UDC: 633.17:338.43(477:100)
DOI https://doi.org/10.15673/gpmf.v25i3.3207

O. Sokolovska, PhD of Technical Science, Associate Professor, *E-mail: sokolovskaya alena@ukr.net*
https://orcid.org/0000-0003-4326-1932, ResearcherID: N-5304-2015
L. Valevska, PhD of Technical Science, Associate Professor, *E-mail: ludmila valev@ukr.net*
https://orcid.org/0000-0003-0511-5643, ResearcherID: F-8756-2016
A. Borta, PhD of Technical Science, Associate Professor, *E-mail: borta.alla@ukr.net*
https://orcid.org/0000-0001-9790-4732 ResearcherID: F-9893-2016
Odesa National University of Technology, *112, Kanatna Str., Odessa, 65039, Ukraine*

COMPREHENSIVE ANALYSIS OF SORGHUM PRODUCTION IN UKRAINE AND THE WORLD

Abstract

In the modern world, facing the challenges of food security and the need to adapt agricultural production to climate change, sorghum appears as one of the most promising crops. Due to its exceptional drought resistance, unpretentiousness to soil conditions and efficient water consumption, sorghum provides stable yields even in regions with adverse climates, where traditional crops such as corn are ineffective. Its versatility covers a wide range of uses: from a valuable source of protein and energy for livestock to the production of biofuels, starch, alcohol and gluten-free products for the food industry. Sorghum is also recognized as a "smart food" due to its high nutritional value (source of vegetable protein, iron, B vitamins, antioxidants), lack of gluten and potential medicinal properties, in particular for diabetes and gastrointestinal diseases. Despite the global growth of interest in sorghum and its position as the fifth largest grain crop in the world, its cultivation in Ukraine remains at a relatively low level. The problem lies in the underutilization of sorghum's potential due to a number of limiting factors, such as fragmented or outdated production data, insufficient awareness of farmers, lack of proper infrastructure for processing and marketing, limited access to quality seed material, as well as the impact of the full-scale invasion of the Russian Federation, which led to a sharp reduction in sown areas in 2022-2023. The article provides a comprehensive analysis of the global and Ukrainian dynamics of sorghum production, highlighting the main trends, such as fluctuations in sown areas (a decrease of 9.2% in the world in 2013-2023) and gross harvests, as well as regional differences in yields. Particular attention is paid to the impact of climate change and the consequences of military operations on the agricultural sector of Ukraine. The study identifies key economic and agrotechnical prospects for sorghum, the need to form a strategy for the development of the industry and assess the export potential of Ukraine. The proposed scientifically based recommendations are aimed at stimulating the development of this crop to increase the country's food, feed and energy security, contributing to the sustainable development of agriculture.

Key words*: sorghum grain, yield, sown areas, production volumes, main producers.*

Introduction

In the modern world, food security and sustainability of agricultural production are among the most important global challenges. Climate change, population growth and the need to reduce the burden on limited resources require the search for new, more adapted and efficient agricultural crops. In this context, sorghum stands out as one of the most promising crops, capable of playing a key role in ensuring food, feed and energy security, especially in conditions of increasing water scarcity and variability of climatic conditions.

The relevance of the research topic is due to several key factors:

Climate change and adaptation of agriculture: Ukraine, like many other countries, is experiencing the consequences of global climate change, which are manifested in the increase in droughts, an increase in average annual temperatures and a change in the precipitation regime. Sorghum, known for its high drought resistance and unpretentiousness to soil conditions, is an ideal crop for adapting the agricultural sector to these changes. Its ability to efficiently use moisture allows for stable yields even in regions with adverse climates, where traditional crops such as corn may be ineffective.

Growing demand for fodder and industrial crops: Sorghum is a versatile crop with a wide range of uses. It is a valuable source of protein and energy for livestock, is used in the production of biofuels (bioethanol), starch, alcohol, and in the food industry (gluten-free products). The growing demand for these products in both domestic and global markets creates significant prospects for expanding sorghum acreage in Ukraine.

Diversification of agricultural production: Over-reliance on a limited set of agricultural crops makes the agricultural sector vulnerable to market fluctuations and climate risks. Including sorghum in crop rotation allows for diversification of production, reduction of risks, and increased resilience of agribusiness.

Economic feasibility: Due to its adaptability and relatively low cost of cultivation compared to some other crops, sorghum can provide high profitability for agricultural producers. This is especially important in conditions of fierce competition in the agricultural market.

Use of degraded and low-yielding lands: The ability of sorghum to grow on less fertile soils opens up opportunities for the effective use of lands that are poorly suited for growing other crops, which contributes to the optimization of land use.

Sorghum cultivation in Ukraine remains at a relatively low level compared to other agricultural crops and its potential. The problem lies in the insufficient use of the potential of sorghum in Ukraine and the lack of a comprehensive understanding of the factors affecting its production and integration into the agricultural sector of the country.

Literary review

Global warming is one of the key challenges for modern agriculture, particularly in Ukraine. Its direct consequence is an increase in the frequency and intensity of droughts, which significantly affects crop yields. According to [1-5], weather factors can cause crop fluctuations of up to 50%, especially in the southern regions of the country. An increase in air and soil temperature leads to a decrease in the yield and quality of grain crops, and also increases the risk of fires that destroy crops [1-5]. In addition, a decrease in precipitation negatively affects the growth and development of plants during their growing season.

Moisture deficiency is also manifested in a decrease in the water level in the soil and surface water sources, which worsens the yield and quality of products. A decrease in water resources can also lead to an increase in the area of salt marshes and other soil problems. Under these conditions, efficient water use becomes critically important for grain crops. Researchers [5, 6] point out the need to implement drip irrigation systems to precisely control the water supply to plants. In the absence of irrigation, effective methods are to conserve water in the soil through mulching and increasing the content of organic matter, as well as the selection of drought-resistant crops.

Among the crops that demonstrate high adaptability to arid conditions, sorghum occupies a special place. It is one of the most drought-resistant crops that can grow effectively under limited moisture supply. As noted [1, 3, 5-7], sorghum has a well-developed root system that provides plants with moisture even in difficult conditions. The crop also has a high water-saving potential, accumulating moisture in leaves and stems.

In addition to drought resistance, sorghum demonstrates a high level of resistance to diseases and pests, which minimizes its vulnerability to climate change and ensures stable yields. Sorghum grain is characterized by high energy value, which makes it attractive for use in feed production. It is also a promising raw material for the production of biofuels (in particular, ethanol) and other products [1,5].

Sorghum, occupying the fifth place among cereals in terms of global production, was traditionally grown in Africa. However, recently there has been a growing interest in this crop in Europe and other parts of the world. This is due not only to its adaptability, but also to its unique nutritional properties. Sorghum belongs to the category of so-called "smart foods" - products that are not only tasty, but also maximally beneficial for humans. This cereal is a rich source of vegetable protein, iron, vitamin B6, niacin, phosphorus, potassium. It is a high-calorie product, rich in antioxidants, and, importantly, does not contain gluten, which makes it safe for people with celiac disease. In addition, sorghum contains a significant amount of beneficial dietary fiber.

