

Prospects for the Production of Niche Grain Crops in the Context of the Need to Ensure Food Security

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Abstract: One of the tools of strategic development of the agricultural sector, which plays a key role in ensuring food security, is diversification, which can be niche production, particularly the cultivation of niche grain crops. The concept of "niche crops" is briefly revealed in the context of the aggravation of the world's food security problem. Their economic importance and potential are detailed and disclosed using the example of oats and millet due to their inherent advantages in the economic, ecological, agrotechnical, and social plane, multifunctionality, and the possibility of producing various products with high benefits. Using the example of the main commodity producers, the dynamics of the production of niche grain crops in Ukraine in 2020-2022 were studied. Using the index method and the method of regional rating assessments, the competitiveness of oats and millet in agricultural enterprises was determined separately for each type and region of Ukraine.

Keywords: niche crops, niche grain crops, oats, millet, production, diversification, agribusiness, added value, risks, food security

1. Introduction

According to the UN, the number of people affected by hunger worldwide in 2021 rose to 828 million, an increase of about 46 million compared to 2020 and 150 million since the start of the COVID-19 pandemic. Accordingly, already in 2022, the world's food security level has reached an unprecedented level in terms of scale and severity (Ensuring Global Food Security 2022; European Union 2022). As of early 2024, the Food and Agriculture Organization (FAO) estimates that more than 820 million people are still suffering from hunger worldwide, and one of the factors contributing to this dire situation is climate change (FAO 2024). Food security problems affect all continents, the most suffering from malnutrition in African and Asian countries. According to forecasts, the problem of ensuring food security in the world will continue to worsen in the coming decades. Food prices are likely to increase due to climate change and world population growth, and demand for food products will increase accordingly. Thus, the World Resources Institute expects that by 2050, global demand for beef and lamb will grow by 30% compared to 2006, with the largest demand coming from China (+116%) and India (+138%) (Food security 2024). In addition, the state of food security in the world is also affected by the change in diet and approaches to nutrition in modern society. Bearing in mind that when the incomes of the population increase, food preferences also change accordingly. As much of the world is projected to become wealthier in the coming decades, demand for processed foods, meat, and dairy products will increase. To meet this demand and the demand associated with population growth, more domestic animals will have to be kept and fed, increasing the demand for grain. Food security



is a serious problem in urban areas, and with the rapid development of urbanization, solving this problem is becoming increasingly important (Djan 2023). In general, the problem of food security in the modern world comes to the fore, and without solving it, it seems difficult to solve other acute economic and social problems (Karimzada 2020). A healthy and productive society is possible with adequate food security, which means reliable access to sufficient, safe, affordable, and nutritious food at all times (Savary et al. 2019). Considering this, the task of ensuring and maintaining food security is included in the UN Sustainable Development Goals list and is also in the field of view of the world community in general (Burkovska 2021). At the same time, numerous global challenges and risks significantly affect food security, especially in developing countries, so forming a sustainable food system based on coordinated economic, social, and environmental policies is a priority task for the world community in the 21st century (Petrunencko 2021).

In this regard, various organizations and institutions worldwide are working on ensuring food security and developing ways to solve it.

For example, the European Food Security Crisis Preparedness and Response Mechanism (EFSCM), established to improve cooperation between the public and private sectors and assess risks in the event of crises, has developed a contingency plan to ensure food supply and food security during a crisis. This plan aims to ensure an adequate and diverse supply of safe, nutritious, affordable, and sustainable food for citizens at all times (Ensuring global food supply 2024).

In particular, the plan envisages such measures to ensure food security as: 1) reduction of food waste and food loss (the relevance of this issue is confirmed by the fact that according to estimates in today's conditions, a third of the food produced is lost – food waste and food loss in monetary terms amount to about 750 billions of dollars per year); 2) improvement of infrastructure, in particular in the context of optimization, which also guarantees the reduction of food losses and improves food security; 3) promotion of fair trade – it is about the fact that access to food markets is needed not only by large commercial companies, small farmers should also receive a fair price for their products; 4) reducing the yield gap. Due to inefficient management methods, the yield of agricultural land in some places is much lower than it could be, therefore, it is advisable to introduce crop rotations and the use of sustainable production methods and new technologies; 5) fight against climate change. The main causes of crop loss in many cases in today's conditions are droughts and floods, which in turn are a consequence of global climate change. Therefore, combating climate change will reduce crop failures; 6) develop diversification. Farming practices have already shown that focusing on one type of crop depletes the soil and makes the crop more vulnerable to diseases and pests, and farmers face problems if their crops fail and have no alternative. Therefore, diversification is important for ensuring food security; 7) elimination of indirect causes of a decrease in the level of food security. The imbalance between imports and exports affects the level of food security. Since not every country can grow all the food it needs, it is necessary to have sufficient capital to import food. Healthy food must be affordable for all population groups (Ensuring global food supply 2024).

