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# Application of Biologization Elements in Buckwheat Organic Cultivation Technology

Uliana Karbivska[1*], Galyna Kunychak[2], Olga Dutchak[1,2], Lesia Karpuk[3], Lyudmila Tatarchuk[4], Tetiana Kashtanova[4], Diana Shelenko[1], Yaroslava Hryhoriv[1], Victoria Gniezdilova[1], Iryna Sluchyk[1]

[1] Vasyl Stefanyk Precarpathian National University 57 Shevchenko Street, Ivano-Frankivsk, 76018, Ukraine
[2] Precarpathian State Agricultural Research Station of the Institute of Agriculture of the Carpathian Region, National Academy of Agrarian Sciences of Ukraine, 21a Stepan Bandera Street, Ivano-Frankivsk, 76014, Ukraine
[3] Bila Tserkva National Agrarian University 8/1, Soborna Square, Bila Tserkva, Kyiv region, Ukraine
[4] National Scientific Agricultural Library of NAAS, 10, Heroiv Oborony Street, Kyiv, 03127, Ukraine

## ABSTRACT

The article examines the potential of buckwheat cultivation as an ecologically oriented crop, which, due to its biological and economic characteristics, can generate profits and contribute to improving the ecological state of production. Buckwheat, being a high-yielding and environmentally friendly crop, has the potential to become an important component of the agricultural sector. Currently, it may not yield as high as corn, sunflower, or soybeans, but buckwheat cultivation allows for profit generation that surpasses most other grain and legume crops, particularly when compared to winter wheat production. Due to its unique properties, buckwheat is valuable in many aspects: it can be used as a soil precursor and improver in agriculture, is an important source of honey, and contains many nutrients that can be utilized to create functional products with medicinal and health properties. The use of organic cultivation methods and the application of organic biostimulant fertilisers, such as "Vermimag", can significantly improve the growth and development of buckwheat, increase its competitiveness, yield, and the economic efficiency of organic production. According to research results, the best conditions for the growth and development of plants, increasing branching and the number of inflorescences, fruit set, and productivity of buckwheat were achieved by combining buckwheat seed treatment with two-time spraying of crops with the organic fertilizer "Vermimag". Variants where organic fertilizer was applied showed better development of buckwheat plants, increased branching, and ultimately increased buckwheat yield.

**Keywords:** buckwheat, organic production, organic fertilizer-biostimulant, yield.

## INTRODUCTION

Over the past two to three decades, buckwheat cultivation worldwide has decreased due to low yields (Popovic et al., 2014; Farooq et al., 2016). Sometimes, low grain yields can be related to the technological level of buckwheat cultivation (Grahi´c et al., 2016). Studies of the impact of different agroecological conditions have shown that buckwheat can be successfully grown on different types of soil using natural soil fertility (Ikanovic et al., 2013). However, according to research by Dutch scientists, high yields of agricultural crops cannot always be guaranteed on organic farms (De Ponti et al., 2012). It is known that the primary task of modern agriculture is the conservation and restoration of soil fertility, based on the formation of a favorable qualitative state of the soil and achieving its high productivity (Hryhoriv et al., 2023).

Buckwheat possesses significant biological potential, which agricultural experts have not fully exploited yet, and it can have a substantial

impact on the food security of a country. Therefore, the problem of increasing the production of this crop is of particular importance today. Although market saturation is possible through buckwheat imports, as evidenced by the importation of 20,000 tons of buckwheat from China to Ukraine several years ago, such imports may not be advantageous for Ukrainian producers. Additionally, they could lead to instability in the domestic market and have unfavorable effects on pricing and consumer perception (Ivanyshyn et al., 2016; Shuvar et al., 2019).

Buckwheat is well-known as a food and dietary product in many countries worldwide, as it contains a significant amount of flavonoids such as rutin, quercetin, catechin, orientin, vitexin, isovitexin, and isoorientin (Arai et al., 2000; Park et al., 2000). Buckwheat cultivation dates back thousands of years in Asia and arrived in Europe in the 13th century (Gondola et al., 2010; Woo et al., 2010). In recent years, China has become the world leader in buckwheat cultivation area (37.6 % of the total), while in Ukraine, it occupies 9.0 % (Jacquemart et al., 2012). Buckwheat is an important agricultural crop as its grains are used for human consumption as well as for livestock feed (Popovi´c et al., 2013).

