

Application of green technologies in modern agriculture

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Abstract. This study explores the key groups of green technologies applicable in modern agriculture, their functional roles, and potential centers for cooperation and testing in regional university laboratories. In the Russian Federation, the adoption of green technologies is crucial for agricultural producers to reorient towards modern methods, automate processes, and increase high-tech usage. The future of green technologies lies in their contribution to rural area development and preservation of local production processes. As a vital sector in the Kursk region, even a small increase in efficiency through green technology adoption can ensure the region's sustainability due to its significant scale.

1 Introduction

In the modern world, green technologies are used in various spheres of the national economy and the agricultural sector is no exception. The use of technologies that preserve the ecosystem is becoming a priority for the regions of the Russian Federation.

The applied principles of using traditional technologies in agriculture show us a decrease in their efficiency due to resource depletion. With the increase in environmental pollution, the likelihood of soil depletion also increases, which entails a decrease in the economic potential of the region. That is why the development strategy of the Kursk region takes the vector of introducing green technologies in agriculture and the agricultural processing industry. The Kursk region, being in a zone of favorable agroclimatic conditions of a temperate continental climate, is the owner of predominantly chernozem soils - about 65%, with a high humus content. The land fund of 3 million hectares includes 76.7% of agricultural land, more than half of which is arable land.

When considering green technologies, it means the use of technologies and scientific approaches to produce environmentally friendly products and the use of technological chains that reduce the negative impact on environmental pollution. Innovations in the field of agricultural development make it possible to reduce the negative human impact on the environment, while introducing technological processes that allow the introduction of equipment that helps reduce costs, as well as supporting the sustainable development of the industry. Speaking of lean production, the goal is to preserve soil fertility through the use of environmentally friendly technologies, as well as to produce environmentally friendly agricultural products.

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2 Materials and methods

Currently, under the influence of sanctions and the implementation of import substitution programs, the introduction of innovative green technologies in agriculture plays a primary role in the production of competitive products. While exploring the use of green technologies in the Kursk region using the regional development strategy, an analysis of the possible use of green technologies in agriculture was carried out. During the study, methods such as specification, generalization and classification were used.

3 Results

We will consider the main green technologies used in agriculture at the present stage of social development (Figure 1). The figure shows that the main groups of green technologies include renewable energy sources, biotechnologies, engineering solutions.

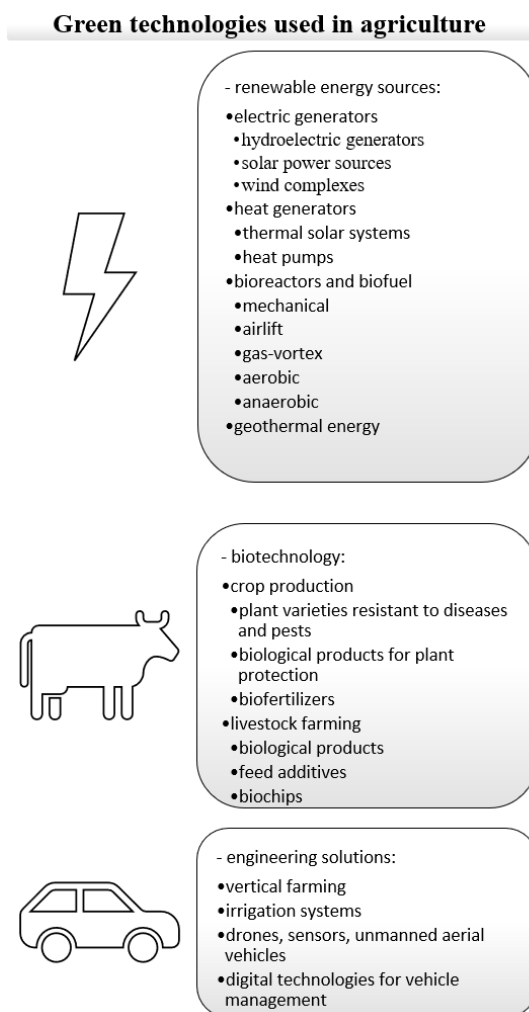


Fig. 1. The main groups of green technologies used in the agro-industrial complex.

Providing the agro-industrial complex with alternative sources of heat and energy is a powerful lever for developing a competitive environment in the agricultural market. There are many alternatives for generating electricity with various types of generators: gas, diesel, gasoline, inverter, but we will look at more environmentally friendly ones.

Hydroelectric generators are used to convert water energy into electricity. The difficulty of using these generators is that you need a river with a fast flow, which is why they are rarely used and for our region they are irrational.

The use of solar power sources is more appropriate in the spring and summer. The advantage is that this type of energy generator is easily installed on free areas, walls, roofs and is capable of generating solar energy by converting it into electricity. The use of this equipment can perform a wide range of tasks: lighting, feeding pumps, electric shepherd on pastures, honey extractor and more. The disadvantage of such equipment is the insufficiently long daylight hours in the winter and cloudy days [1,2].

Wind complexes have a number of advantages over other sources of energy generation - there is no connection to fuel, but at the same time, interruptions in operation during calms and hurricanes are possible [3]. But with the use of energy storage devices, this drawback can be solved, and the experience of using wind generators shows that it pays off within the first year of operation.

Bioreactors and biofuel are used in livestock and poultry farms, which are based on animal waste during the decomposition process, which releases heat and methane gas, which can be used to generate energy. The advantages of such technologies are raw materials that do not need to be purchased, and the output is biogas, organic fertilizers, heat and electricity.

Another type of green technology used in agriculture is heat generators. The operating principles of the heat generator are simple; it accumulates heat from the environment and is used to heat premises, greenhouses and other buildings of agricultural enterprises. These include heat pumps, which accumulate energy from the environment, water, earth, as well as solar heat generators, which convert the sun's energy into heat. Such systems are used for drying grain and heating premises in hard-to-reach areas where farms are located far from the main electrical and gas mains.

