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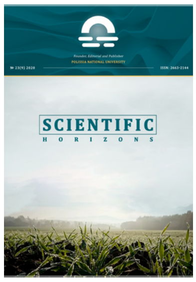

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Regulation of soybean water regime under tillage and fertilisation for sustainable agriculture

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Abstract. Reduced soil moisture due to climate change can reduce crop yields, which negatively impacts food security and food system resilience. Therefore, the study aimed to determine the effect of tillage and fertilisation systems on the accumulation of available soil moisture and soybean yields. The research was conducted on chornozem podsolised medium loamy soil in 2019-2022. The research methods used

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were field, laboratory, comparative and correlation. Soybeans were grown in a 4-field crop rotation according to the generally accepted technology for the conditions of the study region. The dynamics of available moisture reserves in 0-20, 0-40 and 0-100 cm soil layers during the growing season under the influence of tillage and fertilisation systems were presented. The reserves of productive moisture in the soil and the yield of soybean grain under the influence of mouldboard, flat-cut, chisel, disc and differentiated tillage on mineral and organo-mineral nutrition backgrounds were determined. The maximum reserves of available moisture in the root layer of the soil (0-20 cm) on mineral and organic-mineral fertiliser backgrounds were observed in the phase of full germination and flowering of soybeans under chisel tillage, and the minimum under mouldboard tillage. The highest soybean grain yields were obtained with mineral and organo-mineral fertilisation and chisel tillage. In the flowering phase of soybeans under the influence of soil tillage systems, a medium correlation (r = 0.66) was found between grain yield and available moisture reserves in the 0-40 cm soil layer under mineral fertilisation and a weak correlation (r = 0.36) under organic-mineral fertilisation. The fertiliser system had the greatest impact on soybean grain yields (62.5%). The study results can be used in informed decision-making on sustainable soil management and conservation to promote global food security and mitigate climate change

Keywords: moisture reserves; soil layer; grain yield; correlation; share of influence

INTRODUCTION

The world is currently experiencing a shortage of dietary protein, which is set to continue in the coming decades. The issue of reduced dietary protein intake is exacerbated by "hidden hunger" due to a deficiency of vitamins, and macro- and microelements in diets. The traditional way to increase the resources of food and feed plant protein is to grow pulses. Soybeans have the highest protein content in grain, especially lysine. One of the reserves for increasing soybean production is the optimisation of the crop's cultivation technology, using soil cultivation and fertilisation systems. This is particularly relevant in the context of climate change and moisture deficit. Therefore, the development and research of soil cultivation methods that improve the water regime, rational use of available moisture by plants and prevent unproductive losses due to evaporation are promising and should be further refined.

Soybeans (*Glycine max*) are of great economic and social importance due to their high oil content (18%), high-quality protein (up to 40%), positive role in soil fertility, high productivity and profitability (Korobko *et al.*, 2024). Soybeans are a source of polysaccharides, dietary fibre, phytosterols, lecithins, saponins and phytochemicals (isoflavones). Due to its valuable properties, the consumption of soy products in the human diet improves health and reduces the incidence of debilitating diseases, including hyperglycaemia, hypertension, dyslipidaemia, obesity, inflammation, cancer, etc. According to R. Modgil *et al.* (2021), soybeans are also used to produce paper, plastics, pharmaceuticals, inks, paints, varnishes, pesticides, cosmetics, and biodiesel. Soybeans are demanding weather conditions during the growing season. The limiting factor for high soybean yields is providing plants with moisture, especially during flowering, bean formation and grain filling. According to Q. Li *et al.* (2023), grain losses can range from 45 to 70% due to drought. In the context of climate change, it is necessary to minimise the stressful impact of drought on plants and protect the genetic potential of the crop.

One of the main technological operations in agricultural production that directly affects the growth and development of crops is ploughing (Kyrylyuk *et al.*, 2019a). According to M. Xiao *et al.* (2023), deep ploughing is necessary in fields to provide deep-rooted plants with additional nutrients. Equally important aspects of tillage are crop residue management and increasing the even distribution of moisture, increasing the supply of nutrients to crops and reducing pests and weeds (Lavrenko *et al.*, 2021). However, despite the potential benefits, current conventional tillage methods have substantial drawbacks, including increased soil degradation due to increased erosion rates, disruption of soil structure, compaction and destruction of topsoil, loss of moisture and organic matter, and reduced soil biodiversity (Hrytsiuk *et al.*, 2020).