Buckwheat has peculiar biological properties, as its growth phases coincide during the growing season. Buckwheat flowering usually lasts for about two-thirds of the growing season, although even with a large number of flowers, the percentage of grain formation may remain low (Maleti´c et al., 2003). Studies by many scientists have shown that buckwheat productivity depends on bee visitation and hydrothermal conditions during the growing season (Inoue et al., 1998; Gebremedhn et al., 2014; Romanovskaja et al., 2016). The morphological structure of the plant and the developed vegetative biomass are equally important in the formation of buckwheat grain yield. Studies by Italian scientists indicate that the number of vegetative structures (stems, branches and leaves) in buckwheat helps to estimate the potential yield, as it directly depends on the biomass (Brunori et al., 2005).

Recently, organic agriculture has become increasingly relevant due to the escalation of environmental problems, the rise in population health issues, and the growing environmental awareness among consumers. However, organic buckwheat cultivation is not widespread in Ukraine due to several reasons. Firstly, the unstable yields of this crop can be attributed to its sensitivity to changes in weather conditions and insufficient attention to cultivation technology. Since buckwheat is an important food product for people, there is a need for the cultivation of environmentally friendly buckwheat that does not contain pesticide residues and nitrates in the grain (Ivanyshyn et al., 2016).

The transition to organic production is becoming extremely important for providing society with safe and high-quality food products, as well as for preserving and improving the environment. The interest in growing buckwheat is explained by the fact that this crop contains a complex of very useful substances for the human body. It is widely used for food purposes in the form of cereals. In terms of fat content, buckwheat groats are only surpassed by oat and wheat groats, while in terms of protein content, it exceeds all grains except legumes (the protein is characterized by good digestibility and assimilation). That's why this crop is actively cultivated in organic farming (Hryshchenko et al., 2016).

Regarding the prospects of buckwheat production, it's worth noting that buckwheat has a short vegetative period, which in modern varieties under normal growing conditions does not exceed 75–80 days (Tryhub et al., 2018; Tryhub et al., 2022). Late sowing, at the end of April or beginning of May, allows for the proper distribution of sowing production capacities and enables effective weed control during the pre-sowing period, serving as an efficient method not only in the current year but also in the next few years. Buckwheat is a crop that can be grown both conventionally and in wide-row cultivation, while considering the weediness of fields. In conventional cultivation, buckwheat itself serves as a good competitor to weeds, while in wide-row cultivation, conditions are created for inter-row cultivation, such as mechanical methods of weed control.

Buckwheat stands out among other food crops due to its high rank attributed to its nutritional and therapeutic-dietary properties. Additionally, it is renowned for its significant role as an excellent honey plant, effective precursor for many agricultural crops, and it holds great importance as a fodder crop. The main direction of buckwheat cultivation in Ukraine is the production of buckwheat groats, which contains a significant amount of essential proteins, fats, carbohydrates, and organic acids necessary for the human body. Buckwheat is recognized as an economically viable crop due to the high price of grain and low production costs.

Taking into account the increasing popularity of buckwheat in recent years, it is expected that the area under its cultivation will increase. The development and improvement of environmentally friendly technologies with high seed yields will enable the provision of high-quality dietary products to the population without the use of synthetic fertilizers, pesticides, and GMOs.

The concept of sustainable agricultural development involves combining environmental protection, economic growth, and social development, with the cultivation of organic produce becoming a practical realization that allows for obtaining high-quality food as an essential component of food security. Research on the state of organic production and the prospects for its development in Ukraine is the subject of study for scientists such as V.I. Artish, V.V. Pysarenko and others (Malynka et al., 2020; Burdyha 2017).

