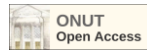




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DYNAMICS AND TRENDS OF CORN GRAIN PRODUCTION IN UKRAINE IN THE PRE-WAR AND WAR PERIODS

Abstract.

The article is devoted to the analysis of trends, substantiation of problems and directions of strengthening the production volumes of grain corn in Ukraine in the pre-war and war periods. The place of Ukraine among the leading exporters of corn in the world and the dynamics of its production indicators are analyzed. An assessment of the trends in yield, gross harvest and production of grain corn in Ukraine in different regions is provided. A statistical assessment of the relationship between area and yield and area and gross grain harvest, as well as between yield and gross grain harvest of corn in some regions of Ukraine and for certain growing periods is carried out. A statistical assessment of the correlation relationships between area, yield and gross harvest in different growing periods is carried out. Special attention is paid to the comparative analysis of the results of grain production in the pre-war (2013–2021) and war (2022–2025) periods. Based on the data obtained, trend forecast models for the development of the industry until 2027 were developed. The main problems of the development of grain production in Ukraine in the pre-war period and during the country's wartime period were characterized. The results obtained indicate that, despite the challenges of wartime, the industry retains significant adaptive potential. According to the results of correlation-regression analysis, a high density of the relationship between yield and production volumes was established, which confirms the determining role of the intensification of technologies in modern conditions. Based on the constructed forecast models (linear and polynomial trends), scenarios for the development of the industry until 2027 were substantiated. According to the forecast, provided that logistics routes are stabilized, a gradual recovery of gross tonnage to the level of 25.6–27.8 million tons is expected. The practical significance of the results obtained lies in identifying key factors restraining exports, including the destruction of port infrastructure and the high cost of energy carriers for drying grain. Recommendations are formulated for the diversification of logistics routes and the expansion of internal processing of corn as a tool for increasing added value.

Keywords: corn for grain, sown area, yield, production, drying and storage of corn grain, statistical processing, trend forecasting models

Introduction

The standard of living of the population and national food security largely depend on the stability of the agro-industrial complex, where grain production plays a strategic role. Corn in Ukraine has remained a key crop in the last decade, successfully grown in almost all regions of the country. It is not only an important raw material for the food and processing industries, but also a powerful energy resource for the production of bioethanol.

By 2022, Ukraine confidently ranked third in the world in terms of corn exports, second only to the USA and Brazil, which emphasized its critical role in the global food supply system. However, the full-scale Russian invasion made significant adjustments to the functioning of the industry. The destruction of energy and railway infrastructure, the blockade of seaports, and the increase in the cost of logistics created unprecedented challenges for farmers. Despite this, even during wartime, corn demonstrates high adaptability.

The relevance of this study is due to the need for a deep analysis of the transformations that corn production underwent under the influence of war factors. Understanding the statistical relationships between the area sown and the harvest allows not only to assess the cur-

rent state of the industry, but also to build scientifically based forecasts. This is critically important for forming a strategy for restoring export potential and strengthening Ukraine's position in the world grain market in the post-war period.

Literature review.

The standard of living of the population and the country's food security largely depend on the state and pace of development of the agro-industrial complex, in which the leading role belongs to grain production, which is able to fully satisfy its needs for grain and also export grain to the world market. Ensuring the safety of grain is one of the most important tasks of enterprises of the grain procurement system. It determines the continuous and significant increase in the production capacity of elevators and warehouses equipped with high-tech equipment [1,2].

Corn in Ukraine over the past decade has been and remains a strategic crop, which is grown in almost all regions, regardless of climatic conditions and the size of farms. It is a valuable raw material for the food and processing industry. Today, the problem of grain production is a priority task within the framework of the development of the agricultural sector in Ukraine. The need to



provide the population with food and feed grain is growing annually, therefore it is important to consider this problem from the point of view of ensuring the food security of Ukraine [3]. Corn is a late-ripening crop, so it is harvested with high grain moisture. Even in conditions of significant climate warming, as has been observed recently, the moisture content of corn during harvesting significantly exceeds the permissible norm. In this regard, the harvested grain is subject to mandatory drying and bringing to a dry safe state as soon as possible. Drying corn, as a later-ripening crop, compared to other grain crops, also requires greater energy consumption, especially when the seeds are processed. When drying it, special conditions must be maintained: these are mild temperature regimes and slow evaporation of moisture, which is necessary to preserve the quality of the seeds. But these conditions simultaneously lead to an increase in the consumption of fuel energy materials.

Various technical and technological methods of drying are known, depending on which the level and structure of energy consumption changes. Such methods include two-stage drying of cobs with further drying in the grain, pulse drying mode with alternating heating and cooling, drying at the maximum permissible temperature [4].

Corn grain production is an important part of all agricultural production in Ukraine. This crop largely determines not only the economic state of livestock farming, but also the grain industry as a whole. The food, processing, medical industries, as well as the fuel and energy sector of the state are interested in corn production, since the grain of this crop is a high-energy raw material for the industrial production of bioethanol and other fuel materials. Corn grain is also used for food purposes. More than 150 food and technical products are made from it: flour, groats, flakes, starch, syrup, glucose, alcohol.