J. Somasundaram *et al.* (2020), and F. Jiang *et al.* (2024) determined that conservation tillage is important in arid regions with a lack of precipitation to preserve moisture and improve agricultural productivity. The study established that zero tillage with straw mulching and zero tillage with stubble leaving increases the moisture content of the soil. Z. Peng *et al.* (2019), and Z. Ren *et al.* (2024) highlighted the positive effects of conservation tillage, namely reducing soil erosion, preserving soil structure, increasing soil organic carbon content, improving soil fertility and moisture retention. All these benefits contribute to sustainable agricultural development and mitigate environmental degradation. According to E. Šarauskis *et al.* (2024), optimising tillage depth can improve soil health, conserve resources, and increase the overall sustainability of agriculture. Conservation tillage systems help to preserve soil and soil moisture and increase crop yields. Decomposed crop residues from conservation tillage improve soil structure and soil health.

Excessive use of synthetic fertilisers can cause changes in soil pH, reduce organic matter content and negatively affect beneficial soil microorganisms. Conversely, the use of organic fertilisers has a positive effect on pH, water-holding capacity, nutrient availability and carbon sequestration, and contributes to soil microbial diversity (Matisic *et al*., 2024). I. Al-Shammary *et al*. (2024) highlighted the positive impact of integrated nutrient management on soil health and crop yields. Smart nutrient management substantially improves nutrient cycling, preventing soil imbalances and acidification. Implementing such practices is essential for sustainable agriculture. Since most soil physical properties, including soil moisture reserves, vary significantly throughout the year, it is necessary to account for these changes during the development of best practices for sustainable soil management and conservation. Rationalisation of tillage practices to replace mouldboard tillage with reduced tillage could be an alternative method to achieve agricultural sustainability and reduce negative impacts on agricultural ecosystems. Therefore, the study aims to determine the peculiarities of the accumulation of available soil moisture and soybean yields under different systems of basic tillage and fertilisation. The objectives of this study were to determine the impact of tillage and fertilisation systems on the amount of available soil moisture in the 0-20 and 0-100 cm soil layers during the germination, flowering and maturation phases of soybean; to compare moisture reserves in the 0-40 cm soil layer during the flowering phase of soybean under the influence of tillage and fertilisation systems; to determine the influence of soil tillage and fertilisation systems on the formation of soybean grain yield; to establish the correlation between soybean yield and moisture reserves in the 0-40 cm soil layer in the flowering phase under mineral and organo-mineral fertilisation and different soil tillage systems.

MATERIALS AND METHODS

The research was conducted in 2019-2022 at the Khmelnytsky State Agricultural Experimental Station on chornozem podsolised medium loamy soil (width 49°45′33″, length 27°23′13″). The soil of the experimental plots was characterised by the following indicators: pHsol – 6.0-6.5, humus content in the topsoil – 2.62-3.12%, total nitrogen – 0.150-0.163%, mobile phosphorus – 12.5-19.61 mg per 1 kg of dry soil, potassium – 65.0-72.0 mg per 1 kg of dry soil. The experimental design includes factors:

- Factor A – soil cultivation: 1. mouldboard (to a depth of 25-27 cm) – control; 2. Flat-cutting (to a depth of 25-27 cm); 3. Chisel (to a depth of 25-27 cm); 4. Disc (to a depth of 10-12 cm); 5. Differentiated (to a depth of 25-27 cm).
- Factor B – fertilisation system: 1. Mineral – $N_{60}P_{60}K_{60}$; 2. Organic-mineral – $N_{30}P_{30}K_{30}$ + winter wheat straw + N_{10} per 1 tonne of straw.

The area of the plot was 40 m^2. The arrangement of variants in the experiment was systematic and replicated four times. Soybeans were grown following conventional technology in a short rotation crop rotation after winter wheat. The crop rotation in the 4-field crop rotation was as follows: winter wheat, soybeans, spring barley, and white mustard. The research was conducted according to generally accepted methods. Soil samples for moisture determination were taken three times during the growing season at the following stages of soybean growth and development: germination, flowering and full maturity. Soil moisture was determined by the thermostat-weight method in layers. At each plot, soil samples were taken with a drill in quadruplicate. After collection, soil samples were placed in aluminium boxes and covered with lids. Then they were weighed and dried in a thermostat for 3 hours at 105°C. The boxes were re-weighed after drying. The reserves of productive moisture in the soil were determined using Formula 1:

$$W_{m^{\cdot}c^{\cdot}} = (hxDvxW)/10, \quad (1)$$

where $W_{m^{\cdot}c^{\cdot}}$ – soil moisture reserves, mm; h – thickness of the soil layer, cm; D_v – bulk density of the soil, g/cm$_3$; W – soil moisture content, %; 10 – conversion factor in mm.

