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Development and implementation of energy-saving technologies for growing sunflower hybrids in the south of Ukraine

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Abstract. The development and implementation of energy-saving technologies for growing sunflower hybrids is a relevant area of research to ensure sustainable development of the agricultural sector and environmental protection. The study aimed to analyse the impact of different tillage methods on sunflower yields in southern Ukraine. To achieve this goal, a field study was conducted in the fields of the Educational and Research Centre of Mykolaiv National Agrarian University in 2021-2023. The study determined that the method of soil cultivation has a significant impact on its density, moisture reserves and structural stability. Reducing the intensity of cultivation, especially when using no-till, preserves moisture in the soil more effectively, but increases its density. With no-till, before sowing sunflower, it was 1.11 g/cm^3 at a depth of 0-10 cm and 1.21 g/cm^3 before harvesting, while with conventional tillage, the soil density was 1.02 g/cm^3 and 1.1 g/cm^3, respectively. In addition, no-till tillage provided

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the best sunflower productivity indicators, including 1000-seed weight (47.3 g), basket diameter (20.2 cm) and yield (2.6 t/ha). No-till cultivation also improves the quality of the sunflower crop, increasing the content of oleic acid (86.5%) and crude fat in the seeds (48.3%). The obtained results contribute to the development of integrated approaches to the introduction of energy-saving technologies in the cultivation of sunflower hybrids in southern Ukraine, which will increase production efficiency and reduce production costs

Keywords: soil cultivation; yield; seed quality; field and laboratory experiments; agrophysical soil parameters

INTRODUCTION

Energy-saving technologies play a key role in modern agriculture, as they help to reduce production costs and reduce the negative impact on the environment. With rising energy prices and increasing pressure on natural resources, efficient use of energy is becoming a necessity. The cultivation of sunflower hybrids, one of the leading oilseeds, is a significant segment of the agricultural sector, where the introduction of energy-saving technologies can bring significant economic and environmental benefits (Casali *et al*., 2022). Global trends in agricultural development are increasingly focused on the integration of innovative solutions that reduce energy use and increase crop yields. Countries such as the United States, Canada, Brazil, China, and the European Union are actively implementing modern agricultural practices and technologies that optimise all stages of the production process (Melnyk *et al*., 2019; Basile *et al*., 2021).

Y. Majeed *et al.* (2023) argue that the introduction of energy-saving technologies in agriculture is extremely important for ensuring the sustainable development of the agricultural sector. They emphasise that the efficient use of energy resources not only reduces production costs but also helps to reduce environmental impact. T. Vician *et al.* (2022) emphasises that modern agrotechnical methods, such as precision farming, minimal and no-till tillage, and the use of renewable energy sources, have significant potential to reduce energy consumption and increase crop productivity. At the same time, to achieve sustainability in the agricultural sector, it is necessary to implement integrated approaches that consider the specific climate and soil conditions of the regions. J. Akuaku *et al.* (2020) also emphasise the importance of adapting these technologies to specific conditions, which allows for the most efficient use of natural resources and high yields with minimal energy consumption.

Sunflower is a crop widely grown in Ukraine and holds a leading position in the global production and export of sunflower oil. However, according to S. Kalenska *et al.* (2020), traditional methods of growing this crop are often accompanied by significant energy consumption, which necessitates the modernisation of production processes. The use of energy-saving technologies in growing sunflower hybrids includes the introduction of modern agrotechnical techniques, the selection of energy-efficient varieties and hybrids, and the optimisation of all stages of the production process. Effective implementation of such technologies can involve several aspects. This includes the use of precision farming systems that optimise the use of fertilisers, plant protection products and water resources, the transition to no-till and minimum tillage systems that reduce energy consumption for mechanical operations, and the use of renewable energy sources such as solar and wind power to meet the needs of farms (Ryzhenko *et al*., 2020; Duca *et al*., 2022)).

