



Research Article

Development of Organic Agriculture Based on the Biologization of Agricultural Technologies

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Abstract

Organic agriculture is an integral part of the modern "green revolution", which aims to ensure food security and sustainable development in the face of modern challenges. Research shows that the introduction of innovative technologies and biological farming techniques can significantly increase the productivity of crops and animals while reducing the negative impact of production on the environment. In this regard, organic agriculture based on innovative agricultural technologies and biological techniques is becoming the most important component of modern agricultural policy, recognized as a strategic vector for the development of agricultural production in almost all countries of the world due to the negative consequences of the use of intensive farming technologies for nature and society, and consumers of non-organic food products.

Introduction

The prospects for the technological development of modern agriculture, as well as other sectors of the economy, are focused on the application of agrobiotechnologies in business practice, which are classified as high agro-industrial technologies "Agriculture 4.0. Agrobiotechnology is necessary for the development of organic agriculture, as an alternative to excessive chemicalization and intensification of agriculture, which harm the environment and human health. In Russia, "the production of organic agricultural products, in the technological processes of which biomaterials, natural fauna, and agrotechnical techniques are used instead of chemical fertilizers, pesticides, and fungicides" [1], is increasingly developing. However, the growth rate is low [2], because farmers and specialists of agricultural organizations often do not perceive other ways to increase soil fertility and plant protection other than intensive ones based on the use of chemical plant protection products and soil fertility replenishment. To support the strategic development of organic agriculture, to meet the increasing demand for organic food products in the domestic and global

markets, the Federal Law "On the Development of Agriculture" defines "The main directions of state support in the field of agricultural development", including "the development of organic agriculture and support for producers of organic products" [3].

The purpose of the scientific work is to justify the feasibility of developing organic agriculture based on the technologies of organic product production, the use of organizational and technical methods, and the biologization of agriculture. The scientific novelty of the work lies in the presentation of an integrated system for protecting plants grown for food supply from diseases, pests and weeds, including the use of entomophages, biological methods of pest control, crop rotation, and proven technical and technological methods, as

well as the digitalization of business processes using unmanned aerial vehicles, while achieving socio-ecological and economic effects.

Materials and methods

The research is based primarily on the works of the founders of organic farming and modern agricultural scientists studying the prospects of organic agriculture and agrobiotechnology [4–14]. The paper uses a systematic approach, general scientific, and empirical research methods. Along with tabular and graphical methods, cartographic methods were used to visually present the results obtained, in particular, the integrated plant protection system against diseases, pests, and weeds, and to formulate conclusions about the effectiveness of the proposed techniques. Methods of economic and statistical modeling and competitive analysis, digitalization have been applied to identify the effectiveness of the use of mineral and organic fertilizers in the fields of grain cultivation. The One Soil Internet platform has been used to map farm fields and crop rotations in organic farming.

Results and discussion

According to an up-to-date study by the Research Institute of Organic Agriculture (FiBL) and the International Federation of the Organic Agricultural Movement (IFOAM), “The world of organic agriculture 2022”¹, sales of organic products continue to grow and have reached another record high of 129 billion dollars, as evidenced by data from 190 countries (2020 data). In 2023, the organic market continued its development. A total of 262 organic certificates were issued from 2019 to 2022. In 2023, their number increased by 123 (14%), reaching 385 [7]. According to Roskachestvo, with the adoption of the Strategy for the Development of Organic Production in the Russian Federation until 2030, the number of Russian and foreign manufacturers wishing to certify their products according to Russian standards has increased several times. In other words, the policy of the president and the government of the country is a guarantor of the prospects for the development of the production of organic agricultural and food products to ensure the health of the population, its growth, increase exports, and preserve the natural resource potential and wealth of Russia. However, further growth in organic production requires the development of technologies and organization of production processes, the use of which allows not only to maintain the achieved production volumes, but also to increase the volume and quality of products, replenish soil fertility, preserve the environment, and achieve economic growth are inseparable

