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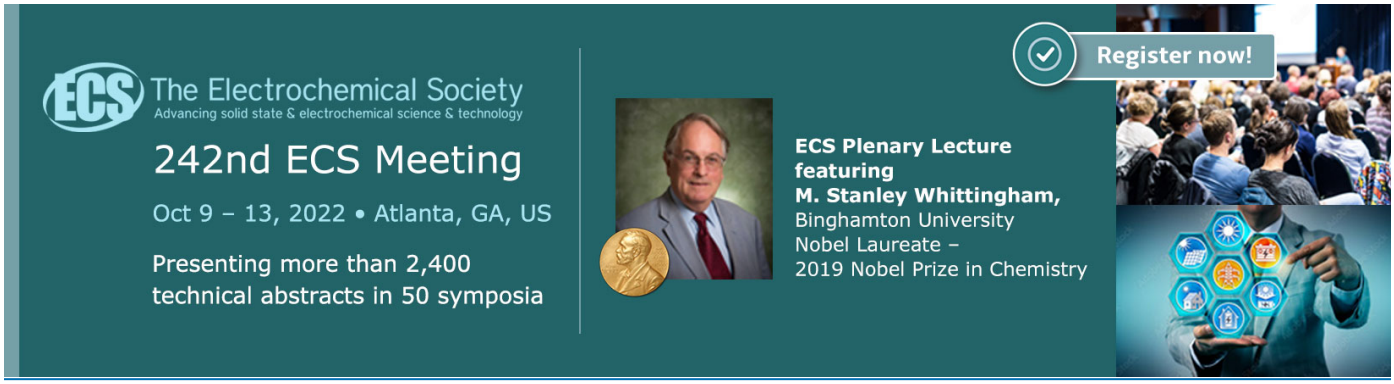

Prospects for technological development of grain production in Ukraine

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Abstract. The article examines the problems of technological support for the production of grain crops and the development of the grain industry in Ukraine. A retrospective analysis of the dynamics of the yield of grain crops and the main food crop - wheat in Ukraine is presented. The necessity of improving agrotechnological methods and introducing zoned varieties of agricultural crops due to the differentiation of climatic conditions necessary for the development of agriculture on the territory of Ukraine has been proved. A factorial analysis of the effect of intensification on the yield and efficiency of growing winter wheat has been carried out, a direct dependence of wheat yield on production costs and an inverse relationship between profitability and production costs have been established. The essence and advantages of using No-till technologies that do not require preliminary preparation of the field for sowing grain crops are disclosed. Modern trends in the development of technologies in agriculture in Ukraine are presented. The advantages of using various models of intensive technologies aimed at maximizing the realization of the potential of varieties and hybrids of grain crops are disclosed. A comparative characteristic of the elemental costs of growing winter wheat with high-cost and resource-saving technologies is given. The system of indicators for evaluating the economic efficiency of methods for improving the technological support of the production of grain crops is substantiated. Key words: technology, crops, intensification, productivity, technological operation, resources.

1. Introduction

The soil cover of Ukraine with various types of highly productive chernozems, occupying 26.5 million hectares, or 44% of the total area of the territory of Ukraine and 6.7% of the world's chernozems, moderate and quite favorable climatic conditions for the production of most cultivated plants have a positive effect on the development of agricultural production. Commodity producers in the agricultural sector of the economy are constantly striving to minimize costs, achieve high yields and grain quality, and improve soil fertility. The main factor in the successful development of agriculture, increasing its competitiveness is the energy-saving technology of growing crops, which contributes to increasing production. Numerous attempts are being made in the industry to introduce foreign technologies and technical means, and discussions are underway to determine the optimality of a particular production technology.

Girka A. D., Kompaniets V. A., Kulik A. A. note the importance and necessity of further development of grain farming, and in particular - the production of high-quality winter wheat food grain and focus their research on the development of differentiated standards of monetary, labor and energy costs for the production of winter wheat grain (depending on the predecessor), as well as the analysis of technological aspects of the formation of costs by items and periods of field work [1]. Methodological aspects of a comprehensive assessment of the potential of agricultural enterprises to ensure the sustainability of grain production were studied by Grinchuk Yu.S., Tkachenko E.V. [2]. The problems of scientific and technological modeling of increasing the efficiency of grain production were considered in the works of V. Yu. Cherchel, M. S. Shevchenko [3], V. A. Kolodiychuk. [4]. Modern aspects of the development of technologies in crop production were studied by V. F. Petrichenko and V. V. Likhochvor [5]. Features of the use of strip-till technologies in agriculture were considered by such authors as Brown M. [6], Selik A. [7], Kravchuk V., Brovarets O. [8]. Kharchenko A.G. was engaged in optimization of the main stages of the implementation of No-till technologies. [9], Malienko A. M. [10], Yasnolob I. O., Chaika T. O. [11]. Skrypnik A., Klimenko N., Tuzhuk K. [12] and others were engaged in substantiating the prospects for sustainable development of grain production in Ukraine.