There is a significant need today for the implementation of biological farming, especially in buckwheat cultivation. Many authors point to the positive effects of microbiological preparations. In recent years, the focus of research has been on next-generation microbial preparations with high biological activity, which have been shown to increase grain crop yields by 5–15 % and buckwheat yields by 11 %. Along with the positive properties of buckwheat, the development of agrotechnical features of its cultivation is insufficiently studied. The problem of improving the elements of buckwheat cultivation technology in Ukraine was studied by Kvashchuk O.V., Poltoretskyi S.P. and other scientists (Poltoretskyi et al, 2012; Kvasnitska et al., 2018).

## MATERIALS AND METHODS

The research was conducted at the experimental field of the Precarpathian State Agricultural Research Station of the Institute of Agriculture of the Carpathian region, within the crop rotation of organic production, covering the laboratory for soil processing, weed control, and organic farming technology of agricultural crops of the Kolomyia Department of Scientific Research and Innovative Development of Agricultural Production during the period of 2022–2023.

The soil of the experimental plot is sod-podzolic, superficially glazed, medium loamy, drained by pottery drainage. In the experiment, buckwheat of the "Volya" variety was sown using a row (15 cm) and wide-row (45 cm) sowing method. The "Volya" variety is intended for consumption, with a grain yield level of 74–76 % and is developed by LTD NVMK "Antariya". It is one of the best versatile buckwheat varieties for various regions of Ukraine and exhibits high adaptability and versatility to all types of soils. It belongs to the group of mid-ripening varieties and matures in 96–102 days (3.5 months). Plants are tall, reaching up to 106 cm, and the variety is highly resistant to drought and shedding of ripe grain.

The soil cultivation system for buckwheat included discing to a depth of 6–8 cm, ploughing to a depth of 20–22 cm, early spring moisture conservation (harrowing), and three cultivations, including pre-sowing and post-sowing rolling. In wide-row buckwheat planting, two inter-row tillage was conducted: the first inter-row loosening to a depth of 4–5 cm after the emergence of the first true leaf, and the second during the budding phase of buckwheat plants to a depth of 8–10 cm. Organic fertilizer was used as a biostimulant in the research with the aim of enhancing seed germination energy, stimulating active root system development, and reducing the impact of temperature stresses. Over the past decade, in many countries, including Ukraine, complex humic biopreparations have been widely used to achieve high-quality crops. One of them is the growth regulator "Vermimag" (produced by PE "Bioconversion"), which is registered with the Ministry of Ecology and Natural Resources of Ukraine and permitted for use in organic farming. "Vermimag" is a liquid organic fertilizer-biostimulant made on the basis of Vermistim with the addition of mesoelements (sulfur and magnesium) of natural origin. The nutrients contained in the "Vermimag" biostimulant are applied to the surface of leaves and leaf mass, where they are quickly absorbed and follow the same synthesis pathway as the elements that enter the plant through the root system, but 5-8 times faster. Microelements in chelated form, which are included in the composition of biostimulants, activate fundamental processes of seed germination, plant growth, and development, promoting the development of a strong, branched root system and the production of specific functional proteins that increase plant resistance to stressful growing conditions, such as drought, pest damage, wind, hail, and disease infection. The experiment was conducted according to the following scheme (Table 1). The sowing area was 90 m², and the area for recording was 50 m², with the experiment repeated four

**Table 1.** Experiment scheme

| Factor A - sowing method | Factor B - fertilization |
|---|---|
| Row sowing (15 cm)<br>Wide-row sowing (45 cm) | Seeds treated with water, 10 l/t (control) |
| | Seeds treatment with a biopreparation |
| | Seeds treatment with a biopreparation + one spraying of crops with a biopreparation |
| | Seeds treatment with a biopreparation + two spraying of crops with a biopreparation |

times. Buckwheat seeds treatment was conducted on the day of sowing. Sowing was carried out in sections using the SN-16M seeder, employing both row and wide-row methods. Phenological observations were carried out in two non-adjacent repetitions to track the main phases of plant development. The plant density was measured at full emergence and before harvest. The counting was carried out on constant experimental plots of 0.25 m² each, located in the areas of the first and third repetitions (2 sample areas per repetition). Meteorological conditions were assessed using data from the Kolomyia weather station. Statistical processing of experimental data was conducted using the method of variance analysis (Ushkarenko, 2020).

