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METHOD OF INTRODUCING INNOVATION TO LAND USE IN AGRICULTURE

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Abstract. The *purpose* of the research is to make the method of introducing innovations, taking into account its economic, environmental, and social aspects. *Methodology.* To carry out the research, a multilateral approach to assessing the choice of technology, changing the operational capabilities of technology, get an integrated effect is applied. *Results.* The method of introducing innovations is recommended to take into account the quantitative and qualitative reproduction of the technical base of agricultural production. The method consists of five stages, including the division of the target into macro-, meso-, micro-levels, remote observation of changes in soil characteristics, consideration of the interaction of participants in land relations during the creation of projects, the use and next adjustment of the results of scientific achievements, comparison of potential benefits with actual data. It contains an economic calculation that confirms the advantage of minimal tillage over traditional technology. The authors have proved the expediency of using the sowing complex of the SC "Kuzbass", reducing the cost of labour, the purchase of fuel and fuels and lubricants and others. The total savings of operating costs will be 1628.1 roubles from 1 hectare, or 51.6%. The development of new technologies in agricultural land use makes it possible to obtain economic benefits, ecological and social effect. The *scientific novelty* of the research is to improve the method of introducing innovations, taking into account economic, ecological, and social aspects by streamlining the interrelated processes of using scientific achievements in agricultural land use: structuring the goal, obtaining analytical information, the use of a multilateral approach to the evaluation of technology choices, change in the operational capabilities of technology, the establishment of an integral effect. *Practical implications.* The author's method is recommended to state bodies, agricultural organizations in order to develop organizational, managerial, socio-economic, ecological, technical and technological areas for increasing the efficiency of agricultural land use, contributing to optimization of working conditions, preserving and improving the quality of the land, use of resource-saving equipment and of the progressive achievements in agriculture, etc. *Conclusion.* The research defines the economic indicators of innovative soil cultivation technology, lists the ways to achieve environmental benefits and social efficiency.

Key words: method, innovation, minimal tillage, land use, agriculture, efficiency.

JEL Classification: C40, O31, Q15, Q16

1. Introduction

Currently, the state of land use is characterized by heterogeneity, instability, uncertainty of further development. It is affected by the destruction of the cover, salinization, desertification, etc. More than a third of the country's soils of agricultural land in the country are subject to degradation processes. Agricultural machines strongly compact the arable land. Soil fertility is reduced as a result of the permanent cultivation of sunflower (Zavorotin, Afanasief et al., 2017). In this situation, effective agricultural land use is necessary. In our opinion, it should be implemented through amendments and additions to legislative documents,

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redistribution of financial resources, application of administrative, economic instruments for regulating land conservation activities, technical and technological modernization (Zavorotin, Gordopolova et al., 2017). Thus, the purpose of the research is to make a method for increasing the efficiency of agricultural land use. The objective of the research is to scientifically substantiate the need to apply innovations in agricultural land use. The scientific novelty of the method of introducing innovations consists in justifying the application of soil-saving, soil restoration technologies, creating investment attractiveness of innovative projects, preventing deterioration of physical properties of the soil, reducing crop losses, enhancing the agricultural land use culture, improving social and labour and other relationships.

2. Theory

The introduction of modern high-performance equipment and the application of innovative technologies make it possible to implement the priority areas of the Strategy for Scientific and Technological Development of the Russian Federation and ensure an increase in the efficiency of agricultural land use. Efficiency is traditionally determined by the ratio of the result obtained to a unit of resource or production costs. In our opinion, effective agricultural land use should be systemic, an organized use of the functional potential of lands with minimal costs and negative consequences, most adapted to legal, economic, environmental, and social conditions.

Many modern foreign scientists were engaged in the identification, structuring of the main issues of the effectiveness of agricultural land use, determination of ways to solve them.

I. Kühling, G. Broll, D. Trautz have quantitatively evaluated the changes and patterns of decreasing the intensity of land use and proved the importance of developing a strategy for sustainable land management (Kühling, Broll & Trautz, 2016).

R.I. Rozum, I.V. Liubezna, O.M. Kalchenko determined the influence of environmental and economic factors on the quality and fertility of soils, the efficiency of land use, confirmed the need to create a material base for increasing the level of economic returns of the land (Rozum, Liubezna & Kalchenko, 2017).

B.J. Cade-Menun, L.D. Bainard, K. LaForge, M. Schellenberg, B. Houston, C. Hamel established an increased degradation of soil after cultivation of sunflower and an increased compaction of soil by reason of heavy agricultural technics (Cade-Menun, Bainard et al., 2017).

