

COMPARISON OF AGRICULTURAL PRODUCTION TECHNOLOGIES BY ENVIRONMENTAL INDICATORS IN THE CONTEXT OF THE INTERNATIONAL SMART ECONOMY

Viacheslav Padalka¹, Maksym Kulyk², Ilona Rozhko³, Oleksandr Kalinichenko⁴, Nadiia Zaritska⁵, Mykola Zos-Kior⁶, Iryna Hnatenko⁷, Oleksandr Gorbenko⁸

¹ PhD, Prof., Poltava State Agrarian University, 1/3 Skovorody St, Poltava, Ukraine, Email address: viacheslav.padalka@pdau.edu.ua

² Dr. Sc. Prof., Poltava State Agrarian University, 1/3 Skovorody St, Poltava, Ukraine, Email address: maksym.kulyk@pdau.edu.ua

³ PhD. Assoc. Prof., Poltava State Agrarian University, 1/3 Skovorody St, Poltava, Ukraine, Email address: ilona.rozhko@pdau.edu.ua

⁴ PhD. Assoc. Prof., Poltava State Agrarian University, 1/3 Skovorody St, Poltava, Ukraine, Email address: oleksandr.kalinichenko@pdau.edu.ua

⁵ PhD. Assoc. Prof., Kyiv National University of Technologies and Design, 2 Mala Shiyanska (Nemirovich-Danchenko) St., Kyiv, Ukraine. Email address: znn@kntd.edu.ua

⁶ Dr. Sc. Prof., Poltava State Agrarian University, 1/3 Skovorody St, Poltava, Ukraine, Email address: mykola.zos-kior@pdau.edu.ua

⁷ Dr. Sc. Prof., Kyiv National University of Technologies and Design, 2 Mala Shiyanska (Nemirovich-Danchenko) St., Kyiv, Ukraine, Email address: q17208@ukr.net

⁸ PhD. Assoc. Prof., Poltava State Agrarian University, 1/3 Skovorody St, Poltava, Ukraine, Email address: oleksandr.gorbenko@pdau.edu.ua

Received 07 05 2026; Accepted 26 05 2026

Abstract

Food security is at the highest level of existence of any civilized country. Analysis of agricultural technologies for the production of crop products implemented in Ukraine showed that due to the global specialization of our country in the world production of food products and relatively large areas of arable land, both well-known classical technologies and modern ones are used simultaneously, especially those aimed at biological agriculture. Among the analyzed technologies implemented in Ukraine, the best for preserving and increasing fertility are No-till (biological) and the technology implemented in the private enterprise “Agroekologiya” of Myrhorod district, Ukraine. In these agricultural technologies, the main role in obtaining a sustainable harvest is played by soil moisture supply and increasing its fertility using biological methods.

The ecological technology implemented in the Agroecology PE does not involve the use of systems for feeding and protecting plants with preparations of artificial and synthetic origin, therefore, plant and animal products are in demand in the ecological food chain of most developed countries of the world. Analysis of the signs of the influence of factors on the biological indicators of products by technology showed that the proposed comprehensive general indicator for the ecological farming system implemented in the Agroecology PE is (+6), which corresponds to the high level of biological processes in agricultural production. Agrotechnologies focused on the production of ecological products with the support of soil fertility should take a leading place in Ukrainian agriculture to provide the population with high-quality biologically pure food products in the conditions of an international smart economy.

Keywords: *Environmental Friendliness, Agro-Industrial Sector, Technologies, Agriculture, Soil Fertility, Quality of Agricultural Products, International Smart Economy, Export Potential, Food Security, Livestock.*

JEL Codes: *Q56, O13, F18.*

Introduction

Food security is at the highest level of existence of any civilized country. Saturation of the domestic market with food products is an integral part of stability in the state, a guarantee of economic, social and political development. As is known, many industries of production and processing direction are developed in Ukraine. Experience shows that the most stable and mostly profitable is the agricultural production industry [1,2]. Regardless of the economic and security aspects of modern agricultural production, the agro-industrial sector has a strong potential for the production and processing of food products both for the country's population and for providing the livestock industry with high-quality feed. The introduction of advanced world technologies has allowed to significantly raise the culture of production, which contributed to an increase in the volume of gross reproduction of products of biological origin in the conditions of the international smart economy.

Whatever the agro-climatic conditions that have a direct impact on the gross indicator of the agro-industrial complex, Ukraine is able to fully satisfy its own needs for food. There is a well-known problem of overproduction of agricultural products and some types of its processing, which allows sending more than 70% to export and this is a weighty argument in creating a source of foreign exchange earnings for the state [3,4].

Widespread implementation of modern intensive technologies, in particular in crop production – “herbicides” with systems for protecting and stimulating plant growth and productivity using synthetically created substances. Also in livestock breeding - growth stimulants “premixes”, pharmaceutical drugs for combating diseases “antibiotics” and others, which are also of synthetic origin. There are quite contradictory results of scientific research on the impact of the aforementioned synthetic substances on the human body, as a biological creature [5]. Therefore, some states, through regulatory and other preventive measures, are trying to limit the access of such “dangerous” products to their own consumer market. On the other hand, the aforementioned policy creates a rather attractive market for environmentally

friendly food products. Sometimes, the difference in the price of similar food products is several times greater. Therefore, the introduction of ecological farming and animal husbandry technologies is an urgent and nationwide problem, and the requirements for such technologies are useful for a wide range of agro-industrial enterprises conducting economic activities on the lands of Ukraine.

Purpose and objectives of research

Objective: based on the results of a comparative analysis of agricultural production technologies implemented in Ukraine, to outline the features that are basic for the implementation of ecological agriculture and animal husbandry in the conditions of an international smart economy. Compare them with the experience gained by the Agroecology Private Enterprise.

To implement the objective, we will consider the tasks that are solved by methods of scientific observation and comparison, which consist in a purposeful process of perception of objects of reality and their influence on the final results:

1. To analyze existing technologies implemented in agricultural production from the standpoint of obtaining ecological products.
2. To describe the experience of the Agroecology Private Enterprise and technologies implemented in production.
3. To provide recommendations regarding the orientation of modern technologies to the norms and requirements for obtaining ecological products in the conditions of Ukraine.

Review of scientific literature sources

The search for the best technology in agriculture is the most painful issue for every producer of products [6,7,8]. As rightly noted by Kulyk and Padalka (2020); Deo et al. (2024); Deo et al. (2024); Padalka (2015), regardless of the equipment of the enterprise with the main means of production, the potential level of soil fertility, the agro-climatic conditions where production activities are carried out, the economic and social situation prevailing at the enterprise, and modern political conditions, force us to raise the issue of not only the direct production of products, but

especially the search for ways to market them to the first level. It is quite clear that the most important factor is the profitability of the adopted production system. Therefore, the analysis of existing technologies with the possibility of application in ecological production systems is a relevant issue with the further promotion of products to the European market and other consumers of high-quality organic food [9].