from the concepts of “responsible consumption” in relation to natural resources and society. Such achievements require interdisciplinary scientific research, combining the potential of scientists in the fields of agronomy, biotechnology, engineering, and economics. As a scientific team created according to this principle, we conduct scientific research. The scientific team created by us on this principle conducts research and experimental work on the biologization of technologies and the application of organizational and technical techniques in organic agriculture in the foothill territories of the Altai Territory, in particular in Stepnoy LLC of the Biysk region, which has not applied mineral fertilizers or chemical plant protection products against weeds and pests since 2008 and diseases. The farm grows grain crops (buckwheat, rye, oats, wheat, peas, and rapeseed) on an area of more than 12 thousand hectares. The company is certified according to the organic standard GOST 33980–2016, and works in conjunction with organic processors Kurai Agro Plus LLC and Predgorye LLC. The association was created on the principles of cooperation, it includes 7 affiliated companies that solve the issues of selling organic products, including in a specialized organic food store opened jointly in the city of Biysk, Research shows that the economic efficiency of organic production according to the proposed technology in some years is higher than the average in the Biysk region, It has been increasing in recent years (Table 1).

According to the Results of the activity, the farm is profitable, and the level of profitability varies over the years depending on crop yields (Table 2). The selling prices of organic grain products of the farm differ little from the average prices on the grain market. Cost analysis for the production of grain and leguminous crops by Stepnoy LLC in dynamics for 2019–2023. A significant increase in material costs in 2023 by 67.4% compared to the data for 2019. Mainly due to rising prices for energy resources, seeds, and at zero costs for the following items: mineral fertilizers, plant protection products. Calculations by economic scientists based on technological maps of agricultural cultivation [15] prove the economic benefits of organic agriculture.

Calculations by Economic scientists based on technological maps of agricultural cultivation [15] prove the economic benefits of organic agriculture. Modern scientific research is aimed at biologizing agricultural technologies in order to replenish soil fertility and protect plants from pests. Russian scientists propose environmentally friendly biologics that can replace 40% – 50% of imported expensive agro-chemicals [16–18].

Table 1: Yield of main crops, hundredweight/ha in LLC “Stepnoy” (household), Biysk region, in comparison with the average indicators for the Biysk region (district) of the Altai Territory.

Indicators	2017	2018	2019	2020		2021		2022	2023	2024
	Farming	Farming	Farming	Farming	District	Farming	District	Farming	Farming	Farming
Winter wheat	10,3	27,1	32,2	19,3	23,1	26,5	26,9	22,2	14,8	9,7
Spring wheat	24,0	25,0	14,5	13,7	0,9	1,0	5,3	8,3	5,9	20,9
Barley	27,5	21,0	20,9	18,4	19,8	13,0	26,6	15,0	9,1	9,6
Oats	27,1	31,1	30,7	17,5	15,0	21,0	18,8	20,9	26,1	36,0
Buckwheat	10,2	10,0	17,9	10,1	11,6	8,3	10,2	9,5	13,4	14,2

Table 2: Dynamics of financial performance indicators of Stepnoy LLC for 2019-2023, thousand rubles.

Indicators	2023	2022	2021	2020	2019	Deviations 2023 (+;-) from	
						2022	2019
1	2	3	4	5	6	7	8
Profit (loss) before taxes	25 854	20 246	30 159	10 113	13 406	5 608	12 448
Net profit (loss)	25 408	19 975	29 792	9 755	12 830	5 433	12 578
Cost of sales	95 330	121 834	98 710	78 490	55 424	26 504	39 906
The level of profitability of the products sold	27,1	16,6	30,5	12,9	24,2	10,5	2,9

Scientists in Mongolia propose the biofertilizer Azophos, the use of which increases crop yields by 1.5–2.0 times. A new type of biological product, Mongol em, proved to be safe for food and harmless to human health [18,19]. Scientific developments of Altai scientists offer new high-yielding, disease-resistant varieties of grain crops, fruit and berry crops, antiparasitic drugs for animals used in organic agriculture, and technologies for the production of organic products based on biologization. Our research on the effectiveness of the use of expensive mineral fertilizers in agricultural organizations of the Altai Territory has allowed us to substantiate the conclusion that “about the low impact of increasing the amount of fertilizers applied on increasing the yield of grain and leguminous crops. Analysis of statistical data for 1966–2022. Based on the results of solving a multifactorial economic and statistical problem, he showed that there is a weak direct relationship between the yield of grain crops and the application of mineral fertilizers per 1 hectare of crops in the Altai Territory, with a correlation coefficient of $r = 0.29$ [19].

