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The economic essence of the category of precision agriculture

Gennady Beznosov
Department of Economics and Organization of Enterprises
Ural State Agrarian University
Ekaterinburg, Russia
beznosov-ga@mail.ru

Alexander Semin
Institute of Economics
Ural State Economic University
Ekaterinburg, Russia
aleks_ural_55@mail.ru

Egor Skvortsov
Mechanical Engineering Institute
Ural Federal University
Ekaterinburg, Russian
easkvortcov@mail.ru

Svetlana Volkova
Department of Foreign Languages
Ural State Agrarian University
Ekaterinburg, Russian
svetlanka.volkova@inbox.ru

***Abstract*—Precision agriculture technologies started in late 1980s in the United States and Australia with the development of a global positioning system (GPS), geographical information systems (GIS), remote sensing and simulation modeling. Their use increase crop yields, the efficiency of fertilizer application and plant protection products, and reduce the agrochemical load on the environment and improve significantly the quality of crop production. According to the Ministry of Agriculture of the RF by the end of 2018, the share of coverage of agricultural lands with these technologies had been 10%. According to the experts of the Kuban State Agrarian University, the elements of precision farming are used in 52 regions, the Krasnodar territory is a leader in the number of farms (189 farms). One can find the following synonyms of the category "precision agriculture" in the scientific literature: precision farming, coordinate farming, information technology, technology using GPS, etc. The basic stages in the system of precision agriculture can be grouped in a primary exploratory analysis, an analysis of monitoring results and development of field treatment strategies for a specific agricultural operation or in general, introduction of relevant agro-technological operations. On the territory of Russia, it is possible to use the American NAVSTAR and (or) the Russian GLONASS in precision agricultural technologies. The use of digital technologies will improve the efficiency of agricultural production significantly. A further study of the conceptual framework of this field of research is relevant.**

Keywords—precision agriculture, precision farming, coordinate farming.

I. Introduction

At present, the agricultural organizations in Russia are making transition to digital technologies. According to the experts of the research company "Json and Partners Consulting", the total economic effect of the transition of Russian agriculture to digital technologies could reach more than 4.8 trillion rubles annually, or 5.6% of GDP growth (by indicators of 2016) [1]. The introduction of digital economy technologies, according to the Analytical Center of the Ministry of Agriculture of Russia, provides positive economic effects and reduces costs by at least 23% with introduction of an integrated approach [2].

One of the solutions based on technological breakthroughs in the digital industry is precision agriculture technologies.

The use of precision agriculture systems became possible due to advances in technologies such as global positioning systems (GPS), geographic information systems (GIS), remote sensing and simulation modeling, and robotics. These technological breakthroughs have allowed making opportunities for assessing and managing spatial and temporal variability with use of appropriate methods. Such an approach is usually referred to as precision agriculture or crop and soil management [3].

II. Main part

For the first time, the elements of a precision agriculture system that require GPS to determine the position to which any measured field parameter should be associated [4]. Precision agriculture technologies started in late 1980s in the United States and Australia [5,6,7]. At present, the efficiency of introducing precision agriculture, depending on the gross output, can be observed mainly in medium and large-scale farms. For this reason, precision agriculture is widespread only on large territories of the United States, Germany, Denmark, the Netherlands, and the United Kingdom. Such technologies are beginning to be introduced in Russia.

Against the background of a significant increase in yield, the payoff of fertilizers and plant protection products increased in 1.5–1.7 times, the agrochemical influence on the environment decreased by 35–60%, and the quality of crop production significantly increased [8].

The average level of application of precision agriculture technologies in the USA is at the level of 30-50%, while at large-scale farms the level of technology use is 2 times higher than at small farms. Its most common elements are: a computer with high-speed Internet access, an analysis of soil samples (98%); yield maps, yield monitors, GPS navigation systems (about 80%); differential fertilization technologies (60%); satellite images and a vegetative index analysis - (no more than 30%) of farmers.

There is a serious difference in the assessments of the current application level of precision agriculture technologies in Russia. So, according to the Ministry of Agriculture of Russia, the elements of precision agriculture are used at 1591 farms of the country on an area of 7521 thousand hectares [9] (Fig.1).

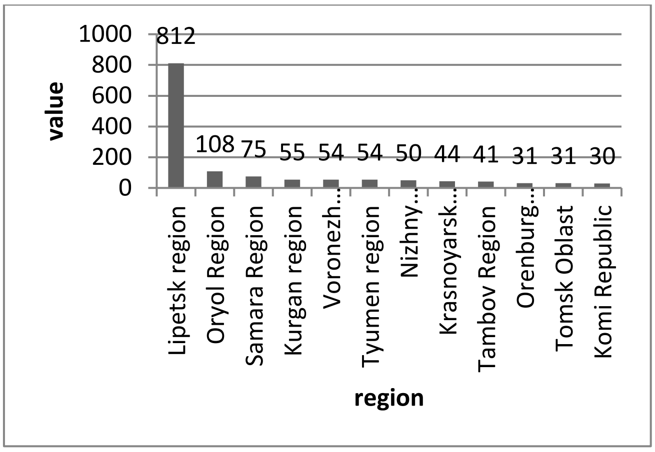

Fig. 1. A rating of regions which use the elements of precision agriculture (by the number of farms) according to the Ministry of Agriculture

According to the Ministry of Agriculture, the Lipetsk, Oryol, Samara, Kurgan, Voronezh and Tyumen regions have a leading position in the number of farm. The share of coverage of agricultural lands with various communication technologies in 2018 is at the level of 10%.

