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PROSPECTS OF SOYBEAN GROWING IN THE WESTERN POLISSIA ZONE

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Abstract. *Modern climatic changes, namely significant warming in the northern Forest-Steppe and Polissia zones of Ukraine, provide opportunities for growing a number of grain and leguminous crops (maize for grain, soybeans, sunflower, and others), previously unusual for this region. Among the above-mentioned crops, soybean is a crop that can significantly improve the nitrogen balance of the soil without the use of mineral fertilizers; its cultivation to some extent can be an alternative to expensive nitrogen fertilizers because, under the condition of inoculation, soybean can leave up to 80 kg/ha of biological nitrogen, which equivalent to 300 kg of ammonium nitrate, which is enough for forming decent harvest of winter wheat or corn. The analysis of meteorological data shows that when having the current amount of heat supply during the growing season in the Western Polissia zone, it is possible to grow ultra-early and early-ripening soybean varieties with a duration of the growing season of up to 90–100 days and a required number of heat units – up to 2400–2500 CHU. It was established that the main factor limiting the cultivation of soybeans on the peat soils of the Western Polissia zone is a significantly shorter frost-free period (compared to the adjacent sod-podzolic soils on dry land). Therefore, for growing on peat soils, it is necessary to choose ultra-early varieties of soybeans with a growing season of up to 85 days and the required number of heat units – up to 2400–2500 CHU. That will allow obtaining physiologically ripe seeds before the onset of the first autumn frosts, which in some years can already occur in the first decade of September. On peat soils, the yield of the Yunka soybean variety by the variants of the experiment ranged from 15,1–24,8 t/ha, while on the adjacent sod-podzolic light loamy soils it was 30,3–46,8 t/ha. The reason for the significantly lower soybean yield on peat soils is a short frost-free period compared to sod-podzolic soils, which did not allow the studied varieties to fully realize their potential for 2 years in a row. The research has established that on sod-podzolic light loamy soils of the Western Polissia zone, under favorable conditions, the yield of such ultra-early and early-ripening soybean varieties as Yunka and Astor of the Sevita genetics selection (Canada) can be up to 45,0–46,8 t/ha. The use of Rizofix inoculant in a combination with Rice Pi phosphorus-mobilizing product allows increasing the productivity of soybeans to 6,7–7,0 t/ha. Additional profit from their use is about 8–8,3 thousand hryvnias from 1 ha.*

Keywords**:** *soybean, soil, Polissia zone, climate change, biological preparations, fertilizers*

Relevance of research. Soybean is one of the most widespread leguminous crops in world agriculture. This is a potentially highly productive crop, as confirmed by American farmers, where a grain yield of 7–8 t/ha is normal. The world record for soybean yield belongs to the US farmer Randy Dowdy (Missouri) – 12,78 t/ha. Record high yields (more than 10 t/ha) in production conditions were obtained by the farmer from the USA, Kip Cullers (California). In Ukraine, in production conditions, no more than 4–5 t/ha of soybean grain is usually obtained [1; 2].

In the USA, crop rotation with alternating soybean and corn is widely used. Soybean monoculture is common here, but genetically modified varieties resistant to Glyphosate are mainly grown in unchanged plantings. The importance of soybeans is evidenced by the fact that the United States annually exports more of its grains than the Russian Federation of oil, gas, and metal. For comparison, corn in the USA occupies 32% of the cultivated area, and soybeans – 29% [2; 3].

The total area of grain and leguminous crops in Ukraine has remained almost unchanged for more than 30 years, but the share of their production by natural and climatic zones has changed. Thanks to the increase in yield, 65 % of grain is grown in Polissia and the Forest Steppe zones, although the share of their plantings in these regions is only 53 % [1; 3; 4].

As for the sown areas of soybeans in Ukraine, in 2021 they amounted to about 1.28 million hectares. In general, since 1990, soybean acreage has increased more than 20 times. A comparison of the data for the last 10 growing seasons showed an increase in the area of soybean crops in 16 regions of Ukraine. Thus, for the period from 2010 to 2019, the largest increase was recorded in the farms of the Forest-Steppe zone: Khmelnytsky region – 100.64 thousand hectares; Sumy region – 53,3 thousand hectares, Ternopil region – 64,2 thousand hectares. In the humid zone, the largest increase in cultivated area under soybeans was recorded in the Zhytomyrska region – 99,34 thousand hectares; Chernihiv region – 62,06 thousand hectares, Lviv region – 53,66 thousand hectares. In the Rivne region, the sown area under soybeans increased from 23,000 hectares to 86,000 hectares, and in the Volyn region from 9,000 hectares to 37,000 hectares [4].

