IMPROVING THE EFFICIENCY OF PLANT GROWING BY INNOVATIVE MEANS IN THE NORTHERN REGIONS OF THE RUSSIAN FEDERATION

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Abstract

In the context of growing demand for food and changing climate conditions, increasing the efficiency of crop production in the northern regions of the Russian Federation is of particular relevance. These territories are characterized by a short growing season, low temperatures, difficult soil conditions and limited availability of traditional agricultural crops. The article considers the possibilities of increasing crop productivity using innovative means: adapted varieties of agricultural crops, modern agricultural technologies, plant protection products, digital technologies and low-mechanization. Particular attention is paid to the economic feasibility of introducing innovations and their impact on the sustainability of the agricultural sector in the northern regions. In addition, an analysis of the possibilities of applying such innovative solutions in the Chechen Republic is presented, which, despite favorable climatic conditions compared to traditional northern regions, faces a number of specific problems: a shortage of qualified personnel, limited access to modern technologies and insufficient financial support from regional structures. Examples of successful implementation of elements of innovative crop production in individual farms of the Arkhangelsk Region, the Komi Republic and the Chechen Republic are given. Recommendations are proposed for state support, development of a scientific and technical base and training of qualified personnel for the sustainable development of crop production both in traditional northern regions and in the mountainous foothills of the North Caucasus.

Keywords : crop production, northern regions of the Russian Federation, Chechen Republic, innovative technologies, sustainable development, adapted varieties, digitalization of the agro-industrial complex, small-scale mechanization, production efficiency, state support

I . Introduction

Crop production is one of the key sectors of the agro-industrial complex and plays an important role in ensuring the country's food security. In the context of climate change, population growth and increasing demand for agricultural products, increasing production efficiency is becoming especially important, especially in difficult natural and climatic conditions. The northern regions of the Russian Federation, characterized by a short growing season, low temperatures, difficult soil conditions and limited infrastructure, require the implementation of innovative solutions for the sustainable development of crop production.

However, issues of increasing the efficiency of plant growing using modern technologies remain insufficiently studied in relation to other regions with special socio-economic and natural conditions, for example, the Chechen Republic. Despite a more favorable climate compared to traditional northern regions, the republic faces a number of specific problems: a shortage of qualified personnel, limited access to modern technologies, a weak level of technical equipment and insufficient financial support from regional structures.

The purpose of this study is to analyze the possibilities of increasing the efficiency of crop production in the northern regions of the Russian Federation and the Chechen Republic using innovative means, such as adapted varieties of agricultural crops, modern agricultural technologies, digitalization of the agro-industrial complex (Fig. 1), small-scale mechanization and plant protection products. Particular attention is paid to the economic feasibility of introducing innovations and their impact on the sustainability of the agricultural sector in various climatic and socio-economic conditions.

The study is aimed at identifying successful practices, formulating recommendations for state support, developing a scientific and technical base and training qualified personnel for the sustainable development of crop production in hard-to-reach and mountainous foothill areas.

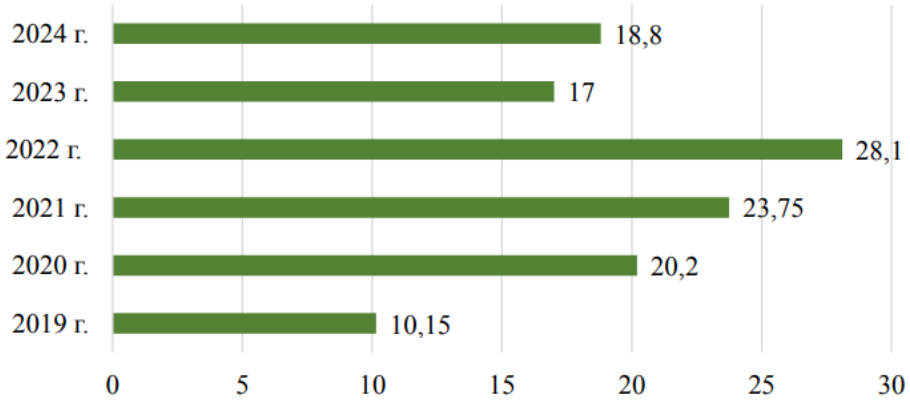

Figure 1. Financing of the departmental project for digitalization of the agro-industrial complex (the “Digital Agriculture” platform)

