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INNOVATIVE TECHNOLOGIES IN CROP GROWING: RESOURCES AND ASSESSMENT METHODOLOGY

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Abstract

The paper addresses the relationship of the main components as parts of innovation infrastructure. The key challenges of resource support are identified that are directly related to the use of innovative technologies in agricultural production within the main groups – staff, scientific and information support, technical, technological and financial facilities. There are pointed out the main levels of crop production development involving to some extent the innovative technologies. The levels we state are: technical, technological, industrial, socio-economic. The variety of levels is needed, along with expanding the border, to conduct more relevant research in this field. The indicators applied to assess the progress have been selected along with the level identifying the production efficiency with the use of innovative technologies, the use of which in analytical activity provides a new opportunity to identify deficiencies in management decisions in innovative activities and their timely correction. The crucial branches for efficiency analysis regarding crop production involving some innovative technologies are proposed. The integral index was calculated on the basis of normalized indicators obtained by linear scaling in order to identify the degree of production development by indicators of the socio-economic effect in the crop sector in the Russian Federation and the Saratov region as itself. The result of the study shows the overall progress level in socio-economic development regarding crop production with innovative technologies within the time under consideration. The issue of practical application on how to conduct the efficiency evaluation with its further improvements has been discussed.

Keywords: Innovations, crop growing, assessment, standardization, production development.

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1. Introduction

The current stage of agricultural development is characterized by the need to constantly increase the technological level of agricultural production, which involves scientifically-based highly effective innovative technologies, where the importance of their use is confirmed by the world experience of the developed countries and it demonstrates the comprehensive progress in agricultural development. The issues on the efficient functioning of agriculture are currently put forward among the significant priorities of the state policy in the Russian Federation for many reasons, among which there is the role of the industry as one of the foundations of the socio-economic well-being of the state. The steady growth in the industry in recent years does not mean solving numerous systemic problems, despite the active use of innovative technologies and the implementation of large investment projects (Shchetinin, 2018). In crop production, one of the key sectors of agriculture, there continues to be the dependence on import of seeds and planting material, lack of technical support and a high level of depreciation of basic assets, deterioration of agricultural land, low investment activity, low rates of development of the infrastructure, including scientific and production support and many other problems.

The complicated economic situation in crop growing, despite the high successes observed due to good agrarian policy, is aggravated by the backwardness from the best world indicators evaluating the productivity and by relatively low competitiveness of agricultural production. The crop-production situation is also complicated by the fact that following the previous approaches can lead (according to forecasts) to a decrease in production volumes.

The reasons for it are: 1) re-industrialized farms reach yield limits that are technologically and economically justified, and 2) there is a tendency for slow technological modernization of agricultural enterprises with different technological structures. The emergence of new problems caused by the constant increase in the science-based intensity of innovative technologies as a result of scientific and technological progress, which complicates their development and application in agricultural enterprises, and addresses the issues of institutional support in terms of the innovation process.

The need to solve the existing problems in crop production and in agriculture as a whole, including increasing exports and developing import-substituting industries, requires the search for new effective ways and methods to identify priority areas, run scientifically based management decisions at different hierarchical levels. It is known that one of the important aspects of effective management is the ability to assess the level of industry development to identify priority areas and find effective, science-based management decisions.

The necessity to conduct more research in this field served as an impetus to search for new tendencies, adapted to changing conditions, corresponding to the realities of the time and allowing to have the adequate assessment of qualitative changes happening in the industry due to the innovative development management (Aleksandrova et al., 2017).

2. Problem Statement

The problem is to differentiate levels describing the use of innovative technologies at enterprises (dealing with crop growing industry) and to develop a set of indicators to each level. To solve this

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problem we need to design an assessment system that will be applied to identify the levels of production development. The effectiveness of innovative technologies used n crop production needs to be assessed.

3. Research Questions

How to expand the possibilities of assessing the use of innovative technologies in the crop production sector to minimize the possible risks, to get some socio-economic effects, and to achieve the rational use of the resource?

4. Purpose of the Study

The aim of the paper is to develop the proposals to clarify the theoretical, methodological statements and practical recommendations for improving the assessment system targeted at how innovative technologies in crop production are used, which can contribute to creating and maintaining favourable conditions for stable development of agricultural production under its consequent modernization.

