

# Using high-precision farming systems in the agricultural sector—the path to digital agriculture

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**Abstract**—The article analyzes the current state of land and agricultural resources in the Russian Federation and the Permskiy kray. It is noted that the use of geographic information systems is possible in the diagnosis of plants by express methods of remote sensing of the earth. The necessity of introducing high-precision farming systems at agricultural enterprises of the Permskiy kray is revealed. The use of GIS systems improves the technology of precision farming, which is being developed in the agricultural sector. A survey conducted in the framework of the survey showed that out of 42 agricultural producers, 13 enterprises use elements of the precision farming system (31% of the total). Basically, these companies use transport monitoring systems and course indicators for agricultural and automotive equipment. The experience of the Permskiy kray is analyzed in connection with the introduction of automated complexes of satellite monitoring systems for agricultural equipment and vehicles, as well as navigation equipment and video surveillance systems into the activities of agricultural enterprises.

**Keywords**—*agricultural plants, digital farming, precision farming, monitoring of transport.*

## I. INTRODUCTION

The population of the Earth in recent decades has been growing at a tremendous pace. Currently, 7.5 billion people lived on Earth in 2018. According to the forecast of scientists, by 2050 there will be a lot of people on the planet - 9.6 billion people (this is 2.1 billion more than today). Agricultural enterprises will need to grow twice as many agricultural products, which will inevitably entail an increase in the demand for agricultural land and an increase in the yield of the main food crops.

On Earth there are still significant agricultural land resources; their total area in the world totals 4 billion. 650 million hectares, including arable land - 3.2 billion hectares, compared to the currently used ones - 1 billion. 480 million hectares, including more than 220 million hectares, or 15% of irrigated land. Thus, 0.3 hectares of arable land per one person living on the planet means that the area of arable land can be doubled. Nevertheless, the best lands have been plowed long ago, and the reserve consists of territories that require significant investments to improve their fertile

properties, land reclamation, irrigation, and other agricultural practices. Currently, ferralitic soils, chernozems, deserted soils, podzolic and sod-podzolic and alluvial soils are most used.

The soil cover of Russia accounts for approximately 1.4 billion hectares out of 1.7 billion hectares of the total area of the country, with only 13.4% or 122 million hectares being used in agriculture. According to the latest updated agrochemical surveys, more than 70 million hectares of arable land in Russia are characterized by high acidity, 56 million hectares have low humus content, more than 25 million hectares - low phosphorus content and 11.5 million hectares - low potassium. Disruption of the balance between biological and man-made factors in agro-ecosystems, with underestimation of the law of return of substances, leads to changes in the physical, agro-physical and physico-chemical properties of the soil and to the irreplaceable use of resources and the degradation of soil fertility.

The productivity of field crops is determined by a combination of influencing factors, including soil and climatic, and has a regional focus. Even today, the soil remains the main means of agricultural production and the basis for the stability of agroecological systems and society. Plants are obtained from the soil to 95% of all nutrients.

One of the important factors for obtaining a high yield of agricultural crops on sod-podzolic soils, characterized by low natural fertility in conditions of short growing season and lack of heat for normal growth and development of plants, is the availability of nutrients. Agricultural plants in considerable quantities need nitrogen, phosphorus, potassium, calcium, magnesium, sulfur and iron, etc. And the human body “feeds” on these elements for life, but it is a scientifically based use of agrochemical agents.

According to the agrochemical service center for 2018, in agriculture in the Permskiy kray, 78.5% of arable land needs liming, and 84.0% of arable land falls into the category of low and very low humus security. Up to one ton of organic and 11.1 kg / ha of mineral fertilizers is applied annually to one hectare of arable land, while the removal of nitrogen, phosphorus and potassium with the crop prevails over their input. The sharp decrease in the use of organic and mineral

fertilizers in the last 25 years has led to the formation of a negative balance of nutrients in the soil. The emerging negative balance of nutrients in 1995 was 26.9 kg / ha, of which 16.1 kg / ha for nitrogen, and on average for 2000-2003 it was 43.2 kg / ha, of which 18, 2 kg of nitrogen. According to scientists' forecasts, in 2018 they amounted to 116.9 and 43.3 kg / ha, respectively, which led to a decrease in crop yields.