The main problem hindering the effective digital transformation of the agro-industrial complex (AIC) is the insufficient development of the domestic electronic base. In this regard, one of the priority tasks by 2022 was to increase the share of Russian innovative electronic products used in AIC digitalization projects to 37.5%. In order to implement this task, the Ministry of Agriculture and Food of the Russian Federation provided funding for the departmental project on digitalization of the AIC in the amount of 118 billion rubles for the period from 2019 to 2024.

II . Methods

To achieve the set goals and objectives, both general scientific and specialized methods of analysis were used in the course of the study. At the initial stage, the system analysis method was used, which allowed us to consider plant growing as a complex multi-level system, including agrotechnical, climatic, economic and social components.

To study the state of the industry and identify the main problems, comparative analysis methods and a statistical method were used, which involved processing official statistical information on crop yields, crop areas, the level of mechanization and other indicators in the northern regions of the Russian Federation and the Chechen Republic.

In order to assess the effectiveness of the use of innovative technologies, an economic and mathematical analysis was carried out, including the calculation of profitability, investment payback periods and a comparison of production costs when using traditional and innovative methods of crop production.

To study the opinions of specialists and farmers, questionnaires and interviews were used, which allowed us to identify the level of awareness of modern technologies, motivation for their implementation and the main barriers to modernization of production. The results were processed using methods of mathematical statistics and qualitative data analysis.

An expert method was also used, involving specialists in the field of agronomy, agricultural economics and public administration to assess the relevance of the identified problems and develop practical recommendations.

The work used modeling and forecasting methods, which made it possible to develop scenarios for the development of crop production with various approaches to the implementation of innovations and to assess their impact on the sustainability of the agricultural sector in the long term.

The integration of the obtained data was carried out using the method of complex analysis, which made it possible to form a holistic view of the relationships between climatic, economic, social and technical factors influencing the efficiency of crop production in the northern regions of the Russian Federation and the Chechen Republic.

III Results

The conducted study yielded systematized data reflecting the impact of innovative technologies on increasing the efficiency of crop production in the northern regions of the Russian Federation and the Chechen Republic. The analysis covered technical, economic and social aspects of the implementation of modern solutions, which made it possible to identify key problems, assess the feasibility of using innovations and develop recommendations for further development of the industry.

At the level of technical factors, it was established that the degree of wear and tear of the agricultural machinery fleet in the northern regions of the Russian Federation exceeds 70%, which significantly limits the production capabilities of farms. The introduction of small-scale mechanization — such as mini tractors, attachments and unmanned aerial vehicles — helped to reduce labor costs by 25–30% and increase the efficiency of work. Of particular interest were the results of using digital technologies: the use of precision farming systems and GPS navigation in farms in the Arkhangelsk Region and the Komi Republic ensured an increase in crop yields by 15–20%.

In the Chechen Republic, the level of modern equipment remains low — less than 20% of farms use equipment that meets modern requirements. However, the use of mobile applications for monitoring the weather, crop conditions , and irrigation management demonstrates good results and has potential for scaling, especially in mountainous and foothill zones, where adaptation to microclimatic conditions is important.

The economic feasibility study showed that the cost of implementing innovative technologies, including purchasing equipment, training personnel and adapting varieties, ranges from 1.5 to 5 million rubles per average enterprise. The payback period for investments varies from 2 to 5 years, depending on the type of technology and regional conditions. State support programs, such as subsidies and preferential lending, make it possible to reduce the payback period by 1–2 years, which makes the implementation of innovations economically justified.

