COMMODITY BULLETIN
Journal homepage: https://c-bulletin.com.ua/en
DOI: 10.62763/ef/1.2024.134

*Article's History: Received: 31.12.2024 Revised: 20.03.2024 Accepted: 26.04.2024*

**Vol. 17, No. 1, 2024, 134-145**

UDC 620.21:631.1

# Global market trends of grain and industrial crops

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**Abstract.** Analysing the dynamics of cultivation and consumption of major agricultural crops worldwide is crucial for understanding trends and planning for sustainable food production. It is important to have an integrated approach that involves collaboration between scientists, and farmers to implement sustainable practices. The analysis of global market trends of grain and industrial crops is the goal of paper. Methods of analysis, synthesis, generalisation, forecasting and databases of the Food and Agricultural Organization of the United Nations were used in the process of work. Such crops as wheat, corn, sunflower and flax were chosen for the study, because they are the major food needs of the world population. They are grown for grain (seeds), and flax is a plant of complex use, in which both the stem and the grain are important. They provide essential nutrients such as carbohydrates, proteins, fats, vitamins, and minerals that are crucial for human health. Cultivating these crops has been integral to the food security and economic stability of many countries, supporting large populations. As a result of the conducted research, it was found that India, China, the USA and Canada remain the largest producers of wheat in the world, but only India increases the cultivated area. A global trend to increase corn production has been identified. It was established that Ukraine remains an important producer of sunflower seeds. In addition, a gradual increase in interest in flax was noted. Although the increase in cultivated area can help to meet the growing demand for food products, the problem of using the agricultural plant residues also increases proportionally. This is an international problem, so its solution is of global importance. It has been founded that current research is focused on improving agricultural plant residues processing to obtain goods of various applications. The new knowledge received in the paper will allow working on the improvement of processing wheat, corn, sunflower and flax, which will be able to adequately meet the food needs of the growing world population without harming the environment

**Keywords:** agricultural crops; population; food production; plant residues; processing; environmental

***Suggested Citation:***
Yaheliuk, S., Fomych, M., & Rechun, O. (2024). Global market trends of grain and industrial crops. *Commodity Bulletin*, 17(1), 134-145. doi: 10.62763/ef/1.2024.134.



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## Introduction

The rapid increasing of the world population and the growing need for food causes new opportunities for the agriculture but aggravation environmental problems. The environmental impact of agriculture must be taken to ensure long-term food production. Study the production dynamics of grain and industrial crops such as wheat, corn, sunflower and flax on a global scale is relevant and important for understanding trends and ensuring sustainable food production and agricultural plant residues can be a valuable resource for the production of environment-friendly goods.

According to H. Ritchie *et al.* (2022), it can be noted that grains and industrial crops like wheat, corn, sunflower, and flax are very important for meeting humanity's nutrient needs. These crops have provided proteins, fats, vitamins, and minerals that are crucial for human nutrition. The cultivation of these crops has been integral to the agricultural systems of many countries, playing a crucial role in supporting populations and economies. Wheat is one of the oldest cultivated grain crop and has been a part of human diets for thousands of years. M.J. Iqbal *et al.* (2022) noted in their article that wheat contains proteins, carbohydrates, iron, B vitamins (riboflavin, niacin), soluble fiber and trace elements. Wheat is the leading source of vegetable protein in the human diet. Corn is one of the highest-yielding grain crops. R. Zhang *et al.* (2021) highlights corn provides about 85% of worldwide starch production. According to research, during the processing of starch, various by-products (corn germs, corn bran, and gluten) are formed. They are inexpensive and rich in proteins, oils, carbohydrates and minerals. Using these by-products is widely attractive from a nutritional and economic standpoint. Nowadays these by-products can often be found in feed production, nutrient extraction and other industries. B.S. Adeleke & O.O. Babalola (2020) notes the importance of sunflower – an oil crop. It is valued by consumers for its nutritional and medicinal properties. Sunflower contains dietary fibers, minerals, vitamins, flavonoids, phenolic acids, carotenoids, peptides. Organically grown sunflower has a special value. Due to its positive effects on health, sunflower is recognised as a functional food. I. Dudarev & V. Say (2020) are discussing the importance of preserving the flax stem integrity during the harvesting. Flax is a versatile crop. Traditionally, flax has been used for both its seeds (which yield linseed oil) and its fibers (which can be woven into linen fabric). The authors' research demonstrates that using new technologies for collecting flax can enhance the quality of the seed and fiber, making it more perspective for commercial use.

Common thing among wheat, corn, sunflower, and oilseed flax is that, traditionally, only the grain or seed is processed for consumption, while the rest of the plant, including the stem, is often treated as waste. According to the State Statistics Service of Ukraine (2021), the amount of agricultural crop waste generated only in Ukraine amounted to 10779 thousand tons, of which 1363 thousand tons are plant waste from agricultural production that needs to be disposed of. The increased production of crops can contribute to environmental problems, particularly when the disposal of agricultural waste involves burning. Burning agricultural crop residues releases a variety of pollutants into the air, including particulate matter, carbon monoxide, nitrogen oxides, and volatile organic compounds. Also, burning crop residues removes organic matter from the soil, which is essential for soil fertility. Balancing the need for increased food production with environmental conservation and social responsibility is a complex task that requires a holistic and integrated approach at local, national, and global levels.

Researchers are actively working on finding sustainable solutions to address this problem. R. Sadigov (2023) analyses and evaluates the problems that may be caused by the growth of the world population. One of the biggest problems is providing the population with food, which in turn leads to an increase in the production of agricultural crops and their waste.

According to S. Yaheliuk *et al.* (2021) the management and disposal of agricultural crop waste, become crucial for environmental sustainability. Proper disposal and recycling methods can help minimise the environmental impact associated with agricultural plants residues. The classification of the agricultural plants residues as for main characteristics is the first step in solving problem. By understanding the composition, volume, and potential uses of different types of agricultural waste, appropriate disposal and recycling methods can be identified.

The issue of processing crop residues is often raised by different scientists in the world. Research S. Yaheliuk *et al.* (2020) focus on developing sustainable methods for utilising agricultural crop residues such as bioenergy production. Converting crop residues into bioenergy solid fuel can provide an alternative and renewable energy source, reducing dependence on non-renewable resources. According to M. Grégoire *et al.* (2020) some crop residues can be used in the production of materials like textile, paper, or other biodegradable products, contributing to a circular economy. Research into the use of composite materials reinforced by natural fibers like flax, hemp has been a growing area of interest. These materials offer advantages such as being lightweight, renewable, and biodegradable. C. Baley *et al.* (2019) and S. Rangappa *et al.* (2022) explored the mechanical properties, manufacturing processes, and potential applications of plant fiber-reinforced composites. The findings of this research could contribute to advancements in the development of eco-friendly composite materials.

