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## AGRICULTURAL SCIENCES



## ECONOMIC SCIENCES

# FEATURES OF APPLICATION OF MINERAL FERTILIZERS IN THE GROWING OF WINTER BARLEY

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**ABSTRACT**

Winter barley can give high grain yields only on fertile soils and for the application of a sufficient amount of fertilizers. Therefore, in modern intensive technologies, the use of mineral fertilizers has an important place. It is especially important to carry out nitrogen fertilization of crops, which should be moderate in autumn and during tillering and the formation of elements of the yield structure.

Plants assimilate nitrogen most intensively during the period of active growth - from the spring tillering phase to the heading phase. Introduction of diammofosk $N_{10}P_{26}K_{26}$ + $N_{34}$ for top dressing in the phase of the beginning of tillering + $N_{46}$ the beginning of the emergence of plants into the tube under pre-sowing cultivation for growing winter barley winter barley plants and foliar feeding with urea at a dose of $N_8$ + microfertilizer Ecolist at a rate of 4,0 l/ha contributed to the opportunity to obtain grain yield of winter barley varieties Atlant Mironovsky at the level of 6,81 t/ha, Paso variety – 7,29 t/ha, which is more for the control plots without fertilization, by 4,97-5,23 t/ha.

**Keywords:** winter barley, agrocenosis, technology, mineral fertilizers, microelements, productivity.

**Formulation of the problem.**

Grain production is the most problematic issue in our country's agriculture. The current level of yield of winter crops (winter wheat, rye, triticale, barley) can not be considered satisfactory, and the frequent recurrence of years when crops die makes grain production in the state unstable. Nevertheless, even in these conditions, advanced farms receive 45–50 c/ha of grain [4].

Barley in Ukraine was and remains one of the leading crops, because the grain is the most balanced in amino acid composition and approaches in terms of feed qualities to standard concentrated feeds.

Winter barley is the main fodder and industrial crop in the grain balance of Ukraine. The sown area of winter barley is about 1,0–1,2 million ha, and there is a tendency to increase [1]. The main reason for its rapid spread is that winter barley is one of the most productive winter crops.

In the system of measures aimed at growing and production of barley grain, the use of mineral fertilizers is important, as they significantly increase its productivity. Grain gains from the use of mineral fertilizers can reach up to 50%. Such a reaction of barley to fertilizer application is one of the important conditions for further expansion of its sown areas in Ukraine [8].

To date, the potential level of yield of winter barley varieties is not fully realized. Creation and improvement of intensive technologies for growing winter barley, with a high level of adaptability for specific growing conditions, given the significant climate change in recent years - a very important issue for agro-industrial production of Ukraine and requires an immediate solution.

Therefore, selection of grades, efficiency of application of various systems of fertilizers are questions which it is expedient to study in each soil - climatic zone of Ukraine, in particular in Vinnytsia region.

**Analysis of recent research and publications.**

Winter barley occupies a significant part in the production of grain in the agro-industrial complex of Ukraine. It is a valuable grain, fodder and food crop. Its main areas have recently been concentrated only in the southern regions, and now - in other regions of Ukraine.

Ukraine is one of the five largest grain producers: 9.9 million tons were harvested in the 2016/2017 marketing year, the fourth highest in the world. Only Australia, Russia and the EU receive more barley grain.

Domestic consumption of barley in Ukraine is 3.9 million tons, so more than half of grain products are exported. The yield of winter barley has increased from 2,0 t/ha to 3,4 t/ha over the last 7 years, but it is unfortunately twice lower than the EU (7,0 t/ha) [11].

A number of scientists Gamayunova V.V., Panfilova A.V., Baklanova T.V., in their work note that recently there has been a decrease in sowing areas under barley, especially spring, while in winter over the past eight years, they have grown almost threefold. The total sown area under barley significantly decreased from 3,9 million hectares in 2000 to 2,5 million hectares in 2018 [5].

The advantage of winter barley is that due to earlier ripening, it is able to avoid moisture deficiency in late summer, which observed almost annually. Thanks to better plant development, it is easier to tolerate drought. But at the same time, winter barley is more demanding to agricultural technology, more affected by disease [15].

Among the reasons for the low yield of winter barley is that it does not take into account the peculiarities of intensive technology of its cultivation, in particular introduction of modern high-yielding varieties, application of recommended norms of mineral fertilizers, sowing dates, preparations that increase winter hardiness and plant productivity, etc.

