Diagnostics of using IT in agriculture of the Nizhny Novgorod region

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Abstract—Modern agriculture is in full need of digital transformation through the introduction of digital technologies into the production process of all sub-sectors and spheres. This phenomenon is reflected through a variety of cause-and-effect relationships on each consumer of agricultural products and products of its processing. In this regard, the relevance of this issue increases for each person in connection with daily food consumption. In the scientific community, the development of digital agriculture is receiving increasing attention from both Russian and foreign authors. Digital transformation affects all branches of the national economic complex, depending on the current level of their development, and the agricultural sector is no exception. Therefore, the article is devoted to the diagnosis of the current state of digital agriculture.

Keywords—information support, agricultural development program, agriculture, trends in the development of digital agriculture, precision farming technologies, precision animal husbandry technologies, digital transformation of agriculture, digital economy.

I. INTRODUCTION

The influence of the IT factor on the efficiency of agricultural organizations is constantly and steadily increasing. Two decades ago information technologies acted as a supporting element of the management system, played an auxiliary (technological) role in the implementation of information exchange between participants in the management process, today technical modernization and intellectualization allows them to transform into one of the main elements of increasing competitiveness and strengthening the viability of agricultural organizations. The development, implementation and use of an effective IT system becomes the main component determining the optimality and success of any economic entity, including agricultural. The introduction of information and communication technologies into the organization's activities makes it necessary to pay close attention to the effectiveness of all elements of the production system: production, sales, logistics, personnel and, especially, management.

II. DISCUSSION

Information technologies in the Russian economy are developing rapidly as part of the implementation of the national project "Digital Economy of the Russian Federation". Its main objectives are the accelerated introduction of digital technologies in all sectors of the national economy through the creation of a stable and secure information and telecommunications infrastructure for high-speed transmission, processing and storage of large amounts of data, accessible to all organizations and households, the development and implementation of digital technologies [1,2,3,4,5]. The Center for Forecasting and Scientific and Technological Development of the Agro-Industrial Complex of the Kuban State Agrarian University has been monitoring the use of precision farming elements in the regions of Russia since 2017. According to their data, in the Nizhny Novgorod region in 2017, 50 farms using IT were recorded on an area of 158 thousand hectares, which compared with the reporting data of the Ministry of Agriculture and Food Resources of the Nizhny Novgorod region in 2020, there was an increase of 53% in the number of farms and 61% in the area of the use of precision farming elements. Agriculture, as an object of management, refers to territorial and sectoral objects that use a hierarchical principle at the heart of their organization. There are four levels in the agricultural management system:

1. Federal level of agriculture management;
2. The level of agriculture management of the subject of the Federation;
3. Municipal level of management;
4. he individual organization level of management.

Such a division of industry management into levels implies continuous improvement of its information support and increasing the degree of using information technologies. This requirement is explained by the fact that information support for the management of the agricultural economy sector, its composition and structure must clearly correspond to the implemented functions of the agricultural sector management system at all levels.

The reliability of information at the highest level of management depends on the entire chain of its occurrence, processing, storage and transmission from the lowest (operational) level – from the agricultural producer, their qualifications, integrity and other qualities, otherwise the picture of the real situation can be significantly distorted. This is evidenced by the report on the results of the expert-analytical event "Analysis of the impact of measures for the development of housing construction and engineering

infrastructure on the level of rural development" implemented in 2018, 2019 and 2020 within the State Program for the Development of Agriculture and regulation of agricultural products, raw materials and food markets and the state program of the Russian Federation "Integrated development of rural areas", approved by the Board of the Accounts Chamber of the Russian Federation on January 26, 2021. An important role in the process of improving the information support of agriculture in general and individual agricultural organizations, in particular, is played by material and technical support. Analyzing the availability of agriculture in the Russian Federation and the Nizhny Novgorod region, a tendency to reduce the number of equipment is revealed. So, in 2019, the number of vehicles in the Russian Federation is noticeably lower than at the beginning of 2015 (the tractor fleet in the Russian Federation in 2019 amounted to 65% of the level of 2015 and 90% of the level of 2016). In the Nizhny Novgorod region, the 2020 indicator by 2016 is 93.7%. This circumstance indicates the difficulties of agriculture in providing organizations with the necessary equipment. As for computer equipment and software, the analysis showed a low level of equipment for most agricultural organizations (in some agricultural organizations of the region, the IT infrastructure is completely absent).

