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RESEARCH ON ACIDIC PROPERTIES OF GRAY FOREST SOILS

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The research was carried out at the Department of Agriculture, Soil Science and Agrochemistry of Vinnytsia National Agrarian University, which made it possible to use the existing educational and laboratory base and conduct observations during 2022–2024, obtaining representative data to assess the dynamics of changes in the main agrochemical indicators. Studies have shown that growing winter wheat and soybeans causes changes in the acidity of the soil solution, which reflects the impact of crops on the chemical properties of the agroecosystem. Analysis of soil agrochemical parameters showed that the soil under winter wheat was characterized by increased acidity (lower pH) compared to other crop rotation options, which may be a consequence of physiological processes of nutrient absorption by the root system and microbiological activity in the rhizosphere zone. This trend is consistent with the literature, where a decrease in soil pH is often recorded for wheat crops during the growing season, which is associated with biochemical changes and the removal of nutrients by plants (pHKCl 4.6±0.07) and exceeds the optimal values for this crop. It was established that such a level of acidity potentially slows down plant growth, reduces the availability of essential nutrients and negatively affects the activity of beneficial soil microflora. Hydrolytic acidity (Hg) was 3.27±0.09 mg-eq/100g of soil, which further emphasizes the need for agrotechnical measures. In areas with soybeans, the soil pH was higher – 5.6±0.06, which is closer to the optimal. The generalization of the data allows us to note that the cultivation of winter wheat and soybeans has different effects on soil acidity indicators. Winter wheat demonstrates greater sensitivity to increased acidity and the presence of mobile aluminum, which can limit its productivity. Soybeans, on the contrary, are grown under more favorable pH conditions and lower concentrations of mobile aluminum, which ensures more stable physiological activity of plants and the formation of a high-quality harvest. The results of the study emphasize the importance of regular monitoring of soil acidity and the use of agrotechnical measures to regulate it. Practical results can be tested to develop recommendations for crop selection and agrotechnologies in different soil and climatic conditions, aimed at maintaining soil fertility and sustainable agricultural production.

Keywords: *acidity, soil monitoring, soybean, winter wheat, yield level.*
Table 1., Fig. 1. Lit. 11.

Problem statement. The modern agricultural sector operates under conditions of increasing pressure on natural resources and constant uncertainty caused by climate change [1]. Intensive use of arable land, crop rotation disruptions, and insufficient return multi-quality organic soil fraction lead to its degradation, reduced fertility, and deterioration of agrophysical and agrochemical properties. Combined with the increase in droughts, uneven distribution of precipitation, and temperature stresses, this creates serious risks for the stability of agricultural production and food security [2].

Under such conditions, the need for prompt and well-founded soil management based on reliable information about their properties and dynamics of changes becomes particularly important. However, traditional approaches to soil diagnostics and agrochemical analysis mostly require significant financial costs, specialized laboratory equipment, and a long time to process the results [3-5]. This limits the ability to make quick management decisions and does not always allow for timely response to degradation processes or adjustment of crop cultivation technologies.

In this regard, there is growing interest in the implementation of new, more flexible and affordable approaches to soil condition monitoring, which combine accuracy, efficiency and economic feasibility. Such innovative solutions can ensure timely detection of negative trends, optimize fertilizer application and resources, and also contribute to increasing yields while simultaneously preserving and restoring soil fertility [6-7]. The rational introduction of this species into the green infrastructure of the region contributes to the preservation of natural resources and the formation of environmentally sustainable landscapes.

Analysis of recent research and publications. Modern agricultural technologies are increasingly focused on the use of operational data and accurate measurements, which allow timely and informed management decisions [8].

A number that determines the acidity/alkalinity of a grounded solution when dissolved in pH, which indicates the concentration of active water ions (H^+) in a grounded solution; this value is measured on a scale from 0 to 14, where lower values indicate a more acidic reaction and higher values indicate a more alkaline reaction. This indicator is one of the key agrochemical parameters, since it directly affects the chemical, biological and physiological processes occurring in the environment (soil, plant). In important feature of the pH scale is its logarithmic nature, which means that even a seemingly insignificant change in the indicator is accompanied by significant shifts in the acid-base balance. In particular, a decrease or increase in pH by one unit corresponds to a tenfold change in the ratio of hydrogen ions. It has been proven that a soil solution with a pH parameter of 5 is ten times higher than that with pH 6. At the same time, at a pH reaction of 4, its acidity level is a hundred times higher than that of a neutral reaction. To classification, soils with a pH close to 7 are considered neutral. At pH below 7, the soil is considered acidic, and above this level, it is alkaline. In agricultural production practice, soils with a pH of up to 6.6 are usually considered acidic, as this reaction can limit the availability of nutrients and reduce the activity of beneficial soil microflora [9-11].