To convert the reserves of productive moisture in mm/ha, the resulting figure was divided by 10. The soybean yield was measured at full ripeness by harvesting from each plot separately and weighing the grain. The mathematical processing of the research results was carried out by the method of analysis of variance using Excel and Statistaca 6.0. The agrometeorological conditions during the years of the study differed significantly from the average long-term parameters in terms of precipitation, temperature and distribution during the growing season. The standards of the Convention on Biological Diversity (1992) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1979) were applied.

RESULTS

In the soybean phase, when mineral fertilisers ($N_{60}P_{60}K_{60}$) were applied, the most moisture (36.8 mm) was contained in the root layer of soil 0-20 cm, which exceeded the control by 2.7 mm (Table 1).

Under chisel and differentiated tillage, the moisture content was not significant (by 0.1 and 0.2 mm) compared to disking. When using an organo-mineral fertilisation system ($N_{30}P_{30}K_{30}$ + winter wheat straw + N_{10} per 1 tonne of straw) in the 0-20 cm soil layer, the maximum moisture content (36.2 mm) was determined at the chisel system, which exceeded the control by 3.0 mm. In the phase of soybean germination, the highest moisture content (212.3 mm) was recorded in the 0-100 soil layer under the differentiated tillage system, which will be used in the future for the growth and development of the crop. In this variant, the height of soybean plants at the stage of completion of budding – beginning of flowering was 3-8 cm higher than the control and other systems on both backgrounds. With mineral fertilisation in the soybean flowering phase, a significant advantage in moisture content in the 0-20 cm and 0-100 cm layers was established when chisel tillage was used.

Table 1. *Dynamics of productive moisture in soybean crops under tillage and fertilisation, mm (average for 2019-2022)*

Soil cultivation (Factor A)	Fertilisation (Factor B)	Vegetation phases					
		growth		blooming		maturation	
		soil layer, cm					
		0-20	0-100	0-20	0-100	0-20	0-100
Mouldboard (control)	M	34.1	210.6	8.7	96.2	13.9	84.1
	OM	33.2	198.0	11.1	100.4	12.3	87.4
Flat cutter	M	34.9	208.4	10.5	84.0	14.3	96.0
	OM	34.7	207.9	9.2	102.8	13.1	82.8
Chiselled	M	36.7	207.1	12.7	107.0	12.2	85.9
	OM	36.2	208.2	12.8	125.9	16.6	107.4
Disc	M	36.8	209.3	9.0	82.4	12.8	83.4
	OM	34.4	206.9	11.1	102.7	12.9	92.8
Differentiated	M	36.6	212.3	10.3	100.7	13.5	82.4
	OM	35.9	212.3	12.4	122.9	14.6	92.8

Note: *M – mineral fertiliser system, OM – organic-mineral fertiliser system*
Source: *compiled by the authors*

When using the organo-mineral fertilisation system, a higher moisture content was also observed in these aspects than in the chisel ploughing. Under the differentiated system, a slight decrease in moisture content was recorded from 0.4 mm in the 0-20 cm layer to 3.0 mm in the 0-100 cm layer on the organic-mineral background. The moisture content during this period had the greatest impact on the formation of the crop yield because the variants with the highest moisture reserve also had the highest soybean grain yield. The lowest moisture content (26.3 mm) in the soil layer 0-40 cm at the flowering stage of soybean plants was found in the case of mouldboard and disk tillage against the background of using an organic-mineral fertiliser system (Table 2).