5. Research Methods

During the study, there were applied the general scientific methods, complex analysis and synthesis, monographic, and statistical methods, as well as methods of systematization, generalization, comparison, grouping, tabular and graphical representations of the data. The standardization (unification) of selected indicators for assessing the socio-economic level of production development through full normalization (linear scaling method) was used, which involves the conversion of indicators into one measurement scale (numerical values in the interval [0; 1]). The zero value of the converted indicator corresponds to the lowest quality for this property, and the maximum value – to the highest one. When calculating the private index, the maximum and minimum values (reference points) were determined based on the dynamics of the indicators defined in recent years (2014–2018). The aggregation method was used to form the integral assessment index, where the aggregation formula is a simple arithmetic mean of the normalized values of indicators from the set used (Kazantseva et al., 2011).

6. Findings

One of the main principles of the innovation policy in agriculture is the resource support of innovations (Golubev, 2015; Fedorenko et al., 2010). The effective development of innovative technologies in agricultural sectors and their use in mass practice is due to the close relationship of resource support and innovative infrastructure (Figure 01).

Properly functioning innovative infrastructure is a necessity providing conditions to the industry innovative development through the mass practice of recent achievements, which, in turn, generate more and more new advanced technologies and methods of conducting agricultural businesses (Vorotnikov et al., 2015).

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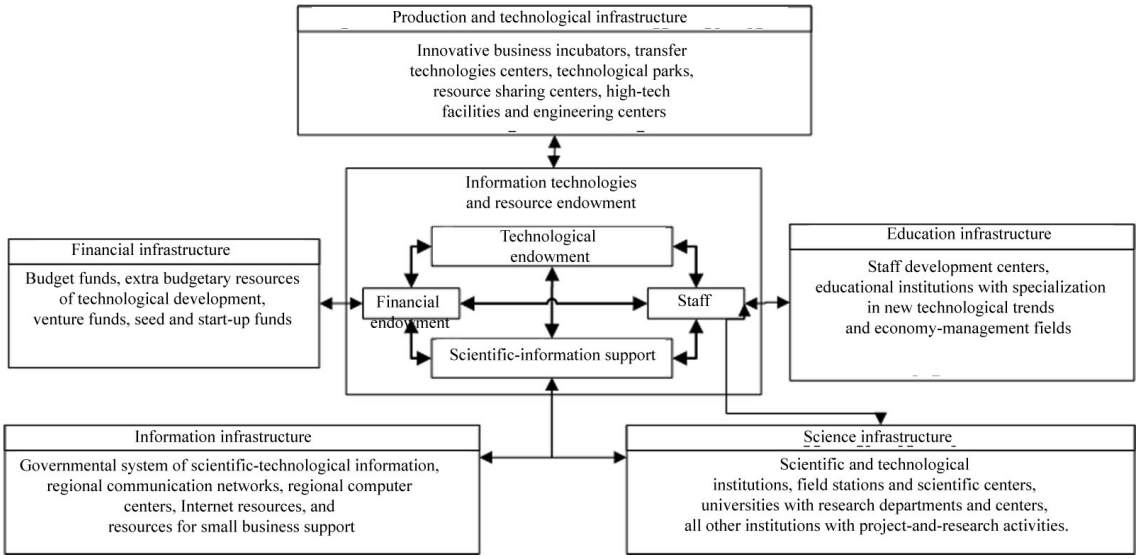

Figure 01. The main components of innovation infrastructure affecting the resource endowment of the production process in agriculture

Demand for innovative technologies and an opportunity to use them in the agricultural production process is the main critical factor for agricultural industry development. The large-scale opportunity of using innovative technologies is complicated by the increased possibility of an adverse outcome that might be expressed in undesirable or unexpected economic consequences in crop production, mainly due to some natural risks (e.g. emergencies caused by dangerous effects of natural phenomena, the penetration and spread of harmful organisms) and due to some innovative risks caused by the technologies themselves. Obviously, the activity of agricultural enterprises when they apply new technologies in the production process is very risky, but at the same time, it gives new opportunities and prospects for significant development in competitive production.

Sufficient resource endowment and their rational use are of great importance for increasing the production volume and improving production efficiency (Sandu, 2012). Solving the resource problems arising at agricultural enterprises allows finding a decision in acquiring and rational implementation of innovative technologies in production (Table 01).

