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Original article

ISSUES OF IMPROVING CROP PRODUCTION
IN DIGITAL AGRICULTURE

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Abstract

Background. The agribusiness ensures the country's food security, creates conditions for forming labour and demographic potential. The key industry is crop production.

Purpose. To study the state of crop production in the Bryansk region.

Materials and methods. The materials and methods of the study present an analytical review of agricultural innovations in crop production based on scientific and technical achievements.

Results. It is shown that the region is among the leaders in the potato and grain production, and the number of profit-making organizations using resource-saving technologies is growing. The specifics of the crop production transformation into a high-tech and knowledge-intensive sphere are noted. It has been established that large and medium-sized organizations make use of digital agricultural innovations and "smart" agricultural machinery. The problems in staffing for agricultural enterprises have been identified. The ways of their solution are considered. The requirements of modern crop production for "digital" agronomists are analyzed. The necessity of further cooperation between the state, business, agrarian science, and education is shown.

Conclusion. State support and implementation of programs for the development of the agricultural sector have allowed domestic producers to gain certain competitive advantages in the world agricultural market. There is a large-scale trans-

formation of crop production into a high-tech and knowledge-intensive industry. The Bryansk region demonstrates high achievements in the agricultural sector, it provides high-quality products to the population of the region, Russian and foreign markets. Precision farming, rational use of natural resources are being introduced in farms, and “smart” agricultural machinery is being used. Staffing problems are being successfully solved at the regional level. For the further development of the regional crop production, it is necessary to accelerate the digital modernization of the agrarian sector by increasing resource availability, to develop infrastructure, systems of additional professional education and self-education, to improve the image of rural work, and to increase the level of entrepreneurial culture.

Keywords: Bryansk region; crop production; innovations; seed production; “digital” agronomists

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Научная статья

ВОПРОСЫ СОВЕРШЕНСТВОВАНИЯ ПРОИЗВОДСТВА ПРОДУКЦИИ РАСТЕНИЕВОДСТВА В ЦИФРОВОМ СЕЛЬСКОМ ХОЗЯЙСТВЕ

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Аннотация

Обоснование. Аграрный бизнес обеспечивает продовольственную безопасность страны, создает условия для формирования трудового и поселенческого потенциала. Ключевой отраслью выступает растениеводство.

Цель. Изучить состояние растениеводства в Брянской области.

Материалы и методы. Материалы и методы исследования представляют собой аналитический обзор агроинноваций в растениеводстве, опирающихся на научно-технические достижения.

Результаты. Показано, что регион по производству картофеля и зерновых входит в число лидеров, растет число рентабельных организаций, применяющих ресурсосберегающие технологии. Отмечены особенности трансформа-

ции растениеводства в высокотехнологичную и наукоемкую сферу. Показано влияние настроек комбайна на травмированность семян. Установлено, что крупные и средние организации используют цифровые агроинновации, «умную» сельхозтехнику. Выявлены проблемы в кадровом обеспечении агроформирований. Рассмотрены пути их решения. Проанализированы требования современного растениеводства к «цифровым» агрономам. Показана необходимость дальнейшего сотрудничества государства, бизнеса, аграрной науки и образования.

Заключение. Государственная поддержка и реализация ряда программ по развитию аграрной отрасли позволили отечественным товаропроизводителям приобрести определенные конкурентные преимущества на мировом аграрном рынке. Происходит масштабное преобразование растениеводства в высокотехнологичную и наукоемкую отрасль. Брянская область демонстрирует высокие достижения в аграрной сфере, обеспечивает высококачественной продукцией население области, российский и внешние рынки. В хозяйствах внедряются точное земледелие, рациональное природопользование, используется «умная» сельхозтехника. Проблемы кадрового обеспечения успешно решаются на региональном уровне. Для дальнейшего развития регионального растениеводства необходимо ускорить цифровую модернизацию отрасли на основе повышения ресурсообеспеченности, развития инфраструктуры, системы дополнительного профессионального образования и самообразования, улучшения имиджа работы на селе, роста уровня предпринимательской культуры.

Ключевые слова: Брянская область; растениеводство; инновации; семеноводство; «цифровые» агрономы

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Introduction

In the conditions of technological advancements the paradigm of sustainable agricultural development is focused on ensuring food security, enhancing the competitiveness of the farming industry, and improving of the population well-being. The agribusiness ensures the country's food security, creates conditions for forming labour and demographic potential. The key industry is crop production. Achievements in the crop production of the country are supported by the government due to investment projects, digital solutions, by application

of science-based technologies and precision farming systems, export-oriented production, and adaptation to changing conditions.