Soy occupies a leading position due to the high profitability of cultivation and stable demand of domestic and global agricultural markets. In addition, soybean is a unique fodder, food, technical, and medicinal crop and an excellent previous crop for any crop, including winter wheat, corn, winter rapeseed, and sugar beet [5].

Analysis of recent research and publications. In modern economic conditions, producers are rapidly moving to the cultivation of several export-oriented crops, the vast majority of which are corn for grain, sunflower, winter rapeseed, winter wheat, and soybeans [6]. Among the above-mentioned crops, soy is the crop that can significantly improve the nitrogen balance of the soil without the use of mineral fertilizers [7]. The rest of the crops are characterized by very high rates of removal of nutrients per unit of the crop. Therefore, their cultivation technologies are based on the application of increased rates of mineral fertilizers, without which it is almost impossible to achieve a high yield. In addition, soybean is a crop that is very sensitive to the content of certain trace elements in the soil, such as sulfur and magnesium [1; 2]. In the conditions of a significant increase in the cost of mineral fertilizers and especially nitrogen fertilizers, which are limiting in the technology of growing corn, sunflower, and winter wheat, soybean plants get up to 65–80 % of the total need for nitrogen from the atmosphere [8].

Soybean is, without exaggeration, a new crop for the Western Polissia zone, because 15–20 years ago, its cultivation here was considered very risky [1; 2; 9]. The main limiting factor for growing soybeans for grain in the Western Polissia region is the low natural fertility of most soil types, high acidity and light mechanical composition of the soil, limited heat resources, etc. [9; 10]. At the same time, because of climate warming, a real opportunity has appeared to grow soybeans in this zone, and it has every prospect of occupying its niche among other crops [1; 3; 11].

The possibility of successful soybean cultivation in this soil-climatic zone is indicated by the fact that as the results of the experiments in the territory of the neighboring Republic of Belarus (which is located much north of the Western Polissia zone of Ukraine), 19–29 t/ha of physiologically ripe soybean grain of the ultra-early Yaselda variety was obtained [12].

Under certain conditions, soybean almost does not need nitrogen fertilizers. Therefore, in the conditions of a significant rise in the cost of nitrogen fertilizers, there is every reason to claim that its acreage will increase significantly in the coming years in Ukraine because the application of nitrogen fertilizers is minimal when cultivating soybeans. If inoculants are used for growing soybeans, the need for nitrogen fertilizers is eliminated. Soy leaves up to 60–80 kg of nitrogen per 1 hectare in the soil, so it is an excellent previous crop for subsequent crops in a crop rotation [7; 13; 14]. In modern agriculture, winter wheat or corn is widely cultivated after soybeans. Soy replenishes up to 70 % of the total nitrogen consumption due to its biological fixation from the air with the help of symbiosis with nodule bacteria [1; 7; 10].

Since the soils of the Polissia zone do not contain symbiotic nodule bacteria Rhizobiumjaponicum, the introduction of bacterial preparations is mandatory [2; 7]. World practice has proven that inoculation is a relatively inexpensive and effective measure to increase soybean productivity, since the cost of using most preparations per 1 ha is on average 5–6 US dollars, and the yield increase, by the averaged data from scientific institutions, is 2–6 c/ha [8; 13].

Soy is a monsoon climate crop, and when planning its cultivation in the Polissya zone, scientists recommend choosing the most early-ripening varieties, which are guaranteed to ensure the production of physiologically ripe seeds under the condition of limited heat resources [1; 2; 7].

In previous years' research conducted by the Sarny Research Station on test plots located on drained peat soils, ultra-early soybean varieties with a growing season of 75–85 days had enough time to form physiologically ripe grain before the onset of persistent frosts. Even later ripening varieties with a growing season of 100–105 days ripened on the adjacent sod-podzolic soils.

The soil cover of the Polissia zone consists of 2 large groups of soils – mineral and organic. Mineral soils are mainly represented by various types of sod-podzolic soils, among which the light loam and loam types are the most suitable for growing soybeans [9; 10; 11].