The most common in the Poltava region is traditional farming technology. Proponents of this type of farming are oriented towards the idea that the main deep tillage of the soil allows for better structuring, moisture accumulation, more intensive control of unwanted plants and their seeds, diseases and pests that are in the natural system of soil biogeocenosis. Also, periodic or annual plowing allows you to increase the proportion of nitrogen-containing substances due to more intensive soil aeration and the crop residues of predecessors are well plowed. The almost forgotten technology of no-ploughing (the use of flat cutters, no-dumping) somewhat reduces the effect of soil erosion, but does not solve them in general.

This farming system gives a good economic effect provided that the soil fertility is sufficient and its agrophysical indicators are satisfactory. Common means of mechanization are fully integrated and provide soil preparation, plant care and feeding, harvesting and primary processing for storage.

The main drawback, in our opinion, is the slow but sure utopianism and futility of using such a farming system. The main factors that allow obtaining sufficiently high yields are relatively uncontrolled. These include the restoration of fertility and the accumulation of moisture in the soil at a level sufficient for plant vegetation throughout the year, the loss of organic material and pollution of groundwater. The low biological quality of the grown products and the accumulation in them of unnatural (synthetic) substances used to stimulate growth and in systems of protection against pests and diseases. Given the change in climatic conditions and the catastrophic decrease in the biological fertility of soils, producers are forced to use fertilizers and chemicals more intensively, which makes it practically impossible to offer such products on

the organic food market. We periodically observe such a trend when exporting products to a number of countries in the world.

Mujjabi et al. (2024) note that the next stage in agriculture, which is implemented in the country, is resource-saving technologies. Their list can include technologies of minimal tillage, which differ in the level of minimization and manufacturability: law-tell, no-till, strip-till, verti-till, closed soil technologies and other interpretations of them [10].

A positive evaluation feature of this group of technologies is the economic effect of reducing the volume of mechanized tillage work, replacing them with more intensive means of plant care and protection, the introduction of varieties and hybrids resistant to deteriorated conditions for their vegetation, the use of more active synthetic substances to stimulate development and protection against diseases and pests.

The increase in gross output of products, together with the combination of modern production culture, the use of highly intelligent and precise means of mechanization, has allowed to increase the yield several times compared to traditional technology. At this stage of agricultural development, the issue of mass production of such technologies is being addressed.

However, the proposed systems of agricultural production do not allow to obtain high-quality products that can compete in the markets of countries with special requirements. Also, the natural potential of soils is catastrophically reduced, the varietal natural feature of plants and their species is lost. Such production has a negative impact on livestock, as the main consumer of the feed base grown in the fields using such technologies. The combination of the aforementioned resource-saving technologies with changes in agro-climatic conditions can also, in the future, lead to the degradation of the country's food production. Unfortunately, in modern economic conditions, these warnings are not perceived as relevant and inevitable.

In the paradigm of production intensification, modern ways of increasing the gross output of agricultural products should be defined by radically raising the culture of production processes. With the development of

microprocessor technologies and electronics, the direction of precision agriculture was formed. Which, in our opinion, should be considered as an improvement of known and already implemented technologies.

Technologies have radically changed the concept of agricultural production, making it more profitable, efficient, safe and productive. It is necessary to single out the five best new technologies in agricultural production, recognized by farmers: GIS technologies in agriculture (the use of satellites and drones to collect valuable data on vegetation, soil conditions, weather and relief from a bird's eye view) and GPS agriculture, satellite images, drones and other aerial photographs, Information technologies for agriculture and online data, unification of datasets.

The introduction of such new systems improves production conditions but has the same drawbacks that belong to the basic technologies of agriculture. The concept of soil as a biological basis is lost, which requires not only care but also restoration.

Shmygol et al. (2024) noted that less common, but significant for the existence of people, should be distinguished technologies of biological agriculture and animal husbandry [11]. The main goal of their implementation is to restore soil fertility, or maintain it at a sustainable level and obtain products of the highest quality in terms of natural origin and the absence of the influence of synthetic (artificial) chemicals, the effect of which on the human body has not been sufficiently scientifically studied. Such systems include preservative technology, organic farming technology.

Despite the economic risks that are emphasized in the works of scientists, these technologies have been implemented in Ukraine [12-23]. As practical experience shows, the disadvantages include relatively low production yields, high cost and the need to increase costs for plant care by mechanical means. Underestimation of the significance of the introduction of technologies and social negativism in the absence of excess profits from production. The instability of the political, economic and social situation that

affects the agricultural sector has a significant impact [24-39].

As noted earlier, in our opinion, the main factor in the economic feasibility of agricultural production is not the cost of production and its volumes, but the sale of environmentally friendly products [40-52]. The search for a comprehensive solution that allows producing a competitive product in the market, where there is a demand for such food products with increased cost, makes it possible to preserve soil fertility, not to use synthetic plant care products. At the same time, it is also possible to produce products of animal origin, the basis of which is plant growing, built on ecological principles, which is especially important in the conditions of the international smart economy.

Research methods

The biological development of plants is influenced by natural and technological factors. Natural factors include: soil moisture (FSM), soil fertility (FSF), varietal purity of seeds (FVP) or hybrid quality. Technological factors include technological features of: sowing (TS), caring for plants (TC), harvesting (TH), primary processing of products (TPP) and logistics of transporting crops (TTP) and their impact on the final result of crop production, and as a basic component of animal feed production.

Moisture (FSM). As is known, the biological basis of a plant mainly consists of water. Biological development of a plant is impossible in the absence of this natural component. Analyzing the ways of moisture accumulation in the soil, it should be noted that the main natural source of moisture is precipitation and moisture that condenses from the atmosphere during daily changes in ambient temperature. In the conditions of the continental climate, where Ukraine is located, the amount of precipitation is uneven throughout the year [53]. The majority (about 80%) of water enters the soil through precipitation that prevails in the autumn period of the year. There are also conditions that some of the moisture that falls in the form of snow does not reach the soil and does not accumulate because it is weathered during the thaw and the layer of frozen soil that exists in the winter also

prevents its penetration into the lower layers. The use of artificial irrigation has its advantages and disadvantages, but in most cases, it is economically impractical for large-scale agriculture. A sufficient amount of moisture in the soil, which is accumulated in the autumn season, is the main guarantee of fruitful vegetation of plants throughout the entire life cycle.