In addition, in recent years this crop has taken an increasingly stable position in the world grain market. Due to the favorable geographical location and favorable natural and climatic conditions of Ukraine, it is possible to ensure not only domestic needs for corn grain, but also significantly increase its export potential, which in particular in the best years can amount to over 20 million tons of high-quality grain [5-8].

Corn is an annual herbaceous plant from the cereal family, which plays an important role in world agriculture. The anatomical structure of the grain includes three main parts for cereals - the shell, endosperm and embryo. Each of the parts of the grain is characterized by its structure and chemical composition, which determines the main goals in organizing technological processes for processing grain into food products [6].

Corn is characterized by the presence of up to 98% of starch and 75% of protein substances in the endosperm of the grain, with the main part of the protein located in the upper layer of the endosperm - the aleurone layer.

In many countries of the world, approximately 20.0% of corn grain is used for food needs, 15.0-20.0% for technical purposes, 60.0 - 65.0% for livestock feed [5].

Economic value of corn:

- grain is used for food products (flour, groats,

starch, oil);

- the main feed crop for livestock (grain, green mass, silage);

- raw material for the production of biofuels, alcohol, bioplastics.

Grain, feed and sweet corn are grown. Modern hybrids are distinguished by high yields, resistance to lodging, diseases and pests.

However, it is necessary to pay attention to one very important thing, namely – the chemical composition of corn, which plays a very important role in economic value. As indicated in [8-10], the chemical composition is as follows: hemicellulose, cellulose and lignin are the main components of cell walls, the share of which in the whole plant is approximately – 40%, starch content is 30%, sugar – 9%, crude protein, fat and ash – 8; 3 and 5% respectively.

The energy value of corn hybrids primarily depends on the degree of development of the cob and its amount in the green mass. During the ripening process of corn, the starch content, its digestibility and, accordingly, energy value gradually increase [7-9].

Corn occupies a leading position in the lists of the most common agricultural crops with each season. Only about 12% of the world's corn is used for food purposes, but another 60% goes to feed for livestock and poultry.

In Ukraine, the volume of corn cultivation is increasing every year. Corn is considered one of the most profitable crops, and its yield exceeds all grain crops. In modern conditions, the introduction of intensive cultivation technologies allows you to get the maximum yield. Most often, corn is grown for grain, but with the development of livestock farming, corn is also grown for silage [8,9].

Let's consider the yield and gross harvest of corn grain in the pre-war period - in the 2016/17...2020/21 marketing years. It can be seen that in the 2017/18 marketing year, corn yield reached its maximum value of 78.4 centners/ha. [11].

In the 2020/21 marketing year, 38.7 million tons of corn were harvested, which is 28% higher than the same period in the previous year. This is the largest gross harvest in all previous years of Ukraine's independence. Such a significant increase in the gross harvest of corn was achieved both by increasing the area sown and yield [11].

The 2021/22 marketing year was no exception, but on the contrary showed a significant increase in production compared to the previous season. A total of 1,206 million tons of corn grain were harvested, which is 83 million tons more than the previous season (+7%) and is the best result ever [12].

Analysis of the obtained data showed that the lowest yield value (5.7 t/ha) was observed in 2015, and the highest (7.8 t/ha) in 2021. The highest corn grain yield (7.8 t/ha) and the highest gross harvest (42 million tons) were observed in the pre-war years, in 2018 and 2021, respectively.

During the war period (2022–2025), the minimum values of yield and gross harvest were within the limits of 6.7–6.5 t/ha and 27.0–26.8 million tons, respectively, and their maximum values were quite close and amounted to 7.7–7.3 t/ha and 32.5–32.0 million tons, respective-



ly [12].

According to experts, corn production in the State is not standing still, for the second war year in a row, the volume of hybrid corn seed exports exceeds the volume of its imports. Thus, in the first half of 2022 alone, 24.4 thousand tons of seeds of domestic and foreign selection were exported from Ukraine, while imports amounted to only 4.1 thousand tons, that is, 6 times less. During this time, hybrid corn seeds worth \$ 67.4 million were sold to world markets. Corn seed export indicators have increased approximately twice in both quantitative and value terms. For example, if in 2022, 14.6 thousand tons were exported for \$33.5 million in 7 months, then in 2024 – 24.4 thousand tons for \$67.4 million.

It is known that the largest importer of corn seeds is Hungary, which purchased 6715 tons of this type of product in January-July 2023. In addition, EU countries also made significant purchases of seed corn in Ukraine. Thus, corn seeds were imported to European countries in volumes to France (4766 tons), Austria (3823 tons), Romania (3659 tons), as well as Egypt (1513 tons) and Moldova (995 tons). These data indicate that imports to the EU increased more than 20 times, if we analyze the corresponding period of the pre-war year 2021 [14].

According to the analysis of data in Ukraine for at least the last decade, corn has always been the leading crop. Given the trends in the fluctuation of corn grain yields over the years, in general, there is a positive trend towards growth in indicators.

The indicators decreased slightly in the 2022 season, but already in 2023 the leaders in the gross harvest of corn grain were Poltava region, Cherkasy and Chernihiv regions.