Analysing the dynamics of cultivation and consumption of major agricultural crops globally is crucial for understanding trends, identifying challenges, and planning for sustainable food production. The strategy of managing the production of enough amount environmental safety food is based on informational training and the possession of data on the development trends of the world market of agricultural crops and processing them for consumes.

The information and data play a crucial role in the strategic management of agricultural crop production. Market trends and demand analysis, access to data on global and regional market trends, consumer preferences, and demand forecasts is essential for farmers and agribusinesses. Understanding market dynamics allows for better planning regarding which crops to grow, in what quantities. The goal of the paper is to research global trends in grain and industrial crop production, with a focus on analysing the trends to improve the processing of agricultural plant residues to obtain goods of various applications and reduce environmental impacts while meeting growing food demands.

## Materials and methods

The research methodology encompasses a comprehensive approach that utilises various analytical methods, including analysis, synthesis, generalisation, forecasting method and graphic method, to investigate global production trends of major crops.

Analysis involves breaking down the research subject into its main components, such as crop production trends (specifically focusing on wheat, corn, sunflowers, and flax) and understanding what countries most related to these crops. Synthesis integrates the insights gained from the analysis to achieve specific goals, such as making informed decisions about crop cultivation and processing them for various applications. This step involves combining the findings from the analysis to develop strategies for optimising crop production, addressing food demand, and identifying opportunities for environmental processing.

The primary source of information for the study was FAOSTAT (2023) data used to analyse the harvested agricultural areas (wheat, corn, sunflower, flax). FAOSTAT (2023) data is utilised to compile a list of the most cultivated agricultural crops globally, helping to understand which crops are most significant in terms of production and consumption on a global scale. The State Statistics Service of Ukraine (2021) has provided important data on agricultural crop residues. The data of the State Statistics Service is used to determine the amount of waste generated after harvesting in Ukraine. This data contributes to understanding the environmental impact of agricultural practices. Furthermore, data from the United Nations Department of Economic and Social Affairs (2024) were also utilised. Using this data, the countries with the highest population growth rates were identified, which made it possible to understand in which regions the demand for agricultural products may increase due to population growth. These sources played a pivotal role in assessing various aspects of agricultural production and waste management practices within the study, contributing to a comprehensive analysis of the subject matter.

By selecting the timeframe of 1995 to 2021 the study allows analyse long-term trends in agricultural production and market dynamics. In addition to analysis and synthesis, graphical methods were employed to enhance the research process. The graphical representations, complemented by duplicated graphical dependencies, facilitated the tracking of production trends for each crop. The visual approach improved the comprehension of complex data and helped in identifying patterns and trends over time.

Utilising the forecasting method allowed the formation of assumptions regarding the future development of the wheat, corn, sunflowers and flax production. Overall, the forecasting method enables informed decision-making by providing insights into the potential future outcomes of the agricultural sector, food production and environmental.

## Results

Wheat is a staple crop and one of the most widely grown cereals globally. It is rich in carbohydrates (mainly starch), protein (gluten), B vitamins, dietary fibers and minerals (iron, magnesium). Wheat is cultivated in a wide range of climates using various methods, including conventional tillage and precision agriculture. Improvements in seed varieties, irrigation techniques, and fertilisation contribute to increased yields. Wheat is a primary ingredient in various products, including bread, pasta and pastries. Consumption trends are influenced by population growth, dietary preferences, and changes in global trade. According to the data in Figure 1 and Table 1 the following conclusions are made. India, China, the USA, Canada and Ukraine have the largest area and production of wheat in the world (FAOSTAT, 2023).

