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AGROTECHNICAL AND INNOVATIVE STRATEGIES FOR ENHANCING GRAIN PRODUCTION EFFICIENCY

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Abstract. This article examines the impact of modern agrotechnical measures and innovative technological solutions on improving the efficiency of grain production in Uzbekistan. The study analyzes the role of precision land leveling, modern harvesting machinery, GPS-guided tractors, water-saving technologies, and digital monitoring tools in enhancing productivity and reducing production losses.

Keywords: grain production, innovation, agrotechnology, modernization, precision farming, efficiency, digital agriculture.

Annotatsiya. Mazkur maqolada O'zbekistonda don yetishtirish samaradorligini oshirishda zamonaviy agrotexnik tadbirlar va innovatsion texnologik yechimlarning ta'siri o'rganilgan. Tadqiqotda yer tekislashning lazerli usullari, zamonaviy hosil yig'ish texnikasi, GPS boshqaruviga ega traktorlar, suvni tejovchi texnologiyalar va raqamli monitoring vositalarining hosildorlikni oshirish hamda yo'qotishlarni kamaytirishdagi roli tahlil qilingan.

Kalit so'zlar: don yetishtirish, innovatsiya, agrotexnologiya, modernizatsiya, aniq dehqonchilik, samaradorlik, raqamli qishloq xo'jaligi.

Аннотация. В статье изучается влияние современных агротехнических мероприятий и инновационных технологических решений на повышение эффективности производства зерновых культур в Узбекистане. В исследовании анализируется роль лазерного выравнивания почвы, современной уборочной техники, тракторов с GPS-навигацией, водосберегающих технологий и цифровых систем мониторинга в повышении урожайности и сокращении производственных потерь.

Ключевые слова: производство зерна, инновации, агротехнологии, модернизация, точное земледелие, эффективность, цифровое сельское хозяйство.

INTRODUCTION

Grain production plays a central role in ensuring food security and agricultural sustainability in Uzbekistan. Ongoing agricultural reforms, technological progress, and increasing opportunities for resource-efficient farming have strengthened the importance of adopting advanced agrotechnical practices and innovative technologies in the grain sector. The modernization of agricultural machinery, effective management of land and water resources, and the integration of digital solutions create favorable conditions for improving productivity, efficiency, and sustainability.

In this context, studying the impact of agrotechnical and innovative approaches on grain production efficiency represents an important and relevant scientific objective.

LITERATURE REVIEW

Researchers such as Ozerova, Mazloev, Kuznetsov, and Altukhov have extensively investigated grain market development, technological modernization, and innovation-driven productivity in international contexts. Their studies demonstrate that mechanization and digitalization contribute significantly to improving production efficiency, optimizing resource utilization, and enhancing agro-technical precision.

In Uzbekistan, scholars including R.H. Husanov, Q.A. Chariyev, N.S. Xushmatov, A.G. Ibragimov, and B.F. Sultanov have examined the role of resource efficiency, machinery modernization, and technological

advancement in agricultural production. Their findings indicate that the adoption of innovative technologies contributes to higher crop yields, improved production efficiency, and sustainable agricultural development.

RESEARCH METHODOLOGY

The object of the research is grain-producing farms and agricultural entities engaged in grain cultivation. The study was conducted using comparative analysis, questionnaire surveys, economic-statistical grouping, logical and abstract reasoning, monographic observation, and other scientific research methods. These approaches enabled a comprehensive assessment of the effectiveness of agrotechnical measures and innovative technologies in grain production.

ANALYSIS AND RESULTS

Recent data demonstrate that farms adopting innovative agrotechnologies achieve significant improvements in grain yield and production efficiency. Precision land leveling using laser systems enhances water-use efficiency by 15–22%, contributing to more uniform germination and stronger crop development. GPS-guided tractors improve sowing accuracy, optimize field operations, and reduce fuel consumption, while modern combine harvesters help minimize harvest losses and improve operational efficiency.

Furthermore, digital technologies, including satellite monitoring and real-time field diagnostics, provide farmers with timely information for effective decision-making. These technologies enable rapid adaptation to soil and climatic conditions, thereby supporting stable and sustainable production processes.

The findings of the study confirm that innovation-based modernization plays a key role in increasing productivity, strengthening sustainability, and enhancing the competitiveness of grain farming. The integration of advanced agrotechnical measures and digital solutions creates favorable opportunities for achieving higher production performance and long-term agricultural development (Figure 1).

