

# TECHNOLOGICAL AND TECHNOLOGICAL SUPPORT AS THE MAIN FACTOR OF SUSTAINABILITY DEVELOPMENT OF AGRO-INDUSTRIAL PRODUCTION

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*Abstract: Creation of prerequisites for increasing the efficiency of crop production through the innovation development of the industry on the basis of knowledge-intensive technologies and technology and their compliance with the conditions of conducting agrarian business. Monographic, economic-mathematical, graph-analytical, system engineering. It was established that the main reserve for improving the efficiency of agricultural production is the innovative development of the industry on the basis of resource-saving technologies and technology of the new generation. It is determined that the characteristic feature of the modern period of development of agricultural production is the need to ensure the continuity and rhythm of production processes, their adaptability to changing natural and climatic conditions, increase resource - and energy efficiency due to technical and operational-technological characteristics of the technology, its universalization. Requirements for the development of the material and technical base of the agrarian sector of the Ukrainian economy are determined. The general direction of the development of the technical and technological base of agricultural production should be the creation and production of universal machines equipped with automation tools that are easy to adapt to the specific production conditions and requirements of agrotechnics, and ensure the implementation of technological processes in the established agricultural machinery with the minimum possible costs of energy resources for the production of safe food products.*

**KEYWORDS:** TECHNICAL AND TECHNOLOGICAL BASE, INNOVATIVE DEVELOPMENT, SCIENCE-INTENSIVE TECHNIQUE, COMPLEXES OF MACHINES.

## FORMULATION OF THE PROBLEM

Agriculture of Ukraine is a major budget-and export-oriented sectors of the national economy. Its share in GDP in 2016 was 14%. More than three million people work in the agricultural sector and 40% of foreign exchange earnings brought efficiency. Today is the only industry that shows a positive dynamics of production [1].

The natural and climatic conditions of Ukraine are favorable for the production of many types of agricultural products, but they are characterized by a large variety of soils and climatic zones, which significantly affects the structure and technology of production, requirements for technical and operational parameters of agricultural machinery, productivity of machine-tractor aggregates and production efficiency.

The technologies of cultivating crops have come a long way in evolutionary development. However, what was not perfect was the technology in the agricultural system, it remained an unrealizable dream until it was provided with the same perfect technique.

In the context of exacerbation of environmental, economic, energy, social, demographic and other factors, the question of finding rational, effective, environmentally friendly methods of agricultural production becomes more and more relevant. The perspective variants should embody the basics of strategic development of the country's agroindustrial complex, ensure food independence, and solve the society's pressing issue of preserving the village as the primary source of the nation. A simple solution to these issues does not exist. Therefore, today not only is the optimization of the production process, which in many cases is artificially simplified, limited to a small number of factors, and the maximum use of all components of influence, which in the end can significantly minimize the negative effects of the development of the agro-industrial complex.

Energy-saving production in Ukraine is one of the topical issues of today, and agricultural production, as one of the largest fuel consumers in the country, can not and should not stand aside from current scientific advances in the development of technologies and equipment for energy-saving, environmentally safe production of agricultural products.

The low level of techno-technological support of agricultural enterprises is the main reason that holds back their innovative development and increase of efficiency of management.

## ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

Considerable attention was paid to the problems of the efficiency of the agricultural sector and the development of its

technical and technological base in the research of P. T. Sabluka, G. M. Pidlisetskogo, J. K. Belouska, V. L. Tovstopyata, V. P. Sitnika, A. V. Sidorchuka, V. S. Shebanina, V. M. Trigobchuka and others. [1-10]. In his writings, the authors mentioned the state and problems of provision of agricultural technical resources.

## THE PURPOSE OF RESEARCH

Creation of prerequisites for increasing the efficiency of production of crop production due to the innovative development of the industry based on science-intensive technologies and technology and their compliance with the conditions of agrarian business.

## RESEARCH METHODS

Monographic, economic and mathematical, graph-analytical, system engineering.

## RESEARCH RESULTS

The analysis of the costs of agricultural production shows that their structure in the post-Soviet years has changed significantly: since 1990, labor costs have decreased by almost one-sixth, while the cost of mineral fertilizers, fuel and oils has doubled, while expenditures on agricultural work by hired technicians have increased more than three times (Table 1). This is due to a change in the structure of crops and the introduction of energy-saving hi-tech technologies and technical means for their implementation on large areas.