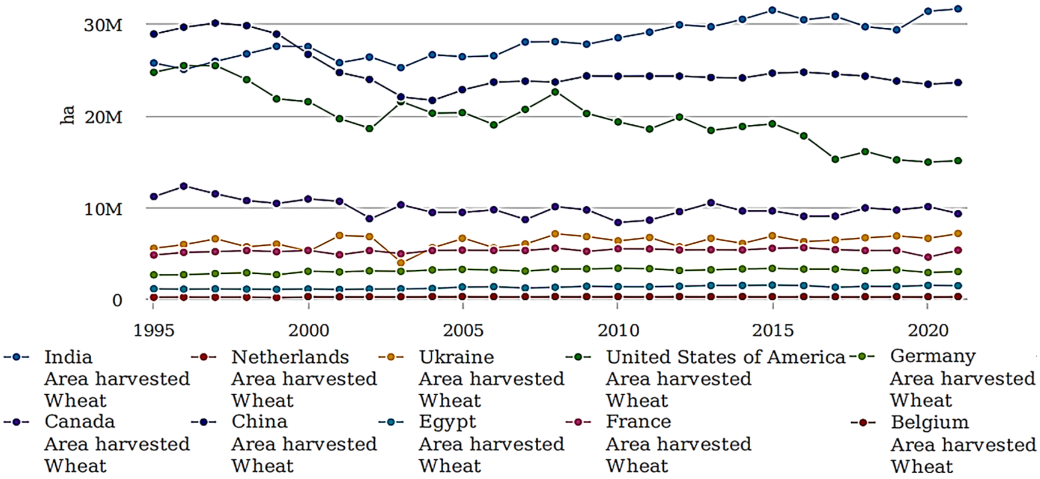


***Figure 1.*** *Wheat cultivation area (thousand hectares)*

***Source:*** *compiled by the authors based on data from the FAOSTAT (2023)*

***Table 1.*** *Wheat cultivation area (thousand hectares)*

| Country | Year | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2004 | 2007 | 2009 | 2012 | 2015 | 2017 | 2018 | 2019 | 2020 | 2021 |
| China | 26653326 | 21626074 | 23721070 | 24291081 | 24270311 | 24599116 | 24480542 | 24268721 | 23732560 | 23383000 | 23571400 |
| India | 26344700 | 26594700 | 27994500 | 27752400 | 29860000 | 31470000 | 30785230 | 29650590 | 29318780 | 31357020 | 31610000 |
| USA | 21474064 | 20221956 | 20638784 | 20191200 | 19797644 | 19058470 | 15198130 | 16030580 | 15132980 | 14888140 | 15039490 |
| France | 5248436 | 5237005 | 5238602 | 5147394 | 5297826 | 5480208 | 5332084 | 5234090 | 5244250 | 4512420 | 5276730 |
| Ukraine | 5161600 | 5533700 | 5951300 | 6752900 | 5629700 | 6839500 | 6377400 | 6619600 | 6825300 | 6564500 | 7099400 |
| Canada | 10854800 | 9388900 | 8616100 | 9660400 | 9479100 | 9558300 | 8983300 | 9880800 | 9655800 | 10017800 | 9247000 |
| Belgium | 213100 | 213035 | 199897 | 201768 | 217060 | 201628 | 197592 | 195690 | 203760 | 194660 | 209180 |
| Egypt | 1034985 | 1094741 | 1140979 | 1335295 | 1336234 | 1457506 | 1227611 | 1326401 | 1316678 | 1429684 | 1394558 |
| Netherlands | 136700 | 137287 | 140000 | 150888 | 151625 | 142468 | 115923 | 111660 | 120550 | 108910 | 118140 |
| Germany | 2968940 | 3111651 | 2992075 | 3226036 | 3056700 | 3282700 | 3202600 | 3036300 | 3118100 | 2835500 | 2939000 |

***Source:*** *compiled by the authors based on data from the FAOSTAT (2023)*

India has been increasing its wheat production, as indicated by the expanding cultivation area – 3161000 hectares in 2021. This suggests a positive trend in wheat farming in the country. China wheat cultivation area in 2021 was 23571400 hectares. China has an extensive wheat cultivation area, and while the data doesn't explicitly mention production volumes, the vast acreage suggests a significant focus on wheat cultivation. The USA has a substantial wheat cultivation area (15039490 hectares), but the data suggests a reduction in the wheat cultivation area in 2012-2021. This could be due to various factors, including shifts in agricultural practices or changes in market demands. Similar to the USA, Canada has experienced a reduction in wheat cultivation area. Changes in land use, crop rotation, or market dynamics could be influencing this trend. The data shows Ukraine maintaining a significant wheat cultivation area. While the absolute numbers are lower than some other countries, Ukraine remains an important player in global wheat production. The increase in wheat area in India is consistent with the country's efforts to improve food security and meet growing demand for wheat. Reductions in wheat acreage in the United States, China, and Canada may indicate changes in agricultural practices, land use, or market dynamics.

Corn (Maize) is a versatile crop. Corn is consumed directly and is a key ingredient in livestock feed. It's also used in the production of biofuels, starch, and various industrial products. Corn is high in carbohydrates (mostly starch), fiber, protein, vitamins (B vitamins, vitamin C), and minerals (magnesium, potassium).

Cultivation techniques include crop rotation, conservation tillage, and genetic engineering for pest and disease resistance.

According to data (Table 2), China, the USA, India and Ukraine had the largest area and production of corn in the world in the early 2000s. According to data from the FAOSTAT (2023), in 2021, China planted 4335859 thousand hectares; USA – 34555670 thousand hectares; India – 9860000 thousand hectares; Ukraine – 5481800 thousand hectares. It can be seen that there is a tendency to increase the production of corn in the world (Fig. 2). China has a substantial corn cultivation area. The data suggests a continued focus on corn production, aligning with the country's demand for animal feed, food, and industrial uses. The USA is a major player in global corn production, and the data reflects a significant corn cultivation area. India has a notable corn cultivation area, and the data suggests a focus on corn production. Changes in dietary preferences, industrial uses, and livestock farming practices may contribute to this trend. The country's contribution to global corn production may be influenced by factors such as export demand, internal consumption, and livestock farming.

***Table 2.*** *Corn (Maize) cultivation area (thousand hectares)*

| Country | Year | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2000** | **2004** | **2007** | **2009** | **2012** | **2015** | **2017** | **2018** | **2019** | **2020** | **2021** |
| China | 24310506 | 25467145 | 29496901 | 31203367 | 35046465 | 44995748 | 42429378 | 42158995 | 41309740 | 41292000 | 43355859 |
| India | 6581500 | 7430400 | 8117300 | 8261600 | 8710000 | 9258000 | 9633200 | 9380070 | 9027130 | 9569060 | 9860000 |
| USA | 27829720 | 29797730 | 35013780 | 32168810 | 35355740 | 32678310 | 33481220 | 32891580 | 32916270 | 33311250 | 34555670 |
| France | 1915822 | 1821419 | 1529775 | 1744416 | 1709936 | 1637081 | 1435699 | 1426260 | 1506100 | 1691130 | 1549520 |
| Ukraine | 1122800 | 2299600 | 1902800 | 2089100 | 4371900 | 4083500 | 4480700 | 4564200 | 4986900 | 5392100 | 5481800 |
| Canada | 1267500 | 1072300 | 1368700 | 1142000 | 1426100 | 1340400 | 1406200 | 1430700 | 1451200 | 1408200 | 1390500 |
| Belgium | 35800 | 52174 | 53238 | 66670 | 68500 | 58384 | 49005 | 53990 | 48640 | 51880 | 48220 |
| Egypt | 843029 | 788520 | 775910 | 983081 | 1041345 | 1060996 | 1096680 | 680025 | 1533571 | 976401 | 1027057 |
| Netherlands | 20300 | 22400 | 19300 | 18846 | 15505 | 11188 | 8671 | 13760 | 19010 | 19420 | 17200 |
| Germany | 360841 | 461697 | 403210 | 464333 | 526200 | 455500 | 432000 | 410900 | 416000 | 419300 | 430700 |