2. Materials and methods

The purpose of the article is to identify the main problems of technological support for the cultivation of grain crops in Ukraine and substantiate the directions for its improvement through the scientifically based application of technological elements of intensification.

Achieving this goal involves solving the following tasks: identification of the influence of intensification factors on the yield and efficiency of growing grain crops; systematization of intensification advantages of no-till technologies; modeling the application of methods of saving resources and increasing the yield with resource-saving technology; substantiation of priority imperatives of technological development of grain production in Ukraine.

The authors used in the research: the dialectical method of cognition of market processes and a systematic approach (to study the problems that arise in the field of technological support for growing grain crops); analytical generalizations, statistical comparison, computational-constructive (for generalization, factorial analysis and comparative assessment of resource-intensive models of intensive technologies), tabular (for illustrating research results), abstract-logical (for formulating conclusions).

3. Results

In its evolutionary development, soil cultivation technology has gone through the following stages: manual farming with a hoe; plowing and loosening the soil with primitive tools using the draft power of domestic animals; intensive tillage with the use of tractors and agricultural implements; the use of a chemical method of weed control, in connection with which the intensity of mechanical tillage decreased, and labor productivity and crop yields increased sharply (figure 1).

Thus, the yield of grain and leguminous crops has increased in our country by 4.5 times over more than a century, or from 10 centners per hectare in 1913 to 49.1 centners per hectare in 2021. However, such an increase is not described by a straight-line dependence of yield from the progressive development of scientific and technological progress and the introduction of advanced production technologies over time, but by a polynomial approximating function, characterized by periods of decrease and increase in yield in dynamics. During the Second World War, the yield dropped to the level of 1913. The technical and technological renewal of agricultural production from 1953 to 1989 contributed to an increase in grain yields by almost 2.8 times. During the period of market transformations in the agrarian sector of the economy (1990-2007), the decrease in the yield of grain and leguminous crops was due to the insufficient level of material, technical and technological support for grain production.

A similar situation has developed with respect to the main food crop - wheat (figure 2).

Differentiation of climatic conditions for the development of agriculture on the territory of Ukraine lead to the need to use various agricultural technologies (technological operations) for the production and introduction of released varieties for growing crops. The factor effect of intensification on the yield and efficiency of wheat cultivation is presented in table 1.

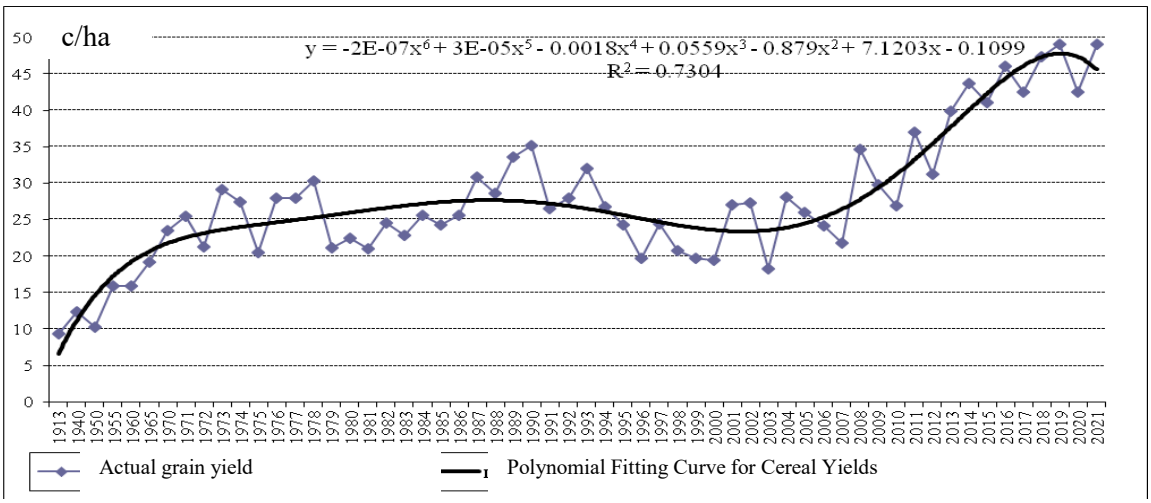

Figure 1. Dynamics of grain crop yields in Ukraine.