Organogenic soils of the Polissya zone are mainly represented by lowland peat soils of various thicknesses, which, unlike sod-podzolic soils, are well supplied with nitrogen and moisture. One of the advantages of peat soils over sod-podzolic soils is the presence of significant moisture reserves [15]. The analysis of long-term data of the Sarny Research Station shows that in the one-meter layer of peat, the total moisture reserves, even in the driest years, amount to more than 4600–5000 m^3 per 1 ha; that is more than enough for the normal growth and development of all crops.

So, until recently, the issue of growing soybeans in the Western Polissia zone has been poorly studied, as well as the selection of varieties by the ripeness groups, the effectiveness of fertilization, inoculation, and the use of plant growth regulators, etc.

The goal of the research is to specify the possibility and expediency of growing new high-yielding varieties of soybeans of different ripeness groups and the effectiveness of using phosphorus-mobilizing and nitrogen-fixing preparations of biological origin on the drained land of the Western Polissia zone.

Research materials and methods. In 2021, a study on the possibility of growing soybeans on drained sod-podzolic and peat soils under the condition of limited heat resources was started at the Sarny Research Station of the Institute of Water Problems and Land Reclamation of the National Academy of Agrarian Sciences of Ukraine. For research, 5 varieties of soybeans of different ripeness groups (from ultra-early to medium-late) were chosen to establish the possibility of obtaining physiologically ripe seeds in the climatic conditions of the Western Polissia zone. In the experiment, 4 (non-GMO) soybean varieties of Canadian selection (Sevita genetics) and 1 of American selection were studied:

– Yunka, vegetation period is 85 days; the required number of heat units is 2350 CHU;

– Astor, vegetation period is 105 days; the required number of heat units is 2500 CHU;

– Niagara, the vegetation period is 108 days; the required number of heat units is 2600 CHU.

– Neptune, vegetation period is 120 days; the required number of heat units is 2700 CHU.

– SB142 – a variety of American selections, vegetation period is 125 days; the required number of heat units – 2750 CHU.

The above soybean varieties were studied in 2 blocks of field experiments (on drained peat and sod-podzolic light loam soils), which are the most common in the Western Polissia zone; that makes the obtained data representative for the entire region.

In the first block of field research, in 2 identical experiments, the yield potential of new soybean varieties of different ripeness groups and the effectiveness of nitrogen-fixing and phosphorus-mobilizing preparations were studied on drained peat and sod-podzolic light loamy soils. In the experiments, the effectiveness of Rise P and RhizoFix Soy preparations of a well-known Canadian brand Lallemand, the official distributor in Ukraine – the company «Agritema» was studied.

RhizoFix Soy is a high-quality dry inoculant for soybeans that contains at least 4x109/g (4 billion CFU/g) of live cells of Bradyrhizobium elkanii bacteria. The preparation initiates the mass formation of productive nitrogen-fixing nodules already at the initial stages of plant development. That is a dry sterile peat-based preparation of highly effective strains U1301 and U1302 of the bacterium Bradyrhizobium elkanii. **Rise P** is a phosphorus-mobilizing preparation (Bacillius anyloliquefacies bacterium) strain IT 45. Agritema company is the official representative and distributor of these preparations in Ukraine.

Research results and their discussion. When choosing soybean varieties by ripeness, it is necessary to pay attention to the heat supply indicators during the growing season, which include the average monthly air temperatures and their anomalies, the dates of the beginning and end of different temperature periods, in particular the growing season (warm) and the period of the active growing season, the sum of the active and effective temperatures and others [13; 14; 16]. The dates of stable transition of the average daily air temperature over 0, 5, 10, and 15 °C and the duration of the periods with the temperatures above these limits are used to determine the duration of the vegetation of cold-resistant (period with a temperature above 5 °C) and heat-loving (above 10 °C) crops, the period of their intensive growth (over 15 °C), when planning the dates of the start of fieldwork in the spring (dates of transition over 5 °C) and their termination (transition over 0 °C) in autumn, etc. (Table 1).