It is worth noting that several scholars, including O. Kovalenko *et al.* (2024), agree that the development and implementation of energy-saving technologies in the cultivation of sunflower hybrids not only increases the economic efficiency of production but also contributes to the conservation of natural resources and reduces greenhouse gas emissions. This is in line with global trends towards sustainable development and environmental safety. Thus, energy-saving technologies are becoming an important component of modern agricultural production, striking a balance between economic benefits and environmental responsibility.

Despite a considerable amount of research on the implementation of energy-saving technologies in agriculture, there are some gaps in the literature, especially when it comes to specific regional conditions such as southern Ukraine. This region is characterised by hot summers with high temperatures and low humidity, which affects sunflower cultivation and necessitates integrated solutions for efficient energy use. Thus, the purpose of this study was to investigate the impact of different tillage technologies on the yield of sunflower hybrids in the south of Ukraine. To achieve this goal, the following tasks were performed: to analyse the impact of different tillage methods on soil agrophysical properties, as well as to assess the impact of each method on sunflower yield and productivity indicators.

MATERIALS AND METHODS

To study the energy-saving technologies for growing sunflower hybrids, a field experiment was conducted using laboratory and field observations of the growth and development of plants grown under different methods of soil cultivation in southern Ukraine. The study was conducted in the fields of the Educational and Research Centre of Mykolaiv National Agrarian University in 2021-2023.

The soil of the experimental plots is represented by southern chernozem, low-power, low-sunny, heavy loamy on loess. The reaction of the soil solution was neutral (pH 6.8-7.2). The humus content in the 0-30 cm layer was 123-125 g kg^{-1}. On average, the topsoil contained the following: nitrates (by the method of interaction of nitrates with disulfophenolic acid, from which trinitrophenol is formed). In an alkaline environment, it gives a yellow colour due to the formation of potassium trinitrophenolate (or sodium, depending on the alkali used) in an amount equivalent to the nitrate content) – 15-25 mg/kg^{-1}, mobile phosphorus (by extraction of mobile phosphorus and potassium compounds from the soil with a 1% solution of ammonium carbonate, pH 9, at a temperature of 25 ± 20°C) – 41-46 mg/kg^{-1}, exchangeable potassium (flame photometer) – 389-425 mg/kg^{-1} of soil (Panfilova, 2021).

The subject of the study was the sunflower hybrid P64HE133. The sunflower was sown at a soil temperature of 8-10°C with a seeding rate of 50,000 germinating seeds per hectare. The experiment was replicated three times. The total area of the experimental plot was 320 m^2, while the area of the accounting plot was 90 m^2. The sunflower's predecessor was winter wheat. The experimental design included three variants of tillage methods:

1. Traditional soil cultivation includes ploughing to a depth of 25 cm, harrowing and cultivation to a depth of 5-10 cm.

2. Minimum tillage, which included reducing the number of mechanical tillage operations by using disc harrows to a depth of 10-15 cm.

3. No-till tillage – when the soil is not subjected to traditional tillage using ploughs or harrows. Crop residues remain on the surface, which helps to protect the soil from erosion and retain moisture.

The study determined the following agrophysical parameters of the soil: density of the topsoil – by the method of M.A. Kachinsky, whereby the density in different layers was assessed every 10 cm to a depth of 30 cm, the content of water-resistant soil aggregates – by the Savvinov method, soil moisture – by the thermostat-weight method, whereby the moisture content in different layers was assessed every 10 cm to a depth of 100 cm by drying at a temperature of 105°C. Overall sunflower plant productivity data, including the diameter of the boll and the weight of 1000 seeds, were determined directly at harvest by measuring and weighing. The crude fat content of the seeds was determined by the defatted residue (according to Rushkovsky method), and the oleic acid content of the oil was determined by the refractometric method. Harvest accounting was carried out by the method of continuous harvesting on the accounting plot, with further conversion per hectare.

