Promising Intelligent Technologies for Agricultural Development[*]

Aleksandr B. Orishev[0000-0003-1953-9543]1(*), Azer A. Mamedov[0000-0003-3194-1930]1, Irina N. Sycheva[0000-0003-3784-0508]1, and Maksim V. Sherstyuk[0000-0001-9630-871X]1

1 Russian State Agrarian University – Moscow Timiryazev Agricultural Academy, Moscow, Russia

Orishev71@mail.ru, azermamedov@mail.ru, in_sychewa@mail.ru, maxim99@mail.ru

Abstract. The paper discusses the increasing application of intelligent technologies in agriculture. The authors analyze potential benefits, and outlines further development prospects of intelligent technology in Russian agriculture and beyond. The digitalization of agriculture is based on two main conditions: a) intelligent mechanisms: receiving, sending, producing, processing data, and b) connected equipment: communication and interface ensuring the permanent exchange of information between digital technology and portals. A review of the up-to-date publications on the development of intelligent technology in agriculture clearly shows that intelligent technologies are widespread in the agricultural sector. They are used in such areas as phytopathology, fruit growing, water resources management, use of soil resources, climate forecasting, and ethology. The paper provides numerous examples and discusses future prospects.

Keywords: Intelligent technologies, Artificial intelligence, Agriculture, Agro-industrial complex

1   Introduction

Intelligent technologies are widely used in agriculture: they automate production processes and modernize the production process and work that is associated with significant risk to the workers' health and well-being. For agriculture, the use of such technologies is of particular importance, since the nature of production labor in this sector of the economy is associated with numerous complexities, and is subject to the action of life-threatening factors. New technologies and specialized monitoring are used to effectively and efficiently manage the cultivation of agricultural plants. Intelligent technology provides the possibility of introducing specialized sensors in the

intensification of greenhouses, increasing the efficiency of livestock farms, conducting environmental research, and addressing problems of nature protection.

There have been major changes in the development dynamics of the agricultural sector in Russia and beyond [6; 13; 28]. The information revolution leads to the increasing dependency on information technology. The increasing complexity of the economic sphere of activity has led to the development of new information technologies. The information revolution has caused the formation of the information field of information and telecommunication systems. Information plays a major role in the agro-industrial complex [10; 26]. The agricultural sector is facing increased demand for quality products, increased yields and increased productivity. New technologies are used that reveal the reserves of agro-industrial production and attract investments [15]. Scientific and technical developments facilitate the control and administration of the enterprise, which increases the efficiency of animal husbandry. Achievements of organizations and industries are impossible without latest data on market conditions, as well as advances in production and distribution technologies. The use of digital technologies increases the profitability of agricultural production in the agro-industrial complex, as numerous independent sources and calculations suggest [19; 27; 31].

This short paper provides a review of the latest advances in the use of intelligent technology in agriculture in Russia and beyond, discusses potential benefits, and outlines further development prospects. The relevance of the study is due to digitalization processes, which are the key determinant that ensures economic growth and development. The success of digital transformation implementation determines the competitiveness of the domestic agro-industrial sector. The agro-industrial complex has historically been an area less prone to innovation than other sectors of the Russian economy. Therefore, it is of the highest importance to analyze the current state and potential benefits of the application of intelligent technologies in agriculture.

2   Application Of Intelligent Technologies In Agriculture: Latest Advances, Potential Benefits, And Further Prospects

The agro-industrial complex faces the global task of increasing food production due to population growth. In 2025, it will be necessary to produce 70% more in basic food products, such as bread, meat, milk, etc. Forecasts are focused on the growth of demand for food, the emergence of global problems and requirements for increasing production efficiency in agriculture. The territory of Russia, despite being a fairly large area, is an agricultural zone of risky agriculture, subject to climatic, soil, biological, and geographical factors, leading to high production and administrative costs. Consequently, there is an objective need to increase and maintain competitiveness of Russian agriculture with all possible means, and the use of information technology in agriculture promises high benefits. The use of digital methods and models in agriculture ensures

the efficient functioning of the agricultural sector of the economy. The predominance of inertial methods of management and old technologies in the dynamic economic conditions of agrarian reforms can lead to the destabilization of functions in agro-industrial production, imbalances in the dynamics of the agrarian sector, and the destruction of economic and cooperative ties in agriculture.