Table 01. The main problems of resource endowment affecting the successful implementation of innovative technologies in agricultural enterprises

Problem	**Troubleshooting Solutions**
Financial support Investment deficiency. Lack of financial resources of an enterprise. Low income from production.	Budgetary financing. Market infrastructure development. Measures to increase the income of agricultural producers. New mechanisms of procurement interventions to reduce fluctuations in levels of income among agricultural producers. Improving bank loan mechanisms and investment initiatives development.
Staff potential development Shortage of highly qualified managerial and special staff (veterinarians, livestock specialists, agronomists, etc.). Weak social infrastructure.	State support for staff potential development involved in the agro-industrial sector. Development of tools for strategic staff management, management at the individual level. Development of institutional capacity in the field of agricultural sciences and management of an agricultural enterprise.

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Problem	Troubleshooting Solutions
Resources Weak resource base.	Leasing. State support for technical and technological modernization of industries.
Scientific and information support Growing demand for information resources and communication technologies.	Development of an information infrastructure providing information, IT and communication technologies for agricultural producers and organizational support infrastructure for enterprises. Creating an available marketing system.

Issues concerning how effective innovative technologies are used arise due to the need to make a wide range of managerial decisions. Strengthening the role of quality assessment and monitoring at all levels of conducting analytical activities in order to identify determining factors that negatively affect the success in applying innovative technologies in production activities, raise questions of the methodological character (Zaruk & Vinnichek, 2002).

A clear distinction towards the technologies at levels denoting how innovative technologies are used and further split into sublevels allows approaching the analysis in more detail. The level-based approach allows either to get the data when conducting relevant analytical activities to make better management decisions. Assessment by levels, in turn, involves the subsequent development of a set of interrelated supportive measures whose aim is to create favorable conditions for effectively achieving the certain, required, level.

The literature review allowed us to conclude that the full development and rational use of innovative technologies in crop production occurs in the sequential reach of three levels (Table 02).

Table 02. Levels within crop production development with innovative technologies

Level	Features	Changes	Key analysis points
Technical and technological	Production transition from the project level to practice with the use of innovative technologies. The use of material, labour, land and human resources with a new technology, introduced for the first time.	Quantitative and qualitative changes in agricultural resource production.	Analysis of resources endowment: land, material and technical ones.
Production	Industry products for sale. Re-equipment of agricultural production with the required resources to improve the process of production development to accelerate the progress in plants' growing and reduce expenses caused by the implementation of innovative technologies.	Changes in the basic values of production indicators. Qualitative improvement of products.	Analysis of labour productivity, yield level and gross yield, cost reduction: reduction in production costs, revenue increase.
Socio-economic	Getting socio-economic effects from IT implementation. Gradual transition regarding making the innovative processes into routine ones.	Increasing socio-economic effect.	Budget efficiency. Product profitability. Export. Analysis of improving the quality of employees' life.

The crucial branches for efficiency analysis regarding crop production involving some innovative technologies are proposed. It can be used at different levels of management and here we mean: analysis of the result, expenses analysis, feasibility analysis:

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1. Analysis of results. Identification of the production level what will be achieved with innovative technologies by comparing the actually achieved values (indicators) with their target values (planned or expected). The comparison analysis will allow identifying the progress level or efficiency as itself from the use of innovative technologies.

2. Cost analysis. Identification of to what extent the target values have been achieved (planned or indicators obtained at the leading enterprises of the industry) by comparing the expenses incurred for the production development with involvement innovative technologies in the process.

3. Feasibility analysis. Comparison of the level (values) that has been achieved after some actions undertaken with the aim to bring some technological changes into production technological changes in production with the level (values in figures) actually achieved due to the traditional (commonly used) approach.

The approximate list of indicators is given, which allows conducting the analysis of the development in crop production via the implementation of innovative technologies in the enterprise, which provides the opportunity to identify weaknesses in management decisions requiring timely resolution (Table 03).