***Source:*** *compiled by the authors based on data from the FAOSTAT (2023)*

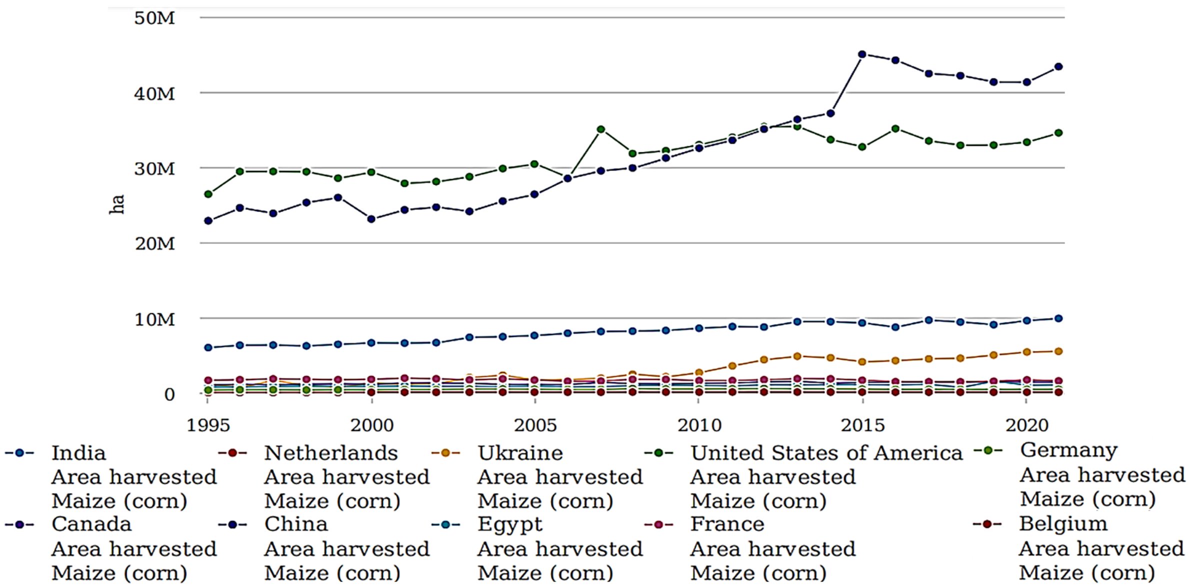


***Figure 2.*** *Corn (Maize) cultivation area (thousand hectares)*
***Source:*** *compiled by the authors based on data from the FAOSTAT (2023)*

Sunflower is cultivated for its seeds, which are a source of edible oil. Sunflower oil is widely used for cooking and as an ingredient in various food products. Trends in health consciousness and cooking habits influence consumption patterns. Sunflower contains healthy fats (mainly unsaturated fats), protein, dietary fiber, vitamin E, and minerals (copper, selenium). It grows well in sunny locations with well-drained soil.

Planting methods include direct seeding and transplanting. Breeding for high-yielding varieties and efficient nutrient management are common practices.

According to the data from the FAOSTAT (2023), in 2021, sunflowers were collected in a total volume of 58185633.69 tons in the world. From the early 2000s, Ukraine, China, India, France, and the USA has the largest area and production of sunflowers in the world (Table 3). According to the data of 2021, 6665100 thousand hectares were sown in Ukraine; China – 940000 hectares; France – 698360 thousand hectares; the USA – 503350 thousand hectares; India – 255869 thousand hectares. Ukraine has a substantial sunflower cultivation area, and the data suggests a significant focus on sunflower production. The observation of potential future increases indicates the country's continued emphasis on sunflower cultivation, likely due to factors such as export demand, climate suitability, and economic considerations. China has a notable but comparatively smaller sunflower cultivation area. France maintains a substantial sunflower cultivation area. The country's sunflower production is likely influenced by factors such as agricultural practices, market demand, and climate conditions. The data suggests that Ukraine is a major player in global sunflower production, with a substantial cultivation area (Fig. 3).

***Table 3**. Sunflower cultivation area (thousand hectares)*

| Country | Year | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2004 | 2007 | 2009 | 2012 | 2015 | 2017 | 2018 | 2019 | 2020 | 2021 |
| China | 1229090 | 934900 | 719200 | 958730 | 888510 | 973000 | 1170750 | 921350 | 850000 | 910000 | 940000 |
| India | 1073800 | 2160600 | 1910000 | 1476600 | 820000 | 474000 | 381110 | 283510 | 262010 | 228280 | 255869 |
| USA | 1071210 | 692425 | 814236 | 790560 | 744630 | 619990 | 539780 | 492670 | 28800 | 674090 | 503350 |
| France | 728555 | 616169 | 519501 | 724843 | 679974 | 536962 | 586225 | 552070 | 603920 | 778400 | 698360 |
| Ukraine | 2841600 | 3427000 | 3411400 | 4193000 | 5081700 | 6086700 | 6060700 | 6166500 | 5958900 | 6480900 | 6665100 |
| Canada | 68800 | 55400 | 78100 | 63500 | 39700 | 27500 | 25500 | 26900 | 28800 | 45000 | 40300 |
| Germany | 25794 | 31557 | 19161 | 23600 | 26400 | 18400 | 18000 | 19500 | 22500 | 28200 | 38300 |

***Source:** compiled by the authors based on data from the FAOSTAT (2023)*

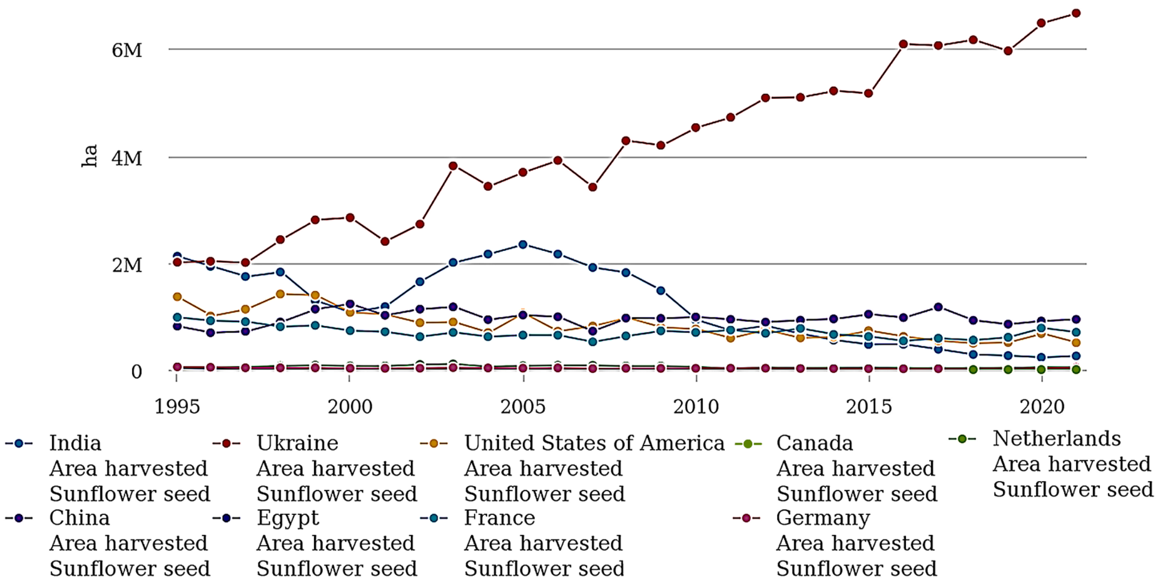


***Figure 3.** Sunflower cultivation area (thousand hectares)*
***Source:** compiled by the authors based on data from the FAOSTAT (2023)*

Flax is cultivated for its seeds (linseeds) and fibers. Flaxseeds are used for human consumption due to their nutritional benefits, including high Omega-3 fatty acids, lignin, dietary fiber, protein, vitamins (B vitamins), and minerals (manganese, magnesium). Flax fibers are used in textiles and various industrial applications. The dual-use nature of flax makes it an economically significant crop. Flax prefers cool, moist climates and well-drained soils. Cultivation method includes direct seeding. Selecting suitable varieties and optimising soil fertility are essential for successful flax production. The demand for flax-based products has grown, particularly in the health food and sustainable textile markets, where consumers appreciate its natural and eco-friendly characteristics.

