

# Malting barley in the Northern Urals

R.I. Belkina\*, M.S. Lukyanets, M.V. Gubanov, and D.V. Raichert

FSBEI HE Northern Trans-Ural SAU, Tyumen, Russia

**Abstract.** The article presents the results of studying the yield and grain quality of malting barley varieties grown on different backgrounds of fertilizers. Barley grain is a valuable raw material for the cereal, brewing, and feed processing industries. In the Northern Trans-Urals, barley is the most important forage and food crop. The purpose of the research was to study the effect of increasing norms of mineral fertilizers on the yield and grain quality of malting barley varieties in the conditions of the northern forest-steppe of the Tyumen region. Studies were conducted in 2022 and 2023 with the varieties Acha, Despina, KVS Hobbs, Beatrice. The experiment options included: 1) control without fertilizers; 2)  $N_{30}P_{30}K_{30}$ ; 3)  $N_{60}P_{60}K_{60}$ . The soil cover of the experimental field is leached chernozem, heavy loamy in granulometric composition. The chemical composition of the soil is characterized by an average humus content in the arable layer, an average supply of phosphorus, potassium, low nitrogen and a slightly acidic reaction of the soil solution. The conditions of the 2022 growing season were characterized by high air temperature and sufficient precipitation. Meteorological indicators in 2023 were characterized by excessively high air temperatures and uneven precipitation, which negatively affected the yield of barley varieties. In the conditions of 2022, the varieties showed responsiveness to fertilizers. The greatest increase in yield was obtained against an increased background ( $N_{60}P_{60}K_{60}$ ): in the Acha variety – 1.48 t/ha; in the Despina variety – 2.71 t/ha, in the KVS Hobbs variety – 2.12 t/ha, in the Beatrice variety - 1.60 t/ha. In 2023, reliable increases from the action of fertilizers were obtained in two varieties – Acha (+0.57 t/ha) and Beatrice (+0.67 t/ha) against an increased background of fertilizers. Barley varieties were characterized by high indicators of grain nature and germination ability. The protein content corresponded to the standards for brewing in the Despina and KVS Hobbs varieties in the version without fertilizers and in the  $N_{30}P_{30}K_{30}$  variant, in the Beatrice variety – in all variants, in the Acha variety – only in the version without fertilizers.

## 1 Introduction

Barley is widely distributed in various soil and climatic zones of Russia, Western Europe, Asia and other regions of the world. It is a high-yielding grain crop [1,2]. In Western Siberia, barley occupies an area of about 3 million hectares, in the Tyumen region – an

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\* Corresponding author: [belkina@edu.tsaa.ru](mailto:belkina@edu.tsaa.ru)

average of 140 thousand hectares. It is noted that the yield of this crop in the region is quite high and has some advantage in comparison with wheat [3, 4].

Barley grain is widely used in various branches of the processing industry, in particular in cereals, brewing, and feed. In the Northern Trans-Urals, barley is one of the most important food and fodder crops [5].

Despite the value of barley as a raw material for the processing industry, due to changes in market conditions, there is a slight reduction in its acreage. In 2012-2017 alone, the acreage of spring barley in the country decreased by 12.6%, which is due to a decrease in consumer demand for grain of this crop [6].

The brewing industry has special requirements for barley: the grain must have a high germination rate – at the level of 90-95%, good alignment, sufficient size, film content of no more than 10%, low protein content – no more than 12% and an increased amount of starch (up to 65%). It is also recommended for batches of malting barley grain to have a certain ratio between extractivity and protein content. It is noted that batches of barley grain do not always meet the specified requirements. At the same time, barley malt produced in Russia is used not only for the domestic market, but is also exported to the near and far abroad [7, 8].

A significant increase in the production of malt and beer, as well as an improvement in the quality of these products, largely depends on the quality of raw materials and methods of its rational use [9]. The necessary quality of barley grain is provided by certain elements of its cultivation technology. The peculiarities of brewing barley cultivation technology include a reduced background of nitrogen fertilizers (no more than 30-35 kg/ha a.d.). It is believed that an increase in this rate may contribute to an increase in the protein content of the grain, and may also cause lodging of plants. An increase in the protein content in the grain can also cause fractional application of nitrogen fertilizers. For malting barley, increased doses of phosphorus fertilizers are recommended – 80-90 kg/ha a.d. and potash fertilizers – 60-70 kg/ha a.d. Such doses ensure the production of grain with high brewing properties [10].