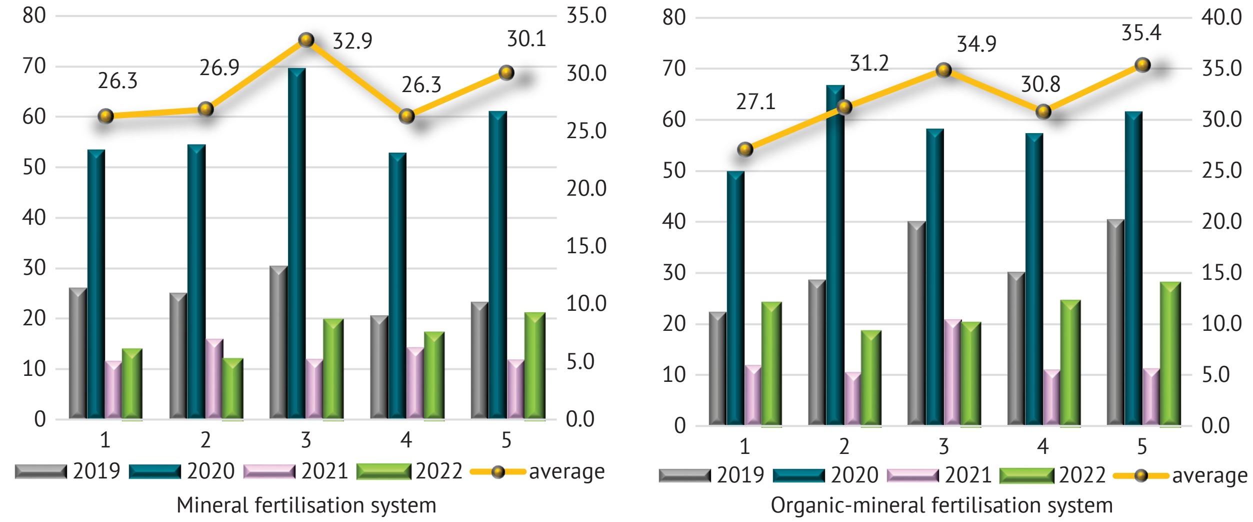

Figure 1. *Moisture reserves in the 0-40 cm soil layer under the influence of tillage and flertilisation at the BBCH stage of 61-65 soybean (2019-2022), mm*
Note: *1 – Mouldboard tillage (control); 2 – Ploughshare tillage; 3 – Chisel tillage; 4 – Disc tillage; 5 – Differentiated tillage*
Source: *compiled by the authors*

The maximum amount of available moisture (32.9 mm) was recorded in the 0-40 cm soil layer at the BBCH stage of 61-65 soybeans using the mineral fertilisation system under chisel tillage. With the differentiated tillage system, the amount of moisture was 31.1 mm, which is 25% and 14% higher, respectively, compared to mouldboard tillage. The use of an organo-mineral fertiliser system ensures the maximum amount of available moisture in the 0-40 cm soil layer under chisel (34.9 mm) and differentiated (35.4 mm) tillage systems. This is 29 and 31% more than in the control. The lowest moisture content (27.1 mm) was found in the case of mouldboard tillage (control). When using the organo-mineral fertilisation system, the content of available soil moisture in the 0-40 cm layer during soybean flowering was 0.8-5.3 mm higher than in the mineral background, depending on the tillage system. Thus, a higher reserve of available moisture in the 0-40 cm soil layer at the stage of soybean flowering was found in the differentiated and chisel system on both fertilisation patterns. A significant advantage of organic-mineral fertiliser (3-18%) over mineral fertiliser was also recorded, which significantly influenced the formation of crop yields. As a result of statistical analysis, the indicators of the share of influence of the studied factors A (tillage) and B (fertiliser system) on the accumulation of moisture in the 0-40 cm soil layer at the BBCH stage of 61-65 soybean were established (Fig. 2).

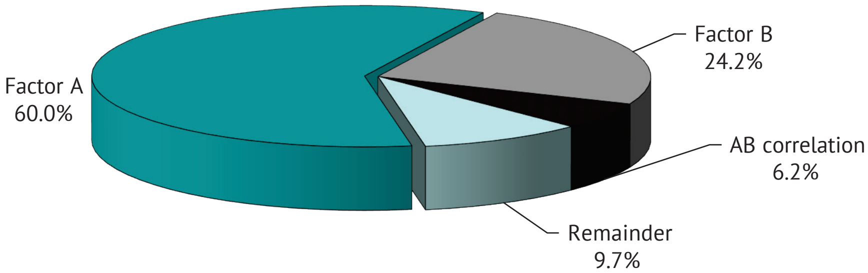

Figure 2. *The share of influence of the studied factors on the amount of moisture in the 0-40 cm soil layer at the stage BBCH 61-65 of soybean*
Note: *HIP$_{05}$ factor A = 0.811 mm, HIP$_{05}$ factor B = 0.207 mm)*
Source: *compiled by the authors*

The two-factor variance analysis determined that the share of the influence of tillage systems on moisture reserves is 60.0%, and the share of fertiliser influence on moisture reserves is 24.2%. The effect of each of the factors on moisture reserves is reliable and significant at the level of $P \leqslant 0.05$. At the same time, the share of interaction between the studied factors is insignificant and amounts to only 6.2%. With the application of mineral fertilisers ($N_{60}P_{60}K_{60}$), the yield of soybean grain on average over the four years of the experiment varied from 2.25 to 2.49 t/ha (Fig. 3).