In turn, the World Bank Group is working with several partners to build food systems that feed everyone everywhere daily and improve food safety. The bank is a leading financier of food systems. In fiscal year 2022, it allocated \$9.6 billion in new IBRD/IDA commitments for agriculture and related sectors. The bank's activities include interventions and short-term programs that promote farming systems that use climate-smart practices and produce a more diverse food mix to improve the sustainability of food systems, increase farm incomes, and ensure greater availability of nutrient-rich foods. In addition, the World Bank supports long-term global food security programs. In particular, the Bank implements the Global Agriculture and Food Security Program (GAFSP) – a global financial instrument that pools donor funds and directs additional financing for the development of agriculture along the entire value chain. Since 2010, GAFSP has reached more than 13 million smallholder farmers and their families, providing more than \$1.3 billion in grants for 64 projects in 39 countries and \$13.2 million in small grants to support producer organizations. In response to the COVID-19 pandemic, GAFSP allocated more than \$55 million in additional grant funding (The World Bank 2023).

The Food and Agricultural Organization (FAO) in the UN system also works tirelessly to ensure food security worldwide. This specialized agency is responsible for eradicating hunger, malnutrition, and poverty worldwide by promoting sustainable agriculture. FAO plays an important role in developing policies and strategies to improve food security and nutrition security by providing technical assistance and support to countries in the development and implementation of national food security policies and strategies; promotes sustainable agricultural practices that help increase food production and improve farmers' livelihoods; supports small farmers by providing them with technical assistance, training, and financial support; plays a key role in responding to food emergencies such as natural disasters, conflicts and other crises; provides emergency food aid, seeds and tools to affected communities to help them recover and rebuild (Food Security 2024). The key guidelines from FAO, the observance of which should ensure food security for all are: 1)

diversification of agricultural production, which involves encouraging farmers to grow a variety of crops to preserve soil fertility, minimize the risks of crop losses due to pests and diseases, ensure a more balanced and nutritious diet for consumers; 2) supporting smallholder farmers who are key players in food production for local communities by providing them with access to training, credit and markets that can help them increase incomes and increase food security; 3) reducing food waste in order to save resources, reduce greenhouse gas emissions and ensure that more food reaches those who need it; 4) strengthening social protection through various programs such as food vouchers and school feeding programs, which can help vulnerable sections of the population gain access to food; 5) combating climate change by promoting climate-smart agriculture, investing in research and technology, and reducing greenhouse gas emissions (FAO 2024).

In general, today, ensuring food security has become a key issue for countries with different degrees of economic development, and the strategic role in improving food availability and achieving food security is assigned to the agricultural sector (Petrychenko et al. 2022, Pawlak & Kołodziejczak 2020, Otsuka 2013, Smutka et al. 2015).

More and more scientists and practitioners agree that a possible method of eradicating hunger is a better food supply, which is primarily ensured by increasing the productivity of agriculture and expanding the range of agricultural land use (Smyth et al. 2015). But despite the rapid development of the world's agricultural sector, food security remains a global and serious problem in some parts of the planet (Rice Crop 2021).

For example, the war, which has been going on for the third year in Ukraine, has destroyed the production and sale of agro-food products, leading to negative changes in the food market. Although Ukraine has sufficient food reserves, in the conditions of hostilities, the problem of ensuring national food security is significantly aggravated. Due to the war in Ukraine, the scale of agricultural production has significantly decreased and its structure has changed, so it is likely that this will negatively affect the state of national food security in the near future. Certain changes will likely occur in the world food market (Nitsenko & Havrysh 2016, Shubravskaya & Prokopenko 2022).