Thus, in order for an agricultural organization to initiate measures for informatization and digitalization, it is necessary to be more actively involved in the processes of creating investment budgets for digital technology implementation projects, registration and receipt of appropriate grants, development of projects that allow obtaining financing through participation in various programs. It is particularly possible to highlight legislative and regulatory acts in the Russian Federation on this issue. The most significant for 2021 is the Departmental project "Digital Agriculture of Russia" created by the Ministry of Agriculture of the Russian Federation. The project includes: development goals and objectives; prerequisites for the need for project development; a phased implementation plan and other sections.

The main goal of the project is to achieve productivity growth at "digital" agricultural enterprises by 2 times by 2024 due to the digital transformation of agriculture through the introduction of digital technologies and platform solutions to ensure a technological breakthrough in the agro-industrial complex.

The results of the project implementation will be expressed in the growth and bringing up to 100% of data on agricultural facilities included in the digital platform by 2024. Based on the existing and target values, there is a tendency that the work on digitalization of data on agricultural land has already been started before 2018 and bringing its share to 100% is probably the fastest – already in 2022.

Agricultural machinery is at the second place in terms of digitalization of agricultural facilities. As of 01.01.2018, the share of information on it in digital form has already been formed by 25% and in 2023 it is possible to reach the level of 100%.

The most backward object for which no information was collected in 2018 (0%) is working and productive agricultural cattle. Bringing digitized information on this object is possible only by the end of the project – 2024.

III. RESULTS

Based on these targets, many practical questions arise: who will digitize data on organizations, who will be responsible, at what expense. If there are already significant developments in the direction of digitizing data on agricultural land (for example, a draft public cadastral map on the basis of which data can be integrated and transmitted, and integration databases from the State Traffic Inspectorate can be used according to technology data), then digital data on farm animals will have to be done almost from scratch. At the same time, it should be taken into account that all data on animals should be comparable between agricultural organizations, and more precisely, all animals should undergo a single certification. In developed farms, of course, such work is carried out, but in many organizations, including peasant farms, individual agricultural entrepreneurs, personal subsidiary farms, it is at a low level or completely absent. One of the most striking examples of the digitalization of agricultural processes is the application of the technology "Precision farming and precision animal husbandry". Precision farming is understood as an agricultural management system based on information and technologies for identification, analysis and management, taking into account differentiated spatial and temporal soil variations in a particular field, to optimize costs, increase the sustainability of agrocenosis and environmental stability of production.

Elements of precision farming:

1. Digitizing fields;

2. Local sampling of soil in the coordinate system;

3. Parallel driving;

4. Satellite monitoring of vehicles;

5. Differential spraying of weeds;

6. Differentiated fertilizer application;

7. Differentiated seeding;

8. Differential irrigation;

9. Differentiated tillage according to soil maps;

10. Monitoring the condition of crops using remote sensing (aerial or satellite photography);

11. Compilation of digital yield maps.

Precision farming technologies include: parallel driving, differentiated sowing, differentiated fertilization, differentiated spraying according to the weed map, differentiated irrigation, differentiated tillage according to soil maps, harvesting logistics, etc.

The goal of all technologies is to increase the efficiency of the production process by reducing fuel costs, saving time, increasing productivity, saving the main resource used (herbicides, water, etc.).

Despite the existing positive experience of introducing precision farming technologies, domestic farmers are in no hurry to introduce the latest technologies into the economy.

A survey conducted by the Kleffmann Group (1,756 respondents) showed that 57% of the surveyed farmers have no experience in using integrated precision farming solutions. The main limiting factor hindering the implementation of such solutions, respondents indicated a lack of funds for innovation. The use of precision animal husbandry elements is becoming increasingly popular. The main component of precision animal husbandry is the creation of the possibility of efficient execution of production processes using modern technology, software and hardware, and information and communication technologies. The following main groups of business processes are distinguished: the study of the quality of livestock products, the architecture of business processes of production, identification and satisfaction of personal needs of animals depending on their productivity, assessment of the health of the herd, automation of the milking process, microclimate regulation and control of harmful gases.