All experiments were repeated three times for each variant of the experiment. The obtained research results were processed for reliability by applying the multivariate method of MANOVA analysis of variance using Microsoft Excel software and the Statistica 10 software package. Differences in the results obtained are possible at a significance level of $P \leqslant 0.05$ according to the Student's criterion. The authors adhered to 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

Different tillage methods can significantly change the soil structure, water regime and aeration, which in turn affects plant growth and development. Soil cultivation is also one of the key agronomic operations that affect the agrophysical properties of the soil, particularly its density. The study found that there is an influence of tillage methods (traditional, minimal and no-till) on soil density at different depths before sowing and before harvesting sunflower during 2021-2023. In particular, under traditional tillage, the lowest density was found in the topsoil (0-10 cm) before sowing – 1.02 g/cm^3, which indicates sufficient soil loosening. Minimal tillage led to an increase in soil density compared to the conventional method at all depths, which may be due to a reduction in the number of mechanical tillage operations and less intensive loosening. No-till tillage has the highest soil density among all tillage methods, which is due to the absence of mechanical tillage, which leads to the accumulation of organic residues on the soil surface (Table 1).

***Table 1**. Influence of tillage methods on soil density (average for 2021-2023)*

Soil cultivation method	Soil layer, cm	Soil density, g/cm^3	
		before sowing	before harvesting
Traditional soil cultivation	0-10	1.02	1.1
	10-20	1.12	1.16
	20-30	1.21	1.25
Minimum soil cultivation	0-10	1.06	1.13
	10-20	1.16	1.2
	20-30	1.28	1.33
No-till tillage	0-10	1.11	1.21
	10-20	1.22	1.3
	20-30	1.31	1.36

***Source:** compiled by the authors*

Thus, a decrease in the intensity of tillage leads to an increase in soil density at all depths, which should be addressed when choosing a tillage method to ensure optimal conditions for sunflower plant growth. Furthermore, productive soil moisture reserves are one of the key factors affecting the growth and development of crops, including sunflowers. Soil moisture depends on many factors, including soil tillage methods, which can significantly affect the soil water regime. Analysis of the data shows that a decrease in tillage intensity (from conventional to no-till) causes an increase in productive moisture reserves at any specific depths. The no-till method is regarded as the most effective in preserving soil moisture, which can contribute to better conditions for plant growth, especially in the context of insufficient moisture. Soil moisture before harvesting under no-till in the 0-100 cm layer was 135 mm, which is 9 mm more than under minimum tillage and 25 mm more than under conventional tillage (Table 2).

***Table 2**. Impact of tillage methods on productive moisture reserves, mm (average for 2021-2023)*

Soil cultivation method	Soil layer, cm	Soil moisture content, %	
		before sowing	before harvesting
Traditional soil cultivation	0-20	25	31
	20-50	46	61
	50-100	39	41
	0-100	94	110
Minimum soil cultivation	0-20	26	32
	20-50	50	68
	50-100	42	49
	0-100	104	126
No-till tillage	0-20	30	35
	20-50	50	71
	50-100	47	62
	0-100	114	135

***Source:** compiled by the authors*

The content of water-resistant soil aggregates is an important indicator that characterises the structural stability of the soil and its ability to resist erosion. At the same time, the ability of the soil to retain its structure under the influence of water depends on the method of tillage, which affects the size and stability of the aggregates. The study confirms that all three tillage methods lead to an increase in the content of water-resistant aggregates in the soil before harvest. No-mouldboard tillage demonstrates the largest increase in the total content of water-resistant aggregates (+10%) at the time of sunflower harvest (Table 3).