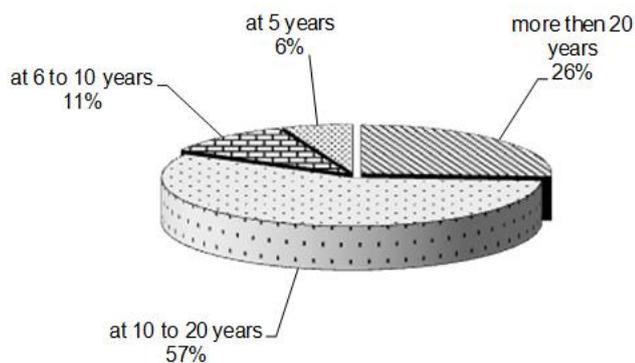
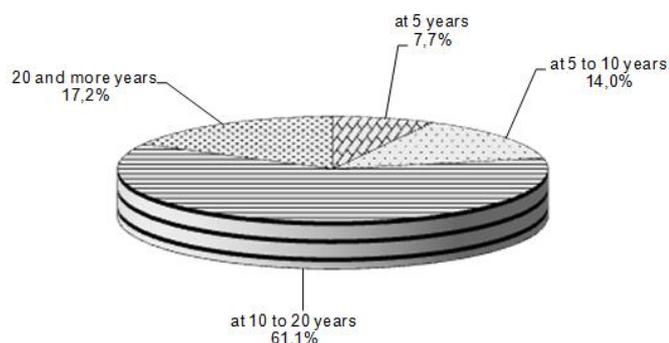
Main reserve for increasing the efficiency of agricultural production is the innovative development of the industry based on energy-saving technologies and new generation technology. However, the low level of technical and technological base of most domestic agro-industrial enterprises does not ensure the intensive transition of the industry to the innovative direction of development. It is only available to large agri-companies and agroholdings with sufficient investment opportunities.

In the structure of the machine-tractor park of small agricultural enterprises, a high proportion of morally and physically worn machinery and equipment. In particular, the share of tractors and combine harvesters in service for more than 10 years is about 80% (Fig. 1, 2).

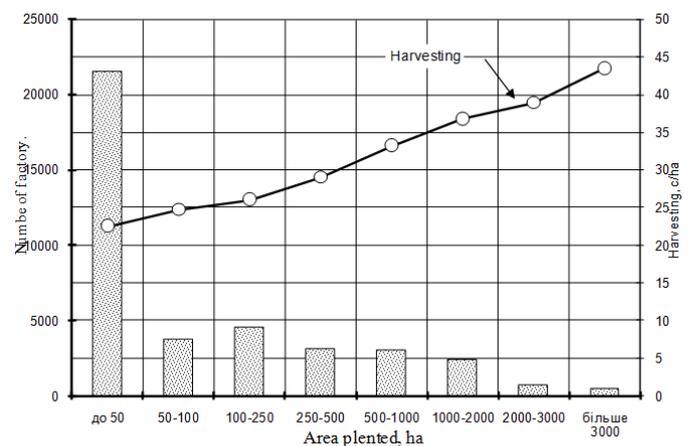
Morally outdated, physically worn out technique does not ensure timely performance of work, which leads to a significant shortage and loss of crop, impedes the introduction of advanced technologies for agricultural production. As a result, small farms remains low crop yields [2] (Fig. 3), and agricultural production and intensive labor-intensive, which reduces its competitiveness in the market and profitability.

**Table 1.** Structure of expenditures on agricultural production in agricultural enterprises, %

Costs	Years				
	1990	2010	2012	2015	2016
Salary expenses	35,6	9,1	9,2	5,4	5,5
Deductions for social events	4,2	3,2	3,4	1,9	1,2
Material costs, which are included in the cost of production,	40,4	70,0	68,7	73,7	71,2
100,0	100,0	100,0	100,0	100,0	100,0
in particular:					
- seeds and planting material	13,7	11,6	13,9	12,5	12
- feed	52,1	26,2	24,9	19,2	20
- other agricultural products	5,3	2,8	3,5	1,8	1,8
- electricity	1,4	2,3	2,0	1,5	1,6
- mineral fertilizers	9,0	15,4	18,6	19,5	20,0
- fuel and oil	5,1	14,2	14,5	13,7	11,3
- fuel	0,7	1,5	1,9	1,4	1,1
- spare parts, repair and building materials	6,0	6,9	7,1	8,1	8,3
- payment for services and works executed third-party organizations	6,7	19,1	19,7	22,6	23,9
Depreciation of fixed assets	9,8	5,7	5,3	4,5	4,9
Other expenses,	3,0	12,4	13,4	14,5	16,5
100,0	100,0	100,0	100,0	100,0	100
of them:					
- rent for land parcels (shares)	–	56,7	59,2	60,3	62,4
- property shares	–	0,8	0,4	0,7	0,4

**Fig. 1.** Structure of the fleet of tractors for the length of stay in operation**Fig. 2.** The structure of the park of combine harvesters for the length of stay in operation at agricultural enterprises of Ukraine

The technologies of cultivating crops are characterized by considerable length of time in the process of crop formation and depend on a number of controlled and uncontrolled factors such as the potential of the variety, plant protection system, fertilizer system, soil and climatic conditions, soil cultivation systems and sowing, characteristics of technological materials and technical means, terms of work, etc.