The wide use of existing tillage agricultural machines also has an impact on the ability to accumulate this valuable resource for the arid region. The vast majority of machines and their working elements that affect the soil change some of its physical and mechanical properties. The structure and density of the soil are significantly changed, the layer that is the direct environment for the development of the plant's root system is loosened. The disadvantage of the constant impact on the soil of the working bodies of these machines is the formation of compacted waterproof layers: "under-soil" sole at the depth of the main cultivation (20 - 25 cm); surface compaction after cultivators and disk machines, respectively (5 - 15 cm). These artificial formations significantly reduce the possibility of water penetration and accumulation in the middle and deep layers of the soil, which are the main source of moisture for plants during their growing season [54-55].

Destruction of formations associated with the impact of the working parts of machines on the soil is possible in several ways. The most common is the use of deep cultivators, which are able to change its structure at a considerable depth. The introduction of such a method is an effective step, but also economically expensive, since it requires significant costs for mechanical impact on the soil. Natural capillaries and larger channels through which water had the opportunity to enter deeper layers are also destroyed. They are silted up and, as a result, more compaction and the need for regular mechanical cultivation occur.

A natural method of combating soil compaction is to use the biological characteristics of the plants themselves. As is known, the energy of plant growth allows you to destroy any obstacles, in particular over-compaction of the soil, due to the development of the root system. This process is slower, but the loosening of the soil due to the vital activity of the root system and

the formation of channels by the roots of the predecessor plants is more effective and ensures the structure of the soil for a longer period. A well-known example is the absence of accumulation of water on the surface (hole formations) in natural meadows and perennial crops. Under these conditions, water penetrates unhindered to a sufficient depth, and is also a source of replenishment of surface aquifers.

The accumulation of water in the soil is the main problem of agriculture, especially in arid climates. The transition to biological and natural accumulation of moisture at the depth of plant germination requires a reduction in the impact on the soil of mechanical tools for soil cultivation and the support wheels of agricultural machinery and vehicles. This technique should reduce additional costs for the production of crop products.

Soil fertility (FSF). The biological capacity of plant vegetation is directly related to the fertility of the soil on which they germinate. The ability to contain nutrients and restore their level directly affects the qualitative and quantitative indicators of the resulting plant products [56]. Mainly, the level and capacity of soil fertility is formed by the vital activity of biological forms of natural origin over hundreds and thousands of years.

Modern technologies allow changing fertility, but the magnitude of this change and its duration require analysis from the point of view of the impact on the qualitative indicators of the resulting products. The intensity of crop production is based on the need for mass use of fertilizers, since the basic fertility of existing lands practically does not allow obtaining products with programmed qualitative and quantitative indicators [57]. By origin, fertilizers are mainly divided into organic (natural origin) and synthetic (artificially produced products).

Organic fertilizers are by-products of animal husbandry, crop production and other natural biological processes. Such fertilizers are almost completely suitable for bacterial symbiosis, which exists in the soil and increases its fertility. Their time of action on the soil lasts several years and are completely safe for the biological environment. The main disadvantage of using such fertilizers is their insufficient quantity and the high cost of their production. Reducing the volume of animal husbandry, using

crop residues for other national economic purposes or their physical destruction reduces the possibility of biological restoration of soil fertility.

Synthetic fertilizers are more attractive to use, as they are mostly concentrated, allow point application and have an intensive effect on plant development [58]. Despite the positive features, such fertilizers carry a certain danger. Due to their concentration of certain chemical compounds of synthetic origin, fertilizers are difficult to regulate at the level of microbiotic connections of the soil environment. Accordingly, some of them are washed out by moisture into the lower layers of the soil and into surface waters. There is also an accumulation in the plants themselves of particles of chemical substances that directly affect the quality indicators of the obtained plant products. Accordingly, the “traces” of these substances also have an effect on products of animal origin.

Maintaining soil fertility and increasing it naturally will allow providing food for future generations of people, which is a global problem not only for Ukraine but also for the whole world. The use of synthetic fertilizers has negative consequences for the health of people of several generations.

Varieties and hybrids (FVP). With the development of agriculture, there is always a search for new ways to increase crop yields due to the biological characteristics of plants. The level of biological yield of most crops increases with each generation due to the artificial separation of genetic differences. A number of physiological features, their hereditary fixation in varieties leads to the appearance of high-yielding plants, resistant to external natural factors and some other varietal characteristics that positively affect the manufacturability of their implementation in agricultural production. With the development of genetic engineering, quite a few questions arise regarding the safety of consuming such products for humans. There are widespread opinions, based on the lack of scientific justification for the safety of their consumption, that the cultivation of GMOs (genetically modified organisms) harms biological organisms in an explicit or hidden way.

In modern seed technologies, the following ways of obtaining plants with special

characteristics are common: pure varieties, hybrids, seeds with GMO modifications.

Pure crop varieties are plants that exist according to natural laws and do not pose a threat to their consumption, since they are created in close biogeocenosis with the environment. A common drawback of their use in agricultural technologies is insufficient productivity and poor resistance to weather conditions of vegetation: lack of moisture, requirements for the level of soil nutrients, climatic conditions, etc. These shortcomings are partially solved with the development and implementation of technologies for producing hybrids based on varieties with certain biological characteristics. Currently, this is the best way to obtain a high gross yield, although it requires the development of the industry of industrial production of hybrid seeds.

Seeds with GMO modifications have also been introduced into agricultural production. Their obvious advantages: resistance to plant protection products, resistance to microflora, the effects of diseases, high and guaranteed yield, ability to withstand climatic adversity, etc., leads to their spread among agricultural producers.

Seed production plays a significant role in obtaining high-quality biological products. While the safety of consumption for humans and animals of crops with genetically modified traits has not been scientifically proven, the introduction of hybrids with certain biological characteristics is the predominant way to increase the gross production of plants.

Sowing (TS). With the development of crop production, the technology and method of sowing occupy a leading place among the factors that have a direct impact on the value of the gross yield of the crop. Optimal positioning of seeds in the soil [9] and the creation of the best conditions for their germination, in particular the structure of the soil in each layer, allows you to increase the yield due to the absence of screening, uniformity and friendliness of seedlings, the establishment of an optimal feeding area and other positive features.

Modern sowing complexes are designed to perform the technological process in accordance with the agrophysical conditions of the soil, climatic conditions and the selected agro-background. They perform spot feeding of the

corresponding zones directly around the seed and form a capillary structure of the soil for optimal water exchange in the root system zone. The qualitative indicators of the obtained products are not directly affected by the sowing method and the type of seeder used, which require selection for the conditions of process feasibility and quality of its implementation.