***Table 3**. Content of water-rich aggregates (>0.25) under different tillage methods, % (average for 2021-2023)*

Soil cultivation method	Soil layer, cm	Number of water-intensive aggregates (>0.25), %	
		before sowing	before harvesting
Traditional soil cultivation	0-10	32.3	32.6
	10-20	32.5	33.2
	20-30	32	32.5
	30-40	31.3	31.8
	0-40	32.1	32.7
Minimum soil cultivation	0-10	32.1	35.3
	10-20	32.8	34.8
	20-30	32.5	34
	30-40	31.2	31.4
	0-40	32.3	32.8
No-till tillage	0-10	32.4	35.9
	10-20	32.9	35
	20-30	32.6	34.5
	30-40	31.7	33.4
	0-40	32.4	33.2

***Source:** compiled by the authors*

In general, tillage methods are important for ensuring the growth and development of sunflower plants under optimal conditions. Reducing the intensity of tillage leads to an increase in soil density and moisture

reserves, while conventional tillage and no-till tillage show the lowest and highest soil density, respectively. At the same time, no-till is the most effective in preserving soil moisture, which can contribute to better conditions for plant growth and development, especially in conditions of insufficient moisture. In addition, all three tillage methods lead to an increase in the content of water-resistant aggregates in the soil before harvesting, with no-till showing the largest increase at the time of sunflower harvesting. Thus, the choice of tillage method is crucial for ensuring the growth and development of sunflower plants in optimal conditions, addressing soil density, water regime and soil structure. Sunflower productivity indicators, such as 1000-seed weight and kernel diameter, are important because they help to assess the efficiency of growing the crop and have a direct impact on its yield. An increase in the weight of 1000 seeds may indicate a higher number of seeds per boll, which in turn will lead to higher yields. A larger basket diameter may indicate a larger number of flowers and, consequently, a larger number of seeds. Thus, high values of these parameters lead to higher sunflower yields, while lower values lead to lower yields. This data is important for producers as it helps them choose the best agronomic practices and identify ways to improve sunflower cultivation to obtain high and stable yields.

In the study, under no-till tillage, sunflower plants formed the highest values for both the weight of 1000 seeds (71.3 g) and the diameter of the sunflower basket (16.2 cm). This indicates that this method provides the best conditions for the growth and development of culture. Minimum tillage provided slightly lower values compared to conventional tillage. The weight of 1000 seeds (65.4 g) and the diameter of the head (15.9 cm) of sunflower were reduced, but not significantly. This may be a result of less soil disturbance, which helps to preserve its structure. Traditional cultivation demonstrates the lowest values for both indicators. The weight of 1000 seeds (63.2 g) and the diameter of the basket (15.3 cm) are significantly lower compared to the other two methods (Table 4).

***Table 4**. Weight of 1,000 seeds and diameter of the sunflower basket (average for 2021-2023)*

Soil cultivation method	Mass of 1000 seeds, g	Basket diameter, cm
Traditional soil cultivation	63.2 ± 0.6	15.3 ± 0.4
Minimum soil cultivation	65.4 ± 0.3	15.9 ± 0.2
No-till tillage	71.3 ± 0.2	16.2 ± 0.5

***Source:** compiled by the authors*

The study also found that the method of soil cultivation significantly affected sunflower yields. Thus, the yield of the crop under conventional tillage ranged from 3.54 to 3.58 t/ha over the three years, with an average of 3.56 t/ha. Yields under minimum tillage ranged from 3.81 to 3.89 t/ha with an average of 3.85 t/ha and remained close to the conventional tillage. However, under no-till cultivation, sunflower yields were higher and ranged from 3.91 to 3.98 t/ha with an average of 3.95 t/ha for the period 2021-2023 (Table 5).

***Table 5**. Sunflower seed yield, t/ha*

Soil cultivation method	Year			Average for 2021-2023
	2021	2022	2023	
Traditional soil cultivation	3.57	3.58	3.54	3.56
Minimum soil cultivation	3.85	3.81	3.89	3.85
No-till tillage, cm	3.91	3.95	3.98	3.95
$Hip_{0.05}$	0.05	0.12	0.08	0.12