Sorghum products are ideal for people with diabetes, as they contain few soluble sugars (1-5%) and many free sugars. Sorghum is also known to help fight some gastrointestinal diseases. For example, in Africa it is used to treat gallstone disease, stomach ulcers and colitis, and in China – to stop cholera-like diarrhea. Many countries actively support sorghum cultivation through subsidy programs, research and development of new varieties, recognizing its strategic importance for the agricultural sector and economic development [4, 8].

Recent scientific studies confirm that food sorghum is a promising crop with high nutritional value, economic benefits and environmental sustainability. Experts emphasize that sorghum is a unique product used in the food industry for the production of cereals and flour, luxury alcohol, beer, starch (which is superior to corn and not inferior to potato), as well as sorghum "honey", rich in fructose, which does not crystallize and can be consumed by diabetics [5, 8].

In particular, scientists [9] emphasize the need to increase production and expand the range of gluten-free bakery products. They are investigating the development of technologies for these products using starch, flour of cereal crops - rice, corn, sorghum, as well as food additives-structurers. Scientists justify the feasibility of using flour from Ukrainian-produced grain sorghum in a mixture with corn and potato starch in the technology of gluten-free bread.

A number of scientists [2, 5-9] also consider the scientific and practical aspects of growing sorghum in intensive farming systems in the conditions of southern Ukraine

Scientists from different countries have studied the relevance of sorghum production and expanding the spectrum of its use in various industries [10–17]. They propose systems of agrotechnical measures aimed at optimizing production processes of the crop, improving product quality, obtaining maximum economic effect and minimizing anthropogenic pressure on the environment. Further research on food sorghum is important for expanding knowledge and practical application of this promising crop for the stability of production in the conditions of global climate change and ensuring world food security.

Thus, food sorghum is an important crop in terms of food security, economic benefits, environmental sustainability and meeting the growing demand for healthy food.

Formulation of the problem

Despite the obvious advantages of sorghum, in particular its drought resistance and versatility of use, this crop is still grown at a relatively low level in Ukraine, not corresponding to its significant potential. The main problem is the insufficient use of this potential and the lack of a comprehensive understanding of the factors that prevent the full integration of sorghum into the country's agricultural sector. To reveal all the possibilities of sorghum, systematic research and elimination of existing barriers are necessary, which will allow its role in increasing the stability and efficiency of Ukrainian agriculture to be fully realized.

Key aspects of the problem can be identified:

Lack of up-to-date data on production volumes: For effective planning and development of the industry, accurate and up-to-date data on current sorghum production volumes, sown areas, yields and regional distribution are necessary. Existing data may be fragmented or outdated, which complicates an objective assessment of the situation.

Lack of clarity of factors limiting production: There are a number of reasons that prevent the wider introduction of sorghum in Ukraine. These may include insufficient awareness of farmers about the benefits of the crop, lack of proper infrastructure for processing and marketing, limited access to high-quality seed material, insufficient scientific and methodological support, as well as competition with traditional crops. The author seeks to identify and analyze these limiting factors.

Uncertainty of economic and agrotechnical prospects: It is necessary to conduct a deep analysis of the economic feasibility of growing sorghum for different regions of Ukraine, taking into account the specifics of soil and climatic conditions and market prices. It is also important to assess optimal agrotechnical practices to ensure maximum yield and product quality.

Lack of an industry development strategy: In order for sorghum to take its rightful place in the structure of agricultural production in Ukraine, a clear industry development strategy is needed, which would include state support measures, scientific research, expansion of sales markets and popularization of the crop among agricultural producers. The author seeks to provide substantiated recommendations for the formation of such a strategy.

Export potential assessment: An important aspect is the analysis of Ukraine's potential as an exporter of sorghum and its processed products. Research on world markets and demand for sorghum will allow us to identify promising areas for Ukrainian producers.

Thus, the work is aimed at filling information gaps, comprehensively analyzing the current state and potential of sorghum production in Ukraine, identifying key problems and developing scientifically based recommendations to stimulate the development of this promising industry. This will make sorghum cultivation more attractive and effective for Ukrainian farmers, contributing to the sustainable development of the country's agriculture.

The aim of the work is to carry out a comprehensive analysis and assessment of the dynamics of sorghum production on a global scale and in Ukraine to identify key trends and factors that determine the development of this crop in the context of ensuring food, feed and energy security.

To achieve this goal, the following research tasks have been identified:

- analyze world sorghum production volumes and identify leading producing countries;
- to investigate the dynamics of gross sorghum grain harvests in Ukraine;
- to assess changes in sorghum sown areas in Ukraine;
- to carry out a comparative analysis of sorghum yields in different regions of Ukraine, taking into account farm categories.

Results of the study and their discussion

Currently, sorghum is grown on almost all continents and in many countries of the world. In recent years, the area sown to sorghum in the world has reached 42.4–43.8 million hectares, and the gross harvest has fluctuated within 60–65 million tons.

According to research and analysis of the specialized report World Agriculture Production prepared by market experts of the United States Department of Agriculture last year, significant areas sown to this crop were in the countries of Africa and Asia (Sudan, India, Nigeria, Niger), as well as in the USA and Mexico [18].

The annual area sown to sorghum is almost 50 million hectares. It is grown in more than 85 countries of the world. Over the past 50 years, the area sown to sorghum in the world has increased by 60%, and grain production by 244% [18].

The world area sown to sorghum over the past decade has undergone noticeable fluctuations, demonstrating both periods of growth and significant decline. According to the graph, in 2013 the total area under the crop was 43,897.9 thousand hectares, and in 2023 it was 39,851.4 thousand hectares, which indicates a total decrease of 4,046.5 thousand hectares, or approximately 9.2% (Fig. 1).