The main component of the ecological system of the field is a variety adapted to agroecological conditions, which with the appropriate culture of zonal agriculture contributes to an increase in yield by 10-50%. Signs of ecological adaptability of varieties are different duration of the growing season, high frost, winter hardiness, drought resistance, high resistance to lodging and diseases, grain weight from the ear, harvest index, resistance to environmental stressors, environmental plasticity, etc, so breeding programs are focused on stable yields and grain quality [6, 10].

Breeders are doing a lot of fruitful work. It is thanks to them that we have varieties of winter barley with a potential yield of 60 - 70 c/ha and more [3]. In most regions of our country instead of extensive varieties began to grow intensive with high yield potential, such as: Valkyrie, Academic, Storm, Vintmalt, Galatian, Luran, Mascara, Snow Queen, Hobbit, Ninth Shaft and others. They have increased photosynthetic ability, make good use of high agro background conditions, better respond to the introduction of optimal doses of organic and mineral fertilizers [7].

Intensive technologies for growing winter barley involve the widespread use of mineral fertilizers. To produce 6 t/ha of grain with the appropriate amount of straw, it consumes 180 kg of nitrogen, 80 kg of phosphorus and 155 kg of potassium. Barley responds well to both mineral and organic fertilizers. The fertilizer system involves the application of phosphorus and potassium fertilizers under the main tillage, and nitrogen - mainly during the spring-summer growing season. In this case, according to the Myronivsky Institute of Wheat NAAS, the best ratio of nutrients N: P: K is 1,5: 1: 1 or 2,0: 1: 1 [9].

The use of mineral fertilizers promotes better tillering of plants. This formation of crops improves the realization of the potential of the elements of ear productivity by the number of grains in the ear and the weight of the grain.

Nitrogen stimulates growth processes, increases the intensity of respiration and metabolism. Excess or lack of nitrogen in the soil has a negative effect on the peculiarities of plant development. Excess nitrogen leads to excessive vegetative growth and strong tillering of plants and their subsequent lodging. The root system increases less than the aboveground mass.

Plants are less hardened. Nitrogen deficiency is manifested in the fact that the plants turn yellow and then die. The root system develops relatively well in the soil, and the ratio of the aboveground part of the plant to the roots narrows. Plants are better hardened. Nitrogen enters the plant from the first days of its growth to milk or full maturity, but the maximum use of nitrogen by winter barley is during the tillering and tube phases. Depending on the growing conditions, with a grain yield of 60 c/ha, nitrogen removal of winter barley from the soil is 120 - 128 kg/ha [14].

Phosphorus stimulates the development of the root system, ear formation, accelerates ripening. Lack of phosphorus in the nutrient medium delays the use of nitrogen by the plant. Protein synthesis is also inhibited if the level of phosphorus nutrition is reduced. Phosphorus fertilizers affect the development of plants, in particular the root system, and increase bushiness. Barley needs phosphorus fertilizers during the first 4 - 5 weeks of the growing season. It is established that phosphorus starvation in the earliest period cannot be compensated by the next good supply of this element. Removal of phosphorus by winter barley from the soil at a yield of 60 c/ha of grain is 42 - 90 kg/ha.

Potassium intensively enters plants from the first days of growth and before flowering. Lack of potassium in the soil leads to reduced plant growth; at the same time plants strongly react to extreme fluctuations of temperature and moisture in soil; grain quality deteriorates, its nature decreases, yields fall. Potassium has a certain effect on the formation of the root system, increases the number of thin roots, which enhances the overall absorption surface of the root system. Potassium also increases stem strength and reduces plant disease.

Cereals, in addition to N, P, K can not do without trace elements, especially Cu and Mn. Therefore, in farms that attach great importance to the correct technology of copper and manganese should be provided. A very good effect is given by micronutrient feeding during drought, in cold weather conditions and also with the introduction of high doses of nitrogen and phosphorus-potassium fertilizers. The introduction of Ecolist in the exit phase into the tube increases the number of spikelets and grains in the ear, and subsequently - an increase in yield to 5 kg/ha [12].