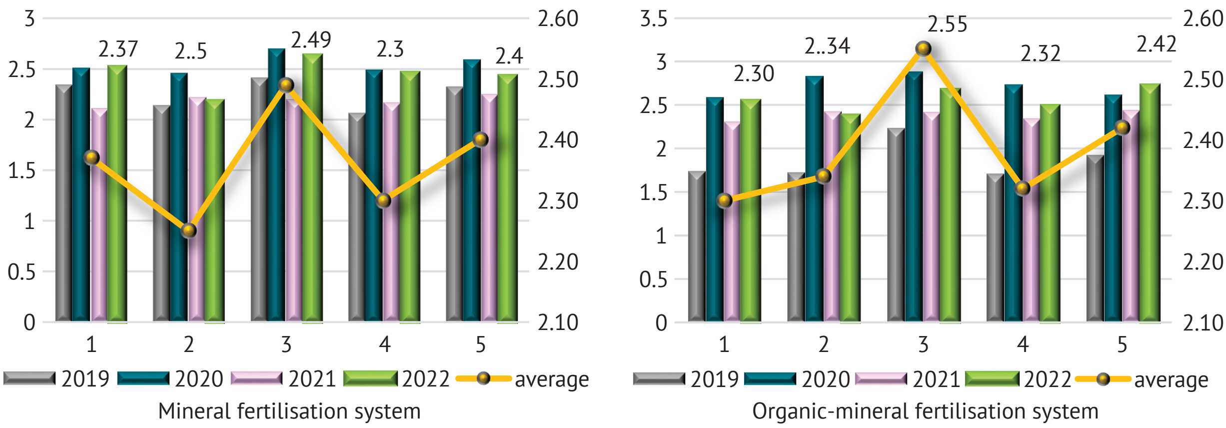

Figure 3. *Soybean grain yield under tillage and fertilisation, t/ha*
Note: *1 – Mouldboard tillage (control); 2 – Ploughshare tillage; 3 – Chisel tillage; 4 – Disc tillage; 5 – Differentiated tillage*
Source: *compiled by the authors*

With the flat-cutting fertilisation system on the mineral fertilisation background, a 5% decrease in soybean grain yield was observed compared to the control. With the use of mineral nutrition and chisel tillage, the maximum soybean grain yield was recorded – 2.49 t/ha. This is 5% more than in the case of mouldboard tillage (control). Under the disc and differentiated tillage system on a mineral fertiliser pattern, the grain yield was 2.3-2.4 t/ha. These figures are only 1-3% higher than the soybean grain yield in the control variant. With the use of the organo-mineral nutrition system, the average soybean grain yield was

2.3-2.55 t/ha over the four years of the experiment. The highest soybean grain yield was formed under the influence of the organic-mineral nutrition system and chisel tillage. This is 10.9% higher compared to mouldboard tillage. The use of organo-mineral fertiliser and differentiated tillage increases soybean grain yield by 5.3% compared to the control.

The organic-mineral fertiliser background exceeded the mineral fertiliser background by 1-4% for all tillage methods, except for mouldboard tillage. When using the organo-mineral system and mouldboard tillage, a slight decrease in soybean grain yield (3%) was observed compared to mineral fertilisation. The moisture content during this period had the greatest influence on the formation of soybean grain yield because the variants with the highest moisture reserve recorded the highest soybean yield. As a result of correlation analysis, the dependence of soybean grain yield on moisture reserves in the 0-40 cm soil layer at the BBCH 61-65 stage was established with the use of mineral fertiliser and different soil tillage (Fig. 4).

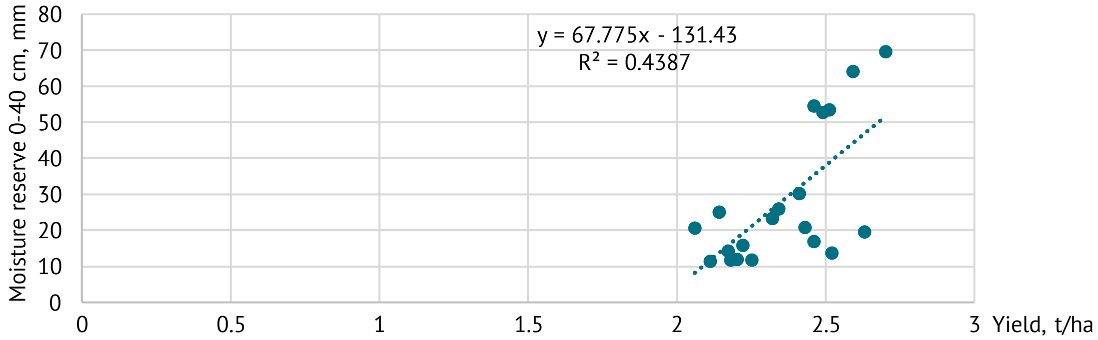

***Figure 4**. Correlation between soybean yield and moisture reserves in the 0-40 cm soil layer in the flowering phase on a mineral fertiliser background under different tillage systems (2019-2022)*
***Source:** compiled by the authors*

The regression model of the dependence of the indicator (Y) – soybean grain yield on moisture reserves in the 0-40 cm soil layer at the BBCH 61-65 stage under different tillage systems on a mineral fertiliser background is as follows (2):

$$Y = 67.775x - 131.43, \qquad (2)$$

where Y – soybean grain yield, t/ha; x – moisture reserves in the 0-40 cm soil layer, mm.