According to the website Latifundist.com [15], as of 2023, the largest indicators of the gross harvest of corn seeds in Ukraine by region were obtained: in Cherkasy, Poltava, Chernihiv, Vinnytsia and Kyiv regions, at the level of 3341.4-2247.6 thousand tons. If we equate the data to last year's corn yield indicators, we can state the fact that in 2023 17% more corn grain was obtained. Given the dry and warm weather of 2024, farmers managed to harvest corn grain on time.

In a situation that arose against the backdrop of difficulties with logistics and temporary restrictions on the export of certain agricultural crops, part of the harvest was exported.

Our Ukrainian corn remains the cheapest on the world market and is in great demand, despite record harvest figures in the largest producing countries of this crop.

During 2022, world grain markets were significantly affected by the Russian invasion of Ukraine and the almost complete cessation of Ukrainian grain exports.

Since Ukraine is the main exporter of wheat and corn, the result was a sudden shift in demand to other suppliers. This demand is offset by increased exports from Brazil, Canada and India, but, as a result, we see a significant increase in export prices for grain.

Previously, corn was one of the main crops in our economy, but in 2023 it was not included in the crop structure at all, primarily due to high production costs and the high price of fertilizers at that time. In addition, due to closed export routes since the beginning of the

full-scale invasion, there was no sale, so the harvest from the previous 2022 remained in the warehouses. But in the 2024 season, this crop was returned to the crop rotation, sowing 350 t/ha.

Nevertheless, for the 2025 harvest, it is planned to increase the area by another 100 hectares - up to 450 hectares. Because even with such a low yield, corn is profitable for us [16].

According to the State Customs Service, corn exports from Ukraine reached 3 million tons as of October 11. Exporters say that there are no transitional crop residues in the country, so corn supplies gradually decreased from July to September. At the same time, prices and demand for Ukrainian grain from foreign buyers are increasing.

Analysts note several trends:

- an increase in our corn exports to Turkey is forecasted due to a decrease in the export potential of the Russian Federation for this crop,

- high demand for Ukrainian corn from buyers in the EU is being formed due to crop failure and a significant content of aflatoxins in the European harvest. Ukrainian corn has accounted for half of European imports since the beginning of the season (a total of 5.2 million tons were imported).

The Ministry of Agrarian Policy predicts that Ukraine in the 2024/25 MY may harvest a corn harvest of 25 million tons [16]. As of October 3, 2025, 7 million tons of grain were harvested.

Corn yield in Ukraine and its export volumes in recent years, Ukraine has confidently occupied third place in the world in terms of corn exports, losing the leading positions to the USA and Brazil.

Analysts conducted a study to determine how many tons were exported from Ukraine during the current marketing period (July 2018 - June 2019).

According to UkrAgroConsult, our country supplied about 4.4 million tons to Europe, which exceeds the volume of supplies last year by 123%.

Thus, Ukraine displaced Brazil from the first place in terms of exports, which occupied second place, the volume of supplies of which slightly decreased.

The export value of corn in Ukraine depends on numerous factors. First of all, global demand, the area sown by the main exporting countries, the volume of the harvested crop, climatic conditions, exchange rates, etc.

The price is undoubtedly affected by the quality of the product, which depends on the variety of the crop, the integrity of the grain, humidity, presentation and other qualities. When selling for export, the presence of appropriate quality certificates is important [16, 17].

The low marginality of grain crops in Ukraine has been a major factor in farmers reducing the area sown for the new crop, especially corn (by 3% per year). At the same time, disruptions in food and fertilizer exports from Ukraine have critically affected 279 countries, jeopardizing the food security of the least developed countries and highlighting the urgent need for decentralization of supply chains. This necessitates the development of new diversification strategies to ensure stable access to agricultural products at the global level [18-20].



For example, for most of the 2023/24 MY season, corn was \$5-7/ton cheaper than feed wheat in the ports of Reni and Izmail.

In the first forecast for 2024/25 MY, UZA analysts in March predicted a decrease in grain and oilseed production in Ukraine in 2024 by 8% per year - to 76.1 million tons. Their forecast is based on average weather conditions over the past 5 years, but spring and summer periods may introduce their own adjustments. Thus, the wheat harvest in 2024 may decrease by 9% per year - to 20 million tons, and corn production may decrease by 11% - to 26.3 million tons [21].

If we talk about the EU, which is a key importer of Ukrainian corn, then it will need less of its grain due to the expected growth of its own production.

The European Commission predicts an increase in the EU corn harvest in 2024 after two years of decline – to 69 million tons (+11% per year), due to the expansion of areas and improved yields.

The largest increase in areas is expected in France, which will allow the country to harvest 13.6 million tons of corn (+7% per year).

In addition, yields in Hungary and Romania will also grow – by 12%-13% per year – to 7 and 12.3 million tons, respectively.

Bulgaria can harvest 3.5 million tons of corn in 2024 (2.2 million tons in 2023.)

In turn, a decrease of 6% is predicted in Poland – to 8.6 million tons due to the reduction of areas and deterioration of yields [21].

If we talk about the main European importers of Ukrainian corn, then Spain and Italy can increase production by 40% - to 4 million tons of grain, and by 11% - to 5.9 million tons.