**Fig. 3.** Average yield of grain crops in farms with different sizes of sown area

The existing form of this expression can be written:

$$T = f(A, C, G, K, O, L, D, U, Z, P, M), \quad (1)$$

where  $A$  – agricultural machinery growing of agricultural crops;  
 $C$  – the potential of the variety;  
 $G$  – fertility potential of soils;  
 $K$  – climatic conditions;  
 $O$  – system of cultivation of soil;  
 $L$  – a way of sowing;  
 $D$  – system of care for crops;  
 $U$  – fertilizer system;  
 $Z$  – plant protection system;  
 $P$  – level of staffing;  
 $M$  – level of logistics.

Today, agricultural producers are offered various technologies for the cultivation of basic crops, which is usually in line with the business interests of sellers and manufacturers of machinery based on the prescription principle of performing technological techniques with specific brands of agricultural machines or aggregates.

One of the main basic elements of different technologies which further defines the identity of each technology to a particular

group, is a system of cultivation. It is the soil cultivation system and the complex of technical means for its implementation to a large extent determine the level of energy efficiency of a specific technology, its ecological and economic orientation.

The value of mechanical cultivation is due to the effect of the working bodies of machines on all the properties of the soil, since it is the soil cultivation that promotes the creation of a proper agrochemical environment in the roots of the soil layer.

For agriculture, the economic efficiency of soil cultivation is also relevant, since soil cultivation is one of the most energy-intensive and labor-intensive processing operations. Depending on the technology, up to 40%, up to 41% of energy consumption and up to 25% of labor costs account for up to 40% of direct operating costs. Different methods of soil cultivation differ significantly in energy costs, so their choice should be aimed at achieving the goal set before them with minimal energy consumption. Equally important is the ecological effectiveness of soil tillage systems, since among them there are those that have a mobilizing effect on soil fertility reserves (shelves), while others have a more cost-effective effect on the use of energy resources and labor costs (surface, "zero", lane cultivation of the soil).

For technical support cultivation systems representing a sequence of interconnected field operations may use a large variety of means that are different than the way the impact on the soil and on the technical and operational parameters, but they should, with appropriate training to work, to ensure the implementation of technological techniques in accordance with agrotechnical requirements both to quality and to the timing of their implementation.

NSC "IAEE" in cooperation with machine-building enterprises created and brought to serial production more than 20 types of technical means for providing the latest energy-saving technologies for soil cultivation. These are cultivators, disk harrows, discs and chisels.

The main task of agrarian production at the present stage is the use of new generation technologies that allow maintaining the biological and ecological balance in nature, ensuring a reduction in the costs of all kinds of resources per unit of products, improving its quality and safety. The production of competitive ecologically safe agricultural products does not imply simplification of technology, but justified the effective use of natural conditions, rational application of soil cultivation and fertilization systems, plant protection and other measures that ensure the production of products with minimal cost of material and technical resources and labor. The basis of such technologies is optimization of the placement of crops in crop rotation and the implementation of the entire complex of works in the best possible terms, in accordance with the requirements of agricultural technology in terms of their quality. Therefore, the technology for such technologies should be equipped with means of automation of control and management of technological processes.

Now in Ukraine for the preparation of soil for agricultural crops the following basic technologies are practiced: a classic (differentiated) soil cultivation system; surface cultivation; preservative; zero (No-till) and strip making (Strip-till). Each technology has its advantages and disadvantages, which are manifested differently in various soil-climatic conditions of Ukraine.

The differentiated soil tillage system is based on the use of plows, disk implements and cultivators to prepare the soil for sowing in the crop rotation system. This technology is economically feasible in the case of sufficient rainfall, time deposits, technical and operational resources for its implementation, as well as the need to earn a large amount of plant residues, organic fertilizers or siderates in the soil, and reduce the pesticide load on the soil.