Elements of precision animal husbandry are:

1. Monitoring the quality of livestock products;

2. Electronic database of the production process

3. Identification and monitoring of individual animals using modern IT technologies (feeding ration, milk yield, weight gain, body temperature, activity), satisfaction of their individual needs;

4. Flock health monitoring;

5. Robotization of milking processes;

6. Automatic climate control and control of harmful gases in livestock buildings.

TABLE I. STYLES EQUIPMENT OF FARMS IN THE NIZHNY NOVGOROD REGION WITH ELEMENTS OF PRECISE AGRICULTURE, 2021

№	Elements and technical means used	Quantity, units	Cultivated area, hectares	Load per 1 unit, hectares	Percentage of farms using the element, %
1. Digitization of fields					
1.	John Deere Autotrac	1	1930	1930	0.3
2.	Trimble CFX 250	34	25903	761,8	2.5
3.	Garmin Etrex 10	1	3200	3200	0.3
4.	Teltonika FM3200 /	14	6812	486,6	1.1
5.	ARNAVI	2	6812	3406	0.5
6.	G7Farmnavigator /	1	3155	3155	0.3
7.	Trimble CFX 255	1	4200	4200	0.3
3. Parallel driving					
8.	GPS	115	25982	225,9	28.5
9.	TeeJet Matrix 430	1	1970	1970	0.3
10.	TeeJet Cenyer Lin 220	2	1840	920	0.5
11.	TeeJet Matrix 570 Pro	2	6837	3418,5	0.5
12.	JDlnk	1	5000	5000	0.3
13.	Trimble CFX 750	43	66008	1535	6.1
4. Satellite monitoring of vehicles					
14.	Glonass system	736	111342	151,3	8.7
15.	SCOUT	21	8200	390,5	0.6
16.	Autograph platform	40	13010	325	1.5
5. Differentiated spraying of weeds					
17.	John Deere 730	1	1970	1970	0.3

18.	Lemken primus A-35	1	2700	2700	0.3
19.	Sprayer-spreader Mist	1	5222	5222	0.3
20.	Sprayer-spreader Trackol	1	3429	3429	0.3
6. Differentiated application of fertilizers					
21.	Kuhn MDS 735 Spreader	12	1970	164,2	0.5
22.	Amazone	7	26850	3835,7	1.8
23.	Sprayer-spreader Trackol	1	3429	3429	0.3
24.	Sprayer-spreader Mist	1	5222	5222	0.3
25.	Amatron-3 Terminal	6	4500	750	1.0
7. Differentiated seeding					
26.	Maxima Precision Corn Seeder	1	1500	1500	0.3
27.	Amazone EDX 9000 Corn Seeder -TS	8	12423	1552,8	1.8
8. Differentiated irrigation					
28.	Valley	2	1337	668,5	0.7
9. Differentiated tillage according to soil maps					
29.	Kverneland Plow	4	8651	2162,7	1.2
10. Monitoring of the condition of crops using remote sensing					
30.	DJI Phantom 4Pro Drone	5	11467	2293,4	2.1
31.	Cropio system	1	4544	4544	0.3
32.	Exact Farming	1	1404	1404	0.3
11. Compilation of digital yield maps					
33.	Combine harvester	3	5082	16984	1.0

Digitization of fields was carried out in 22 farms or in 23.4% using elements of precision farming. This element creates electronic contours of fields in agronomic databases for their more efficient use, which allows fixing the types and timing of field work, a differentiated approach when using cultivation technologies, fertilization, etc. In the region, this element is used negligibly little in farms. The load on 1 unit of equipment is on average 963 hectares, and only about 6% of the total area of agricultural land is processed.

Differentiation of administrative-territorial entities and farms of the Nizhny Novgorod region using precision farming is high. To systematize the state of this process, according to the reporting data of the Ministry of Agriculture and Food Resources of the region, the indicator “The share of areas cultivated with the use of precision farming in the total area” was calculated; its values range from 0 to 1, where 1 is the maximum value involving the use of precision farming elements on 100% of the area. Also, 5 clusters with the following values were identified by expert method by groups 0–0.20; 0.21–0,40; 0.41–0.60; 0.61–0.80; 0.81–1.00 (Table 1). The 1st cluster includes 25 administrative-territorial entities with a low level of using precision farming, and in all of them the value of the calculated indicator equals 0. This cluster accounts for 43% of all sown areas of the region. The 2nd cluster is represented by two entities: the Uren Municipal District and the city district of Vyksa with the values of the indicator respectively 0.24 and 0.36. The share of sown areas of this cluster is small – less than 4%. The 3rd cluster includes 9 administrative-territorial formations (ATF) and they account for 25.7% of the acreage of agricultural enterprises. In the 4th cluster there are also 9 ATF with 18.3% of the acreage. The 5th cluster consists of 4 administrative-territorial entities (7.7% of their total number). Vacha and Spasskoe municipal districts have a high index of precision farming application with a value of 1.0, and in Vad and Lukoyanov municipal districts, the values are 0.85 and 0.81, respectively. It is worth noting that the total cultivated area of the 5th cluster with a high level of precision farming is 8.9% of the total sown area of the region. Indicators of the efficiency of grain production by clusters are shown in Table 2.

