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## Management of expenses for fertilizers and chemical plant protection products in the accounting and control system of agrarian formations

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### Abstract

A wide variety of soil and climatic conditions requires extensive study of the characteristics of the use of fertilizers and chemical plant protection products, which sometimes negatively affects the environment. Therefore, there is a need not only to know the ways and amount of application of fertilizers and chemical protectors but also to have a clear idea of the processes occurring in the soil, plants, ecology of the production environment and the rural population. This knowledge will allow us to carefully approach the practical issues of chemicalizing the crop industry and prevent possible negative consequences. To study the integrated interdisciplinary object of management accounting related to the assessment of the reproduction of agricultural land fertility, the functions and complex interaction of IT management, and analysis of specific situations of the impact of costs on fertilizers and chemical plant protection products on the gross crop production in the Kuban economic entities were applied. The study found that modern science has formulated the main theoretical aspects of the economic and environmental efficiency of the use of mineral fertilizers and chemical plant protection products in agriculture. Noting the significant achievements of scientists and practitioners in this field of agricultural development, we believe that the use of digital technologies for assessing the quality of soil fertility, methods and methods of using chemical agents can qualitatively improve information on the costs of their use, and determine the most rational and environmentally friendly areas. The studied experience in the application of methods indicates a fairly high accuracy in assessing the quality of soil fertility. Moreover, the results make it possible to change the associated types of managerial work, such as the planning of the procurement of fertilizers and plant protection products, precisely determine their types, and coordinate the place and time of their use.

**Key words:** *accounting and control system, agrarian formation, cost of fertilizers, efficiency information technology, management*

### INTRODUCTION

The country's agriculture is one of the most important sectors of the economy of any country. At all times of the existence of mankind, agricultural products have always been in short supply. Each country has experienced some shortage of food. The hardest tests for people were the lean years and the resulting acute shortage of food or, simply put, hunger [MOLAJOU *et al.* 2021; POULADI *et al.* 2020].

Extensive agricultural technologies have long been exhausted due to limited resources and, above all, the lack of agricultural land. Intensive agricultural production methods associated with various techniques of saving resources also have their limits [CORBACHO *et al.* 2003]. However, as before, not one of the most advanced technologies for the production of agricultural products is complete without the use of mineral fertilizers and chemical plant protection products. The share of costs for the use of this type of

resources is constantly growing, and the role of management to control these expenses is also growing. In our opinion, at present, the main reserve for increasing the effectiveness of the use of chemicals is their rational use on the basis of automation and intellectualization of the agricultural sector.

Problems of the effectiveness of the use of fertilizers and chemical plant protection products are considered by many domestic and foreign authors. From our point of view, the most outstanding contributions to the solution of this problem were made by TIESSEN *et al.* [1994], REEVES [1997], WOLF and SNYDER [2003], CUNFER and KRAUSMANN [2009], BRANNON and WIKLUND [2016], ARUNRAT *et al.* [2017], MARKINA *et al.* [2018], ASIAN *et al.* [2019], MAROUF and REMINI [2019], GOVINDAN *et al.* [2020], and HOU *et al.* [2020].

The issues of digitalizing the processing of economic information in the accounting and control system of agricultural formations attract more and more attention of representatives of the academic and business community. Digitalization can be defined as the targeted efforts of economic entities to actively use digital technologies at all levels to optimize internal processes and modify the general model of conducting production and financial activities. The current discussion on the priority of using digital methods and tools indicates the need to integrate information technologies and accounting and control procedures to solve the tasks [VLADIMIROVNA *et al.* 2020]. And although few people cast doubt on the feasibility of such changes, the specific challenges and possible effects in this area require clarification [AKHMADEEV *et al.* 2019; VORONKOVA *et al.* 2020].

## MATERIALS AND METHODS

As the objects of study, 117 agrarian formations of the central natural and economic zone of the Krasnodar Territory (Kuban) were selected, which distinguishing feature is the same production line of activity, approximately the same size in terms of area and production of gross output, and the level of provision with fixed and working capital. All surveyed business entities carried out the boundary surveying of agricultural land, and the share of land owned by them is 85% or more, which is very important in developing scientifically based crop rotation.