Considering the role of the Ukrainian agricultural sector in the world food market, the problems of developing agricultural production and ensuring food security, especially in the context of military aggression against Ukraine, require further careful attention. Diversification is a recognized tool for strategic modernization of the agricultural sector. In particular, in our opinion, diversification of agricultural production towards non-traditional and rare crops can help increase agricultural productivity, stabilize production, increase food security, and reduce climate change risk. After all, plants provide more than 80% of the food consumed by humans and are the main source of nutrition for livestock (FAO 2020). In addition, in today's conditions, agricultural production is being transformed. This is due to several main reasons: a decrease in prices for traditional grains, climate changes, and aggravation of logistical problems. That is, the risks are growing and, accordingly, farmers have to: look for new profitable directions and additional opportunities both to optimize production and to save resources; be more flexible; react more quickly to changes. Today's conditions also force agrarians to make faster decisions, including introducing the production of niche crops, to which attention is increasingly growing worldwide and which are also called special or alternative crops. For example, the US earns \$79.8 billion annually from niche crops alone, representing 17.6% of the agricultural value produced annually in the country (iSelected Fund 2021). In Ukraine, for most farmers, niche crops in general and niche grains in particular still do not have a significant market value, which is evidenced by the low level of interest of commodity producers in their permanent cultivation. Of course, it is difficult to get 60-100% and higher profitability from the first time on niche crops, as it is possible for some oil crops. However, more and more practical examples confirm significant and still unappreciated opportunities for diversifying agricultural exports and increasing the profitability of the grain industry by introducing niche crops into production. First, these opportunities are connected with the development of organic agriculture and global trends that are changing people's views on a healthy lifestyle. In this context, niche crops, in general and niche grains, in particular, and the development of their production are attracting increasing attention.

The problems of developing niche production in the agrarian sphere in the last decade have attracted more and more attention from scientists and practitioners. Therefore, there are already quite a lot of studies on the development of this direction. For example, a team of scientists led by Gebrin-Bayda studies the cultivation of niche crops in the context of the prospects of eco-innovative agricultural production in Ukraine (Hebryn-Baidy et al. 2021). Hamlin et al. (2016) research niche production in agricultural production through the prism of the need for diversification, primarily for small and small farmers. Kim (2016), continuing the previous opinion, emphasizes that niche crops can contribute to diversification in agriculture and strengthen people's health and well-being by providing a diverse range of food crops. Kimberly and Morgan (2021) present research on the production, financial, regulatory, and price risks specific to niche crops grown in the United States. It is also argued that the development of the production of niche crops in combination with the

development of animal husbandry is a possible tool for balanced and integrated development of agricultural production in the context of world food security (Mirzoieva et al. 2021, Atamanyuk et al. 2023). Most of the publications are subject-specific and dedicated to specific niche crops. Puzynska et al. (2021) consider, for example, oats as an effective component of the oat-vetch mixture in organic and conventional farming systems and emphasize that in recent years in Europe, there has been a growing interest in their cultivation, as they are an important element of agricultural diversification. Decker et al. (2014) research on oat processing and the impact of processing operations on nutrition and health benefits emphasizes that oats are a uniquely nutritious product and that the development of oat processing is extremely important. In general, the problem of the production of niche crops is currently attracting considerable attention from scientists and practitioners in Ukraine and the world (Zakharchuk et al. 2023). Nevertheless, taking into account the wide variety of niche crops, as well as the further need for efforts to ensure food security in today's changing conditions, further research into the problems of the production of niche crops in general and cereals, in particular, as a tool for diversifying agricultural production is necessary. Especially considering the fact that Russia's military aggression against Ukraine has disrupted the state of the international grain market and food security in the world.

This publication aims to justify the feasibility of spreading niche grain crops (for example, oats and millet) within the framework of diversification of agricultural production to ensure food security in Ukraine and the world in the conditions of modern risks.

This is a classical style study. The first part reflects the relevance of the chosen topic and serves as the basis of the study through the prism of the issue of food security in the modern world and the role of the agricultural sector in ensuring it, as well as the problems of the development of niche production in the agricultural sector, in particular in the context of niche crops. The second part outlines the methodology used and allows for substantiating the theoretical and applied aspects of this research. In the result part, attention is focused on niche crops, and their economic value and attractiveness are revealed and substantiated using the example of oats and millet. In particular, a historical excursion was made regarding the development of the production of the mentioned crops and their role in ensuring the nutrition of humanity; the advantages of oats and millet in the context of achieving a number of economic, ecological, agronomic, and social effects are determined. In addition, the result part of the study contains a detailed analysis of the dynamics of the production of niche grain crops in Ukraine (on the example of oats and millet) during 2020-2022 and the geography of their sowing on the state's territory. The result part of the study ends with calculations of the competitiveness of niche crops in agricultural enterprises separately for each type and region of Ukraine. In the fourth part, future research directions regarding the presented issues are revealed in the discussions. The conclusions summarize the factors that determine the relevance of niche crops in general and niche cereals, in particular, and the expediency of expanding their production; incentives for the development of technologies for growing niche crops for representatives of agribusiness, primarily micro and small; the expediency of shifting the emphasis of producers in the selection of agricultural crops for production in the context of the need to ensure food security.