The digitalization of agriculture is based on two main conditions: a) intelligent mechanisms: receiving, sending, producing, processing data, and b) connected equipment: communication and interface ensuring the permanent exchange of information between digital technology and portals. The digital agricultural sector has become a reality in such area as GPS navigation for controlled crop production [14; 18], specific objects that ensure plant protection throughout the entire production period through repeated communication [11; 22]. A real future for agricultural production is the automatic processing of information and the integration of coordinated networks. However, the implementation of future plans requires targeted efforts of stakeholders.

Our review of the up-to-date publications on the development of information technology in agriculture clearly shows that intelligent technologies are widespread in the agricultural sector. They are used in such areas as phytopathology, fruit growing, water resources management, use of soil resources, climate forecasting, and ethology [7; 9; 12; 22; 24; 25; 33]. Artificial intelligence technologies carry out the execution of tasks during work requiring abstract conclusions, identification of samples, actions with incomplete information. Artificial intelligence technologies in agriculture have common features and characteristics: technical solutions, software and hardware for forecasting development depending on climate, soil conditions, precipitation, market prices. Intelligent technologies are frequently used with robotics. A robot manipulates objects and tools, and artificial intelligence technologies provide spatial direction, choose tools for the robot when performing tasks, identify obstacles.

There is an objective need to constantly receive new information anywhere at a convenient time for farmers to make optimal decisions. It is well-known that irrigation management works play an important role in the agricultural economy and require high-tech efforts. Precision farming has gained the possibility of practical application through the use of computer software, the creation of remote sensors and the automation of agricultural work. The use of synoptic forecasts makes it possible to effectively use chemical means of protection in crop production, which reduces the level of environmental pollution. Evaluation of evapotranspiration is a process of particular complexity and plays an important role in the administration of crop production, as well as for modeling irrigation processes. A method for calculating the average evapotranspiration rate for desert regions using digital technologies has been developed by a group of authors [4].

For the rational and efficient administration of the cultivation of plant varieties, the latest technologies and monitoring are widely used. The possibility of using sensors to improve the efficiency of greenhouses is being studied by a number of researchers. Climate control systems provide access to Internet resources. It becomes to use sensors

and photo and video equipment controlled remotely using information technology as a local network. As a result, remote visual control and assessment of plant health are performed. Another critical problem in agriculture is identifying and killing weeds. Artificial intelligence technologies detect unwanted plant organisms in crops with high precision. For instance, a method of hypoelectric visualization has been developed to identify weed species [30]. This method identifies weeds and allows one to obtain economic benefits while reducing herbicide sowing treatment. Intelligent systems contribute to the conservation of livestock, increased productivity, and the use of progressive methods of keeping livestock and providing them with feed.

Intelligent processing of Earth remote sensing data allows solving many problems in the field of agriculture, as numerous sources in the literature argue [8; 29; 32]. For example, various climatic and economic factors in agriculture lead to changes in the area and structure of arable land used in different regions of the world and our country. Accordingly, the task of recording, identifying, and evaluating arable land used in agriculture is extremely relevant for farmers around the world. Among the main tasks for the study of land use, one can include the determination of the composition of the soil, the determination of moisture, temperature, soil salinity, as well as the assessment of the degree of soil degradation and desertification. The use of remote sensing data, coupled with intelligent technologies, makes it possible to assess the agro-climatic conditions for the cultivation of agricultural crops and the intensity of the use of soil resources. Analysis of multi-temporal data allows one to delve deeper into the dynamics of changes in vegetation cover, land resources, identify problem areas and make long-term forecasts.