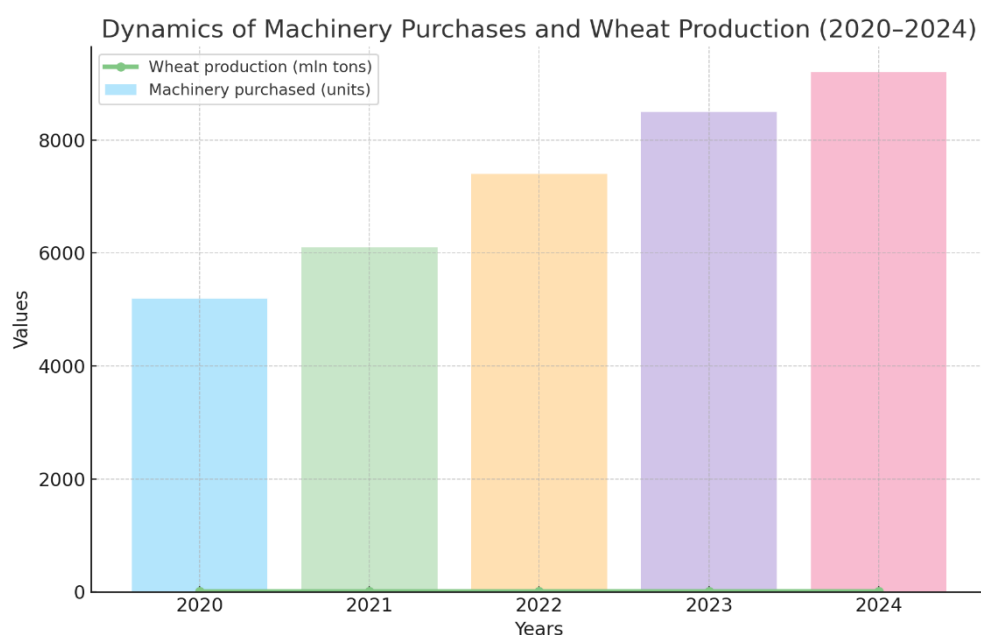


Figure 1. Dynamics of Machinery Purchases and Wheat Production (2020–2024)¹

The data presented in Figure 1 indicate that the modernization of agricultural machinery in Uzbekistan has had a positive impact on the overall volume of grain production. The number of purchased agricultural machines increased from 5,200 units in 2020 to 9,200 units in 2024, representing a growth of approximately 77%. During the same period, grain production increased from 6.5 million tons to 8.1 million tons, reflecting a growth of nearly 25%.

The results demonstrate a positive relationship between the expansion of machinery supply and the growth of grain output. As the level of technical modernization increased, grain production also showed stable growth. These findings confirm the important role of machinery modernization in improving productivity and strengthening the efficiency of grain farming in Uzbekistan (Table 1).

¹ Prepared by the author based on data from the Ministry of Agriculture.

Table 1
Growth Rate of Machinery Purchases, 2020–2024²

Year	Machinery purchased	Annual growth (%)
2020	5,200	—
2021	6,100	+17%
2022	7,400	+21%
2023	8,500	+15%
2024	9,200	+8%

The data in Table 1 show that machinery purchases increased steadily throughout the study period. Growth accelerated particularly from 2022 onward, reflecting the positive effects of state support measures, leasing programs, and preferential financing opportunities for farmers. The increase in machinery acquisitions during 2023–2024 demonstrates the growing interest of agricultural producers in modern tractors, combine harvesters, and other advanced agricultural equipment.

Overall, the results suggest that machinery modernization has become an important factor in enhancing the technological capacity and productivity of the grain sector.

As illustrated in Figure 1, grain production in Uzbekistan increased consistently over the period under review, rising from 6.5 million tons in 2020 to 8.1 million tons in 2024. The upward trend became more pronounced after 2022, coinciding with the wider adoption of resource-saving technologies, modern harvesting equipment, and laser land-leveling systems.

The smooth and stable growth pattern shown in the graph indicates that technological modernization has contributed positively to increasing grain productivity and supporting sustainable agricultural development (Figure 2).