1. Dates of stable transition of temperature over 0, 5, 10, 15 °C and the duration of the corresponding periods in the drained peat bog massif Chemerne (Rivne region), average for 2007–2021

Value	Dates of temperature transition over certain limits and the duration of the corresponding periods											
	> 0°	< 0°	days	> 5°	< 5°	days	> 10°	< 10°	days	> 15°	< 15°	days
$D_{average}$	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	31.11	331	11.04	25.11	248	30.04	23.10	188	7.06	18.09	141

The analysis of the dates of the stable temperature transition confirms the trend of the last decades towards an earlier start of the growing season (on average 10 days earlier than usual) and a later ending, which ultimately results in an increase in the length of the growing season by an average of 11 days. Over the years of research, its duration varied from 186 to 248 days with an average value of 217 days. The duration of the period of active vegetation (with temperatures > 10 °C) exceeded the norm by an average of 5 days, and the period of intensive vegetation (> 15 °C) by 10 days. In most cases, the growing season began in the third decade of March, and the period of active vegetation began in the third decade of April.

It should be noted that by the data of Belarusian scientists (Republican Center of Hydrometeorology) in the territory of Belarusian Polissia, since 1989, an abnormally early steady transition of the air temperature over 0 °C in spring has also been registered. On average, for 1989–2018, the transition of air temperature over 0 °C in spring occurs 8–13 days earlier compared to the multi-year dates. The transition of air temperature over 5 and 10 °C in spring also occurs earlier than multi-year dates by 7–10 and 2–7 days, respectively [17, 18]. These data are fully consistent with the data of our meteorological station for almost all key indicators.

The sum of active temperatures above 10 °C, at which ultra-early soybean varieties ripen having a duration of the vegetation period (VP) up to 91 days, amounts to 2100–2200 °C; for early ripening varieties with a duration of VP of 91–100 days, the sum of active temperatures is 2200–2600 °C, while for medium-early ripening ones with a duration of VP of 101–110 days, the sum of active temperatures is 2600–2800 °C, and for medium-ripening ones with a duration of VP of 111–120 days, the sum of active temperatures is 2800–3000 °C. There are more late-ripening varieties of soybeans; however, it is impractical to consider them for growing in the Polissia zone [1; 2]. The hydrothermal conditions of active vegetation period on the drained peat bog massif Chemerne of the Sarny research station are given in the table. 2.

Based on the data given in Table 2, it can be stated that having the current heat supply during the growing season in the Western Polissia zone, it is possible to grow ultra-early and early-ripening soybean varieties with a growing season of up to 100 days. However, it should be kept in mind that during the vegetation period heat-loving crops use less active heat than the amount entering the regions of the Western Polissia zone. This is due to the fact that the vegetation period is limited by spring and autumn frosts, which can occur even after the average daily air temperature is higher than 10 °C.

One of the dangerous meteorological phenomena complicating the cultivation of soybeans in the Western Polissia zone is a short frost-free period. Frosts on peat soils are especially dangerous. The duration of the frost-free period on the drained peat bog massif Chemerne of the Sarny research station is given in the table 3.

Based on the data of the weather station of the Sarny research station (the only one in the

2. Hydrothermal conditions during active vegetation period on the drained peat bog massif of the Sarny research station

Years	Active vegetation period							
	Dates		days	Σt > 10 °C	Σp, mm	HTC	T aver, °C	Σd, mb
	beginning	end						
2018	04.04	19.10	198	3186	248	0,78	16,9	1231
2019	23.04	28.04	188	2864	323	1,13	16,2	1121
2020	28.04	16.10	171	2760	342	1,24	16,7	968
2021	30.04	18.09	141	2477	228	0,92	18,0	968
2022	24.04	20.09	149	2412	201	0,83	16,8	982
Average	**25.04**	**30.09**	**158**	**2498**	**302**	**1,23**	**16,3**	**822**

3. Duration of the frost-free period on the drained peat bog massif of the Sarny experimental station

Year	Date of the last spring frost in the air	Date of the first autumn frost in the air	Duration of the frost-free period
2018	28.04	26.09	150
2019	09.05	19.09	132
2020	21.05	20.09	121
2021	09.05	05.09	118
2022	24.05	01.09	99
Average	08.05	23.09	137

system of hydrometeorological observations of Ukraine, which is located directly on the peat bog massif), in some years the last spring frosts in the Western Polissia zone can be observed even in the 2nd decade of May, while the first autumn frosts can be already observed in the beginning of September, as was the case in 2021–2022. The average long-term duration of the frost-free period for the Chemerne peat bog massif is 137 days. However, there are years with an abnormally short frost-free period. So, for example, in 2022, the frost-free period on the Chemerne peat bog massif was only 99 days.