The technology of surface cultivation is widespread during the preparation of the soil for winter sowing. It is based on the use of wide-reaching lap, disk and combined implements that loosen the soil to a depth of 16 cm. It is a moisture-saving, high-performance, energy-saving unit per square meter. This technology provides loosening of the surface layer of soil with preservation of 60-80% of

plant residues as mulch on the surface.

The conservation technology of cultivating soil at a depth of 25-40 cm is carried out by heavy cultivators, deep-throwers, chisels or combined implements. Technology – moisture-accumulating, energy-saving per unit of production. It can be used mainly during soil tillage in all soil-climatic zones of Ukraine. This technology provides loosening of the compacted layer (plow sole) and intensive loosening of the surface layer with the preservation on the surface of up to 40% of plant residues.

The technology of seeding in unprocessed pre-soil (No-till) is based on the use of special units of direct sowing of agricultural crops and chemical means of combating weeds and pests. It is highly efficient, minimizes direct energy costs for soil tillage, moisture-retaining, on the surface of the field all plant remains, which protect the soil from deflation. Positive results for this technology are achieved only for 4-5 years from the beginning of application and are lost when other technology is used.

With the technology of striping (Strip-till), the soil is loosened to a depth of 30-35 cm only in the seeding zone with simultaneous placement in the loose zone of nutrients. At the same time, the plant remains on the surface of the line from the zone of the line are moved to the intermediate row, act as mulch and inhibit the growth of weeds.

In order to implement this technology, the NSC "IAEE", together with LLC Krasnyanske Joint Venture "Agromash", created an aggregate for the strip cultivation of the soil.

In practice, in successful farms, elements of all technologies are used, taking into account technical equipment, specific conditions that are predicted and formed at the farm at the time of preparation of the soil. Experienced technologists approach the choice of technologies and their elements are always creative, differentiated.

According to foreign economists, technological innovations provide an increase of 70-80% of the gross domestic product. In the United States, the growth of the national gross income per capita by technological innovations reaches 90% [5]. Underestimation of the leading role of technology greatly reduces the competitiveness of production.

The use of outdated resource intensive technologies in agricultural production does not allow to reach high yields and obtain competitive products, which is especially relevant in the context of lowering the cost of grain on world markets.

In order to overcome technical and technological backwardness in the agricultural sector of Ukraine, it is necessary to develop and implement a technological breakthrough strategy that would involve the widespread use of progressive resource-saving technologies for the production and processing of agricultural products. However, what is not perfect technology in the agricultural system, it will remain an unfulfilled dream if it is not provided with the same perfect technique. Therefore, the search for ways to improve the economy of agricultural enterprises should be oriented towards creating conditions for optimal provision of their modern equipment as a prerequisite for the innovative development of the industry.

In modern conditions, agriculture needs not just a new technology, but a material and technical base that will increase the productivity of labor several times. Its formation is possible only on the basis of technical means of the new generation, the parameters of which should be oriented towards the achievement of high levels of productivity with minimum costs of living and settled labor per unit of production.

To ensure the production of crop production with minimum labor costs and material and technical resources, it is necessary to form a corresponding set of technically, technologically and organizationally interconnected means of mechanization that will ensure the fulfillment of the requirements of agrotechnics regarding the quality of performance of work in specific soil-climatic conditions in the specified agro-technology.

The totality of technically, technologically and organizationally interconnected technical means for the mechanized

production of a certain type of product form technological complexes of machines.

The main factors for justifying the parameters of the machine-tractor park are technologies, work processes and technical means.

Technology in this research is considered as a way of qualitative transformation of the objects of labor (soil, agricultural materials) from the state "as it is" into the state "as it should be", regulated by a certain set, sequence and time periods of implementation using the appropriate means of labor [8]. The basis of these methods are physical, chemical, biological and combined effects.

The aggregate of knowledge about the ways of qualitative transformation of objects of work from the state of "as is" to the state "as it should be" is called machine technology.

Technical means for the qualitative transformation of labor objects are divided into working bodies, machines, machine-tractor units, technological systems of machines.

The working bodies perform elementary (working) operations for the qualitative transformation of labor objects from the state "as it is" to the state "as it should be".

Work processes, based on which different ways of transforming the objects of labor, are realized with the help of appropriate working bodies. To substantiate their rational structural and technological parameters taking into account the time modes of functioning, the dependence of the quality of the implementation of the work process  $I_p$ , on the initial properties of the subject of labor, the method of its qualitative transformation  $Q$ , the modes of implementation of the work process  $W_p$ , and the structural and technological parameters of  $P_o$ , are investigated:

$$I_p = f(Q, C_n, W_p, P_o). \quad (2)$$

One or another method of qualitative transformation of the subject of work can be realized by various working bodies, which differ in structural parameters, the mode of execution of the work operation and the energy required for this. In this connection, the task of selecting from among several well-known working bodies is the one that will ensure the highest quality performance of the operation with the least energy consumption. To do this, research on various working bodies and their combinations and the comparison of indicators of qualitative transformation of the subject of labor and energy expenditure. According to the results of the research, the most effective working bodies synthesize in the design of the machine, defining it as a single-operation or multi-operational.