The largest area under sorghum was recorded in 2016 – 44934.1 thousand ha, which is the peak value for the analyzed period. Until then, a gradual increase was observed: in 2014 – 44661.8 thousand ha, and in 2015 the area decreased slightly to 41892.0 thousand ha, but reached a maximum the following year. This trend was

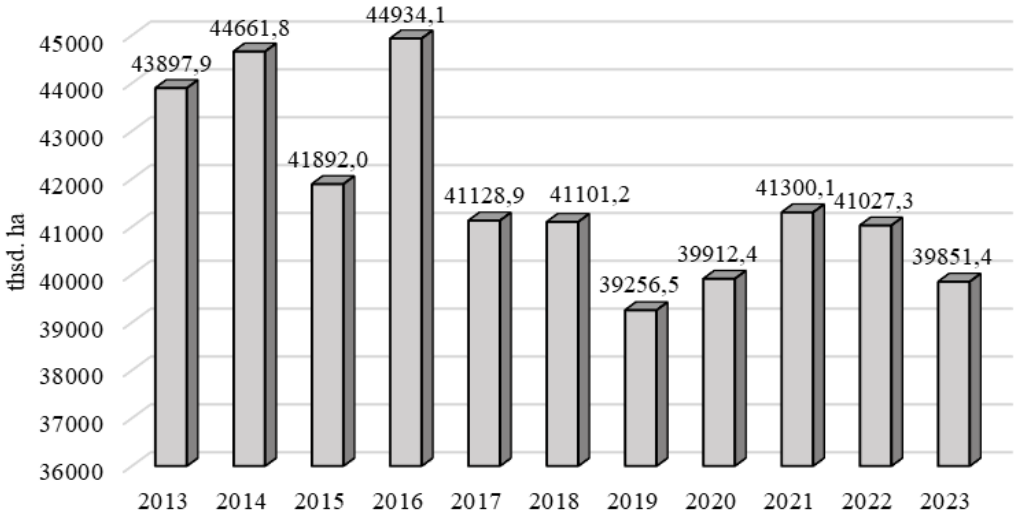

Fig. 1 – Sorghum sowing areas in the world

probably due to the growing demand for sorghum as an alternative drought-resistant crop suitable for cultivation in adverse climatic conditions, as well as due to the increased use of sorghum for bioenergy purposes. However, since 2016, a period of steady reduction in area has begun, which lasted until 2019. In particular, in 2017, the area decreased to 41,128.9 thousand hectares, in 2018 – to 41,101.2 thousand hectares, and in 2019 – to 39,256.5 thousand hectares. This decline could be caused by a change in market conditions, a decrease in the profitability of the crop compared to corn or soybeans, as well as the impact of climate change.

In 2020–2021, a slight recovery of the area was observed: in 2020 – 39,912.4 thousand hectares, and in 2021 – 41,300.1 thousand hectares. This could be a response to a new wave of interest in sorghum as an energy and feed crop, in particular in the context of global food and feed shortages.

However, in the following years, the areas decreased again: in 2022 - to 41027.3 thousand hectares, and in 2023 - to 39851.4 thousand hectares. Such fluctuations indicate the instability of the sorghum market, which depends on many factors, in particular on state policy, the economic benefits of growing the crop, climatic conditions and scientific and technical support.

The average yield of sorghum in 2016 in the world did not exceed 1.50 t/ha and was characterized by quite high variability in different countries - from 0.37 t/ha in Sudan to 5.72 t/ha in the EU. High yields were obtained when growing sorghum in Egypt - 5.36 t/ha and the USA - 4.89 t/ha, as well as in Argentina - 4.50 t/ha.

The trend towards an increase in areas was also observed in the countries of Eastern Europe. This shows the growing interest of producers in this crop, whose resistance to adverse weather conditions is a real advantage. And this year's sorghum yield confirms this: with an average of 5.62 t/ha, it is generally increasing, even if it hides very uneven results.

In Italy, Austria, Hungary and Spain, sorghum yields increased significantly compared to 2019 and compared to the average of the last 5 years.

In France, due to a very severe drought, there was a slight decrease in yields compared to the average of the last 5 years and in 2020 the average yield in this country was 5.06 t/ha.

The Black Sea basin countries were also hit by drought this year, which led to a significant decrease in yields in Ukraine (-27%), Romania (-30%) and Bulgaria (-8%).

Understanding the dynamics of its global production is critical for the analysis of food security, market trends and agricultural policy planning.

During the analyzed period (2013-2023), global sorghum production showed significant fluctuations, without revealing a clear upward or downward long-term trend. The average annual production volume for this period is approximately 61.2 million tons (Fig. 2) (based on data [18]).

Analyzing the dynamics of global sorghum production for the period 2013-2023, one can trace a trend of a gradual decrease in production volumes after a peak growth in the middle of the studied period. According to the data provided, in 2014 the maximum indicator was reached - 68.3 million tons, which exceeded the level of 2013 (61.9 million tons) by almost 6.4 million tons.

The following years were marked by instability. This trend coincides with a period of decline in global sorghum acreage, indicating a direct relationship between acreage and gross crop yields. In 2018–2019, production remained relatively stable at 60.1 million tonnes in 2018 and 56.8 million tonnes in 2019, which may indicate some stabilization of the agricultural sector and weather conditions in the main sorghum producing countries.

After a moderate increase in 2020 (58.1 million tons), there was a temporary recovery in production, which in 2021 reached 60.9 million tons, approaching the 2018 figures. However, in 2022–2023, production decreased again - to 57.7 million tons and 57.3 million tons, respectively, which may be a consequence of a decrease in sown areas, climate change, as well as a decrease in the market attractiveness of sorghum in certain regions.

Global sorghum production is characterized by both geographical diversity and dynamic changes in the share of individual countries. We have conducted a comparative analysis of the main sorghum producers in the world for 2022 and 2023, based on gross harvest data (Table 1).

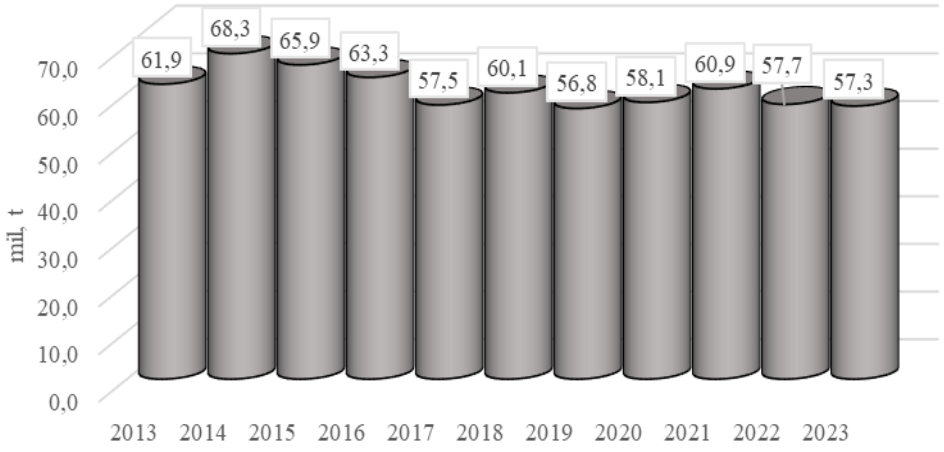

Fig. 2 – Sorghum production in the world

Table 1 – Major sorghum producers in the world (thousand tons) [18]

Country	2023 year, thsd. ha	Place 2023 p	2022 year, thsd. ha	Place 2022 year	Volume change (2023-2022)	Change of place
USA	8071	1	4769	3	+3302	▲ +2
Nigeria	6402	2	6806	1	-404	▼ -1
Mexico	4815	3	4762	4	+53	▲ +1
Brazil	4498	4	2930	8	+1568	▲ +4
Ethiopia	4010	5	4140	6	-130	▲ +1
Ethiopia	3814	6	4150	5	-336	▼ -1
Ethiopia	3055	7	5248	2	-2193	▼ -5
China	2966	8	3039	7	-73	▼ -1
Australia	2326	9	2648	10	-322	▲ +1
Burkina Faso	1772	10	(not in the top -10)	-	-	New member
Argentina	(not in the top -10)	-	2883	9	-	Eliminated from the top

Analysis of key changes in the structure of sorghum production in the world:

1. USA: New Leader (69% increase): In 2023, the USA made an impressive jump from 3rd to 1st place, increasing production from 4,769 thousand tons to 8,071 thousand tons (+3,302 thousand tons). This indicates a significant expansion of the planted area, favorable agro-climatic conditions or high demand for sorghum from processing industries (e.g. for ethanol production or exports).

