ASSESSMENT OF THE EFFECTIVENESS OF BIOFERTILIZERS IN THE CULTIVATION OF COMMON BUCKWHEAT (*FAGOPYRUM ESCULENTUM*) IN AN ORGANIC CROP ROTATION SYSTEM

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ABSTRACT

This study evaluates the effectiveness of biofertilizers in enhancing the productivity of common buckwheat (*Fagopyrum esculentum* Moench) within an organic crop rotation system in the Sumy region of Ukraine. A two-year field experiment (2022–2024) assessed the impact of the biofertilizer Leanum applied through seed inoculation, foliar spraying, and their combination on two buckwheat varieties: Selianochka and Simka. Key productivity indicators – including the number of grains per plant, grain mass per plant, 1000-grain weight, and overall yield – were analyzed. The results demonstrated that biofertilizer application significantly improved all yield components, with the highest productivity observed in the Selianochka variety under combined treatment, achieving yields up to 2.6 t/ha. The findings highlight the crucial role of biofertilizers in improving crop yields and soil health in organic farming systems, supporting sustainable agricultural development and food security, especially under the current land use constraints in Ukraine.

Keywords: biofertilizers, yield, soil fertility, sustainable agriculture, climate challenges, organic farming, varieties, productivity.

INTRODUCTION

Currently, one of the main tasks of Ukraine's agriculture is to maintain the volume of food production. This need is especially urgent due to ongoing military actions, which have led to the temporary loss of agricultural land across nearly a quarter of the country's territory (Karbivska et al., 2023; Datsko et al., 2025).

There are several ways to address the issue of increasing production volumes, including the use of more productive crop varieties or hybrids (Radchenko et al., 2023; Kovalenko et al., 2024), as well as improving cultivation technologies – particularly by increasing the application rates of mineral and organic fertilizers and utilizing biological preparations (Kolisnyk et al., 2024; Spychak et al., 2025).

Enhancing the microbiological activity of the soil promotes faster nutrient cycling in the soil–plant–soil system, improves plant nutrition, accelerates the decomposition of plant residues, and increases nutrient availability for crops. It also stimulates gas exchange between plants, soil, and the soil surface (Litvinov et al., 2020; Mishchenko et al., 2022; Dehodiuk et al., 2024). Scientific research and field trials confirm that modern organic fertilizers significantly boost soil microbiological activity even under extreme climatic and agrochemical conditions. Their use activates nutrient mobilization processes, improves the availability of macro- and micronutrients for plants, and stimulates root system development. In turn, this ensures stable, high-quality yields and contributes to long-term soil fertility improvement (Ilchenko et al., 2019; Kvitko et al., 2021; Datsko et al., 2024).

One of the key areas for ensuring food security is the cultivation of buckwheat, which traditionally holds an important place in the Ukrainian diet (Averchev, 2021). This crop has high biological value and is a source of essential amino acids, minerals, and vitamins, making it strategically important under limited resource conditions. Moreover, buckwheat is undemanding in terms of growing conditions and is capable of producing yields even on low-fertility soils, which is especially relevant given the current reduction in agricultural land. Its positive impact on agroecosystems is also important, thanks to its rapid growth that suppresses weeds and its ability to improve soil structure (Voitovyk et al., 2023; Chuiko & Tryhub, 2025; Mishchenko et al., 2025).

Therefore, the aim of this article is to substantiate the feasibility of cultivating buckwheat as an important factor in ensuring Ukraine's food security under conditions of reduced agricultural land, as well as to assess the effectiveness of modern agricultural technologies in increasing the yield of this crop and improving soil conditions.

MATERIAL AND METHODS

The research was conducted at the experimental field of Institute of Agriculture of the North-East of the National Academy of Agrarian Sciences of Ukraine. This field is located in the Sumy region (Ukraine), with geolocation coordinates of 50°53'22.3" N latitude and 34°42'34.1" E longitude. The experiments were conducted from 2022 to 2024.

