykh sivozminakh na chornozemi typovomu. Mizhvidomchyy tematychnyy naukovyy zbirnyk "Zemlerobstvo". Vyp. 83. S. 17-21.
[16] Yeshchenko V.O. (2014). Mistse naukovo obhruntovanykh sivozmin u suchasnomu zemlerobstvi. Visnyk Umans'koho natsional'noho universytetu sadivnytstva, №2, s. 3-6.

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Урожайність озимої пшениці залежно від попередників у Правобережному Лісостепу України

Анотація. У статті наведено результати досліджень особливостей формування врожайності пшениці озимої залежно від попередників. Встановлено, що в Правобережному Лісостепу за здатністю забезпечувати пшеницю озиму в період сівби (0-10 см шар ґрунту) доступною вологою попередники розташовувалися таким чином: горох – ріпак озимий – соняшник – соя – кукурудза на силос. На момент сівби озимої пшениці достатні запаси доступної вологи в шарі ґрунту 0-10 см встановилися після гороху та озимого ріпаку, відповідно 11,5 та 10,9 мм. Соя та кукурудза на силос, як попередники, не забезпечили достатніх запасів вологи для посіву озимої пшениці як у шарі ґрунту 0-10 см, так і 0-30 см. Найвища врожайність озимої пшениці в 2019-2021 рр. в середньому 5,68 т/га була досягнута за сівби її після гороху. Використання в якості попередника озимого ріпаку та сої знижувало її врожайність на 4,40 та 5,40% відповідно, що в абсолютному вираженні становило 0,25 та 0,31 т/га. При вирощуванні озимої пшениці після кукурудзи на силос та соняшнику врожайність зменшилася на 0,48 та 0,67 т/га відповідно. Найвищі показники якості зерна озимої пшениці - вміст білка 13,1 і 13,3% та клейковини 25,2 і 25,5% – були отримані при розміщенні її після бобових культур (гороху та сої). Озимий ріпак, як попередник, забезпечив показники якості зерна на рівні 13,0% білка та 24,5% клейковини. При розміщенні після соняшнику та кукурудзи на силос вміст білка в зерні озимої пшениці становив 12,6% та 12,8% відповідно, а вміст клейковини - 24,0% та 24,1%

Ключові слова: пшениця озима, попередник, запаси доступної вологи, урожайність