Stepnoy LLC constantly monitors the soil condition. An agrochemical analysis of the farm’s soils conducted by us at the end of 2022 showed that at the time of the survey, almost all had an acidic or close to neutral reaction of the soil environment: salt pH – 5.3–5.7, water pH – 5.9–6.3. Nitrogen in nitrate form was at a high level, but since it has great mobility in the autumn period, this is not a significant indicator of the time when there are no crops in the field. More important at this point may be the indicator of the content of ammonium nitrogen, which is less mobile and is fixed in the soil absorbing complex – its content was at a low and average level. Also, at the level of low soil indicators, farms are provided with mobile phosphorus. This fact indicates the need to mobilize the element using a method available in organic agriculture, for example, applying bacterial preparations based on phosphate-mobilizing bacteria to the soil and pre-sowing seeds.

To increase the nitrogen content in the soil, we recommended including legumes in crop rotations: peas, soybeans, bean siderates – sweet clover, white lupine, yellow. It is also possible to sow legumes as intermediate crops during early field release, for example, after winter crops.

For organic agriculture, it is important to keep a history of the fields. Modern conditions dictate the need to quickly collect information from the fields and save this information in a format that is accessible at any time. To keep a history

of fields: crops sown, varieties, norms and dates of sowing, applied drugs, development of diseases and insects, types of weeds, yields, equipment used – all this data can be entered and stored in the One Soil application, which is installed on a computer and smartphone. It is also possible to monitor the condition of crops using the NDVI index (Normalized Difference Vegetation Index), which is a numerical indicator of the condition of plants. It is calculated from satellite images, indicates the quality and quantity of vegetation, and depends on how plants reflect and absorb light waves of different lengths. The range of index values is from 0 to 1. In the middle of the season, a healthy plant with a lot of chlorophyll and a good cellular structure actively absorbs red light and reflects near-infrared. The NDVI of such a plant is high. But a high NDVI does not always mean that everything is fine with the plant. For example, at the end of the season, crops ripen, and the index usually drops. At the beginning of the season, a low index, on the contrary, is considered abnormal: most likely, plants with low NDVI did not overwinter well. Figure 1 shows a map of the fields of Stepnoy LLC developed in the One Soil program.

The One Soil application updates the NDVI vegetation index every 3–5 days, and an agronomist can monitor their appearance and carry out mechanical processing of the field in a timely manner. Also, with the help of this tool, it is possible to draw up crop rotation schemes – scientifically based alternation of crops in the fields and leaving fumes. By properly alternating crops in the field, it is possible to deprive parasites of their habitual environment – and thereby prevent diseases.

There is a shortage of legumes on the farm, and a large percentage of the land is allocated for buckwheat as a more economically profitable crop for the farm. Table 3 shows the schemes of scientifically based crop rotations recommended for agriculture.

The Company uses traditional technology of tillage and grain cultivation, observing the principles and requirements of organic production. The seed turnover goes through a certain cycle, starting with the original variety: original – super elite