The relevance and quality of the information received were ensured by the use of the unified information technologies (IT) for the formation, digitization and use of descriptors of the accounting and control system by the examined economic entities. The objective of the study is to posterior prove the advantages of digital methods and tools when processing information on accounting for the costs of fertilizers and plant protection products, as well as the possibility of applying the results of space sensing of the mineral composition of the fertile soil layer when substantiating and making management decisions on scientifically based mineral nutrition and increasing efficiency production of final agricultural products.

In the course of the undertaken survey of the agrarian formations of the central natural and economic zone of the Krasnodar Territory, the use of information systems and

technologies for assessing the condition and use of soil fertility in the cultivation of individual crops was analysed.

During the study, annual agricultural production programs, regulations for rationing and budgeting of business entities in general and responsibility centres, material costs budgets, crop rotation data, etc. were used.

To study the integrated interdisciplinary object of management accounting related to the assessment of the reproduction of agricultural land fertility, the functions and complex interaction of IT management, and analysis of specific situations of the impact of costs on fertilizers and chemical plant protection products on the gross crop production in the Kuban economic entities were applied.

## RESULTS AND DISCUSSION

A generalization of the collected data on the use of IT technologies for managing the cost of fertilizers and chemical plant protection products allowed us to answer the questions about the role of methods and tools of digital information processing in the accounting and control system of agricultural formations.

The historical, political, and geographical features of many spheres of life in Russian society led to the emergence of the concept of a special “Russian path” for the development of the agricultural sector of the economy. In recent years, the agricultural sector of the Russian Federation in certain types of crop production has occupied a leading position in the world (export of wheat, barley, rice and oilseeds). In terms of export performance, the agricultural sector of the economy has come up to and even exceeded arms exports.

Actual political and scientific discussions around the prospects of the food market are focused mainly on gross production, less often on its quality. The reason for the study of gross food production is its insufficient quantity with a simultaneous increase in the population. Moreover, even with an increase in food production, an equally important problem is the improvement of its quality.

One of the most important vectors in the growth of crop production has been the rational use of mineral fertilizers and chemical plant protection products. In developed countries, the management of the costs of mineral nutrition and chemical protection of plants over the past decade has transformed from a function of the usual growth in the production of finished products into an instrument to increase production efficiency and improve the quality of crop production. This is evidenced by the statistical indicators of Germany, Italy, Denmark, Norway and other countries.

Unlike developed countries, little is known about the role of agrochemicals in economies in transition, such as Russia. During the years of the change in the social formation from socialism to capitalism, the coherence of the chemical industry and agriculture was lost in the country, the norms for using the mineral nutrition of plants were practically lost or lost their relevance, the types of mineral fertilizers and chemical plant protection products, agricultural production technology changed. At the same time, the organizational and legal status of economic entities of an agrarian orientation has radically changed: the bulk of

agricultural production is now based on private property. All this happens against the background of the loss of connection between crop production and animal husbandry in agrarian entities, which traditionally complement each other. As a result, arable land has almost lost the most important source of fertility restoration – organic fertilizers.

Economic entities of the agricultural sector replenish the mineral nutrition of agricultural crops by increasing the dose of chemicals. This made it possible to significantly increase the gross harvest of finished agricultural products, but at the same time led to excessive accumulation of unused and sometimes aggressive chemicals in the fertile soil layer.

As a result of the growth in gross production, crop production has acquired an export-oriented orientation, and the industry has increased efficiency and investment attractiveness. However, serious barriers associated with the degradation of soil fertility in agrarian formations can hinder the implementation of this scenario, as evidenced by the results of space sensing of the fertile layer of agricultural land are presented in Table 1.

**Table 1.** The presence of nutrients in the fertile soil layer in the agrarian formations of the central zone of the Krasnodar Territory, 2019

Parameter	Nitrogen (N)	Phosphorus (P <sub>2</sub> O <sub>5</sub> )	Potassium (K <sub>2</sub> O)
	Mg·ha <sup>-1</sup>		
Standard value for the central zone (minimum threshold)	6.0	3.0	6.0
Nutrient availability based on space sensing data	4.3	10.8	3.8
Deviation: deficiency (+), surplus (-)	-1.7	7.8	-2.2

Source: own elaboration.