The export prospects of Ukrainian corn in the 2024/25 MY may decrease, both due to reduced production and weakened demand from key importers and increased competition.

The 2025/26 Ukrainian corn export season started very slowly. As of the end of November, only 2.4 million tons were shipped to foreign markets - almost half as much as in October-November last year. This is the weakest start in the last three seasons. The reasons for the slowdown are obvious: a delay in the harvesting campaign, extended drying times, energy and railway infrastructure damaged by Russian missile and drone strikes, problems with grain delivery to ports - all this is holding back exports today [22].

If we sum up all realistic sales directions, Ukraine can achieve approximately the same export volume as last year – about 20 million tons. But this is where the key imbalance arises. This season's production will be higher – not 26.8 million tons, but about 31 million tons, and possibly more. This creates an export potential of 24.5 million tons. The difference between potential and actual demand, according to ASAP Agri, is almost 5 million tons. In other words, this is the corn that today simply has no buyer on the world market" [22].

The surplus creates obvious risks. First of all, the growth of transitional stocks, which will put pressure on prices in the new season. Then, the probable decrease in domestic CPT prices, as soon as domestic logistics to ports improve. In fact, the price risks reacting already in

the second half of the season, when more supply will enter the market at the same time [22].

The global corn market is projected to enter a stabilization phase after 2020, with a moderate increase in area of 37% being the most likely scenario. Significant regional differentiation is expected, with China and Brazil expanding rapidly, while the United States remains neutral and Ukraine faces high uncertainty about its agricultural future [23, 24]. Analyzing the dynamics of global production and consumption of major crops is crucial for understanding trends and planning sustainable food production. It is important to have a comprehensive approach that involves collaboration between scientists and farmers to implement sustainable practices [24].

Program, objects and methods of research

The purpose of the research was to establish the dynamics of changes in sown areas, yields and gross corn grain yields in Ukraine in the pre-war and war years and to provide trend forecasts of their possible changes until 2027.

To achieve the goal, the following tasks were set:

- based on statistical data, to compile tables of sown areas, yields and gross corn grain yields in Ukraine for the period from 2013 to 2025;
- to conduct a statistical assessment of the relationship between area and yield, area and gross yield and between yield and gross grain yield;
- based on the data obtained, to construct graphical dependencies that provide a visual characteristic of the dynamics of changes in sown areas, yields and gross corn grain yields in the years under study;
- to develop trend forecast models for changes in sown areas, yields and gross corn grain yields and provide forecast values for sown areas, yields and gross corn grain yields in Ukraine until 2027.
- to draw conclusions from the conducted research and the obtained results.

The research program consisted in the consistent implementation of the tasks set.

The object of the research was statistical data on sown areas, yields and gross corn grain yields in Ukraine for the period from 2013 to 2025.

Research methodology. Analytical and statistical research methods were used in the conducted research. The research results were processed in the MS Excel-2007 environment. Using its tools, when processing statistical data, the correlation coefficients r and determination R^2 were determined, the necessary graphical dependencies were constructed according to the tasks, trend forecast models of the dynamics of changes in the studied components of grain production were developed, and the forecast values of sown areas, yields and gross corn grain harvests in Ukraine until 2027 were determined.

Research results

In accordance with the task of the first stage of research, using data from the literature review, a table of sown areas, yields and gross corn grain harvests in Ukraine for the period from 2013 to 2025 was compiled (Table 1).

Analysis of the data obtained showed that the lowest yield (5.71 t/ha) was observed in 2015, and the high-



Table 1 – Sown areas, yields and gross harvests of corn grain in Ukraine in the period 2013...2025

Years	Area, thousand hectares	Yield, t/ha	Gross yield, million tons
Pre-war period			
2013	4,825	6,40	30,90
2014	4,625	6,20	28,45
2015	4,085	5,71	23,333
2016	4,239	6,60	27,969
2017	4,433	5,44	24,115
2018	4,567	7,84	35,805
2019	4,991	7,19	35,887
2020	5,395	5,62	30,297
2021	5,486	7,68	42,126
War period			
2022	4,05	6,67	27,0
2023	4,20	7,74	32,5
2024	4,10	6,54	26,8
2025	4,40	7,27	32,0

est (7.84 t/ha) in 2021. The highest corn grain yield (7.84 t/ha) and the highest gross harvest (42.125 million tons) were observed in the pre-war years, in 2018 and 2021, respectively.

During the war period (2022–2025), the minimum yield and gross harvest values were within the limits of 6.67–6.54 t/ha and 27.0–26.8 million tons, respectively, and their maximum values were quite close and amounted to 7.74–7.27 t/ha and 32.5–32.0 million tons, respectively.

At the next stage of the research, the correlation coefficients r were calculated and a statistical assessment of the relationship between area and yield, area and gross harvest, and between yield and gross grain harvest was carried out. The results obtained are summarized in Table 2.

The determined correlation coefficients r provided the following statistical assessment of the studied relationships in the studied pre-war and war periods.

In the pre-war period (2013–2022), a moderate correlation was found between area and grain yield (correlation coefficient $r=0.310$).