The total amount of flax was grown around the world was 333914518 tons in 2021 (FAOSTAT, 2023). According to the data of 2021 (Table 4), 403500 thousand ha were sown in Canada; China – 260000 ha; India – 183725 thousand hectares; USA – 10846. It can be seen that from the 2000s to 2019 there was a reduction in the sowing of flax, but in the following years the area of sowing of flax increased (Fig. 4). The global increase in flax cultivation areas in the years 2020-2021 suggests a potential shift or resurgence in interest in flax as a crop. Canada remains a major contributor to global flax cultivation, with a significant share of the total sown area.

***Table 4.*** *Flax cultivation area (thousand hectares)*

| Country | Year | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2004 | 2007 | 2009 | 2012 | 2015 | 2017 | 2018 | 2019 | 2020 | 2021 |
| China | 497870 | 500000 | 339900 | 336930 | 317860 | 292310 | 284000 | 279000 | 260000 | 250000 | 260000 |
| India | 593100 | 476500 | 426000 | 407900 | 323000 | 285000 | 325220 | 326180 | 172710 | 179900 | 183725 |
| USA | 209220 | 206800 | 141240 | 127070 | 135980 | 184540 | 110080 | 80130 | 114930 | 119790 | 10846 |
| France | 16239 | 6172 | 17030 | 9633 | 12077 | 22308 | 29116 | 24760 | 21840 | 32070 | 37500 |
| Ukraine | 20000 | 14000 | 24100 | 46800 | 52900 | 66700 | 47500 | 31800 | 16900 | 14000 | 27600 |
| Canada | 590900 | 518000 | 524000 | 623300 | 358200 | 626900 | 418900 | 341800 | 339300 | 371300 | 403500 |
| Belgium | 13700 | 20529 | 14297 | 11227 | 10581 | 12000 | 15000 | 90 | 60 | 110 | 130 |
| Egypt | 16000 | 17138 | 16000 | 5369 | 4276 | 3128 | 6000 | 5000 | 5000 | 5000 | 6000 |
| Netherlands | 4400 | 4485 | 3500 | 2163 | 2077 | 2405 | 2494 | - | - | - | 1800 |
| Germany | 102500 | 12900 | 6300 | 4100 | 4200 | 5000 | 4600 | 3800 | 3400 | 3900 | 5200 |

***Source:*** *compiled by the authors based on data from the FAOSTAT (2023)*

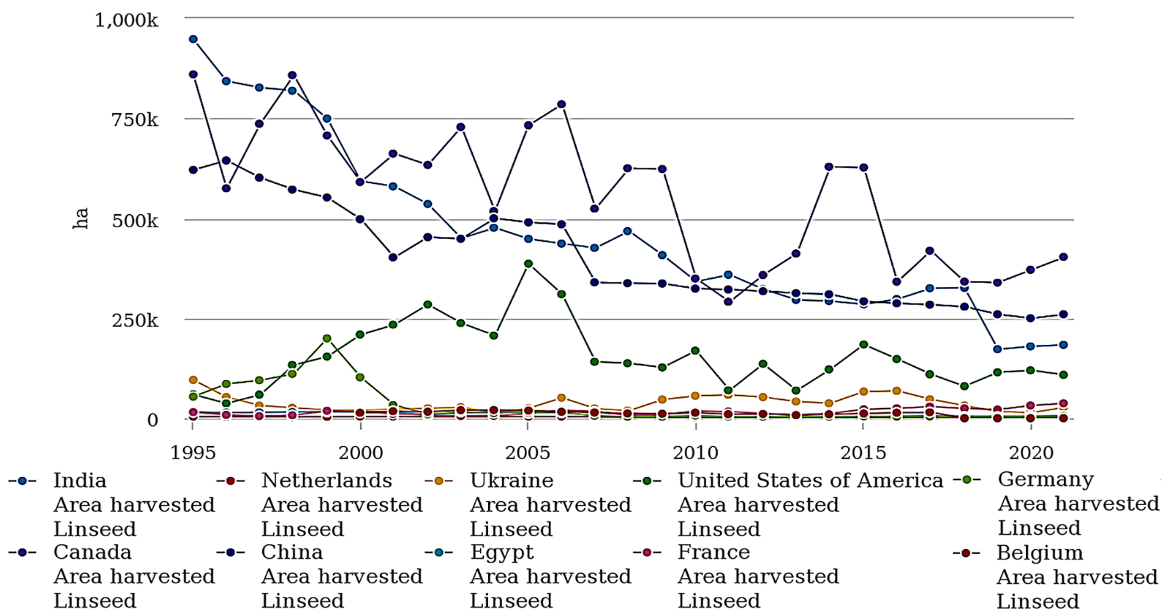


***Figure 4.*** *Flax cultivation area (thousand hectares)*

***Source:*** *compiled by the authors based on data from the FAOSTAT (2023)*

Economic viability of flax cultivation is influenced by factors such as commodity prices and global market trends. Advances in flax varieties, cultivation practices, and processing technologies could have influenced to farmers to reconsider flax as a viable crop. It's important to continue monitoring these trends and consider additional factors such as yield per hectare, technological advancements, and policy changes to gain a more comprehensive understanding of the dynamics in global flax cultivation.

Based on the results of the research, a histogram of the cultivated areas of wheat, corn (maize), sunflower and flax in the world was created (Fig. 5). The areas of cultivation of wheat, corn, sunflower and flax are constantly growing.