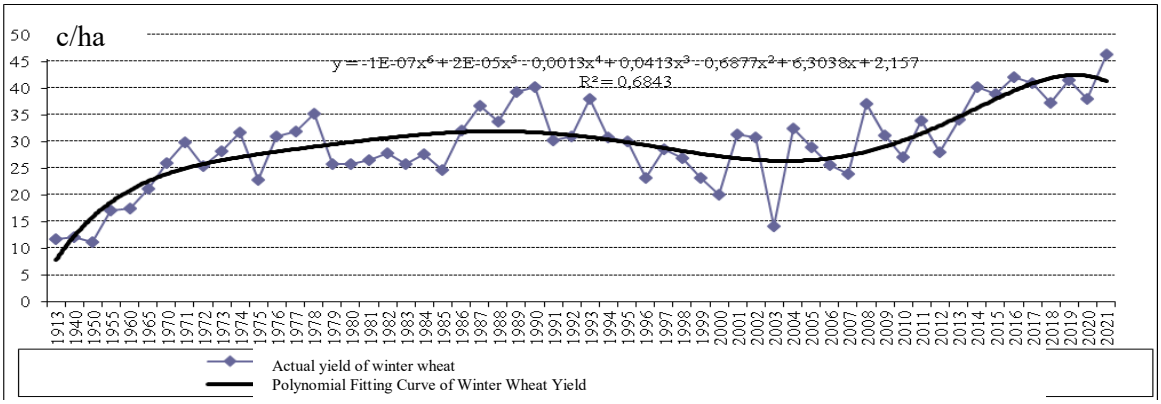

Figure 2. Yield dynamics of winter wheat in Ukraine.

Research has established the presence of a direct relationship between wheat yield and production costs and an inverse relationship between profitability and costs of wheat production per 1 ha. So, with production costs up to 3000 UAH/ha, the wheat yield is 25.2 centners/ha. This indicator is largely provided by the natural fertility of the soil with a profitability of production of 55.2%. With an increase in the level of production costs, the yield of wheat increases, and the profitability of production decreases. The highest yield of 51.5 c/ha was provided by production costs, the value of which exceeds 11,500 UAH/ha. The level of profitability was only 19.0%. A direct relationship is also observed between production costs, prime cost, selling price of products, concentration of production and average farm size. A 2.6-fold increase in yield ensured a 5-fold increase in production costs per 1 ha and a 3.8-fold increase in production concentration. Therefore, the level of costs for growing wheat is determined by the limits of production efficiency.

An important stage in the development of the agricultural sector was the development of no-till technologies that do not require preliminary preparation of the field for sowing. At this stage, such a technological stage as tillage has reached the limit of its development. Importance has acquired the improvement of technology and technological operations, taking into account the various soil, climatic

and social conditions of production and labor. The rapid growth in the use of no-till systems indicates the spread of this effective approach.

Table 1. Impact of production costs on wheat yield in agricultural enterprises, 2020 [13].

Groups by the value of production costs 1 ha, UAH	Number of farms in the group	Area, ha	Productivity, c/ha	production costs per 1 ha, UAH	Full cost of 1 c, UAH	Selling price of 1 c, UAH	Profitability level, %	Average farm size, ha. land
Up to 3000	508	455	25.2	2732	281.8	437.4	55.2	1312
3001–4500	612	529	27.5	4195	313.6	456	45.4	1449
4501–5500	897	643	30.5	5293	344.2	466.2	35.4	1757
5501–6500	999	692	34.8	6436	367	480	30.8	2090
6501–7500	992	970	39.1	7433	393.8	480	21.9	2361
7501–8500	808	931	42.6	8454	409.4	495.2	21.0	2496
8501–10000	657	1307	43.3	9956	417.4	524	25.5	2572
10001–11500	478	1934	48	11107	427	513.4	20.2	3284
over 11500	978	1747	51.5	14749	450.2	535.8	19.0	3203
In Ukraine	6929	1014	38	8618	411.6	501.8	21.9	2304

Research institutions of the National Academy of Agrarian Sciences of Ukraine are working on creating models of intensive technologies (alternative, resource-saving, resource-saving biologized, minimal, zero, etc.), are engaged in scientific substantiation, development and implementation of adaptive technologies for growing crops in order to implement maximum yield potential of varieties and hybrids. These technologies are based on managing the process of crop formation, reducing the gap between the potential and actual productivity of agricultural crops. Intensive technologies are aimed at realizing the biological potential of plant productivity, increasing their resistance in ontogeny to stressful biotic and abiotic factors, as well as production efficiency through the introduction of advanced agricultural techniques for growing plants, organizing production and labor, and optimally using material and technical resources.