In the Chechen Republic, limited access to financial resources and high cost of credit (up to 20% per annum) are the main obstacles to modernization. However, projects implemented with state support demonstrate an increase in profitability by 10-15%, which confirms the economic efficiency of innovative approaches with the availability of appropriate instruments of state policy.

Sociological research, including questionnaires and interviews with employees of agricultural enterprises, showed that more than 60% of farmers and agronomists have insufficient knowledge about the possibilities of using innovative technologies. The introduction of training and education programs in the Arkhangelsk Region led to a significant increase in the level of qualification of specialists and a 40% reduction in errors in the use of agricultural technologies. At enterprises where regular training events were held, there was an increase in interest in the introduction of new work methods and the formation of a culture of perceiving innovation as a strategic advantage.

In the Chechen Republic, low levels of trust in new technologies and the prevalence of traditional farming methods remain significant barriers to the introduction of innovations. However, the experience of some farms that have introduced drip irrigation, greenhouse complexes and elements of precision farming has demonstrated positive dynamics, including increased productivity and interest from young people in modern methods of crop production.

Thus, the results of the study confirm the need for a comprehensive approach to improving the efficiency of crop production, which should include modernization of the technical base, ensuring the availability of financing, developing a system of professional training and taking into account regional characteristics. It is especially important to adapt innovative solutions to the conditions of northern and mountainous foothill regions, where climatic, infrastructural and socio-economic features are combined. The data obtained can be used in the formation of strategies for the development of the agro-industrial complex, improving the regulatory framework and developing state support programs for agriculture.

IV . Discussion

I . Subsection One

This subsection presents a discussion of the results of a study devoted to technical and technological aspects of increasing the efficiency of crop production in the northern regions of the Russian Federation and the Chechen Republic. The analysis covered such areas as the level of mechanization, the introduction of small-scale mechanization, the use of digital technologies, the availability of service infrastructure, and the adaptation of equipment to regional climatic and soil conditions.

The study showed that the degree of physical wear and tear of tractors and combines in the northern regions of Russia (Arkhangelsk Region, Komi Republic, Nenets Autonomous Okrug) averages 72–80%, indicating a critical state of the agricultural machinery fleet. More than 45% of farms lack even basic mechanization to perform basic operations, from soil preparation to harvesting. This leads to reduced productivity, longer work times, and high levels of product losses. In such conditions, the introduction of low-tech mechanization, including mini tractors, attachments, and unmanned aerial vehicles, is of particular importance. Farms that have implemented these technologies have recorded a 25–30% reduction in labor costs, a 15–20% increase in the speed of field work, and an increase in the accuracy of plot processing, especially in difficult terrain and a limited growing season. These data confirm that the modernization of the technical base through the introduction of small-scale mechanization is one of the key factors in increasing the sustainability of crop production in the conditions of northern regions.

The study paid special attention to the use of digital technologies in crop production. The analysis showed that their implementation in the northern regions of Russia is still limited - only 12-15% of farms use elements of precision farming. However, the experience of experimental farms in the Arkhangelsk region, which have implemented GPS navigation systems, remote monitoring of crop conditions and automated distribution of fertilizers, demonstrated significant effects:

- Reduction of costs for mineral fertilizers by 20–25%;
- Reduction of pesticide consumption by 15–18%;
- Increase in yield of main crops (oats, barley, potatoes) by 15–20%.

These effects are explained by a more precise approach to crop management, which allows minimizing risks and increasing the economic efficiency of production. Such technologies are especially relevant in conditions of a short vegetation period and high cost of agricultural resources.