Great importance of plant nutrition is currently given to foliar plant nutrition. Foliar feeding is used as an operative way to eliminate the symptoms of nutrient deficiency, because the absorption of nutrients by the leaf is much faster than when absorbed by the roots. Microfertilizers are applied to the sheet by spraying. Mineral salts from weak solutions can penetrate into a plant through leaves, and at the same time exchange adsorption is shown. Therefore, foliar feeding has been used in many technologies for growing crops. Foliar treatment with various mineral elements is actively used to increase the yield and grain quality of various cereals, including winter barley. On the one hand, foliar treatment of plants allows them to make full use of mineral elements and at the same time reduce the anthropogenic load on the environment by reducing the level of soil mineralization. On the other hand, such treatment stimulates the root absorption of the same element or other elements by stimulating growth processes in the root. Foliar treatment, which is used in periods of low soil moisture, provides rapid absorption of mineral elements by the leaf surface. This increases yields and improves the quality of plant products [13].

The technology of foliar application of fertilizers is a unique, dynamic and effective method of feeding winter barley. Foliar feeding provides an excellent solution when the root system of plants does not function optimally or harvesting through the soil does not work. This form of fertilization is ideal when root uptake is disrupted by factors such as excessively cold or warm soils, high soil pH, high weed competition, or nematode infestation. Foliar fertilizers are also ideal for use as a precaution to avoid defects and reduce stress.

Thus, the analysis of literature sources shows that in Ukraine it is possible to obtain high and stable grain yields of winter barley, but a more complete and rational use of agri-environmental potential of the zone of its cultivation is possible only with the improvement of the existing elements of the technology of cultiva-

tion, and therefore the study of the application of mineral fertilizers and varietal resources for crop productivity is relevant.

**The purpose of research.** Identify the features of the formation of grain productivity of winter barley on gray forest soils depending on the optimization of nitrogen nutrition of winter barley plants and different doses of mineral fertilizers, the peculiarities of their influence on the formation of winter barley varieties.

**Material and methods of research.** The research was conducted in the research field of Vinnytsia National Agrarian University. The soil at the experimental site is gray forest medium loam. According to the agrochemical survey, the humus content in the arable layer is low - 3%. The content of light hydrolyzed nitrogen (according to Cornfield) is low – 7,0-8,0; mobile phosphorus (according to Chirikov) high - 16,0-19,4; exchangeable potassium (according to Chirikov) increased – 9,5 mg/100 g of soil. Hydrolytic acidity is high and is 4,32 mg-eq./100 g of soil. In terms of metabolic acidity, pH 5,0-5,4 is a medium-acid soil. The soil of the experimental site and its agrochemical parameters are typical for this area and suitable for growing winter barley.

In studies, the precursor of winter barley was soybeans. Under pre-sowing cultivation, complex diamophos fertilizers were applied. Sowed in the third decade of September with a grain seeder SZ-3,6. The method of sowing in the experiment is ordinary row, with a row spacing of 15 cm.

The seeding rate was 4,0 million similar seeds per 1 ha. Depth of seed wrapping in the soil 5-6 cm. In order to improve the conditions for its germination, soil compaction was carried out with ring-spur rollers 3KKSH - 6A.

Sowing was carried out with varieties of winter barley Atlant Myronivsky and varieties of foreign selection Paso. For spring fertilization of crops used (ammonium nitrate – 1,0 kg/ha). During the growing season of plants of the studied varieties of winter barley care for crops consisted of early spring harrowing and application in the early phase of the tube growth regulator Modus at a rate of 0,5 l/ha, herbicide Agritox at a rate of 1 l/ha, fungicide GreenFortF norm of 2,0 l/ha and two treatments with insecticide Knockout at the rate of 0,15 l/ha. Nitrogen fertilizers and microfertilizers were applied according to the research options. The estimated area of the plots is 42 $m^2$ with three repetitions. The crop was harvested with a small Sampo-500 combine.

**Presentation of the main research material.**

The highest and most stable grain yields of winter barley depend on the possibility of using the variety of soil and climatic conditions of cultivation at the maximum level, as well as the ability to overcome adverse meteorological factors that impair plant growth and development. Therefore, new varieties must be characterized by a complex system of biochemical, physiological and economically valuable traits and properties that ensure adaptability to specific growing conditions.

In recent years, climate change has become apparent in the central forest-steppe of Ukraine. Autumn and spring periods are often accompanied by drought, air storms. Precipitation is uneven, which is typical for the zone of unstable moisture. The summer months are accompanied by excessive drought, which often occurs during the grain filling phase of early cereals and causes a decrease in their yield. Under such conditions, there is a need to study the basic elements of the technology of growing winter barley in the context of climate change.

