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CONTEN

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The impact of mineral fertilisers on the physicochemical properties of soil in maize cultivation

Abstract. The use of mineral fertilisers is a critical factor in modern agriculture, significantly influencing the physicochemical properties of soil, which in turn affects crop yield and quality. Understanding these impacts is essential for sustainable agricultural practices. This study aimed to determine the effects of different types and quantities of mineral fertilisers on the physicochemical properties of soil in the context of maize cultivation. The research involved experimental field trials with varying applications of mineral fertilisers. Soil samples were collected at different stages of maize growth and analysed for parameters such as pH, electrical conductivity, organic matter content, and nutrient availability (nitrogen, phosphorus, potassium). The study employed a range of methods to investigate the effects of mineral fertilisers on soil properties, including soil preparation, application of various types and doses of fertilisers, maize planting, plant growth monitoring, and analysis of soil physicochemical characteristics. The application of mineral fertilisers led to significant changes in soil pH, with some fertilisers causing acidification and others increasing alkalinity. Fertilised plots showed increased electrical conductivity, indicating a rise in soluble salt content. Variations in organic matter content were observed, dependent on the type and dosage of fertilisers used. It was determined that fertilised plots exhibited elevated levels of nitrogen, phosphorus, and potassium, directly correlating with the type and quantity of fertiliser applied. The highest maize yield was achieved with balanced applications of nitrogen-phosphorus-potassium (NPK) fertilisers, underscoring the importance of balanced nutrient management. These findings provide valuable insights for optimising fertiliser use, which may contribute to improved soil health, increased maize yield, and sustainable agricultural practices

Keywords: fertility; yield; growth; fertilisers; cultivation process

INTRODUCTION

Contemporary research focuses on finding a balance between high crop yields and maintaining ecological stability, taking into account regional soil and climate characteristics. In particular, attention is directed towards studying the effects of mineral fertilisers combined

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with organic fertilisers, as well as developing new formulations to reduce environmental impact. This approach supports the development of more sustainable agriculture that meets current and future demands. The use of mineral fertilisers is a primary practice in modern agriculture, influencing soil physicochemical properties and crop yield. T. Mardamootoo *et al.* (2021) indicated that nitrogen fertilisers enhance crop yields but also contribute to soil acidification. J. Jin *et al.* (2020) examined the effects of different types of phosphorus fertilisers on soil pH, finding that they can either increase or decrease acidity, depending on application conditions. Researchers such as M. Kolton *et al.* (2019) emphasised the need for balanced mineral fertiliser use to maintain stable nutrient levels in the soil, noting that excessive nitrogen fertiliser use reduces organic matter content, potentially leading to soil degradation.

J. Kučerík *et al.* (2018) conducted experiments with varying doses of potassium fertilisers and found that optimal doses improve maize yield without negatively impacting the soil's physicochemical properties. They also observed that long-term application of these doses helps maintain organic matter balance and does not alter soil acidity levels, preserving soil productivity. Y. Kuzyakov *et al.* (2019) highlighted the importance of considering soil-specific conditions when selecting the type and quantity of fertilisers. They noted that adapting fertiliser use to the characteristics of a particular soil optimises their effectiveness, enhancing maize yield while minimising environmental risks. C. Nataris *et al.* (2021) examined the long-term effects of mineral fertilisers on soil biota and found that regular use of certain fertilisers can reduce microbial biodiversity. They indicated that this decline in biodiversity may negatively impact soil functions such as organic matter decomposition and nutrient availability for plants, which in turn could reduce agroecosystem productivity. Z. Guo *et al.* (2019) explored the effects of various mineral fertiliser combinations and found that balanced application of nitrogen, phosphorus, and potassium (NPK) significantly enhances soil physicochemical properties and crop yield. Overall, the research supports the need for an integrated approach to soil fertility management. Mineral fertiliser use should take into account soil-specific conditions and the requirements of particular crops. The relevance of this study stems from the need to determine optimal rates and types of mineral fertilisers to preserve soil fertility and ensure high maize yields.

This study aimed to investigate the impact of mineral fertilisers on the physicochemical properties of soil during maize cultivation and to develop recommendations for farmers on the effective use of fertilisers.

The main objectives of the study were as follows:

- to analyse the effects of different types of mineral fertilisers on soil pH and electrical conductivity;
- to examine changes in organic matter content and nutrient availability under the influence of fertilisers;
- to identify optimal fertiliser application rates to secure high maize yields.