Optimal conditions for growing malting barley on sod-podzolic soil are shown: with a high supply of nutrients in wet and cool weather ( $HTC = 2.3$ ), indicators of nature, size, germination ability and protein content at the level of established standards were formed. It was revealed that the Novosil phyto regulator, when treating barley plants with it in conditions favorable for protein accumulation, is able to lower the concentration of proteins in malting barley grain [11].

In the Ryazan region, the yield and grain quality of brewed varieties of barley Vladimir, Nadezhny, and Yaromir under the influence of fertilizers were studied on dark gray forest soil. It was found that the yield of barley varieties significantly depended on weather conditions. Thus, in the most favorable humidification year of 2017, the yield of barley varieties averaged 4.50-5.18 t/ha, in 2018, with a lack of moisture and elevated air temperatures, the yield decreased to 2.74-3.00 t/ha. According to the complex of grain quality indicators, a Reliable variety was distinguished, which, according to the authors of the research, provided a level of indicators within the required standards for malting barley [12].

The effect of mineral fertilizers on the yield and grain quality of brewed spring barley of the Vladimir variety was studied on sod-podzolic soils of the Central Non-Chernozem region [13]. It was found that the yield and quality of grain depended not only on the level of mineral nutrition, but also largely on meteorological conditions during the period of plant growth and development. To a greater extent, the grain met the standards for brewing in all variants with fertilizers in a hot and dry year ( $HTC = 1.09$ ), as well as in an excessively humid year ( $HTC = 2.39$ ) with a dose of mineral fertilizers not exceeding  $N_{50}P_{50}K_{75}$  [13].

The effect of meteorological factors of the growing season on the formation of laboratory germination, weight of 1000 seeds, grain type in spring barley varieties in the conditions of the Pre-Kama zone of the Republic of Tatarstan has been studied. It was found that the value of these indicators for barley varieties depended on the weather conditions in which seeds were formed for sowing these varieties. Varieties (Koldun, Nord 17/2645, and Nord 17/2610) have been identified, in the seeds of which no fungal infection has been detected, based on this, the authors recommend including these varieties in hybridization programs [14].

The quality of barley grain of the Biom variety grown in the conditions of the Novosibirsk region has been studied. It is shown that the total grain hardness was 24%, the mass of 1000 grains was 49.7 g, the grain size was 715 g/l, the film content was 6.95%. The amylolytic activity of grain of normal quality was determined - 70.27 c.u.,  $\alpha$ -amylase - 4.71,  $\beta$ -amylase - 1.97. The indicators of sprouted grain increased significantly: on the 4th day, the activity of amylases amounted to 128.53 c.u.,  $\alpha$ -amylase - 28.45,  $\beta$ -amylase - 11.36; on the seventh day of germination, amylolytic activity reached 136.8 units,  $\alpha$ -amylase - 41.32,  $\beta$ -amylase - 20.24 [15].

The technological properties of barley grain in the conditions of the Belgorod region have been studied to differentiate varieties considering the intended purpose. It was found that the following varieties met the standards for brewing purposes to a greater extent: on a low background of fertilizers – Hadjibey, Knyazhich, Annabel, Xanadu; on an average background of fertilizers – Hadjibey, Knyazhich, Annabel, Scarlet, Oskolets; on a high background of fertilizers – Knyazhich, Vakula; on an intense background, the Knyazhich variety stood out [16].

D.S. Afanasyeva and her co-authors evaluated the seeds of 30 varieties of spring barley of domestic and foreign breeding according to endophytic microflora. Bacteria were isolated from seeds without grinding (external endophytes) and with grinding (internal endophytes). Researchers have identified differences between barley varieties in the number of those and other bacteria. Nevertheless, no internal endophytes were found in some varieties, while external endophytes were isolated. The authors believe that the results obtained can be used both in the evaluation of barley breeding material and for the creation of new biological products [17].

In the conditions of the North Caucasus region, the quality indicators of malting barley grain were studied depending on its location in the ear. It was noted that the grain with the highest indicators differed from the middle, then the lower, and last of all from the upper part of the ear [18]. There is evidence that it is possible to improve the brewing qualities of barley by such a technique as seed treatment before sowing with growth regulators. Thus, the research of S.I. Danilin and co-authors showed that the treatment of Annabel barley seeds with the Epin-Extra growth regulator, along with the introduction of a reduced fertilizer rate compared to the control, contributed to an improvement in the brewing qualities of grain: the nature increased by 32 g/l, the extractivity by 11%, the protein content decreased from 12.4% (control version) to 11.1%, which is more in line with established standards [19].