***Source:** compiled by the authors*

Analysis of the quality of oilseeds is an integral part of sunflower product evaluation. Oilseeds are a key component to produce sunflower seed oil, so it is important to have a clear understanding of their quality. Quality indicators, such as crude fat content and oleic acid content, help to evaluate the raw material and determine its suitability to produce high-quality sunflower oil. The crude fat content of sunflower seeds is determined by the amount of fat-like substances contained in one gram of seeds. This indicator is relevant as it determines the oil content that can be extracted from the seeds and, accordingly, the production of a quantitatively significant amount of oil. Oleic acid, a monounsaturated fatty acid, is one of the key components of sunflower oil. Its content in the raw material determines the quality of the oil and its beneficial properties. A high oleic acid content often indicates a high quality of raw materials and the potential for producing high-quality oil. The results of the study confirmed that soil cultivation methods affect the quality composition of sunflower seeds. Thus, the content of oleic acid in sunflower oil under conventional tillage

was 88.8%, and the content of crude fat was 50.6%. With minimal tillage, the oleic acid content was 89.7% and the crude fat content was 51.2%. Under no-mouldboard tillage, the quality characteristics of sunflower seeds were the highest and amounted to an oleic acid content – of 90.5%, and crude fat content – of 52.5% (Table 6).

***Table 6**. Oleic acid content in sunflower oil and crude fat in seeds, % (average for 2021-2023)*

Soil cultivation method	Oleic acid content	Crude fat content
Traditional soil cultivation	88.8	50.6
Minimum soil cultivation	89.7	51.2
No-till tillage, cm	90.5	52.5

***Source:** compiled by the authors*

Thus, conventional tillage accumulated the highest content of oleic acid in oil and crude fat in sunflower seeds, while no-till tillage showed the lowest values. This may be due to the varying degrees of nutrient retention in the soil and plants when different cultivation methods are used. According to the study, the problem with no-till tillage is that considering all aspects (moisture, soil aggregates, seeds), the yield increase with such tillage may be insignificant. Therefore, to increase yields in such conditions, other methods can be used, such as minimum tillage technology.

Summarising the results of the study, it is possible to state that soil tillage methods affect soil density, productive moisture reserves, water-resistant soil aggregates, 1000-seed weight and sunflower head diameter, as well as the yield of the crop itself. Traditional tillage provided the best conditions for sunflower growth and development, while no-till tillage showed the lowest values for most indicators. To increase yields in southern Ukraine, farmers can take measures to improve soil quality, such as using minimum or combined tillage technologies. Thus, the development and implementation of energy-saving technologies for growing sunflower hybrids in southern Ukraine is a key step towards optimising agricultural practices in this part of Ukraine.

DISCUSSION

The development and implementation of energy-saving technologies in sunflower cultivation is an urgent task due to the need to ensure sustainable development and reduce the negative impact of the agricultural sector on the environment. The use of such technologies can help reduce energy and resource consumption, which in turn will reduce emissions into the atmosphere and ensure more environmentally friendly crop cultivation (Avgoustaki & Xydis, 2020; Sydiakina & Ivaniv, 2023). Most authors agree that global warming is causing significant changes in the environment that require a response from agriculture (Casali *et al.*, 2022).

T. Kachanova *et al.* (2023) investigate the optimal rates of mineral fertilizers to enhance the yield of high-oleic sunflower hybrids in the Southern Steppe of Ukraine, revealing that the Kadet hybrid achieved the highest yield and seed quality with $N_{90}P_{90}K_{60}$ fertilization. Results indicate that proper mineral fertilization significantly boosts crop productivity, with the Kadet hybrid yielding 24.1% more than with lower fertilizer rates, while also showing superior oil quality compared to other hybrids under various fertilization conditions. V.I. Trotsenko *et al.* (2020) emphasise that the use of energy-saving technologies that help to use resources efficiently, reduce environmental impact and increase productivity is becoming an increasingly important aspect of modern agriculture. This approach not only contributes to the sustainable development of the industry but also ensures food security and preserving ecosystems for future generations. In addition, energy-saving technologies can help reduce dependence on imported oil, increase the country's energy independence and create new opportunities for agricultural development. In this regard, Y. Domaratskiy *et al.* (2023) and I.O. Kolosok (2022) note that the development and implementation of energy-saving technologies in sunflower cultivation should be one of the priority areas for agricultural development in Ukraine. This will not only reduce the negative impact of the agricultural sector on the environment but also ensure the sustainable development of the industry.