Biotechnologies deserve special attention to the use of green technologies in agriculture. Plant growing has long been using this technology to create new plant varieties that are more resistant to a number of modern diseases, and by changing the DNA structure of the plant, it is less susceptible to various pests, which increases the yield and consumer quality of products [4].

Animal husbandry is also not developing in the field of biotechnology; various drugs are produced that are used to treat animals from infections and viral diseases, making animals more resistant to most diseases. In addition, feed additives are being developed that promote better digestion of food and the accumulation of nutritional minerals and other useful elements in the body, improving the quality of products, and silage starters are being developed that contribute to longer and better preservation of feed.

An innovative technique for detecting livestock diseases using biochipping is being implemented in a number of farms, which not only makes it possible to identify a specific individual animal, but also transmits data to the registry about its condition, which makes it possible to provide the necessary assistance to animals in a timely manner.

Another direction of introducing green technologies in agriculture is the use of various engineering solutions that make it possible to use technology more efficiently, replacing manual labor with automated processes, introducing a system of various sensors and robots when controlling machines and equipment, thereby reducing man-made disasters.

Unmanned systems are increasingly used in transport systems when cultivating fields; the operator configures the machine according to information from an intelligent system that uses geolocation [5]. When installing modern soil diagnostic sensors, the equipment is

automatically configured with dosing of sprayed substances, and in crops where it is impossible to use ground equipment, unmanned aerial vehicles and drones are used, which are controlled by the operator using intelligent settings.

Table 1 presents a diagram of the possibility of using innovative green technologies at various stages of agricultural production processes in the Kursk region.

In the field of agricultural production, a certain set of green technologies can be distinguished: pest control, preservation of soil fertility, modern biotechnologies, the use of geolocation technologies, drones, digital sensors to monitor climate change in the environment, the biological state of animals and plants, and others.

Table 1. Opportunities and advantages of using green technologies in agriculture of the Kursk region.

Type of technology	Contents, advantage	Possibility of application	Centers for cooperation and support for the development of green technologies
Renewable energy: solar thermal technology, wind technology, biomass.	Generation of heat and electricity. The technology is applicable in places of installation of mobile irrigation units, temporary livestock parking, heating of spring-autumn animal keeping stations, drying of grain, etc.	Dependence on natural conditions, low efficiency in large-scale use	Possibility of innovative engineering developments SWSU, Kursk State Agricultural Academy.
Biotechnology	Ability to grow plants with specific traces (changes in crop DNA). The use of modern technologies to modify biomaterial increases yields, reduces the impact of pests and reduces the use of pesticides compared to conventional crops.	The use of these technologies in the region allows the development of new types of crops	Possibility of breeding development Kursk State Agricultural Academy
Vertical farming (aquaponics and hydroponics)	Growing crops in a closed and well-controlled environment. Greenhouse farming method (allows for saving water resources and fertilizers)	Application in farms with a small area of land resources	Interaction on the development of engineering technologies - SWSU, on the development of biomaterials and cultivation technology - Kursk State Agricultural Academy
Irrigation	Organization of water delivery to land plots for timely irrigation. Allows you to increase productivity during dry periods. Using sensors and dispensers, control the irrigation process remotely	Applicable for farms with large land areas.	Engineering development of land irrigation systems – Kursk State Agricultural Academy

Drones, sensors and unmanned aerial vehicles	Detection of deviations from planned indications and rapid response to environmental changes, pest and disease control	Application of tracking technology both in large areas of agricultural producers	Cooperation with leading universities in the region on engineering development of green technologies, hardware and software solutions - SWSU, Kursk State Agricultural Academy
Genetics and digital technologies in livestock farming	Monitoring the condition of animals and collecting data to improve the maintenance and breeding of new breeds. Increasing productivity, monitoring the health and controllability of animals	Creating digital twins	Cooperation with leading universities in the region on engineering development of green technologies, hardware and software solutions - SWSU, Kursk State Agrarian University and other educational and research institutions in the region
Digital technologies for vehicle and equipment management	Monitoring and controlling equipment using geolocation systems, robotics and other innovative technologies. Systems collect, analyze and transmit information to operators to monitor the technological process	Applicable at agricultural enterprises in the region and vehicles for cultivating fields	Development of software and engineering designs in the field of agricultural machinery innovation – SWSU, Kursk State Agricultural Academy

When talking about the use of green technologies in agricultural activities, it is necessary to take an integrated approach, since one technology is not able to provide the expected result. The relevance of the use of green innovative technologies is attractive both for manufacturers and consumers of agricultural machinery, and for investors due to the constant depletion of natural resources.

4 Concluision

Green technologies allow us not only to see opportunities for improving technological production processes, but also to consider a systematic approach to the use of green technologies in modern agriculture, which includes three components:

- managerial;
- organizational;
- production.

The management component must include the process of planning the introduction of green technologies, as well as the implementation process, which, due to the seasonality of the activities of agricultural enterprises, has its own specifics. Then you should not forget about the stage of implementation of green technologies in the technological cycle and control, as well as the analysis of the use of technology in the production cycle[6,7].

Particular attention should be paid to the organizational component, since it includes training of both management personnel and direct production workers who ensure the implementation of the production process. This can also include incentives for employees,

thereby increasing their interest in using this technology, as well as the use of information collection and control functions to timely eliminate deficiencies in the use of this technology and timely retraining of the personnel involved.

The production component of the system approach gives us the opportunity to track the production process from the planning stage with the development of relevant indicators, diagnostics of the production process and organizational activities, to the implementation of the control function for making changes and eliminating identified deficiencies in the production process using green technologies.

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