Table 03. The approximate list of statistical indicators for analyzing the levels of production development (management level – an agricultural enterprise)

Level	Indicators
Technological	The proportion of innovative equipment and machines to their total number; assessment of the informatization level used in management. Mechanization and automation of production processes in crops growing, workers' labour who are engaged in production operations. Computerization level. Use of machine-and-tractor fleet, motor vehicles, endowment with tractors, combines, plows, other machinery. The use of fertilizer systems and chemical plant protection products. Payback on innovative technology.
Production	Labour productivity for 1 employee who applies innovative technologies, etc.: dynamics and the increase in labour productivity (labour efficiency); analysis of the impact of reducing labour costs (the impact of reducing losses of working time) on the level of production; the level of labour productivity for implemented actions involving innovative technologies (saving the number of employees). Productivity, gross yield. The effectiveness of crop growing with modified technologies (revenue and profit, level of profitability, production cost).
Socio-economic	Profitability of products produced with some genetic improvements conducted through agricultural technologies (in the context of certain crops). The effectiveness of using innovative technologies. The number of new high-tech jobs created by increasing agricultural lands productivity and involvement some new ones in the production process. Increased competency among employees engaged in crop production. The growth of nominal wages of employees and other indicators of improving the quality of employees' life. The proportion of exported crop products produced with IT to the total volume of crop production exports.

To assess the level of products' production with innovative technologies in the crop sector, we offer a widely used method that can track the dynamics of indicators, a method based on integrated indicators calculated via standardization, by carrying out a linear transformation procedure that brings the data to a single, comparative base, scale.

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Several layers of indicators are involved in this assessment (Sidorov, 2014): 1) basic indicators (data collected during statistical accounting); 2) relative indicators (obtained by comparing absolute values, expressed as coefficients or percent for conducting inter-territorial and inter-section comparisons); 3) indices of standardized indicators; 4) integral indices of various aggregation.

We focus on the socio-economic level of production development, the assessment of which gives a general idea about some socio-economic effect from using innovative technologies in the industry. To assess the socio-economic level of the development in crop production, the analysis was carried out on the basis of official statistics, carried out sequentially. Namely, the indicators adequate for assessing the socioeconomic level have been developed, available statistical data have been highlighted for the crop industry (the use of some direct indicators is difficult due to the lack of many indicators in the regional context), data are collected on the indicators and normalized within the linear scaling method, allowing us to track the dynamics of the selected indicator relative to stable reference points (Table 04).

Budget efficiency is determined by the ratio of the growth of the marketable crop production in value terms by 1 rub. of the budgetary funds for financing the development of the crop growing sector (actions from the governmental program).

Table 04. Individual indices of standardized indicators used in assessing the socio-economic level of production development (calculated according to the Rosstat and Saratovstat records)

Indicators / **Year**		**2014**	**2015**	**2016**	**2017**	**2018**	**5-year average**
Growth of crop production withdrawn from the constituent entities of the Russian Federation (including export)	RF*	1.00	0.00	0.37	0.33	0.93	0.53
	SR*	0.42	0.00	1.00	0.26	0.29	0.39
Corn and grain farming per capita	RF	0.02	0.00	0.52	1.00	0.27	0.36
	SR	0.40	0.00	0.56	1.00	0.31	0.46
The average monthly nominal accrued salary of agricultural employees (crop growing sector) for a full range of farms	RF	0.00	0.20	0.51	0.71	1.00	0.48
	SR	0.12	0.00	0.45	0.78	1.00	0.47
The profitability level (loss ratio) of crop production	RF	0.06	0.09	1.00	0.99	0.00	0.43
	SR	0.28	0.30	1.00	0.99	0.00	0.51
Budget efficiency	RF	0.73	0.87	0.70	0.00	1.00	0.66
	SR	0.56	0.66	1.00	0.00	0.36	0.52

*SR – Saratov Region, RF – Russian Federation

Trends in the integral index changes are reflected in the graph below (Fig. 02) and confirm the existence of difficult to solve problems on the entire chain of development and use of innovative technologies in crop production.