2. Nigeria: Declining but stable position: Nigeria, which was the leader in 2022 (6,806 thousand tons), decreased its production to 6,402 thousand tons in 2023, dropping to 2nd place. This could be due to domestic factors such as weather conditions or security concerns affecting agriculture. Despite the decline, Nigeria remains a key global producer.

3. Sudan: Biggest decline and fall: Sudan has seen the biggest drop in production of any country on this list, falling from 2nd place (5,248,000 tonnes) in 2022 to 7th place (3,055,000 tonnes) in 2023. This drop of 2,193,000 tonnes is likely due to political instability and conflict, which have significantly affected agricultural production in the country.

4. Brazil: Significant growth: Brazil has shown impressive progress, rising from 8th place in 2022 (2,930,000 tonnes) to 4th place in 2023 (4,498,000 tonnes), increasing production by 1,568,000 tonnes. This may indicate an expansion of sorghum as a second crop after soybeans or corn, as well as favorable weather conditions.

5. India and Ethiopia: Small declines: Both countries showed a small decline in production in 2023 compared to 2022, but maintained their positions among the top producers, confirming their importance in global sorghum production.

6. Mexico and China: Relative stability: These countries showed little change in production and positions, indicating a relative stability in their contribution to global sorghum supply.

7. Australia and Burkina Faso/Argentina: Changes at the bottom of the top 10: Australia slightly decreased production, but rose one position. Argentina dropped out of the top 10 in 2023, while Burkina Faso entered the list, ranked 10th with a production of 1,772,000 tonnes. This indicates the variability in sorghum production in regions with more weather-sensitive agricultural systems.

Next, we analyzed sorghum production in Ukraine (Fig. 3) [19]. Climate change is the most important problem of today. Climate change in Ukrainian agriculture is caused, first of all, by global warming, a direct consequence of which is drought, which negatively affects the yield of agricultural crops, because due to weather factors, crop growth can fluctuate up to 50%, especially in the southern zone of our country. Therefore, the main task of farmers is to improve the known elements of the technology of growing field crops and develop new measures to ensure the stability of the industry and reduce its dependence on climatic factors. Global warming can have a serious impact on the cultivation of grain crops. In particular, an increase in air and soil temperature can lead to a decrease in the yield and quality of cultivated crops. High temperatures can cause fires that destroy fields and crops. In addition, global warming may lead to a decrease in precipitation, which will negatively affect the growth and development of plants during their growing season. It should also be noted that global warming may lead to a decrease in water levels in the soil and surface water sources, which may reduce the yield and quality of crops grown. The decrease in water levels may also lead to an increase in the area of salt marshes and other soil problems.

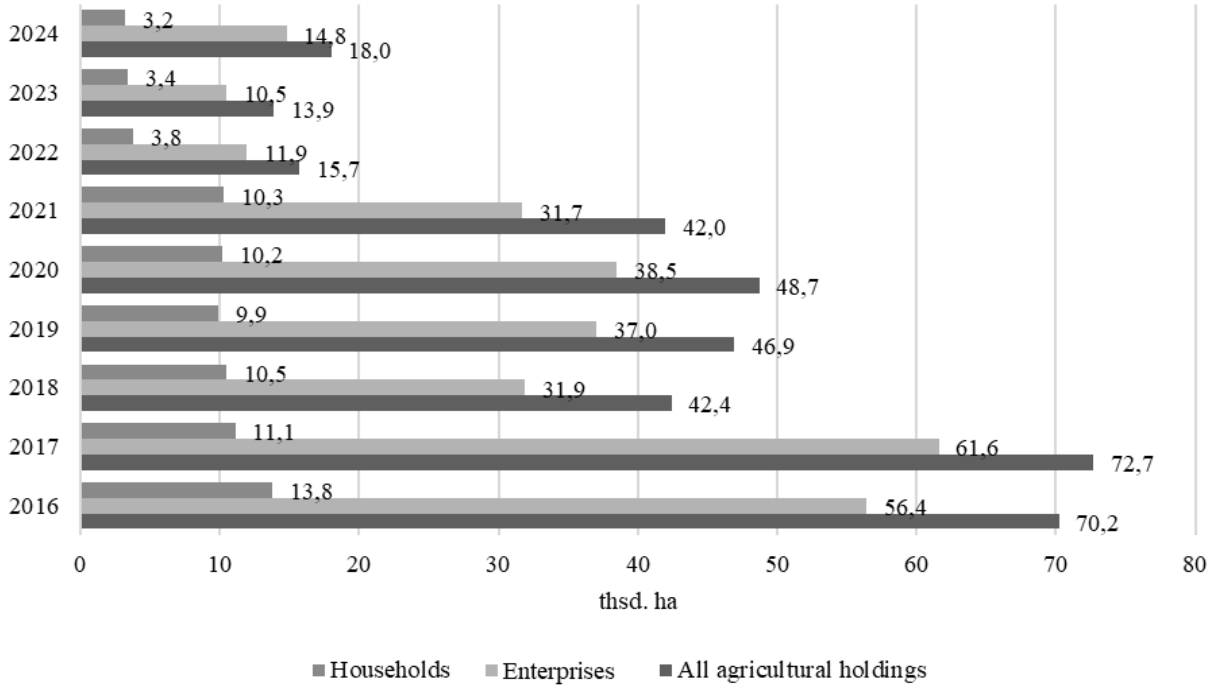

Fig. 3 – Sorghum sown areas in Ukraine 2016-2024

The analysis of the sown area of sorghum in Ukraine in 2016-2024 was conducted:

Period of stabilization and reduction (2016-2021). After peak values of sown areas in 2016 (70.2 thousand ha) and 2017 (72.7 thousand ha), there was a significant reduction in 2018 to 42.4 thousand ha. During 2019-2021, the sown areas remained relatively stable, fluctuating in the range of 42.0-48.7 thousand ha. This may indicate a certain balance of market demand and supply, or competition with other grain crops.

