

SCIENTIFIC HORIZONS

Journal homepage: <https://sciencehorizon.com.ua>

Scientific Horizons, 29(3), 9-19

UDC 631.559:633.34:631.81

DOI: 10.48077/scihor3.2026.09



Features of soybean cultivation under the soil and climatic conditions of Western Polissia, Ukraine

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Article's History:

Received: 14.05.2026

Revised: 02.09.2026

Accepted: 23.09.2026

Published: 02.10.2026

Abstract. The relevance of this study lies in identifying the optimal soybean maturity group for cultivation in Western Polissia under the current thermal conditions of the growing season. The study aimed to provide a comprehensive assessment of the feasibility of soybean cultivation on sod-podzolic and peat soils in Western Polissia. To achieve this aim, a series of field experiments was conducted to examine interactions between the study object and biotic and abiotic factors. Laboratory and mathematical-statistical methods were also applied, including analysis of variance and statistical data processing, to assess the reliability of the research findings. Limited thermal resources were found to be the main constraint on soybean cultivation in Western Polissia. An analysis of current hydrothermal resources, based on data from the meteorological station of the Sarny Research Station, showed that the thermal resources of sod-podzolic soils in Western Polissia were sufficient to produce physiologically mature seed of ultra-early and early-maturing soybean varieties with a growing season of up to 100 days. On peat soils, however, only ultra early varieties with a growing season of up to 85 days can reach physiological maturity. Under favourable conditions on sod-podzolic light loamy soils of Western Polissia, the yields of the ultra-early soybean variety Yunka and the early-maturing variety Astor, bred by Sevita Genetics (Canada), reached 3.67 and 4.36 t/ha, respectively. The application of the microbial inoculant Rizofix in combination with the phosphate-mobilising preparation Rice Pi increased soybean yield by up to 0.67 t/ha. The results also showed that soybean yields on peat soils were unstable and did not exceed 2.64 t/ha, which was associated with a less favourable hydrothermal regime than that of the adjacent sod-podzolic soils. The practical significance of the findings lies in determining the optimal soybean maturity group for cultivation on sod-podzolic and peat soils in Western Polissia, thereby enabling the production of physiologically mature seed under current hydrothermal conditions

Keywords: drained land; sod-podzolic soils; peat soils; hydrothermal conditions; fertilisation system; inoculant; phosphate-mobilising preparation

Suggested Citation:

Polishchuk, O. (2026). Features of soybean cultivation under the soil and climatic conditions of Western Polissia, Ukraine. *Scientific Horizons*, 29(3), 9-19. doi: 10.48077/scihor3.2026.09.



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INTRODUCTION

The substantial increase in thermal resources during the growing season has led to shifts in the geographical distribution of crops in Ukraine. Economically attractive steppe and forest-steppe crops that were previously uncommon under these conditions, including maize, sunflower and soybean, are becoming increasingly widespread in the northern regions of Ukraine, displacing crops traditionally grown in the area, such as winter rye, perennial grasses and buckwheat, as reported by G.V. Voropay (2020). S.M. Ryzhuk *et al.* (2022) noted that most of the soil cover in Western Polissia consists of sod-podzolic soils characterised by low humus content, high acidity and poor availability of essential nutrients. In addition, these soils generally have a light texture and low water-holding capacity. These characteristics require crop production technologies to be adapted accordingly, particularly fertilisation systems and varietal selection.

In addition to sod-podzolic soils, lowland peat soils account for approximately 30% of the soil cover in Western Polissia and are generally characterised by low phosphorus availability and, in particular, potassium deficiency, according to R.S. Truskavetskyi (2010). Therefore, achieving high yields of cereal and grain legume crops on peat soils requires the application of scientifically justified rates of phosphorus and potassium fertilisers, as well as micronutrients and secondary nutrients such as copper, magnesium and sulphur. Soybean is a strategically important crop in global agriculture and, owing to its high ecological adaptability, is now cultivated under a wide range of soil and climatic conditions, as noted by S.M. Islam *et al.* (2022). Soybean makes a major contribution to global food security because of the high protein and oil content of its seed and its relatively low dependence on nitrogen fertilisation. Unlike other crops widely grown in global agriculture, soybean can improve soil fertility by fixing atmospheric nitrogen and leaving part of it in the soil for subsequent crops in the rotation.

As noted by O. Mazur *et al.* (2025), when properly inoculated, soybean can leave up to 90100 kg/ha of biologically fixed nitrogen in the soil, which justifies its recognition as one of the best preceding crops for most agricultural crops. I. Fedoruk *et al.* (2021) demonstrated the effectiveness of combining an inoculant, Wuxal and the insecticidal-fungicidal preparation Standak Top in a tank mixture, which increased soybean yield by up to 0.6 t/ha. In the study by V. Ratoshniuk *et al.* (2023), soybean grown on sod-medium podzolic soils after grain maize, with complete mineral fertilisation at $N_{60}P_{60}K_{60}$ and foliar application of micronutrient fertilisers under optimal moisture conditions, produced yields of 2.65–3.28 t/ha. V. Moldovan *et al.* (2021) established a significant effect of sowing date on soybean yield under Forest-Steppe conditions; sowing at the optimal time increased yield by 13.8%.

Despite the considerable body of research on the expansion of soybean cultivation, its productivity and individual components of cultivation technology, the selection of varieties from different maturity groups for cultivation on sod-podzolic and peat soils of Western Polissia, taking current thermal resources into account, remains insufficiently studied. Therefore, the study aimed to determine the feasibility and suitability of cultivating soybean varieties belonging to different maturity groups on drained land in Western Polissia under current hydrothermal conditions. The main objectives were to identify the optimal soybean maturity group for cultivation on sodpodzolic and peat soils of Western Polissia under the current thermal conditions of the growing season; to investigate the effectiveness of the microbial inoculant Rizofix and the phosphate-mobilising preparation Rice Pi on sod-podzolic and peat soils; and to determine the effect of drainage depth on soybean yield when grown on sod-podzolic soils.