Plant care (TC). The natural development of plants determines the symbiotic relationship between different plants, bacteria, diseases, pests and other equal inhabitants of the soil environment. Giving priority to the development of cultivated plants requires the use of means and methods of caring for them. The implemented plant care technologies can be divided into mechanical and preparative (herbicides, fungicides, insecticides, etc.).

Mechanical plant care technologies consist in the use of agricultural machinery with mechanical impact on the soil environment. Cultivators and thinners, scarifiers and hillers allow to sufficiently process areas of the field not occupied by cultivated plants, carry out surface aeration and protect the soil from rapid evaporation of moisture, allow to influence pests and reduce the spread of bacteria and diseases due to ventilation between plants. Such technologies were until recently the most common, but their laboriousness and insufficient quality of operations forced to look for another, more progressive method. With the development of the chemical industry, various preparative forms of agents have been developed that allow selective control of unwanted plants, diseases, and the destruction of pests and bacteria [59]. Their obvious advantage has ensured their wide distribution. Artificial growth stimulants are used both in crop production and in animal husbandry. A significant disadvantage of the application is their artificial origin. The rates of application, methods of preparing mixtures, and storing preparations have an undesirable effect not only on the symbiotic community in the soil, but also on the resulting production products. Their effect on the biological human body also requires constant scientific research.

Preparative forms obtained by biological means are becoming widespread. The use and study of their effect is being studied and will allow

in the future to replace synthetic origin preparations.

Plant care directly affects their productivity, and synthetic preparations have an effect on the biological indicators of the resulting product.

Harvesting (TH). The technological process is associated with the separation of grown products and their primary purification from by-products. Mostly, this process is maximally mechanized. The use of combines, loaders, and harvesting mechanisms practically do not require manual labor and are technological.

The impact on the quality indicators of products can be divided into two categories: mechanical impact on products and impact on the physical and mechanical properties of products at the time of harvesting.

Mechanical effects include deformation and excessive crushing of agricultural products. Such effects negatively affect quality indicators and reduce storage suitability.

The physical and mechanical properties of the resulting products depend on the technological scheme of the harvesting machine and the biological ripeness of agricultural crops. Overripening of the crop leads to an increase in the level of losses during harvesting, and unripe grain is the cause of increased humidity and deterioration of quality indicators.

The pace of harvesting work, when using modern mechanized technologies, is determined based on the choice of innovative designs of highly productive harvesting agricultural machines.

Primary processing of products (TPP), aimed at obtaining food products, also requires cleaning, bringing the humidity to the recommended level, packaging and storage.

The working parts of the machines mechanically affect the processed products, damaging them and reducing their quality. Deformed and substandard material is rejected, and accordingly is lost as a marketable result of labor.

Active temperature drying leads to internal changes in the structure of the product, which also affects its biological quality.

Primary preparation of the obtained products must be carried out in accordance with the requirements of the purchasing organization

for quality indicators and comply with the recommended standards and requirements.

Results

The features of agricultural production technologies in the Agroecology Private Enterprise (Mirgorod district, Ukraine) are based on long-standing agricultural traditions that can be described by the following principles:

- basic tillage (plowing) is dangerous for symbiotic relationships formed in the soil;
- the formation of a "soil sole" does not allow creating a sufficient annual moisture supply for plants;
- to preserve and increase fertility, only fertilizers of biological origin should be used;
- weed control is carried out exclusively by agrotechnical and mechanical means. Synthetic fertilizers, herbicides, growth stimulants and other chemicals of artificial origin are prohibited in the biological farming system;
- the presence of weeds and pests in the field is a sign of the biological purity of the field;
- seed moisture reduction occurs due to heliothermal methods and the use of means with forced seed heating is not recommended;
- transportation of export grain products exclusively in containers, which reduces its deformation and destruction;
- the decrease in gross production of marketable products is compensated by its high quality indicators, which allows to obtain a stable production profit.

The enterprise has not used deep tillage for more than 40 years. There are practically no moisture-proof layers. Natural capillaries and the root system of predecessors allow to accumulate a sufficient amount of moisture. Recently, with a sufficient amount of snow cover, the enterprise has restored snow retention in the fields. Pre-sowing field preparation is carried out to the depth of seed sowing. Taking into account a sufficient amount of moisture in the soil, an agronomic approach to provoking weed seed germination and two-time control of sprouted weeds in the "white thread" stage is widely used. Accordingly, sowing of the main crop does not require herbicide protection, cultivated plants have a greater potential for growth. Plant care is carried

out exclusively by mechanical means. Interrow cultivation is carried out by modern cultivators with positioning of working bodies in a row using GPS navigation, video control, etc. Crop rotations have been introduced in the fields, which also reduce their weed contamination. To obtain grain with high quality characteristics, the farm uses a combined method. Since there is a certain amount of weeds in the fields, it is necessary to mow the mass into swaths to reduce losses, followed by their natural drying and threshing. This technology allows you to obtain grain mass with appropriate moisture, which does not require additional drying by active methods. Crushed crop residues and additionally applied organic fertilizers are incorporated into the soil, which affects its overall fertility. Primary seed processing consists in bringing it to the consumer's requirements and packing it in containers. Transportation of grain in containers reduces its deformation and simplifies transportation logistics. Substandard grain is sent to the production of concentrated feed and allows for the production of high-quality livestock products.

According to the selected criteria, we will analyze the impact of technologies introduced into production at three levels: (-1) - negative impact of the studied factor that has signs of reducing the quality of products according to biological indicators; (0) - the studied factor that does not affect or has a slight impact on the quality characteristics of biological products; evaluation indicator (+1) - characterizes the positive impact, improves the quality characteristics of products and contributes to the long-term development of biological agriculture.

Intensive technology, the most widespread in Ukraine. Its implementation is based on a sufficient level of accumulated moisture in the soil and does not contribute to its accumulation and preservation during the vegetation of plants (-1). Also, an unforeseen increase in soil fertility due to biological fertilizers, and mainly synthetic fertilizers (-1) and plant protection systems (-1) are used. To increase the yield, modern varieties and hybrids of crops are used, optimal ones in agroclimatic conditions are searched for and improved (+1), although sowing is carried out

using traditional sowing equipment (0). Harvesting of grain crops is carried out by classic combine harvesters with sufficiently large grain damage (-1) and artificial thermal drying (-1), which negatively affects the biological quality indicators of seeds due to damage to the internal structure - compression damage. Storage in ridges and repeated mechanical overload also leads to its damage (-1).