Machines perform one or several technological operations and are components of technological complexes.

An indispensable stage in the research of technological complexes of machines is the substantiation of parameters and modes of operation of machine aggregates, which can be implemented as self-propelled machines or machine-tractor aggregates. The peculiarity of the research units of machine is something that it can not be done without a machine research results. In order to justify the parameters and modes of operation of machine aggregates, the technological processes (TP) that will be executed by the machine aggregate are initially investigated. The main method of research is modeling processes. Due to the fact that the process of processes is influenced by a number of factors, many of which are probabilistic, the adequacy of models for real processes can be guaranteed only with the use of statistical simulation. Models are developed based on empirical or predictable data.

To substantiate the rational technological complexes of machines, the work of the whole set of machines that are part of the complex is modeled. At the same time, both technological and transport processes, which provide spatial displacement of seeds, fertilizers and other technological materials and cultivated crop between warehouses and machine aggregates, are modeled.

Due to the fact that the problem has a large dimension, it is extremely complicated, and the interaction of its components both internally and with the external environment is not sufficiently studied, its research is carried out by means of decomposition into a

number of tasks, which are:

- research of technologies of agricultural production and requirements of agricultural machinery to the quality and timing of technological operations in time and space;
- research of machine processes, substantiation of technological and structural parameters of a machine and operating modes, which make it possible to fulfill the requirements of agrotechnics to the quality of work with minimal energy consumption;
- substantiation of technological complexes of machines that enable mechanized production of the corresponding type of agricultural products;
- research of the organizational structure of the agrarian sector and determination of parameters of model farms and demand function for cars of the corresponding type;
- substantiation of standardized series of machines, the use of which will promote the production of agricultural products with minimal cost in agrarian formations of different sizes;
- substantiation of the structure of machine-tractor park of model farms and technological need in technical means of different functional purposes.
- identification of priority technical means, use of technical progress in the industry and the production of competitive agricultural products;
- research of the main directions of development of scientific and technological progress in crop and agricultural engineering, identification of priority research and development works in the technical and technological support of production of crop production.

The economic effect of the use of new technologies and technology in agroindustrial production is estimated by the growth of production volumes, reduction of labor costs and expenses of material and technical resources and energy resources per unit of production, minimizing the technogenic load on the environment. In general, indicators of efficiency in agriculture are manifested in the growth of crop yields and animal productivity, an increase in gross output and characterized by cyclical growth and varying intensity.

A characteristic feature of the modern period of development of agricultural production is to ensure the continuity and rhythm of production processes, their adaptability to changing natural and climatic conditions, increase resource and energy efficiency, with the technical and operational-technological characteristics of technology, its universalization. In these conditions, the importance of controlling factors in technological and production processes increases. The general direction of the development of the technical and technological base of agricultural production should be the creation and production of universal machines equipped with automation tools that are easy to adapt to the specific production conditions and requirements of agrotechnics and ensure the implementation of technological processes in the established agricultural machinery with the minimum possible costs of energy resources for the production of safe products food.

On the basis of the above we can formulate the following requirements for the development of material and technical basis of the agrarian sector of the Ukrainian economy:

- universalization, multifunctionality of technical means;
- increase energy consistency and power of the new generation of power modules, equipped with means of automatic control and operating mode control, in particular control of technical condition;
- creation and use of combined multi-operation machines and multifunctional units, which ensure high quality of technological operations;
- increasing the reliability of machines, reducing the time and labor costs for technical and technological maintenance of machinery and maintaining them in a state of technical readiness;
- creation and use of self-propelled machinery in agricultural production processes;

- consistency of technical and operational parameters of machines and aggregates with the scope of work and timing of their implementation.

These requirements include the development and implementation of machine technology, the harmonization of technical and operational parameters of machines with characteristics of labor objects, their physical, agronomic and zootechnical features.

## CONCLUSIONS

The general direction of the development of the technical and technological base of agricultural production should be the creation and production of universal machines equipped with automation tools that are easy to adapt to the specific production conditions and requirements of agrotechnics and ensure the implementation of technological processes in the established agricultural machinery with the minimum possible costs of energy resources for the production of safe products food.

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