**The purpose of the research:** To study the effect of increasing norms of mineral fertilizers on the yield and grain quality of malting barley varieties in the conditions of the northern forest-steppe of the Tyumen region.

## 2 Material and research methods

The experiments were laid on the experimental field of the Agrotechnological Institute of the State Agrarian University of the Northern Urals. The experimental field is located in the forest-steppe zone, which occupies 29.9% of the territory of the southern part of the region.

The soil cover of the experimental field is leached chernozem, heavy loamy in granulometric composition. The chemical composition of the soil is characterized by an average humus content in the arable layer, an average supply of phosphorus, potassium, low nitrogen and a slightly acidic reaction of the soil solution. Under these conditions, the effect of fertilizers on the yield and quality of barley grain has been studied. Varieties used for sowing: Acha, Beatrice, Despina, KVS Hobbs. Azophoska fertilizer was applied. The experiment options included: 1) Control without fertilizers; 2)  $N_{30}P_{30}K_{30}$ ; 3)  $N_{60}P_{60}K_{60}$ .

The area of the plot in the experiment is 5 m<sup>2</sup>, the repetition is fourfold. The placement of plots is randomized. Sowing of barley varieties was carried out with a seeder SSFC-10, harvesting with a combine harvester SK-110. The yield was considered by direct threshing with data reduction to 100% purity and 14% humidity.

The following indicators of barley grain quality have been determined: weight of 1000 grains, nature, germination ability, protein content.

3 Results and Discussion

Meteorological conditions in 2022 and 2023 had a significant difference, which became one of the factors influencing the quality of barley grain. The air temperature and precipitation are shown in Figures 1 and 2, respectively.

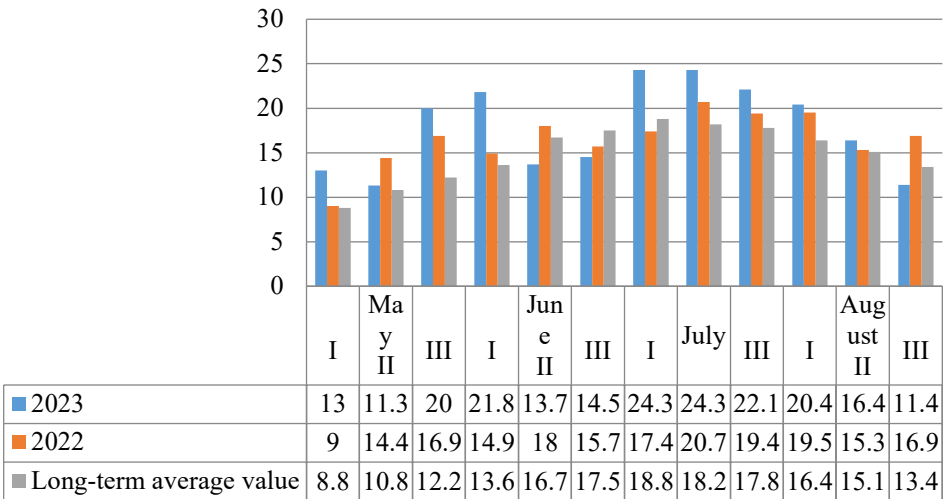
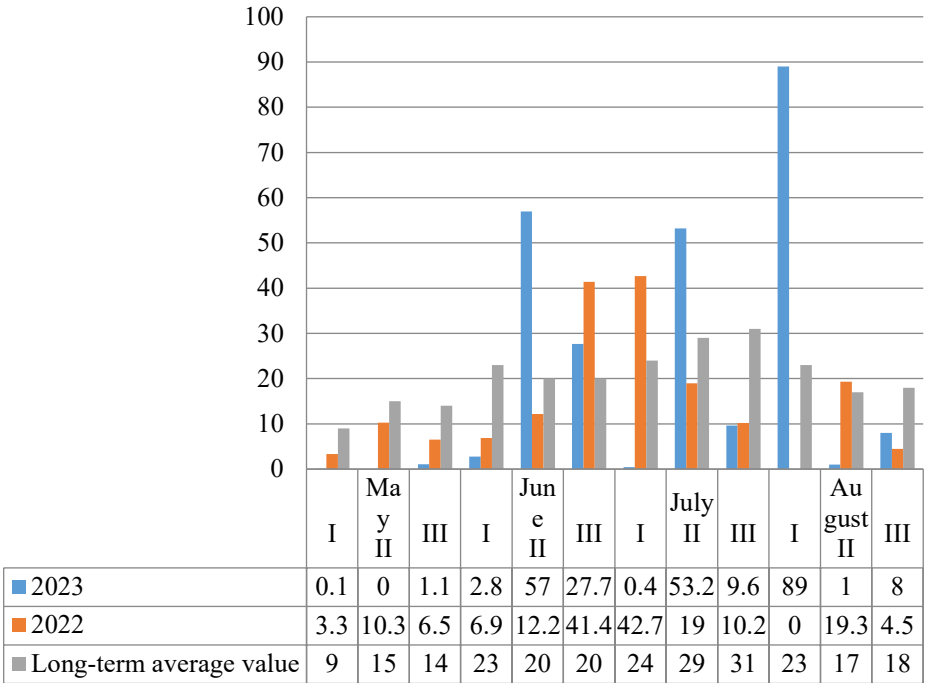