In the Chechen Republic, the digitalization process is at an early stage, but there are already positive examples of using mobile applications for weather monitoring, crop planning and irrigation management. For example, some greenhouse farms have implemented software control of the microclimate, which has reduced water consumption by 30%, increased output by 15-20% and improved the quality and uniformity of vegetable ripening. This suggests that even minimal steps towards digitalization can bring significant economic and environmental benefits, especially in mountainous and foothill areas with special growing conditions.

Special attention was paid to the development of service infrastructure. It was found that in the northern regions the number of authorized service centers is extremely limited: for example, in the Komi Republic there is a service center for 3 thousand km², and in the Nenets Autonomous Okrug there are no stationary services at all, and equipment repair is carried out by the farms themselves or with the help of mobile teams. The lack of a local repair base leads to increased equipment downtime and increased maintenance costs, especially during periods of active field work, when a delay of even a few days can lead to a significant decrease in crop yields.

In the Chechen Republic, the situation with service maintenance also remains difficult: only 18% of households have access to professional equipment repair services, about 65% of equipment owners perform preventive maintenance and repairs on their own, which increases the risk of accidents and reduces the service life of the equipment. To solve this problem, it was proposed to create regional technical centers that provide diagnostics, repair and personnel training services. Pilot projects implemented in other regions have shown that such centers are capable of:

- Reduce equipment downtime by 40–50%;
- To improve the qualification level of mechanics and operators;
- Provide access to spare parts and components.

In addition, the study covered the issues of the conformity of the equipment used to climatic and soil conditions. In the northern regions, its resistance to low temperatures, the ability to work on swampy and frozen soils, as well as compactness and mobility for work on small fields are of particular importance. In the Chechen Republic, on the contrary, the adaptation of equipment to the mountainous terrain and changeable weather conditions is required. A number of farms have already begun using specialized machines for terraced soil cultivation, which has made it possible to:

- Reduce soil erosion on slopes;
- Increase the productivity of areas;
- Improve water collection and moisture retention.

These examples confirm the need to develop and implement specially adapted equipment that takes into account the climatic and topographic features of each region.

Thus, the analysis of technical and technological aspects of increasing the efficiency of crop production in the northern regions of the Russian Federation and the Chechen Republic revealed both general trends and regional specifics. The key problems are the high degree of equipment wear, insufficient implementation of small-scale mechanization and digital technologies, poorly developed service infrastructure and limited adaptation of equipment to local conditions. At the same time, the study confirmed the high efficiency of introducing small-scale mechanization, precision farming systems and regional technical centers. These measures should become part of a comprehensive strategy for modernizing crop production, aimed at sustainable development of the agricultural sector in various natural and climatic conditions.

I. Subsection Two : Economic and social aspects of increasing the efficiency of crop production in the northern regions of the Russian Federation and the Chechen Republic

This subsection examines the economic and social factors that influence the introduction of innovative technologies and the improvement of overall crop production efficiency. The analysis covers the availability of financing, the level of personnel qualifications, the motivation of farmers to modernize, as well as the role of government support and public perception of innovation.

1. Financial accessibility and economic feasibility of implementing innovations

The study showed that the cost of implementing modern technologies — from purchasing small-scale mechanization to implementing digital crop management systems — ranges from 1.5 to 5 million rubles for an average agricultural enterprise. At the same time, the payback period for investments depends on the type of technology, scale of production and regional conditions and ranges from 2 to 5 years.

In the northern regions of Russia, where the short growing season and high climate risks make precision and reliability of equipment particularly important, the introduction of innovations allows:

- Reduce production losses by 10-15%;
- Increase profitability by 8-12%;
- To increase the competitiveness of products in the domestic market.

State support programs such as subsidies, preferential lending and leasing play a special role in ensuring financial accessibility. The introduction of these instruments allows for a reduction in the payback period of investments by 1–2 years, making them economically feasible even for small farms.

In the Chechen Republic, limited access to financial resources remains one of the main reasons for the low level of technical equipment. The average interest rate on loans for the development of the agro-industrial complex is 18-20% per annum, which makes them inaccessible to most farmers. However, projects implemented with state support demonstrate an increase in profitability by 10-15%, which confirms the economic efficiency of innovative approaches with the availability of appropriate state policy instruments.