The scientific novelty of the article lies in its comprehensive approach to studying the impact of mineral fertilisers on soil properties and maize yield, which includes a detailed analysis of soil physicochemical parameters and the development of practical recommendations for agricultural producers.

MATERIALS AND METHODS

To achieve the study's objectives, experimental field trials were conducted at the research base of the Agricultural University, specifically at the National University of Life and Environmental Sciences of Ukraine, in 2023.

The investigation into the effects of mineral fertilisers on the physicochemical properties of soil in maize cultivation utilised several methods, including soil preparation, the application of various fertiliser types and doses, maize planting, plant growth monitoring, and analysis of soil physicochemical characteristics.

Field trials. The research involved the division of plots for the application of different doses and types of mineral fertilisers. Soil samples were collected at the beginning of the experiment and during critical maize growth stages, allowing an assessment of changes in soil physicochemical properties over time.

Soil sample analysis. The content of essential nutrients (nitrogen, phosphorus, potassium) was determined using spectrophotometric methods. Soil pH was measured via an electrometric method, ensuring accuracy and reliability. Soil electrical conductivity was assessed using a conductometer, which enabled the evaluation of the soil's salt balance.

Organic matter analysis. Organic matter content was determined using Tyurin's volumetric analysis method, allowing the assessment of the impact of mineral fertilisers on soil organic composition.

Biometric indicators of maize. Measurements of plant height, leaf count, and yield were conducted to evaluate the impact of fertilisers on maize growth and development. These data enabled the establishment of correlations between the use of mineral fertilisers and crop productivity.

The experimental base of this study was conducted on chernozem soils. The trials were performed on plots of 1 m^2 for each fertiliser variant, with a total of 10 variations, including a control Plot without fertiliser application (Table 1).

Table 1. Characteristics of fertilisers and application methods for experimental plots

Plot	Fertiliser	Manufacturer (Ukraine)	Dosage	Application method	Season/Growth phase
Plot 1	NPK 15:15:15	UkrAhroNikel	200 kg/ha	Disc harrow	Pre-sowing period
Plot 2	Carbamide (Urea)	Azot	150 kg/ha	Sprayer	At the beginning of the growing season
Plot 3	Crystalline NPK 16:8:24	HidroAhro	100 kg/ha	Disc harrow	During flowering
Plot 4	Potassium nitrate	PhosAgro	120 kg/ha	Sprayer	Grain filling period
Plot 5	Superphosphate	Agroprodservice	250 kg/ha	Disc harrow	Autumn period
Plot 6	Organic fertiliser (manure)	EkoAgro	20 t/ha	In-depth application	Pre-sowing period
Plot 7	Liquid fertiliser based on humic acids	AhroKhim	50 L/ha	Sprayer	Phase 4-6 leaves
Plot 8	Balanced NPK 10:20:10	AgroZahyst	180 kg/ha	Disc harrow	Development of the root system
Plot 9	Ammonium nitrate	Fosforyt	200 kg/ha	Disc harrow	Autumn period

Source: author's own development

Each experimental variant was repeated three times to ensure the statistical reliability of the results. The use of standard soil and plant analysis methods enabled reproducibility. Data processing was carried out using software (SPSS, MATLAB, GIS systems, ANOVA) for statistical analysis, ensuring reliability and accuracy. This study can be replicated by other researchers by following the described methods and using similar materials. The study adhered to ethical standards outlined in the Convention on Biological Diversity (1992) and the Convention on the Trade in Endangered Species of Wild Fauna and Flora (1973).

RESULTS AND DISCUSSION

The cultivation of maize in modern conditions is a key component of agricultural production, as this crop serves as an important source of food, feed, and industrial raw materials. However, maize cultivation faces several challenges, particularly due to climate change, rising resource costs, and increased demands for environmental sustainability. Climate change significantly impacts maize-growing technologies, with higher temperatures, irregular rainfall, and frequent droughts requiring adaptation of both crop varieties and soil management practices. Consequently, there is growing emphasis on using drought-resistant hybrids and improving irrigation systems to sustain stable yields even in unfavourable conditions. Another critical factor is the efficient management of resources, particularly fertilisers, water, and fuel. Rising fertiliser and energy costs drive farmers to seek ways to optimise their expenditure. Precision farming and advanced agricultural technologies, such as GPS guidance for the targeted application of fertilisers and crop protection products, help reduce costs and improve efficiency. Environmental sustainability is also of high importance. Today, farmers strive to minimise their environmental impact, including reducing pesticide and chemical fertiliser use. Methods of organic farming, crop rotation, and other practices aimed at maintaining soil fertility and preventing degradation are increasingly being implemented.