Today the decision-making in crop production is one of the key issues in agricultural science and practice as in digital farming numerous factors are taken into consideration simultaneously. These factors are multidimensional and poly-structural; they cover various seasonally and weather adjusted periods; they are multivariant due to a great number of stochastic parameters and indicators; they involve multiple business processes consisting of stages and phases breaking up into separate operations, etc. In global challenges, introducing a new model of economic behaviour of agricultural enterprises, digital platforms serve as an effective tool to support crop producers. Currently, the world's organic farmland is about 75.0 million hectares, and in 2020 the global organic food market reached 120.6 billion euros.

According to the Federal State Statistics Service, the share of the people employed in the agricultural sector is more than 5.5%. In 2022 the labour productivity index amounted to about 108.0%, and the number of profit-making organizations is still growing. The digital transformation of the agricultural sector causes the problems in staff resources. In the context of digitalization of crop production, personnel with digital competencies are a key asset.

Materials and methods

The materials and methods of the study present an analytical review of agricultural innovations in crop production based on scientific and technical achievements.

Results

Agro-industrial complex is a geographically distributed, heterogeneous, probabilistic and dynamic system of controlled and uncontrolled factors with interacting animate and inanimate objects. In conditions of digitalization business is becoming science-intensive and high-technology; however, there is a risk and some uncertainties about implementing business processes. The growth of the agrarian sector has led to loss of biodiversity, depletion of natural resources, and spread of pests and pathogens. About 40% of the world's lands are recognized as degraded. [1; 5 - 9].

The Russian leading scholars (A. Petrikov, I. Ushachev, L. Bondarenko, B. Lukyanov, et al) have thoroughly and consistently studied the dependence of employment and income of rural people on the level of science intensity and technological efficiency of the agricultural sector. According to the Federal

State Statistics Service, for the year 2022 the digitalization of the country's economy has increased the number of high-performance workplaces by more than 250 thousand, and by almost 70 thousand in the agricultural sector. Correspondingly, this indicator has risen in the Central Federal District, and in the Bryansk region (Fig. 1).

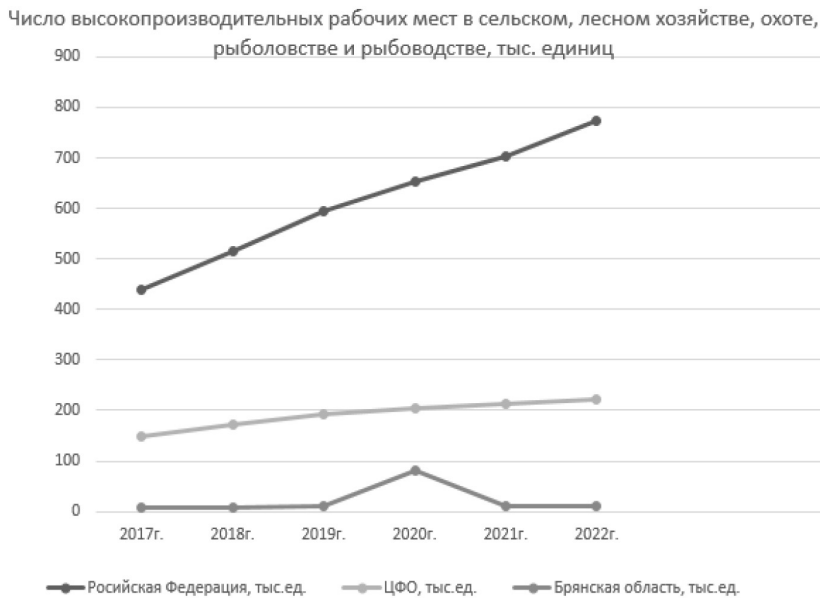


Fig. 1. Dynamics of high-performance workplaces in the agricultural sector (compiled by the authors)

About 10% of arable lands in the world belong to Russia, while up to 40% of the lands are in the zone of risky farming. In 2023 the country became the leader in exports of wheat, peas, and barley; took second place in exports of sunflower oil; earned about \$44 billion, and by 2030 exports may grow to \$55 billion. New markets are appearing in Asia and Africa. It is planned to put into use about 44 million hectares of underutilized agricultural lands, including 20 million hectares of arable ones. [2-4; 11-13; 16; 17; 20]

Crop production, providing economic and food security, forms the agrifood market, labour and demographic potential. The crop sector applies satellite communication and positioning systems, the Internet of things, digital twins, machine learning and computer vision, agrodrones, big data, etc. Digital solu-

tions make it possible to create a digital model of the agricultural landscape, to obtain soil characteristics, to monitor the crops, to predict crop yields, to control the performance quality of agricultural machinery, and to plan agro-technical measures.