Period of full-scale invasion (2022-2024). Catastrophic decline: 2022 saw a sharp, unprecedented reduction in sorghum acreage to 15.7 thousand hectares, a direct result of the Russian Federation's full-scale invasion of Ukraine. This decline is about 62.6% compared to 2021.

Continuation of decline: In 2023, the acreage continued to decline, reaching an absolute minimum for the entire analyzed period of 13.9 thousand hectares.

Minor recovery: In 2024, there was a trend towards a very slow recovery, with an area of 18.0 thousand hectares. However, this figure is still extremely low compared to the pre-war years. This reflects the ongoing impact of military operations on the agricultural sector, including the occupation of territories, mining of fields, logistical problems, and resource shortages.

The dominant role of enterprises. Throughout the analyzed period (2016-2024), enterprises are the main subject of sorghum cultivation in Ukraine, occupying the lion's share of the sown area.

In 2017, enterprises occupied 61.6 thousand hectares, while households - only 11.1 thousand hectares. In 2021, enterprises allocated 31.7 thousand hectares for sorghum (75.5% of the total area), and households - 10.3 thousand hectares (24.5%). This trend persists even in war conditions: in 2023, out of the total 13.9 thousand hectares, enterprises accounted for 10.5 thousand hectares (75.5%), and households - 3.4 thousand hectares (24.5%). This indicates that large-scale sorghum production is concentrated precisely in agricultural enterprises.

Dynamics of areas in households: Sorghum sown areas in households also show a tendency to decrease. From 13.8 thousand ha in 2016, they gradually decreased to 9.9 thousand ha in 2019, then increased slightly to 10.3 thousand ha in 2021. However, after 2022 they also decreased sharply (to 3.8 thousand ha in 2022 and 3.4 thousand ha in 2023), although their relative contribution to the total area remains stable.

Yield is a key indicator of agricultural production efficiency, reflecting not only climatic soil conditions, but also the level of agricultural technologies, access to resources, the degree of mechanization and the quality of management. Based on the presented diagram, an analysis of sorghum yield in three categories of farms was conducted: all categories, agricultural enterprises and households.

Sorghum yield in Ukraine in 2016–2024 experienced noticeable fluctuations (Fig. 4). The highest indicators were recorded in 2018–2019, while 2020 and 2022 are marked by the worst results.

The highest average yield in farms of all categories was observed in 2018 - 46.3 c/ha, and the lowest - in 2020 - 22.4 c/ha.

Agricultural enterprises. This category consistently demonstrates the highest yield throughout the period. The maximum was reached in 2018 - 52.6 c/ha, which indicates a high level of technology and management. In 2020, the yield decreased to 23.6 c/ha, but remained higher than that of the population.

In 2023–2024, the yield in enterprises gradually increased to 35.3 c/ha in 2023 and 27.7 c/ha in 2024, which may indicate partial adaptation to the challenges of recent years.

Households. The yield in this category is consistently the lowest. The highest indicator was 29.9 c/ha in 2016, after which the indicators fluctuated within 16.9–29.9 c/ha. In 2024, the yield decreased to 16.9 c/ha, which is 10–12 c/ha lower than in enterprises. This indicates limited access to quality seeds, fertilizers, technology, and knowledge.

So, 2016–2018: a period of relative stability and high yields, peaking in 2018. 2019–2020: a gradual decline in performance, especially sharp in 2020, possibly due to adverse weather conditions or the economic crisis. 2021–2024: recovery of productivity in 2021, but a further decline in 2022, and partial stabilization in 2023–2024.

Next, we analyzed the volume of sorghum production in Ukraine in 2016-2024 (Fig. 5). In 2016, 273.71 thousand tons of sorghum were produced in Ukraine, which was the highest figure for the period under study. However, in 2017, the volume decreased sharply to 198.5 thousand tons, which is 27.4% less. This trend towards a decrease in total production continued, especially since 2020. The lowest level of production was recorded in 2022 - only 40.31 thousand tons, which is almost 7 times less than in 2016. A moderate recovery was observed in 2023–2024: production increased to 42.37 thousand tons in 2023 and 46.47 thousand tons in 2024, however, these volumes still remain significantly lower than the levels of 2016–2019.