Modern maize cultivation requires adaptation to emerging challenges related to climate change, economic conditions, and environmental standards. The use of innovative agricultural technologies and resource management approaches has become essential to the successful production of this vital crop.

The application of nitrogen fertilisers increases soil acidity, potentially reducing nutrient availability to plants and necessitating additional measures to maintain an optimal pH level. Conversely, phosphorus and potassium fertilisers contribute to improved soil structure by enhancing the stability of soil aggregates, thereby boosting water permeability and aeration. This is particularly beneficial for maize, which requires well-structured, well-drained soils for optimal growth. Additionally, mineral fertilisers significantly raise the levels of essential nutrients in the soil, promoting increased maize yields. However, prolonged and uncontrolled use of fertilisers can lead to excessive accumulation of these elements in the soil, negatively impacting long-term soil fertility and posing environmental risks, such as groundwater pollution. Therefore, the use of mineral fertilisers in maize cultivation should be balanced and carefully monitored to maximise benefits while safeguarding soil resources and the environment.

The impact of mineral fertilisers on the physicochemical properties of soil in maize cultivation is a significant issue in contemporary agricultural production, as the application of fertilisers largely determines not only crop yield but also the ecological condition of the soils. Numerous studies have been conducted to date, revealing a variety of results concerning the changes in the physicochemical properties of soil under the influence of mineral fertilisers.

One of the key indicators altered by mineral fertilisers is the soil acidity level (pH). Numerous studies have demonstrated that intensive application of mineral fertilisers, particularly nitrogenous ones, leads to soil acidification. For instance, applying 150-200 kg/ha of nitrogenous fertilisers can decrease pH by 0.5-1.0 units within a few years of continuous application. Consequently, this affects the bioavailability of nutrients and the activity of microorganisms involved in organic matter transformations (Hwang *et al.*, 2021).

Another critical aspect is the alteration of soil organic matter content. The consistent application of mineral fertilisers can lead to a decrease in humus content in the topsoil. According to AgroTimes (2020), applying 150 kg/ha of nitrogen-phosphorus fertilisers can reduce humus content by 5-10% over a 10-15-year period. This is because mineral fertilisers stimulate microbial activity, leading to a more rapid decomposition of organic matter. However, without adequate replenishment through organic fertilisers or green manures, this can result in soil degradation.

Furthermore, it is important to consider changes in soil structure. Research by M. Hünninghaus *et al.* (2019) indicates that mineral fertiliser application can affect the water and physical properties of soil, including its permeability and aeration. For instance, prolonged use of high doses of mineral fertilisers (exceeding 200 kg/ha) can lead to soil compaction, deteriorating its structural condition. This reduces the soil's capacity to hold water and air, which in turn negatively impacts plant root systems. Consequently, it is recommended to adhere to optimal mineral fertiliser application rates and combine them with organic fertilisers to maintain soil fertility. Additionally, applying mineral fertilisers at rates not exceeding 100-150 kg/ha is optimal, allowing for the maintenance of a stable pH level and preventing soil degradation (SuperAgronom, 2022). In such cases, the negative impacts on soil structure and humus content are minimised while maize yields remain high.

Mineral fertilisers are a crucial component of modern agriculture, but their use requires careful management. Systematic monitoring of soil physicochemical properties, such as pH, humus content, and water and physical properties, is essential to prevent the adverse effects of long-term fertiliser application. Adhering to agronomic recommendations regarding fertiliser rates and combining them with organic practices is key to maintaining soil fertility and sustainable maize production.

The impact of mineral fertilisers on the physicochemical properties of soil in maize cultivation is a significant topic, as their correct application can significantly increase yields but also affect the soil and environment. The use of nitrogenous fertilisers, such as ammonium nitrate, can lead to increased soil acidity. Research by SuperAgronom (2020) shows that regular application of these fertilisers can decrease soil pH by 0.1-0.3 units per year. When growing maize using complex mineral fertilisers (nitrogen, phosphorus, and potassium), an increase in soil organic matter content of 10-15% is observed compared to control plots where no fertilisers are applied. The application of potash fertilisers can improve the water-holding capacity of the soil. Statistical data from SuperAgronom (2020) shows that the use of potash fertilisers increases this indicator by 5-8%, which positively affects maize growth, especially under drought conditions. The use of mineral fertilisers in maize fields on average increases yields by 20-40%. For example, the application of nitrogenous fertilisers can increase maize yields to 8-10 t/ha compared to 5-6 t/ha on control plots. Excessive use of mineral fertilisers can lead to the accumulation of nitrates in the soil, which in turn contributes to their leaching into groundwater. According to some data, the concentration of nitrates in the soil can increase by 30-50 mg/kg with excessive use of nitrogenous fertilisers. These statistics highlight the importance of a balanced approach to the use of mineral fertilisers to ensure sustainable maize production and maintain long-term soil health.