Farmers need analytical systems that include advanced analytics and intellectual data analysis. According to expert estimates, digitalization of the agrarian sector will result in reducing product losses up to 40%. The Ministry of Digital Development, Communications and Mass Media has ranged the regions by the level of digital maturity dividing them into three groups: high, medium, and low. Moscow, St. Petersburg and a number of regions are obviously on the top. Sixty-two regions are of a medium level of “digital maturity”, including the Bryansk region. Fourteen regions have got a low level.

Precision agriculture appears to be a promising trend in crop production. In Russia it is provided by domestic designers of navigation equipment and software. In the country about 10-15% of agricultural enterprises use elements of precision farming in crop production. The Lipetsk, Samara and Oryol regions take the leading positions.

The Bryansk region has unique natural conditions for the cultivation of field crops. Arable lands are sandy loam with the humus content not exceeding 3.6%. Agricultural enterprises make use of more than 1 870 thousand hectares of farmland with the sown area of about 850 thousand hectares. Annually, more than 30 thousand hectares of bushy and forest-covered lands are put into use. There are about 600 agricultural companies in the agrarian sector.

The region provides both the regional population and the Russian and foreign markets with high-quality products. Agriculture accounts up to 30% of the gross regional product. Agricultural enterprises cultivate more than 80% of the acreage, peasant (private) farms – about 17%. In the country grain crops (wheat, grain corn, oats, barley, rye) and leguminous crops occupy about 32%, forage and industrial crops – about 42% and 19%, respectively.

Potatoes occupy more than 46 thousand hectares and are cultivated mainly in the Starodub and Pogar districts. In 2022 the grain yield was about 5 500 kg (weight after processing). The region is among the top five in the country in grain yield. In 2023 the Bryansk region was the leader in gross yield of potato with a share of more than 15% in the total volume. The horticulture industry is dynamically developing. In 2023 in all farms the area of fruit and berry plantations amounted to more than 2,600 ha. Over 3 thousand tons of fruit and berry have been collected there [14; 15; 18; 19]. Peasant (private) farms have high achievements (Fig. 2).



Fig. 2. Dynamics of agricultural production (compiled by the authors)

Resource-saving technologies are being introduced in the region, with their share in grain production exceeding 90%, in potato growing being about 40%. Further increase in potatoes, grains, and vegetables production is interconnected with solving the task of ensuring their storage. The construction and modernization of storage facilities are priority guidelines in the development of these sectors.

Speaking about the achievements in the regional agro-industrial complex, and crop production in particular, a decrease in both the population of the region and rural residents should be noted. Economic entities meet staffing issues caused by the unfavorable age distribution of the population (Fig. 3).

The analysis of the regional labour market reveals a concernment of the growing number of business organizations capable of solving problems of food security and reducing the human impact on the environment. However, the supply of specialists and managers in agriculture does not exceed 90%. Agricultural enterprises are facing staff shortage, as in the region there are not enough agronomists, mechanical engineers, etc. In the struggle for talents, farmers use cloud technologies and services, job sites, social networks, online tools, etc.

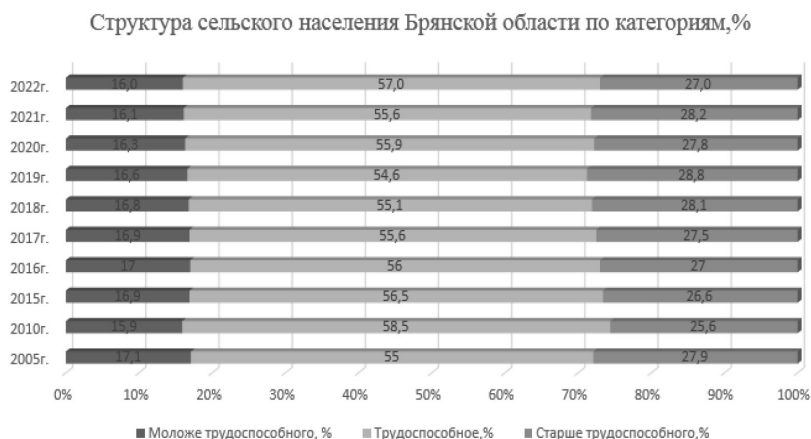


Fig. 3. Age structure of the rural population of the Bryansk region, %
(compiled by the authors)