Thus, the yield of grain crops in the Permskiy kray today is 1.3-1.5 t / ha. According to many years of research conducted at the Perm Research Institute of Agriculture, a branch of the PFC Center of the Ural Branch of the Russian Academy of Sciences and the Perm State Agro-Technological University, it has been established that with a balanced plant nutrition, the yield of grain crops can reach 2.5-4 t / ha

The disparity in prices for mineral fertilizers and agricultural products established in the last decades in the agrarian sector does not allow the use of mineral fertilizers in full. Therefore, at the present stage of economic development, the regulation of plant nutrition, especially during critical periods, when the lack of any nutrient in the nutrient medium adversely affects plant growth and development, is of particular importance in an efficient production process. For crops, the first 10–15 days after emergence remain a critical period, with an excess or lack of nutrients manifested in plant diseases, a decrease in yield and quality of crops. Therefore, the analysis of plants during this period allows you to control plant nutrition, clarify the applied scheme and fertilizer system, and identify the need for dressings, acquire energy-saving technologies, including the effective use of organic and mineral fertilizers, involving prediction of the need for nutrients and their balance. In this regard, the relevance of identifying the stress state of important agricultural grain and fodder crops in specific soil and climatic conditions [1, 2, 3, 4, 5] at the early stages of plant growth and development is increasing.

## II. METHODS

Currently, there are several ways to express plant diagnostics based on fluorescence, reflected light and thermography. The most effective of all can be methods of remote sensing of the earth, which are based on the difference between the spectra of reflected light or the fluorescence spectra of plants in normal and stressful states.

That is why the questions of express - assessment of the "stress" of plants remain relevant at the present time and require close attention from the scientific community.

In modern conditions it would be impossible without the existence of global information systems (GIS), which are already widely distributed in the modern world with the use of digital technologies and one of these types of information is. GIS in the conventional sense is a network information retrieval service in a database across the entire Internet. In other words, it is a combination of a large number of electronic cards [9, 10].

Agriculture is actively developing and improving, keeping pace with the times. One of the directions of development of GIS is the introduction and improvement of technologies for the use of precision farming. Thus, it is important to study this direction, since it is the most promising. The use of GIS in agriculture allows you to more

effectively manage resources, technology and time. In agriculture, it is used to collect data from the fields, obtain information about remote sensing, obtain information about the properties and characteristics of the soil, compile a map of crops by year, keep a history of field processing, and this is not a complete list of the use of GIS in agriculture. Due to the fact that the GIS system uses data from satellites, the development of precision farming has gained great momentum.

Among the methods used in this study, a sociological survey of farm representatives was used to identify the number of pieces of equipment needed to use precision farming technology, which made it possible to obtain accurate data on the current state in the industry.

## III. RESULTS AND DISCUSSION

The state and problems of the digital economy in the agro-industrial sector are low penetration of digital technologies in rural areas and agricultural production (less than 10% of digitalization), poor coverage with data transmission networks; the lack and incomplete information about existing and developed digital technologies; inadequate legal framework for legal frameworks ensuring coordination and interagency cooperation in the collection of information and the introduction of digital technologies for agriculture, providing the population with food and increasing agro-export;

- the lack of programs that promote the introduction (subsidizing production costs) on the digitization of the agro-industrial complex for small and medium-sized agricultural producers, including private households;

- lack of legal grounds for interaction and collection of information on the introduction of agricultural activities by household farms (PFs) and the associated possibility of supporting their activities;

- low margins (developing segment) of the industry - unattractiveness for a technological and infrastructure investor.

