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YIELD OF WINTER BARLEY DEPENDING ON MINERAL NUTRITION

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Dudar I., Lytvyn O., Pavkovych S., Korpita H., Kozliuk O. Yield of winter barley depending on mineral nutrition

The article presents the results of studies of the influence of mineral fertilizers on the yield of winter barley in the Western Forest-Steppe.

It has been found that grain yield depends on providing plants with mineral nutrients throughout the growing season. The results of scientific research on the influence of mineral nutrition on seed germination, plant survival during the growing season, grain yield and structure of winter barley cultivated on gray podzolic soils in the Western Forest-Steppe are described. The authors of the research studied different doses of mineral fertilizers: 1) without fertilizers (control); 2) $N_{30}P_{30}K_{30}$; 3) $N_{60}P_{60}K_{60}$; 4) $N_{90}P_{90}K_{90}$.

A decrease in field germination by 1.1–2.3 %, with an increase in the level of mineral nutrition was determined.

The positive effect of mineral fertilization on the survival of winter barley has been proved. The lowest level of plant survival was in the areas without fertilizers, and the highest - under application of mineral fertilizers in the norm $N_{90}P_{90}K_{90}$.

The positive effect of fertilization on the number of productive stems, the weight of grain from the ear and the number of grains in the ear was demonstrated. A positive correlation was established between fertilizer and the number of grains in the ear (r = 0.96) and fertilizer and grain weight from the ear (r = 0.77). It was found that the studied rates of fertilizers were effective for the nutritional regime of winter barley agrocenosis in the Western Forest-Steppe. The optimal dose of fertilizers which ensures maximum grain yield was determined. Application of phosphorus and potassium fertilizers ($P_{90}K_{90}$) for plowing and nitrogen ($N_{30+30+30}$) in three steps: during the restoration of spring vegetation, in the phase of tube emergence and earing provided a significant increase in yield as compared to control (without fertilizers) and options $N_{30}P_{30}K_{30}$ and $N_{60}P_{60}K_{60}$.

Key words: winter barley, doses of mineral fertilizers, field germination of seeds, plant survival, yield.

Дудар І., Литвин О., Павкович С., Корпіта Г., Козлюк О. Урожайність ячменю озимого залежно від мінерального живлення

Відображено результати досліджень впливу мінерального удобрення на врожайність ячменю озимого в умовах Лісостепу Західного.

Досліджено публікації щодо впливу мінерального удобрення на продуктивність ячменю озимого. З'ясовано, що врожайність зерна залежить від забезпечення рослин елементами мінерального живлення упродовж усієї вегетації. Описано результати наукових досліджень щодо впливу рівня мінерального живлення на польову схожість насіння, виживання рослин за період вегетації, урожайність зерна ячменю озимого та його структуру на сірих опідзолених ґрунтах в умовах Лісостепу Західного. Вивчено норми мінеральних добрив, а саме: 1) без добрив (контроль); 2) $N_{30}P_{30}K_{30}$; 3) $N_{60}P_{60}K_{60}$; 4) $N_{90}P_{90}K_{90}$.

Виявлено зниження польової схожості на 1,1–2,3 %, із підвищенням рівня мінерального живлення.

Доведено позитивний вплив мінеральних добрив на виживання ячменю озимого. Найнижчий рівень виживання рослин був на ділянках без удобрення, а найвищий – за внесення мінеральних добрив у нормі $N_{90}P_{90}K_{90}$.

Виявлено вплив удобрення на кількість продуктивних стебел, масу зерна з колоса та кількість зерен у колосі. Встановлено позитивний кореляційний зв'язок між удобренням та кількістю зерен у колосі (r = 0,96) і удобренням та масою зерна з колоса (r = 0,77). З'ясовано, що досліджувані норми добрив ефективні для поживного режиму

агроценозу ячменю озимого в умовах Лісостепу Західного. Визначено оптимальну норму добрив, що забезпечує максимальну врожайність зерна. Внесення фосфорно-калійних добрив ($P_{90}K_{90}$) під оранку та азотних ($N_{30+30+30}$) у три прийоми: під час відновлення весняної вегетації, у фазі виходу в трубку та колосіння забезпечило істотний приріст урожаю порівняно з варіантами без добрив та варіантами $N_{30}P_{30}K_{30}$ *та* $N_{60}P_{60}K_{60}$.

Ключові слова: ячмінь озимий, норми мінеральних добрив, польова схожість насіння, виживання рослин, урожайність.