In order to establish the yield potential of the studied soybean varieties on sod-podzolic soils, mineral fertilizers were applied at the rate of $N_{60}P_{60}K_{60}$ and $N_{35}P_{60}K_{90}$ on peat soils. The previous crop in both cases was corn for grain (Table 4).

As the research carried out during 2021–2022 showed, in general, high yields of soybean grain were obtained for all studied varieties that were sown on drained sod-podzolic light loamy soils. The highest yields were obtained for the varieties of the early ripeness group, namely Yunka and Astor varieties – 45,1 and 45,0 t/ha, respectively.

The varieties of the later ripeness group – Niagara and Neptune – lower yields were obtained – 34,3 and 37,6 t/ha, respectively. The American selection variety Sb_{142} (the most late-ripening variety of the studied ones) provided a lower yield compared to the Canadian selection varieties – 27,5 t/ha)

It should also be noted that in the experiments on sod-podzolic soils, it was necessary to desiccate crops of such varieties as Astor, Niagara, Neptune and Sb_{142} for 2 years. Among the studied varieties, only the Yunka variety provided grain with a moisture content of 14,2–14,6% without desiccation for 2 years.

Regarding the studied biological preparations, on sod-podzolic soils, higher efficiency was obtained with the use of RhizoFix Soy inoculant, the increase in yield from its use in the studied varieties was 3,5–4,0 t/ha. The use of the phosphorus-mobilizing preparation Rise P was somewhat less effective, the increase in yield from its use in the studied varieties was 2,8–3,4 t/ha.

When combining RhizoFix Soy inoculant and the phosphorus-mobilizing preparation Rise P the yield increase in the studied varieties was 5,2–7,0 t/ha. The rather low efficiency of inoculation on peat soils is explained by their high nitrogen content.

Results of the research on organogenic soils**.** Soil and climatic conditions on drained peatlands are fundamentally different from soils of mineral origin on dry land located in their immediate vicinity [15; 17]. The study on the possibility of growing soybeans on peat soils in the very first year revealed a number of limiting factors and risks, without taking into account of which a partial or complete loss of the yield is possible. The yield of studied soybean varieties on drained peat soils is given in the Table 5.

4. Effect of nitrogen-fixing and phosphorus-mobilizing preparations on soybean productivity on drained mineral soils, average for 2021–2022

Variety	Duration of the vegetation period, days	Number of heat units,CHU	Soybean yield by the variants of using preparations, tons/ha			
			Without preparations	RhizoFix Soy	Rise P	RhizoFix Soy + Rise P
Yunka	85	2350	38.5	42.5	41.6	45.1
Astor	105	2575	38.0	41.8	41.4	45.0
Niagara	108	2600	28.7	32.3	31.9	34.3
Neptune	120	2700	31.2	34.7	34.0	37.6
Sb_{142}	124	2750	22.3	26.0	25.1	27.5
$Hip_{0.5}$ c/ha			1.75	1.44	1.56	1.72

5. Effect of nitrogen-fixing and phosphorus-mobilizing preparations on soybean productivity on drained peat soils, average for 2021–2022

Variety	Duration of the vegetation period, days	Number of heat units,CHU	Soybean yield by the variants of using preparations, tons/ha			
			Without preparations	RhizoFix Soy	Rise P	RhizoFix Soy + Rise P
Yunka	85	2350	21.0	22.0	25.6	26.2
Astor	105	2575	19.7	20.2	22.8	23.7
Niagara	108	2600	19.2	19.9	22.4	23.2
Neptune	120	2700	15.9	16.4	19.1	19.6
Sb_{142}	124	2750	13.7	14.3	18.3	18.8
Hip $_{0.5}$ c/ha			1.19	1.27	1.17	1.25

In contrast to sod-podzolic light loamy soils, relatively low yields of soybeans were obtained on peat soils for 2 years for all studied varieties. Especially low yields, compared to sod-podzolic soils, were recorded for late-ripening varieties, namely Neptune and Sb_{142}.