In the studies of Tsygansky V.I. it was confirmed that the agroecological assessment of soils is based on a complex of soil regime indicators, among which the reaction of the soil solution (pNH_2O and pHKCl) and hydrolytic acidity (Hg) are of key importance. These characteristics are the main indicators of the state of the soil and directly affect the physiological processes of plants, the activity of soil microorganisms and the availability of nutrients.

In particular, they determine the solubility and digestibility of 17 hard-to-reach forms of nutrients, the processes of coagulation and peptization of soil colloids, as well as the efficiency of fertilizer application [11].

The acidic soil environment is one of the factors limiting the production of high and high-quality yields of agricultural crops. Increased soil acidity can reduce the availability of macro- and microelements, create a toxic effect due to an excess of mobile aluminum, and also reduce the activity of beneficial soil microorganisms that contribute to nitrogen fixation and mineralization of organic matter. In contrast, optimal pH values ensure normal development of the root system, effective absorption of nutrients and increased crop productivity.

Thus, control and regulation of soil acidity indicators is an important element of agrotechnical measures aimed at maintaining soil fertility, increasing yield and quality of agricultural products. Taking these factors into account in practical agriculture allows creating favorable conditions for crop growth, improving the efficiency of fertilization and ensuring the stability of agroecosystems.

The level of acidity has different significance for individual crops, since each of them is characterized by its own biological requirements. For wheat, optimal conditions for growth and development are formed in a fairly wide pH range – from 5.5 to 7.5. Within these limits, the best availability of essential nutrients is ensured, soil microorganisms are activated and favorable conditions are created for the formation crop capacity. Difference of pH from optimal values can lead to disruption of plant nutrition, reduced productivity and deterioration of the quality indicators products [8, 10].

However, in practice, a significant part of agricultural enterprises and farms continues to use traditional, often outdated methods of the soil. Laboratory analyses, although they are characterized by high accuracy, require significant financial costs, special equipment and a long time to obtain results, which complicates their regular use in conditions of intensive farming. The lack of continuous monitoring of soil parameters limits the possibilities of effective management of water and nutrient resources, especially under conditions of unstable weather factors. In this context, rapid soil research methods acquire special importance, as they allow for rapid assessment of key fertility parameters without significant expenditure of time and money. First of all, this concerns the determination of soil moisture and acidity, which are the main factors in increasing productivity.

Didur I.M. proved it is noted that the level of acidity of the soil environment significantly affects the availability of macro- and microelements for plants, the activity of soil microflora and the course of biochemical processes. At pH values below 6.0, the absorption of nutrients deteriorates, the activity of beneficial microorganisms decreases and the growth of crops slows down [3].

At the same time, Pantsyreva G.V. noted that an excessively alkaline soil reaction (pH above 7.3) can also lead to a deficiency of individual nutrients, in particular phosphorus and microelements, which negatively affects plant development [6].

Tkachuk O.P. established that soil moisture is an equally important indicator, since it determines the conditions for the formation of the root system, the intensity of physiological processes and the efficiency of nutrient absorption. Both a lack and an excess of moisture disrupt the normal growth and development of crops, causing inhibition or even death of plants [7].

Therefore, the implementation of operational soil control methods is an important component of modern resource-efficient agriculture aimed at increasing productivity and preserving soil fertility.

Conditions and methods of conducting research. The subject of the study was the dark gray forest soil of the experimental field of Vinnytsia National Agrarian University. Experimental work was carried out in stationary conditions at the Department of Agriculture, Soil Science and Agrochemistry during 2022–2024, which allowed obtaining reliable data and tracking the dynamics of changes in the main agrochemical indicators over three years. The research studied the influence of predecessors, in particular winter wheat and soybeans, on changes in the acidity of the soil solution. Conducting research in a stationary environment ensured the stability of conditions and high reliability of the results. The soil of the experimental site is characterized by an average level of natural fertility, typical of dark gray forest soils of the Forest-Steppe zone. The humus content, determined by the Tyurin method, was on average 2.16%, which indicates a moderate supply of soil with organic matter and a satisfactory potential for its productivity. The reaction of the soil solution was slightly acidic: the pH values of the saline solution, determined by the potentiometric method, ranged from 5.6 to 5.8, which may limit the availability of individual nutrients and necessitate the use of acidity regulation measures. The hydrolytic acidity of the soil, determined by the Kappen method, was 2.3-2.7 mEq/100 g of soil, which indicates the presence of exchangeable acidic cations and the need for agrochemical control of this indicator. The soil nitrogen supply was average: the content of alkaline hydrolyzed nitrogen according to Kornfield was within 77-91 mg/kg of soil. At the same time, the soil was characterized by an increased content of mobile phosphorus (186-251 mg/kg) and an average level of exchangeable potassium supply (83-98 mg/kg), determined by the Chirikov method. The combination of the above indicators allows us to consider the dark gray forest soil of the experimental field excellent for agronomic experiments and assessing the effectiveness of various elements of agricultural technologies.