At the same time, there are assessments of scientists of the Kuban State Agrarian University (Fig.2).

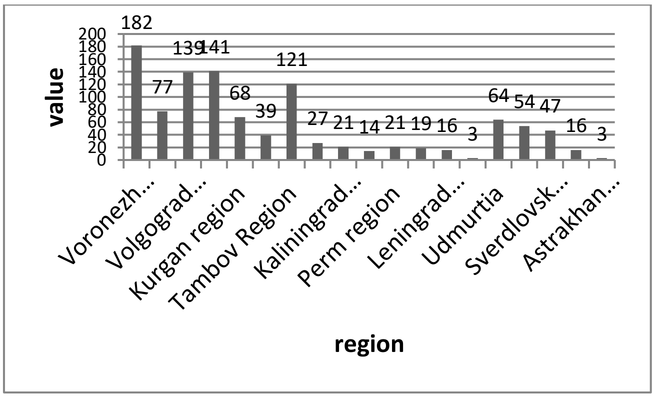

Fig. 2. A rating of regions which use the elements of precision agriculture (by the number of farms) according to the Kuban State Agrarian University

The analysis of the number of farms which use the elements of precision agriculture on the basis of 52 regions (carried out by the scientists of the Kuban State Agrarian University) shows that the Krasnodar Krai (189 farms), Voronezh region (182 farms), Novosibirsk region (141 farms) are leaders. The Voronezh Region (1129164 ha), the Krasnodar Territory (962981 ha), and the Omsk Region (921293 ha) have the leading positions by the total area on which the elements of precision agriculture are used.

One can find the following synonyms of the category "precision agriculture" in the literature: precision farming, coordinate farming, information technology, technology using GPS, etc. [10]. Their definitions are given in Table 1.

TABLE I. DIFFERENT APPROACHES TO THE DEFINITION OF THE CONCEPT OF PRECISION FARMING

Definition	Meaning	Source/author
Coordinate farming	GOST R 56084-2014 [11]	It is a system for managing the production process of crops, based on the integrated use of modern information, navigation and telecommunication technologies, software tools and systems that ensure the optimization of agro-technological solutions for specific soil-climatic and economic conditions
Precision agriculture	Robert, P. C. [12]	Characteristic of soil conditions at the field level for soil specific management
Precision agriculture	Pallottino, F; Biocca, M; Nardi, P; Figorilli, S; Menesatti, P; Costa, C. [13]	Precision agriculture is a management concept based on observing, measuring and responding to intra-field variability in crops
Precision agriculture	Casa and Castrignanò [14]; Basso et al. [15]; Hedley [16]	The use of data on crop variability in relation to soil maps, regarding spatial and temporal changes in nutrients, especially in field crops (mainly cereals)
Precision agriculture	Berezin L.V., Karpachevsky L.O. [17]	Management of crop productivity with consideration of the variability of plant habitats in the field.
Precision agriculture	Shayahmetov M.R., Dubrovin I.A. [18]	It assumes the need to change the elements of an agro-technology depending on the status of a land object and the objective change in space of factors that determine the effectiveness of a particular variant of its amelioration.
Precision agriculture	Sidorova V.A., Zhukovsky E.E., Lekomtsev P.V., Yakushev V.V. [19]	Local differentiation of agrotechnical impacts with consideration the spatial variability of soil and other factors of yield formation within a particular agricultural field.
Information technology	Afanasyev R.A. [20]; Yakushev V.P. [21]; Yakushev V.P., Yakushev V.V 22]	It is based on capabilities of modern geo-information systems, which allow on-line determining the coordinates of operating agricultural machines and, thus, regulating technological regimes in accordance with specific conditions at individual parts and certain areas of the field.
Precision agriculture	Zhukova O. [23]	It is a technology when all agrotechnical measures should be carried out with consideration of characteristics of individual areas of the field that differ in agrochemical and agrophysical indicators or a surface and require an individual approach, i.e. to plant differentially, to apply fertilizers and plant protection products with a minimum error.
Precision agriculture	Runov B.A., Pilnikova N.V. [24]	It assumes making all operations at cultivation of agricultural crops with consideration of spatial and temporal variability of soil fertility parameters, the status of plants, and climatic conditions.
Precision agriculture	Grigoryev M.N., Uvarov S.A. [25]; Smelik V.A., Tsyganova N.A., Teplinsky I.Z. [26]	A set of technologies, technical tools and decision-making systems aimed at managing the parameters of fertility that affect plant growth.