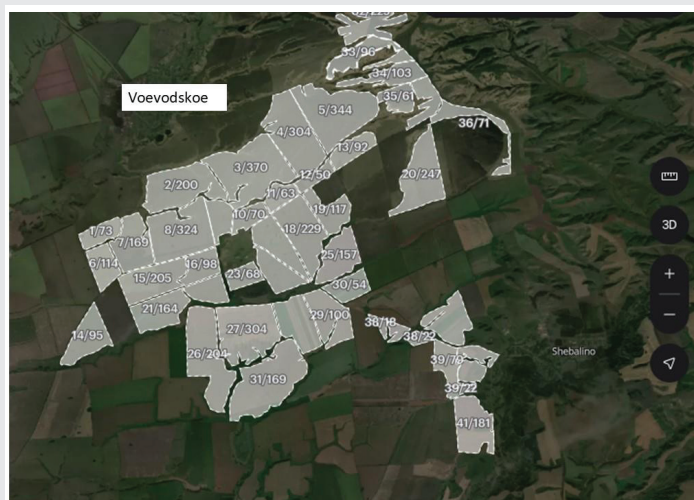


Figure 1: A map of the fields of Stepnoy LLC developed in the One Soil program, indicating their number and areas.

Table 3: Scheme of recommended crop rotations.

1	2	3	4	5	6
1. The steam is clean	1. The steam is clean	1. Corn for strength.	1. The steam is clean	1. Annual herbs.	1. Annual herbs.
1. Winter wheat	1. Winter wheat	2. Winter wheat	1. winter rye	2. winter rye	2. oats
2. spring wheat	2. oats	3. Annual herbs. + Perennial herbs	2. oats	3. Oats	2. buckwheat
3. Buckwheat	2. buc. heat	4. Perennial herbs. 1 year	2. buckwheat	4. buckwheat	3. buckwheat
4. buckwheat	3. buckwheat	5. Perennial herbs. 2 years	3. buckwheat	5. buckwheat	4. buckwheat
5. buckwheat		6. buckwheat		6. buckwheat	
		7. buckwheat			

- elite - first reproduction - second reproduction - third reproduction. After that, it is officially (according to science) considered that the grain is degenerating, and it is necessary to start sowing with the seeds of the original. In this regard, it is possible to identify the first problem in organic crop production – the high cost of seeds.

The second problem is tillage due to the complexity of weed control. Various tillage systems are being considered, mechanisms and techniques are being tested – they are at the search stage. Crop residues and rotted manure are introduced into the fields to maintain fertility. If a strong blockage of the field is detected, it is vaporized. In the future, it is planned to produce and apply vermicompost. The company uses a 6-pole crop rotation: wheat-buckwheat-barley, peas-steam-fodder crops. The complex of weed control measures involves preventive, extermination, special, and other measures that significantly reduce the harmfulness of weeds and increase the efficiency of crop production.

Preventive measures are aimed at identifying sources, foci, and ways for seeds or vegetative organs of weed propagation to enter the fields. Since most types of weeds end up in fields with seeds of cultivated plants, special attention must be paid to cleaning the seed material. Depending on the physical properties of seeds of cultivated and weedy plants (size, shape, specific gravity, presence of spines, etc.), the appropriate grain cleaner is selected. Machines, their adjustments, and operating modes. Seeds of different lengths are divided into trieres, different in thickness and width, on longitudinal and circular sieves, different in windage, by aspiration. Fruits and seeds with a rough surface or hooks are separated on slides, spherical ones are separated on inclined spiral surfaces, and various specific gravities are separated in solutions at a certain concentration.

Measures to reduce or stop surface water runoff during intense snowmelt or precipitation, as well as during irrigation, help reduce the transfer of weed seeds across the field. Before the seeds of weeds mature, it is necessary to systematically mow the roadsides of fields, roads, power lines, forest strips, between exclusion zones, around outbuildings, currents, places of storage of equipment, and in micro-depressions of the relief. During harvesting, measures should be taken to ensure the non-proliferation of weed seeds with harvesting machines and vehicles when transporting crops and moving to new fields. Harvesting equipment should be well-regulated and equipped

with weed seed catchers. For mowing weeds with unripe seeds in clogged fields, it is preferable to harvest at a low cut and at the optimal time.

An integrated system of plant protection measures against weeds has been developed for Stepnoy LLC, which includes:

1. Mulching of the soil in the form of crop residues. Mulching helps to preserve moisture in the soil, prevents its rapid evaporation, prevents the germination of weeds, blocking access to sunlight, protects the soil from wind and water erosion, and protects the aboveground part of plants from pathogenic microorganisms living in the soil.

