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# Innovative Technologies in Agriculture

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***Abstract:*** ***Agriculture is a key industry for solving problems on food security, economic and environmental sustainability. Due to this, issues of restoring the industry intensity are becoming vital. In the article it is emphasized that this process should be implemented through an evolutionary transition to the fifth technological mode. This implies bringing the number of agricultural machinery to standard values and its subsequent equipping with means of information control over the operation of all technical systems, as well as parallel driving. The search for ways to restore soil fertility by using biologization of agriculture is becoming highly relevant under the conditions of increasing toxicity of chemical mineral fertilizers remaining in soils, the acute imbalance and nutrient deficiency. The Russian agriculture should be reindustrialized by using achievements of biotechnology. The use of the biological product system of fertilizers and the protection of plants from pests and diseases should result in the widespread development of the organic agricultural production. However, the availability of innovative technologies remains low for most agricultural producers. The reason for this situation is the low intensity of the reproduction process in the industry, accompanied by low profitability of agribusiness. The state should motivate the transition to innovative agricultural production technologies. On the one hand, it should initiate the creation of enterprises on producing resources for using innovative technologies in agriculture, and on the other hand, – regulate the intersectoral redistribution of the created value, avoiding the "zero" profitability of production among participants of production systems, and, on the third hand, – maintain or increase the profitable part of the budget.***

***Keywords*****:** ***agriculture, allocation, biotechnology, industrialization, informatization, technological mode.***

## I. INTRODUCTION

Agriculture is a branch of the agro-industrial complex that produces raw materials for the food, garment, perfumery, and cosmetics industries and provides the country's population with freshly consumed food (vegetables, fruits, potatoes, etc.). Its top priority task is to fully provide all domestic potential customers with high-quality agricultural products. The permanence of this task throughout the history of the mankind is determined by the basic need in the people's nutrition and protection from the adversative environment [1], [2].

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At the present stage of the society's development this problem can be solved by increasing the industry intensification based on the use of industrial methods of agricultural production. The awareness of this need caused the development of machine systems used in all sectors of agriculture. Their permanent perfection continues.

## II. PROPOSED METHODOLOGY

### *A. General Description*

The study was carried out by using economic methods, including the monographic, analytical, synthesis methods, calculation and constructible, economic and statistical methods that had made it possible to obtain reliable results that laid the foundation for the conclusions.

### *B. Algorithm*

Until the early 1990s the Russian agriculture had been industrialized systematically (Table 1). This resulted in an accelerated increase in the agricultural production and the development of the agro-industrial complex as a whole. Thus, during 1961 – 1990 the production of grain had increased 1.5 times, sugar beets – 1.8 times, sunflower seeds – 1.3 times, milk – 1.8 times, cattle meat – 2.7 times, and pork – 2.4 times.

**Table 1. Periodization of Agricultural Industrialization in Russia in the 20th Century**

| Area of agricultural industrialization in Russian | Period |
|---|---|
| 1. Introduction of power machines | 1928 – 1940 |
| 2. Chemicalization and amelioration, as well as the use of machine systems | 1950 – 1970 |
| 3. Intensification of using the resource potential | Late 1970s – early 1980s |
| 4. Use of the integrated approach to intensification | 1980s |
| 5. Mechanization and automation | Late 1980 |

## III. RESULT ANALYSIS

In the 1980s the Russian agriculture was industrialized in several areas of accelerating the agricultural production and was characterized by high dynamism. They included the integrated approach to developing the industry management systems that covered aspects of the complete mechanization of production processes, breeding work to develop highly productive varieties of agricultural plants and livestock breeds suitable for the machine-based work, as well as testing solutions on organizing agro-industrial formations established by various types (hard, soft) of the inter-industry interaction.

Unfortunately, during the 1990s and the first decade of the 21st century, the agrarian sector of the economy was de-industrialized and de-technologized. The industry lost at least RUB 1.1 trillion.

The de-industrialization as a transition to a lower technological mode in the Russian agriculture came not only with a drop in the production, but also with an outflow of capital from the industry to the fuel and energy complex of the country. The mechanism of disparity in prices for products in the national economy, combined with a tight monetary policy and the adopted way of privatizing the agro-industrial complex of the country violated the reproduction process in the industry, which determined the systemic crisis in agriculture.