Problem setting. Barley is the main grain crop in Ukraine. Its yield depends on the intensification of cultivation technology. Mineral nutrition is one of the main factors regulating the growth and development of plants [11].

To form highly productive agrocenoses, it is important to provide spring barley with available mineral nutrients, including nitrogen, phosphorus and potassium. They are needed by plants in a shorter time as compared to other cereals due to the high rate of growth and development of barley.

The optimal balance of nutrients is ensured by applying mineral fertilizers to the soil. Their efficiency is achieved under the condition of rational use taking into account the specific conditions of the economy.

Modern approaches to the peculiarities of mineral nutrition are due to the biological characteristics of spring barley. Timely and correct application of fertilizers creates optimal conditions for winter barley plants and needs to be clarified in specific soil and climatic conditions.

Analysis of recent research and publications. Intensification of the technologies for growing cereals sets increased demands to optimization of soil factors that significantly affect the growth and development of plants [4].

An important factor in increasing the yield of winter barley is to provide plants with a set of essential nutrients during the growing season. To form 1 ton of grain, winter barley consumes 20–30 kg of nitrogen, 5–15 kg of phosphorus and 20–30 kg of potassium [8].

Recently, the attention of many domestic and foreign scientists has been drawn to the fertilization of winter barley as a means of increasing the productivity of agrocenosis [2; 9; 10; 12–14; 17; 18].

Scientists recommend applying phosphorus and potassium fertilizers once, under the main tillage, nitrogen – in stages [3]. The first feeding is carried out on frozen thawed soil, the second – in the spring tillering phase – the beginning of the tube and the third – in the earing phase – grain filling. [8; 17].

It is important when choosing the timing of fertilizers to take into account the dynamics of formation of the yield components [16].

The works of scientists revealed the patterns of formation of the structure of the winter barley crop from the use of mineral fertilizers [2], nitrogen nutrition [10] and meteorological conditions [13].

The research data indicate both the positive effect of increased rates of mineral fertilizers ($N_{120}P_{120}K_{120}$) on the productivity of winter barley [1] and negative. Yield losses due to crop thickening and lodging of plants from N_{120} application can be significant [6; 18].

There is no consensus among experts on the rate of application of mineral fertilizers in the cultivation of winter barley, as it varies depending on soil and climatic conditions, the availability of nutrients in the soil and other factors.

Therefore, finding ways to optimize the nutrient regime of barley agrocenosis in a particular farm is of paramount importance.

Setting objectives. The aim of our research was to study the dependence of field seed germination, plant survival, winter barley grain yield on mineral nutrition.

Presenting main material. The research was conducted in 2019–2021.

The soil is gray podzolic. Humus content – 2.2 %. The reaction medium is close to neutral (pH – 6). The soil is relatively well provided with mobile forms of nitrogen, phosphorus and potassium.

The scheme of the experiment included: 1) without fertilizers (control); 2) $N_{30}P_{30}K_{30}$; 3) $N_{30+30}P_{60}K_{60}$; 4) $N_{30+30+30}P_{90}K_{90}$.

Phosphorus-potassium fertilizers were applied in the form of superphosphate (19 %) and potassium chloride (60 %) under the main tillage. Fertilization with nitrogen fertilizers (ammonium nitrate (34 %) was carried out in portions: N_{30} – during the restoration of spring vegetation (BBCH-25); N_{30+30} – during the restoration of spring vegetation and in the phase of entering the tube (BBCH 31); $N_{30+30+30}$ – during the restoration of spring vegetation, in the phase of tube emergence and earing (BBCH 51).

The forecrop of winter barley was winter rape.

The experiments examined the winter barley variety Vintmalt (originator KWS, in the register since 2009). Variety – two-row (N. s. Distichum L.).

Yield data and laboratory results were processed by the analysis of variance. The experiment

was established and conducted according to the method of B.A. Dospekhov [4]. Yield data and results of laboratory tests were processed by the method of analysis of variance of a one-factor experiment using the program «Statistica».

The estimated area of the plot was 100 m^2. Repetition of the experiment – three times. Variants of the experiment were placed systematically, in one tier.

The technology of growing winter barley on the experimental site, except for the issue studied in the experiment, is generally accepted for the zone of the Western Forest-Steppe of Ukraine.

An important task of winter barley cultivation technology is to ensure high field germination of seeds and survival of plants during the growing season. The future harvest of spring barley largely depends on these indicators.