2. Methods

The substantiation of this study's theoretical and applied aspects is based on both general scientific and special methods of scientific knowledge. In particular, the methods of analysis, synthesis, generalization, and induction were used, as well as special methods, such as economic statistics, economic mathematics, cartographics, index, and comparative rating evaluation. Thus, the methods of analysis and generalization of information were applied to determine the economic value and potential of oats and millet in the conditions of modern risks. By searching and selecting information on the Internet and printed publications, information on the advantages of oats and millet, which form their economic value and potential in the economic, ecological, agrotechnical, and social spheres, was analyzed, described, and summarized. Both publications from specialized scientific issues and current publications posted on the websites of specialized international organizations and those implementing programs to ensure food security in the world and sustainable development of agricultural production came into view. Application of the method of scientific systematization made it possible to determine the main characteristics of millet and the product of its processing. With the help of a complex study and synthesis of information on the economic value of oats and millet, the potential of their production, and the possibilities of application in various directions of processing, the patterns inherent in most niche crops were revealed – in particular, multifunctionality and the possibility of producing several products with high added value on their basis in the context the popular trend of healthy eating and ensuring food security in general. For greater objectivity of the research, the level and dynamics of oat and millet production were analyzed using the economic-statistical method, using the example of the main commodity producers of Ukraine. Using the cartographic method, they presented the main regions of oat and millet produc-

tion in Ukraine as of 2021 – before the full-scale invasion of the Russian Federation. Regional rating assessments were performed to calculate the competitiveness of oats and millet in agricultural enterprises separately for each type and region of Ukraine.

3. Results

The concept of "niche crop" (alternative, special) is quite conditional. The same crop in different countries can be both main and niche, taking into account, first of all, the presence or absence of favorable conditions for cultivation. For example, rice in China is a leading crop due to the favorable natural conditions for cultivation, while in Ukraine, it is a niche crop. Attribution of this or that crop to a group of niches is also situational in nature. A certain crop and products of its processing may not be in demand in a certain period, agribusiness representatives lose interest in it, the area, accordingly, decreases, and it passes into a niche group. And vice versa – with the growth of demand due to certain factors, the cultivated area under a certain culture can be increased, and the crop moves from the group of niches to the main ones. Therefore, there is no clear division between niche and main crops. Based on this, within the scope of this study, oats and millet are classified as niche crops, particularly cereals. These crops are mainstream in some parts of the world and niche in others. Since Ukraine is a significant player in the international food market, oats and millet are niche crops at this stage of the development of agricultural production. Accordingly, the prospects of their production are considered in the context of the niche segment.

Oats are a cereal crop that is grown all over the world. According to various rankings, it is the sixth or seventh most important cereal crop after corn, wheat, rice, grain, sorghum, and millet. Oats are grown in temperate climates worldwide, with significant acreage in Northern Europe and North America, as well as in China and Australia (Holopainen-Mantila et al. 2023, Yang et al. 2023). In particular, Northern China is the main production area of whole-grain oats, a valuable grain crop, worldwide (Qin et al. 2022). Although oats are a traditional crop in many countries, there have been significant changes in oat production over the past 50 years due to the transformation of agricultural production and competition from other cereals (Marshall 2013). At the same time, oats are experiencing an unprecedented revival worldwide. The main reason for this is the global trend for developing high-quality products, so-called healthy superfoods based on oats, and the ever-increasing demand for functional foods.

The homeland of oats is the southeastern provinces of China and Mongolia. Having learned about the fodder properties of oats in the second millennium BC, farmers began to cultivate them. Oats have long been considered useful, medicinal, and dietary. Mentions of him are found in the writings of Asclepius and his students. He appreciated oats and Hippocrates, who recommended oatmeal as the best way to strengthen the body after a long and exhausting illness. In ancient Greece, oats were also revered, as they were believed to have been given to humanity by Demeter herself, the goddess of abundance and fertility (Dibrova & Stepasiuk 2023, Better understanding 2022). In Europe, the first traces of oats were once found in modern Switzerland, France and Denmark territories. Currently, the largest producers of oats in the world are the EU countries, the share of which is 34.7% of the total production volume.