## RESULTS AND DISCUSSION

According to the collected data, organic farming is practiced in 172 countries worldwide, with 40% in Asia, 26% in Africa, 17% in Latin America, 15% in Europe, 1% in North America, and 1% in Oceania. Approximately 1% of the world's agricultural land area is used for organic production, with around 3% of agricultural land in the countries of the European Union dedicated to organic farming. Australia leads in organic production with over 900 million hectares of agricultural land used for cultivation using techniques adapted to organic farming. Argentina and China are also ahead in this ranking (Iezerkovskyi, 2017).

The use of preparations of organic origin and agrotechnical methods in buckwheat cultivation technology led to an improvement in the phytosanitary condition of crops. Better growth and development of buckwheat plants, and therefore their higher competitiveness compared to weeds, contributed to a reduction in weed infestation during the growing season in cases where organic fertiliser-biostimulant was used. The lowest level of weed infestation before harvesting was recorded in plots where a combination of buckwheat seed treatment and two-time spraying of crops with organic fertilizer-biostimulant using the row method of sowing was employed. In these plots, weed density amounted to 68 plants/m², which was 29.2% lower than in the control group.

The application of organic fertilizer-biostimulant contributed to the improvement of conditions for plant growth and development, resulting in increased productivity. It is important to note that under the weather conditions in 2023, characterized by high temperatures and significant rainfall in July-August, there was intensive vegetative mass growth, significantly increasing the height of the plants. This corresponds to the characteristics of the buckwheat variety "Volya," which reaches a height of 105 cm. According to the results of our research, it was established that the height of buckwheat plants in the control group was 115 cm, and it increased by 10-15 cm in plots where organic fertilizer was used (Fig. 1).

The buckwheat plants reached the highest height in the variants where the seeds were treated with the biopreparation and two foliar applications of nutrients, reaching heights ranging from 134 cm to 137 cm. The weight of 1000 buckwheat seeds also varied depending on the fertilizer applied. For instance, in the control group, it was 26.5 grams, and it increased by 0.4–1.5 grams when organic fertilizer-biostimulant was used. Specifically, the highest weight of 1000 buckwheat seeds was observed both in row and wide-row planting methods when the seeds were treated with a biopreparation and crops were sprayed twice, reaching 27.9 and 28.0 grams respectively (Fig. 2). The same trend was observed during the analysis of grain weight, where in the control group it amounted to 604 g/l and was higher by 14 g/l compared to the combination of seed treatment and twice spraying in the row planting method (Fig. 3).

The gradual and uniform flowering, pollination, and ripening of buckwheat seeds occurred more evenly in plants that were sown using the row planting method. This led to obtaining higher grain quality in these plots. The application of the organic fertilizer-biostimulant "Vermimag"