There is a correlation of medium strength between area and gross grain yield, which is confirmed by the higher value of the coefficient, which is $r=0.637$.

However, the strongest correlation was found between yield and gross grain harvest, which is estimated by an increased correlation coefficient of $r=0.848$.

During the war period (2022–2025), the strength of correlations changed.

The relationship between area and yield became very weak, as evidenced by the too small value of the correlation coefficient $r=0.085$.

But between area and gross harvest, as well as between yield and gross grain harvest, the strength of correlations remained practically at the level of the pre-war

Table 2 – Statistical evaluation of the relationships between corn coats, yield and gross grain harvest

Connections	Correlation coefficients r	Relationship assessment
Pre-war period		
Area – yield	0,310	moderate
Area – gross collection	0,637	average
Yield – gross harvest	0,848	high
War period		
Area – yield	0,085	very weak
Area – gross collection	0,678	average
Yield – gross harvest	0,786	high

period - respectively, medium strength ($r=0.678$) and strong level ($r=0.786$).

Further, using the data in Table 1, graphical relationships were constructed that provide a visual description of the dynamics of changes in sown areas, yields, and gross corn grain harvests in the studied years of the pre-war (2013–2021) period, as well as taking into account the war (2013–2025) period.

The analysis of the dynamics of changes in sown areas, yields and gross corn grain yields in the pre-war years (2013–2021), shown in Fig. 1, showed that changes in yields and gross corn grain yields have a wave-like character in the period 2013–2021 with coinciding phases of fluctuations over the years.

The lowest yield (5.44 t/ha) was observed in 2017, and the highest (7.84 t/ha) was observed in 2018. The lowest gross corn grain harvest (23.333 million t) was observed in the pre-war years (2015), and the highest (42.125 million t) was observed in 2021.

In the dynamics of changes in sown areas, unlike yields and gross grain harvests, significant fluctuations were not clearly observed. In the pre-war period, starting in 2015, a stable growth in sown areas for corn began - from 4,085 thousand ha to 5,486 thousand ha in 2021.

The dynamics of changes in the sown areas, yields and gross corn grain harvests during the period including the war years (2013–2025) is shown in Fig. 2.

During the war period (2022–2025), yields and gross yields fluctuated annually, but their minimum (6.67–6.54 t/ha, 27.0–26.8 million tons) and maximum (7.74–7.27 t/ha, 32.5–32.0 million tons) values were quite close. However, the sown area during the war years decreased from 5,486, which was reached in 2021, to the level of 4.05–4.4 thousand hectares in 2022–2025.

Further research was related to the development of predictive trend models for changes in sown areas, yields and gross yields of corn grain in the pre-war (Fig. 1) and together with the war years (Fig. 2) periods.

To select trend models that most accurately describe the dynamics of changes in annual statistical data on sown areas, yields and gross grain harvests, using the tools provided in Excel, trend models of exponential, linear, logarithmic, polynomial and power types were considered with the corresponding equations and values

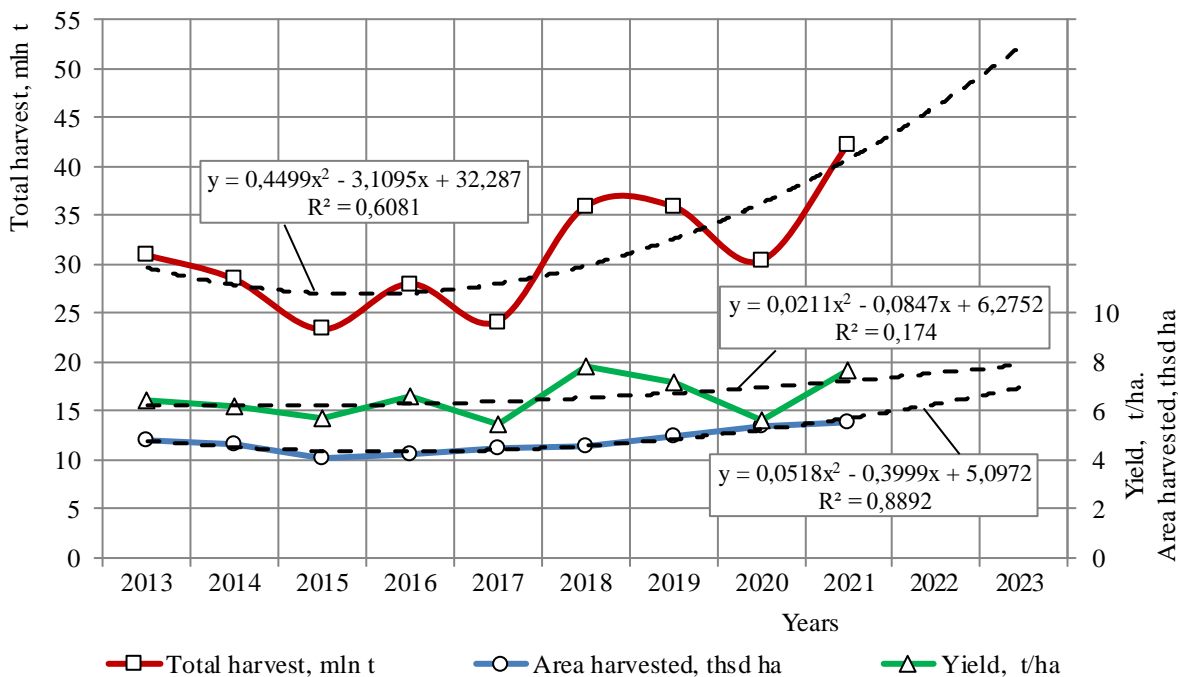


Fig. 1 – Dynamics of changes in sown areas, yields and gross harvests of corn grain in the pre-war period (2013–2021)