Also, one can increase the effect from intelligent processing of Earth remote sensing data by applying sensors monitoring the presence of disease or weeds to determine the health of plants and animals. The sensors use laser radar technology, ultrasonic, and electromagnetic devices. Remote sensors use infrared wave technology, spectrophotometers, atomic resonators. On-board performance sensors determine application rates for fertilizer, water and pesticides. They define the technical parameters of the technique.

The use of automated systems based on intelligent technology promises high benefits in labor productivity. Automation is the direction of scientific and technological progress in the agricultural sector. Automation includes herd management, waste disposal, egg collection, microclimate maintaining, as well as automation of equipment, fertilization, milking, feeding [2; 20]. Based on intelligent systems, automation stabilizes the parameters of the subjects of production, optimizes work processes, controls production, reduces the amount of manual labor, as well as contributes to the protection of people, biomaterials, animals from hazardous and emergency modes of operation [1].

It is possible to reduce the cost of equipment production, maintenance, and control if one has full knowledge of the equipment and the capabilities of information technology. The construction of a software and hardware complex guarantees the effect

of the operation of agricultural machinery. There are numerous programs developed for optimizing animal nutrition, planning the distribution of feed [28–30]. With their help, groups of agricultural animals are controlled: pigs, poultry, dairy cattle. The purpose of such programs is to plan the feeding process according to recipes and nutritional mixtures. There are programs for automation, control, and analytics in animal husbandry. Such programs monitor the physiological state of the herd, diagnoses diseases. The introduction of information technologies into agro-industrial complexes will help increase profitability in a short period of time, depending on the initial investment and the effectiveness of implementation.

In our opinion, the agrarian sector needs intelligent information systems that simulate agricultural management and provide an opportunity to receive comments on activities and consultations from specialists. Increasing the productivity of this system requires the introduction of regional divisions, and such steps would allow for the full-scale application of Big Data and Artificial Intelligence in agriculture [17; 21]. The input data must be provided by the farmers themselves, and they must contain reference data on the main economic indicators, as well as a description of the technical means and innovations used by them. Input data should be passed to the analytics department to validate the submitted data for the relevance and feasibility of development and application in the relevant region. In the analytical department, a commission with experts in different areas should be created. After appropriate verification procedures, the data is transmitted to the database of the information system for open access and general use. Open information resources have proven to be an important factor in production. The agro-industrial complex is currently experiencing difficulties in the distribution of information resources, which affects its evolutionary development. The use of information systems allows one to create a scientific knowledge base for agro-industrial complex organizations. Intelligent information systems also provide a constant access to reliable information resources and allow for cross-scale and cross-territorial intelligent analysis.

Modern technologies and scientific and technological progress in market conditions are developing very quickly, outstripping agricultural production relations by several years. External relations of agricultural enterprises are subject to the greatest dynamism, which leads to an increase in the volume and speed of information transfer. For effective management in agriculture, it is highly necessary to reduce the time before making decisions. Consequently, one should focus on an increase in the speed of information delivery. At present, information has begun to influence the process of exchange, consumption, and distribution of created services and goods in agriculture, as well as the development of the market and economic mechanisms with the establishment of fairly constant ties between business entities and the entire spectrum of the economic sector. This allows information to be categorized as a factor of production, and intelligent systems and tools become of the highest importance in agricultural production and management.

The introduction of digital systems with the application of intelligent technology in large industries is profitable. The experience of successful agricultural producers shows that digital technologies can create conditions for increasing yields and productivity during the production cycle. Practice shows that the introduction of digital technologies into the development of agricultural organizations pays off in 2-3 years [23]. The use of new developments of software systems and information technologies in the agro-industrial complex intensifies the work of agricultural complexes, automates production activities and increases productivity.

3   Conclusion

Intelligent technologies are used in agriculture to identify plant diseases, classify plants, identify weeds, in fruit growing, cadastral registration, and weather forecasts. Further development and use of such technologies are associated with technical progress and abilities of agricultural organization to introduce them. Manufacturing, service, and transactional structures with software are global in nature. The innovative development of agriculture and the technical modernization of the industry depend on artificial intelligence technologies and their widespread use.

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