The essence of intensive technologies focuses on optimizing yield factors during the growing season of plants. If, with traditional technology, the provision of material and technical resources depends on the capabilities of a particular farm, then with intensive technology, it depends on the need for them to obtain a programmed level of yield at a lower cost per unit of production. At the same time, the introduction of intensive technologies requires an increase in production costs per 1 hectare of crops by 1.5 times or more. But they are not always compensated by the increase in yield, which leads to an increase in the cost of a unit of production and a decrease in the level of profitability of production.

An important technological direction in grain production is the optimization of the seeding rate of grain crops, since the price of elite seeds significantly increases the cost of grown products. High seeding rates, currently 300 kg/ha or more, should be used only in case of unsatisfactory seed quality, poor soil preparation for sowing, or late sowing of grain. With the introduction into production of new highly productive varieties and hybrids of agricultural crops, which ensure the full realization of the possibilities of intensive technology, it is possible to reduce the seeding rates of grain crops by 2-3 times. Modern intensive technologies involve the complete supply of plants with nutrients. A sign of modern intensive technologies for growing crops is the widespread use of plant protection products to

control weeds, pests, diseases, and lodging [5]. This was the basic basis for revolutionary changes in crop technologies.

Of course, all technological operations of growing crops using intensive technologies require technical re-equipment of the crop industry, the introduction of modern high-performance equipment, multifunctional units that allow you to perform various operations in one pass. To increase the efficiency of the use of technical means of production, the units are equipped with GPS navigation systems. Accordingly, the number of passages of equipment across the field decreases, the structure of the soil is less destroyed by heavy equipment, and fuel is saved. The structure of production costs, which makes it possible to identify reserves for their reduction in certain areas, is important for a comparative analysis of various technology options (table 2).

Thus, resource-saving technological methods help to reduce the cost of material and labor resources. The science-based use of the biological potential of winter wheat makes it possible to obtain the same high-quality grain yield as with high-cost technologies. However, the attractiveness of no-till technology does not yet ensure high efficiency in crop production.

Table 2. Comparative characteristics of costs when growing winter wheat using intensive technologies in the conditions of the western forest-steppe [5; 10; 14]

Technological operation	Intensive technologies		Saving resources or increasing yields with resource-saving technology
	high-cost	resource-saving	
Fertilizers	PK_{90-120}	PK_{45-60}	Fertilizer rate is reduced due to the predecessor
Sowing	Seeding rate - 5–6 million/ha or 200–300 kg/ha	Seeding rate - 3–4 million/ha or 120–200 kg/ha	Saving 100 kg/ha of seeds due to improved technology of soil preparation and sowing + grain growth of 3–4 centners/ha
	Sowing time - September 10–25	Sowing date - September 30	Grain growth 2–4 c/ha
	Sowing depth - 3-5 cm	Sowing depth - 2-3 cm	Grain growth 1–2 c/ha
Plant protection	Application rate - herbicides 2–3 l/ha, redandants 4–6 l/ha, foundationol 0.6–0.8 l/ha + tilt 0.5 l/ha	Application rate - redandants 1.5–2.0 l / ha,	Consumption rates of preparations are reduced due to the fact that the fight against weeds, lodging, diseases is carried out by agrotechnical measures
Crop care	The number of passes of equipment is at least 6	The number of passes of equipment is not more than 3	Reducing the number of treatments saves fuel
Harvest	Separate or direct combining	Stationary threshing	Yield increase of 5–10 c/ha due to minimal grain losses during harvesting

In the early years of introducing a farming system, yields can drop sharply. In addition to awareness and knowledge of the technology, the successful application of no-till requires the following activities:

- Analyze the soil of the fields and carry out activities to achieve a balance between nutrients and pH;
- Analysis of soil drainage possibilities for technology application;

- Leveling the soil surface of the field, loosening the soil to reduce its density;
- Mulching of the soil surface, the use of crop rotations and green manure cover;
- The acquisition of appropriate technical means, the study of best practices and innovations. The orientation towards the use of such technologies, given the current limitations on the ability of commodity producers to invest in updating the material and technical base of the industry, is of a discrete stepwise nature [10].