The soil of the experimental plots is classified as typical deep, medium-loamy chernozem (black soil), characterized by a humus content of 4.1% to 4.3% (based on the Tyurin method) and a salt pH ranging between 6.2 and 6.5. The average nutrient content was as follows: nitrogen (determined by the Kornfield method) – 128.5 mg/kg of soil; phosphorus and potassium (measured by the Chirikov method) – 211.6 mg/kg and 81.1 mg/kg of soil, respectively. In 2022, total precipitation during the growing season of spring durum wheat amounted to 370 mm, exceeding the long-term average of 237 mm by 133 mm.

The monthly distribution was: April – 107 mm, May – 26 mm, June – 155 mm, and July – 82 mm. In 2023, total precipitation reached 222 mm, which was 15 mm below the long-term average. The monthly breakdown was: April – 54 mm, May – 17 mm, June – 71 mm, and July – 80 mm. In 2024, the growing season saw a marked deficit, with total precipitation of 150 mm, 87 mm less than the long-term average. The monthly distribution was: April – 48 mm, May – 34 mm, June – 51 mm, and July – 17 mm (Fig. 1).

These climatic and soil parameters provide essential context for interpreting the experimental results and understanding the environmental conditions under which the research was carried out.

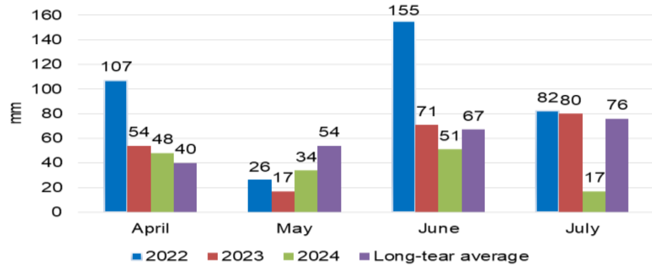

Figure 1. Precipitation during growing seasons of 2022–2024.

In 2022, the average daily temperature during the growing season of spring durum wheat was 16.0 °C, which was 0.2 °C above the long-term average of 15.8 °C. The monthly temperature distribution was as follows: April – 8.3 °C, May – 13.3 °C, June – 21.0 °C, and July – 21.3 °C. In 2023, the average daily temperature rose to 16.6 °C, exceeding the long-term average by 0.8 °C, with monthly values of: April – 9.8 °C, May – 15.5 °C, June – 19.3 °C, and July – 21.6 °C. In 2024, the average daily temperature reached 19.2 °C, significantly surpassing the long-term norm by 3.4 °C. The monthly distribution was: April – 12.9 °C, May – 16.0 °C, June – 22.4 °C, and July – 25.4 °C (Fig. 2).

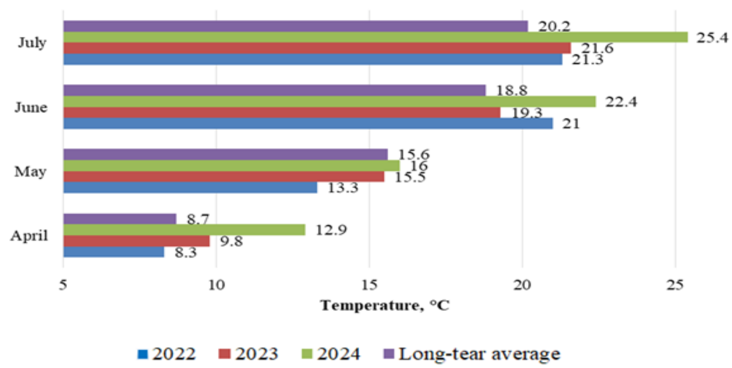

Figure 2. The average daily air temperature during the growing season of 2022–2024.

Overall, the most favorable years for crop yield formation were 2022 and 2023, which exhibited relatively balanced precipitation and moderate temperature conditions. In contrast, 2024 was marked by pronounced drought stress, characterized by both low precipitation levels and elevated temperatures, leading to challenging conditions for crop development. The study was designed as a two-factor experiment aimed at evaluating the effect of the biofertilizer Leanum. The experimental layout included the following treatments: control (C); seed inoculation with Leanum before sowing at a rate of 2 L/t (I); foliar application at 2 L/ha (F); and a combined treatment involving both inoculation and foliar application at 2 L/t + 2 L/ha (I + F). The tested crop was buckwheat the determinant variety – Selianochka and indeterminate variety – Simka. Primary data were processed mathematically and the reliability of results assessed using Microsoft Excel. Descriptive statistical analyses were performed with Statistica 10.0 software (StatSoft Inc., Tulsa, USA).