The use of modern control and automation systems for sunflower cultivation opens great opportunities for optimising the use of fertilisers and crop protection products. This is becoming a key aspect in ensuring sustainable and environmentally friendly sunflower cultivation. One of the main advantages of these systems, according to E.D.S. Coêlho *et al.* (2022), is their ability to accurately dose and distribute fertilisers and chemical protection products on the field, which avoids oversaturation of the soil with chemicals and prevents groundwater pollution and environmental degradation. In addition, according to O.I. Tsyliuryk *et al.* (2021), modern control and automation systems provide the ability to monitor the level of soil and water pollution in real-time. This makes it possible to respond promptly to problems and take the necessary measures to eliminate them. This approach helps to reduce emissions of harmful substances into the environment and improve the environmental sustainability of the agroecosystem (Demir, 2020).

The use of stress-tolerant sunflower hybrids has a significant impact on yields and resistance to pests and diseases. Stress-tolerant sunflower hybrids are characterised by their ability to adapt to adverse environmental conditions such as drought, soil salinity, or excessive irrigation (Nardón *et al.*, 2021). These hybrids demonstrate better productivity and crop preservation under stressful conditions. V. Giannini *et al.* (2022) confirm that the use of such hybrids can reduce the amount of pesticide use and increase yields by 20%. A comparison of the results with previous studies in this area confirms the consistency and complementarity of the findings. According to C.M. Nobile *et al.* (2020), this reduces production costs and the negative impact of agricultural activities on the environment. In addition, the use of no-till tillage systems reduces fuel and energy consumption, which reduces CO_2 and other harmful emissions into the environment. This contributes to a more sustainable and environmentally friendly system of growing crops, including sunflowers.

The results of the study by M. Janmohammadi and N. Sabaghnia (2023) are also echoed in the present study that the use of no-till tillage systems has a significant impact on soil fertility. The study determined that no-till tillage systems help to preserve soil structure and water permeability. This retains moisture in the soil and prevents erosion, which is important for maintaining soil fertility and increasing crop yields. V. Pichura *et al.* (2023), and A.U. Jan *et al.* (2022) point to the importance of optimising tillage technologies, especially in the southern regions. Considering the specifics of these zones, in particular, drought management and soil moisture conservation, is extremely important for achieving successful crop production results. According to research, optimal tillage practices can have a significant impact on conserving resources and increasing sunflower yields in conditions of insufficient moisture. In addition, according to R. Puttha *et al.* (2023), geospatial models can be used to analyse various factors, such as soil structure, climatic conditions, and other factors, to optimise sunflower cultivation processes. This makes it possible to accurately determine the optimal tillage and irrigation methods for each specific site, which maximises yields and reduces resource use.

In general, the various results of the researchers and the study demonstrate that the use of energy-saving technologies in sunflower cultivation is an important step towards the sustainable development of the agricultural sector. These technologies not only help to conserve natural resources and reduce the negative impact on the environment but are also an important element of economically sustainable crop production and meet modern requirements for sustainable development. Thus, the growing awareness of environmental issues and the need for sustainable production requires continuous improvement of agricultural practices. An important part of this process is the integration of scientific research, innovative technologies and efficient resource management. Modern approaches to soil cultivation, the use of resistant hybrids and crop varieties, and crop control open up new opportunities to increase production while reducing negative environmental impact. Thus, the combination of scientific knowledge, technology and environmental responsibility can contribute to a sustainable and efficient agricultural system that meets the needs of modern society without harming the environment.

CONCLUSIONS

The study found that the choice of soil cultivation method has a significant impact on its agrophysical parameters, in particular, density, productive moisture reserves and structural stability. Reducing the intensity of tillage, especially when using no-till, leads to an increase in soil density at all depths. Thus, the soil density under no-till was 1.11 g/cm³ at a depth of 0-10 cm before sowing and 1.21 g/cm³ before harvesting, while conventional tillage formed a density value of 1.02 g/cm³ and 1.1 g/cm³, respectively.

