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Spring barley is a promising crop in agricultural production

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Abstract. Spring barley occupies an important place in modern agriculture, offering both economic and environmental benefits, which confirms its importance in the context of food security and sustainable development of the agricultural sector. In 2023, the gross harvest of spring barley reached 27 million tons globally, where the largest producers are countries such as Canada, Australia, and Germany, providing high yields thanks to modern agronomic practices and optimal climatic conditions. In Russia, the average yield of spring barley varies from 2.4 to 3.0 t/ha, with a gross harvest of about 5.5 million tons, and the most significant volumes are obtained in the Krasnodar and Stavropol territories. The prospects for growing spring barley look promising due to its adaptability to changing climatic conditions and its ability to effectively use minimal resources. Spring barley is also a valuable source of proteins and carbohydrates, which makes it irreplaceable in the diet for both humans and farm animals. In general, spring barley is a promising crop for development both in Russia and in the world, and its cultivation will contribute to improving food security and sustainability of agriculture in face of global changes.

1 Introduction

Spring barley (*Hordeum vulgare L.*) is one of the key crops in the world, playing an important role in both food and feed production. It is an important agricultural crop with many useful qualities for both production and ecology. The high yield of spring barley, reaching 5.5 t/ha in favorable conditions, makes it relevant for both food and feed production [1, 2]. Barley is used in the human diet as a valuable cereal plant rich in proteins (14-18%) and carbohydrates, which contributes to improving health and increasing the energy value of nutrition. In feed production, spring barley is an excellent source of feed for livestock due to its high nutritional composition and energy, which makes it irreplaceable on farms. In addition, spring barley contributes to the accumulation of nitrogen in the soil, which is ensured by its ability to fix atmospheric nitrogen due to symbiosis with certain microorganisms. This makes it an effective crop to improve soil fertility and reduce the need for synthetic nitrogen fertilizers. Spring barley also acts as an excellent precursor for other crops due to its ability to improve the microbiological activity of the soil and reduce the spread of pests and diseases. The use

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of spring barley in crop rotation contributes to a higher yield of subsequent crops, thus increasing the agronomic efficiency and sustainability of the farming system.

Barley (*Hordeum vulgare L.*) is a self-pollinating species of monocotyledonous plants belonging to the cereal family (Poaceae). Spring barley has a diploid set of chromosomes (2n = 14). The genetic diversity of barley is determined by the presence of many varieties and hybrids that are adapted to various agro-climatic conditions. Spring barley goes through several key stages of development: germination, tillering, earing, flowering, and maturation. In addition, spring barley shows a fairly rapid growth rate. The full growing season can vary from 75 to 120 days, depending on the variety and growing conditions [3, 4]. Spring barley is highly resistant to diseases such as powdery mildew and root rot. Nevertheless, certain varieties may be susceptible to fungal diseases. Spring barley is an annual herbaceous plant with an upright stem 50-100 cm high. The leaves are narrow, linear, with a characteristic waxy cuticle, which reduces transpiration and promotes moisture retention (Kolesnikov et al., 2020). The inflorescence of spring barley is an ear consisting of 2-5 spikelets. The barley fruit is a grain, which, depending on the variety, can be light, dark or with characteristic stripes. Spring barley has a low fat content (1-2%), but a high concentration of carbohydrates and proteins (up to 14-18%).

Spring barley is much more adapted to arid and semi-arid climatic conditions than other crops. It can grow in soils with different pH, which makes it a versatile cultivator with limited resources. The relatively low water requirements of spring barley make it more resistant to drought. At the stage of vegetation, water consumption is minimal, which allows it to effectively use available resources.

The unique properties of spring barley for agriculture are the following:

- effect on soil fertility: spring barley is effective in crop rotation, as it is able to improve soil structure and reduce erosion. It also helps to increase the content of organic substances in the soil, being an excellent precursor for other crops;

- nutritional properties for livestock feeding - spring barley grain is a valuable source of nutrients for animals. It is not only high in calories, but also rich in proteins, which makes it irreplaceable in the diet for live cattle;

- Environmental sustainability: spring barley requires less use of synthetic fertilizers compared to other crops, which makes it a more environmentally friendly choice and contributes to the development of sustainable agriculture;

- grain quality: the quality of spring barley grain is a significant factor determining its economic value. According to a study by Mirza et al. (2020), the protein content in spring barley grain varies from 12% to 15%, due to varietal characteristics and agronomic conditions. The high protein content makes barley a valuable source of feed for livestock.

Grain quality analysis shows that barley grown under optimal conditions has the best set of qualitative characteristics, such as gluten and the amount of sugar released, which indicates its high nutritional value for humans.

The nitrogen content in spring barley grain is an important indicator that determines its protein value. Studies show that the optimal nitrogen content in grain can vary from 1.5 to 2.2%. The analysis of nitrogen metabolism processes indicates that the use of nitrogen fertilizers in combination with agronomic practices can lead to a significant increase in the protein content in grain.

2 Materials and Methods

Based on the analysis of literature data and open sources, the prospects of spring barley cultivation for the development of production both in Russia and in the world, to increase food security and sustainability of agriculture in the context of global changes are presented.