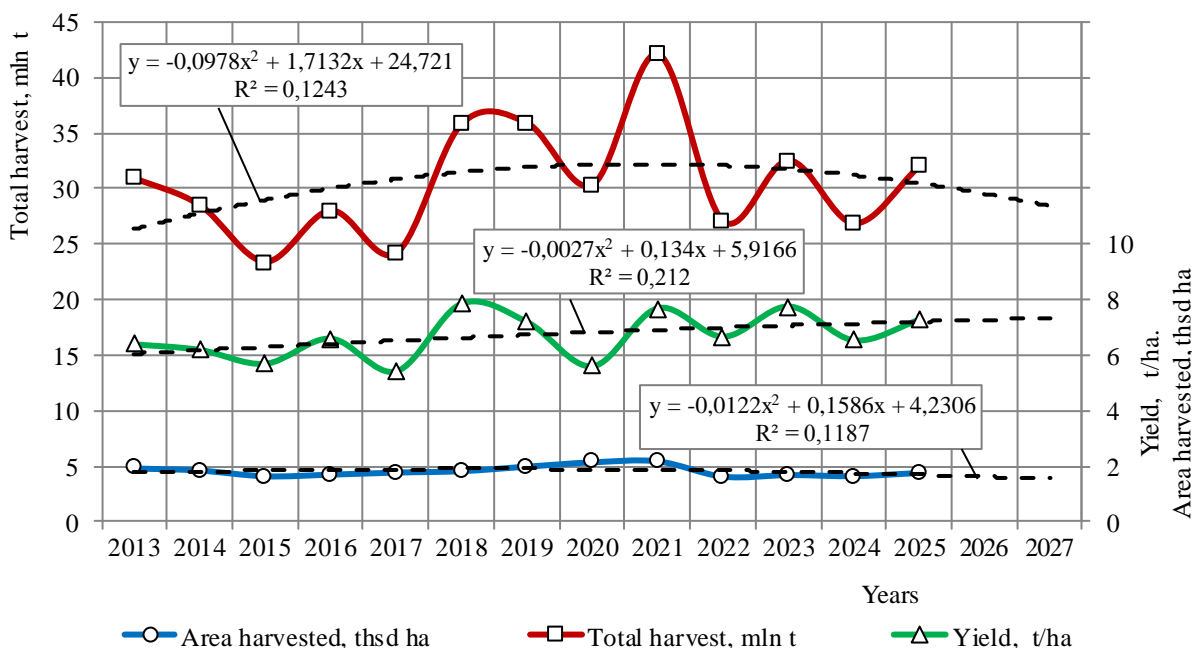


Fig. 2 – Dynamics of changes in sown areas, yields and gross corn grain harvests during the period including the war years (2013–2025)

of the probabilities of their approximation (coefficients of determination R²). The results obtained are given in Tables 3 and 4.

In the formulas of trend models, the symbol "x" denotes the serial numbers of the years in the studied period. That is, in the period 2013–2022, for 2013, x=1, for 2014, x=2, etc.

Analysis of the results of the constructed trend models by the coefficient of determination R² showed that among the considered types of trend models, only quadratic trend lines have the largest values (highlighted in bold). However, not all of them adequately reflect the dependence of gross grain harvests, yields and sown are-

as for corn on the time series of the period.

According to the definition, the coefficient of determination R² measures what proportion of the variation of the dependent variable "y" can be explained by the variation of the independent variable "x_i" in the trend statistical model. In simple words, it shows how well the model "fits" the data, that is, how well the independent variable explains changes in the dependent variable. Even more simply, we can say that the coefficient of determination R² is the percentage of variation in the dependent variable "y_i" that can be explained by the independent variable (or variables) "x_i".



It is believed that when:

$0 \leq R^2 < 0.45$ – the trend model is inadequate, i.e. there is no relationship between the variables;

$0.55 < R^2 \leq 1.0$ – the trend model is adequate, i.e. there is a relationship between the variables;

$0.45 \leq R^2 \leq 0.55$ – the coefficient of determination is uncertain, i.e. it is impossible to determine the adequacy of the trend model by its value.

Thus, according to the above, only the following polynomial (quadratic) models can be considered adequate trend models for the period 2013–2021:

– for gross grain harvest $y_1 = 0.449x^2 - 3.109x + 32.28$, $R^2=0.608$;

– for grain sowing area $y_3 = 0.051x^2 - 0.399x + 5.097$, $R^2=0.889$.