Scientists and practitioners have noted a significant imbalance of basic nutrients in the fertile soil layer, namely nitrogen, phosphorus, and potassium. It is known that the Kuban chernozems should have 6–15 Mg of nitrogen (N), 3–9 Mg of phosphorus (P<sub>2</sub>O<sub>5</sub>), 6.0–6.5 Mg of potassium (K<sub>2</sub>O) per 1 ha [KOLESNIKOV *et al.* 2000]. This mineral structure allows plants to receive the required amount of nutrients and provides high yields. The reproduction of soil fertility was due to the introduction of organic fertilizers. Organic fertilizers helped neutralize aggressive chemical residues. The special role of organic fertilizers is also explained by the fact that they have a direct effect on the balance of organic matter in the soil, passing partially into humic compounds. Mineral fertilizers do not possess such properties.

According to scientific agronomists, a violation of the mineral structure of the fertile soil layer is the result of the production of a limited number of cultivated agricultural crops (mainly cereals and oilseeds) [BUCZKO *et al.* 2017], in individual cases, the transition to the production of monoculture, the shift away from scientifically based crop rotation. As a result of the loss of the patterns of lean management and excessive enthusiasm for chemicals, this is an increase in the proportion of phosphorus in the fertile soil layer. This often leads to the death of agricultural crops or a decrease in gross output.

To overcome such a state of soil fertility, it is necessary to start preparing now. It should be noted that at the federal

and regional levels, national and regional target programs for the restoration of soil fertility have already been developed. Effective measures are already being taken to eliminate these shortcomings, but the transition to innovative environmentally-oriented (green) agriculture can take several decades.

For example, to solve this problem, the Legislative Assembly of the Krasnodar Territory, in order to restore soil fertility, decided that the share of perennial grasses in the structure of crops of agricultural formations should not be lower than 30.0%. The provision of state aid is only discussed for those agricultural groups that, along with the production of crop products, are engaged in the production of livestock products, ensuring the development of traditional agricultural production (except for agricultural groups located in the recreation zone).

The study found that the share of perennial grasses in the rotation of agricultural formations not only restores soil fertility but also contributes to an increase in the yield of other agricultural crops in the rotation are presented in Table 2.

**Table 2.** Relationship of winter wheat yield to the share of perennial grasses in the crop rotation structure of agricultural units in the central zone of the Krasnodar Territory, 2019

Group of agricultural units by the share of perennial grasses in the crop rotation (%)	The number of agricultural formations per group	The share of perennial grasses in the crop rotation on average per group (%)	Productivity (Mg·ha <sup>-1</sup> )	Profitability (%)
I <10.0	21	6.8	2.635	39.7
II 10.1–20.0	73	17.3	3.245	65.8
III ≥20.1	23	28.4	3.485	124.9
Total mean	117	18.2	3.160	77.1

Source: own study.

The agrarian formations of the central natural and economic zone of the Krasnodar Territory, where the share of perennial grasses is 20.1% or more (III group of farms), had the yield of winter wheat in 2019 higher than the farms with a share of perennial grasses up to 10.0% (I group of farms), per 0.85 Mg·ha<sup>-1</sup>. At the same time, the production of 0.05 Mg of grain was lower in labour intensity by 0.14 man-hours, and the profitability of production was higher by 85.2 percentage points.

The study found that if all the requirements of agronomic science for crop rotation and filling them with clover and alfalfa agrarian formations of the Krasnodar Territory are met, it will make it possible to produce 75.8 thous. Mg of biological nitrogen.

To introduce an equivalent amount of mineral fertilizers, the required expenses shall be 4.32 mln USD. Therefore, an increase in the share of perennial grasses in crop rotation is an important vector of soil fertility growth.

The study found that in recent years the dynamics of the coefficient of nutrient return and soil fertility recovery has a pronounced tendency to decrease is presented in Figure 2.

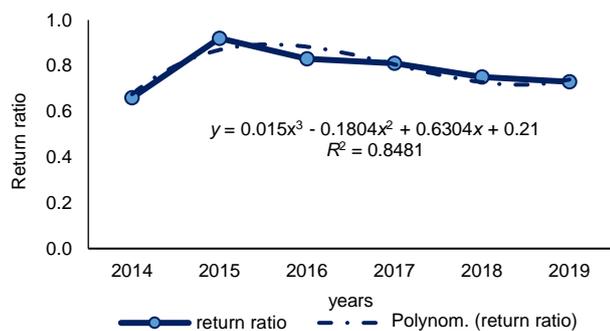


Fig. 1. Dynamics of the return ratio of soil fertility through the use of mineral fertilizers; source: own study

In 2014–2019, the return ratio of soil fertility in the agrarian formations of the central zone of the Krasnodar Territory varied under the influence of the level of state support for domestic agricultural producers and the level of use of organic fertilizers. After the anti-Russian sanctions in 2014, state support for agricultural groups increased.