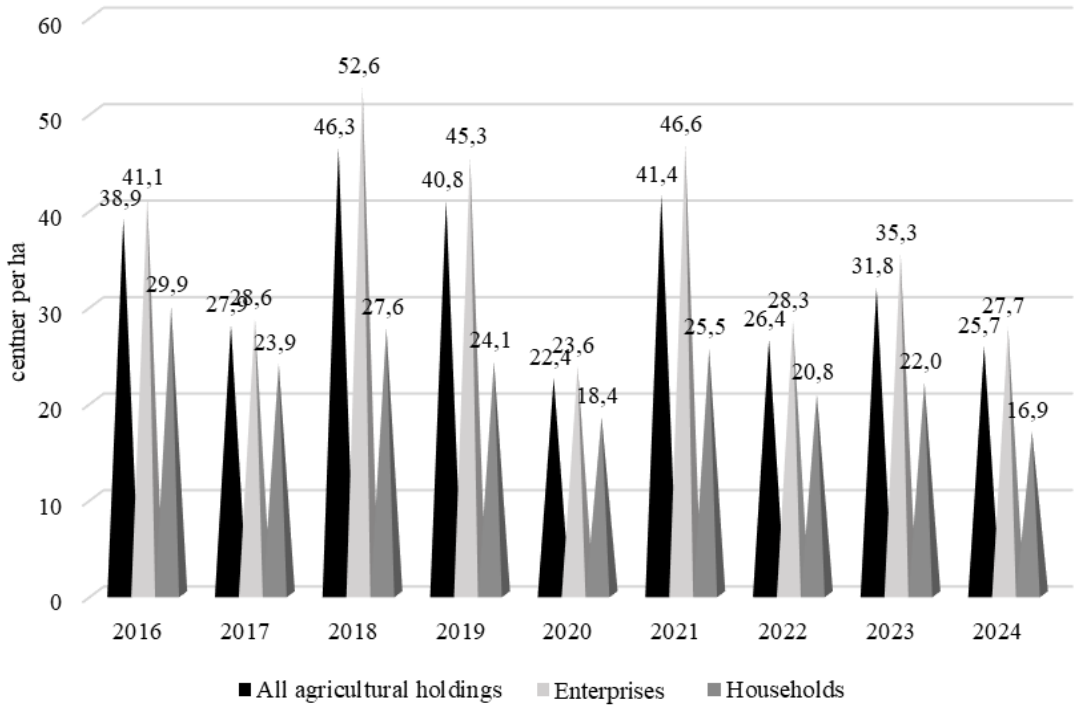

Fig. 4 – Sorghum yield in Ukraine 2016-2024, years

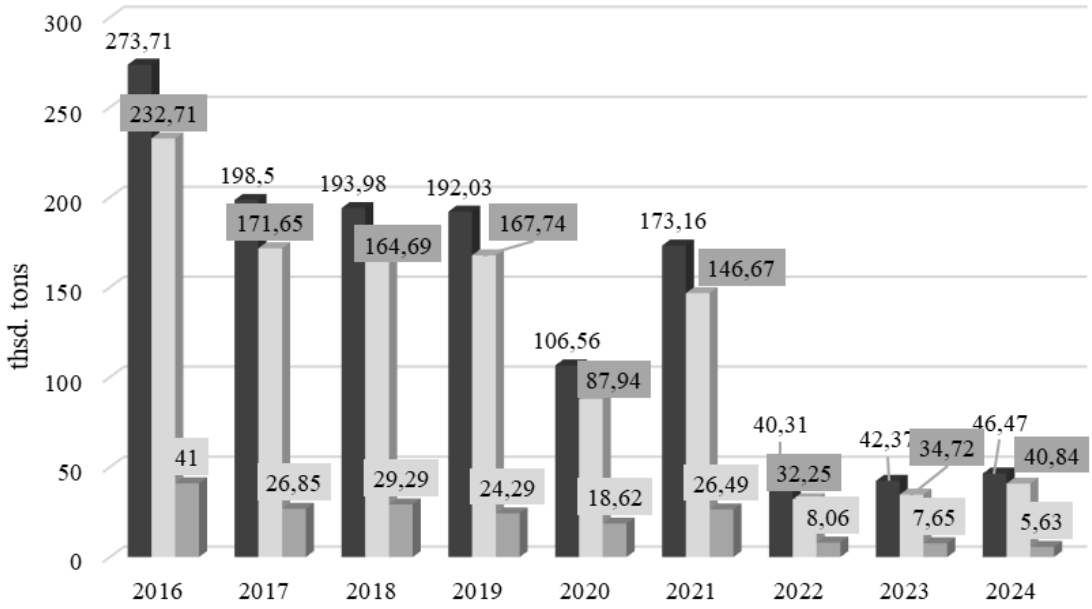

Fig. 5 – Sorghum production volumes in Ukraine 2016-2024

Enterprises are the main producer of sorghum. Throughout the entire period, agricultural enterprises remained the main producers of sorghum. In 2016, they accounted for 232.71 thousand tons or more than 85% of the total. In 2022, they provided 32.25 thousand tons, which is 80% of the total. In 2024, this sector produced 40.84 thousand tons - that is, it retains a dominant role in the production structure. This is explained by the presence of powerful equipment, better seeds, irrigation systems, agricultural support and logistics at enterprises. Sorghum production in households remains relatively insignificant: In 2016, they produced 41 thousand tons (15%). In 2022 - 8.06 thousand tons. In 2024 - 5.63 thousand tons, which is less than 13% of the total.

Despite the general downward trend, the share of the population remains stable, although the rate of decline there was even slower than that of enterprises.

A comparative analysis of the leading regions was conducted, regions with significant changes in production were identified, and general trends in redistribution were analyzed (Fig. 6).

In 2021, before the full-scale invasion, sorghum production volumes in Ukraine were significantly higher (173.16 thousand tons according to the previous analysis), and their distribution was characterized by the following key regions. The largest sorghum producers were Donetsk region (13.37%), Odesa region (11.74%): Kirovohrad region (13.27%): It was also one of the leaders, Mykolaiv region (10.02%): It had a significant contribution to production. Kyiv region (10.53%): It was among the five leading regions. In 2021, production was relatively evenly distributed among several large producers in the South, East and Center of Ukraine.

In 2024, sorghum production in Ukraine decreased sharply (to 46.47 thousand tons according to the preliminary analysis), which significantly affected the regional distribution. Odesa region (12.27%) became the largest sorghum producer in 2024. Although its percentage share increased, absolute production volumes decreased significantly compared to 2021. Kirovohrad region (8.35%) maintained a significant share, but its absolute volumes also decreased. Kyiv region (6.79%): Maintains its position among the leaders, although its share decreased. Mykolaiv region's share (6.11%) and absolute volumes decreased, but it remains in the leaders. Cherkasy region's relative share (3.34%) also decreased.

It is worth noting that some regions that were significant producers in 2021 (for example, Donetsk, Kherson, Luhansk), judging by the data provided in the 2024 diagram, either do not produce sorghum at all (are absent from the diagram), or their contribution has become insignificant and is not reflected. This is due to the occupation of territories, hostilities and mining.

The full-scale invasion has radically changed the geographical landscape of sorghum production in Ukraine. The regions that were among the leaders in 2021 (Donetsk, Kherson, Luhansk), due to active hostilities and the occupation of significant territories, have practically fallen out of the list of significant sorghum producers. Leadership has passed to regions that, although affected by the war, have retained more agricultural potential and relative security. Odesa, Kirovohrad and Kyiv regions have become the main centers of sorghum production in 2024.

While the percentage shares of some regions (e.g. Odessa) may have increased or remained stable, it is important to remember that overall sorghum production in Ukraine has declined sharply. So, even the "leaders" are producing significantly less sorghum in absolute terms in 2024 than in 2021.