It took three decades to overcome this, and it started with the intensification of state participation in the redistribution of the national income created in the country's economy. However, the efforts of the state in this area of restoring self-financing of agribusiness are not systemic, and in cases of unreasonable market outbursts in the fuel and resource market, they require "hands-on management" from the country's government. Such situations do not contribute to improving the stability of the development environment in agriculture and form critical external risks for the management of agricultural enterprises. In the context of the increasing shortage of material and technical support for agricultural producers, the de-industrialization of production is steadily deepening (Fig. 1).

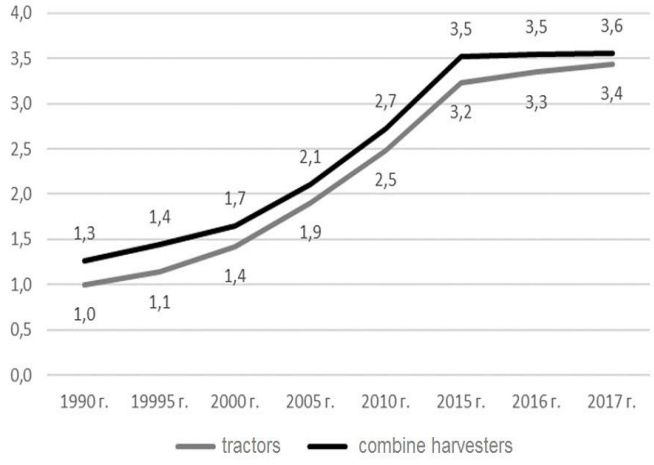


**Fig. 1. Exceeding the Actual Load of Arable Land per One Tractor and Seeds of Grain Crops per One Combine Harvester over the Standard Value in Russia for 1990 – 2017, Times**

By 2017, the excess of the actual load of arable land (grain crops seeds for combine harvesters) per one tractor over the standard value had been 3.4 times, per one combine harvester – 3.6 times. For 2013 – 2017 the machine and tractor fleet had been annually renewed on average only in relation to 3.2 % of the technical equipment, which was three times less than the required level. In order to fully renew tractors and combine harvesters under such speed of putting new equipment into exploitation, it will take at least 35 years, which is unacceptable in the context of the new industrialization of the industry.

It is necessary to note that the conclusion on a radical innovative renewal of the machine and tractor fleet is untenable: the power equipment per 100 hectares of the sown area was 198 hp, which is 1.8 times less than in 1990 (Fig. 2).

The increase in the energy labor ratio of labor in agriculture over the period under study by 64.7 % is only due to the excess of the rate of reduction in the number of workers employed in the agricultural production over the rate of decrease in the energy capacities involved in the industry.

There is a difficult situation elated to the soil fertility restoration. Despite the increasing volumes of mineral and organic fertilizers applied for crops, which amounted to 55.02 kg/ha of mineral fertilizers and 1.5 tons of organic fertilizers in 2017, the balance of nutrients in the soil is sharply deficient (Fig. 3). V.I. Turusov notes that in the Voronezh Region – the one with the black soil recognized as the standard for soils in the world, the amend of nitrogen yields is 60 %, of phosphorus – 50 %, and of potassium – 40 %. For 1991 – 2017 the level of mineral fertilizers had decreased from two to three times, and the manure of the arable land – from three to five times [3].