RESULTS AND DISCUSSION

Buckwheat yield is clearly influenced by such productivity indicators as the number of grains per plant, their weight per plant, and the weight of 1,000 seeds. These data are presented in Figures 3–5.
Figure 3 shows the mean number of grains from one plant for two buckwheat varieties, Selianochka and Simka, under different biofertilizer treatments. Across all treatments, Selianochka consistently produced a higher number of grains per plant compared to Simka, with notable variability in response to inoculation and foliar application, especially in treatments I and F.

Figure 4 demonstrates that Selianochka consistently outperformed Simka in the number of grains per plant across all treatments. The control treatment exhibited minimal differences between the varieties, with relatively stable grain numbers. In contrast, both seed inoculation and the combined application produced the highest grain counts in Selianochka, indicating a strong positive response to biofertilizer application, while Simka showed a much more moderate increase. Foliar application also enhanced grain numbers in Selianochka, though to a lesser extent than seed inoculation alone or the combined method.

Figure 5 presents the mean 1000-grain weight for two buckwheat varieties. In the control treatment, both varieties showed similar grain weights, with minor differences. However, application of Leanum – especially via seed inoculation and the combined method – resulted in a notable increase in 1000-grain weight for Selianochka, while Simka exhibited a much smaller response. Foliar application also improved grain weight in Selianochka, though the effect was slightly less pronounced compared to inoculation. These results suggest that Leanum biofertilizer positively influences grain filling, particularly in the Selianochka variety, highlighting a clear interaction between genotype and biofertilizer treatment method.

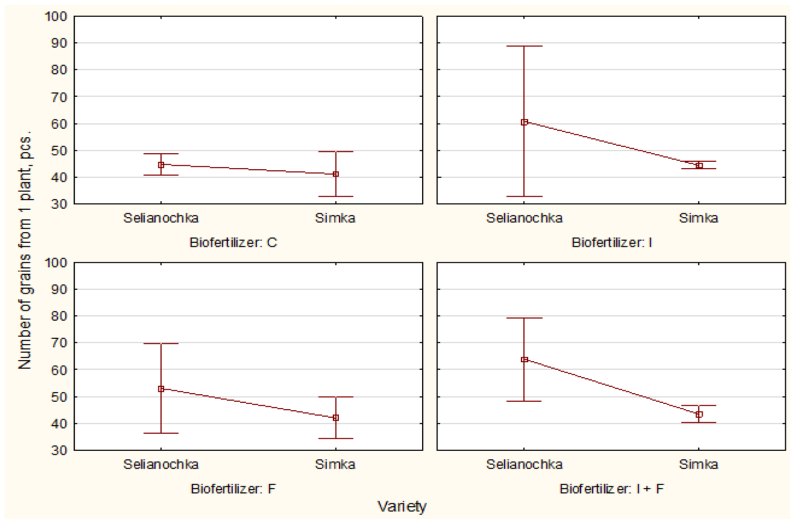

Figure 3. Mean number of grains from one plant for varieties Selianochka and Simka.