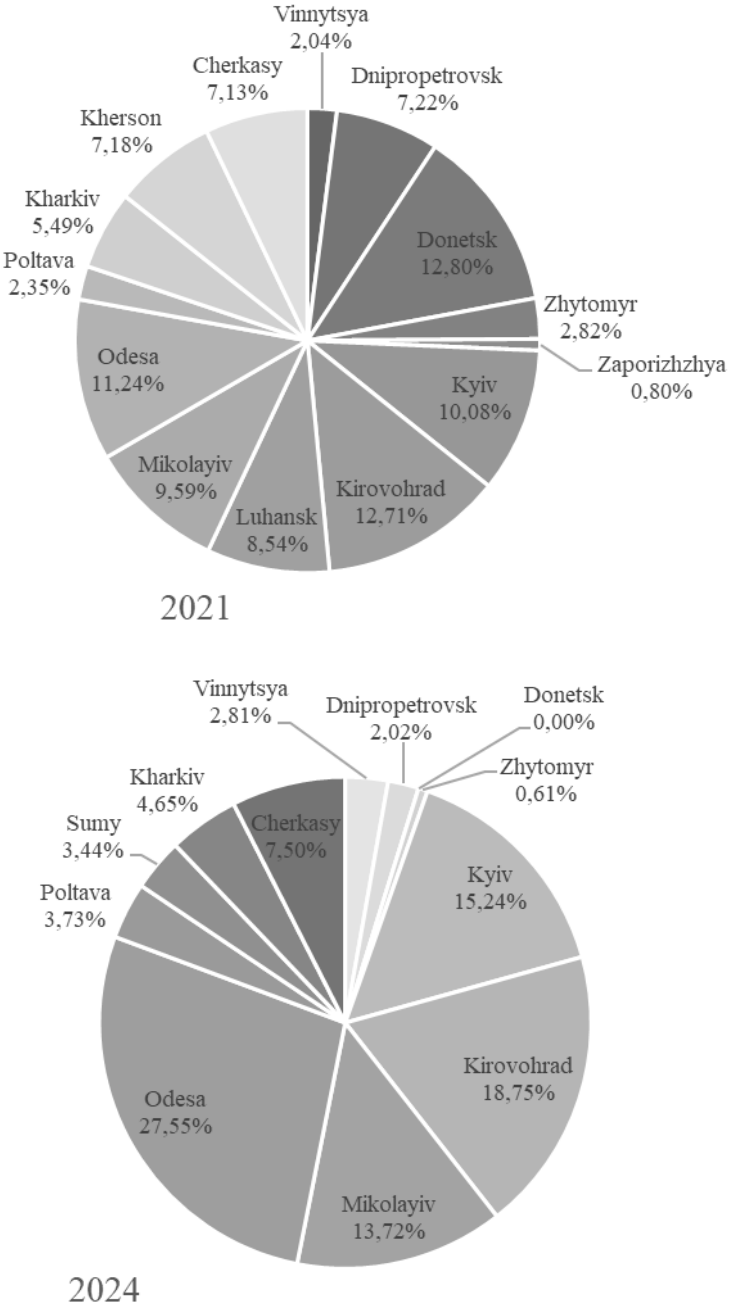

Fig. 6 – Regional distribution of sorghum production in 2021 and 2024

Some traditional sorghum-growing regions that are close to the front line or have been occupied (for example, Zaporizhia Oblast, which in 2021 had 0.84%, and probably Donetsk, Kherson, and Luhansk Oblasts, which were significant producers), have either ceased production or their volumes have become insignificant.

Conclusion

The conducted study of sorghum production volumes and prospects for its cultivation in Ukraine and the world provides grounds for the following conclusions:

Global challenges and relevance of sorghum. Modern agriculture faces significant challenges, such as climate change, population growth and resource constraints, which requires the search for new adapted crops. Sorghum, due to its high drought resistance, efficient use of moisture and versatility of use (feed base, biofuel, food industry), stands out as one of the most promising crops for ensuring food, feed and energy security.

The untapped potential of sorghum in Ukraine. Despite the obvious advantages, sorghum cultivation in Ukraine remains at a relatively low level compared to its potential. The main problem lies in the insufficient use of this potential and the lack of a comprehensive understanding of the factors that prevent the full integration of sorghum into the country's agricultural sector. These factors include fragmented and outdated production data, poor farmer awareness, lack of adequate infrastructure, limited access to quality seeds, and insufficient scientific and methodological support.

Dynamics of global sorghum production. Global sorghum acreage has fluctuated, peaking in 2016 (44,934.1 thousand ha), but has declined overall by 9.2% to 2023 (39,851.4 thousand ha). Global sorghum production has also fluctuated significantly, with no clear long-term trend, with an average annual production of around 61.2 million tonnes over 2013-2023. The United States emerged as the new leader in 2023, increasing production by 69%, while Sudan experienced the largest decline, likely due to political instability.

Status of sorghum production in Ukraine:

Dynamics of sown areas: In Ukraine, sorghum sown areas decreased significantly after 2017 (72.7 thousand ha), and with the beginning of the full-scale invasion in 2022, there was a sharp drop to 15.7 thousand ha, reaching a minimum in 2023 (13.9 thousand ha). Despite a slight recovery in 2024 (18.0 thousand ha), the indicators remain extremely low, reflecting the ongoing impact of military operations.

Main producers: Throughout the analyzed period, agricultural enterprises remain the main producers of sorghum in Ukraine, occupying the lion's share of sown areas (about 75-85%) and production volumes.

Yield: The highest average yield across all farm categories was observed in 2018 (46.3 c/ha), and the lowest in 2020 (22.4 c/ha). Agricultural enterprises consistently demonstrate higher yields compared to household farms, indicating better access to technology and resources.

Production volumes: In 2016, 273.71 thousand tons of sorghum were produced in Ukraine, which is the highest figure for the period under review. However, since 2017, there has been a downward trend, with the lowest level in 2022 (40.31 thousand tons).

Regional distribution: By 2022, sorghum production was relatively evenly distributed between several large regions of the South, East, and Center of Ukraine, including Donetsk, Kirovohrad, Odesa, Mykolaiv, and Kyiv regions. However, the full-scale invasion radically changed the geographical landscape, and the regions that were among the leaders (Donetsk, Kherson, Luhansk) practically fell out of the list of significant producers due to hostilities and occupation. Leadership passed to Odessa, Kirovohrad and Kyiv regions, although the total volume of production in absolute terms decreased sharply.

To reveal the potential of sorghum in Ukraine, systematic research and removal of existing barriers are necessary. Important areas are: identification and analysis of limiting factors, assessment of economic and agrotechnical prospects, development of a strategy for the development of the industry with state support and scientific research, as well as analysis of Ukraine's export potential. Further research is key to expanding knowledge and practical application of this promising crop for the stability of production in the face of global climate change and ensuring world food security.

REFERENCES

1. Baklanova TV, Gamayunova VV, Sidyakina OV. Current trends in sorghum growing in Ukraine and the world. Tavria Sci Bull. 2023;(134):9–17. https://doi.org/10.32782/2226-0099.2023.134.2
2. Ivanyuta SP, Kolomiyets OO, Malinovska OA, Yakushenko LM. Climate change: consequences and adaptation measures: analytical report. Kyiv: NISD; 2020. 110 p. https://niss.gov.ua/sites/default/files/2020-10/dop-climate-final-5_sait.pdf
3. Fedorchuk MI, et al. Scientific and theoretical foundations and practical aspects of the formation of environmentally safe technologies for growing and processing sorghum in the steppe zone of Ukraine: monograph. Kherson; 2017. 208 p.
4. Bezugla L. Economic aspect of territorial production of amaranth, hemp and sorghum in Ukraine. Econ Soc. 2021;(25). https://doi.org/10.32782/2524-0072/2021-25-79
5. Gamayunova VV, Khonenko LG, Fedorchuk MI, Kovalenko OA. Selection of drought-resistant crops for the Southern Steppe of Ukraine. Grain Crops. 2021;5(1):13–22. https://doi.org/10.31867/2523-4544/0153
6. Titarenko OS, Karpuk LM. Efficiency of grain sorghum cultivation under different post-crop care measures. New Agric Technol. 2021;(9). https://doi.org/10.47414/na.9.2021.259698
7. Gamayunova VV, Kovalenko OA, Khonenko LG, Baklanova TV, Pylypenko. Sorghum crops and their significance in organic production in the conditions of climate change in Southern Ukraine. In: Proc 11th Int Sci Pract Conf "Organic Production and Food Security". 2024. p. 98–101.
8. Titarenko OS. Economic assessment of the efficiency of grain sorghum cultivation. Agrobiology. 2022;(2):200–6. https://doi.org/10.33245/2310-9270-2022-174-2-200–206
9. Boyko MO. Sorghum as a food product: prospects and new opportunities. Tavria Sci Bull. 2024;(138):15–21. https://doi.org/10.32782/2226-0099.2024.138.2
10. Drobot VI, Prykhodko YuS, Berezhna GO. Sorghum flour in gluten-free bread technology. Sci Works NUFT. 2019;25(1):208–214. https://doi.org/10.24263/2225-2924-2019-25-1-21
11. Tanwar R, Panghal A, Chaudhary G, Kumari A, Chhikara N. Nutritional, phytochemical and functional potential of sorghum: A review. Food Chem Adv. 2023;3. https://doi.org/10.1016/j.focha.2023.100229