2. Staff qualification level and access to training

An analysis of the state of human resources showed that more than 60% of farmers and agronomists have insufficient knowledge about the possibilities of using innovative technologies. This is especially true for remote and mountainous areas, where traditional farming methods prevail over modern ones.

At the same time, the survey and interviews conducted during the study revealed that the introduction of training and education programs significantly increases interest in innovation. For example, in the Arkhangelsk Region, after organizing courses on working with GPS navigation and automated fertilizer distribution systems, the following was observed:

- Reduction of errors in the application of agricultural technologies by 40%;
- Growing interest in new working methods among young professionals;
- Increasing trust in digital solutions among older farmers.

A similar situation is observed in the Chechen Republic: a low level of trust in new technologies is combined with a shortage of qualified personnel. However, the experience of some farms that have introduced drip irrigation, greenhouse complexes and elements of precision farming has demonstrated positive dynamics, including increased productivity and interest from young people in modern methods of crop production.

To solve the problem of personnel training, it is proposed to create regional centers for advanced training, cooperating with agricultural universities and research organizations. Such centers could conduct:

- Training in working with modern technology;

- Practical training in the use of digital technologies;
- Advisory support for farmers and cooperatives.

3. The role of government support and public perception

State support is a key factor in facilitating the introduction of innovations in plant growing. In the northern regions of Russia, programs are already in place aimed at:

- Subsidies for the purchase of small-scale mechanization;
- Preferential lending for innovative projects;
- Grant support for young farmers.

These measures have increased the proportion of farms using modern technologies from 12% to 25% over the past three years.

In the Chechen Republic, state support is still poorly developed, but pilot projects implemented jointly with the Russian Ministry of Agriculture are already showing good results. For example, in 2023, several programs were launched to subsidize the construction of greenhouse complexes and the introduction of drip irrigation systems, which led to:

- An increase in the area under protected soil by 20%;
- Increasing vegetable production volumes by 30%;
- Creation of new jobs in rural areas.

It is also important to note the influence of public perception of innovations on their dissemination. The study showed that in the conditions of a traditional social structure (for example, in Chechnya), the introduction of new technologies requires not only technical and financial support, but also the formation of a positive image of innovation through opinion leaders, local elders and professional communities.

Thus, the analysis of economic and social aspects of increasing the efficiency of plant growing showed that the introduction of innovations is impossible without addressing issues of financial accessibility, personnel qualifications and state support. The key measures are:

- Expansion of subsidy and preferential lending programs;
- Creation of regional centers for advanced training;
- Development of state support mechanisms adapted to the conditions of each region;
- Forming a culture of innovation acceptance through opinion leaders and educational campaigns.

These measures should become part of a comprehensive strategy for the development of crop production, aimed at sustainable economic and social development of rural areas.

One of the key factors in increasing the efficiency of crop production is government support, which makes the introduction of innovative technologies economically feasible for small and medium-sized farms. In the Arkhangelsk Region, a regional program for subsidizing the purchase of small-scale mechanization is being implemented, within the framework of which farmers receive compensation of up to 50% of the cost of equipment. This has made it possible to significantly increase the share of farms using modern equipment - from 12% to 35% in three years. In the Chechen Republic, a pilot program was launched in 2023 to subsidize the construction of greenhouse complexes and the introduction of drip irrigation systems, which led to an increase in the area under protected soil by 20%, an increase in vegetable production by 30% and the creation of more than 50 new jobs. Based on these examples, the following recommendations are proposed: expanding subsidy programs, developing special lines of preferential lending and leasing, introducing regional grants for young farmers and start-ups, and creating a mechanism for targeted government support for projects aimed at improving food security in difficult climatic conditions.