In the formation of a scientifically based forecast of the development of digital agriculture in the Permskiy kray, information is needed on the farms using new technologies. In this regard, the Department of General Agriculture and Plant Protection of Perm State Agro-Technological University, together with the Precision Technology Laboratory of the PFC Center of Ural Branch of the Russian Academy of Sciences and the Ministry of Agriculture of Permskiy kray, organized the collection of statistical information on the use of elements of precise agriculture in the region through regional administrations of agriculture.

When collecting statistical information, the issues presented below were considered (table I). The reliability of the results obtained is primarily related to the accuracy of the information provided by the regional agricultural administration authorities.

**TABLE I. THE USE OF ELEMENTS OF PRECISION AGRICULTURE IN THE ENTERPRISES OF THE PERM REGION (COMPILED BY THE AUTHORS)**

<b>Agricultural enterprise</b>	<b>Municipal district</b>	<b>Used elements of precision farming system</b>
Agroenterprise LLC "Zarya Putino"	Vereshchaginsky	<ol style="list-style-type: none"> <li>1. Determination of field boundaries using satellite navigation systems (satellite navigation system Wialon Hosting).</li> <li>2. Local soil sampling in the coordinate system</li> <li>3. Parallel driving</li> <li>4. Satellite monitoring of vehicles (satellite navigation system Wialon Hosting)</li> <li>5. Differentiated spraying of weeds</li> <li>6. Differential fertilization</li> <li>7. Differentiated seeding</li> <li>8. Differential irrigation</li> <li>9. Differentiated tillage on soil maps</li> <li>10. Monitoring of the state of crops using remote sensing (aerial or satellite photography)</li> <li>11. Compilation of digital yield maps</li> <li>12. Mapping the electrical conductivity of soil</li> </ol>
Agrofirma Trud LLC	Kungursky	<ol style="list-style-type: none"> <li>1. Sowing maize with TEMPO-8 precision seeding planter</li> <li>2. Sowing crops (tractors equipped with satellite navigation for parallel driving)</li> <li>3. Processing crops with pesticides (self-propelled sprayer equipped with satellite navigation for parallel driving)</li> <li>4. Tractors and cars installed satellite monitoring system GLONASS</li> </ol>
SEC "Kolkhoz Chapaev"	Kungursky	<ol style="list-style-type: none"> <li>1. Processing crop crops with herbicides (self-propelled sprayer "Trimble EZ-Guide 250" is equipped with satellite navigation for parallel driving)</li> </ol>
SEC (collective farm) "Pravda"	Octyabersky	<ol style="list-style-type: none"> <li>1. Navigation terminals Arnavi-4 (installed on vehicles) - telematic electronic information about the location of transport, distance traveled, engine running time, amount of fuel filled and drained, amount of fuel consumed</li> </ol>
"Talitskoe" LLC	Ochersky	<ol style="list-style-type: none"> <li>1. E-book history fields</li> <li>2. Wialon Hosting tracking system - 40 pieces of equipment</li> </ol>
Ocherskoye LLC	Ochersky	<ol style="list-style-type: none"> <li>1. Navigation system Standard 59</li> </ol>
LLC "Voskhod-Agro"	Ochersky	<ol style="list-style-type: none"> <li>1. Satellite tracking system "Glonass"</li> </ol>
"UralAgro" LLC	Chastinsky	<ol style="list-style-type: none"> <li>1. Satellite tracking system "GLONASS"</li> </ol>
"Niva" LLC	Chastinsky	<ol style="list-style-type: none"> <li>1. Satellite tracking system "GLONASS"</li> </ol>
LLC "State Farm Druzhniy"	Chernushinsky	<ol style="list-style-type: none"> <li>1. Satellite monitoring of vehicles, the Omniki program</li> </ol>
Collective farm (SEC) "Na strazhe mira"	Chernushinsky	<ol style="list-style-type: none"> <li>1. Satellite monitoring of vehicles, the Omniki program</li> </ol>
LLC "Urals"	Permsky	<ol style="list-style-type: none"> <li>1. System of course indicators</li> </ol>
FSUE "Uchkhoz" Lipovaya Gora	Permsky	<ol style="list-style-type: none"> <li>1. Hardware-software complex "GPS-AGRO".</li> <li>2. Satellite tracking system "GLONASS"</li> </ol>

As shown by the survey results, as of 01.02.2019, out of 42 agricultural producers, 13 (31%) enterprises use elements of the precision farming system in agriculture of the Permskiy kray. For the most part, vehicle monitoring systems and course indicators are used for agricultural and automotive equipment.