LITERATURE REVIEW

Based on experimental findings, V.M. Polyovyi *et al.* (2022b) reported that the cultivation of economically attractive crops such as soybean, sunflower and grain maize in Polissia is not always profitable because of the need for high rates of mineral fertilisers. Their yields in this region are generally lower than those obtained in the Forest-Steppe zone, as the limited thermal resources of Polissia do not always allow the crops to realise their full yield potential. At the same time, a study by M.A. Krayna & O.A. Furmanets (2023), conducted in the northern part of Rivne Region, showed that selecting the most adapted varieties and hybrids and applying appropriate agronomic practices can provide stable yields of 3–4 t/ha for sunflower, winter oilseed rape and soybean, and approximately 10–12 t/ha for grain maize. Cultivation technologies should therefore be based on organo-mineral fertilisation systems that use crop residues as a source of organic matter for soil replenishment, together with differentiated application of mineral fertilisers. Summarising their findings, T. Ratoshniuk *et al.* (2026) concluded that the highest economic efficiency of crop production under Polissia conditions is achieved through organo-mineral fertilisation systems in which crop residues are used as organic fertiliser.

Among the new economically attractive crops becoming increasingly widespread in Western Polissia, soybean merits particular attention because, under suitable conditions, it can substantially improve the soil nitrogen regime, as reported by Y.O. Tarariko *et al.* (2025). Similar conclusions were reached by S. Kobak *et al.* (2025), who found that, with effective inoculation, soybean can leave up to 80–100 kg/ha of biologically fixed nitrogen in the soil, which is sufficient to meet the needs of the following crop in the rotation.

J.K. Ladha *et al.* (2022) noted that, in global agriculture, biological nitrogen fixation provides a basis for ecological intensification in cereal production systems.

Since 1990, the area sown to soybean in Ukraine has increased more than twentyfold, reaching 1.4 million ha in 2024, as reported by A.A. Korobko (2021). Within the humid zone, the largest increases in soybean area were recorded in Zhytomyr Region, reaching 99.3 thousand ha, Chernihiv Region, 62.1 thousand ha, and Lviv Region, 53.7 thousand ha. In Rivne Region, the soybean area increased from 23.0 to 86.2 thousand ha, while in Volyn Region it rose from 9.0 to 37.3 thousand ha. Based on current climate change scenarios, T.K. Kostyukovich *et al.* (2021) concluded that favourable agroecological conditions for soybean development are expected in the Forest-Steppe and Polissia zones of Ukraine during 2021-2050, which may ultimately increase total soybean production by at least 15%-20%. During 2021-2026, the area under soybean in Ukraine has remained at approximately 1.5-2.0 million ha, with most production shifting towards the Forest-Steppe and Polissia zones because of climatic factors. Under current climatic conditions, soybean cultivation in the Steppe zone is feasible only with irrigation. Until 2014, the main soybean-producing areas were concentrated in the Forest-Steppe zone (66%), followed by the Steppe (19%) and Polissia (15%). Between 2016 and 2020, the share of soybean area in Polissia increased by 10%, whereas that in the Steppe declined by more than half (Biliavska *et al.*, 2021). According to T.A. Zabarba & V.V. Cheresnyuk (2024), the most favourable conditions for soybean occur when annual precipitation ranges from 500 to 600 mm, with more than 300 mm received during the growing season. Soybean has its greatest water requirement between flowering and full seed filling.

Based on a synthesis of statistical data, S.H. Pereyhatko & O.L. Rudik (2021) found that increases in total soybean production have resulted mainly from the expansion of the cultivated area rather than improvements in yield. During 2016-2026, soybean yields in Ukraine ranged from 1.62 to 2.58 t/ha, which is below the crop's potential productivity. With appropriate agronomic practices and favourable growing conditions, some farms are able to achieve stable soybean yields of at least 4-5 t/ha. This disparity indicates the strong influence of weather conditions and the generally insufficient level of crop management applied in soybean production.

In a study by V. Mazur *et al.* (2022), yields among 160 soybean varieties belonging to the medium-early maturity group and grown under the conditions of Kyiv Region ranged from 1.72 to 3.70 t/ha, representing a more than twofold difference. This finding highlights the importance of selecting varieties that are highly adapted to specific soil and climatic conditions. V.S. Kravchenko & S.P. Krykun (2025) found that soybean yields varied

considerably between cultivation zones: 1.53 t/ha in the Steppe, 2.31 t/ha in the Forest-Steppe and 2.40 t/ha in Polissia. The Forest-Steppe was identified as providing the most favourable conditions for consistently high yields. The study also showed that the soil and climatic conditions of Ukraine are generally favourable for realising the biological yield potential of medium-maturing soybean varieties.

Soybean is a crop that, under suitable conditions, requires little or no nitrogen fertiliser. Given the substantial increase in fertiliser prices, this characteristic makes soybean an important component of resource-efficient crop production technologies. According to V.V. Lykhochvor & V.F. Petrychenko (2020), soybean plants obtain 60%-80% of their total nitrogen requirement through symbiotic nitrogen fixation. Expanding the area under soybean can therefore substantially improve the soil nitrogen regime and reduce expenditure on nitrogen fertilisers in short-rotation crop systems. The authors also noted that soybean is sensitive to the availability of particular nutrients in the soil, including sulphur, copper, magnesium and boron. Sulphur application can increase soybean yield by up to 0.5 t/ha.

Soybean is a relatively new crop in the northern regions of Ukraine, although climate warming may lead to a substantial expansion of the cultivated area in these regions in the future (Polyovyi *et al.*, 2022a). At the same time, soybean is a crop adapted to monsoon climates; therefore, when planning its cultivation in regions with limited thermal resources, preference should be given to the earliest-maturing varieties, which are more likely to produce physiologically mature seed within a short growing season (Tarariko *et al.*, 2022). In their study, A.M. Rybalchenko & A.Ye. Serdiuk (2023) found that early-maturing soybean varieties produced the highest yields under the conditions of the Left-Bank Forest-Steppe. Based on long-term studies assessing soybean varieties from different maturity groups under varying environmental conditions, O.P. Tkachuk *et al.* (2023) concluded that the earliest-maturing varieties showed the greatest drought tolerance in the Forest-Steppe zone. Summarising long-term data, V.I. Sichkar (2023) noted that a considerable proportion of soybean varieties have insufficient adaptability to the diverse agroclimatic conditions of Ukraine. Ukraine therefore requires a longterm strategy for developing new-generation varieties characterised by greater adaptation to the conditions of specific soil and climatic zones.