They show that the gross grain yield by 60.8% and the sown area by 88.9% depend on the serial number of the year in the studied period. The coefficient of determination for grain yield $R^2=0.174$, i.e. changes in yield depending on the year can only be explained by the serial number of the year by 17.4%, i.e. the trend model is inadequate.

For the period 2013–2025, there are no adequate trend models, since all three quadratic polynomial models for gross harvest, grain yield, and corn sown area have determination coefficients of 0.124, 0.212, and 0.118, respectively, which lie in the range of inadequate values ($0 \leq R^2 < 0.45$), when there are no reliable relationships between the variables.

Above, Fig. 1 and 2 show the forecast values of the studied indicators (gross harvest, grain yield, and grain sown area) for the next 2 years. However, only the values for gross grain harvest and sown area that were determined by adequate trend models will be reliable.

Thus, based on research from 2013–2021, the probable forecast values for corn grain will be as follows:

– gross harvest in 2022 46.09 million tons, in 2023 52.41 million tons;

– sown areas in 2022 6.21 thousand hectares, in 2023 6.88 thousand hectares.

The predicted values for corn grain yield in 2022–2023 could reach 7.54–7.89 tons/hectare, however, the probability of such data is only 0.212.

Based on trend models compiled for 2013–2025, which includes the martial law period, the following results could be expected in 2026 and 2027:

– gross harvest – 29.69 and 28.59 million tons;

– yield – 7.40 and 7.48 tons/ha;

– sown areas – 4.09 and 3.90 thousand hectares.

However, the probability of such data is too low – it is 0.124, 0.212 and 0.118 for gross grain harvest, its yield and sown areas, respectively. This situation is a consequence of military actions on occupied and withdrawn from circulation sown areas of the agricultural sector of Ukraine.

Conclusions

1. Based on statistical data, tables of sown areas, yields and gross grain yields of corn in Ukraine for the period from 2013 to 2025 were formed and graphical dependencies were constructed that provide a visual characteristic of changes in the studied indicators.

2. A statistical assessment of the relationship be

tween area and yield and area and gross grain yield, as well as between yield and gross grain yield, showed the

Table 3 – Summary of trend model indicators for the pre-war period (2013–21)

Model type name	Trend Model Formula	Probability of approximation R^2
<i>Gross corn grain harvest</i>		
Exponential	$y_1 = 24,67e^{0,042x}$	0,362
Linear	$y_1 = 1,389x + 24,03$	0,395
Logarithmic	$y_1 = 3,817\ln(x) + 25,55$	0,205
Polynomial	$y_1 = 0,449x^2 - 3,109x + 32,28$	0,608
Power level	$y_1 = 25,94x^{0,113}$	0,179
<i>Corn grain yield</i>		
Exponential	$y_2 = 5,916e^{0,017x}$	0,130
Linear	$y_2 = 0,126x + 5,888$	0,152
Logarithmic	$y_2 = 0,388\ln(x) + 5,967$	0,099
Polynomial	$y_2 = 0,021x^2 - 0,084x + 6,275$	0,174
Power level	$y_2 = 5,995x^{0,053}$	0,080
<i>Corn sowing area</i>		
Exponential	$y_3 = 4,179e^{0,024x}$	0,428
Linear	$y_3 = 0,118x + 4,147$	0,447
Logarithmic	$y_3 = 0,292\ln(x) + 4,322$	0,189
Polynomial	$y_3 = 0,051x^2 - 0,399x + 5,097$	0,889
Power level	$y_3 = 4,337x^{0,058}$	0,175

Table 4 – Summary of trend model indicators for the period including the war years (2013–25)

Model type name	Trend Model Formula	Probability of approximation R^2
<i>Gross corn grain harvest</i>		
Exponential	$y_1 = 27,84e^{0,011x}$	0,071
Linear	$y_1 = 0,344x + 28,14$	0,065
Logarithmic	$y_1 = 1,740\ln(x) + 27,53$	0,065
Polynomial	$y_1 = -0,097x^2 + 1,713x + 24,72$	0,124
Power level	$y_1 = 27,41x^{0,054}$	0,063
<i>Corn grain yield</i>		
Exponential	$y_2 = 5,997e^{0,014x}$	0,208
Linear	$y_2 = 0,096x + 6,011$	0,210
Logarithmic	$y_2 = 0,446\ln(x) + 5,910$	0,174
Polynomial	$y_2 = -0,002x^2 + 0,134x + 5,916$	0,212
Power level	$y_2 = 5,922x^{0,065}$	0,165
<i>Corn sowing area</i>		
Exponential	$y_3 = 4,650e^{0,00x}$	0,015
Linear	$y_3 = -0,012x + 4,659$	0,010
Logarithmic	$y_3 = -0,04\ln(x) + 4,642$	0,004
Polynomial	$y_3 = -0,012x^2 + 0,158x + 4,230$	0,118
Power level	$y_3 = 4,639x^{-0,01}$	0,007



following. In the pre-war period (2013–2022), there was a moderate correlation between area and yield (correlation coefficient $r=0.310$), there was an average correlation between area and gross grain yield ($r=0.637$), and a strong correlation was observed between yield and gross grain yield ($r=0.848$).