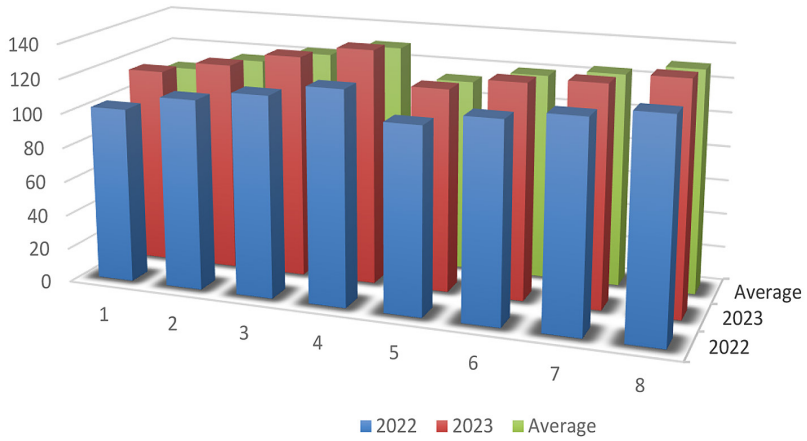


**Figure 1.** Plant height, cm

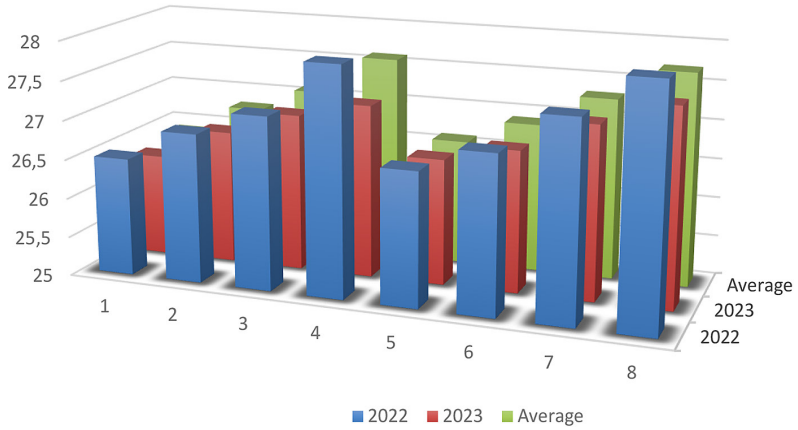


**Figure 2.** Weight of 1000 grains, g

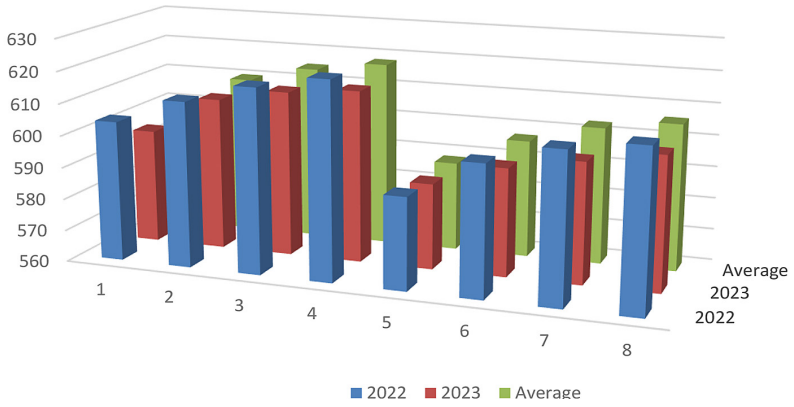


**Figure 3.** Grain weight, g/l

contributed to creating better conditions for plant growth and development, increasing branching and the number of flowers, promoting fruit formation, and enhancing buckwheat yield. Research has shown that the use of this fertilizer positively influenced the growth and development of buckwheat, ultimately leading to increased yield. One of the main reasons for the limited cultivation of buckwheat is its low yield, which averages 0.9 tons per hectare in Europe. Buckwheat is sensitive to environmental conditions, leading to significant fluctuations in yield. In our research, it was found that the use of the organic fertilizer "Vermimag" significantly improved the growth

and development of buckwheat plants, leading to increased yields both in row and wide-row planting methods. In 2022, the highest yield of buckwheat was obtained during the research using an organic fertiliser-biostimulant and double spraying of plants in row sowing. The yield was 2.23 tonnes per hectare, which is 0.83 tonnes or 59.3% more than in the control group. The application of this fertilizer in wide-row sowing also led to an increase in yield by 0.56 tonnes per hectare, or by 40.0% compared to the control group. Buckwheat plants treated with the fertilizer exhibited higher growth and better branching, resulting in an increase in the number of flowers and grains.

According to the results of the 2023 research, the yield of buckwheat in the control group (row sowing method, without fertilizer application) was 1.26 tonnes per hectare. In the similar wide-row sowing variant, the yield was almost at the same level as the control – 1.22 tonnes per hectare. Specifically, seed treatment with organic fertilizer contributed to an increase in buckwheat yield in the row sowing method by 0.18 tonnes per hectare, or by 14.3%, and in the wide-row sowing method by 0.15 tonnes per hectare, or by 11.9%. Significant yield increases were observed with both single and double foliar spraying of buckwheat crops. So, the combination of seed treatment and single foliar spraying of crops increased buckwheat yield in the row sowing method by 0.42 tonnes per hectare, or by 33.3%. In the wide-row sowing method, the yield increase relative to the control was 0.35 tonnes per hectare, or 27.8%. On average over two years of buckwheat cultivation, the yield of the control variant ranged from 1.30 to 1.33 tons per hectare. The yield increased from 0.18 to 0.2 t/ha when seeds were treated with the biopreparation (Table 2). The highest buckwheat yield was obtained by applying the organic fertilizer-biostimulant for seed treatment and two-time foliar spraying of plants in the row sowing method, where it amounted to 2.10 tonnes per hectare. This represents an increase of 0.77 t/ha, or 57.9%, compared to the control.