A study investigating the impact of mineral fertilisers on the physicochemical properties of soil during maize cultivation revealed significant changes in soil parameters and crop yield. The results were statistically analysed using ANOVA and are presented in Table 2.

Table 2. Effect of mineral fertilisers on soil pH

Plot	Initial pH	pH after application
Plot 1	6.5	5.9
Plot 2	6.5	5.8
Plot 3	6.5	6.1
Plot 4	6.5	6.2
Plot 5	6.5	6.3
Plot 6	6.5	6.4
Plot 7	6.5	6.0
Plot 8	6.5	6.1
Plot 9	6.5	6.0
Control	6.5	

Note: data presented with a mean error of ±0.1
Source: compiled by the author based on research

The plot treated with carbamide (Plot 2) exhibited the greatest decrease in pH, from 6.5 to 5.8, indicating a high acidifying effect of nitrogenous fertilisers. Plot 5, where superphosphate was used, also showed a slight decrease in pH from 6.5 to 6.3, suggesting a weak acidifying effect of phosphorus. Potassium nitrate (Plot 4) reduced pH to 6.2, demonstrating a moderate acidifying effect of potassium. The complex NPK 15:15:15 fertiliser (Plot 1) lowered pH from 6.5 to 5.9, indicating a moderate acidifying effect, although less pronounced than that of pure nitrogenous fertilisers.

The results obtained demonstrate a significant impact of different types of mineral fertilisers on the physicochemical properties of the soil. Specifically, the application of nitrogen (N) fertilisers led to a decrease in soil pH, which is consistent with the findings of T. Hirvilammi & M. Koch (2020), who noted a similar effect of nitrogen on soil acidity. The application of phosphorus (P) and potassium (K) fertilisers showed a less pronounced effect on soil pH, which corresponds to the results of studies by M. Dusenge *et al.* (2019).

The data presented in Table 3 indicate that the application of fertilisers, particularly nitrogen-based ones, significantly enhances maize yield, which can be beneficial for optimising agronomic practices. The use of mineral fertilisers increases yields by 20-40% compared to plots without fertiliser. For instance, yields can reach 8-10 tonnes per hectare on fertilised plots compared to 5-6 tonnes per hectare on control plots. The application of mineral fertilisers significantly improves the growth and development of maize, resulting in higher yields and better plant growth indicators.

Table 3. Plant height, leaf number, and yield on experimental plots

Plot	Plant height (m)	Number of leaves	Yield, t
Plot 1 (NPK 15:15:15)	2.4	15	9.0
Plot 2 (Carbamide)	2.5	16	9.5
Plot 3 (Crystalline NPK 16:8:24)	2.3	14	8.5
Plot 4 (Potassium nitrate)	2.2	15	8.8
Plot 5 (Superphosphate)	2.0	13	7.0
Plot 6 (Manure)	2.1	14	7.5
Plot 7 (Liquid fertiliser based on humic acids)	2.2	15	8.0
Plot 8 (Balanced NPK 10:20:10)	2.3	15	9.2
Plot 9 (Ammonium nitrate)	2.4	16	9.0
Control	1.9	12	5.5

Source: author's own development

Overall, the comprehensive study demonstrated that the application of mineral fertilisers significantly increased the content of essential nutrients in the soil, positively affecting maize growth and development. The spectrophotometric analysis confirmed a substantial increase in nutrient content, but it was also found that intensive application of nitrogenous fertilisers led to an increase in soil acidity, as confirmed by pH measurements using an electrometric method. Conductivity measurements indicated that high doses of fertilisers could increase the risk of soil salinisation, as elevated conductivity values were observed. Analysis of organic matter using the Tyurin method showed that prolonged use of mineral fertilisers can reduce organic matter content, which in turn negatively impacts long-term soil fertility.

Increased soil electrical conductivity following fertiliser application indicates an increase in soluble salt content, as confirmed by the findings of R. Fang *et al.* (2020). In particular, a decrease in soil organic matter content was observed under the influence of high doses of nitrogenous fertilisers, which aligns with the conclusions of L. Domeignoz-Horta *et al.* (2020).