Traditional technology consists of classic approaches to agriculture. Moisture accumulation (-1) and soil fertility (-1) are used as a lossless reserve and are not aimed at their biological increase. Seed material (0) and classic sowing units (0) are not updated and are not improved to improve their impact on the biological quality of future products. Crop care (-1) and their protection, if carried out, is carried out exclusively with synthetic artificial preparations that only harm the biological quality of the product. During direct combining, there is an increased impact on the grain, which leads to its internal destruction (-1) and requires artificial drying (-1). During primary cultivation (-1) and transportation of the harvested crop (-1), the negative mechanical impact on the grain increases, which reduces its biological indicators. In general, traditional technology, in terms of preserving the biological component of natural grain, takes last place.

No-Tille (modern). The technology uses the paradigm of minimal soil cultivation and the use of mechanization tools that reduce energy consumption to the minimum possible and is limited to pre-sowing cultivation, sowing and harvesting. This technology is based on the condition of sufficient moisture accumulation (-1) and sufficient soil fertility (-1), and there are no ways to restore these reserves, which negatively affects the prospects for agriculture. The use of resistant varieties and hybrids allows you to get a good harvest and conduct research on the resistance of plants (1) to such vegetation conditions. The introduction of modern stubble

seeders and zero-seeding seeders has a positive effect on the conditions for plant development (1). Plant care is also carried out using synthetic preparations (-1). Harvesting (-1) using classical technologies (-1), primary processing using artificial dryers (-1) and seed deformation (-1) during storage and transportation negatively affect the final product.

No-Tille (biological) is based on classical biological principles where moisture accumulation (+1) and soil fertility (+1) are the main issues in the implementation of such technology. Despite the long duration of the initial stages of implementation, the reduction of the gross harvest in such a technology, the use of modern varieties (+1) and sowing machines (+1) increases the biological quality of products. The use of direct harvesting of grains (-1) with subsequent artificial drying (-1) with intensive mechanical impact on the grain (-1) during primary processing reduces the biological quality indicators of products.

Biological (PP Agroekologiya) - the proposed original technology, which has been implemented and used for several decades. The accumulation of moisture in the soil is a priority task in agriculture (+1). The use of exclusively organic fertilizers solves the problem of increasing soil fertility (+1) and the use of mechanical means of mechanization for care (+1) are positive signs for biological quality indicators. Classic sowing units perform their functions quite qualitatively when sowing grain and industrial crops (0). Combined grain harvesting (+1) without additional artificial drying (+1) and transportation (+1) in containers reduces the mechanical impact on the product and is a positive sign for the biological indicators of the final product. The proposed indicators of factor analysis and their impact on the biological indicators of the technologies implemented in Ukraine are presented in Figure 1.

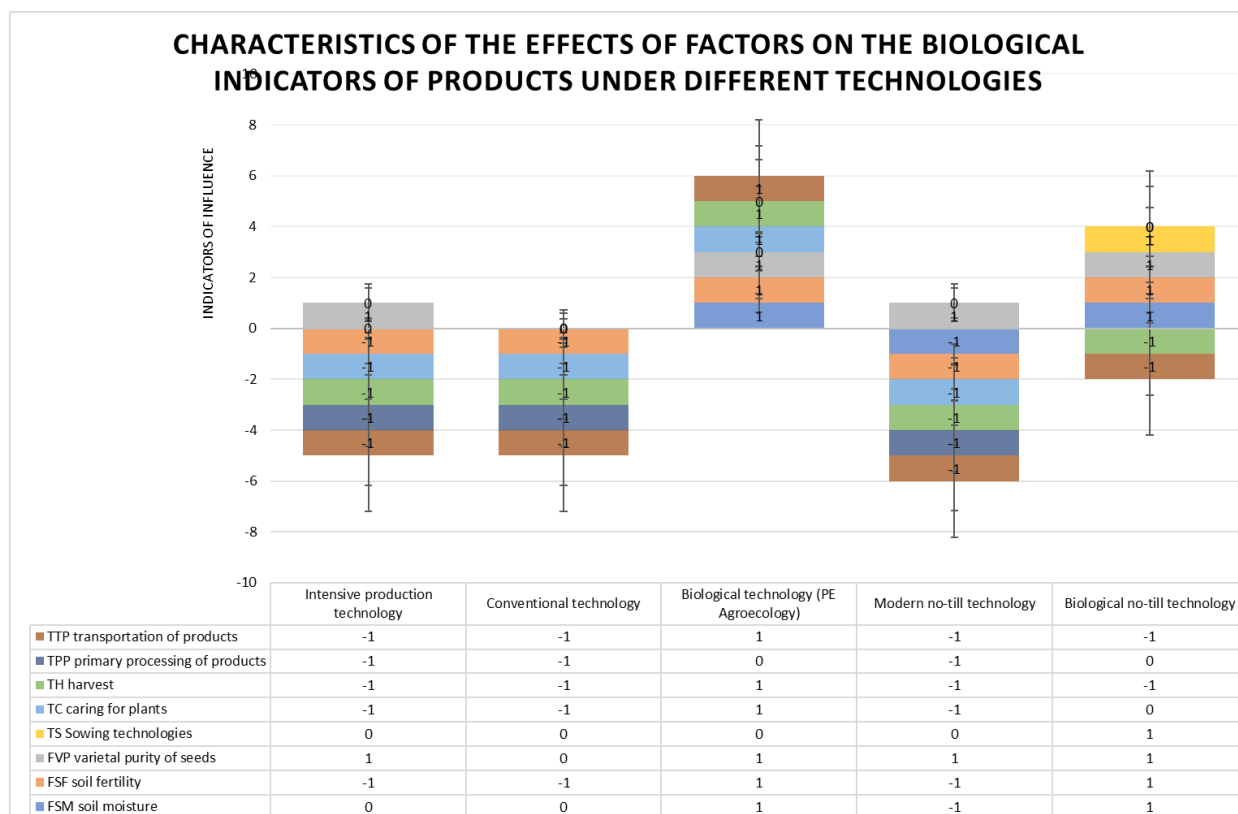


Figure 1. Signs of the influence of factors on biological indicators of products by agricultural technologies

The complex indicator ($\sum E$) of the influence of technology on biological indicators of products and factors of development of ecological agriculture is calculated by the expression:

$$\sum E = T_{TP} + T_{PP} + T_H + T_C + T_S + F_{VP} + F_{SE} + F_{SM}$$

The best agricultural technology for obtaining high-quality biological products will be that which will have the maximum complex indicator of the impact of technology on biological characteristics. According to the results of the analysis, the optimal technology for obtaining ecological products is the technology implemented in “PE Agroekologiya”, which has a complex coefficient value at the level of (+6) and allows exporting products to the countries of the European Community as a biologically pure product.