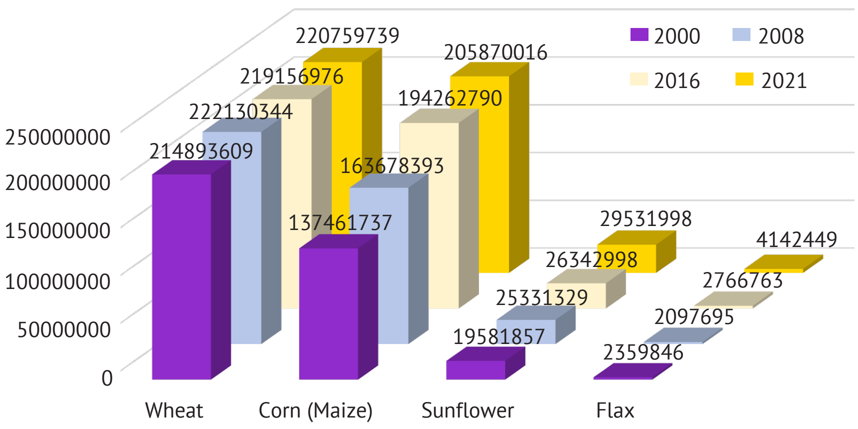


***Figure 5.*** *Histogram of cultivated areas of agricultural crops in the world, thousand hectares*
***Source:*** *compiled by the authors based on data from the FAOSTAT (2023)*

Large-scale cultivation of these crops can lead to habitat loss and biodiversity decline. Intensive irrigation practices for crop production can deplete water resources and contribute to water pollution through runoff. Chemical inputs used in crop cultivation can lead to soil degradation, water contamination, and harm to non-target organisms. Monoculture practices can reduce genetic diversity, making crops more susceptible to pests, diseases, and climate change.

While increasing cultivation areas can help meet growing demands, sustainable agricultural practices are essential to minimise environmental impact and ensure long-term food security. It's important to continue monitoring these trends and assess the impact of factors such as climate change, technological advancements, and global market dynamics on agricultural production. Overall, the histogram depicting the growth in cultivation areas provides valuable insights into the trends shaping global agriculture and highlights the importance of these crops in meeting diverse needs.

By understanding and addressing these aspects, scientists and farmers can work towards more sustainable and efficient cultivation, utilisation, and disposal of grain and technical crops, minimising their environmental impact. Stems, husks, and other plant residues can be used for animal feed, composting, or bioenergy production. Waste from grain and oil seed processing can be recycled or used as feedstock for other industries, such as animal feed or biofuel production (Fig. 6).

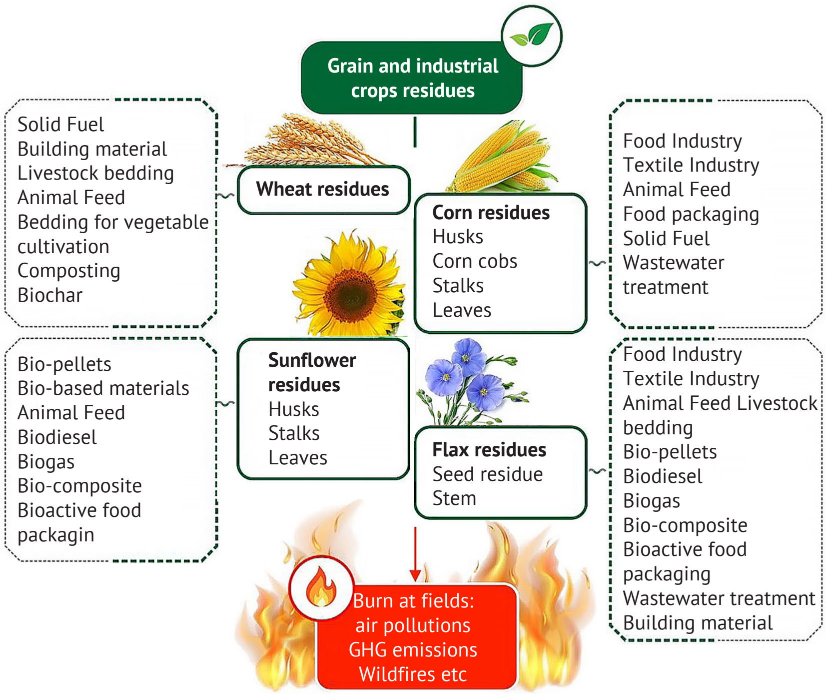


***Figure 6.*** *Residues of grain and industrial crops and the possibilities of their processing to obtain goods of various applications*
***Source:*** *created by the authors*

Wheat residues, for instance, can be used to obtain solid fuel, building materials, livestock bedding, animal feed, bedding for vegetable cultivation, and composting. Corn residues have a wide range of potential applications across various industries. Corn husks can be processed into ingredients for food products, such as fiber supplements or sweeteners. Fibers extracted from corn cobs can be used in textile production. Corn residues can serve as nutritious feed for livestock. Sunflower husks, stalks and leaves can be compacted into bio-pellets, providing a renewable source of energy. Components of sunflower residues can be used in the production of biodegradable materials, such as packaging or bioplastics. Sunflower husks can serve as a feedstock for biodiesel production. Extracts from sunflower residues may possess bioactive properties that can be incorporated into food packaging materials. Flax offers numerous possibilities for producing various application goods. From healthy foods to textiles, animal feed, composites, and solid fuels, the potential is vast. Harnessing these residues for multiple purposes not only maximises resource efficiency but also fosters innovation and creates new economic opportunities.

Future investigations are needed to examine also the impact of factors like yield per hectare, technological progress and environmental conditions on the formation of the global market for grain and industrial crops in order to gain a deeper understanding of the global production of wheat, corn, sunflower and flax, and strategies for waste processing.

## Discussion

The obtained and analysed data indicate further global growth in the production of grain and technical crops, such as wheat, corn, sunflower, flax, which will be accompanied by an increase in crop waste. This prediction aligns with the ongoing trend of increasing agricultural production by factor such as population growth. The data from the United Nations Department of Economic and Social Affairs (2024) regarding population growth, especially in Asia and Africa, underscores the urgent need to address food security issues in the world. The demand for food products will increase as the population continues to grow and will reach an estimated 8264364509 people in 2026. This growing demand underscores the importance of addressing diverse interconnected issues, such as environmental sustainability, food safety, and technological advancements in agriculture.

Despite population growth, only Egypt is an active participant in the production of grain and industrial crops in Africa. This suggests that there is untapped potential for agricultural production in many other African countries. Researchers are paying attention to the possibilities of agricultural development on the African continent. Studies, such as those conducted by T. Allen *et al.* (2018) and L. Christiaensen & M. Maertens (2022) explore various aspects of agricultural development, including population demographics, employment patterns, and prospects for the agro-industrial complex. Aligns with global trends African countries are paying particular attention to the cultivation of oil crops.