MATERIALS AND METHODS

Experimental studies assessing the feasibility and suitability of soybean cultivation in Western Polissia were conducted at the Sarny Research Station of the Institute of Water Problems and Land Reclamation of the National Academy of Agrarian Sciences of Ukraine (IWPLR NAAS) during 2021-2024. The experiments

were carried out on the two most widespread soil types in the region: sod-podzolic and lowland peat soils. The agrochemical properties of the soils were as follows:

- sod-podzolic light loamy soil: humus content, 2.34%; readily hydrolysable nitrogen content (Cornfield method), 147 mg/kg soil; mobile phosphorus and potassium (Kirsanov method), 144 and 156 mg/kg soil, respectively; pH_{salt} 5.4;

- peat soil: readily hydrolysable nitrogen content (Cornfield method), 750.0 mg/kg soil; mobile phosphorus and potassium (Kirsanov method), 239 and 150 mg/kg soil, respectively; pH_{salt} 5.2.

Five soybean varieties belonging to different maturity groups were studied in the field experiments. In the first field experiment, conducted during 2021–2023, the following five varieties were evaluated:

- Yunka (Sevita Genetics): growing season of 85 days; required heat units, 2,350 Crop Heat Units (CHU); RM 0.4;

- Astor (Sevita Genetics): growing season of 105 days; required heat units, 2,575 CHU; RM 0.5;

- Niagara (Sevita Genetics): growing season of 108 days; required heat units, 2,600 CHU; RM 0.4;

- Neptun (Sevita Genetics): growing season of 115 days; required heat units, 2,700 CHU; RM 0.9;

- SB₁₄₂ (SB&B Foods Inc.), an American-bred variety: growing season of 123 days; required heat units, 2,750 CHU; RM 0.9.

These soybean varieties were studied on drained peat soils and sod-podzolic light loamy soils. In addition, two experiments with identical designs were conducted to assess the effectiveness of the phosphate-mobilising preparation Rise P and the nitrogen-fixing microbial inoculant RhizoFix Soy, produced by the Canadian brand Lallemand. RhizoFix and Rise P were applied as seed treatments immediately before sowing, at the rates and according to the recommendations specified by the manufacturer. Mineral fertilisers were applied to the sodpodzolic soils at a rate of $\text{N}_{60}\text{P}_{60}\text{K}_{60}$. On the peat soils, mineral fertilisers were applied at $\text{N}_{55}\text{P}_{60}\text{K}_{120}$. Grain maize was the preceding crop in the soybean field experiments. Soil tillage consisted of mulching the field after maize harvest, followed by disking and autumn ploughing. Pre-sowing tillage involved

cultivation to a depth of 9–12 cm. The experimental plots measured 50 m²; treatments were arranged systematically and replicated three times.

In the second field experiment, conducted during 2022–2024 on sod-podzolic light loamy soils, the effect of groundwater table depth on the yield of the Astor soybean variety was investigated. Owing to differences in field topography, the groundwater table during the growing season occurred at depths of 75–85, 85–100 and 100–140 cm below the soil surface, thereby simulating different operating conditions of the drainage network. The sod-podzolic light loamy soils of the experimental plots had a humus content of 2.47%, readily hydrolysable nitrogen content (Cornfield method) of 159 mg/kg soil, and mobile phosphorus and potassium contents (Kirsanov method) of 174 and 187 mg/kg, respectively; pH_{salt} was 5.5. Mineral fertilisers were applied at $\text{N}_{60}\text{P}_{60}\text{K}_{60}$ in the form of nitroammophoska. Soil moisture content and soil water reserves were determined by the gravimetric oven-drying method in the 0–50 cm soil layer, at 10 cm intervals, in triplicate once every ten-day period. Groundwater levels were measured every five days using a measuring tape in observation wells. Yield was determined by complete threshing of the entire harvest area of each plot. The results of the field experiments were statistically processed by analysis of variance using STATISTICA 6.1. Weather conditions were assessed using data from the meteorological station of the Sarny Research Station (n.d.). The authors complied with the standards of the Convention on Biological Diversity (1992) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1979).

RESULTS

One of the main factors limiting soybean cultivation in Western Polissia is the insufficient thermal supply during the growing season. To assess this factor, long-term data from the meteorological station of the Sarny Research Station (n.d.) were analysed. The dates of stable transitions of air temperature across 0°C, 5°C, 10°C and 15°C, together with the duration of the corresponding periods on the drained peatland area, are presented in Table 1.

Table 1. Dates of stable air-temperature transitions across 0°C, 5°C, 10°C and 15°C and duration of the corresponding periods (mean for 2007–2024)

Value	Dates of temperature transition across specified thresholds and duration of the corresponding periods											
	>0°	<0°	days	>5°	<5°	days	>10°	<10°	days	>15°	<15°	days
D _{mean}	24.02	5.12	284	25.03	30.10	217	22.04	3.10	163	12.05	7.09	116
D _{min}	26.01	9.11	254	14.03	6.10	186	4.04	24.09	128	27.04	24.08	100
D _{max}	30.03	31.12	318	11.04	25.11	248	30.04	23.10	188	7.06	18.09	141

Source: developed by the author

The data on stable temperature transitions show that the period with a mean daily temperature above 5°C ranged from 186 to 248 days, with an average

duration of 217 days. The period with temperatures above 10°C ranged from 128 to 188 days, averaging 163 days. The period of intensive vegetation (>15°C)

ranged from 100 to 141 days, with an average of 116 days. In most years, the growing season began in the third ten-day period of March, while the period of active vegetation began in the third ten-day period of April. Overall, even the shortest recorded period of active vegetation with a mean daily temperature above 15°C, namely 100 days, is sufficient for ultra-early and early-maturing soybean varieties to reach maturity. Under the maximum recorded duration of this period, even medium-early soybean varieties can reach maturity.

A further limiting factor is the short frost-free period, particularly on peat soils, where the probability of early autumn frosts is considerably higher than on adjacent sod-podzolic soils. According to long-term observations from the meteorological station of the Sarny Research Station of the IWPLR NAAS – the only station

in Ukraine's hydrometeorological observation network located directly within a peatland area – the long-term mean duration of the frost-free period at the peatland site where the experiments were conducted is 137 days. At the same time, the frost-free period varied considerably over the past ten years, ranging from 99 to 150 days. Thus, in years with the shortest frost-free period, its duration is sufficient only for ultra-early soybean varieties with a growing season of 85 days to reach maturity. In addition, the soybean growing season is longer in the northern regions of Ukraine because of longer daylight hours and cooler weather, which slow plant development and extend the period from sowing to maturity compared with the southern regions. Weather conditions during the study years, including precipitation and temperature patterns, are presented in Figures 1 and 2.