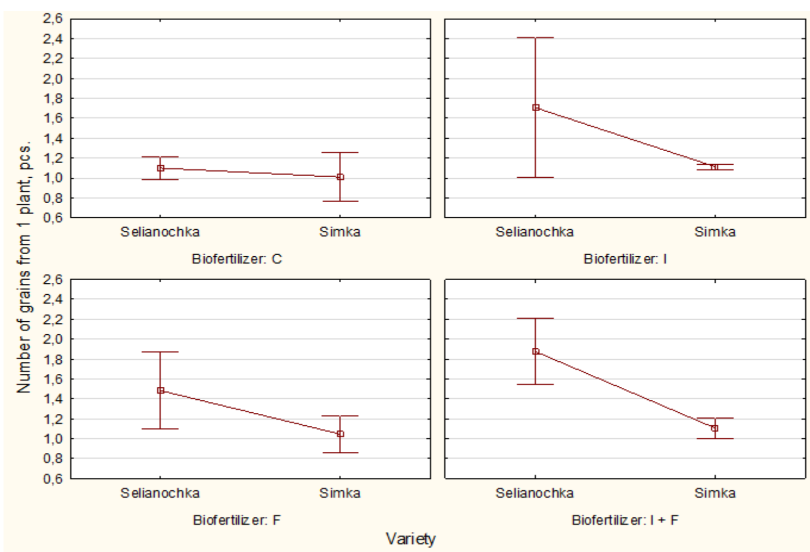

Figure 4. Mean number of grains per plant for varieties Selianochka and Simka.

Figure 6 demonstrate a clear influence of both variety and biofertilizer treatment on crop yield. In all treatment variants, the variety Selianochka consistently outperformed Simka in terms of yield, indicating a higher productivity potential under various biofertilizer conditions.

At control variant yield of Selianochka was approximately 1.5 t/ha, while Simka produced around 1.2 t/ha. When inoculant was applied, a substantial increase in yield was observed for both varieties. Selianochka reached a yield of about 2.3 t/ha, while Simka achieved approximately 1.7 t/ha. Foliar application of the biofertilizer also enhanced yield, with Selianochka yielding around 2.0 t/ha and Simka around 1.3 t/ha. The response was moderate compared to the inoculant treatment but still significant. The highest yields were recorded when both inoculation and foliar treatment were applied. In this treatment, Selianochka reached nearly 2.6 t/ha, while Simka reached about 1.6 t/ha. This synergistic effect suggests that combined biofertilizer treatments can maximize yield, particularly for high-performing varieties such as Selianochka.

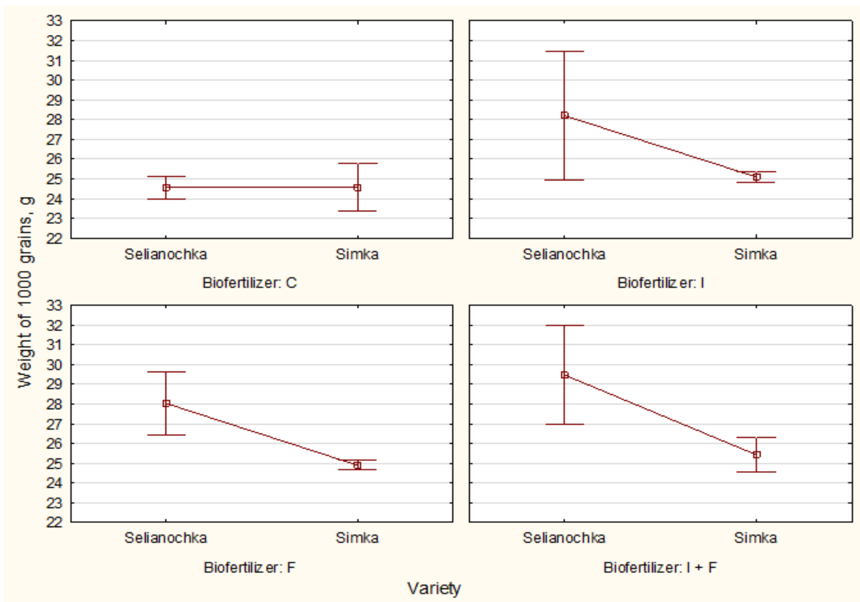

Figure 5. Mean 1000-grain weight for varieties Selianochka and Simka.