A number of its various advantages determine prospects for the development of oat production. The agroeconomic advantages of oats include a relatively short growing season and undemanding soil and climate. Oats are characterized by a high ability to survive on poor soils – in this, they are second only to rye. An additional advantage is that this crop is not afraid of frost, it can be sown earlier than others (Kernasiuk 2017). All types of drained land can be used for growing oats, and they can be sown both as the first crop when fallows are developed and after long-term cultivation of perennial grasses. In addition, oats are a good precursor for most crops and a versatile cover crop, and can be a spring siderate or a companion crop. Experts claim that you can get a fairly high oat harvest by following simple recommendations, particularly in Ukraine. First of all, this requires attention and knowledge, as well as the use of effective agricultural techniques (Stepanushko 2020, Bazaluk et al. 2022).

Revealing the potential of oats, which determines its production prospects, it is impossible to ignore its advantages in the ecological plane. From the point of view of sustainable development, increasing biodiversity in the fields, including through the inclusion of oats in crops, brings significant ecological benefits. In particular, this often leads to improved soil conditions, as farmers can use less fertilizer. Oats are a particularly successful crop for both soil health and water quality. American scientists note that oats are phenomenal for groundwater quality because they have a deep root system that can collect and retain nitrates (Klein 2022). In the group of grain crops, relatively high resistance to fungal pathogens and competitiveness against weeds characterize oats. For this reason, oats play a beneficial phytosanitary role in crop rotation with a high proportion of cereals. It is also the best among spring cereals in terms of weed suppression. Oats are the only cereal crop with the potential to loosen crop rotations, consisting of cereals and canola. Being a summer

crop, it creates an opportunity to be used as an intermediate crop during the winter months, particularly in the climatic conditions of Ukraine. Oats are suitable for extensive cultivation due to the minimum requirements for plant protection. The high productivity of the crop when grown extensively is another reason for its popularity among organic farmers (Oats 2021).

From an economic point of view, oats' advantage is that its cultivation costs are lower than other grain crops, as the plants do not require intensive fertilization or complex control of diseases and pests. The economic value of oats and the economic attractiveness of their production are also largely determined by their multifunctionality. It is worth noting that this feature is characteristic of most niche cultures. Oats are a valuable fodder, food, and technical crop. Their grain contains 10% protein and 37-48% starch. In addition, oats have the highest amount of fat (6.2%) and fiber (10.7%), which is more than buckwheat when compared to other grains. This crop is generally unique regarding the optimal ratio of fats, proteins, and carbohydrates. First, oats are considered a fodder crop, as their grain acts as a standard for other fodder crops because 1 kg corresponds to one fodder unit. Almost the entire plant is valuable in animal husbandry. Oat grain is an excellent concentrated feed; oat straw and chaff have the highest fodder value compared to other species and are not inferior to meadow hay; oat hay and oat silage are valuable; the strong stalk of oats is better compared to barley. Oats are grown for green fodder in their pure form, and their most popular use is as a component in mixed crops with leguminous crops. Raw and processed oats have unique markets. There is "racy oats", which means a grain that is fed to horses. Their owners are known to be picky about the visual appeal of the oats they buy, often paying a significant premium to get the whitest and most shiny grain. Another export market for oats is the poultry seed segment. For example, a significant proportion of households in the Caribbean, Central America, and Mexico keep parrots, and oat groats make up a large proportion of the mixes produced by bird seed suppliers in these regions (McKeeh 2023). The main by-product of oat production is oat husk. About 10% of it is burned as biofuel or pelletized for home fireplaces; 20% is used for poultry bedding, as oat husk has high absorption; and the remaining 70% of the husk is used for animal feed, mainly for cattle, to a lesser extent in pig diets. For a long time, about 95% of grown oats were used for animal feed, and only 5% was intended for human consumption. In recent years, this ratio has changed significantly in the direction of being used to meet people's needs.