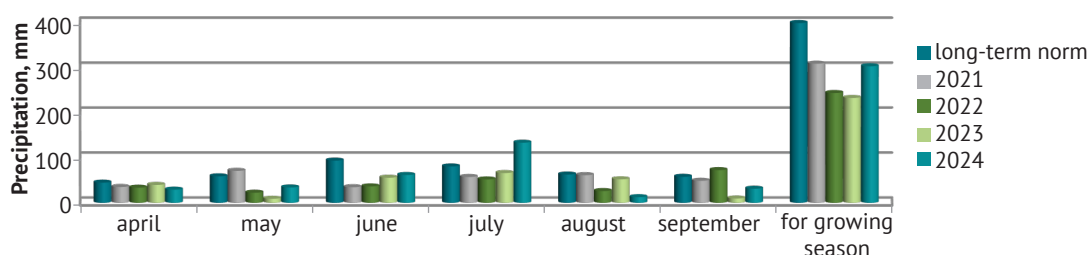


Figure 1. Precipitation, mm

Source: developed by the author

Analysis of weather conditions showed that precipitation during the 2021 growing season amounted to 309.5 mm, which was 90.5 mm below the long-term average. During the 2022 growing season, 244.3 mm of precipitation was recorded, 155.7 mm below the long-term average; in 2023, the corresponding value was 233.3 mm, or 166.7 mm below the long-term average. In 2024, precipitation totalled 304.0 mm, which was

96.0 mm below the long-term average. Overall, precipitation was distributed very unevenly among the months of the growing season throughout the four-year study period. Particularly pronounced variation in rainfall distribution was observed during the summer months. The temperature regime during the 2021-2024 growing seasons was also characterised by substantial month-to-month fluctuations (Fig. 2).

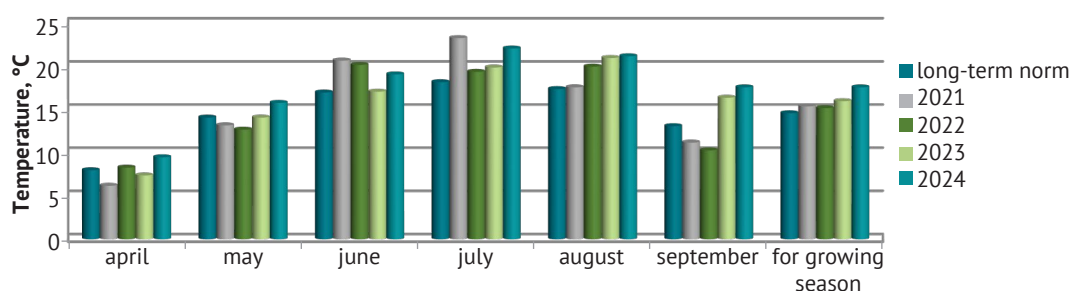


Figure 2. Mean monthly air temperature during the 2021-2024 growing seasons

Source: developed by the author

The temperature regime during the 2021 growing season resulted in the onset of vegetation occurring 2-3 weeks later than in previous years. April and September were unusually cold, with mean monthly air temperatures 1.8°C and 1.9°C below the long-term averages, respectively, whereas temperatures during the remaining months of the growing season, from May to August, were considerably higher. Overall, the mean

air temperature during the 2021 growing season was 15.4°C, which was 0.8°C above the long-term average. Mean monthly air temperatures differed substantially from the long-term averages across individual months of the growing season.

The 2022 growing season was characterised by a prolonged and cold spring. May was particularly cold, with the mean monthly air temperature 1.4°C below

the long-term average. In June, July and August, mean monthly temperatures exceeded the long-term averages by 3.2°C, 1.2°C and 2.6°C, respectively. September, however, was unusually cold, with the mean monthly temperature 2.8°C below the long-term average.

The temperature regime during the 2023 growing season was characterised by a cold start, with the mean monthly air temperature in April 0.6°C below the long-term average. Temperatures in May and June were close to the long-term averages, whereas mean monthly air temperatures from July to September were considerably higher. The 2024 growing season was characterised by mean monthly air temperatures above the long-term averages. July, August and September were particularly warm, with mean monthly temperatures exceeding the long-term averages by 3.9°C, 3.8°C and 4.3°C, respectively.

In Ukraine, the thermal resources of soybean-growing regions are traditionally assessed using accumulated active or effective temperatures. However, as noted by S.M. Kalenska & R.V. Hovenko (2022), the sum of active temperatures is a generalised indicator that does not allow the thermal requirements of a crop to be assessed with sufficient accuracy. For many spring crops, accumulated effective temperatures are therefore more commonly used. However, this indicator does not always account for diurnal temperature patterns,

particularly absolute minimum and maximum temperatures, which can substantially affect plant development. Western Polissia is characterised by relatively wide fluctuations between minimum and maximum daily air temperatures. As early as August, night-time minimum temperatures frequently fall below 10°C, particularly on peatlands (Tarariko *et al.*, 2022). Therefore, for the northern regions of Ukraine, including minimum air temperatures in assessments of thermal resources provides a more accurate representation of local climatic conditions.

Soybean varieties of American and, particularly, Canadian origin, which have become increasingly widespread in Ukraine in recent years, are classified into maturity groups according to their required CHU, a system used to determine the amount of accumulated heat required for a crop to reach full maturity. The CHU system was developed by American researchers, and its method of calculating accumulated heat units provides a more accurate practical characterisation of the thermal regime of a region (Kalenska & Hovenko, 2022). Canadian soybean varieties are assigned to maturity groups according to the total number of heat units required from sowing to full crop maturity. The calculated accumulated CHU values for sod-podzolic and peat soils are presented in Table 2.