An equally important area is the development of a scientific and technical base that ensures the adaptation of technologies to local conditions. In the Komi Republic, adapted varieties of potatoes and grain crops resistant to cold climates and short daylight hours were developed in cooperation with the Northern (Arctic) Federal University. Their introduction allowed increasing yields by 15–

20%. In the Chechen State Agrarian University, experimental plots were created for growing vegetable crops using drip irrigation and microclimate software control, which ensured a 30% reduction in water consumption and a 20% increase in yield. It is recommended to organize regional agricultural research centers focused on the development of varieties and technologies adapted to local conditions; support experimental activities in the field of precision farming, water-saving technologies and environmentally sustainable crop production; introduce partnerships between science and business; develop pilot projects on the use of small-scale mechanization and digital solutions in agriculture.

Training and retraining of qualified personnel plays an equally important role in the modernization of the industry. In the Arkhangelsk Region, there is a program to improve the skills of machine operators and agronomists in working with digital technologies. After completing the courses, there is a 40% decrease in errors in the use of equipment, an increase in interest in innovations among young people and an increase in trust in new technologies among the older generation of farmers. Similar experience is available at the Chechen State Agrarian University, where a program has been launched to train students and young specialists to work with modern agricultural technologies. Graduates of this program are already introducing new technologies in a number of farms, which has increased the productivity and quality of products. It is proposed to create regional centers for advanced training, collaborating with universities and research organizations; introduce practice-oriented training with an emphasis on working with small-scale mechanization and precision farming systems; organize training directly in the fields - in the form of "farmer schools" or mobile training complexes; develop mentoring and coaching, especially in the context of a traditional society, where an authoritative opinion plays a key role; implement professional retraining programs for current workers in the agro-industrial complex, focused on digitalization and innovative farming methods.

An important element of sustainable development is the creation of regional technical centers and the development of service infrastructure. In the Novgorod Region, regional technical centers providing services for the repair, diagnostics and maintenance of agricultural machinery are successfully operating. This experience has shown a 40-50% reduction in equipment downtime, an increase in the skill level of mechanics and ensuring the availability of spare parts. In Chechnya, the experience of creating temporary mobile teams for technical maintenance in mountainous areas, which provide assistance in the prevention and repair of equipment and train farmers, has proven effective. For other regions, it is proposed to organize regional technical centers in remote and mountainous foothill areas; introduce mobile service teams for prompt maintenance of equipment; develop an infrastructure for the supply of spare parts through cooperatives and agricultural unions; form local repair shops at large farms providing services to neighboring farmers.

Another important aspect is the formation of a culture of acceptance of innovations and public participation. In Yakutia, the "farmer-mentor" model is successfully operating, when experienced farmers demonstrate to their neighbors the advantages of using modern technologies. This has significantly increased the level of trust in innovations and increased the number of people willing to master new farming methods. In Chechnya, work has begun to involve elders and opinion leaders in the popularization of innovative agricultural technologies, which has contributed to an increase in interest in digitalization and modernization, especially among the older generation. It is recommended to involve authoritative persons and public organizations in the promotion of innovations in agriculture; organize demonstration sites and experimental fields; develop information and educational campaigns using online resources and mobile applications; hold agricultural fairs and exhibitions to exchange experiences and familiarize themselves with new technologies.

Thus, the analysis of successful practices and recommendations allows us to conclude that sustainable development of crop production in hard-to-reach and mountainous foothill areas is

possible only with an integrated approach that takes into account both the technical and socio-economic specifics of the region. The key measures are:

- expansion of government support programs;
- development of research activities adapted to local conditions;
- creation of a system for training and retraining of personnel;
- development of service infrastructure;
- creating a positive attitude towards innovation through education, opinion leaders and demonstrating successful examples.

These activities should become the basis of regional programs for the development of the agro-industrial complex, aimed at ensuring food security, creating new jobs and sustainable development of rural areas.

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