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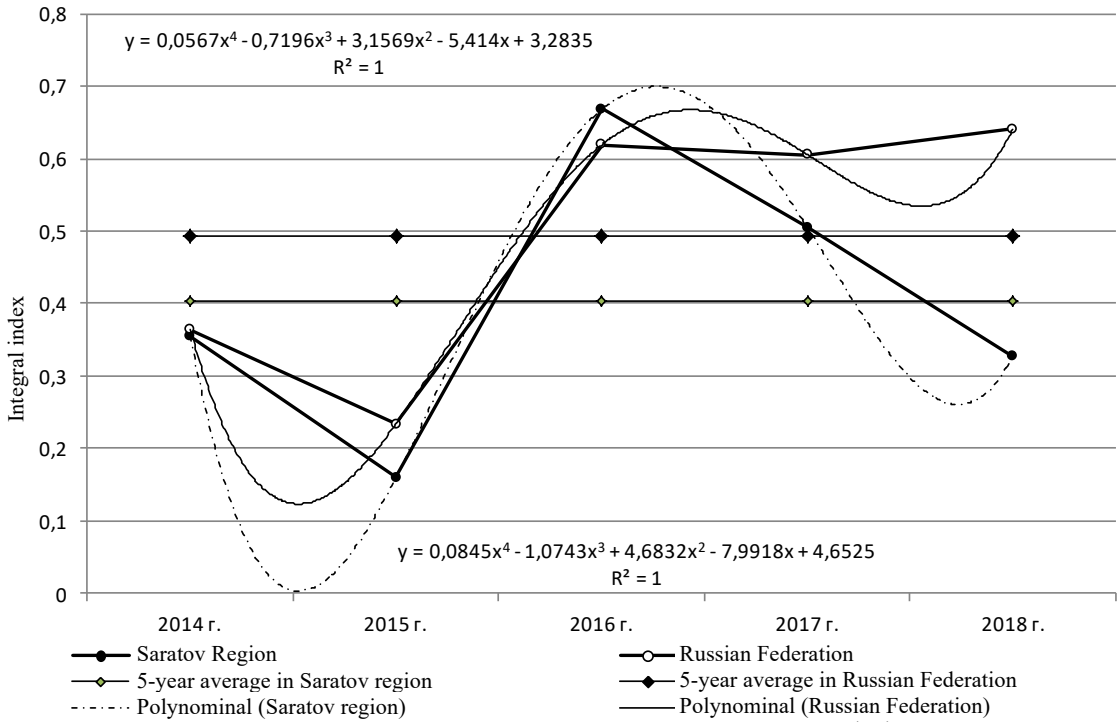

Figure 02. Trends in the integral index changes

Note that the location of the integral index above the threshold level (above 0.5) corresponds to a high degree of production development based on innovative technologies at the socio-economic level, and as the value of the integral index approaches the zero point – a low level:

$$\begin{bmatrix} 0{,}4 < I < 0{,}5 \Rightarrow \text{mid} - \text{level}; \\ 0{,}3 < I < 0{,}4 \Rightarrow \text{insufficient level}; \\ 0{,}2 < I < 0{,}3 \Rightarrow \text{low level}; \\ I < 0{,}2 \Rightarrow \text{very low level}. \end{bmatrix}$$

The presented distinctions of the integral index values are considered for differentiating levels of production development – high from low, with accounting on how the corresponding indicator is remote from the threshold value.

Thus, the calculated values of the integral index on average for 2014-2018 indicate the average level of production development based on innovative technologies: 0.493 – in Russia as a whole, 0.403 – in the Saratov region, which, when compared, indicates a lag in the values of indicators of the socio-economic level in the Saratov region from the average in Russia. In our case, the choice of the threshold value of the integral index corresponds to the commonly used but can be changed in accordance with expert conclusions, etc.

Note that this algorithm for assessing the level of production development based on innovative technologies at the socio-economic level is acceptable for other levels – technical, technological and production. In a comprehensive assessment of the state describing the level of production development, it is recommended to include three groups of indicators, where each one contains a certain number of basic indicators, according to which partial indices of normalized indicators, integral and generalized index are calculated.

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7. Conclusion

Based on the study, it was revealed that the system for assessing the efficiency of the production development based on innovative technologies is a dynamic tool, which in methodological terms is constantly being improved depending on the current situation and the market conditions.

The proposed methodological recommendations are general for the wide field of analytical activity aimed at the innovative development of agriculture. With regard to the specific type of development presented in this paper, the assessment indicators can be supplemented and adjusted. The practical possibilities of the proposed assessment recommendations are as follows:

1) participation in statistical assessment of the level of innovative development in the agricultural sectors, the level of their technological development to facilitate the development of new scientifically-based methods of agricultural production in terms of content and quantity.

2) the use for analytical purposes in the framework of evaluating the efficiency of innovative technologies of the agricultural sectors, as well as for regional comparisons in dynamics (while the maximum and minimum values of indicators among the regions of the Russian Federation within the study period are taken as reference points, which allows to compare all regions).

The latter gains its relevance in terms of the problem underlining the need to eliminate inter-section and territorial imbalances in agriculture due to increased trends in the unevenness of the level and pace of development, due to territorial features, priorities of section development, problems of certain economic areas of the country and municipal government.

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