An article by Y. Hayda & B. Shayniuk (2023) provides an in-depth analysis of the global grain market, focusing on supply, production volumes, and grain stocks. According to the analysis, there is a noticeable upward trend in grain production. To assess the qualitative characteristics of growth trend, the authors examined the balance between grain stocks and consumption on a global scale. An upward trend in this indicator may indicate an increase in global grain stocks relative to consumption, which may indicate improved food security or surplus production. This is confirmed by the research of S. Moshenskyi *et al.* (2024). In their work, they analysed statistical data characterising the latest trends in the development of the agricultural sector of Ukraine. After all, despite the war, Ukraine remains an active participant in the world grain market. Taking into account the difficulties that the parties face for the development of crop production in the conditions of war, separate recommendations were proposed for the formation of state policy. They include promoting the development of new agricultural technologies.

M. Tudi *et al.* (2021) research the environmental consequences of intensification of agricultural production. That is land degradation, water pollution, greenhouse gas emissions and biodiversity loss. Solving the issues is critical to decrease the negative impact on the environment and promoting sustainable agricultural development. In Ukraine, the task of rationalising the use of biomass of the stems of agricultural crops is regulated by the Order of the Cabinet of Ministers of Ukraine "On Approval of the National Waste Management Strategy in Ukraine until 2030" (2017). The implementation of a Waste Utilization Program in Ukraine suggests a strategic approach to dealing with agricultural waste, emphasising the importance of crop residues using.

Q. Yin *et al.* (2024) in their paper highlight the significant increase in crop waste and the low level of recycling in China. The researchers created a three-way model of interaction between local government, social capital and farmers. One of the factors for improving the processing of agricultural plant residues, researchers consider the strengthening of the sense of responsibility of local government and the introduction of engineering and technological innovations. The results of the research are of guiding importance for increasing the level of circular agriculture in China and other countries and forming a complete system of processing agricultural waste.

M. Grigore (2016) and O. Smith *et al*. (2019) emphasised the need for innovative technologies to ensure safe and ecological agricultural production. The new technologies may include recycling and processing of agricultural plants residues. By applying such technologies, farmers can optimise the use of resources, minimise environmental impact and increase productivity. Improved processing methods can reduce waste, energy consumption and environmental pollution while improving product quality and market competitiveness. A. Gomez-Campos *et al*. (2021) discuss the environmental benefits of increased production of flax. Flax is known for its comprehensive zero-waste use, as different parts of the plant can be used for different purposes, including fibers for textiles, seeds for oil production, and by-products for animal feed or industrial applications. Increasing the production of flax products can decrease of agricultural plants residues generation. R. Kumar *et al*. (2023) unravel the ecological issues of agricultural plant residues in India. Air pollution and renewable energy are critical issues in India. The authors suggest using the remains of agricultural plants for the production of fuel. Using local agricultural plant residues can be a sustainable solution to reducing air pollution and energy poverty. However, the formation of any recycling strategy and its practical implementation requires an understanding of the available and projected amount of resources for processing.

The acknowledgement of these trends aligns with the conclusions of Global Trends 2040. A more contested world (2021). It shows the urgency of adopting sustainable practices and modern agricultural technology to meet the growing demand for food while mitigating environmental impacts and ensuring food safety.

## Conclusions

Global trends in grain and industrial crops production were studied in the paper. The analysis of wheat, corn, and sunflower cultivation areas showed steady growth in 2000-2021. The data obtained from the research show a gradual increase of the flax cultivated area in the world after a significant decline. Significant intensification of wheat production is observed in India. Other global producers, such as China, the United States, and Canada, are altering their farming methods and technologies. They aim to boost yields while preserving the area under cultivation. The importance of the China, the USA, India, and Ukraine in the world corn market is evidenced by the large areas of corn crops in these countries. The observed global trend toward increased corn production is consistent with the diverse uses of corn, including food, animal feed and industrial applications such as biofuel production. The potential increase in sunflower crops in Ukraine is consistent with the country's recognition of the economic value and export demand for sunflower products. As the cultivation area of major crops increases to meet growing food demands, the challenge of effective utilisation of agricultural plant residues is also increasing.

Agricultural plant residues can be a valuable resource for the production of environmentally friendly goods. Further research on processing agricultural plant residues to obtain goods for various applications holds global promise and relevance. It's crucial to consider additional factors such as yield per hectare, technological advancements and climate conditions to gain a more comprehensive understanding of opportunities in global grain and industrial crops production and processing dynamics.

## Conflict of interest

None.

## Acknowledgements

None.

## References

[1] Adeleke, B.S., & Babalola, O.O. (2020). Oilseed crop sunflower (*Helianthus annuus*) as a source of food: Nutritional and health benefits. *Food Science & Nutrition*, 8(9), 4666-4684. doi: 10.1002/fsn3.1783.

[2] Allen, T., Heinrigs, P., & Heo, I. (2018). Agriculture, food and jobs in West Africa. *West African Papers*, 14. doi: 10.1787/24142026.

[3] Baley, C., Gomina, M., Breard, J., Bourmaud, A., Drapier, S., Ferreira, M., Le Duigou, A., Liotier, P.J., Ouagne, P., Soulat, D., & Davies, P. (2019). Specific features of flax fibres used to manufacture composite materials. *International Journal of Material Forming*, 12, 1023-1052. doi: 10.1007/s12289-018-1455-y.

[4] Christiaensen, L, & Maertens, M. (2022). Rural employment in Africa: Trends and challenges. Washington, DC: World Bank.

[5] Dudarev, I., & Say, V. (2020). Development of resource-saving technology of linseed harvesting. *Journal of Natural Fibers*, 17(9), 1307-1316. doi: 10.1080/15440478.2018.1558161.

[6] FAOSTAT. (2023). Retrieved from https://www.fao.org/faostat/en/#compare.

[7] Global trends 2040. A more contested world. A publication of the National Intelligence Council. (2021). Retrieved from https://www.dni.gov/files/ODNI/documents/assessments/GlobalTrends_2040.pdf.

[8] Gomez-Campos, A., Vialle, C., Rouilly, A., Sablayrolles, C., & Hamelin, L. (2021). Flax fiber for technical textile: A life cycle inventory. *Journal of Cleaner Production*, 281, article number 125177. doi: 10.1016/j.jclepro.2020.125177.

[9] Grégoire, M., Barthod-Malat, B., Labonne, L., Evon, P., De Luycker, E., & Ouagne, P. (2020). Investigation of the potential of hemp fibre straws harvested using a combine machine for the production of technical load-bearing textiles. *Industrial Crops and Products*, 145, article number 111988. doi: 10.1016/j.indcrop.2019.111988.

[10] Grigore, M. (2016). *Solid biofuels: Producer and property*. Chisinau: Bons Offices.