Table 2. Accumulated CHU on peat and sod-podzolic soils during 2021-2024

Soil type	Period	Accumulated heat units, CHU			
		2021	2022	2023	2024
Peat soil	May-September	2,602	2,538	2,743	3,060
	frost-free period	2,280	2,092	2,236	2,845
Sod-podzolic soil	May-September	2,966	2,893	3,127	3,488
	frost-free period	2,630	2,567	2,596	2,864

Source: developed by the author

The data in Table 2 show substantial differences in CHU values between sod-podzolic and peat soils. These differences are attributable to the specific thermal properties of peat soils, including low thermal conductivity and high moisture content, as well as to microclimatic conditions and differences in the duration of the frost-free period. In addition, minimum nighttime temperatures on peat soils are considerably lower than those recorded on adjacent mineral soils.

Accumulated CHU values varied substantially among the study years on both sod-podzolic and peat soils. On sod-podzolic soils, accumulated CHU ranged from 2,893 to 3,488 during May-September and from 2,567 to 2,864 during the frost-free period. On peat soils, CHU values ranged from 2,538 to 3,060 during May-September and from 2,092 to 2,845 during the frost-free period. Overall, thermal conditions during the growing season differed considerably among the study years, making it possible to identify the optimal

soybean maturity group for cultivation under the conditions of Western Polissia.

Under conditions of substantial climate warming, crop productivity depends to a considerable extent on moisture availability, particularly the distribution of precipitation, groundwater table depth and soil moisture content. Averaged over the three-year study period, groundwater levels ranged from 67 to 117 cm below the soil surface on sod-podzolic soils and from 56 to 111 cm on peat soils. Monitoring of soil water reserves during 2021-2023 showed that, on sod-podzolic soils, water reserves ranged from 49.0 to 91.4 mm in the 0-30 cm soil layer and from 113.8 to 173.1 mm in the 0-50 cm layer. On peat soils, the corresponding values ranged from 113.8 to 173.0 mm in the 0-30 cm layer and from 243.1 to 324.6 mm in the 0-50 cm layer. The effects of the nitrogen-fixing preparation RhizoFix and the phosphate-mobilising preparation Rise P on soybean yield under cultivation on drained sod-podzolic soils are presented in Table 3.

Table 3. Soybean yield on drained sod-podzolic soils, mean for 2021-2023

Variety	Growing season, days	Required heat units, CHU	Yield, t/ha			
			without preparations	RhizoFix	Rise P	RhizoFix + Rise P
Yunka	85	2,350	3.87	4.33	4.21	4.55
Astor	105	2,575	3.15	3.46	3.49	3.85
Niagara	108	2,600	2.74	3.09	3.03	3.23
Neptun	120	2,700	2.59	2.87	2.84	3.12
Sb ₁₄₂	124	2,750	2.39	2.65	2.62	2.77
LSD _{0.5} , t/ha			0.043	0.056	0.061	0.059

Source: developed by the author

Overall, the results showed a substantial yield advantage of the early-maturing varieties Yunka and Astor over the later-maturing varieties Niagara, Neptun and Sb₁₄₂. Over the three-year study period, application of the microbial inoculant RhizoFix increased soybean yield by 0.26-0.46 t/ha, depending on the variety. Application of the phosphate-mobilising preparation Rise P

increased yield by 0.23-0.34 t/ha. In treatments combining the RhizoFix inoculant with the phosphate-mobilising preparation Rise P, soybean yield increased by 0.38-0.70 t/ha. The effects of the nitrogen-fixing preparation RhizoFix and the phosphate-mobilising preparation Rise P on soybean yield on drained peat soils are presented in Table 4.

Table 4. Soybean yield on drained peat soils, mean for 2021-2023

Variety	Growing season, days	Required heat units, CHU	Yield, t/ha			
			without preparations	RhizoFix	Rise P	RhizoFix + Rise P
Yunka	85	2,350	2.11	2.21	2.58	2.64
Astor	105	2,575	1.99	2.04	2.30	2.39
Niagara	108	2,600	1.94	1.99	2.26	2.33
Neptun	120	2,700	1.60	1.65	1.80	1.97
Sb ₁₄₂	124	2,750	1.46	1.50	1.67	1.73
LSD _{0.5} , t/ha			0.038	0.042	0.034	0.045

Source: developed by the author

Comparison of the data in Tables 3 and 4 shows that the yields of all soybean varieties studied were lower on peat soils than on sod-podzolic soils. The difference was particularly pronounced for the latest-maturing varieties in the study, namely Neptun and Sb₁₄₂. These experimental findings indicate that only ultra-early soybean varieties with a growing season of up to 85 days are suitable for cultivation on peat soils. Growing later-maturing varieties on such soils involves a greater risk because thermal resources may be insufficient for the crop to reach maturity. One of the main reasons for the lower soybean yields on peat soils compared with sod-podzolic soils is their less favourable hydrothermal regime, particularly the shorter frost-free period, which is, on average, 15-20 days shorter than on adjacent sod-podzolic soils. In most cases, the first autumn frosts on peat soils occur as early as the first ten-day period of September, as observed in 2021 and 2022, whereas on adjacent sod-podzolic soils they occurred in the third ten-day period of September.

The findings indicate that the earliest-maturing soybean varieties are the most suitable for cultivation on peat soils. The yield of the ultra-early Yunka variety ranged from 2.11 to 2.64 t/ha across the

experimental treatments, whereas yields of the other varieties ranged from 1.46 to 2.39 t/ha. It should be noted that RhizoFix showed relatively low effectiveness on peat soils, with yield increases not exceeding 0.1 t/ha. The phosphate-mobilising preparation Rise P was considerably more effective, increasing yield by 0.20-0.47 t/ha. Combined application of RhizoFix and Rise P increased yield by 0.26-0.53 t/ha, depending on the variety. The low effectiveness of the nitrogenfixing microbial inoculant RhizoFix on peat soils can be attributed to their high nitrogen availability, which appears to suppress nitrogen fixation. Nevertheless, the use of nitrogen-fixing microbial inoculants specifically on peat soils requires further experimental investigation.

As reported by V.F. Petrychenko *et al.* (2016), soybean is sensitive to moisture availability and responds negatively to water deficiency, particularly during seed filling and development. In crop production systems on drained land, regulation of the soil water regime, particularly groundwater table depth, is an important management component (Tarariko *et al.*, 2022). During 2022-2024, the effect of groundwater table depth on the yield of the Astor soybean variety was studied on sod-podzolic soils (Table 5).