The availability of agricultural machinery, its energy capacity and technical condition significantly affect the technological level of crop production. Currently, the agricultural machinery park in the Bryansk region does not fully meet modern requirements. For example, in 2020-2022 the number of tractors decreased by 184 units, the number of combine harvesters lessened by 52 units, the wear rate of agricultural machinery was more than 40%. The energy capacity per 100 ha of crops is decreasing. It should be noted that in the country, in the context of technical modernization of the agricultural business, it is planned to bring the number of high-performance combine harvesters up to 240-260 thousand units with their total engine power of about 60 mln hp. Sales of four-wheel drive tractors have increased by almost 23%, and combine harvesters by 4%. It is expected to produce fifth-generation equipment with energy-saving technologies and a well-developed engineering block equipped with automation systems and controlled via intelligent decision making. By the year 2035 the share of domestic agricultural machinery should have increased from 61% to 80% (2022) [10]. Cognitive Pilot is one of the Russian suppliers of autopilots based on artificial intelligence. By the beginning of 2022 the Cognitive Agro Pilot smart system was used in more than 30 regions of Russia.

One of the global trends in crop production appears to be biologization, ensuring the sustainability of the agroecosystem and being gradually implemented in Russia and in the Bryansk region. Biological or organic farming is based

on differentiated application of soil management techniques, strict adherence to scientifically based crop rotation with legume crops as green manure or siderates, mainly organic fertilization with minerals applied for a deficiency-free humus balance, and reproduction of soil fertility. The application of organic farming systems requires high technological discipline and professional staff.

Seed production is a key part of crop production. Russian farmers annually spend more than 200 billion rubles on seeds. Currently, domestic seed supply of Russia is at the level of 55-60% with the required minimum of 75% or more by the year 2030. Withdrawal from the market of foreign products provides new opportunities for agricultural enterprises. LLC Krasny Oktyabr, being an elite grain crops seed-production farm, is a vivid example in the Bryansk region.

The genotype potential productivity largely depends on the qualitative characteristics of the seed material, having a prolonged effect on the development of cultivated plants. The use of agrotechnological techniques and technical solutions to improve them is an urgent task in crop production. Currently, the working bodies of combines, various loading facilities and other machines dealing with seeds mechanically damage them to a greater or lesser degree (macro- and microdamage). In the threshing unit grain is damaged most. Many microdamages, not affecting the laboratory seed germination, can worsen field germination and crop productivity. The main factors determining the degree of seed damage are the operating regime of a combine, the correct adjustment of its working bodies, taking into account the physical and mechanical properties of the threshed crops. The value of the rotation speed, or the frequency of drum rotation, is of primary importance in reducing seed damages while threshing. According to the Central Machine Testing Station, the total number of injured wheat seeds decreases by more than 2 times when the rotation speed of the combine drum is reduced from 1200 to 900 rpm. Lowering the rotation speed of the drum from 1020 to 850 rpm reduces the number of rye grains with a completely knocked out and partially beaten embryo from 12.6 to 5.2%, and of wheat grains from 2.2% to zero. When harvesting grain seed crops it is recommended to reduce the rotating speed of the drum to 900 rpm, and in case of minor returns up to 800 rpm. The dependence of seed damage on the rotation drum speed even more appears when threshing grain legumes. In order not to damage the seeds, the combine concave clearances both at the inlet and at the outlet should be the largest, but do not allow returns. At the optimum rotation drum speed combine concave clearances are 16-18 mm at the inlet and 4-6 mm at the outlet. When harvesting highly moist plants, combine concave clearances are reduced, and when harvesting dry and easily threshed crops, they are increased. Increasing or

decreasing the mown mass supply without changing the technological adjustments of the threshing device increases the damage of the seeds. When there is less mown mass, the working organs have a greater effect on the seeds, as the protective effect of the plant mass decreases. At the same time the supply of the mown mass greater than in setting for a certain model of the combine increases the damage of seeds due to overfilling of the combine concave clearances and a decrease in their concave separation. The damage of seeds is affected by the adjustment of cleaning sieves, malfunction of augers and elevators and other parts of the threshing machine. When there are sharp edges and protrusions on the working organs of the threshing machine seed damage increases.

A double-drum thresher takes a special place in improving the quality of threshing. It was offered by the founder of agricultural mechanics, academician V. P. Goryachkin. The existing threshing technology and threshing machines are designed to grind seeds tightly connected to the plant. As a result, the ripest seeds get overstressed. In combines with a double-drum thresher, the seeds threshed by the first drum with a reduced rotation speed are allocated to the sieves, and the half-threshed ones come into the second drum, where it is threshed at the maximum required rotation speed. Thus, the use of double-drum threshers allows adjusting the combine operating according to the physico-mechanical properties of seeds and plants, reducing seed damage and losses due to under-threshing. The advantages of double-drum threshers appear only if the rotation speed of the first drum is 200-300 rpm less than the second, and the combine concave clearances are 3-4 mm larger in the first drum as compared to the second one. Hence, there are many ways to reduce seed damage. But first of all, it is necessary to choose the right mode of combine operation depending on the condition, physical and mechanical properties of the harvested crop and variety. It is very important to ensure the proper technical condition of the machines.