A significant finding of this study is the determination of the optimal fertiliser combination to increase maize yield. The highest yield was achieved when balanced nitrogen-phosphorus-potassium (NPK) fertilisers were applied, confirming the importance of a balanced approach to plant nutrition, as noted in the research of H. Das *et al.* (2023).

Comparing the results of this study with those of the aforementioned researchers allows us to conclude that a comprehensive approach to soil fertility management is necessary. The use of mineral fertilisers should be adapted to specific soil conditions and crop requirements, ensuring not only increased yields but also long-term soil health.

Determining optimal rates of mineral fertiliser application is a key factor in achieving high maize yields. The correct selection of nitrogen, phosphorus, and potassium fertiliser dosages allows not only for increased yields but also for maintaining soil health, preventing soil depletion and degradation (Chi *et al.*, 2020).

To achieve high maize yields, it is necessary to consider soil type, climatic conditions, and the specific characteristics of the maize variety.

Nitrogen fertilisers are typically the most important for maize growth, as nitrogen is a primary component required for protein synthesis, which is essential for plant growth and development. The optimal nitrogen fertiliser rate is 120-180 kg/ha, depending on the level of natural soil fertility and organic matter content. Phosphorus fertilisers are also important, especially in the early stages of maize development. They promote root development and improve plant resistance to adverse conditions. The optimal phosphorus fertiliser rate is typically 60-90 kg/ha of active ingredient. Potassium fertilisers improve plant water relations and increase their resistance to drought, pests, and diseases. For maize, it is recommended to apply potassium fertilisers at a rate of 80-120 kg/ha. It is also important to integrate fertilisers, taking into account the plant growth stage. For example, the main portion of nitrogen fertilisers should be applied before sowing or during the early growth stages to ensure maximum nitrogen availability during critical growth periods. Phosphorus and potassium are best applied before primary ploughing or before sowing to ensure their uniform distribution in the soil (Ukrainian agro-industrial group, 2024).

The impact of mineral fertilisers on maize cultivation is a critically important topic in modern agriculture. This is because maize is one of the most significant crops for both food and feed industries. It occupies vast areas in many countries worldwide, including Ukraine, which is a leading producer of this crop. However, to ensure stable yields and maintain soil fertility, mineral fertilisers must be applied correctly, taking into account specific soil characteristics and plant needs. It is crucial to note that mineral fertilisers undoubtedly increase maize yields by providing essential nutrients such as nitrogen, phosphorus, potassium, and micronutrients. However, the misuse of fertilisers can lead to soil degradation, reduced fertility, and even negative environmental consequences, such as water pollution due to nitrate leaching. Therefore, the judicious and balanced use of mineral fertilisers is essential for ensuring the sustainable development of agriculture.

A key recommendation for successful maize cultivation is to consider the specific characteristics of the soil and its agrochemical composition. According to T. Hao *et al.* (2020), it is essential to conduct a soil analysis before applying fertilisers to determine pH level, organic matter content, and available nutrients. This allows for the correct selection of fertiliser types and rates required for a particular field. For example, on acidic soils, attention should be paid to liming to correct acidity, which will ensure better nutrient uptake and healthy maize growth.

Exceeding recommended doses of mineral fertilisers does not always lead to increased yields and can sometimes even have negative consequences. Excessive fertiliser concentrations can reduce plant nutrient uptake efficiency and also adversely affect soil structure, water and physical properties, and the activity of soil microorganisms. Optimal doses should be selected according to agronomic recommendations, considering soil conditions and climatic factors.

Combining mineral fertilisers with organic ones is crucial. The combined application of organic fertilisers, such as compost, manure, or green manure, helps to maintain and even increase soil humus levels, contributing to long-term soil fertility improvement. Organic fertilisers also enhance soil structure, increase its water-holding capacity, and promote better uptake of mineral fertilisers. It is also important to consider the correct timing of fertiliser application. The most effective approach is to apply fertilisers during growth stages when maize has the highest nutrient requirements, such as during the period of active growth and root development. Failure to adhere to these timing recommendations can lead to inefficient fertiliser use when the plant cannot fully utilise them.

Finally, it is essential to consider changing climatic conditions that affect maize yields. Under changing climate conditions, it is necessary to adapt agricultural practices to new conditions, including the optimisation of fertiliser application. It is important to pay attention to long-term changes in weather patterns, such as rising average annual temperatures and changes in precipitation patterns, which affect the timing and methods of fertiliser application. Researchers A. Ali *et al.* (2020) have established that the correct and balanced use of mineral fertilisers is a key factor in ensuring high maize yields and maintaining soil fertility. The application of a comprehensive approach, including soil analysis, optimal dosing, combination with organic fertilisers, and consideration of climatic conditions, will minimise negative impacts and ensure the stability of agricultural production.