The conservation and restoration of soil fertility, the construction of models for assessing the intensity of degradation processes, are examined by D.A. Davidson (Davidson, 1980), S. Assouline, G. Govers, M.A. Nearing (Assouline, Govers & Nearing, 2017).

The formation of legal, process-functional, normative, comparative approaches to the creation of methods to increase the efficiency of agricultural land use is required.

3. Structure of the author's method

The author's method of introducing innovations argues the need for scientific achievement for the use of agricultural land for agrotechnical work with the preservation of productive properties of the soil, improving the working conditions of workers. The method of innovation introduced by the authors is designed to improve the efficiency of agricultural land use. It consists in carrying out interrelated successive actions:

1) setting purposes and objectives of the introduction of scientific developments at meso- and micro-levels – technical re-equipment of agricultural organizations for soil conservation activities;
2) monitoring – identification of the possibilities of preserving land quality indicators, including on the basis of results of land-distance methods of detailed study of agricultural land, analysis of environmental problems in the agriculture of the region;
3) interaction of participants in land relations with state scientific institutions – justification of the choice of ways of equipping with material and technical means;
4) adaptation of developments to the conditions of the region – the exploitation of equipment with its further improvement;
5) estimation of the cumulative effect – getting economic, ecological, social efficiency.

4. Features of the author's method

Technical erosion leads to a significant decrease in soil fertility, which is a prerequisite for the development of relevant scientific provisions and the division of the overall objective of this method into separate blocks (Figure 1).

Modern high-tech products for the implementation of diagnostics with elements of accurate farming involve scanning the soil cover, monitoring the change in the economic status of lands, etc. They perform operational processing, import, structuring and preserving reliable analytical information. This allows you to choose the optimal management decisions that are consistent with the goals and tasks set at the first stage.

Relations between the state, scientific organizations, manufacturers of agricultural machines, financial institutions, and participants in land relations are formed on the provision of mobile technical means. The choice of methods and tools can be automated with the use of information and communication technologies. The input parameters are set by the results of the agroecological assessment (survey) of agricultural land. At the output, projects are being developed to implement the results of scientific achievements. Financial institutions provide