In Lithuania, buckwheat requires an optimal hydrothermal regime of irrigation, with a hydrothermal coefficient (HTC) ranging from 1.0 to 1.5 at the beginning of vegetation in June and during grain ripening in August. In the second year of the study, insufficient rainfall was observed at the beginning of vegetation in June (HTC 0.36). This resulted in reduced plant growth and the formation of less biomass, negatively impacting the yield (Žvikas et al., 2017). Researchers from Italy found that buckwheat yield correlates with vegetative biomass (Horiuchi et al., 1996). The results of our research have confirmed that biomass plays an important role in grain yield formation in ecological farming systems.

In our research, the use of an organic fertilizer-biostimulant with minimal additional costs and a higher price for organic products allowed for increased economic efficiency in buckwheat cultivation using organic methods. The combination of seed treatment and two sprayings of crops with

**Table 2.** Buckwheat yields in organic production (average over the years of cultivation)

| Variant number | Experiment variant | | Yield, t/ha | Yield increase, t/ha | |
|---|---|---|---|---|---|
| | Sowing method | Fertilization | | ± Relative to control, t/ha | ± Relative to control % |
| 1 | Row sowing (15 cm) | Seeds treated with water, 10 l/t (control) | 1.33 | - | - |
| 2 | | Seeds treatment with a biopreparation | 1.53 | 0.20 | 15.0 |
| 3 | | Seeds treatment with a biopreparation + one spraying of crops with a biopreparation | 1.80 | 0.47 | 35.3 |
| 4 | | Seeds treatment with a biopreparation + two spraying of crops with a biopreparation | 2.10 | 0.77 | 57.9 |
| 5 | Wide-row sowing (45 cm) | Seeds treated with water, 10 l/t (control) | 1.30 | -0.03 | -1.3 |
| 6 | | Seeds treatment with a biopreparation | 1.48 | 0.15 | 11.3 |
| 7 | | Seeds treatment with a biopreparation + one spraying of crops with a biopreparation | 1.70 | 0.37 | 27.8 |
| 8 | | Seeds treatment with a biopreparation + two spraying of crops with a biopreparation | 1.90 | 0.57 | 42.9 |

**Note:** $HIP_{05}$ 0.08.

organic fertiliser-biostimulant in row sowing resulted in a yield of 1.90 tonnes per hectare, a net profit of UAH 27642 per hectare and a profitability of 371%. Meanwhile, the cost price of 1 ton of grain amounted to UAH 3825. In the modern world, there is a great need for the implementation of biological farming, especially in buckwheat cultivation. Many researchers confirm the positive impact of microbiological preparations. Recently, special attention has been paid to next-generation microbial preparations, which provide an increase in grain crop yields by 5–15% and buckwheat by 11%. However, in our region, research on the use of these new microbial preparations has not yet been conducted. It is important for agricultural producers to not only consider social and economic conditions but also rely on a responsible attitude towards the environment and future generations, ensuring the replenishment and harmonious use of energy resources and the restoration of agroecosystems.

Therefore, based on our research, it has been established that despite a significant amount of work on studying the elements of buckwheat cultivation technology and their optimization, there is still no unified point of view in the scientific and practical environment. These issues are relevant and important for the further development of agriculture. Given the importance of food security and the need for the application of modern technologies in agriculture, the necessity of further research on buckwheat's response to different cultivation methods and the application of various biological preparations becomes evident.

## CONCLUSIONS

The use of "Vermimag" in buckwheat organic farming technology improved the growth and development of plants and increased buckwheat yield in both row and wide-row planting methods. The combination of buckwheat seed treatment and double spraying of crops with an organic fertiliser-biostimulant increases the yield of buckwheat by 0.77 t/ha, or 57.9% more than in the control cultivation with a row sowing method.

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