3 Discussion

The yield of spring barley in Russia varies depending on climatic conditions, cultivation technologies and varietal characteristics. According to Rosstat, in 2022, the average yield of spring barley was about 2.4 t/ha. In the European Union, spring barley also shows different yield indicators. According to Eurostat: Germany: The average yield is about 5.5 t/ha, which makes it one of the leaders in barley production. France: the yield here is 5.0 t/ha. As in Germany, high yields are achieved thanks to effective agronomic practices. Eastern Europe: [3]. In countries such as Poland and the Czech Republic, yields vary from 4.0 to 4.5 t/ha, due to transitional agronomic systems and adaptation to European standards. At the global level, spring barley, although it occupies a less significant place, still shows high performance in countries such as: Canada: Yields reach 3.8-4.5 t/ha, but thanks to modern technologies and the use of improved varieties, farmers can reach 5.0 t/ha or more [7].

Australia: In this country, spring barley has an average yield of about 3.2-4.0 t/ha, depending on the region and the application of irrigation systems (GrainCorp, 2023). USA: The average yield here is about 4.0 t/ha. In California and other states where intensive farming methods are practiced, farmers can receive up to 5.5 t/ha [8].

Gross yield in Russia. According to official data, the gross yield of spring barley in Russia in 2023 amounted to approximately 21.1 million tons. The main regions with high gross yield: Krasnodar territory: more than 1.0 million tons, Stavropol territory: about 800 thousand tons, the Republic of Tatarstan: more than 600 thousand tons [10].

Gross yield in Europe. In the European Union, the gross yield of spring barley also varies: Germany: more than 3.5 million tons, France: about 2.8 million tons, Spain: 1.2 million tons [4].

Gross yield in the world. At the global level, the total gross yield of spring barley is estimated at 25 million tons. The most significant producers: Canada: 8 million tons. Australia: 5 million tons. China: about 3.5 million tons [5].

Global production of spring barley. According to the FAO (2023), spring barley accounts for a significant part of global grain production, with a total gross yield of about 25 million tons. Major producers include Canada, Germany, Australia, and Russia. Research by Böhner et al. (2021) demonstrates that an increase in barley consumption in emerging economies and an increase in its use as animal feed contribute to an increase in crops area and gross yield of this crop [2].

In Russia, according to forecasts of the Ministry of Agriculture [10], it is planned to increase the acreage under spring barley to 2 million hectares in response to growing domestic and export demand.

The prospects for growing spring barley are determined by its resistance to changing climatic conditions and its ability to adapt to various types of soils. As Zhang et al. (2022) emphasize, spring barley has a high resistance to drought, which makes it a promising crop in face of global climate change, and barley is becoming an increasingly important element in sustainable farming systems.

Modern breeding programs continue to focus on the creation of new varieties that provide high yields and resistance to major diseases, which is also emphasized in the studies of Novikova et al. [11].

Spring barley as a precursor crop in crop rotation. Spring barley occupies an important place in crop rotation due to its agronomic features. It not only improves soil structure, but also reduces the incidence of subsequent crops such as wheat and corn. It follows from the study by Pan et al. [12] that barley has a positive effect on the nutrient content in the soil and can be used in organic farming as a precursor to increase the yield of subsequent crops.

According to many authors, the use of spring barley as a precursor leads to an increase in the total yield of other crops, which emphasizes its importance in modern agronomic systems.

The quality of spring barley grain depends on various factors, including weather conditions, varietal characteristics, cultivation and processing technologies. Usually, the grain of spring barley is characterized by: Protein content: from 10% to 14%, which is high for forage crops. Starch content: 55-65%, which makes it a valuable source of energy for livestock. Indicators of purity and moisture content: the highest quality grain has a low content of moisture and impurities, which is mandatory for storage and processing [13].

Prospects of spring barley for peace and agriculture:

- adaptation to climate change: spring barley adapts well to different climatic conditions, which makes it promising in the face of global climate change. This crop has the ability to grow quickly and can grow on various types of soils, which is ideal for switching to more sustainable agricultural systems;

- environmental benefits: spring barley is effective in crop rotation and significantly improves soil structure by increasing the content of organic substances. It also requires less use of synthetic fertilizers and pesticides, making it a more environmentally friendly choice;

- economic importance: given the growing demand for animal feed and high nutritional values, spring barley can make a significant contribution to food security and agricultural development, creating new financial opportunities for farmers.

4 Conclusion

Spring barley is a valuable and multifunctional agricultural crop with unique biological, morphological, and ecological properties. Its ability to adapt to different conditions and have a positive impact on the ecosystem makes it an important element in agronomy. Considering all the above factors, we can conclude about the importance of spring barley both in the system of traditional and organic agriculture. Spring barley remains an important agricultural crop in Russia. Yields and gross yield vary significantly depending on climatic and agronomic conditions; nevertheless, thanks to scientific achievements and modern technologies, farmers continue to increase productivity. The prospects for the development of spring barley will largely depend on adaptation to changing climatic conditions and the introduction of innovative production methods.

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