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LITERATURE REVIEW ON THE INFLUENCE OF FERTILIZATION NORMS
ON GRAIN QUALITY OF WINTER WHEAT VARIETIES CULTIVATED IN THE
KHOREZM OASIS

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Annotation: *This article presents a literature review on the influence of fertilization norms on the grain quality of winter wheat varieties cultivated under the specific conditions of the Khorezm oasis. The analysis highlights how balanced mineral nutrition, particularly nitrogen, phosphorus, and potassium application, affects protein content, gluten strength, and overall baking quality of wheat. Research results from regional and international studies show that excessive or insufficient fertilization can reduce quality parameters despite increasing or decreasing yield. Special attention is given to identifying optimal fertilization levels that ensure both high productivity and stable technological quality of wheat grain in saline and irrigated soils typical for the Khorezm region. The findings provide a scientific basis for improving agro-technical measures aimed at sustainable wheat cultivation and food security in arid environments.*

Keywords: *Winter wheat, fertilization norms, grain quality, Khorezm oasis, nitrogen, phosphorus, potassium, saline soils, sustainable agriculture.*

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the leading cereal crop in the world, cultivated on more than 220 million hectares, and it provides nearly 20% of the global population's daily caloric and protein intake. In Uzbekistan, wheat cultivation has a strategic importance, as it is directly linked to food security, social stability, and the development of the agro-industrial sector. Within this context, the Khorezm oasis is recognized as a key agricultural zone where winter wheat occupies a considerable share of the cropping system after cotton and rice. However, the productivity and technological quality of wheat grown in this region are strongly influenced by specific agro-ecological conditions such as high soil salinity, water scarcity, and temperature fluctuations.

Grain quality, in addition to yield, is one of the most critical indicators that determine the economic and nutritional value of wheat. Quality parameters such as protein content, gluten strength, and sedimentation index are essential for milling and baking industries. These characteristics are largely shaped by genetic potential of varieties and by agro-





technical measures, particularly mineral fertilization. Among fertilizers, nitrogen is the primary factor affecting protein accumulation, while phosphorus and potassium contribute to energy metabolism, enzymatic activity, and stress tolerance. However, excessive or unbalanced use of fertilizers may not only reduce grain quality but also negatively affect soil health and ecological sustainability.

In recent years, researchers have paid growing attention to the optimization of fertilization norms under saline and irrigated soils of Khorezm. Literature evidence suggests that achieving the right balance of nitrogen, phosphorus, and potassium is essential for ensuring high yields without compromising grain quality. Nevertheless, the region still faces challenges in determining site-specific fertilization strategies that account for local soil fertility, water management, and climatic conditions.

Therefore, this article aims to review and analyze scientific literature on the effects of fertilization norms on the grain quality of winter wheat varieties cultivated in the Khorezm oasis. The review will help identify the most effective approaches for improving both productivity and technological quality, while also contributing to the development of sustainable agro-technical practices adapted to arid environments.

Literature Review. The quality of wheat grain is determined by a combination of genetic, environmental, and management factors, among which fertilization plays a decisive role. Numerous studies worldwide have confirmed that mineral nutrition, especially nitrogen, phosphorus, and potassium, directly affects grain protein content, gluten strength, and baking quality (Shewry & Halford, 2002; Wieser, 2007). Balanced fertilization improves both yield and technological properties, whereas imbalanced application may lead to nutrient deficiencies or excessive accumulation, resulting in reduced grain quality.

Nitrogen fertilization is considered the most influential factor in enhancing grain protein concentration. Research indicates that moderate nitrogen application improves gluten formation, dough strength, and loaf volume (Gooding & Davies, 1997). However, excessive nitrogen may cause lodging, inefficient nutrient uptake, and environmental pollution (Raun & Johnson, 1999).

Phosphorus is essential for root development, energy transfer, and grain filling. Studies have shown that adequate phosphorus application increases the efficiency of nitrogen utilization and contributes to stable grain quality (Grant et al., 2001). Meanwhile, potassium supports water regulation, enzyme activity, and stress tolerance, which are critical in saline and arid conditions like those in the Khorezm oasis (Rengel & Damon, 2008).

In Uzbekistan, several researchers have investigated the effect of fertilizer norms on winter wheat. Local studies emphasize that applying nitrogen at rates of 180–240 kg/ha, in





combination with phosphorus and potassium, results in high yields and acceptable grain quality (Karimov et al., 2015; Tajiyev, 2020). Moreover, experiments conducted in saline soils of Khorezm demonstrated that excessive nitrogen without phosphorus and potassium supplementation leads to poor gluten quality and unstable baking parameters (Urgench State University Research Reports, 2022).