Conclusions

The analysis of agricultural technologies for crop production implemented in Ukraine showed that, due to the global specialization of

our State in world food production and relatively large areas of arable land, both well-known classical technologies and modern ones are used simultaneously, especially those aimed at biological agriculture. Over the past few years, the gross volume of agricultural production has significantly increased, which has allowed to increase the export potential of food products in the world ranking. At the same time, not all technologies equally affect the ability of soils to provide a constant increase in yield. Among the analyzed technologies implemented in Ukraine, the best for preserving and increasing fertility are No-till (biological) and the technology implemented in the Agroecology PE of Myrhorod district, Ukraine. Accordingly, in these agricultural technologies, the main role in obtaining a stable crop is played by the level of moisture supply in the soil layer and the level of increasing soil fertility using biological methods. The resulting products meet the requirements of environmental friendliness and are competitive in the European Community market.

Given that the ecological technology implemented in the Agroecology PE does not involve the use of systems for feeding and protecting plants with preparations of artificial and synthetic origin, plant and animal products are desirable in the chain of ecological food products of most developed countries of the world. More than 40 years of experience have shown that it is possible to obtain consistently high yields without additional capital investments in the purchase of fertilizers and chemical protection preparations, etc.

The analysis of the signs of the influence of factors on the biological indicators of products by

technology showed that the proposed complex generalizing indicator for the ecological farming system implemented in the Agroecology PE is (+6), which corresponds to the high level of biological processes in agricultural production.

Agricultural technologies focused on the production of ecological products while maintaining soil fertility should take the leading place in agriculture in Ukraine to provide the population with high-quality biologically pure food products.

References

- Balanovska, T., Gogulya, O., & Wyrzykowska, B. (2018). The role of entrepreneur competencies in the development of rural areas. *Economic Sciences for Agribusiness and Rural Economy*, (1), 55–61. <https://doi.org/10.22630/ESARE.2018.1.6>
- Balanovska, T., Gogulya, O., Dramaretska, K., Voskolupov, V., & Holik, V. (2021). Using marketing management to ensure competitiveness of agricultural enterprises. *Agricultural and Resource Economics: International Scientific E-Journal*, 7(3), 142–161. <https://doi.org/10.51599/are.2021.07.03.09>
- Balanovska, T., Mykhailichenko, M., Holik, V., Dramaretska, K., & Troian, A. (2021). Development management of agricultural enterprises. *Financial and Credit Activity: Problems of Theory and Practice*, 3(38), 134–143. <https://doi.org/10.18371/fcaptp.v3i38.237434>
- Bazaluk, O., Yatsenko, O., Zakharchuk, O., Ovcharenko, A., Khrystenko, O., & Nitsenko, V. (2020). Dynamic development of the global organic food market and opportunities for Ukraine. *Sustainability*, 12(17), 6963. <https://doi.org/10.3390/su12176963>
- Bazeliuk, V., Kubitskyi, S., Rudyk, Y., Ryabova, Z., & Novak, O. (2021). The system of formation and diagnosis of levels of innovation and entrepreneurship competence of the future managers of education in the conditions of the knowledge economy. *Financial and Credit Activity: Problems of Theory and Practice*, 4(39), 550–558. <https://doi.org/10.18371/fcaptp.v4i39.241442>
- Bialkowska, O., Poprozman, N., Zelenskyi, A., Fedorchuk, N., & Huk, Ya. (2024). Prospects for the introduction of a green economy in the agricultural sector of Ukraine for the next 10 years. *Scientific Horizons*, 27(6), 163–176. <https://doi.org/10.48077/scihor6.2024.163>
- Bilan, Y., Zos-Kior, M., Nitsenko, V., Sinelnikau, U., & Ilin, V. (2017). Projecting the social component of the efficient management of land resources. *Journal of Security and Sustainability Issues*, (7)(2), 287–300.
- Blagun, I. I. (2013). Cognitive model for banking system development in Ukraine. *Actual Problems of Economics*, 142(4), 209–217.
- Blahun, I. S., Dmytryshyn, L., Blahun, I. I., & Blahun, S. (2022). Stock indices as indicators of market efficiency and interaction. *Economic Studies*, 31(8), 87–106.
- Deo, A., Shirsath, P. B., & Aggarwal, P. K. (2024). Identifying resource-conscious and low-carbon agricultural development pathways through land use modelling. *Land Use Policy*, 143, 107208. <https://doi.org/10.1016/j.landusepol.2024.107208>
- Dmytryshyn, L., & Blahun, I. (2016). A model for achieving the allocative efficiency of credit resources in Ukraine's banking system. *Banks and Bank Systems*, 11(3), 5–16.
- Duginets, A., Shvydanenko, O., Busarieva, T., Balanovska, T., & Gogulya, O. (2023). Specific modern features of the transformation of the knowledge component of TNC. *Financial and Credit Activity: Problems of Theory and Practice*, 2(49), 384–397. <https://doi.org/10.55643/fcaptp.2.49.2023.4017>
- Gorb, O., Rebilas, R., Aranchiy, V., Yasnolob, I., Boiko, S., & Padalka, V. (2020). Strengthening Competitiveness of the National Economy by Enhancing Energy Efficiency and Diversifying Energy Supply Sources in Rural Areas. *Journal Of Environmental Management And Tourism*, 11(5), 1114–1123. doi:10.14505/jemt.v11.5(45).09
- Gryshchenko, I., Ganushchak-Efimenko, L., Hnatenko, I., & Rebilas, R. (2023). Management of environment design of the development of innovative entrepreneurship at integrated structures under the conditions of post-war reconstruction. *Financial & Credit Activity: Problems of Theory & Practice*, 5(52), 341–352. <https://doi.org/10.55643/fcaptp.5.52.2023.4199>