It is known that the use of intensive cultivation technologies is possible only with field germination of at least 80 % [7]. The effect of mineral fertilizers on the field germination of winter barley has not been studied enough. Today, there is disagreement about the effect of fertilizers on seed germination. In some cases, scientists argue that mineral fertilizers reduce field germination [12], in others – no such pattern was found [15]. Field germination of seeds, its completeness and timeliness, the formation of optimal plant density depend on a number of soil, climatic and technological factors.

We found that mineral fertilizers affected the field germination of winter barley seeds (Fig. 1). High rates were recorded in all variants of the experiment (90.8–93.1 %) field germination and survival (83.1–87.7 %) of plants depending on fertilizer.

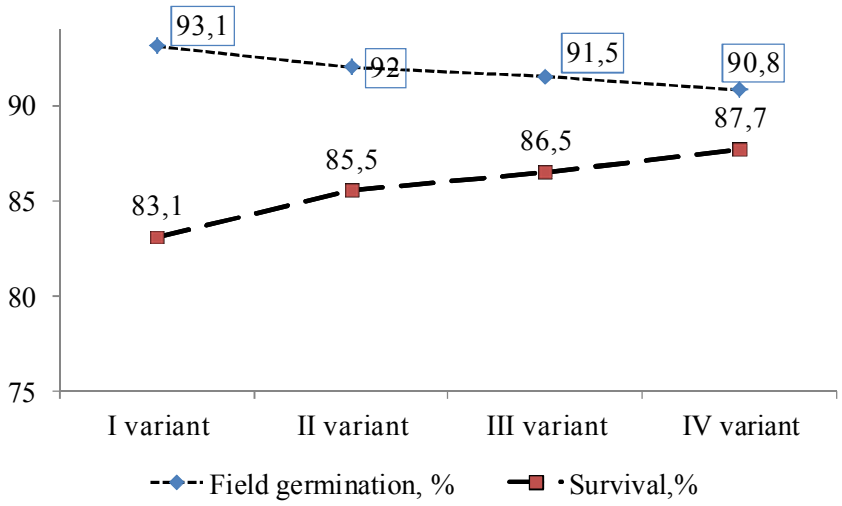

Fig. 1. Field germination and survival of plants depending on fertilizer (average 2020–2021)

There was a decrease in field germination by 1.1–2.3 %, depending on the level of mineral nutrition. Thus, for the application of complete mineral fertilizer $N_{30}P_{30}K_{30}$ and a single application of nitrogen field germination was 92.0 %. With the increase of fertilizer rates to $N_{30+30}P_{60}K_{60}$, it decreased by 0.5 % (91.5 %). The lowest rate of field germination (90.8 %) was recorded for $N_{30+30+30}P_{90}K_{90}$. It is obvious that the increase in the concentration of chemical elements in the soil somewhat inhibits the growth and development of young seedlings of winter barley plants.

The overall survival of plants is extremely important in the formation of productivity. It depends on overwintering and plant death in spring and summer. In contrast to field germination, survival depended more on fertilizer.

Application of mineral fertilizers contributed to better survival of plants on the variant $N_{30+30+30}P_{90}K_{90}$ (87.7 %). High rates were for $N_{30}P_{30}K_{30}$ (85.5 %) and $N_{30+30}P_{60}K_{60}$ (86.5 %). The lowest survival rate was in unfertilized areas of the experiment (control) (83.1 %).

The level of winter barley yield is determined by the main parameters of its structure: the number of productive stems and the weight of grain from the ear. These indicators, depending on the variety and growing conditions, vary significantly.

The results of our research indicate that the increase in the rate of mineral fertilizers had a positive effect on the formation of productive stems (Fig. 2).

With mineral fertilizer, a larger number of productive stems was formed in the variant, $N_{30+30+30}P_{90}K_{90}$ – 619 pieces/m^2. In the variants

$N_{30}P_{30}K_{30}$ and $N_{30+30}P_{60}K_{60}$ there were less productive stems by 107 and 38 pieces/m^2, respectively. However, the least (480 pcs/m^2) productive stems was on the control unfertilized variant.

The use of mineral fertilizers had a positive effect on formation of the number of grains in the ear. Application of mineral fertilizers $N_{30}P_{30}K_{30}$ and $N_{30+30}P_{60}K_{60}$ ensured the growth of grains in the ear by 2.8–3.7 units as compared to the control. The highest indicators of the number of grains in the ear, on average for 2020–2021, were obtained in the variant $N_{30+30+30}P_{90}K_{90}$ (25.2 pcs.).