Research results. Analysis of the pH indicators of the soil of the experimental field showed that the degree of acidity can significantly affect the growth and development of various crops, in particular winter wheat and soybeans. It was established that the optimal pH level for winter wheat is 5.5–7.5. This range ensures maximum availability of essential macro- and microelements, active activity of soil microflora and normal development of the root system. Acidic soils (pH < 5.5) limit the absorption of phosphorus and cause increased toxicity of aluminum, which negatively affects yield. Alkaline soils (pH > 7.5) can reduce the availability of iron, manganese and zinc.

For soybeans, the optimal pH level of the soil is somewhat narrower and is 6.0–7.0. Within this range, active work of nodule bacteria that fix atmospheric nitrogen and effective absorption of nutrients for the formation of beans and seeds is ensured. When pH > 6.0, nitrogen fixation processes decrease, toxicity (Al-Mn) increases, and when pH < 7.5, the availability of trace elements deteriorates, which adversely affects plant growth and yield. The results of the experiment established the resistance of winter wheat to soil acidity in comparison with soybeans (Fig. 1).

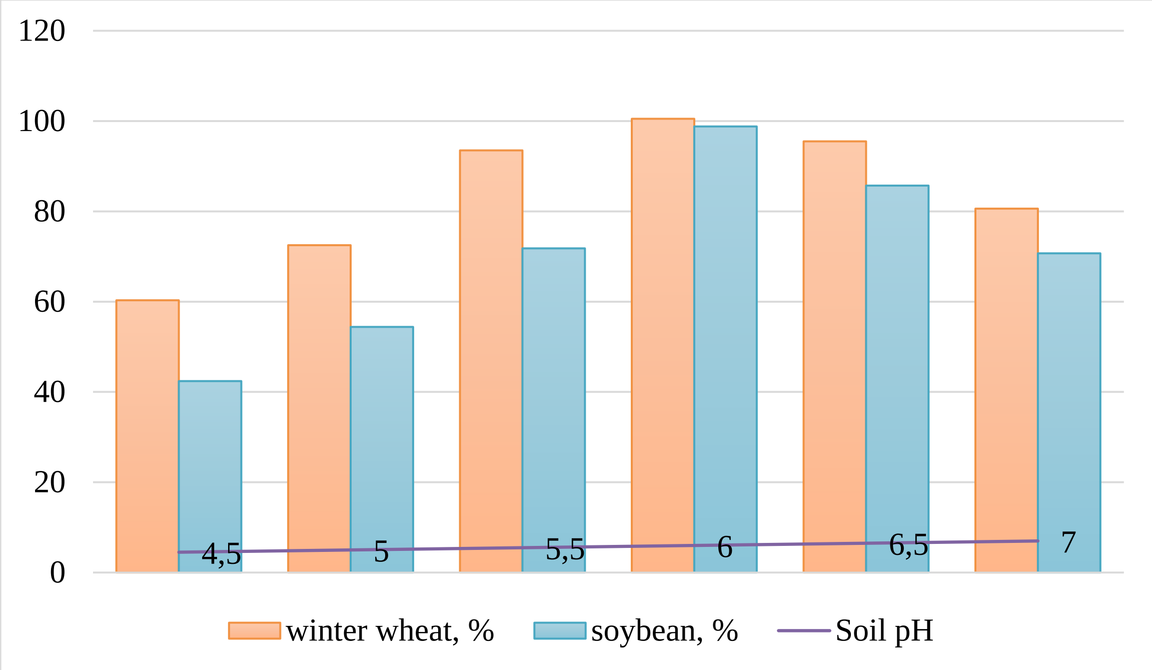

Fig. 1. Dynamics of winter wheat and soybean yield levels due to soil acidity, %

Source: based on own research

Soil acidity indicators under experimental conditions (Table 1) showed that at the beginning of the experiment, the pH level exceeded the optimal values recommended for the successful cultivation of the studied crops.