International findings also highlight the importance of site-specific nutrient management. For instance, Mühling & Döll (2001) reported that nitrogen timing and split application significantly influence protein distribution within the grain. Similarly, Zhao et al. (2009) found that integrated fertilization strategies combining mineral and organic inputs improve both yield and grain quality under stressed soil conditions.

Overall, the literature suggests that optimizing fertilization norms is crucial for maintaining a balance between yield potential and technological quality. However, the unique soil salinity and irrigation practices of the Khorezm oasis necessitate region-specific research to identify the most effective fertilization strategies.

Results and Discussion. The review of scientific literature and regional experiments demonstrates that fertilization norms have a significant effect not only on the yield of winter wheat but also on its technological grain quality in the Khorezm oasis.

Effect of nitrogen on grain quality. Nitrogen application was consistently shown to increase protein content in wheat grain. Studies conducted in Khorezm revealed that applying nitrogen within the range of 180–240 kg/ha enhanced grain protein by 1.5–2.0% compared to the control. However, excessive nitrogen doses above 240 kg/ha reduced gluten quality, leading to weaker dough strength and unstable baking properties. Similar results were reported in international studies, where excessive nitrogen increased yield but negatively influenced sedimentation index and bread-making quality (Gooding & Davies, 1997; Zhao et al., 2009).

Role of phosphorus and potassium. Phosphorus application improved root development, accelerated grain filling, and enhanced the efficiency of nitrogen uptake. Local experiments showed that applying 90–120 kg/ha of phosphorus (P_2O_5) together with nitrogen increased both yield and gluten stability. Potassium application (60–90 kg/ha K_2O) contributed to stress tolerance under saline soils, improving water-use efficiency and maintaining grain quality. These findings are consistent with Rengel & Damon (2008), who reported that potassium plays a vital role in balancing nutrient uptake and enzymatic activity in cereals.

Interaction of nutrient balance. The balance between nitrogen, phosphorus, and potassium was identified as the most important factor for stable grain quality. When nitrogen was applied without phosphorus and potassium, gluten became unstable, and the sedimentation index decreased. Conversely, balanced NPK fertilization improved both





yield and technological quality, ensuring stronger gluten, higher protein, and better loaf volume.

Regional challenges. The saline and irrigated soils of the Khorezm oasis require specific fertilizer management strategies. Salinity reduces nutrient uptake efficiency, especially nitrogen, which often leads to over-application by farmers.

Literature analysis suggests that site-specific fertilization, based on soil testing and split nitrogen application, is more effective in maintaining grain quality than uniform, high-dose fertilizer use.

Comparison with global research. International studies emphasize the importance of timing and method of fertilizer application. Mühlhling & Doll (2001) highlighted that split nitrogen application during stem elongation and heading stages is most beneficial for protein accumulation.

Similar strategies have been tested in Uzbekistan with promising results, indicating that international practices can be successfully adapted to the Khorezm oasis with necessary adjustments for salinity and irrigation regimes.

Discussion summary.

The evidence confirms that optimal fertilization norms for winter wheat in the Khorezm oasis should include moderate nitrogen (180–240 kg/ha), adequate phosphorus (90–120 kg/ha), and potassium (60–90 kg/ha) under balanced application. This combination ensures both high yield and desirable grain quality parameters.

However, over-application of nitrogen without phosphorus and potassium leads to reduced gluten strength and unstable baking quality. Future strategies should focus on integrated nutrient management, split application, and region-specific soil fertility programs to enhance both productivity and quality while preserving ecological sustainability.

Conclusion. The analysis of literature and regional research findings clearly demonstrates that fertilization norms have a decisive impact on both yield and grain quality of winter wheat cultivated in the Khorezm oasis.

Among mineral nutrients, nitrogen plays the central role in protein accumulation, while phosphorus and potassium improve nutrient efficiency, gluten stability, and stress tolerance under saline and irrigated conditions.

Balanced application of nitrogen (180–240 kg/ha), phosphorus (90–120 kg/ha), and potassium (60–90 kg/ha) ensures higher productivity together with desirable technological properties such as protein content, gluten strength, and baking quality. In contrast, excessive nitrogen application without adequate phosphorus and potassium supplementation leads to unstable grain quality and environmental risks.



The findings highlight the importance of adopting site-specific and integrated nutrient management practices that take into account local soil fertility, salinity, and irrigation regimes.

Optimizing fertilization norms in this way not only supports sustainable wheat production in arid regions but also contributes to food security and economic stability.

Future research should focus on developing adaptive fertilization strategies, including split nitrogen application, organic-mineral integration, and precision farming technologies, to further enhance wheat quality and maintain ecological sustainability in the Khorezm oasis.

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