The reason for this is that already in the first decade of September, for 2 years in a row, abnormally early first autumn frosts were observed on drained peat soils, which actually ceased the vegetation of all studied soybean varieties. During the period of the first decade of September, only the most early-ripening variety from the studied ones, namely the Yunka variety, managed to form the largest number of physiologically ripe seeds. Its productivity by the variants was 21,0–26,2 t/ha. However, even for the Yunka variety, there was a significant shortfall in the yield, since the vegetation was ceased at the time of intensive grain filling. Thus, the weight of 1000 seeds of the Yunka variety on sod-podzolic soils was 185–190 grams, while on peat soils it was only 140–145 grams. For the rest of the late-ripening varieties (Astor, Niagara, Neptune and Sb_{142}), the plants did not have enough time to form physiologically ripe seeds in the beans of the upper tier.

Regarding the studied biological preparations, higher efficiency on peat soils, compared to the treatment of seeds with RhizoFix Soy inoculant, was provided by the use of the phosphorus-mobilizing preparation Rise P. The rather low efficiency of inoculation on peat soils is due to the high nitrogen content. While the higher efficiency of the phosphorus-mobilizing preparation Rise P is due to the presence of phosphorus in the peat soil in difficult-to-access forms (vivanite), which, due to the action of bacteria contained in this preparation, is transformed into forms more accessible to plants. In the second block of field research, the productivity of short crop rotation with such an alternation of crops as winter wheat, soybean, corn, sunflower, and sugar sorghum was studied. In the second block of research, the Yunka variety was studied – the earliest ripening one of Sevita genetics selection varieties.

The yield of the Yunka soybean variety depending on the fertilization system and the variants of using biological preparations is shown in Table 6.

As a result of study on sod-podzolic soils it has been established that the use of the inoculant RhizoFix Soy and the phosphorus-mobilizing preparation Rise P against along with the application of mineral fertilizers at the rate of $N_{30}P_{30}K_{30}$ provided an increase in the yield of soybeans by 6,7 c/ha, while the application of mineral fertilizers at the rate of $N_{60}P_{60}K_{60}$ provided an increase in the yield of soybeans by 10,5 c/ha. When increasing the rate of application of mineral fertilizers, the effectiveness of the use of the RhizoFix Soy inoculant and the phosphorus-mobilizing preparation Rise P significantly decreased.

By the results of 2-year study, it was found that in general, the effectiveness of using the RhizoFix Soy inoculant and the phosphorus-mobilizing preparation Rise P on peat soils is lower compared to sod-podzolic soils. This is primarily due to lower soybean inoculation efficiency, as peat soils are naturally rich in nitrogen.

In general, the economic expediency of using the above preparations on sod-podzolic soils in soybean crops is more than obvious. Thus, the cost of using both preparations (RhizoFix Soy + Rise P) per 1 ha of sowing area is about UAH 850–900, while the additional profit from their use is approximately UAH 8000–8300.

Conclusions. Based on the meteorological data of the Sarny Research Station, it can be stated that having the current heat supply during the growing season in the area of the Western Polissia on sod-podzolic soils, it is possible to grow ultra-early and early-ripening soybean varieties with a vegetation period of up to 90–100 days and the required number of heat units – up to 2400–2500 CHU.

On sod-podzolic light loamy soils of the Western Polissia zone, under favorable conditions, the yield of ultra-early and early-ripening soybean varieties can be 35–45 t/ha. The use of

6. Effect of fertilization systems on the yield of the Yunka soybean variety on drained land, Sarny Research Station of IWPLR of NAAS, average for 2021–2022

Fertilization systems	Fertilization variants and biological preparations	Yield, c/ha	± to reference		± to standard	
			c/ha	%	c/ha	%
sod-podzolic soil						
Reference	$N_{30}P_{30}K_{30}$	30.8	–	–	–	–
Organic fertilization system	Agrobiotech (Biosyl + Stimpo + Regoplant)	34.1	3.3	10.7	–	–
	Agritema (RhizoFix Soy+Rise P)	37.5	6.7	21.8	–	–
Mineral fertilization system (standard)	$N_{60}P_{60}K_{60}$	41.3	10.5	34.1	–	–
Organo-mineral fertilization system	$N_{60}P_{60}K_{60}$ + Agrobiotech (Biosyl + Stimpo + Regoplant)	43.1	12.3	39.9	1.8	4.4
	$N_{60}P_{60}K_{60}$ + Agritema (RhizoFix Soy+Rise P)	46.8	16.0	51.9	5.5	13.3
Hip $_{0,5}$ c/ha		1.01				
peat soil						
Reference	Without fertilizers	15.1	–	–	–	–
Organic fertilization system	Agrobiotech (Biosyl + Stimpo + Regoplant)	16.4	1.3	8.6	–	–
	Agritema (RhizoFix Soy+Rise P)	20.3	5.2	34.4	–	–
Mineral fertilization system (standard)	$N_{35}P_{60}K_{90}$	21.4	6.3	41.7	–	–
Organo-mineral fertilization system	$N_{35}P_{60}K_{90}$	23.4	8.3	55.0	2.0	9.3
	$N_{35}P_{60}K_{90}$ + (RhizoFix Soy+Rise P)	24.8	9.7	64.2	3.4	15.9
Hip $_{0,5}$ c/ha		0.78				