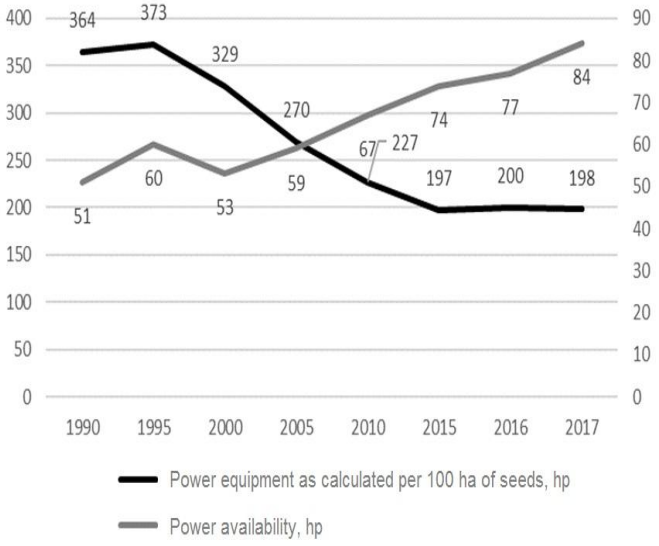


**Fig. 2. Power Equipment and Power Availability in the Russian Agriculture in 1990 – 2017**

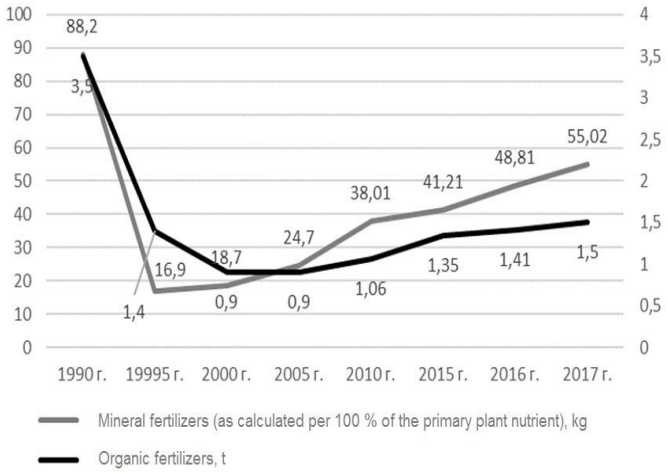


**Fig. 3. The application of mineral and organic fertilizers per 1 ha of seeds in Russia in 1990 – 2017**

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The reasons for the unsatisfactory reproduction of the soil fertility in the country include, firstly, the lack of financial resources for their acquisition in the amount of amending the removal of nutrients from the soil by the crop, and secondly, the lack of technical capabilities to carry out works on fertilizing the soil within the terms in accordance with agricultural requirements.

It is necessary to note that the reduction in the material and technical base of agriculture as a result of the insufficient resource potential of economic producers was degenerative and, accordingly, the revival of renewing the machine and tractor fleet does not dramatically change, i.e., it is renewed within the existing technological mode [4].

According to E.D. Arinicheva [5], the Russian economy covers several structures, but mainly it has the characteristics of the fourth mode.

A. V. Golubev indicates that the modern national agriculture is a combination of the II – IV technological modes that are developing in various industries and categories of farms [6]. The multiformity of the agrarian economy in the country has largely determined the possibilities of agricultural producers for technological development: small organizations and households are focused on using the simplest crop and livestock farming systems, large agricultural formations are more advanced and have innovative technologies of the V mode (poultry farms, greenhouse complexes, and pig farms).

Thus, by the second decade of the 21st century, in agriculture, the material and technical base of the industry, corresponding to the IV technological mode, had not been fully restored. As a consequence, it is decaying to the pre-industrial period.

Theoretically a technological mode is the use of modern achievements of the scientific and technological progress in mass production, and the increase in the parameters of the reproductive process of the final product based on its acceleration or growth of the market size. S. Yu. Glazyev defines it as "a group of technological aggregates allocated in the technological structure of the economy related to one another by the same technological chains and forming reproducing integrity. Each such mode is an integral and sustainable formation where there is a complete macroproduction cycle, including the extraction and obtaining of primary resources, all stages of their processing and the production of final products that meet the relevant type of public consumption" [7]. Based on this point, the industrialization is an intermediate result of the technological mode and the final result of reproduction cycles based on using achievements of the scientific and technological progress. It is inherent in changes when changing technological modes (Table II). In its turn, in the modern economic reality of Russia the industrialization is the result of large-scale implementation of innovations in the production sector.

Common features of industrialization that are characteristic of all technological modes are the minimization of the human labor in the structure of total labor costs and the need in the exponential increase in the level of staff qualification.