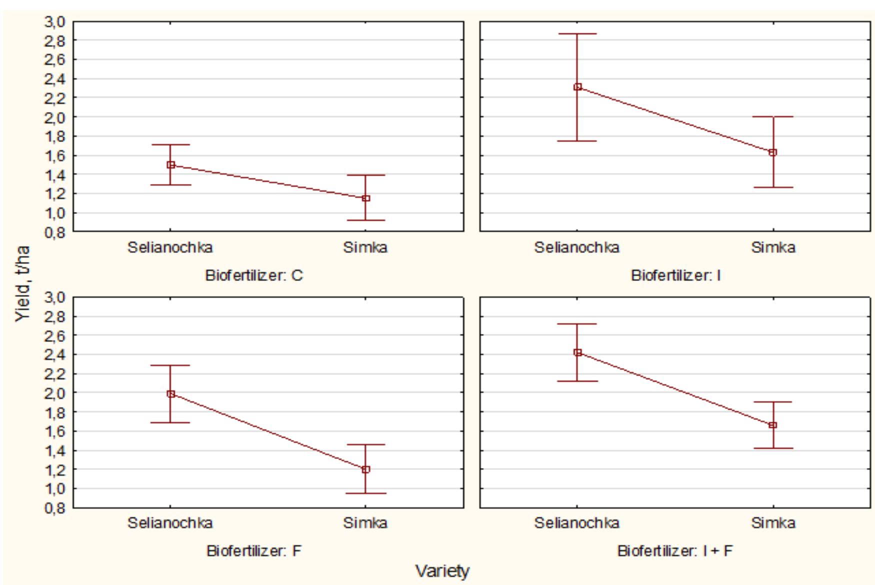

Figure 6. Mean yield of varieties Selianochka and Simka.

The obtained results indicate a significant impact of varietal characteristics and methods of biofertilizer application on the productivity of buckwheat. The main indicators determining the yield level were the number of grains per plant, their mass per plant, and the mass of 1000 seeds. The same conclusions were made in another research. For example, Martyniuk et al. (2024) demonstrated that applying the biofertilizer "BioHel" at a rate of 3 L/ha increases buckwheat productivity under the conditions of the Left-Bank Forest-Steppe of Ukraine and enhances farm profitability. The study of Sokolovska & Mashchenko (2023), Butenko et al. (2025) confirmed the effectiveness of using biofertilizers and bio-based practices in buckwheat cultivation. Field trials (2018–2022) in the Northern Steppe showed that mineral and organo-mineral fertilization systems, especially when combined with bio-preparations, significantly boosted buckwheat yields. The highest profitability and yield gains – up to 54.1% – were achieved with organo-mineral fertilization plus bio-preparations. It`s worth to mentiom that not only biofertilizers are affecting the yield of the crop, but also a variety. The study of Kumar et al. (2024) found that among 12 buckwheat genotypes tested under organic farming, IC 49671 and IC 109433 showed the best agronomic performance. IC 49671 had the highest yield potential, production efficiency, profitability, and nutrient uptake, making it the most promising for organic cultivation in the Eastern Himalayas. These genotypes outperformed others in key traits like dry matter accumulation, branching, and seed clusters, supporting their suitability for sustainable production. The study of Domingos & Bilsborrow (2021) showed that while buckwheat varieties Bamby and Čebelica achieved modest yields in northeast England's cool climate, their nutritional quality – especially protein, iron, zinc, and antioxidants – was high. Bamby performed best in yield and antioxidant content when sown mid-April. Significant seed losses at harvest limited overall productivity, highlighting the need for improved harvesting techniques. The study of Saha et al. (2023) showed that a buckwheat – green gram cropping system can be effective for low-input rainfed farming. The highest buckwheat yield was achieved with 50% organic nutrient substitution, while green gram yielded best with 100% and 50% organic inputs. The Shimla B-1 variety gave the highest overall system yield, despite lower green gram yield afterward, due to its strong buckwheat performance. Integrating vermicompost and Azotobacter helped maintain soil fertility, supporting sustainable crop production.

CONCLUSIONS

- The study confirmed the significant impact of both varietal characteristics and methods of biofertilizer application on the productivity of buckwheat within an organic crop rotation system.
- The variety Selianochka consistently outperformed Simka across all treatments, with the combined application of seed inoculation and foliar spraying of Leanum biofertilizer providing the highest yield increase – up to 2.6 t/ha.
- Key productivity indicators such as the number of grains per plant, their mass, and 1000-grain weight were substantially improved by biofertilizer use, especially in the Selianochka variety.
- These results demonstrate the high potential of integrating biofertilizers into buckwheat cultivation to enhance both yield and soil fertility under organic farming conditions.
- The findings support broader implementation of bio-based agricultural technologies to strengthen food security and sustainable farming in Ukraine, particularly in the face of land shortages and climate challenges.

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