the RhizoFix Soy inoculant and the phosphorus mobilizing preparation Rise P allows to increase the productivity of soybeans up to 6.7 t/ha.

The results of the study conducted in 2021–2022 show that the main limiting factor of the cultivation of soybeans on the peat soils of the Western Polissia zone is a significantly shorter (compared to the adjacent sod-podzolic soils on dry land) frost-free period. Therefore, for growing soybeans on peat soils, it is advisable to choose ultra-early varieties of soybeans with a vegetation period of up to 85 days and the required number of heat units – up to 2400–2500 CHU, which will allow obtaining physiologically ripe seeds before the onset of first autumn frosts, which in some years may be observed in the first decade of September.

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ПЕРСПЕКТИВИ ВИРОЩУВАННЯ СОЇ В ЗОНІ ЗАХІДНОГО ПОЛІССЯ

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Анотація. *Сучасні кліматичні зміни, а саме суттєве потепління в зонах північного Лісостепу та Полісся України, дають можливості для вирощування низки зернових та зернобобових культур (кукурудзи на зерно, сої, соняшнику та інших), раніше непритаманних для цього регіону. Серед вищевказаних культур саме соя є культурою, яка здатна істотно покращити азотний баланс ґрунту без застосування мінеральних добрив, саме вирощування її деякою мірою може стати альтернативою дороговартісним азотним добривам, адже за умови інокуляції після себе соя може лишати до 80 кг/га біологічного азоту, що еквівалентно 300 кг аміачної селітри, чого достатньо для формування пристойного урожаю озимої пшениці чи кукурудзи. Аналіз метеоданих показує, що при нинішніх показниках теплозабезпеченості вегетаційного періоду в зоні Західного Полісся на дерново-підзолистих ґрунтах можливе достигання ультраранніх та ранньостиглих сортів сої з тривалістю вегетаційного періоду до 90-100 днів і необхідною кількістю теплових одиниць – до 2400-2500 CHU. Встановлено, що основним лімітуючим чинником, що обмежує вирощування сої на торфових ґрунтах зони Західного Полісся, є значно коротший, (порівняно з прилеглими дерново-підзолистим ґрунтами на суходолі) безморозний період. Тому для вирощування на торфових ґрунтах слід обирати ультраранні сорти сої з тривалістю вегетаційного періоду до 85 днів і необхідною кількістю теплових одиниць – до 2400-2500 CHU, що дозволить одержати фізіологічностигле насіння до настання перших осінніх заморозків, які в окремі роки можуть бути відмічені уже в першій декаді вересня. На торфових ґрунтах урожайність сої сорту Юнка по варіантах досліду становила – 15,1-24,8 ц/га, в той час як на прилеглих дерново-підзолистих легкосуглинкових ґрунтах – 30,3-46,8 ц/га. Причиною значно нижчого врожаю сої на торфових ґрунтах є короткий безморозний період порівняно з дерново-підзолистими ґрунтами, який протягом 2-х років поспіль не дав змоги повною мірою реалізувати потенціал досліджуваних сортів. Дослідженнями встановлено, що на дерново-підзолистих легкосуглинкових ґрунтах зони Західного Полісся за сприятливих умов урожайність таких ультраранніх та ранньостиглих сортів сої як Юнка та Астор селекції Sevita genetics (Канада) може становити до 45,0-46,8 ц/га. Застосування інокулянту Різофікс у поєднанні з фосформобілізуючим препаратом Райс Пі дозволяє підвищити урожайність сої до 6,7-7,0 ц/га. Додатковий прибуток від їхнього застосування становить близько 8-8,3 тис.грн з 1 га.*

Ключові слова: *соя, ґрунт, зона Полісся, зміни клімату, біопрепарати, удобрення*