Nitrogen nutrition is one of the determining factors in increasing crop productivity. With an acute shortage of organic fertilizers, minimization of legumes in crop rotations, the absence of perennial legumes, the traditional practice of agricultural production is violated, increases its sensitivity to the effects of abnormal climatic phenomena, reduced productivity.

Under such conditions, a set of technological measures aimed at optimizing nitrogen nutrition becomes one of the key elements of sustainability and high productivity of agriculture. Winter barley reacts sharply to the shortage and excess of nitrogen fertilizers. Nitrogen deficiency reduces the yield and quality of barley grain, the excess causes lodging of crops, increases grain losses during harvesting, which ultimately leads to reduced productivity. Optimizing the forms, doses, methods and timing of nitrogen fertilizers are traditional agrochemical measures that can solve this problem. However, their effectiveness depends on the varietal characteristics of winter barley, the supply of nutrients to plants in the most critical periods of growth and development, the involvement in the fertilizer system of micronutrients and growth regulators. In modern agriculture, high yields of winter barley are the result of optimization of agrochemical measures in varietal agricultural techniques of growing this crop.

Winter barley responds well to the application of mineral fertilizers, especially nitrogen. This is due to its intensive tillering and growth of vegetative mass and a short period of active absorption of nutrients from the soil.

Studies have shown that in areas without mineral fertilizers, the number of productive shoots of the Ukrainian variety Atlant Myronivsky in 2019 was higher than in 2020 by 12 pieces/$m^2$ and amounted to 286 pieces/$m^2$.

First of all, this is due to climatic conditions, because 2020 was characterized by higher air temperatures and reduced rainfall during the autumn-winter period. On the average for two years of researches the quantity of productive shoots of this grade was within 280 pieces/$m^2$. In the areas where mineral fertilizers $N_{10}P_{26}K_{26}$ + $N_{34}$ were applied in the fertilization in the phase of the beginning of tillering of winter barley, the number of productive stems on average for two years of research was within 420 pieces/$m^2$.

The largest number of productive stalks of winter barley was observed in areas where mineral fertilizers $N_{10}P_{26}K_{26}$ + $N_{34}$ were applied in the fertilization in the phase of beginning of tillering + $N_{46}$ in the beginning of plants in the tube, and foliar fertilization with urea in the dose of use $N_8$ + microfertilizer Ecolist at a rate of 4 l/ha in the phase of the end of the winter barley, the number of productive shoots of the variety Atlant Myronivsky was within 461 pcs/$m^2$, which is more than in the control plots by 181 pcs/$m^2$.

Similarly, we can note the results of studies of varieties of foreign selection of winter barley Paso. Thus, in the control areas where mineral fertilizers were not applied, the number of productive stems on average for two years of research was within 285 units/$m^2$.

The highest number of productive shoots on average in two years 467 pcs/m$^2$ was observed in those areas where mineral fertilizers $N_{10}P_{26}K_{26}$ + $N_{34}$ were applied in fertilization in the phase of beginning of tillering + $N_{46}$ beginning of plants in the tube, and foliar fertilization with urea in the dose of $N_8$ + microfertilizer Ecolist at a rate of 4 l/ha (Table 1).

Table 1

Number of productive shoots of winter barley varieties depending on the application of mineral fertilizers

| Sort | Application option | Number of productive shoots, pcs / m$^2$ | | | |
|---|---|---|---|---|---|
| | | 2019 yr. | 2020 yr. | Among. | +/- to counter. |
| Atlantis Myronivsky | Control (without fertilizers) | 286 | 274 | 280 | - |
| | N10P26K26 + N34 in fertilization in the beginning of tillering phase (Background) | 426 | 414 | 420 | +140 |
| | Background + N46 beginning of plants in the tube | 454 | 436 | 445 | +165 |
| | Background + N46 the beginning of an exit of plants in a tube + N8 + Ekolist, 4 l/hectare in a phase the end of an exit in a tube | 467 | 454 | 461 | +181 |
| Paso | Control (without fertilizers) | 289 | 280 | 285 | - |
| | N10P26K26 + N34 in fertilization in the beginning of tillering phase (Background) | 433 | 420 | 427 | + 142 |
| | Background + N46 beginning of plants in the tube | 458 | 449 | 454 | +169 |
| | Background + N46 the beginning of an exit of plants in a tube + N8 + Ekolist, 4 l/hectare in a phase the end of an exit in a tube | 473 | 461 | 467 | + 182 |

The main indicator of the efficiency of growing any crop is its yield. The problems of increasing the grain yield of winter barley are solved not only by selection and genetic methods, fertilizers, but also by the use of microfertilizers, which are increasingly becoming an integral part of intensive barley growing technologies.