Thus, it is possible to note a strong connection between soybean grain yield and moisture reserves in the 0-40 cm layer in the flowering phase on the mineral background of fertilisation. The analysis of the correlation between soybean yield over the years of research and moisture reserves in the 0-40 cm soil layer determined in the flowering phase under different tillage and mineral nutrition confirms that there is a positive correlation between these indicators of medium strength with $r = 0.66$ ($P \leqslant 0.05$). The significance level did not exceed the 5% level, which confirms statistical reliability. The dependence of soybean grain yield on moisture reserves in the 0-40 cm soil layer at the BBCH 61-65 stage under different tillage systems on the organic-mineral fertiliser background is shown in Figure 5.

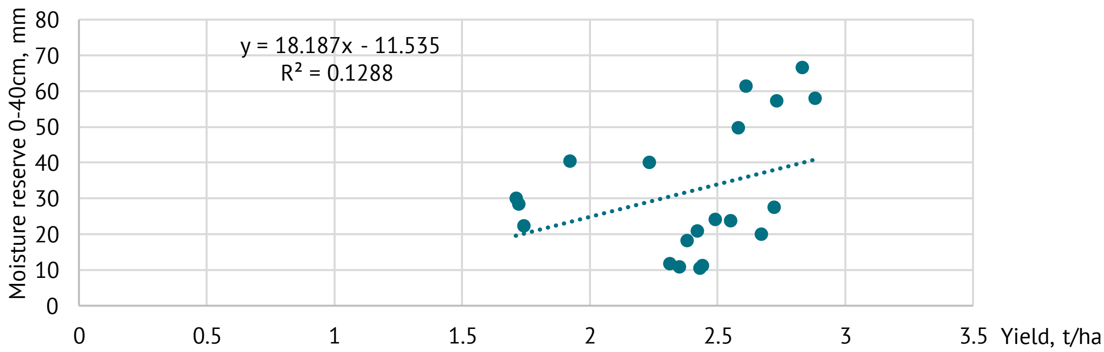

***Figure 5**. Correlation dependence of soybean yield on moisture reserves in the soil layer 0-40 cm in the flowering phase under different tillage systems and organic-mineral fertilisation (2019-2022)*
***Source:** compiled by the authors*

The regression model of the dependence of soybean grain yield (Y) on the amount of moisture in the 0-40 cm soil layer in the flowering phase under the influence of different soil tillage on the organic-mineral fertiliser background is as follows (2):

$$Y = 18.187x - 11.535, \quad (3)$$

where Y – soybean grain yield, t/ha; x – moisture reserves in the 0-40 cm soil layer, mm.

The correlation coefficient between soybean yield and moisture reserves in the 0-40 cm soil layer under different tillage systems and organic-mineral fertilisation is 0.36. This indicates a weak positive correlation between these indicators. The insignificant relationship between yield and moisture level in the tilth layer over the years can be explained by the uneven distribution of precipitation during the growing season. Dry periods during the formation of soybean grain were followed by rainy periods, sometimes with storms. In the analysis of variance of the effect of tillage and fertiliser systems on soybean grain yield, the significance and reliability of the studied factors were determined (Fig. 6).

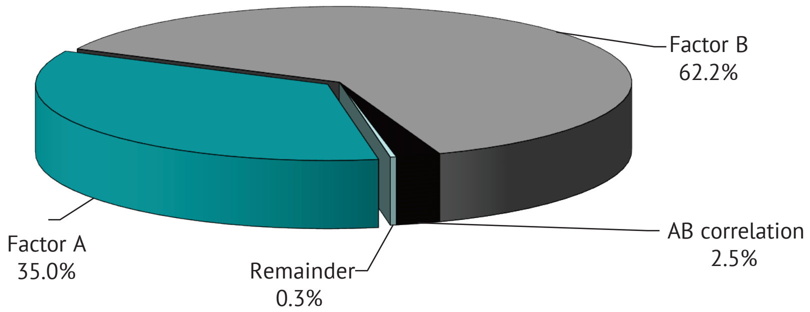

Figure 6*. The share of influence of the studied factors on soybean yield in 2019-2022, %*
Note: *(HIP$_{05}$ (factor A) = 0.009 t/ha, HIP$_{05}$ (factor B) = 0.007 t/ha)*
Source: *compiled by the authors*

Fertilisation (factor B) had a dominant influence on the formation of soybean grain yield with a share of 62.2% ($P \leq 0.05$). The influence of the soil tillage system (factor A) on the formation of soybean grain yield was 35.0%, i.e. almost half. Thus, factor A – fertilisation – has a significant impact on soybean yield among the factors studied. At the same time, the share of interaction between the factors is insignificant and amounted to only 2.5%. The understanding of this interaction is important for sustainable soybean production and facilitating adaptation to climate change. The use of the latest technologies will help to address the new challenges of modern agriculture.