This led to an increase in the use of mineral fertilizers, and, as a result, to an increase in the gross output of finished agricultural products. In 2015, the soil fertility recovery coefficient was 92.0% of the lost nutrient components of the fertile layer were restored with mineral fertilizers. Comparing this indicator with 2014, we note that it is lower by 26.0%. The current trend with the availability of nutrients requires a constant increase in the dose of fertilizers for growing crops.

The study found that over time, the share of state support was levelled by rising prices for fertilizers and chemical plant protection products. The law of “supply and demand” did the thing: an increase in demand for a product led to an increase in its price. As a result, the lack of state financial assistance since 2017 has been a factor in reducing the doses of fertilizers and, accordingly, the return coefficient of soil fertility.

The study found a correlation dependence of the finished goods production efficiency of individual agricultural crops on the level of fertilizer costs are presented in Table 3.

Thus, the efficiency of winter wheat grain production in 2019 in group III farms (average fertilizer costs per farm is RUB8639 per 1 ha of sowing) is significantly higher than in group I farms where fertilizer costs were equal RUB5632 per one ha of sowing. At the same time, the yield of agricultural crops in the farms of group III is 3.485 Mg·ha<sup>-1</sup>, and profitability reached 124.9%.

A comparative analysis of descriptors (natural and cost indicators) of the best business entities of groups I and III indicates a significant deviation of the results of winter wheat production by group III farms from the group I are presented in Table 4.

The organization, which was included in group III by the level of fertilizer costs in 2019, produced 3.52 Mg of grain per 1 ha. At the same time, the profitability of winter wheat grain production in the best economy of group III amounted to 134.8%.

It is known that sugar beets are considered the most responsive to the use of mineral fertilizers in its cultivation. This means that the efficiency of their use is significantly

**Table 3.** The efficiency of production of winter wheat grain based on the level of fertilizer costs in agricultural units of the central zone of the Krasnodar Territory, 2019

Group of agricultural units by the cost of fertilizers per ha of agricultural crops (RUB) <sup>1)</sup>	The number of agricultural formations per group	The cost of fertilizers per 1 ha on average per group (RUB) <sup>1)</sup>	Productivity (Mg·ha <sup>-1</sup> )	Profitability (%)
<b>Winter wheat grain</b>				
I 6000	18	5 632	2.59	49.3
II 6001–8000	43	7 264	3.22	69.9
III ≥8001	56	8 639	3.51	97.4
Total mean	117	7 721	63.2	77.1
<b>Sugar beets grain</b>				
I <8000	31	7 288	16.90	31.4
II 8001–10,000	44	9 867	18.65	35.9
III ≥10,001	42	11 031	19.75	45.0
Total mean	117	9 953	18.90	38.8

<sup>1)</sup> RUB100 ≈ USD1.5.

Source: own study.

**Table 4.** Comparative characteristic of winter wheat grain production descriptors in the best agricultural formations of groups I and III by the level of fertilizer costs, 2019

Farm	Fertilizer cost per ha (RUB) <sup>1)</sup>	Productivity (Mg·ha <sup>-1</sup> )	Profitability (%)
<b>Winter wheat grain</b>			
The best farm from the group I	5 964	2.69	56.4
The best farm from group III	9 127	3.52	134.8
<b>Sugar beets grain</b>			
The best farm from the group I	7 888	17.1	33.8
The best farm from group III	12 120	33.2	87.9

<sup>1)</sup> RUB100 ≈ USD1.5.

Source: own study.

higher than in the production of other agricultural crops are presented in Table 5.

Descriptors of the effectiveness of the use of mineral fertilizers in the production of sugar beets indicate that with an increase in the cost of fertilizers, by one hectare led to the increase in agricultural productivity by 2.85 Mg·ha<sup>-1</sup>, decrease in the labour intensity of production by 0.06 man-hours, and increase in profitability by 13.6 percentage points.