Research has confirmed that no-till is the most effective in preserving soil moisture. Before harvesting, the soil moisture content in the 0-100 cm layer under no-till was 135 mm, which is 25 mm more than under conventional tillage (110 mm) and 9 mm more than under minimum tillage (126 mm). This is especially important for conditions with insufficient moisture, where additional reserves of productive moisture can significantly improve the growth and development of crops. As for sunflower productivity indicators, no-mouldboard tillage provided the highest values for both the weight of 1000 seeds (47.3 g) and the diameter of the basket (20.2 cm), which indicates its effectiveness in creating optimal conditions for the growth and development of the crop. With minimal tillage, the weight of 1000 seeds in sunflower were 45.4 g and the diameter of the head was 19.4 cm, while traditional tillage provided the lowest values: the weight of 1000 seeds reached 38.2 g and the diameter of the head was 17.6 cm.

Sunflower yield also depended on the method of tillage. The highest yield of the crop on average over the years of research – 2.6 t/ha – was established with no-mouldboard tillage. Minimal tillage allowed form a sunflower yield of 2.53 t/ha, and the lowest yield was recorded under traditional tillage – 2.52 t/ha. In addition, the study confirmed that the choice of tillage method significantly affects the quality of the sunflower crop. Traditional cultivation provided the best results in terms of oleic acid (83.8%) and crude fat content in seeds (44.6%), which are important indicators of the quality of oilseeds. In addition, in the long term, reduced tillage methods, such as no-till, can have additional benefits, such as preserving soil structure and accumulating moisture. The prospect of further research

is to study the impact of soil cultivation methods on crop resistance to diseases and pests. The limitation of the study is that the impact of other agronomic measures, such as fertilisation, mulching and irrigation, on sunflower production results was not considered.

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CONFLICT OF INTEREST

None.

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Розроблення та впровадження енергоощадних технологій вирощування гібридів соняшнику в умовах півдня України

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Анотація. Розроблення та впровадження енергоощадних технологій вирощування гібридів соняшнику є важливим напрямком досліджень для забезпечення стійкого розвитку аграрного сектора та збереження навколишнього середовища. Метою дослідження було проаналізувати вплив різних способів обробітку ґрунту на врожайність соняшнику в умовах півдня України. Для досягнення мети проведено польове дослідження на полях Навчально-науково-практичного центру Миколаївського національного аграрного університету у 2021-2023 роках. В результаті виконаного дослідження встановлено, що спосіб обробітку ґрунту має суттєвий вплив на його щільність, запаси вологи та структурну стабільність. Зменшення інтенсивності обробітку, особливо при використанні безвідвального способу (no-till), ефективніше зберігає вологу в ґрунті, проте збільшує його щільність. Зокрема, при no-till перед сівбою соняшника вона становила 1,11 г/см^3 на глибині 0-10 см та 1,21 г/см^3 перед збиранням культури, тоді як за традиційного обробітку щільність ґрунту була 1.02 г/см^3 і 1.1 г/см^3 відповідно. Крім того, безвідвальний обробіток ґрунту забезпечив найкращі показники продуктивності соняшника, включаючи масу 1,000 насінин (47,3 г), діаметр кошика (20,2 см) та урожайність (2,6 т/га). Безвідвальний обробіток також покращує якість врожаю соняшника, підвищуючи вміст олеїнової кислоти (86,5 %) та сирого жиру в насінні (48,3 %). Отримані результати сприяють розробленню комплексних підходів до впровадження енергоощадних технологій у вирощуванні гібридів соняшнику на півдні України, що дозволить підвищити ефективність виробництва та знизити витрати на виробництво

Ключові слова: обробіток ґрунту; врожайність; якість насіння; польові та лабораторні досліди; агрофізичні показники ґрунту