Table 5. Yield of the Astor soybean variety depending on groundwater table depth on sodpodzolic soils

Study year	Yield, t/ha			Yield increase among groundwater table treatments, t/ha	
	Groundwater table depth, cm			85-100 cm up to 100-140 cm	75-85 cm up to 100-140 cm
	100-140 cm	85-100 cm	75-85 cm		
2022	2.81	3.63	4.11	0.82	1.30
2023	2.52	3.44	3.81	0.92	1.29
2024	2.49	3.03	3.41	0.54	0.92

Source: developed by the author

The results showed that soybean yield was significantly affected by groundwater table depth. On plots where the groundwater table was 100-140 cm below the soil surface, soybean yield ranged from 2.49 to 2.81 t/ha. At a groundwater table depth of 85-100 cm, yield ranged from 3.03 to 3.63 t/ha, while at 75-85 cm it ranged from 3.41 to 4.11 t/ha. These findings indicate that, when soybean is grown on sod-podzolic soils, the optimal groundwater table depth during the growing season is 75-85 cm below the soil surface. Lowering the groundwater table to a depth of 100-140 cm during the period of active soybean growth results in a substantial reduction in yield.

DISCUSSION

A distinctive feature of the soil cover in Western Polissia is that approximately 70% of the area is occupied by sod-podzolic soils and their variants. Most are low-humus soils with a light texture, low water-holding capacity and poor availability of major plant nutrients (Voropay, 2020). In Western Polissia, sod-podzolic light loamy soils are the most suitable for soybean cultivation because they are more fertile and retain moisture more effectively than their sandy loam counterparts, as noted by Y.O. Tarariko *et al.* (2025). In the present study, under a comparable fertilisation regime and with the application of the nitrogen-fixing microbial inoculant RhizoFix and the phosphate-mobilising preparation Rise P, the Yunka variety produced yields exceeding 4.0 t/ha on sod-podzolic light loamy soils over the four-year study period.

Soybean cultivation on peat soils remains insufficiently studied. Despite the specific hydrothermal conditions of peatlands, including shorter growing and frost-free periods than on adjacent mineral soils, as well as low availability of phosphorus, potassium and certain micronutrients, these soils are characterised by high nitrogen availability and sufficient moisture reserves, both of which are critically important for soybean cultivation (Truskavetskyi, 2010). Climatic conditions have a substantial effect on soybean yield formation and seed quality. A.M. Rybalchenko & A.Ye. Serdiuk (2023) demonstrated that soybean yield in the Left-Bank Forest-Steppe of Ukraine depends directly on the genetic characteristics of the variety, weather conditions in a particular year and plant adaptation to hydrothermal factors.

The present findings show that the yield of the same soybean variety differed substantially between soils of

mineral origin, represented by sod-podzolic soils, and soils of organic origin. Overall, in every study year, soybean yield was higher on sod-podzolic soils than on peat soils, regardless of maturity group. This indicates that hydrothermal conditions have a pronounced effect on soybean growth and development even within the same geographical area when the crop is grown on different soil types. On peat soils, the hydrothermal regime is less favourable for soybean cultivation, particularly during the spring and autumn periods.

V.F. Petrychenko *et al.* (2016) found that the use of nitrogen-fixing microbial inoculants in soybean cultivation can eliminate the need for nitrogen fertiliser application. In the studies by I. Fedoruk *et al.* (2021) and O. Mazur *et al.* (2025), inoculant application increased soybean yield by up to 0.5 t/ha. According to S. Kobak *et al.* (2025), the optimal time for inoculant application is when the soil warms to above 12°C-14°C in spring. The present findings show that, under favourable conditions on sod-podzolic soils, the combined application of nitrogen-fixing microbial inoculants and phosphate-mobilising preparations can increase soybean yield by up to 0.6 t/ha.

In experiments conducted at the balance lysimeter station of the Institute of Agriculture of Polissia of the NAAN, V. Ratoshniuk *et al.* (2023) found that, on sod-podzolic loamy sand soils under natural moisture conditions, soybean grain yield ranged from 2.33 to 2.65 t/ha when the Nano-Mineralis nanofertiliser was applied against a background of $N_{60}P_{60}K_{60}$ with split nitrogen application and incorporation of crop residues. Foliar application of the Nano-Mineralis micronutrient fertiliser increased soybean yield by 13.1%-28.6%. Artificial water regulation increased soybean yield by 23%. In the present study, artificial water regulation increased soybean yield by up to 53.1%, further demonstrating the high sensitivity of this crop to the drainage regime.

CONCLUSIONS

The experimental findings indicate that, under the current thermal conditions of the growing season, early-maturing soybean varieties with a growing season of up to 100 days are the most suitable for cultivation on sod-podzolic soils in Western Polissia. On peat soils, current thermal resources are sufficient to ensure reliable maturation only of ultra-early soybean varieties with a growing season of up to 85 days. Application of

the microbial inoculant RhizoFix in combination with the phosphate-mobilising preparation Rise P increased soybean yield, with the greatest effect observed on sod-podzolic soils. On peat soils, the effectiveness of the inoculant was considerably lower, probably because of the naturally high nitrogen availability of these soils.

On peat soils, the nitrogen-fixing microbial inoculant RhizoFix showed low effectiveness in soybean crops, increasing yield by no more than 0.1 t/ha. The phosphate-mobilising preparation Rise P was more effective on peat soils, increasing soybean yield by up to 0.47 t/ha. For soybean cultivation on sod-podzolic soils, the optimal groundwater table depth during the growing season was found to be 75-85 cm below the soil surface, whereas lowering the groundwater table to 100-140 cm resulted in a substantial reduction in yield.

The experimental findings also indicate that the hydrothermal conditions of peat soils are less favourable for soybean cultivation than those of sod-podzolic

soils. Overall, soybean yield on peat soils is unstable and depends strongly on the weather conditions of a particular year. Further comprehensive experimental research is therefore required to assess soybean cultivation on peat soils in Western Polissia. Promising areas for future research include evaluating the effectiveness of phosphate- and potassium-mobilising preparations, biologically derived plant growth stimulants, and foliar micronutrient application on peat soils, as these aspects remain insufficiently studied under such conditions.

ACKNOWLEDGEMENTS

None.

FUNDING

None.

CONFLICT OF INTEREST

None.