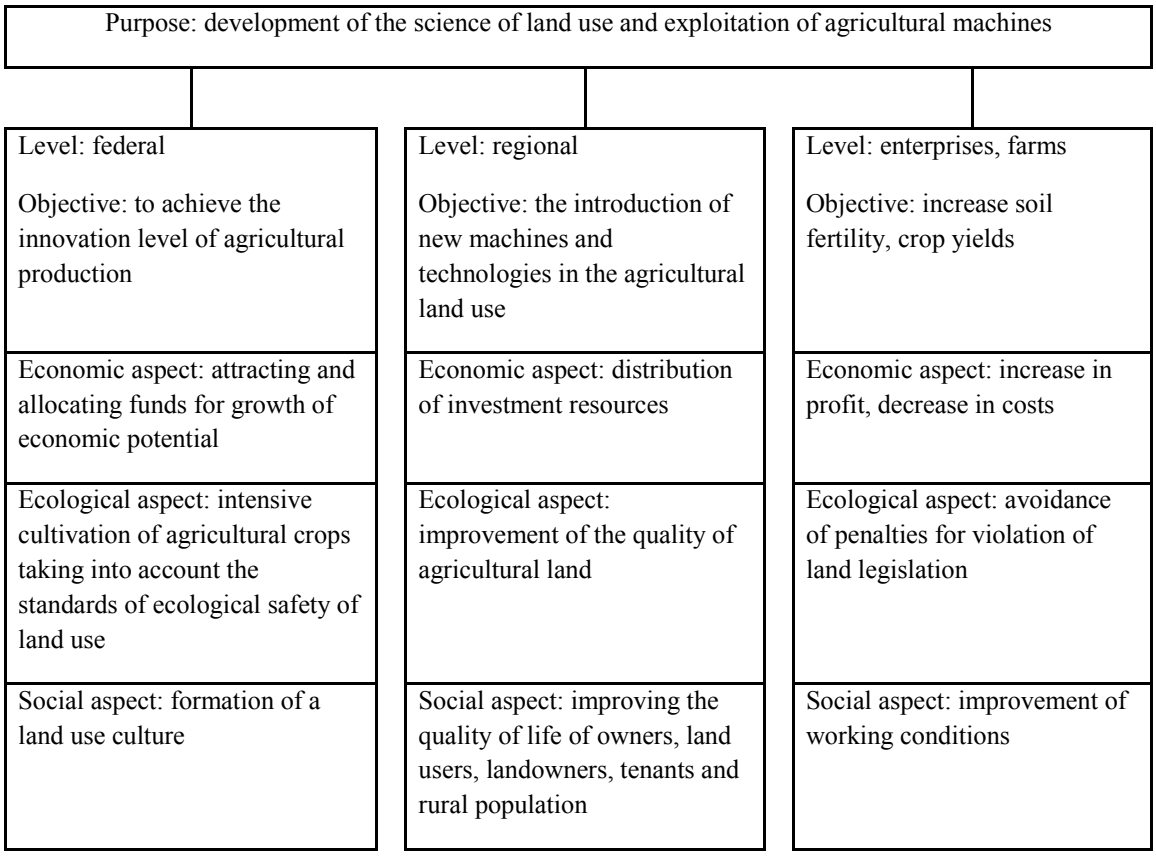

Figure 1. Structuring of the general purpose of the method of introducing innovations into agricultural land use by macro-, meso-, and micro-levels proposed by the authors

Source: the author's development

an opportunity for manufacturers, owners, land users, landowners, tenants to obtain appropriate funds.

In the process of constant accumulation of data on the application of new resource-saving technologies in agricultural land use, scientific institutions assess characteristics of machines and technologies taking into account the natural and climatic conditions. In this case, there is a need to improve the structural elements of the machinery in use, improve products, materials, technologies in order to obtain maximum effect. For example, in areas of risky farming, the imperfection of sowing complexes is manifested; they should be supplemented with appropriate devices. Adding technological elements will slow the movement of aggregates on the field, which can increase costs and the number of passes.

The consolidated assessment of economic, environmental, and social indicators should be carried out taking into account the results of activities carried out at previous stages of realization of the method.

5. Substantiation of the use of technical means

An example of innovative technology in agricultural land use can be minimal tillage in the cultivation of crops with the use of sowing complexes (SC "Kuzbass", Kemerovo, Russia), including the location of the object through the Global Navigation Satellite System (GLONASS, Russia).

Traditional tillage includes a combination of technological operations – from disking to sowing – involving at least 5 machine-tractor aggregate (Chernyaev, Zavorotin et al., 2012).

In one pass of the sowing complex, the following operations are performed: cultivation, sowing, fertilization, harrowing, reconsolidation, land levelling.

Innovative technology can have several advantages:

economic – decrease costs by reducing equipment units, the number of operations,

ecological – conservation of the humus horizon, soil moisture conditioned to the limitation of the effect of erosion and deflation,

social – the absence of the need to hire workers to perform activities on the classical scheme without loss of productivity.

The economic estimation of the relevant indicators for the sowing of cereals with traditional or minimal tillage of soil is presented in Table 1.

Thus, the most significantly reduced costs for the purchase of fuel and fuels and lubricants – by 1177.4 roubles per hectare, or 88.2%. Despite the high cost of the sowing

Table 1

Operating costs for traditional or minimal soil tillage calculated by the authors*

Technological operation	Machine-tractor aggregate	Cost per hectare, roubles					
		wages of workers	energy resources	depreciation	maintenance, repair, storage of equipment	other	total
Traditional technology							
Disking	tractor T-150K + disc harrow LDG-15	12.5	89.5	56.8	33.9	96.3	289.0
Plowing	tractor T-150K + plow PLN-6-35	111.9	802.3	104.7	146.6	582.7	1748.2
Harrowing	tractor T-150K + coupling SP-11 + harrow BZSS-1.0	9.1	65.1	10.6	9.8	47.3	141.9
Cultivation	tractor T-150K + coupling SP-11 + cultivator KPS-4	15.6	112.1	47.8	50.2	112.9	338.6
Sowing	tractor T-150K + coupling SP-11 + sowing SZS-2.1	37.2	266.5	58.4	62.5	212.3	636.9
							3154.6
Innovative technology							
Combined	tractor T-150K + sowing complex SC-8.5 "Kuzbass"	22.1	158.1	345.1	492.4	508.8	1526.5
							1526.5
Saving costs per 1 hectare, roubles							
		164.2	1177.4	–66.8	–189.4	542.7	1628.1

*Note: The authors made a calculation based on the data of the agricultural organization of the Saratov region

complex, significant costs for its maintenance, repair, storage, and depreciation in comparison with traditional tillage, the total cost savings of operating costs will be 1628.1 roubles per hectare, or 51.6%.