DISCUSSION

As a result of warming, there are droughts, floods, uneven rainfall, etc. All these stressors can pose a threat to global food security. Insufficient soil moisture to satisfy the needs of crops causes drought stress. Reduced soil moisture due to climate change can reduce crop yields, which negatively affects food security and food system resilience (Kyrylyuk *et al*., 2019b; Leal Filho *et al*., 2023). Insufficient soil moisture during the growing season limits the growth and development of plants and reduces their yield potential. Therefore, one of the key challenges for sustainable agriculture is to regulate the soil water regime (Dymytrov & Sabluk, 2022).

The yield of soybean grain also depends on meeting its needs for abiotic factors, including heat and moisture supply not only during certain periods of its growth and development but also throughout the growing season. A. de Almeida *et al.* (2024) and J. Daneshian *et al.* (2024) also noted that the lack of soil moisture is the main cause of abiotic stress, which leads to significant losses in soybean yields in many regions of the world. In this study, the highest amount of available moisture in the 0-20 cm soil layer in the soybean germination phase was found under mineral and organo-mineral fertilisation systems in chisel tillage and the lowest – under mouldboard tillage. The results of the research are consistent with the data by V. Hurtovenko and O. Tsiuk (2023) regarding the impact of tillage on the water regime of typical black soil. The maximum reserves of available moisture in the 0-30 cm and 0-100 cm soil layers during the period of sunflower plant germination were observed under no-till tillage. The lowest reserves of available moisture were observed under the mouldboard multi-depth system of basic tillage.

The current findings correlate with those of M. Furmanetc *et al.* (2021). The study determined that under reduced tillage systems with the use of straw as fertiliser, a significant increase in the amount of productive moisture (by 22%) in the one-metre soil layer in the germination phase of corn, spring barley and winter wheat was observed compared to the mouldboard system. The research of T. Arshad *et al.* (2023) also confirmed the positive impact of conservation tillage on soil moisture reserves. O. Mazur *et al.* (2023) highlighted the dependence of soybean yield not only on the biological characteristics of varieties but also on agroecological conditions of cultivation. A particularly notable effect of drought stress on the growth and development of soybean plants was found at the stage from flowering to seed filling (R1-R4). This confirms the findings of M. Srebric *et al.* (2020), demonstrating that at the fruiting stages, moisture deficit has a greater impact on soybean yield formation. This is confirmed by the results obtained on the dependence of soybean grain yield on moisture reserves in the soil layer (0-40 cm) during flowering on a mineral fertiliser background under different tillage systems. According to I. Didur *et al.* (2023), sufficient soil moisture can improve soybean growth and increase the number of soybean pods. According to V. Furman *et al.* (2022), high temperature and drought stress negatively affect the photosynthetic capacity of soybean leaves, flower opening and seed formation. This is consistent with the results of this study.

The results of the conducted research established the advantage of organic-mineral fertilisation over mineral fertilisation, which influenced the increase in soybean grain yield. These results correlate with the research of P. Mthiyane *et al.* (2024), which emphasises the role of balanced use of organic fertilisers and minimum amounts of chemical fertilisers to maximise nutrient use efficiency. According to M. Furmanetc *et al.* (2021), the use of by-products (straw) to optimise the mineral fertilisation system increases the yield of spring barley (by 0.32-0.22 t/ha), winter wheat (by 0.45-0.36 t/ha) and corn (by 0.60-0.46 t/ha) compared to mineral fertilisation. S. Dymytrov and V. Sabluk (2022) highlighted the positive effect of mycorrhisation of winter wheat and maize roots by mycorrhizal fungi on the accumulation of productive moisture reserves in the topsoil. An increase in the amount of available moisture in the 0-30 cm soil layer was observed from 5.3 to 47.8% compared to the variant without mycorrhisation. This helps to increase crop yields and address the problems associated with climate change, declining soil fertility and food security. Addressing these challenges is key to achieving the United Nations Sustainable Development Goals (SDGs) by 2030, in particular SDG 2 (Zero Hunger) and SDG 13 (Climate Action), which focus on ending hunger, promoting sustainable agriculture, and taking urgent action to mitigate climate change (Sustainable Development Goals, n.d.). These results can be used in optimisation of land use patterns, preventing soil erosion and modelling hydrological processes.