In today's conditions, oat grain is used in the production of groats (which, by the way, ranks first in terms of nutrition), flour (in the confectionery industry), and oat coffee. Oats are also one of the main components of dietary and baby food, as they are very quickly and well absorbed by the body. Oat flakes are used to make porridge added to muesli and baked goods. Whole-grain oat grains are germinated, and unshelled oat grains are used to prepare a decoction. Oats are also used to make ice cream and milk, which vegetarians love. In recent years, plant-based milk substitutes have become popular in supermarket refrigerators and coffee shop menus. Oat milk accounted for almost all of the sales increase in this category. The growing demand for oat milk is driven by its appeal to vegans and lactose-intolerant consumers, who are concerned about the impact of large dairy herds on climate change (McKeeh 2023).

Oat grains are not used in large quantities for bread production, as they contain too little gluten. Nevertheless, oats are often called an invaluable product. This is because its composition includes amino acids (lysine and tryptophan), protein close to muscle, fiber, and vitamins (B6, B1, B2, and vitamin K). Oats contain essential oils, gum, small amounts of potassium, magnesium, phosphorus, zinc, iodine, iron and others. Eating foods that contain oats can have a positive effect on human health. For example, recent studies by Canadian scientists indicate that oat fiber significantly helps to reduce/lower cholesterol, which is a risk factor for cardiovascular disease. The Canadian Oat Growers Association secured \$106,000 in 2022 from Agriculture and Food Canada to fund this research. Scientists implementing this research hope its results will give an additional impetus to farmers who grow oats and open new markets for this crop (Better understanding 2022). In addition, the benefits of oats for human health are increasingly coming into the spotlight worldwide due to the spread of plant-based diets and the rise in obesity and type 2 diabetes. Increasingly, the beneficial properties of oats are attracting global interest and investment in research and development for their use in the production of healthy foods. In the US, for example, there are predictions that a new and potentially profitable gluten-free oat industry will soon become a reality in response to the existing high demand. This niche will offer products at premium prices (Harris 2017). Oats are also used in medicine, cosmetology, cooking, and in the field of alcohol production.

According to FAO data, the world's oat production in the last decade was 20-25 million tons. The European Union, Russia, and Canada are the top three producers of oats. Together, they provide up to 70% of the world's oat production. Ukraine is one of the ten largest producers of oats (Dibrova & Stepasiuk 2023, Puzynska et al. 2021). At the same time, in Ukraine, oats currently belong to niche grain crops but are characterized by high economic value and economic attractiveness. Although at the beginning of the 20th century

oat production in Ukraine's right-bank and left-bank provinces was second only to rye and wheat. Traditionally, oats were part of the group of five main grain crops, but they gradually fell into the background, and now the volume of their cultivation in Ukraine is quite small. Ukraine's most rapid decrease in oat production occurred in the last decade. Although, owing to fertile soils and a favorable climate, Ukraine is still among the world's leading producers of this crop. And scientists call this crop multifaceted, and the oat market is invaluable (Kernasiuk 2017).

Thus, worldwide, oats are valued not only as a fodder crop but also as a rather important cereal necessary for healthy human nutrition. This fact largely determines the stable demand for oats and the economic attractiveness of its cultivation. In general, the increase in the volume of trade in oats is caused by several factors. First, the demand for healthy food products containing oats is increasing globally. Secondly, in response to consumer requests, processors create new products from this grain crop. These products have a high price and add additional value to the grain industry. The economic potential of oats is manifested in the fact that in the case of growing gluten-free varieties of this crop or growing it according to organic technology, in the future, it can be used to produce a line of premium products with high-added value. There is a fairly high demand for gluten-free oat products and organic products on the world market, despite the rather high prices for them (Agricom Group 2021). Therefore, the development of oat production directly depends on the development of the processing industry.

In today's conditions, millet also belongs to niche grain crops, primarily in Europe and Ukraine, in particular. Millet is a product of the processing of this crop. Modern geobotany considers the homeland of millet to be China, where it was known according to chronicle sources as early as 2700 BC. Millet has been a traditional food product for hundreds of millions in Africa and Asia for 7,000 years. In Europe, the cultivation of millet began about 3.5 thousand years ago. At one time, millet fell out of favor after the Green Revolution led to high rice and wheat yields. Today, millet is cultivated worldwide and is experiencing a new round of popularity in the context of the climate crisis and worsening food security. In general, in the world, according to ¹FAO, 74-80% of harvested millet (for grain) is used for food purposes. In different years, millet has occupied fourth or sixth place in the world among the main grain crops in terms of cultivated areas. Over 90 million people in Africa and Asia depend on millet for their diet. To meet the needs of such a large population, millet is grown in large quantities in Asia and Africa. India has historically produced the most millet in the world and is the largest producer and consumer of millet crops in general. Niger, Nigeria, Tanzania, Cameroon, and Burkina Faso follow it. China is also among the leaders. India, Niger, and China account for 55% of world millet production (United Nations 2023). In addition to India and African countries, the largest consumers of millet are Germany, Belgium, and the UAE. FAO estimates that millet currently accounts for less than 3% of global grain trade, but the crop is seen as a valuable alternative to traditional grains in the event of sudden market shocks (Six reasons 2023). In general, we consider millet, as well as other niche crops, as a crop that, in today's conditions, increases the diversity of the global grain market, increases the stability of global trade markets, and reduces dependence on major grains.