The positive effect of microfertilizers is due to the fact that they participate in the redox processes of carbohydrates in the environment. Under the influence of trace elements in the leaves improves the process of photosynthesis.

The formation of high productivity of winter barley agrocenoses presupposes the availability of resources for its cultivation technologies and favorable weather conditions. Therefore, the level of grain yield and its stability is significantly affected by weather conditions. It should also be noted that the meteorological conditions that develop during the growing season of the crop, largely determine the effectiveness of a measure. The results of research on the use of fertilizer systems are aimed at maximizing the biological potential of barley, which cannot be achieved without taking into account meteorological conditions.

The results of our observations indicate that the biological properties of varieties provided their specific reaction under certain agronomic and weather conditions, which manifested itself in the formation of different productivity. More favorable weather and climatic conditions in 2019 contributed formation of slightly higher grain yield of winter barley – 7,57 – 7,87 t/ha depending on the studied variety (Table 2).

Table 2

Seed yield of winter barley varieties depending from the fertilizer system

| Sort | Application option | Yield, t/ha | | | |
|---|---|---|---|---|---|
| | | 2019 yr. | 2020 yr. | Aver-age | +/- to counter |
| Atlantis Myronivsky | Control (without fertilizers) | 2,12 | 1,74 | 1,84 | - |
| | N10P26K26 + N34 in fertilization in the beginning of tillering phase (Background) | 5,75 | 4,05 | 4,90 | +3,06 |
| | Background + N46 beginning of plants in the tube | 6,90 | 5,16 | 6,03 | +4,19 |
| | Background + N46 the beginning of an exit of plants in a tube + N8 + Ekolist, 4 l/hectare in a phase the end of an exit in a tube | 7,57 | 6,04 | 6,81 | +4,97 |
| NIR 05 0,21 0,19 | | | | | |
| Paso | Control (without fertilizers) | 2,26 | 1,86 | 2,06 | - |
| | N10P26K26 + N34 in fertilization in the beginning of tillering phase (Background) | 6,32 | 4,46 | 5,39 | +3,33 |
| | Background + N46 beginning of plants in the tube | 7,24 | 5,60 | 6,42 | +4,36 |
| | Background + N46 the beginning of an exit of plants in a tube + N8 + Ekolist, 4 l/hectare in a phase the end of an exit in a tube | 7,87 | 6,70 | 7,29 | +5,23 |
| $NIR_{05}$ 0,20 0,21 | | | | | |

The maximum grain yield of winter barley on average for two years of research was formed when mineral fertilizers were applied for pre-sowing cultivation for growing winter barley at the rate of $N_{10}P_{26}K_{26} + N_{34}$ in fertilization in the phase of beginning of tillering + $N_{46}$ beginning of plants in the tube of winter barley plants, and foliar fertilization with urea in the dose of $N_8$ + microfertilizer Ecolist at the rate of 4 l/ha. Thus, for the cultivation of Atlant Myronivsky variety, the grain yield of winter barley was at the level of 6,81 t/ha, and of the Paso variety – 7,29 t/ha, which is 4,97-5,23 t/ha more than the control plots ( Table 2).

Thus, one of the main measures to obtain high grain yields of winter barley is scientifically sound application of mineral fertilizers and foliar fertilization.

**Conclusions and prospects for further research**

The results of research have shown that in order to achieve the maximum high yield of winter barley grain it is necessary to apply scientifically sound norms of mineral fertilizers, and during the growing season to carry out foliar fertilization with microfertilizers.

Application for pre-sowing cultivation for growing winter barley diamophos $N_{10}P_{26}K_{26} + N_{34}$ in fertilization in the phase of beginning of tillering + $N_{46}$ beginning of plants in the tube of winter barley plants, and carrying out foliar feeding with urea in the dose of $N_8$ + Ekolist microfertilizer at a rate of 4,0 l/ha will help to obtain the grain yield of winter barley variety Atlant Myronivsky at the level of – 6,81 t/ha, Paso variety – 7,29 t/ha, which is 4,97 more than the control plots - 5,23 t/ha.

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