More convincing results of the use of mineral fertilizers in industrial beet production are the natural and cost indicators for comparing the best business entities of each group in terms of the cost of fertilizers per 1 ha of agricultural sowing: an increase in fertilizer costs by 1.5 times allowed the best group III farm to get 16.6 Mg of root crops per 1 ha more, increase labour productivity three times, increase production profitability by 54.1 percentage points are presented in Table 6.

**Table 5.** The efficiency of production of sugar beets grain based on the level of fertilizer costs in agricultural units of the central zone of the Krasnodar Territory, 2019

Group of agricultural units by the cost of fertilizers per ha of agricultural crops (RUB) <sup>1)</sup>	The number of agricultural formations per group	Fertilizer cost per 1 ha on average per group (RUB) <sup>1)</sup>	Productivity (Mg·ha <sup>-1</sup> )	Profitability (%)
I <8000	31	7 288	16.90	31.4
II 8001–10,000	44	9 867	18.65	35.9
III ≥10,001	42	11 031	19.75	45.0
Total mean	117	9 953	18.90	38.8

<sup>1)</sup> RUB100 ≈ USD1.5.

Source: own study.

**Table 6.** Comparative characteristic of sugar beets production descriptors in the best agricultural formations of groups I and III by the level of fertilizer costs, 2019

Agrarian formation	Fertilizer cost per ha (RUB) <sup>1)</sup>	Productivity (thousand RUB thou per capita)	Profitability (%)
The best farm from the group I	7 888	17.1	33.8
The best farm from group III	12 120	33.2	87.9

<sup>1)</sup> RUB100 ≈ USD1.5.

Source: own study.

The study found that the greatest economic effect in the cultivation of sugar beets is achieved by those agrarian formations that, along with mineral fertilizers, rationally use chemical plant protection products in agro landscape technologies, namely, in agrarian formations, where one rub. mineral shipping packaging sets accounted for RUB1.38 of chemical plant protection products, agricultural productivity is more by 6.1 Mg·ha<sup>-1</sup>, and the cost recovery is 1.85 times higher. In the Kuban, a significant spread of agro landscape technologies led in 2019 to the overproduction of sugar beets. Urgent measures have been taken to replace sugar beets in the crop rotation with soybeans and rapeseed, whose products are in great demand in Asia and Africa.

A comparative analysis of the costs of mineral fertilizers and chemical plant protection products indicates the presence of significant reserves for the growth of production of this agricultural crop.

As was shown above, the most important condition for the economic value of information systems on the state and use of land resources of agrarian formations is the improvement of the collection of information on agricultural lands to ensure further growth in the efficiency of agricultural production.

This requires the interconnection of statistical reporting descriptors, management reporting and geospatial data from various sources, including those generated by the Ministry of Agriculture of the Russian Federation. Currently, geospatial information of the Ministry of Agriculture of Russia is available in the “Atlas of agricultural land”, which is

currently being transformed into the Unified Information System on Agricultural Land of the country. Having access to the data of the Unified Information System, each agricultural subject on a scientific basis can generate a passport of any field containing information on crop rotation, the content of mineral nutrition at the time of sowing and after harvesting. This information allows for making budgets for the availability and use of mineral fertilizers and chemical plant protection products.

## CONCLUSIONS

The historical and political features of Russia predetermined the extreme heterogeneity of all spheres of the country's life, exacerbated by its vast territorial extent. At the same time, in many respects, Russia serves as a typical example of a country with a developing economy. When speaking about the unique “Russian road map for rural development”, it is necessary to consider the resource character of agricultural production. Saving the resource potential in modern conditions is possible only when applying the methods and tools of IT technologies in the accounting and control systems of agricultural formations, introducing robots and automating business processes.

A review of the specialized literature on this problem and a study of the soil fertility of the agrarian formations of the Krasnodar Territory as the main food supplier to the country's population indicates a significant degradation of the structure of the fertile soil layer due to unreasonable use of agrochemicals and a significant decrease in the use of organic fertilizers.

At the same time, it was established that at the micro and macro levels of managing the agricultural sector of the economy, effective measures are being taken to eliminate the identified shortcomings. The authors presented the main drivers underlying this scenario, including the use of agro landscape technologies, chemical plant protection products from pests and diseases. In particular, it seems necessary to initiate large-scale measures to scientifically substantiate the construction of agricultural crop rotation, the use of mineral fertilizers and chemical plant protection products only on the basis of indicators of space sensing of the fertile soil layer.

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