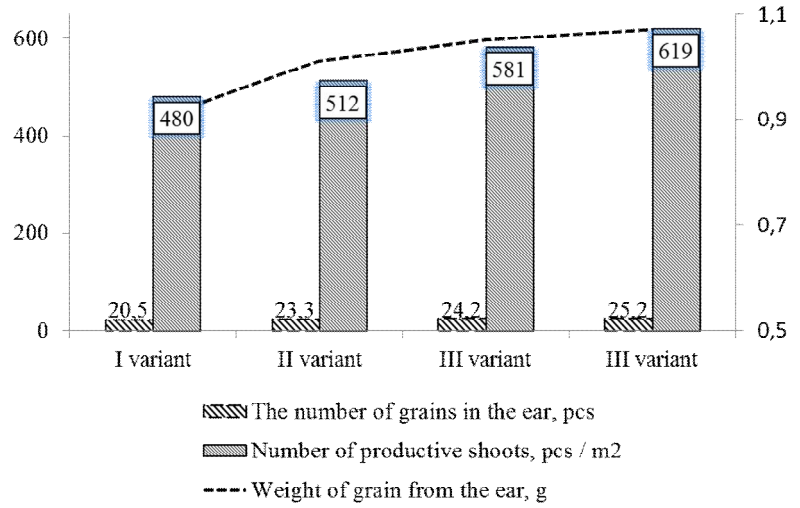

Fig. 2. Elements of the structure of barley harvest depending on the level of muneral fertilizers (avtgage 2020–2021)

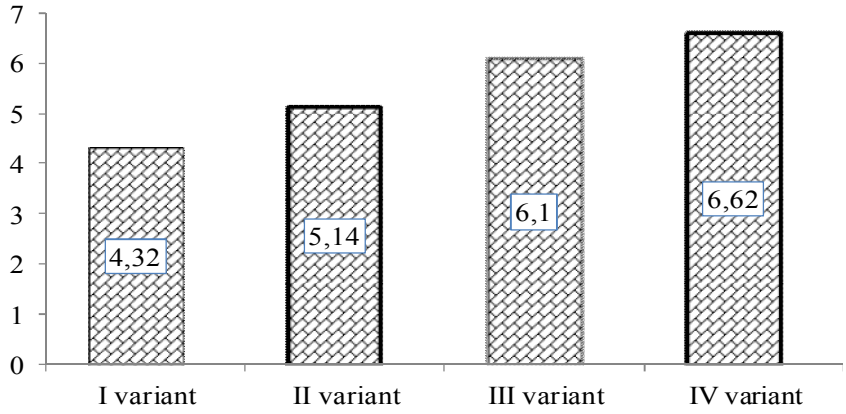

Fig. 3. Biological yield of winter barley depending on the level of mineral nutrition, t/ha (average 2020–2021)

Elements of the structure of winter barley yield depend on the level of mineral fertilizers. The number of grains in the ear is in strong positive relationship (r = 0.96) with doses of mineral fertilizers.

The analysis of our results showed that the mass of grain from the ear increased with increasing rates of mineral fertilizers. Against the background of $N_{30}P_{30}K_{30}$ it was 1.01 g, and with the introduction of $N_{30+30}P_{60}K_{60}$ and $N_{30+30+30}P_{90}K_{90}$, respectively, increased to 1.05 g and 1.07 g. A positive correlation was found between fertilizer and grain weight from the ear (r = 0.77).

The increase in mineral fertilizer doses from 30 to 90 kg/ha leads to the increase of the grain yield of winter barley (Fig. 3). Thus, on the variant of $N_{30}P_{30}K_{30}$ the yield was 5.14 t/ha. Increasing the dose of fertilizers to $N_{30+30}P_{60}K_{60}$ kg/ha provided additional 1.78 and 0.96 t/ha of grain as compared to the control (without fertilizers) and the application of $N_{30}P_{30}K_{30}$.

The highest level of yield was obtained on the $N_{30+30+30}P_{90}K_{90}$ and was 6.62 t/ha.

Statistical processing of the research data by the analysis of variance showed a significant difference between the options (LSD – 0.27 t/ha).

Thus, the yield of winter barley depends on the provision of nutrients to plants. As the fertilizer rate increased from $N_{30}P_{30}K_{30}$ to $N_{90}P_{90}K_{90}$, the number of productive shoots, the number of grains per ear and the weight of grain per ear increased.

Conclusions. The studied doses of fertilizers are the effective factor in increasing the survival of plants, improving the structure of the yield of barley. On gray podzolic soils, the highest grain yield (6.62 t/ha) was provided by the application of $P_{90}K_{90}$ for plowing and $N_{30+30+30}$ – during the restoration of spring vegetation, in the phase of tube emergence and earing.

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