This table allows stating that traditional technologies currently provide an average level of yield and efficiency of grain production – this is the 1st cluster and practically a “control option”. The initial stages of the precision farming use, when only individual elements are used, leads to an increase in cost and does not give the desired economic effect. It is demonstrated by the 5th cluster, in which the grain yield is 40.4% higher than the 1st cluster, the cost price is 13.5% lower, and the profitability is almost 14% higher than the control option.

Let’s analyze the situation with the use of precision animal husbandry elements in the region in 2020. Precision farming is used in 22 municipalities, which are represented by 4 urban districts and 18 municipal districts. The total number of farms using precision farming is 60 units out of 207 producing livestock products (less than 30%), of which only 2 are farms.

TABLE II. INDICATORS OF THE EFFICIENCY OF GRAIN PRODUCTION IN CLUSTERS FOR THE USE OF ELEMENTS OF PRECISION FARMING

Indicators	**Clusters on the use of precision farming elements (numbers and bounda boundaries of groups by the share of cultivated areas)**				
	1 **0-0.20**	**2** **0.21-0.40**	**3** **0.41-0.60**	**4** **0.61-1.80**	**5** **0.81-1.00**
Number of municipalities, units	28	2	9	9	4
Acreage - total, ha	358679	30645	214221	156867	72726
Including grain crops	194742	11322	130776	91685	46446
Grain yield, hundred weight per 1 ha	22.5	10.3	25.7	29.4	31.6
Cost of grain sold, per 1 kilogram of rubles	7.4	10.4	16.7	7.5	6.4
Grain profitability, %	22.4	-11	31.7	32.5	36.3

IV. CONCLUSION

Assessing the processes of introducing precision farming and animal husbandry elements into the practice of agricultural production, it should be noted that, in general, positive dynamics is observed in the Nizhny Novgorod region. At the same time, the significant spatial differentiation is observed: a small number of administrative-territorial entities (less than 10%) and agricultural organizations (almost 20%) actively use precision farming, but almost 60% of both have not yet started this process. To clarify the causes of this phenomenon, a survey was conducted, the experts of which were 20 specialists of agricultural management at the regional and district levels (24%), 17 scientists of agricultural educational institutions (20%) and 47 managers and specialists of agricultural organizations (56%).

Respondents attribute the main obstacles to the development of precision agriculture in the region to insufficient financial resources in organizations for the introduction of new technologies due to the high cost of equipment and software (33%), the lack or insufficiency of qualified specialists (28%), poor coordination and support for the introduction of precision farming at all levels: federal, the subject of the Russian Federation and municipal (36%).

It is necessary to clarify that in the Nizhny Novgorod region there are regulatory legal acts, in accordance with which support for the introduction of elements of precision agriculture can be carried out. For example, according to the decree of the Government of the Nizhny Novgorod Region dated November 2, 2012 No. 781 “On approval of the provisions on financial support of the agro-industrial complex of the Nizhny Novgorod region”, part of the interest rate is reimbursed when purchasing equipment from credit institutions. Within the measures of state support, agricultural producers of the region can purchase modern agricultural machinery, including those equipped with precision equipment. According to the decree of the Government of the Nizhny Novgorod Region No. 729, November 10, 2015 “On the procedure for granting subsidies for reimbursement of part of the costs of purchasing equipment and machinery for the production of flax products”, compensation from 10 to 75% of the cost of the purchased equipment is provided. By the Decree of the Government of the Nizhny Novgorod region, December 15, 2015 No. 834 “On approval of the regulation on the procedure for granting subsidies for reimbursement of part of the costs for the purchase of equipment” provides for reimbursement from 20 to 50% of the costs. Admittedly, these measures do not solve all the problems of precision agriculture.

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