In the no-till system, the importance of crop rotations increases compared to using the traditional method. With this technology, maximizing the biodiversity of crops arranged in a rotation that includes green manure cover crops contributes to saving resources and increasing production efficiency. However, despite the fact that the No-till technology makes it possible to increase labor productivity by 3-5 times, reduce labor costs by 1.6 times, for technical equipment and fuels and lubricants - by 1.5 and 2.2 times accordingly, it is subject to criticism.

If earlier the main attention in discussions regarding this technology was concentrated on the physical parameters of the soil, maintaining its fertility, increasing erosion resistance, reducing energy costs, now the dilemma of the expediency of replacing cheap labor with expensive capital is debatable, that is, there is a transformation of problems from soil-climatic to socio-economic [9]. Thus, for 10 thousand hectares of land it is necessary to have one tractor with a capacity of 500 hp, an 18-25-meter sowing complex, three to four grain combines and one sprayer with a capacity of 1000 hectares per day. In addition, such equipment must be equipped with a GPS global positioning system.

Since a significant number of No-till technology components are not produced in Ukraine, apart from the high price of equipment, the problem of the country's technological dependence also arises. At the same time, the success of the application of no-till technology is largely determined by the level of qualification of agronomic and technical personnel, as well as the need to use imported systemic herbicides such as glyphosates and increase weed resistance to them. In addition, these technologies are closely related to the use of genetically modified crops that are prohibited in Ukraine and are resistant to systemic herbicides of continuous action. In the recent past, the deterrent to the spread of No-till technology was: cheap labor, cheap fuels and lubricants, low prices for fertilizers and equipment. A high yield could be grown without minimum tillage technologies. The problems of protecting soils from erosion were solved thanks to contour and contour reclamation agriculture, deflation was restrained with the help of flat-cutting action. However, at present, the situation is changing in favor of further facilitating labor and reducing energy costs, incl. due to the spread of No-till technologies on the soils of Ukraine suitable for its application, the area of which has already exceeded 4 million hectares.

4. Discussion

Insufficient rates of technical renovation in almost all categories of farms, with the exception of high-value enterprises and agro-industrial associations of the holding type, which are able to manage their economy more efficiently and use capital from other areas of diversified production for their technical re-equipment, led to a rapid increase in the load on existing agricultural machinery.

The technologies of minimum and zero tillage have led to fundamental changes in the development of agriculture, namely: the introduction of multifunctional units formed on the basis of a seeder and a sprayer, the preservation of plant residues on the field after harvesting, the restoration of structural stability and biological activity of the soil, the return to crop rotations using intermediate green manure crops, obtaining economic, energy, environmental and social effects. Although these technologies make it possible to increase labor productivity by 3–5 times, reduce labor costs by 1.6 times, for technical equipment and fuels and lubricants by 1.5 and 2.2 times, respectively, their introduction into production is constrained by high prices for equipment, the need to use imported systemic herbicides, the introduction of computer control of equipment via satellite, the need for highly qualified agronomic and technical personnel.

5. Conclusion

The foregoing allows us to state the existence of a successful practice of science-based application in crop production of methods for improving the technologies of growing grain crops in order to maximize the potential of yields of zoned varieties and hybrids.

The modern practice of scientific substantiation, development and implementation of effective technologies in production is aimed at: managing the process of crop formation; to reduce the gap between the potential and real productivity of crops, the realization of their biological potential; to increase the resistance of plants in ontogeny to stressful biotic and abiotic factors, as well as to increase the efficiency of production through the introduction of progressive agricultural technology, the organization of production and labor; on the rationalization of the use of material and technical resources.

Technologies are a system of organizational, economic and agrotechnological measures, and their economic efficiency can be determined both comprehensively (of the system as a whole) and differentiated by individual technological elements. The main performance indicators are: yield increase, cost of an additional crop per unit area, payback of additional costs, increase in labor productivity, level of profitability, annual economic effect per unit area, rate of return calculated on the basis of data on the performance of work, the resulting yield and quality products, energy efficiency, characterized by savings in energy costs for the performance of work and the production of grain crops.

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