REFERENCES

- [1] Biliavska, L.H., Biliavskiy, Yu.V., Diyanova, A.A., & Mirny, N.V. (2021). Drought-resistant soybean varieties for Steppe and Forest-Steppe of Ukraine. *Bulletin of Poltava State Agrarian Academy*, 1, 135-140. doi: [10.31210/visnyk2021.01.16](https://doi.org/10.31210/visnyk2021.01.16).
- [2] Convention on Biological Diversity. (1992, June). Retrieved from <https://surl.li/rpxdhr>.
- [3] Convention on International Trade in Endangered Species of Wild Fauna and Flora. (1979, June). Retrieved from https://zakon.rada.gov.ua/laws/show/995_129#Text.
- [4] Fedoruk, I., Bakhmat, O., Khmelyanchyshyn, Y., & Horodyska, O. (2021). Agroecological impact of microfertilizers and seed inoculation on soybean crops. *EUREKA: Life Sciences*, 2, 16-24. doi: [10.21303/2504-5695.2021.001747](https://doi.org/10.21303/2504-5695.2021.001747).
- [5] Islam, S.M., et al. (2022). Soybean and sustainable agriculture for food security. *IntechOpen*. doi: [10.5772/intechopen.104129](https://doi.org/10.5772/intechopen.104129).
- [6] Kalenska, S.M., & Hovenko, R.V. (2022). The effect of accumulation of thermal units and various nitrogen fertilizers on corn productivity. *Scientific Works of the Institute of Bioenergy Crops and Sugar Beet*, 30, 33-43. doi: [10.47414/np.30.2022.268943](https://doi.org/10.47414/np.30.2022.268943).
- [7] Kobak, S., Datsko, A., & Chorna, V. (2025). Efficiency of pre-sowing treatment of soybean seeds with bioinoculants at different treatment times. *Feeds and Feed Production*, 99, 99-111. doi: [10.31073/kormovyrobnytstvo202599-09](https://doi.org/10.31073/kormovyrobnytstvo202599-09).
- [8] Korobko, A.A. (2021). Dynamics of soybean production in Ukraine and the world. *Balanced Nature Using*, 4, 125-134. doi: [10.33730/2310-4678.4.2021.253098](https://doi.org/10.33730/2310-4678.4.2021.253098).
- [9] Kostyukevich, T.K., Tolmachova, A.V., Kolosovska, V.V., & Barsukova, O.A. (2021). Agroecological assessment of soybean productivity in the Western Forest-Steppe of Ukraine under climate change. *Environmental Sciences*, 2(35), 99-103. doi: [10.32846/2306-9716/2021.eco.2-35.17](https://doi.org/10.32846/2306-9716/2021.eco.2-35.17).
- [10] Kravchenko, V.S., & Krykun, S.P. (2025). Ecological testing of mid-season varieties of cultivated soybeans in contrasting environmental conditions. *Podilian Bulletin: Agriculture, Engineering, Economics*, 2(47), 86-92. doi: [10.37406/2706-9052-2025-2.11](https://doi.org/10.37406/2706-9052-2025-2.11).
- [11] Krayna, M.A., & Furmanets, O.A. (2023). Productivity of corn when growing on sod-podzol soils of Western Polissia with different doses of main fertilizer. *Bulletin of the National University of Water and Environmental Engineering. Series "Agricultural Sciences"*, 3(103), 130-141. doi: [10.31713/vs320239](https://doi.org/10.31713/vs320239).
- [12] Ladha, J.K., Peoples, M.B., Reddy, P.M., Biswas, J.C., Bennett, A., Jat, M.L., & Krupnik, T.J. (2022). Biological nitrogen fixation and prospects for ecological intensification in cereal-based cropping systems. *Field Crops Research*, 283, article number 108541. doi: [10.1016/j.fcr.2022.108541](https://doi.org/10.1016/j.fcr.2022.108541).
- [13] Lykhochvor, V.V., & Petrychenko, V.F. (2020). *Plant breeding. New technologies for growing field crops: A textbook* (5th ed.). Lviv: Scientific Production Company "Ukrainian technologies".
- [14] Mazur, O., Voloshyna, O., Mazur, O., Zayka, K., Dovgopolyi, V., & Yakovets, V. (2025). The effect of seed inoculation and fertilization on the nitrogen fixing capacity of soybean varieties. *Ecological Engineering and Environmental Technology*, 26(5), 82-95. doi: [10.12912/27197050/202888](https://doi.org/10.12912/27197050/202888).