2. Preserves favorable conditions for the development of the root system in summer, as the high soil temperature prevents the absorption of most micro- and macronutrients. Promotes the development of beneficial microflora and earthworms in the soil. Minimum amount of crop residues: 1 t/ha on moderately heavy soils; 1.5 t/ha on medium soils; 2.5 t/ha on sandy soils. We suggest approaching each field individually, and if possible, where there is no compaction, do not carry out annual deep plowing, only flat-cutting loosening. Plus, there is the option of late sowing of the main crops to control weeds. That is, wheat, for example, we can quite afford to sow on the 20th of May. Then we will fight the early weeds by pre-sowing loosening, and the later ones will be suppressed by the shoots of the main crop. Wheat is a plastic crop; it has enough time to mature. The Biysk zone is a zone of sufficient moisture, so there should be enough moisture for sowing. Although you need to look at the field here, if it is a hill, moisture can leave faster ... The fight against root-springing weeds should be carried out primarily by pruning. But here, too, you need to look at the situation in a specific field.

A number of certified biological products are recommended in the organic farming system. They help fight pathogenic microorganisms. We have conducted a number of trials with biologics on several crops and are constantly studying the properties of biofungicides. The results are good. For example, last year we conducted experiments on potatoes, used biofungicides against late blight, alternariasis, and other fungal diseases. Two treatments were carried out during the budding phase and after on different food backgrounds. The biologics worked. By the way, we tested a bioinsecticide against the Colorado potato beetle, bitoxibacillin, on potatoes. Triple treatment helped to reduce the number of pests below the EPV.

Conclusion

The tasks that “rapid” biologization solves are: reducing the number of fungicidal treatments and partially eliminating the use of a number of expensive pesticides.

Disadvantages of biologics: they do not work instantly like chemistry; it takes a little more time to get the maximum effect. They work most effectively on prevention, and if the disease or parasite has already developed (the moment of appearance is missed), then the chemistry will have to be changed to save the crop or animals. There is a catastrophic shortage of specialists who can work with biological products. Organic farming is more profitable and more important than instant profit. Cooperation is an urgent need for small producers of organic products in order to win the market. The priority of soil and ecosystem health will make domestic agriculture resistant to diseases and droughts. The third problem is product sales. Today, a small part of the products are sold in the EU (gluten-free buckwheat), and the rest of the products are on the domestic market. The main task of the enterprise, which is under implementation, is to create a closed production cycle: production – sale (slaughterhouse, bakery) – finished products. Many commodity producers attribute their reluctance to produce organic products to the high cost of the new farming system, which involves the use of biofertilizers, biologics, new tillage technologies, and breeding methods in the production. Analyzing the production of grain crops at Stepnoye LLC, it is possible to note that with an average yield of 27–28 quintals/ha in recent years (which is higher than the average for the district – 17.6 quintals/ha), the cost of 1 ton of grain is. Leaves 8000 rubles, which is reflected in the financial performance of the company. During the analyzed period, it generated an increase in sales revenue.

Thus, in modern conditions of production in agricultural enterprises, organic agriculture is a low-cost farming system aimed at creating agricultural landscapes that promote the reproduction of soil fertility, provide conditions for sustainable harvests, improve phytosanitary conditions, preserve the environment, and the health of the nation. The main ones can be distinguished: 1) Environmental impact: Measures the environmental impact of a project, which includes reducing pollutant emissions, preserving biodiversity, and saving energy. 2) Economic impact: evaluates the financial results of the project, including cost reduction, income increase, and creation of new jobs. 3) Social effect: measures the impact of a project on the well-being of society. It includes improving the quality of life, education, healthcare, and access to resources. An integrated plant protection system against diseases, pests, and weeds is recommended, including the use of entomophages, biological pest control methods, and organic farming. To replenish and increase soil fertility, and improve soil structure, it is recommended to use scientifically based crop rotation, proven technical and technological techniques, the dynamics of the economic efficiency of using organic technologies in agriculture, and the mechanisms for achieving socio-ecological and economic effects.

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