Fig. 1. Average daily air temperature during barley growing season, °C.

The meteorological conditions of the growing season of 2022 were characterized by an increased air temperature, which was higher than the average annual values throughout the growing season and a sufficient amount of precipitation, which favorably affected the development of barley plants.



**Fig. 2.** Precipitation during barley growing season, mm.

It should be noted that meteorological indicators in 2023 were characterized by increased aridity of summer due to excessively high air temperatures and uneven precipitation, especially at the beginning of the barley growing season (May 2023), when there were almost no rains. This affected the further development of plants and responsiveness to fertilizers applied, as well as barley quality indicators.

The grain yield of barley varieties in 2022 was quite high – from 5.18 to 8.85 t/ha, which was ensured by favorable humidification conditions during the period of plant growth and development. The Beatrice variety had the highest yield, which exceeded the standard Acha variety by 1.0-1.47 t/ha (Table 1).

**Table 1.** Yield of barley varieties, t/ha.

| Variety,<br>factor A                                             | Background of fertilizers, factor B |      |      |      |                                                 |      |
|------------------------------------------------------------------|-------------------------------------|------|------|------|-------------------------------------------------|------|
|                                                                  | control                             |      |      |      | N <sub>60</sub> P <sub>60</sub> K <sub>60</sub> |      |
|                                                                  | 2022                                | 2023 | 2022 | 2023 | 2022                                            | 2023 |
| Acha, standard                                                   |                                     | 3,62 | 6,59 | 3,75 | 7,68                                            | 4,19 |
| Despina                                                          |                                     | 2,91 | 5,41 | 1,76 | 7,89                                            | 2,44 |
| KVS Hobbs                                                        |                                     | 2,89 | 7,73 | 2,27 | 8,85                                            | 2,45 |
| Beatrice                                                         |                                     | 2,45 | 8,06 | 2,81 | 8,80                                            | 3,12 |
| LSD <sub>05</sub> 2022: for factor A – 0.24; for factor B – 0.21 |                                     |      |      |      |                                                 |      |
| LSD <sub>05</sub> 2023: for factor A – 0.33; for factor B – 0.25 |                                     |      |      |      |                                                 |      |

In the conditions of 2022, all varieties showed responsiveness to fertilizers. Thus, in the Acha variety, the yield increase on an average background (N<sub>30</sub>P<sub>30</sub>K<sub>30</sub>) was 0.39 t/ha, on an increased one (N<sub>60</sub>P<sub>60</sub>K<sub>60</sub>) – 1.48 t/ha; in the Despina variety, these indicators corresponded to 0.23 and 2.71 t/ha, in the KVS Hobbs variety – 1.0-2.12 t/ha, for the Beatrice variety – 0.86-1.60 t/ha. In 2023, the yield of barley varieties was significantly lower than in the

previous year, due to high air temperatures and uneven precipitation during the growing season. In the variants with fertilizers, the yield of Despina and KVS Hobbs varieties was significantly lower compared to the control. Reliable increases from the action of fertilizers were obtained in two varieties – Acha (+0.57 t/ha) and Beatrice (+0.67 t/ha) on an elevated background.