**Table 2. Areas of Agricultural Industrialization in the 20th – 21st Centuries**

| Technological mode | Industrialization area |
|---|---|
| IV. Mechanization and electrification | Development of industrial production technologies and machine systems, implementation of industrial principles of production organization (rhythm, flow, synchronization) |
| V. Automation and computerization | Modernization of machine systems in order to more fully use the potential of natural resources and living organisms. |
| VI. Robotization, genetic engineering, nanotechnology | The use of artificial intelligence in the system of production and agribusiness management |

Thus, the transition of agriculture to the V technological mode based on the maximum automation and computerization of the technological process of growing agricultural plants, animals and poultry makes it possible to more fully use the biological potential of varieties and breeds when applying the individual approach to work operations in production, and to the VI one – to almost completely refuse from using the human physical power in the production process.

The basic innovations of the V and VI technological modes that will be used in agriculture include information technology, biotechnology, genetic engineering, and nanotechnology [8].

The information technology is the basis for creating a sufficient information base about an object or process to make a decision on any action. Now they are materially embodied in information systems combining information technologies and technical means for collecting, processing, transmitting, and storing data on the subjects under study. The information systems of the V mode are the ones that control the efficiency of tractors, combine harvesters, sprayers, parallel driving, precision farming, robots for milking cows, animal recognition, of the VI mode – the ones that possess remote control of the machine and tractor fleet.

Biotechnologies are the technologies based on the applying the engineering approach that makes it possible to more fully use the biological potential of living organisms.

In 2017, the global green biotechnology market (improvement of agriculture and food products, combating plant pests and animal diseases) amounted to USD 10 billion, and it will potentially grow up to USD 57 billion by 2035 [9]. In other words, the economic opportunities of the industry will increase proportionally to the increase in the awareness about the need to use the existing technologies to eliminate the risk of starvation and maintain the favorable human environment.

Biotechnologies of the V technological mode include the following:

– Creation of high-yielding varieties of agricultural plants that are resistant to adverse factors,
– Biological fertilizers and means of protection,
– Biohumus production, and
– Development of organic farming.

According to the experts from the Union of Organic Agriculture, the economic effect from producing biological products is 500 – 1,000 % [10].

The leader in the biologization of agriculture is the Belgorod Region that implements a comprehensive program in this area. It provides for the introduction of differentiated crop rotations, the increase in areas with perennial grasses, the use of the occupied vapors practice, the substitution of solid fertilizers with organic ones, and the substitution of chemical plant protection products with the biological ones [11]. According to P.A. Chekmareva and S.V. Lukina, over the years of implementing the agricultural biologization program in the region, the level of using organic fertilizers has increased up to 5.7 t/ha, and the use of mineral fertilizers has decreased down to 93 kg/ha, while the share of legumes in the structure of sown areas has increased up to 19.8 %. It has resulted in the highest crop yields in the Central Black Earth Region of the Central Federal District [12]. The executive power of the Belgorod region (S. Aleinik) recognized the fact of leveling adverse climatic factors and ensuring the realization of the varietal potential of the main crops. In 2019, the decision was made to prolong the program on agricultural biologization. Along with the degradation risks of natural origin, its main task is to combat anthropogenic factors of reducing soil fertility [13].

However, the availability of innovative technologies for most agricultural producers is currently too low. According to A.V. Petrikov, advanced technical and technological solutions are widely used only in 10.3 % of the agricultural organizations, and 9.3 % of the peasant farms (farms) that took part in the agricultural listing in 2016 [14].

This is caused by the independent choice of development areas by business entities that sometimes do not have the required competence in substantiating innovation and investment activities. A conceptual solution to the problem of technological transformation in agriculture was formulated in the protocol of the Presidential Council on the modernization of the economy and innovative development of Russia. It provided for:

– Developing the lists of the best available technologies recommended for agricultural enterprises,

– Conducting independent certification of agricultural producers in order to assess their technological level, and

– Developing offers on differentiating state support for agricultural producers depending on the technological level of their agricultural activities [15].

Based on this conceptual solution, “road maps” were developed for the transition to the V technological mode in the agricultural sector of the country, providing for the use of biodegradable materials in the production of consumed products (at least 8 % of the total volume of consumed products), the development of the liquid and solid biofuel production sector (up to 8 % of the total fuel consumption), the use of biological plant protection products and microbiological fertilizers, the increase in the share of agricultural waste utilization by using technological methods (50 %), etc.