There are 3 basic stages in the system of precision agriculture: 1) a primary exploratory analysis, which is data collecting about a farm, field, crop, region, 2) an analysis of monitoring results and further adoption of appropriate management decisions and 3) development of field treatment strategies for a specific agricultural operation or in general, for the next year and implementation of the decisions taken – introduction of relevant agro-technological operations [27,28] (Table 2).

TABLE II. BASIC STAGES OF THE PRECISION AGRICULTURAL SYSTEM

Stages	Operations
Primary exploration analysis	An assessment of the variability of soil covering
	Determination of the actual field areas and their boundaries
	An assessment of the status of cultivated plants, the presence of weeds at certain field areas
	An assessment of field heterogeneity in soil fertility (NPK, pH, humus, trace elements, etc.)
	An assessment of the soil nutrition elements of each particular field area
	Soil sample taking
	Determination of soil density and moisture
	Identification of plant need for nitrogen with an N-tester (by the content of chlorophyll in leaves)
	An assessment of the spatial variability of the vegetative mass of plants
	Determination of density of plant stand
	Determination of NDVI (Normalized Difference Vegetation Index) - a normalized relative vegetation index
	Remote studies of soil heterogeneity
	A yield assessment at each particular land parcel
Analysis of monitoring results	Making yield cartograms
	Making cartograms of grain moisture
	Making cartograms of grain dockage
	Making agrochemical cartograms
	Making fertility cartograms
	Making a task for differentiated application of fertilizers
	Determination of a unit position on the field
	Making databases required for mapping
	Mapping the spread of weeds and pests
	Determination of the level of grain dockage
Development of field treatment strategies, introduction of relevant agro-technological operations	Crop planting of with a navigation machinery (autopilot)
	Differentiated application of plant protection products
	Differentiated planting
	Seed calibration
	Differentiated fertilizing
	Surface leveling

The Russian territory is covered with the US NAVSTAR (Navigational Satellite Time and Ranging) and the Russian GLONASS (global navigation satellite system) for commercial use of these two satellite radio navigation systems. They allow an unlimited number of objects that have the appropriate equipment, in a query-free mode, almost instantly and with high accuracy to determine their location and speed of movement anywhere on the planet. This gives a real opportunity for a complete provision of agricultural mobile machinery with navigation information and for development of agro-technologies based on accurate knowledge of the environment.

The testing of precision agriculture technologies in practice is of interest. The data of economic and mathematical modeling conducted on the basis of economic activities of a typical agricultural organization show the following results. The production task was to harvest 896.0 centners of products, using a differentiated method of fertilizer application (ammonium nitrate 34% of the active substance). Considerng the planned yield of spring wheat of 14.0 c / ha, the production cost will be 263,605.6 rubles. And the resource intensity of commercial products will be 0.792 rubles with the differentiated application of mineral fertilizers, which is lower by 5.5% compared with the conventional method of application (Table 3).

TABLE III. COMPARISON OF EFFECTIVENESS OF CONVENTIONAL AND DIFFERENTIATED METHODS OF FERTILIZER APPLICATION ON THE EXAMPLE OF THE KURGAN REGION

Indicator	**Conventional method of fertilizer application**	**Differentiated method of fertilizer application**	**Fluctuations**	
			(+;-)	*%*
Grain crops acreage, ha	64,0	64,0	–	–
Grain crops productivity, c/ha	14,0	14,0	–	–
Grain production, c	896,0	896,0	–	–
Grain sales, c	784,0	784,0	–	–
Marketability level, %	87,5	87,5	–	–
Expenses on grain production - total, rub.	279024,5	263605,6	-15419,0	94,5
Costs of sold products - total, rub.	333043,2	333043,2	–	–
Including 1 c, rub.	424,8	424,8	–	–
Resource intensity, rub.	0,838	0,792	-0,046	94,5
Profit (+), loss (-) after sales - total, rub.	88896,7	102388,3	13491,6	115,2
Economic efficiency, %	36,4	44,4	8,0	–

The economic efficiency will be 44.4%, which is higher by 8.0 percentage points than with the conventional method of fertilizer application. As we can see, the proposed economic and mathematical model of resource saving optimization actualizes the feasibility of applying a differentiated method of fertilizer application in a typical agricultural organization with grain specialization.

III. CONCLUSIONS

Conclusions. Advanced technical tools and achievements in the digital sphere allow calculating the yield, the NDVI level of plants, analyzing and considering the variability of the water supply, which is of great importance when cultivating crops. Modern large-scale agricultural production cannot be imagined without precision farming technologies, which are possible on the basis of new unique digital technologies.

The development of precision agriculture technologies is associated with the ever-increasing requirements for the ecological safety of farming. Also the need to reduce the costs of expensive fertilizers and plant protection products, as well as fuel and lubricants should be considered.

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