- [15] Mazur, V., Tkachuk, O., Pantsyрева, H., & Verholuk, S. (2022). Technologicality, ecologicality and productivity of medium-earring matching soybean varieties. *Scientific Reports of the National University of Life and Environmental Sciences of Ukraine*, 18(1). doi: [10.31548/dopovidi2022.01.006](https://doi.org/10.31548/dopovidi2022.01.006).
- [16] Moldovan, V., Moldovan, Zh., & Sobchuk, S. (2021). Sowing time as a way to increase the yield of soybean varieties with different growing seasons. *Feeds and Feed Production*, 91, 71-81. doi: [10.31073/kormovyrobnytstvo202191-06](https://doi.org/10.31073/kormovyrobnytstvo202191-06).
- [17] Peretyatko, S.H., & Rudik, O.L. (2021). Current status and applied aspects of the prospects for the development of soybean production in Ukraine. *Irrigated Agriculture*, 76, 49-53. doi: [10.32848/0135-2369.2021.76.10](https://doi.org/10.32848/0135-2369.2021.76.10).
- [18] Petrychenko, V.F., et al. (2016). *Soybean. Monograph*. Vinnytsia: Dilo.
- [19] Polyovyi, V.M., Furman, V.M., Moroz, O.S., & Lyusak, A.V. (2022a). Monitoring soybean productivity under different fertilization systems in the conditions of the Western Forest-Steppe. *Taurida Scientific Bulletin*, 126, 92-98. doi: [10.32851/2226-0099.2022.126.13](https://doi.org/10.32851/2226-0099.2022.126.13).
- [20] Polyovyi, V.M., Yashchenko, L.A., Rovna, H.F., & Kolesnyk, T.M. (2022b). Ecological and economic aspects of crop cultivation on sod-podzolic soils in Western Polissya, Ukraine. *Agroecological Journal*, 1, 91-98. doi: [10.33730/2077-4893.1.2022.2571279](https://doi.org/10.33730/2077-4893.1.2022.2571279).
- [21] Ratoshniuk, V., Savchuk, O., & Ratoshniuk, V. (2023). Features of soybean productivity formation on sod-podzolic soil in lysimetric studies. *Bulletin of Agrarian Science*, 101(7), 5-13. doi: [10.31073/agrovisnyk202307-01](https://doi.org/10.31073/agrovisnyk202307-01).
- [22] Ratoshniuk, T., Ratoshniuk, V., & Ratoshniuk, V. (2026). Economic analysis of the technological aspects of field crop cultivation on dorno-pidzolic soils in the Polissya region of Ukraine. *Modelling the Development of the Economic Systems*, 2, 379-386. doi: [10.31891/mdes/2026-20-47](https://doi.org/10.31891/mdes/2026-20-47).
- [23] Rybalchenko, A.M., & Serdiuk, A.Ye. (2023). Influence of varietal properties on productivity elements and soybean yield in the Left-Bank Forest-Steppe of Ukraine. *Agrarian Innovations*, 21, 88-92. doi: [10.32848/agrar.innov.2023.21.13](https://doi.org/10.32848/agrar.innov.2023.21.13).
- [24] Ryzhuk, S.M., Savchuk, O.I., Melnychuk, A.O., & Prymachuk, T.Yu. (2022). The effectiveness of short-rotation crop rotations with economically attractive crops on drained sod-podzolic soils. *Bulletin of Agrarian Science*, 100(2), 11-18. doi: [10.31073/agrovisnyk202202-02](https://doi.org/10.31073/agrovisnyk202202-02).
- [25] Sarny Research Station. (n.d.). Retrieved from <https://igim.org.ua/umovi-vikoristannya/sarnenska-doslidna-stanciya>.
- [26] Sichkar, V.I. (2023). *How to adapt soybeans*. Retrieved from <https://agroelita.info/yak-adaptuvaty-soyu>.
- [27] Tarariko, Y.O., Pysarenko, P.V., Zosymchuk, M.D., Saydak, R.V., Soroka, Y.V., & Lelyavska, L.V. (2025). Forest-steppe zone crops on drained soils of Western Polissya. *Bulletin of Agricultural Science*, 103(4), 15-24. doi: [10.31073/agrovisnyk202504-02](https://doi.org/10.31073/agrovisnyk202504-02).
- [28] Tarariko, Y.O., Zosymchuk, M.D., Stetsyuk, M.G., Zosymchuk, O.A., & Soroka, Y.V. (2022). Prospects for soybean cultivation in the Western Polissya zone. *Land Reclamation and Water Management*, 2, 36-44. doi: [10.31073/mivg202202](https://doi.org/10.31073/mivg202202).
- [29] Tkachuk, O.P., Didur, I.M., & Mazur, O.V. (2023). Cultivation of early-ripening soybean varieties under conditions of intensive agriculture and climate change. *Agrarian Innovations*, 18, 128-135. doi: [10.32848/agrar.innov.2023.18.18](https://doi.org/10.32848/agrar.innov.2023.18.18).
- [30] Truskavetskyi, R.S. (2010). *Peat soils and peatlands of Ukraine*. Kharkiv: City Printing House.
- [31] Voropay, G.V. (2020). Agricultural use of drained lands of the humid zone of Ukraine in the context of agricultural sector reform and climate change. *Bulletin of Agrarian Science*, 98(11), 62-73. doi: [10.31073/agrovisnyk202011-08](https://doi.org/10.31073/agrovisnyk202011-08).
- [32] Zabarna, T.A., & Chereschnyuk, V.V. (2024). Agroecological aspects of soybean cultivation in Ukraine. *Agroecological Journal*, 1, 110-118. doi: [10.33730/2077-4893.1.2024.299945](https://doi.org/10.33730/2077-4893.1.2024.299945).

Особливості вирощування сої в ґрунтово-кліматичних умовах зони Західного Полісся України

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Анотація. Актуальність дослідження полягає у встановленні оптимальної групи стиглості сої для вирощування в зоні Західного Полісся відповідно до сучасних показників теплозабезпеченості вегетаційного періоду. Метою роботи було дати комплексну оцінку можливості вирощування сої на дерново-підзолистих та торфових ґрунтах зони Західного Полісся. Для досягнення мети досліджень був проведений комплекс польових дослідів для вивчення взаємодії об'єкта досліджень із біотичними та абіотичними факторами, лабораторні, математико-статистичні – для проведення дисперсійного аналізу і статистичної обробки даних з метою оцінювання достовірності отриманих результатів досліджень. Встановлено, що основними обмежуючими чинниками, що ускладнюють вирощування сої в зоні Західного Полісся є обмежені теплові ресурси. Аналіз сучасних показників гідротермічних ресурсів на прикладі метеопосту Сарненської дослідної станції показав, що на дерново-підзолистих ґрунтах зони Західного Полісся на дерново-підзолистих ґрунтах теплових ресурсів достатньо для одержання фізіологічно стиглого зерна ультра ранніх та ранньостиглих сортів сої з тривалістю вегетаційного періоду до 100 днів, а на торфових ґрунтах – тільки ультра ранніх сортів з тривалістю вегетаційного періоду до 85 днів. На дерново-підзолистих легкосуглинкових ґрунтах зони Західного Полісся за сприятливих умов урожайність ультра раннього сорту сої – Юнка та ранньостиглого – Астор селекції *Sevita genetics* (Канада) становила 3,67 та 4,36 т/га. Застосування мікробного інокулянту Різофікс у поєднанні з фосфор мобілізуючим препаратом Райс Пі дозволило підвищити урожайність сої до 0,67 т/га. Результати проведених досліджень показали, що урожайність сої на торфових ґрунтах є нестабільною і не перевищувала 2,64 т/га, що пов'язано з менш сприятливим гідротермічним режимом порівняно з прилеглими дерново-підзолистими ґрунтами. Практичне значення отриманих результатів полягає у встановленні оптимальної групи стиглості сої для вирощування на дерново-підзолистих та торфових ґрунтах в зоні Західного Полісся, що дозволяє одержувати фізіологічно-стигле зерно за сучасних показників гідротермічних ресурсів

Ключові слова: осушувані землі; дерново-підзолисті ґрунти; торфові ґрунти; гідротермічні умови; система удобрення; інокулянт; фосфоро-мобілізуючий препарат