The economic benefits can be calculated on the basis of typical investment indicators (Pototskaya, 2013). Investment indicators of minimum tillage are presented in Table 2.

So, for the third year of operation of SC-8.5 "Kuzbass", there will be a full compensation of investment costs, net present value (integral effect) will amount to 749.4 per 1 hectare, roubles.

The ecological estimation consists of the assessment of the effectiveness of agricultural land use. It will have a systemic character if the coefficient of the ecological component is determined – the ratio of the actual percentage of the increase in soil density to the permissible (10%) established on the basis of Kaczynski research (1965). With traditional soil cultivation, machine and tractor aggregate compact the soil by 15-20%, which reduces the yield of cereals by no less than 5% (Table 3).

When using SC "Kuzbass", the arable is compacted to 0.05 g/cm3, or 4.17%, less than when applying classical processing methods, which has a positive effect on the yield of grain from 1 hectare. Innovative technology leads to satisfactory agrotechnical conditions since the calculated change in soil density does not exceed the normative value of the coefficient of the ecological component.

The ecological effect consists in reducing the negative impact of machinery on the ground, preventing compaction and destroying the structure of the soil.

The social estimation consists of identifying the most important problems in this area of innovation-non-optimal number, inappropriate qualification of employees, inadmissibility of the proposed changes by workers (Iurkova & Serdobintsev, 2016).

The revealed interrelation of the accepted design decision with possible consequences is presented in Table 4.

Table 2

Investment indicators of minimum tillage*

Name of the indicator	Step			
	0	1	2	3
Inflow (cost savings) per 1 hectare, roubles	–	1628.1	1628.1	1628.1
Outflow (investments) per 1 hectare, roubles	2634.4	–	–	–
Cash Flow per 1 hectare, roubles	–2634.4	1628.1	1628.1	1628.1
Discount Coefficient	1	0.833	0.694	0.579
Discounted Cash Flow per 1 hectare, roubles	–2634.4	1356.2	1129.9	942.7
Accumulated Discounted Cash Flow per 1 hectare, roubles	–2634.4	–1278.2	–148.3	749.4

*Note: The authors made a calculation based on the data of the agricultural organization of the Saratov region

Table 3
The estimation of the state of the soil using the proposed ecological parameter*

Name of the indicator	Technology	
	traditional	innovative
Density of soil, g/cm^3		
before tillage	1.20	1.20
after tillage	1.39	1.25
Fact change of soil density, %	15.83	4.17
Coefficient of ecological component	1.58	0.42

*Note: The authors made a calculation based on the data of the agricultural organization of the Saratov region

Table 4
The impact of innovations on the social environment

Factors	Impact	
	positive	negative
endogenous	development of business activity of project participants, changing the structure of production personnel, saving working time	underestimation of technical capabilities of agricultural organizations, insufficiency and incompetence of labour resources
exogenous	acceptability of innovation for scientific potential, increase in the number of jobs in the region	social harm, inconsistency of results with expectations, decrease in the number of jobs in the region

Source: the author's development

Social efficiency is expressed in improving working conditions, reducing the time spent in carrying out basic work in agricultural land use.

6. Conclusion

On the basis of the research of scientific works, the authors of this paper prove the relevance of made methods ensuring the fullest use of the functional of land for agricultural purposes with the use of advanced technologies for obtaining optimal economic results and reducing negative environmental and social consequences. The integrated method of introducing innovations, developed by the authors, makes it possible to determine and scientifically substantiate the demanded areas for increasing the efficiency of agricultural land use.

The authors established the general purpose of the method and specified sub-goals depending on the economic, environmental, social components for the federal, regional levels, the levels of enterprises, farms.

Comparative analysis of traditional and minimal soil treatments has been carried out, the expediency of taking into account ecological and social aspects is proved, the calculation of cost saving per hectare, discounting indicators, the coefficient of ecological component is done, the impact of innovations on the social environment is identified, taking into account endogenous and exogenous factors.

The method is recommended for use by public authorities to achieve innovative levels of agricultural production, regional agricultural authorities – for the introduction of new machines and technologies in agricultural land use. Farms, agricultural organizations, consumer and production cooperatives can apply this method to increase soil fertility, increase yields of agricultural crops.

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