CONCLUSIONS

In the root layer of the soil (0-20 cm), the highest reserves of available moisture (36.6-36.8 mm) in the phase of full germination of soybeans were on the mineral pattern of nutrition under chisel, differentiated and disc tillage, and the lowest (34.1 mm) – under mouldboard tillage. On the organo-mineral pattern of nutrition, the use of the chisel tillage system provided the highest supply of available moisture in the soil – 36.2 mm. During the flowering period of soybeans, the highest reserves of available soil moisture in the arable layer were observed in chisel tillage using mineral and organic-mineral nutrition systems – 107.0 and 125.9 mm, respectively. During the flowering period of soybeans, the advantage in moisture reserves in the one-metre soil layer on the organic-mineral fertiliser background compared to the mineral background was found to be 4.2-22.2 mm in all tillage systems. The highest reserve of available moisture in the 0-40 cm soil layer was observed with mineral fertiliser in chisel tillage (32.9 mm) and organic-mineral fertiliser in chisel (34.9 mm) and differentiated (35.4) tillage systems. The content of available moisture in the 0-40 cm soil layer during soybean flowering using the organic-mineral fertiliser system was 3-18% higher than in the mineral fertiliser system, depending on soil tillage. The maximum impact on the accumulation of productive moisture reserves in the 0-40 cm soil layer at the stage of soybean flowering was found in soil tillage systems (60.0%). The impact of fertilisation on productive moisture reserves was 24.2%

The highest soybean yields (2.49 and 2.55 t/ha) were obtained with chisel tillage and mineral and organic-mineral fertilisation, which is 5 and 12% higher than in the control. On the organo-mineral fertiliser pattern, soybean yields under all no-till tillage were 1-4% higher than under mineral fertiliser and control. An average direct correlation ($r = 0.66$) exists between soybean yield and productive moisture reserves in the 0-40 cm soil layer in the flowering phase of soybean under different tillage systems on a mineral fertiliser background. On the organic-mineral fertiliser background, a weak positive correlation ($r = 0.36$) was found between soybean grain yield and moisture reserves in the 0-40 cm soil layer under different tillage systems. Soil tillage systems had a significant impact on soybean grain yield (35.0%). The fertilisation system had the greatest influence on soybean grain yield – 62.5% ($P \leq 0.05$). Further research may focus on assessing the physical and chemical parameters of soils under the influence of different tillage and fertilisation systems in the context of climate change.

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CONFLICT OF INTEREST

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Регулювання водного режиму посівів сої за дії обробітку ґрунту і удобрення для сталого сільського господарства

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Анотація. Зниження вологості ґрунту внаслідок зміни клімату може призвести до зменшення урожайності культур, що негативно впливає на продовольчу безпеку і стійкість харчових систем. Тому метою цього дослідження було з'ясувати вплив обробітків ґрунту і систем удобрення на накопичення доступної вологи у ґрунті та урожайність сої.Дослідження були проведені на чорноземному опідзоленому середньо-суглинковому ґрунті протягом 2019-2022. Застосовували методи досліджень – польовий, лабораторний, порівняльно-розрахунковий і кореляційний. Сою вирощували у 4-пільній сівозміні за загальноприйнятою технологією для умов регіону дослідження. Представлено динаміку запасів доступної вологи у 0-20, 0-40 і 0-100 см шарах грунті впродовж вегетаційного періоду за дії систем обробітку ґрунту і удобрення. Було визначено запаси продуктивної вологи в ґрунті та урожайність зерна сої за дії полицевого, плоскорізного, чизельного, дискового і диференційованого обробітку ґрунту на мінеральному і органо-мінеральному фонах живлення. Максимальні запаси доступної вологи у кореневмісному шарі ґрунту (0-20 см) на мінеральному і органо-мінеральному фонах удобрення спостерігали у фазі повних сходів і цвітіння сої за чизельного обробітку ґрунту, а мінімальні за полицевого. Найвищі показники урожайності зерна сої отримано за мінерального і органо-мінерального удобрення і чизельного обробітку ґрунту. У фазі цвітіння сої за дії систем обробітку ґрунту між урожайністю зерна і запасами доступної вологи у шарі грунту 0-40 см встановлено середню кореляційну залежність (r = 0,66) за мінерального удобрення і слабку кореляційну залежність (r = 0,36) за органо-мінерального удобрення. На урожайність зерна сої максимальний вплив (62,5 %) виявила система удобрення. Результати цього дослідження можуть бути використані у прийнятті рішень стосовно сталого управління і збереження ґрунтів для сприяння глобальної продовольчої безпеки і пом'якшення змін клімату

Ключові слова: запаси вологи; шар ґрунту; урожайність зерна; кореляція; частка впливу