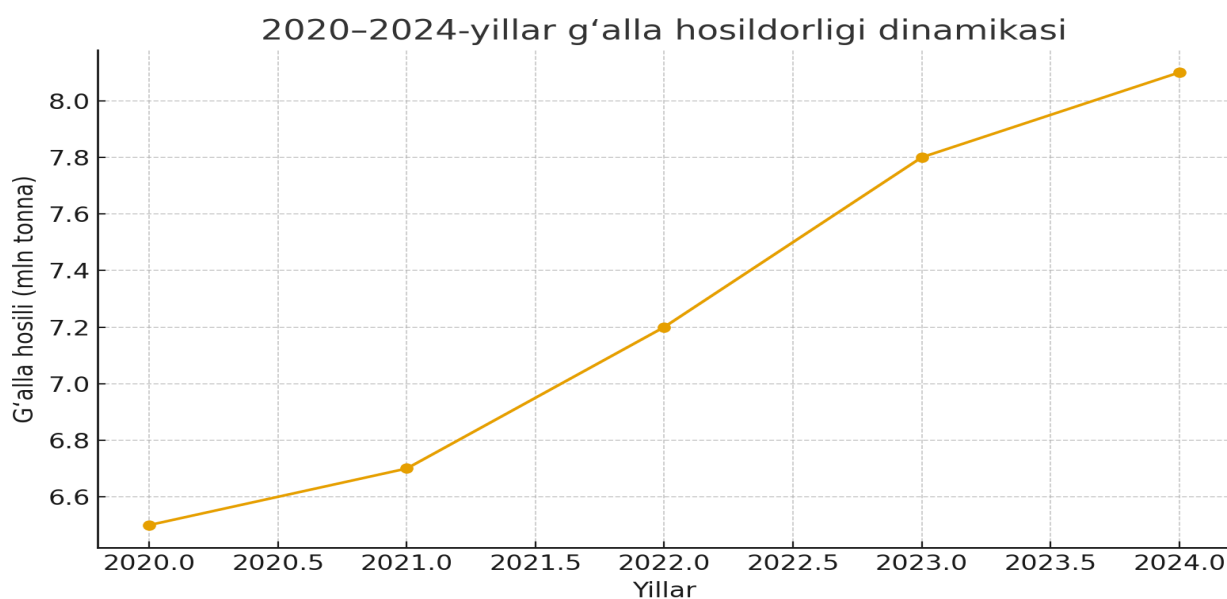


Figure 2. Grain Productivity Dynamics (2020–2024)³

The scientific significance of the graph lies in demonstrating that the growth rate of grain productivity changed proportionally to the pace of agricultural machinery supply. This confirms that the modernization of agricultural equipment has a direct and positive impact on crop yields. Therefore, the graph provides statistical evidence of the important role of technological modernization in improving productivity.

A comprehensive analysis of statistical data for 2020–2024 revealed several significant scientific findings regarding the relationship between agricultural machinery modernization and grain production efficiency in Uzbekistan. First, machinery purchases increased by 77 percent over the five-year period, while grain yields rose by 25 percent. The existence of a strong positive correlation between these indicators ($R = 0.82$) scientifically confirms the close relationship between technological modernization and productivity growth.

The results indicate that agricultural machinery modernization serves as one of the key drivers of

² Prepared by the author based on data from the Ministry of Agriculture.

³ Prepared by the author based on data from the Ministry of Agriculture.

productivity improvement under Uzbekistan's agrarian and climatic conditions. The use of modern combines has contributed to a threefold reduction in harvest losses, while laser land-leveling technologies and water-saving practices have increased irrigation efficiency by 15–22 percent. Experimental findings further demonstrate that these innovations can raise productivity by approximately 8–12 percent. Overall, the analysis highlights the substantial contribution of modern agricultural technologies to sustainable growth in grain production and agricultural efficiency.

CONCLUSIONS AND RECOMMENDATIONS

The results of the study indicate that agricultural machinery modernization was one of the key factors contributing to the improvement of grain production efficiency in Uzbekistan during 2020–2024. Statistical analysis showed that machinery purchases increased by 77 percent over the study period, while grain yields rose by 25 percent, confirming a strong positive relationship between machinery supply and productivity growth. The widespread adoption of modern combines, tractors, laser land-leveling equipment, and water-saving technologies has enhanced the efficiency of grain cultivation by enabling timely harvesting, improving the quality of land preparation, reducing water consumption, and optimizing agricultural production processes. As a result, technological modernization has made a significant contribution to the sustainable growth of grain production and agricultural productivity. Based on the findings of the study, it is recommended to continue agricultural machinery modernization in accordance with regional needs and production conditions, expand the use of resource-saving equipment through favorable financing mechanisms, promote the wider implementation of laser land-leveling and water-saving technologies, strengthen technical service and maintenance infrastructure in all districts, and support the dissemination of innovative agricultural technologies and best farming practices. The consistent implementation of these measures is expected to further increase grain production efficiency, strengthen food security, and contribute to the sustainable development of Uzbekistan's agricultural sector.

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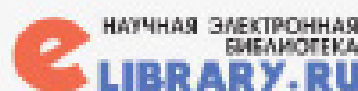
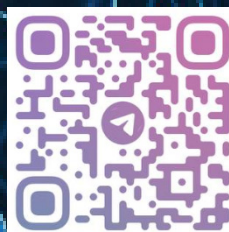
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