[11] Hayda, Y., & Shaynyuk, B. (2023). Grain market in retrospect and perspective: Global analysis. *Innovation and Sustainability*, 4, 30-40. doi: 10.31649/ins.2023.4.30.40.

[12] Iqbal, MJ., Shams, N., & Fatima, K. (2022). Nutritional quality of wheat. In *Wheat – recent advances*. Rijeka: Intech Open. doi: 10.5772/intechopen.104659.

[13] Kumar, R., Kumar, V., & Nagpure, A.S. (2023). Bio-energy potential of available livestock waste and surplus agriculture crop residue: An analysis of 602 rural districts of India. *Science of The Total Environment*, 889, article number 163974. doi: 10.1016/j.scitotenv.2023.163974.

[14] Moshenskyi, S., Grytshen, D., & Petruk, O. (2024). Agricultural and resourse economy of Ukraine and problems for economic growth. *Scientific Horizons*, 27(1), 152-161. doi: 10.48077/scihor1.2024.152.

[15] Official website of State Statistic Service of Ukraine. (2021). *Waste generation by classification groups of the state classification of waste in 2020*. Retrieved from https://ukrstat.gov.ua/operativ/operativ2018/ns/uv_zaklass/arch_uv_zaklass_e.htm.

[16] Order of the Cabinet of Ministers of Ukraine "On Approval of the National Waste Management Strategy in Ukraine until 2030". (2017, November). Retrieved from https://zakon.rada.gov.ua/laws/show/820-2017-%D1%80#n8.

[17] Rangappa, S.M., Puttegowda, M., Parameswaranpillai, J., Siengchin, S., Ozbakkaloglu, T., & Wang, H. (2022). Introduction to plant fibers and their composites. In *Plant fibers, their composites, and applications* (pp. 1-24). Sawston: Woodhead Publishing.

[18] Ritchie, H., Rosado, P., & Roser, M. (2022). *Crop yields. Our World in Data*. Retrieved from https://ourworldindata.org/crop-yields.

[19] Sadigov, R. (2022). Rapid growth of the world population and its socioeconomic results. *The Scientific World Journal*, article number 8110229, 8. doi: 10.1155/2022/8110229.

[20] Smith, O.M., Cohen, A.L., Rieser, C.J., Davis, A.G., Taylor, J.M., Adesanya, A.W., Jones, M.S., Meier, A.R., Reganold, J.P., Orpet, R.J., Northfield, T.D., & Crowder, D.W. (2019). Organic farming provides reliable environmental benefits but increases variability in crop yields: A global meta-analysis. *Frontiers in Sustainable Food Systems*, 3, article number 82. doi: 10.3389/fsufs.2019.00082.

[21] Tudi, M., Ruan, H.D., Wang, L., Lyu, J., Sadler, R., Connell, D., Chu, C., & Phung, D.T. (2021). Agriculture development, pesticide application and its impact on the environment. *International Journal of Environmental Research and Public Health*, 18(3), article number 1112. doi: 10.3390/ijerph18031112.

[22] United Nations Department of Economic and Social Affairs (UN DESA). World population (total). (2024). Retrieved from https://www.worldometers.info/population/world/.

[23] Yaheliuk, S., Didukh, V., Busnyuk, V., Boyko, G., & Shubalyi, O. (2020). Optimization on efficient combustion process of small-sized fuel rolls made of oleaginous flax residues. *INMATEH-Agricultural Engineering*, 62(3), 361-368. doi: 10.35633/inmateh-62-38.

[24] Yaheliuk, S., Fomych, M., Holiy, O., & Khomych, A. (2021). The identification and classification of the agricultural crops residues for further use. *Agricultural Machines*, 47, 95-101. doi: 10.36910/acm.vi47.654.

[25] Yin, Q., Wang, Q., Du, M., Wang, F., Sun, W., Chen, L., & Tang, H. (2024). Promoting the resource utilization of agricultural wastes in China with public-private-partnership mode: An evolutionary game perspective. *Journal of Cleaner Production*, 434, article number 140206. doi: 10.1016/j.jclepro.2023.140206.

[26] Zhang, R., Ma, S., Li, L., Zhang, M., Tian, S., Wang, D., Liu K., Liu, H., Zhu, W., & Wang, X. (2021). Comprehensive utilization of corn starch processing by-products: A review. *Grain & Oil Science and Technology*, 4(3), 89-107. doi: 10.1016/j.gaost.2021.08.003.

## Тенденції світового ринку зернових та технічних культур

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**Анотація.** Аналіз динаміки вирощування та споживання основних сільськогосподарських культур у світі має вирішальне значення для розуміння тенденцій та планування сталого виробництва продовольства. Важливим є комплексний підхід, який передбачає співпрацю між науковцями та фермерами для впровадження сталих практик. Метою роботи є аналіз тенденцій світового ринку зернових та технічних культур. У процесі роботи були використані методи аналізу, синтезу, узагальнення, прогнозування, бази даних продовольчої та сільськогосподарської організації ООН. Для дослідження було обрано такі культури, як пшениця, кукурудза, соняшник та льон, оскільки вони є основними продуктами харчування для населення планети. Їх вирощують заради зерна (насіння), а льон – рослина комплексного використання, в якій важливе значення має як стебло, так і зерно. Вони забезпечують основні поживні речовини, такі як вуглеводи, білки, жири, вітаміни та мінерали, які мають вирішальне значення для здоров'я людини. Вирощування цих культур є невід'ємною частиною продовольчої безпеки та економічної стабільності багатьох країн, вони підтримують велику кількість населення. В результаті проведеного дослідження було виявлено, що Індія, Китай, США та Канада залишаються найбільшими виробниками пшениці у світі, але тільки Індія збільшує посівні площі. Виявлено глобальну тенденцію до збільшення виробництва кукурудзи. Встановлено, що Україна залишається важливим виробником насіння соняшнику. Крім того, відзначено поступове зростання інтересу до льону. Хоча збільшення посівних площ може допомогти задовольнити зростаючий попит на продукти харчування, пропорційно зростає і проблема використання рослинних залишків. Це міжнародна проблема, тому її вирішення має глобальне значення. Встановлено, що сучасні дослідження спрямовані на вдосконалення переробки сільськогосподарських рослинних решток з метою отримання продуктів різного призначення. Нові знання, отримані в статті, дозволять працювати над удосконаленням переробки пшениці, кукурудзи, соняшнику та льону, що дасть змогу адекватно задовольнити продовольчі потреби населення планети, що зростає, не завдаючи шкоди навколишньому середовищу

**Ключові слова:** сільськогосподарські культури; населення; виробництво продуктів харчування; рослинні рештки; переробка; екологія