- Hnatenko, I., Bebko, S., Ievseitseva, O., Kvita, H., & Zos-Kior, M. (2024). Market analysis of the renewable energy market of Ukraine in the context of changes in financial and economic processes. *Financial and Credit Activity: Problems of Theory and Practice*, 5(58), 446–459. <https://doi.org/10.55643/fcaptop.5.58.2024.4576>
- Hnatenko, I., Kuksa, I., Naumenko, I., Baldyk, D., & Rubezhanska, V. (2020). Infrastructure of innovation enterprise: Features of formation and regulation in modern market conditions. *Management Theory and Studies for Rural Business and Infrastructure Development*, 42(1), 97–104. <https://doi.org/10.15544/mts.2020.10>
- Horn, R., Mordhorst, A., & Fleige, H. (2024). The impact of arable soil management on physical functions. *Soil and Tillage Research*, 244, 106221. <https://doi.org/10.1016/j.still.2024.106221>
- Imelda, & Hidayat, R. (2024). Climate change impacts, adaptation and mitigation in the agricultural sector. *Global Journal of Environmental Science and Management*, 10(3), 1457. <https://doi.org/10.22034/gjesm.2024.03.30>
- Kalinichenko, O., & Lesyuk, V. (2021). Assessment of the financial security level of Ukraine. *Science and Innovation*, 17(6), 3–12. <https://doi.org/10.15407/scine17.06.003>
- Kalinichenko, O., Kulyk, M., & Lesiuk, V. (2024). Economic and energy efficiency of resource-saving technology for switchgrass cultivation. *Agricultural and Resource Economics*, 10(2), 31–51. <https://doi.org/10.51599/are.2024.10.02.02>
- Korotkova, I., Marenych, M., Hanhur, V., Laslo, O., Chetveryk, O., & Liashenko, V. (2021). Weed control and winter wheat crop yield. *Acta Agrobotanica*, 74, Article 748. <https://doi.org/10.5586/aa.748>
- Krajewski, S., Żukovskis, J., Gozdowski, D., Cieśliński, M., & Wójcik-Gront, E. (2024). Evaluating the path to the European Commission's organic agriculture goal. *Agriculture*, 14, 477. <https://doi.org/10.3390/agriculture14030477>
- Kubitskyi, S., Shorobu, I., Yevdokymova, N., Vlasiuk, T., & Shevchuk, L. (2023). Development of higher education institutions in the current conditions. *Cadernos Educação, Tecnologia e Sociedade*, 16, 119–128. <https://www.webofscience.com/wos/woscc/full-record/WOS:001222942600007>
- Kulyk, M. I., & Padalka, V. V. (2020). Rozvytok bioenerhetyky na osnovi roslynnoho enerhetychnoho resursu (na prykladi Poltavskoi oblasti). In N. S. Illiashenko (Ed.), *Upravlinnia stratehiiami vyperedzhaiuchoho innovatsiinoho rozvytku* (pp. 109–118). Trytoriia.
- Li, V., Guo, J., Lin, L., Guo, H., & Yang, F. (2024). A color-changed fluorescence sensor for pesticide triclopyr 2-butoxyethyl ester based on naphthalimide Schiff-base. *Journal of Photochemistry and Photobiology A: Chemistry*, 457, 115894. <https://doi.org/10.1016/j.jphotochem.2024.115894>
- Lutkovska, S., Martyn, O., Kalinichenko, O., Kulyk, M., Prokopenko, O., Lesiuk, V., & Lesiuk, A. (2025). Financial and economic management of the efficiency of energy crop production in the system of smart technological development of labor resources. *Management Theory and Studies for Rural Business and Infrastructure Development*, 47(2), 162–173. <https://doi.org/10.15544/mts.2025.13>
- Mazur, N., Khrystenko, L., Pásztorová, J., Zos-Kior, M., Hnatenko, I., Puzyrova, P., & Rubezhanska, V. (2021). Improvement of controlling in the financial management of enterprises. *TEM Journal: Technology, Education, Management, Informatics*, 10(4), 1605–1609. <https://doi.org/10.18421/TEM104-15>
- Meyers, W. H., Karasova, N., & Yatsenko, O. (2018). Highly marginal goods as source of export efficiency rise in agrarian sector. *Management Theory and Studies for Rural Business and Infrastructure Development*, 40(4), 577–586. <https://doi.org/10.15544/mts.2018.50>
- Mujjabi, C., Bohn, M., Wander, M., & Ugarte, C. (2024). Participatory breeding in organic systems. *Journal of Agriculture, Food Systems, and Community Development*, 13(2), 23–36. <https://doi.org/10.5304/jafscd.2024.132.008>
- Mykhailichenko, M., Lozhachevska, O., Smagin, V., Krasnoshtan, O., Zos-Kior, M., & Hnatenko, I. (2021). Competitive strategies of personnel management in business processes of agricultural enterprises focused on digitalization. *Management Theory and Studies for Rural Business and Infrastructure Development*, 43(3), 403–414. <https://ejournals.vdu.lt/index.php/mtsrbid/article/view/2519>
- Padalka, V. (2015). From hard to simple using “Shishaky technologies”. *Mechanization in Agriculture & Conserving of the Resources*, 61(7), 14–16. <https://stumejournals.com/journals/am/2015/7>
- Padalka, V., Liashenko, S., Kalinichenko, A., Burlaka, O., Sakalo, V., & Padalka, Y. (2021). Modeling of resonance phenomena in self-oscillating systems of agricultural machines. In *Proceedings of the IEEE International Conference on Modern Electrical and Energy Systems*. <https://doi.org/10.1109/MEES52427.2021.9598763>
- Plakhonik, O., Syladii, I., Kubitskyi, S., Koycheva, T., & Krulko, L. (2024). Formation of an effective management system in the educational space of higher education institutions. *Amazonia Investiga*, 13(74), 344–360. <https://www.webofscience.com/wos/woscc/full-record/WOS:001250068700029>
- Prokopenko, O., Martyn, O., Bilyk, O., Vivcharuk, O., Zos-Kior, M., & Hnatenko, I. (2021). Models of state clusterisation management, marketing and labour market management in conditions of globalization, risk of bankruptcy and services market development. *International Journal of Computer Science and Network Security*, 21(12), 228–234. <https://doi.org/10.22937/IJCSNS.2021.21.12.34>
- Prylipko, S., Vasylieva, N., Kovalova, O., Kulayets, M., Bilous, Y., & Hnatenko, I. (2021). Modeling of regional management of innovation activity: Personnel policy, financial and credit and foreign economic activity. *International Journal of Computer Science & Network Security*, 21(11), 43–48. <https://doi.org/10.22937/ijcsns.2021.21.11.6>