For example, the introduction of innovative technologies of precision farming is carried out on the sown areas of the federal state unitary enterprise "Uchkhoz Lipovaya Gora" of the federal state budgetary educational institution of higher education Perm State Agro-Technological University named after Academician D.N. Pryanishnikov.

In the Federal State Unitary Enterprise "Uchkhoz" Lipovaya Gora" an agreement was concluded with LLC "Megastroj" for the supply, installation, commissioning of the hardware-software complex "GPS-AGRO". This report on the implementation of innovations was submitted by the farm to the Ministry of Agriculture of the *Permskiy kray* in 2010 as confirmation of reimbursement of part of the costs for the production and sale of milk, according to the Resolution of the Government of the Permskiy kray dated April 1, 2009 No. 182-p.

For the development of the automated complex of the satellite monitoring system of agricultural machinery and motor transport, the company signed an agreement with LLC Standard for the supply, installation and commissioning of navigation equipment and video surveillance systems. This equipment will allow you to track in real time:

- the current location of the vehicle;
- speed and direction of movement;
- readings of the flow sensor and fuel level;
- personnel work during repairs;
- view the history of movements.

The system is based on the technology of determining the location of the vehicle using the signals of the navigation satellites of the global positioning system GLONASS. On-board transport controllers were installed on the company's transport, automatically determining the vehicle's location, speed, direction of travel, and the status of the connected sensors: hours, fuel level in the tank, and other options. The entire amount of navigation and technical information was accumulated in the device, then the GSM / GPRS data transmission channels transmitted information to the telematics server, stored in the database and sent to the control center. The system of satellite monitoring of agricultural machinery and vehicles has a very wide range of possibilities, which allows flexible management of crop production processes at the enterprise.

Thanks to the automated system of satellite monitoring of agricultural machinery and vehicles, the following were obtained:

- monitoring of agricultural machinery in real time;
- reports on the work of the fleet of vehicles at any time and at any point of the enterprise;
- implemented a rapid response to emergency situations;
- accounting and control of fuel consumption;

- effective management of the fleet of agricultural machinery and vehicles;
- control of places of discharge of the collected products;
- control of the trajectory of movement of equipment across the field (the quality of processing the edges during harvesting, planting, processing with pesticides);
- control of the location of transport and technology, their direction and speed of movement.

The development of high-precision systems will require highly qualified specialists capable of working with these systems and equipment, which will entail a revision of the curricula of universities and colleges, but in modern conditions, when the quality of students coming from secondary schools requires much to be desired, higher and secondary special education institutions should be started in conjunction with municipalities training is already at school. This is also understood at the department of general agriculture and plant protection at the Perm State Agro-Technological University.

In 2018, the Department of General Agriculture and Plant Protection of the Perm State Agro-Technological University named after Academician D.N. Pryanishnikov created their own agroclasses at the secondary schools of Kungursky and Permsky municipal districts, where students acquire the skills of theory and practice of piloting unmanned aerial vehicles (UAVs), take part in digitizing farm fields in the *Permskiy kray*, plan crop rotations, exchange information with management specialists on making management decisions using modern technologies (applications, etc.) and the practical use of geographic information systems in farms - products firs. In the process of mastering digital technologies, students of Agroklass form knowledge and skills in the use of modern world, Russian and university information and communication technologies, and resources in their research and education activities.

Thus, the use of high-precision systems of precision farming and the training of future specialists from the school bench is the first step towards digital agriculture, which is noted in the Concept of Digital Agriculture [11]. Without the use of this technology, it makes no sense to talk about the prospects of the agricultural sector in the Russian Federation.

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