12. Khoddami A, Messina V, Vadabalija Venkata K, Farahnaky A, Blanchard CL, Roberts TH. Sorghum in foods: Functionality and potential in innovative products. Crit Rev Food Sci Nutr. 2023;63(9):1170–86. https://doi.org/10.1080/10408398.2021.1960793
13. Osman A, Abd El-Wahab A, Ahmed MFE, Buschmann M, Visscher C, Hartung CB, et al. Nutrient composition and in vitro fermentation characteristics of sorghum depending on variety and year of cultivation in Northern Italy. Foods. 2022;11(20):3255. https://doi.org/10.3390/foods11203255
14. Rooney WL. Sorghum production and improvement practices. In: Reference Module in Food Science. Elsevier; 2016. https://doi.org/10.1016/B978-0-08-100596-5.00198-0
15. Stefoska-Needham A. Sorghum and health: An overview of potential protective health effects. J Food Sci. 2024;89(S1):A30–41. https://doi.org/10.1111/1750-3841.16978
16. McGinnis MJ, Webster M. Current and potential future uses of sorghum to increase nutrient density for human foods. J Food Sci. 2024;89(S1):A42–51. https://doi.org/10.1111/1750-3841.17571
17. Prusova G, Bachevskaya Y, Marchenko A, Duvin V. Sorghum is a promising feed resource for animal husbandry in the context of climate change. Sci Tech Bull Inst Anim Husb NAAS. 2025;(133):122–33. https://doi.org/10.32900/2312-8402-2025-133-122-133
18. Food and Agriculture Organization of the United Nations. FAOSTAT [Internet]. [cited 2025 Jul 14]. Available from: https://www.fao.org/faostat/en/#data/QCL/visualize
19. State Statistics Service of Ukraine. Areas, gross harvests and yields of agricultural crops by species and by region [Internet]. [cited 2025 Jul 14]. Available from: http://www.ukrstat.gov.ua

УДК 633.17:338.43(477:100)

О.Г. Соколовська, канд. техн. наук, доцент, E-mail: sokolovskaya_alena@ukr.net
https://orcid.org/0000-0003-4326-1932, ResearcherID: N-5304-2015
Л.О. Валевська, канд. техн. наук, доцент, E-mail: ludmila_valev@ukr.net
https://orcid.org/0000-0003-0511-5643, ResearcherID: F-8756-2016
А.В. Борта, канд. техн. наук, доцент, E-mail: borta.alla@ukr.net
https://orcid.org/0000-0001-9790-4732 ResearcherID: F-9893-2016
Кафедра технології зерна і комбікормів
Одеський національний технологічний університет, вул. Канатна, 112, Одеса, 65039, Україна

КОМПЛЕКСНИЙ АНАЛІЗ ВИРОБНИЦТВА СОРГО В УКРАЇНІ ТА СВІТІ

Анотація

У сучасному світі, що стикається з викликами продовольчої безпеки та необхідності адаптації сільськогосподарського виробництва до змін клімату, сорго постає як одна з найбільш перспективних культур. Завдяки винятковій посухостійкості, невибагливості до ґрунтових умов та ефективному водоспоживанню, сорго забезпечує стабільні врожаї навіть у регіонах з несприятливим кліматом, де традиційні культури, такі як кукурудза, є малоефективними. Його універсальність охоплює широкий спектр використання: від цінного джерела білка та енергії для тваринництва до виробництва біопалива, крохмалю, спирту та безглютенових продуктів для харчової промисловості. Сорго також визнане як "smart food" завдяки високій поживній цінності (джерело рослинного білка, заліза, вітамінів групи В, антиоксидантів), відсутності глютену та потенційним лікувальним властивостям, зокрема при цукровому діабеті та захворюваннях шлунково-кишкового тракту. Незважаючи на глобальне зростання інтересу до сорго та його позиції як п'ятої за обсягами виробництва зернової культури у світі , в Україні його вирощування залишається на відносно низькому рівні. Проблема полягає у недостатньому використанні потенціалу сорго через низку обмежуючих факторів, таких як фрагментовані або застарілі дані про виробництво, недостатня поінформованість аграріїв, відсутність належної інфраструктури для переробки та збуту, обмежений доступ до якісного насіннєвого матеріалу, а також вплив повномасштабного вторгнення рф, що призвів до різкого скорочення посівних площ у 2022-2023 роках. У статті проводиться комплексний аналіз світової та української динаміки виробництва сорго, висвітлюються основні тенденції, такі як коливання посівних площ (зменшення на 9,2% у світі за 2013-2023 рр.) та валових зборів, а також регіональні відмінності в урожайності. Особлива увага приділяється впливу кліматичних змін та наслідкам військових дій на аграрний сектор України. Дослідження ідентифікує ключові економічні та агротехнічні перспективи сорго, необхідність формування стратегії розвитку галузі та оцінку експортного потенціалу України. Запропоновані науково обґрунтовані рекомендації спрямовані на стимулювання розвитку цієї культури для підвищення продовольчої, кормової та енергетичної безпеки країни, сприяючи сталому розвитку сільського господарства.

Ключові слова: *зерно сорго, урожайність, посівні площі, обсяги виробництва, основні виробники.*

Received 10.08.2025 **Revised 29.08.2025**
Reviewed 20.08.2025 **Approved 02.09.2025**

Cite as Vancouver Citation Style
Sokolovska O., Valevska L., Borta A. Comprehensive analysis of sorghum production in Ukraine and the world. Grain Products and Mixed Fodder's, 2025; 25 (3, 99): 11-20. DOI https://doi.org/10.15673/gpmf.v25i3.3207
Cite as State Standard of Ukraine 8302:2015
Comprehensive analysis of sorghum production in Ukraine and the world. / Sokolovska O.. et al. // Grain Products and Mixed Fodder's. 2025. Vol. 25, Issue 3 (99). P. 11-20. DOI https://doi.org/10.15673/gpmf.v25i3.3207