These measures would make it possible to solve the dual task on improving the environmental safety for the modern generation and preserving the environment for the future generations. However, such development is constrained by the following:

1) The lack of resources for the large-scale construction of factories on biotechnological production, the renewal of the agricultural fleet equipped with devices for information mapping of fields, precision farming systems,

2) The lack of qualified personnel to solve issues on implementing and applying information technologies, and

3) Physical inaccessibility of the production means of the V technological mode.

According to V.I. Chernoivanov, A.A. Ezhevsky, N.V. Krasnoshchekov, and V.F. Fedorenko, about 15 – 20 % of the farms use common technologies, and 10 – 15 % – intensive technologies [16]. Taking into account that the profitability of the agricultural sector of the economy does not exceed 10 %, the formation of sufficient capital for a revolutionary transition to the next technological mode seems to be impossible without the government support.

Many researchers emphasize the need in “new industrialization”, but there are three tendencies in the scientific thought. They focus on essentially different ways of achieving high parameters of the economic development [17]. In relation to the agriculture, they can be formulated as follows:

– Reindustrialization of the industry by increasing the material and technical base of the IV technological mode,

– Neo-industrialization, involving the restoration of agriculture at the level of the modern technological basis characteristic of the industrially developed Western countries and the USA, and

– Over-industrialization, providing for the possibility of technological “leap” or advanced development at the level of large-scale robotization of agricultural production.

Academician E. Sergeev points to the impossibility of a qualitative “leap”. Despite the fact that “the goal of the new industrialization is to transfer to the VI technological mode... This transition is impossible without reconstituting the IV and V technological modes” [18]. This statement is true for agriculture. Modern innovative means of production developed and applied in crop and livestock production cannot be unambiguously referred to the high-tech types of resources of the VI technological mode and allow the combination of resources from earlier generations. For example, the dairy cattle breeding can get the development impetus by using and widely introducing robotic milking and cows caring systems (VI technological mode), and grain production – by using combines equipped with mapping terminals with the ability to determine heterogeneity zones and soil samplers (V technological mode). It is necessary to note that the use of such means in production processes is limited to single items because, despite the increase in the productivity of natural resources, the efficiency from the point of view of the efficiency of capital investments in such facilities is of zero or negative value for agricultural producers. Due to this, the problem of neo-industrialization in agriculture is related to ensuring the possibility of expanded reproduction under the current economic conditions.

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Taking into account the high capital intensity of innovative products of the V and VI technological modes, the shortage of free financial resources of economic entities in the agricultural sector, and the difficulty of attracting the large borrowed capital for the long term, a new industrialization of agriculture is impossible without state participation. It should be the main investor and the motivator for the transition to innovative production technologies in the economy of the country as a whole and agriculture in particular. However, the state should undertake to develop the innovative infrastructure and create such organizational and economic mechanism for the functioning of all participants in the economic field that will allow "fair" distribution of material and cash flows generated within production systems (product subcomplexes of the agro-industrial complex). According to the practice, market relations do not fully contribute to the efficient distribution of the final cost of the product. For example, in 2016 in the grain product subcomplex of the agro-industrial complex in the national economic space, the profitability of the agribusiness amounted to more than 20 %, and that of the grain processing industry – 4.1 %, or five times less, that of grape and wine-making – 6.1 % and 34.2 %, respectively; that of dairy industry – 8 and 1.2 % [19].

In the context of complete economic independence, when each commodity producer, regardless of its place in the technological chain, focuses on achieving the parameters of self-sufficiency, self-financing of activities and maximizing business profitability, the provision on zero profitability in raw materials industries (agriculture) and low-processing industries [20] does not stand up to criticism. According to the authors, the object of the intersectoral redistribution should be the natural rent taken by the state in the form of taxes, rather than the added value created in the initial branches of the technological chain. The fund formed from these payments of the agricultural sector of the economy should be aimed at supporting reproduction processes in related industries.

Taking into account the possibilities of multidirectional tendencies in the movement of intra-industry capital flows, the state functions should include constant monitoring of the economic situation in various product subcomplexes of the agro-industrial complex and regulation of financial flows through pricing, taxation and state support systems aimed at creating an even distribution of total income among participants in the joint production of the final product of the product chain.

## IV. CONCLUSION

The development of agriculture as a system-forming industry should be based on a new industrialization of the industry, combined with the improvement of the organizational and economic mechanism of reproduction of all participants in the technological chain of production and product movement.

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