- Purdenko, O., Artyushok, K., Riazanova, N., Babaiev, I., Kononenko, A., Lepeyko, T., & Zos-Kior, M. (2023). Financial management of innovative eco-entrepreneurship. *Management Theory and Studies for Rural Business and Infrastructure Development*, 45(2), 152–165. <https://doi.org/10.15544/mts.2023.16>
- Saberi Riseh, R., Hassanisaadi, M., Vatankhah, M., et al. (2024). Nano/micro-structural supramolecular biopolymers: Innovative networks with the boundless potential in sustainable agriculture. *Nano-Micro Letters*, 16, 147. <https://doi.org/10.1007/s40820-024-01348-x>
- Semenov, A., Kuksa, I., Hnatenko, I., Sazonova, T., Babiy, L., & Rubezhanska, V. (2021). Management of energy and resource-saving innovation projects at agri-food enterprises. *TEM Journal: Technology, Education, Management, Informatics*, 10(2), 751–756. <https://doi.org/10.18421/TEM102-32>
- Semenova, I., & Vicente-Serrano, S. M. (2024). Long-term variability and trends of meteorological droughts in Ukraine. *International Journal of Climatology*, 44(6), 1849–1866. <https://doi.org/10.1002/joc.8416>
- Shmygol, N., Łuczka, W., Gavkalova, N., Harbar, Z., Koval, V., & Cioca, L.-I. (2024). Analysis and management of organic agriculture development in Eastern European countries. *INMATEH – Agricultural Engineering*, 72(1), 265–279. <https://doi.org/10.35633/inmateh-72-25>
- Shmygol, N., Łuczka, W., Gavkalova, N., Harbar, Z., Koval, V., & Cioca, L.I. (2024). Analysis and management of organic agriculture development in eastern european countries (2024) *INMATEH - Agricultural Engineering*, 72 (1), 265-279. <https://doi.org/10.35633/inmateh-72-25> <https://inmateh.eu/volumes>
- Shumilova, I., Kubitskyi, S., Bazeliuk, V., Rudyk, Y., Hrechanyk, N., & Rozhnova, T. (2023). The system of forming the emotional and ethical competence of the future education manager in the conditions of transformational changes. *Ad Alta: Journal of Interdisciplinary Research*, 13(2), 82–89. <https://ep3.nuwm.edu.ua/28475/>
- Sitnicki, M. (2018). Determining the priorities of the development of EU research universities based on the analysis of rating indicators of world-class universities. *Baltic Journal of European Studies*, 8(1), 76–100. <https://doi.org/10.1515/bjes-2018-0006>
- Sitnicki, M. (2018). Development of a model of digital research universities. *Baltic Journal of Economic Studies*, 4(1), 311–318. <https://doi.org/10.30525/2256-0742/2018-4-1-311-318>
- Sitnicki, M. (2018). Managing financial autonomy of a research university. *E-mentor*, 1(73), 86–93. <https://doi.org/10.15219/em73.1342>
- Sitnicki, M. W., Prykaziuk, N., Ludmila, H., Pimenowa, O., Imbrea, F., Șmuleac, L., & Pașcalău, R. (2024). Regional perspective of using cyber insurance as a tool for protection of Agriculture 4.0. *Agriculture*, 14(2), 320. <https://doi.org/10.3390/agriculture14020320>
- Sitnicki, M., & Netreba, I. (2020). Interdependence assessing for networked readiness index economic and social informative factors. *Baltic Journal of Economic Studies*, 6(2), 47–53. <https://doi.org/10.30525/2256-0742/2020-6-2-47-53>
- Sitnicki, M., Balan, V., Tymchenko, I., Sviatnenko, V., Sychova, A. (2021). Measuring the commercial potential of new product ideas using fuzzy set theory. *Innovative Marketing*, 17(2), 149–163. [http://dx.doi.org/10.21511/im.17\(2\).2021.14](http://dx.doi.org/10.21511/im.17(2).2021.14)
- Sitnicki, M., Horbas, I., Derkach, O., Flowers, A., Wielewska, I., Tucki, K., Zuzek, D., & Pimenov, S. (2024). Development and support of Ukrainian domestic entrepreneurship in the knowledge economy. *Sustainability*, 16(13), 5682. <https://doi.org/10.3390/su16135682>
- Sitnicki, M., Kurinskyi, D., Pimenowa, O., Wasilewski, M., & Wasilewska, N. (2024). Strategic formation of agricultural market clusters in Ukraine: Emerging as a global player. *Sustainability*, 16(21), 9430. <https://doi.org/10.3390/su16219430>
- Starostina, A., Sitnicki, M. W., Petrovsky, M., Kravchenko, V., & Pimenova, O. (2021). Marketing research in a transition economy of the turbulent world. *Amazonia Investiga*, 10(46), 51–70. <https://doi.org/10.34069/AI/2021.46.10.5>
- Tverezovska, N., Kubitskyi, S., Dlubovska, A., Ihnatenko, N., Bodnaruk, I., Lisovy, V., & Kuchai, T. (2022). Management of the educational process using information technologies for high-quality training of specialists in higher education institutions. *JCSNS International Journal of Computer Science and Network Security*, 22(9), 561–568. <https://doi.org/10.22937/IJCSNS.2022.22.9.72>
- Wagg, C., Bender, S. F., Widmer, F., & Van der Heijden, M. G. A. (2014). Soil biodiversity and ecosystem multifunctionality. *Proceedings of the National Academy of Sciences*, 111(14), 5266–5270. <https://doi.org/10.1073/pnas.1320054111>
- Wahab, A., Muhammad, M., Ullah, S., Abdi, G., Shah, G. M., Zaman, W., & Ayaz, A. (2024). Agriculture and environmental management through nanotechnology: Eco-friendly nanomaterial synthesis for soil-plant systems, food safety, and sustainability. *Science of the Total Environment*, 926, 171862. <https://doi.org/10.1016/j.scitotenv.2024.171862>
- Yatsenko, O. M., Yatsenko, O. V., Nitsenko, V. S., Butova, D. V., & Loganathan, N. (2019). Asymmetry of the development of the world agricultural market. *Financial and Credit Activity: Problems of Theory and Practice*, 3(30), 423–434. <https://doi.org/10.18371/fcaptop.v3i30.179821>

Yatsenko, O., Nitsenko, V., Abbas, M., & Tananaiko, T. (2018). The impact of global risks on the world trade and economic environment. *Financial and Credit Activity: Problems of Theory and Practice*, (27), 435–444. <https://doi.org/10.18371/fcaptp.v4i27.154279>

Yatsenko, O., Schneeberger, K., & Tananaiko, T. (2018). Trade facilitation and economic development: Cooperation between Ukraine and the countries of North America. *Management Theory and Studies for Rural Business and Infrastructure Development*, 40(1), 103–117. <http://mts.asu.lt/mtsrbid/article/view/1091>

Zhylinska, O., Sitnicki, M., & Vikulova, A. (2019). Systematic assessment of innovative potential of a research university. *Baltic Journal of Economic Studies*, 5(2), 38–44. <https://doi.org/10.30525/2256-0742/2019-5-2-38-44>

Zhyvko, Z., Morhachov, I., Zhelikhovska, M., Artiukh-Pasiuta, O., Hnatenko, I., Skripnik, V., & Yanechko, S. (2024). The influence of the US stock market on the institutional security strategy of the management of innovative development. *Management Theory and Studies for Rural Business and Infrastructure Development*, 46(1), 104–111. <https://doi.org/10.22937/IJCSNS.2024.24.11.11>