The researchers note that in modern crop production multifunctional competitive employees are in demand, they should be capable of making multicriterion decisions based on processing asymmetric flows of big data, working in conditions of multitasking, uncertainty and risks. High yields of cultivated crops in the “digital” field are due to mutually beneficial cooperation with worldwide suppliers of fertilizers, seeds, agricultural machinery, “smart” machines, and service providers.

Flows of structured and unstructured information distort the assessment of production situations. The “digital” agronomist performs data processing using software tools based on a multidimensional analysis of the results of informa-

tion processing. Cognitive flexibility, emotional intelligence, lean manufacturing, project and process management are professionally important qualities of a modern agronomist who is able to use online tools, digital platforms and services. According to expert appraisal, during one season the farmer makes more than forty decisions in limited time in the interaction of controlled and uncontrolled, subjective and objective factors. Structured and unstructured data can cause misrepresentation of production situations. Due to the high information noisiness of business processes, the ability to promptly make reasoned decision is a valuable professional quality. High level of thinking flexibility is a professionally important quality of a “digital” agronomist, a pre-requisite for the well-being of an agricultural organization in the digital space. In addition, the ability to work with digital equipment can significantly reduce production costs for technological operations.

In the digital space information resources are big data having the properties of variability, high dynamics, scale, multidimensionality, and asymmetry. Turbulence and uncertainty in digital agriculture, the implementation of algorithmic and creative ways to manage problematic situations necessitate adequate preparation of future specialists, the formation of entrepreneurial competencies.

In the digital educational space of the Bryansk State Agrarian University fragments of “digital” activity, its subject-technological and socio-role content are modeled in the conditions of quasi-professional activity of students. The directors and specialists of the best agricultural companies participate in the educational process. They hold masterclasses. Students undergo internships on the basis of the leading enterprises of the region. The implementation of vocational training at the University as mobile business entities in the agricultural sector is sure to provide the labour market with competitive specialists.

The Open Agrarian University “Land of Knowledge”, developed in Russia, acts as an educational platform providing farmers with access to an applied knowledge database. Experts from 23 agricultural universities and 4 research institutes offer their services via distance education.

There is a Farmer’s School and an Agro-Industrial Complex Competence Center in the Bryansk region. Regional programs “AgroStartUp” as projects to hold staff in the farms are being implemented. The regional educational and methodological information and consulting center for rural producers operates on the basis of the Bryansk State Agrarian University.

Digitalization of agriculture, transferring business processes to the online environment, at the same time reducing the cost of transactions, reveals promis-

ing sources of income to market entities, significantly faster launching products and services in digital format for successful entry into local and global markets. In 2023 the level of digitalization of the Russian agro-industrial complex was 20-25% as estimated by the experts. In 2024 the growth rate of digitalization may reach 40-50%, due to stimulating companies through the government subsidies as well.

It should be noted that during the period of 2020-2022 the number of organizations using information and communication technologies is still small in the region. There is a decrease in the number of users of Internet resources, but at the same time the websites of agricultural enterprises have become more (from 19 to 24). The number of personal computers per 100 employees is increasing, and now it is equal to 19. An increase in the cost of purchasing modern hardware and software products from 35 to 90 mln rubles can be referred to positive trends.

The factors hindering the formation of “digital” employees in crop production include the lack of sound personnel policy in organizations, the support for rural youth and youth entrepreneurship, digital inequality, the lack of high-speed Internet connection, digital platforms as a service, the lack of modern infrastructure and financial resources, etc.

Conclusion

To sum up the results obtained, it should be noted that the cooperation of the state, business, science and education results in sustainable development of rural areas of the country. State support and implementation of programs for the development of the agricultural sector have allowed domestic producers to gain certain competitive advantages in the world agricultural market. There is a large-scale transformation of crop production into a high-tech and knowledge-intensive industry.

The Bryansk region demonstrates high achievements in the agricultural sector, it provides high-quality products to the population of the region, Russian and foreign markets. Precision farming, rational use of natural resources are being introduced in farms, and “smart” agricultural machinery is being used. Staffing problems are being successfully solved at the regional level.

For the further development of the regional crop production, it is necessary to accelerate the digital modernization of the agrarian sector by increasing resource availability, to develop infrastructure, systems of additional professional education and self-education, to improve the image of rural work, and to increase the level of entrepreneurial culture.

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