*The mass of 1000 grains* of barley varieties in 2022 was formed quite high – from 51.7 to 62.5 g (Table 2). The studied varieties exceeded the standard in terms of the magnitude of this feature. In the Acha variety, the maximum indicator was obtained against an increased background of fertilizers (55.4 g), against the same background, the highest indicators were in the varieties Despina (62.5 g) and KVS Hobbs (59.8 g). The Beatrice variety showed a decrease in the weight of 1000 grains in the variants with fertilizers by 2.6 and 1.8 g relative to the control.

**Table 2.** Weight of 1000 grains of barley varieties, g.

| Variety,<br>factor A                                           | Background of fertilizers, factor B |      |                                                 |      |                                                 |          |
|----------------------------------------------------------------|-------------------------------------|------|-------------------------------------------------|------|-------------------------------------------------|----------|
|                                                                | control                             |      | N <sub>30</sub> P <sub>30</sub> K <sub>30</sub> |      | N <sub>60</sub> P <sub>60</sub> K <sub>60</sub> |          |
|                                                                | 2022                                | 2023 | 2022                                            | 2023 | 2022                                            | 2023     |
| Acha, standard                                                 | 51,7                                | 46,8 | 52,7                                            | 47,3 | 55,4                                            | 49,5+2,7 |
| Despina                                                        | 55,1                                | 50,8 | 56,8                                            | 48,2 | 62,5                                            | 48,6-2,2 |
| KVS Hobbs                                                      | 55,6                                | 48,9 | 58,2                                            | 46,5 | 59,8                                            | 45,9-3,0 |
| Beatrice                                                       | 57,4                                | 51,4 | 54,8                                            | 50,2 | 55,6                                            | 49,0-2,4 |
| LSD <sub>05</sub> 2022: for factor A – 0.6; for factor B – 0.7 |                                     |      |                                                 |      |                                                 |          |
| LSD <sub>05</sub> 2023: for factor A – 1.4; for factor B – 1.0 |                                     |      |                                                 |      |                                                 |          |

In 2023, all varieties reduced the weight of 1,000 grains compared to the previous year. In the Acha variety, the decrease in the indicator in the experimental variants was 4.9-5.9 g, in Despina – 4.3-13.9 g, KVS Hobbs – 6.7-13.9 g, Beatrice – 5.5-10.1 g. In the studied varieties, in the conditions of 2023, a decrease in the weight of 1000 grains was observed in the variants with fertilizers relative to the control. The standard Acha variety showed a significant increase in the indicator in the variant with an increased background (+ 2.7 g to the control).

*The grain unit* of barley is considered high if its value is at least 630 g/l. As the data in Table 3 show, the grain unit of all varieties is quite high. Some varieties have reduced the amount of unit in the variant with an increased fertilizer rate in 2023: Despina – by 27 g/l, KVS Hobbs – by 16 g/l, Beatrice – by 15 g/l. In 2022, fertilizers had a positive effect on the unit size of these varieties. It should be noted that the standard Acha variety was characterized by the stability of the formation of a high grain size, its maximum value was 697 g/l.

**Table 3.** Grain unit in barley varieties, g/l.

| Variety,<br>factor A                                       | Background of fertilizers, factor B |      |                                                 |      |                                                 |      |
|------------------------------------------------------------|-------------------------------------|------|-------------------------------------------------|------|-------------------------------------------------|------|
|                                                            | control                             |      | N <sub>30</sub> P <sub>30</sub> K <sub>30</sub> |      | N <sub>60</sub> P <sub>60</sub> K <sub>60</sub> |      |
|                                                            | 2022                                | 2023 | 2022                                            | 2023 | 2022                                            | 2023 |
| Acha,<br>standard                                          | 697                                 | 648  | 685                                             | 655  | 684                                             | 651  |
| Despina                                                    | 658                                 | 655  | 662                                             | 642  | 673                                             | 628  |
| KVS Hobbs                                                  | 650                                 | 652  | 667                                             | 644  | 681                                             | 636  |
| Beatrice                                                   | 670                                 | 653  | 670                                             | 656  | 680                                             | 638  |
| LSD <sub>05</sub> 2022: for factor A – 2; for factor B – 1 |                                     |      |                                                 |      |                                                 |      |
| LSD <sub>05</sub> 2023: for factor A – 2; for factor B – 1 |                                     |      |                                                 |      |                                                 |      |

The *germination ability* is a very important indicator for evaluating malting barley grains and the malting stage in beer production. In varieties with a long post-harvest ripening period, this indicator is unstable. The magnitude of this trait also decreases in areas with rainy and cold weather during the cleaning period. Germination capacity should be at least 95% for brewed barley of the first GOST class, and at least 90% for the second.