Table 1

The impact of different winter wheat and soybean growing systems (VNAU research field, 2022–2024)

Culture	pHkcl	pH water	Mobile Al content, mg-eq/100 g of soil	Mobile Al content, mg-eq/100 g of soil	Hydrolytic acidity (Ng), mg-eq/100 g of soil
winter wheat	4,6 ±0,07	5,2±0,08	0,08±0,02	0,12±0,01	3,27±0,09
soybean	5,6 ±0,06	5,8±0,07	0,05±0,01	0,08±0,01	2,62±0,07

Source: based on own research

Excessive soil acidity is a factor that limits the availability of key nutrients, slows down plant growth and suppresses beneficial microflora, which directly affects crop formation. Taking this indicator into account is critically important for assessing the effectiveness of agricultural technologies and planning measures to regulate acidity.

For winter wheat, an increased level of soil acidity was determined: pH by KCl was 4.6±0.07, and by the water method – 5.2±0.08. The content of mobile Al was 0.08–0.12 mg-eq/100 g, while the hydrolytic acidity reached 3.27±0.09 mg-eq/100 g. This indicates significant soil acidity, which can potentially negatively affect plant development. In contrast, in the area where soybeans are grown, conditions were more favorable: pH by KCl was 5.6±0.06, and by the water method – 5.8±0.07, which is close to the optimal range (6.0–7.0). Lower level of mobile Al content (0.05–0.08 mg-eq/100 g) and hydrolytic acidity at 2.62±0.07 mg-eq/100 g.

Conclusions. Comparative analysis shows that the soil under winter wheat is characterized by higher acidity and higher content of mobile Al, which can negatively affect the productivity of this crop. At the same time, soil conditions under soybean are much more optimal for its normal growth, development of the root system and effective absorption of nutrients. The results obtained emphasize the need for systematic control of soil acidity and timely agrochemical correction to maintain stable yields. The results showed that the acidity of the soil under winter wheat is increased: pH in KCl solution – 4.6±0.07, by the water method – 5.2±0.08. The content of mobile Al in this zone varied within 0.08–0.12 mg-eq/100 g of soil. Hydrolytic acidity was 3.27±0.09 mg-eq/100 g. On the contrary, the plot with soybeans had more favorable indicators: pH in KCl solution – 5.6±0.06, by the water method – 5.8±0.07. The content of mobile Al here was significantly lower – 0.05–0.08 mg-eq/100 g soil. Hydrolytic acidity was 2.62±0.07 mg-eq/100 g, which also creates favorable conditions for plant growth and their assimilation of nutrients.

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АНОТАЦІЯ
ДОСЛІДЖЕННЯ КИСЛОТНИХ ВЛАСТИВОСТЕЙ СІРИХ ЛІСОВИХ ҐРУНТІВ

Дослідження реалізовувалися на базі кафедри землеробства, ґрунтознавства та агрохімії Вінницького національного аграрного університету, що дало змогу використати наявну навчально-лабораторну базу та провести спостереження впродовж 2022–2024 рр. із отриманням репрезентативних даних для оцінки динаміки змін основних агрохімічних показників. У дослідженнях вивчали вплив на зміну кислотності ґрунтового розчину за вирощування озимої пшениці та сої. Тому у науковій праці висвітлено результати оцінки впливу вирощування озимої пшениці та сої на зміну агрохімічних показників ґрунту. Проведений аналіз показав, що ґрунт під озиму пшеницю характеризується підвищеною кислотністю (pH_{KCl} *4,6 ± 0,07) та перевищує оптимальні значення для цієї культури. Встановлено, що такий рівень кислотності потенційно уповільнює ріст рослин, знижує доступність основних поживних елементів і характеризується негативним впливом на активну діяльність мікрофлори ґрунту.*

Показники гідролітичної кислотності (Нг) становили 3,27 ± 0,09 мг-екв/100 г ґрунту, що додатково підкреслює необхідність проведення агротехнічних заходів. На ділянках із соєю pH ґрунту був вищим – 5,6 ± 0,06, що ближче до оптимального. Озима пшениця демонструє більшу чутливість до підвищеної кислотності та наявності рухомого алюмінію, що може обмежувати її продуктивність. Соя, навпаки, вирощується за більш сприятливих умов pH та менших концентрацій рухомого алюмінію, що забезпечує стабільнішу фізіологічну активність рослин і формування високоякісного врожаю. Результати дослідження підкреслюють важливість регулярного контролю кислотності ґрунту та застосування агротехнічних заходів для її регулювання. Експериментальні дані є базою для розробки практичних рекомендацій із вибору культур та оптимізації агротехнологій з урахуванням особливостей ґрунтово-кліматичних умов, що сприятиме підвищенню ефективності агровиробництва і стабільності продуктивності культур за різних режимів обробітку ґрунту, спрямованих на підтримку родючості ґрунту та сталого сільськогосподарського виробництва.

Ключові слова: *кислотність, моніторинг ґрунтів, соя, озима пшениця, рівень врожайності.*

Табл. 1., Рис 1., Літ 11.

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