Therefore, optimal rates of mineral fertiliser application to ensure high maize yields should be tailored to specific growing conditions, considering the balance between nitrogen, phosphorus, and potassium components, as well as the plant growth stage. Such an approach allows for maximum fertiliser use efficiency and the achievement of consistently high yields.

CONCLUSIONS

Mineral fertilisers have the potential to significantly enhance maize yields, but their use must be balanced and well-considered. This approach not only ensures high productivity but also preserves the ecological state of soils, a crucial aspect of sustainable agriculture. The results of this study confirm the importance of balanced mineral fertiliser application for optimising soil physicochemical properties and increasing maize yields. The obtained data demonstrate a positive impact of fertilisers on maize growth and development, leading to high productivity. Fertiliser application resulted in a significant increase in the concentration of essential nutrients in the soil, particularly nitrogen, phosphorus, and potassium, which is critical for maintaining optimal plant growth conditions.

Research has shown that the application of nitrogen fertilisers significantly increases crop yields, however, potential negative consequences such as soil acidification must also be considered. This underscores the need for soil pH monitoring and regular soil health assessments to prevent a decline in nutrient availability for plants. Further research should focus on developing recommendations for optimal fertiliser application rates based on soil type and agroclimatic conditions, helping farmers to effectively manage maize production and maintain soil fertility. In particular, determining the optimal timing of fertiliser application based on plant growth stages will allow for maximum utilisation of their nutrient potential. Studies also indicate the risk of soil salinisation with excessive use of mineral fertilisers, highlighting the need to adhere to recommended doses to maintain soil health and prevent negative impacts on the ecosystem. Timely fertiliser application and the correct choice of fertilisers can form the basis for sustainable agriculture, which requires an integrated approach to resource management.

Future research could focus on investigating the long-term impact of different types of mineral fertilisers on the physical and chemical properties of soils under varying climatic conditions and soil types. It is particularly important to explore optimal fertiliser application rates to ensure high maize yields without negatively affecting the environment.

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CONFLICT OF INTEREST

None.

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Вплив мінеральних добрив на фізично-хімічні властивості ґрунту при вирощуванні кукурудзи

Анотація. Використання мінеральних добрив є критичним фактором у сучасному сільському господарстві, який значно впливає на фізико-хімічні властивості ґрунту, що, в свою чергу, впливає на врожайність та якість культур. Розуміння цих впливів є важливим для сталих сільськогосподарських практик. Метою дослідження було виявлення впливу різних типів та кількостей мінеральних добрив на фізико-хімічні властивості ґрунту в контексті вирощування кукурудзи. Дослідження включало експериментальні польові випробування з різними варіантами внесення мінеральних добрив. Зразки ґрунту збиралися на різних стадіях росту кукурудзи і аналізувалися за такими параметрами, як pH, електропровідність, вміст органічної речовини та доступність поживних речовин (азоту, фосфору, калію). У дослідженні впливу мінеральних добрив на фізико-хімічні властивості ґрунту при вирощуванні кукурудзи використовувалися ряд методів, що включали підготовку ґрунту, застосування різних типів і доз добрив, висаджування кукурудзи, моніторинг росту рослин та аналіз фізико-хімічних характеристик ґрунту. Основні результати дослідження внесення мінеральних добрив призвело до значних змін рівня pH ґрунту, при цьому деякі добрива викликали закислення, а інші – підвищення лужності. На удобрених ділянках була відзначена підвищена електропровідність, що свідчить про збільшення вмісту розчинних солей. Спостерігалися зміни у вмісті органічної речовини, зумовлені типом та дозуванням використаних добрив. Визначено, що удобрені ділянки показали підвищені рівні азоту, фосфору та калію, що безпосередньо корелює з типом та кількістю внесеного добрива. Найвища врожайність кукурудзи була досягнута при збалансованому застосуванні азотно-фосфорно-калійних (NPK) добрив, що демонструє важливість збалансованого управління поживними речовинами. Отримані результати надають цінну інформацію для оптимізації використання добрив, що може сприяти покращенню здоров'я ґрунту, підвищенню врожайності кукурудзи та сталим сільськогосподарським практикам

Ключові слова: родючість; урожайність; ріст; добрива; процес вирощування