It follows from the data in Table 4 that in the conditions of 2022, the varieties were characterized by slightly higher indicators compared to those of 2023. At the same time, almost all varieties have indicators at the level of requirements for malting barley.

**Table 4.** The ability of grain germination in barley varieties, %.

| Variety,<br>factor A                                       | Background of fertilizers, factor B |      |                                                 |      |                                                 |      |
|------------------------------------------------------------|-------------------------------------|------|-------------------------------------------------|------|-------------------------------------------------|------|
|                                                            | control                             |      | N <sub>30</sub> P <sub>30</sub> K <sub>30</sub> |      | N <sub>60</sub> P <sub>60</sub> K <sub>60</sub> |      |
|                                                            | 2022                                | 2023 | 2022                                            | 2023 | 2022                                            | 2023 |
| Acha, standard                                             | 98                                  | 92   | 100                                             | 98   | 98                                              | 97   |
| Despina                                                    | 96                                  | 96   | 97                                              | 96   | 98                                              | 94   |
| KVS Hobbs                                                  | 99                                  | 96   | 99                                              | 95   | 98                                              | 91   |
| Beatrice                                                   | 97                                  | 93   | 99                                              | 97   | 99                                              | 97   |
| LSD <sub>05</sub> 2022: for factor A – 4; for factor B – 3 |                                     |      |                                                 |      |                                                 |      |
| LSD <sub>05</sub> 2023: for factor A – 4; for factor B – 3 |                                     |      |                                                 |      |                                                 |      |

The *protein content* in malting barley grain should not be high (no more than 12%), so as not to worsen the quality of beer. Nevertheless, protein is necessary for the nutrition of yeast during the fermentation stage, so a minimum protein content of 9% is recommended. Table 5 shows data on the protein content in barley grain for 2022.

**Table 5.** Protein content in barley grain, % (2022).

| Variety, factor A              | Background of fertilizers, factor B |                                                 |                                                 |
|--------------------------------|-------------------------------------|-------------------------------------------------|-------------------------------------------------|
|                                | control                             | N <sub>30</sub> P <sub>30</sub> K <sub>30</sub> | N <sub>60</sub> P <sub>60</sub> K <sub>60</sub> |
| Acha, standard                 | 10,59                               | 12,74                                           | 13,92                                           |
| Despina                        | 10,66                               | 10,63                                           | 12,73                                           |
| KVS Hobbs                      | 10,19                               | 11,47                                           | 13,21                                           |
| Beatrice                       | 11,87                               | 12,04                                           | 11,53                                           |
| LSD <sub>05</sub> for factor A |                                     |                                                 |                                                 |
| LSD <sub>05</sub> for factor B |                                     |                                                 |                                                 |

The Despina and KVS Hobbs varieties have a protein content of no more than 12% in the control and the version with an average fertilizer rate, the Beatrice variety – in all variants, the Acha variety – only in the version without fertilizers. If we consider the average data for varieties, we can conclude that the fertilizer rate of N<sub>30</sub>P<sub>30</sub>K<sub>30</sub> provides an increase in the protein content of grain relative to the non-fertilizer option by 0.89%, and the fertilizer rate N<sub>60</sub>P<sub>60</sub>K<sub>60</sub> - by 2.02%.

4 Conclusions

1. All varieties showed responsiveness to fertilizers in the conditions of 2022. The maximum yield increase was obtained against an elevated background (N<sub>60</sub>P<sub>60</sub>K<sub>60</sub>): in the Acha variety – 1.48 t/ha; in the Despina variety – 2.71 t/ha, in the KVS Hobbs variety – 2.12 t/ha, in the Beatrice variety -1.60 t/ha. In 2023, the yield of barley varieties was significantly lower than in the previous year, due to high air temperatures and uneven precipitation during the growing season; reliable increases from the action of fertilizers

were obtained in two varieties – Acha (+0.57 t/ha) and Beatrice (+0.67 t/ha) against an increased background of fertilizers.

2. Grain of malting barley varieties was characterized by high indicators of unit and germination ability. The protein content was within the limits of the brewing standards for Despina and KVS Hobbs% varieties under control and in the version with an average fertilizer rate, for the Beatrice variety – in all variants, for the Acha variety – only in the version without fertilizers.

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