During the war period (2022–2025), the relationship between area and yield became very weak ($r=0.085$), and the relationships between area and gross harvest and yield and gross grain harvest remained practically at the pre-war level — medium ($r=0.678$) and strong ($r=0.786$), respectively.

3. The dynamics of changes in sown areas, yields and gross grain harvests of corn in the pre-war (2013–2021) and war years (2013–2025) were studied. It was shown that changes in yields and gross grain harvests of corn in the period 2013–2025 have a wave-like character with coinciding phases of fluctuations over the years. The lowest yield (5.71 t/ha) was observed in 2015, and the highest (7.84 t/ha) in 2021. The highest corn grain yield (7.84 t/ha) and the highest gross harvest (42.125 million t) were observed in the pre-war years, in 2018 and 2021, respectively.

4. During the war period (2022–2025), yield and gross harvest fluctuated annually, but their minimum (6.67–6.54 t/ha, 27.0–26.8 million t) and maximum (7.74–7.27 t/ha, 32.5–32.0 million t) values were quite close.

In the dynamics of changes in sown areas, unlike grain yields and gross harvests, no significant fluctuations were clearly observed. In the pre-war period, starting in 2015, a stable growth in corn sown areas was ob-

served. – from 4,085 thousand ha to 5,486 thousand ha in 2021. However, during the war years, sown areas decreased slightly to the level of 4,05–4.4 thousand ha.

5. The developed predictive trend models for changes in sown areas, yields and gross harvests of corn grain in the pre-war and together with the war years have the form of quadratic polynomials, which provided the largest values of reliability coefficients (R^2 determination) compared to typical (linear, exponential, logarithmic and power) trend lines.

6. In the pre-war period, the trend line for sown areas has the highest reliability ($R^2=0.889$), a slightly lower one ($R^2=0.608$) for gross harvests and a very weak one ($R^2=0.174$) for sown areas. All three trend lines have minima and over the years provide a gradual increase in the considered indicators.

The trend lines obtained taking into account the war years have low reliability, as evidenced by the values of the R^2 determination coefficients, which are 0.212, 0.124 and 0.118 for yield, gross harvests and sown areas, respectively. In addition, the trend lines have maxima (the coefficients at x^2 are negative), which shows a gradual decrease in the forecast values with each subsequent year. The forecast values of sown areas, yields and gross corn grain yields, calculated using the obtained trend equations, are 4.09–3.90 thousand hectares for 2026 and 2027, respectively; 29.69–28.59 million tons and 7.40–7.48 tons/hectare.

However, these values have low reliability, caused by inadequate changes in the considered indicators as a result of military actions, which significantly affected the results of the agricultural sector of Ukraine.

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ДИНАМІКА ТА ТЕНДЕНЦІЇ ВИРОБНИЦТВА ЗЕРНА КУКУРУДЗИ В УКРАЇНІ У ДОВОЄННИЙ ТА ВОЄННИЙ ПЕРІОДИ

Анотація

Стаття присвячена аналізу тенденцій, обґрунтуванню проблем та напрямкам посилення обсягів виробництва кукурудзи на зерно в Україні у довоєнний та воєнний періоди. Проаналізовано місце України серед провідних експортерів кукурудзи у світі та динаміку її виробничих показників. Надано оцінку тенденцій урожайності, валового збору та виробництва кукурудзи на зерно в Україні в різних регіонах. Проведено статистичну оцінку взаємозв'язку між площею та врожайністю та площею та валовим збором зерна, а також між врожайністю та валовим збором зерна кукурудзи в окремих регіонах України та за певні періоди вегетації. Проведено статистичну оцінку кореляційних зв'язків між площею, врожайністю та валовим збором у різні періоди вегетації. Особлива увага приділяється порівняльному аналізу результатів виробництва зерна у довоєнний (2013–2021) та воєнний (2022–2025) періоди. На основі отриманих даних розроблено трендові прогностичні моделі розвитку галузі до 2027 року. Охарактеризовано основні проблеми розвитку зернового виробництва в Україні у довоєнний період та у воєнний період країни. Отримані результати свідчать про те, що, незважаючи на виклики воєнного часу, галузь зберігає значний адаптивний потенціал. За результатами кореляційно-регресійного аналізу встановлено високу щільність зв'язку між врожайністю та обсягами виробництва, що підтверджує визначальну роль інтенсифікації технологій у сучасних умовах. На основі побудованих прогностичних моделей (лінійних та поліноміальних трендів) обґрунтовано сценарії розвитку галузі до 2027 року. Згідно з прогнозом, за умови стабілізації логістичних маршрутів очікується поступове відновлення валового тоннажу до рівня 25,6–27,8 млн тонн. Практичне значення отриманих результатів полягає у визначенні ключових факторів, що стримують експорт, зокрема руйнування портової інфраструктури та висока вартість енергоносіїв для сушіння зерна. Сформульовано рекомендації щодо диверсифікації логістичних маршрутів та розширення внутрішньої переробки кукурудзи як інструменту збільшення доданої вартості.


Ключові слова: кукурудза на зерно, посівна площа, врожайність, виробництво, сушіння та зберігання зерна кукурудзи, статистична обробка, моделі прогнозування трендів.

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