In ancient times, millet was an inferior coarse grain, and today, millet is a general term for the classification of small-seeded grasses, now called nutritious cereals. In today's conditions, millet is known as a super grain, and its popularity is growing, primarily due to its health benefits, economic attractiveness, and positive environmental impact. The United Nations, fitness experts, startups, food industry giants, and just about everyone else who cares about health have been paying attention to millet in the last decade. In 2012, millets came under the spotlight of the Indian government, resulting in a program called the Food Security through Intensive Millet Production Initiative. Later, in 2018, the crop was declared a "nutritious cereal" in India and added to the national food security mission. The same year, India proposed to the UN to declare 2023 as the International Year of Millet. In response, the United Nations declared 2023 the International Year of Millets, and the Indian government launched a mega-advertisement campaign to promote millets. The main goal of FAO's activities within the International Year of Millet is to "uncover the great potential of millet as an affordable food that can contribute to a healthy diet and environment (Six reasons 2023).

Perhaps the most important advantage of millet is that it is drought-resistant. It can grow in conditions other crops cannot withstand and, at the same time, give a fairly good harvest. Unlike rice and wheat, millet has a significant advantage, requiring very little water to grow. With the world's increasing freshwater scarcity, primarily in Africa and the Middle East, water-conserving crops such as millet are being prioritized for cultivation in these areas, thereby reducing the burden of staple crops on groundwater levels. Along with the fact that millet is resistant to drought, it is also tolerant to diseases and crop pests, allowing it to survive in adverse climatic conditions. Millet can grow in different climates and on poor and degraded soils, helping to reduce soil degradation and support biodiversity. All of this allows farmers to grow millet where other crops

may not be viable. In addition, this crop can help increase soil fertility, as it is a nitrogen-fixing crop that helps replenish the soil with essential nutrients (Pathak 2023). Millet can form a high yield of grain and straw in a short growing season and is characterized by high nutrition.

The economic benefit of millet is also obvious – first of all, it is cheaper and relatively easy to grow. Millet does not require expensive fertilizers and pesticides. In addition to economic benefits, this also means that it can help reduce the negative impact of agriculture on the environment. In the conditions of Ukrainian agrarian business, the costs of producing corn, one of the five main grain crops, are 10 times higher than those of millet. Accordingly, millet yield can be much higher than corn's. In general, in today's conditions, when the climate is changing, in many regions of the world, droughts are becoming more and more severe and long-lasting, accordingly, farmers face the risks of crop failures, increasing production costs and decreasing profitability, millet is becoming more and more relevant. Especially considering the acute shortage of wheat, which the world faced due to the war in Ukraine (Food of the future 2023).

The millet market was valued at over USD 9 billion in 2018 and is expected to grow at over 4.5% from 2018 to 2025, with a projected value of over USD 12 billion (Oswal 2023). The advantage of millet is its versatility – this crop can be used in various dishes, increasing the potential for economic benefit. The grain of the crop is used in baking bread and confectionery production. Millet can be a raw material for the food industry in producing malt and other processed products. Known technologies for obtaining technical oil and biologically active substances, products for the microbiological industry, etc., from millet. Due to the significant amount of starch, millet is used to produce alcohol (Taylor et al. 2006, Saleh et al. 2013).

Due to its genetic diversity, millet has many diverse and innovative applications in therapeutics and pharmaceuticals (Six reasons 2023). Also, in recent years, geneticists have been actively working on transforming millet into an energy plant, and the use of the latest varieties of energy millet for biofuel production is growing in importance. This direction of using millet is especially relevant for Ukraine due to the worsening of energy security in martial law conditions. In view of the war in Ukraine, the European Commission proposes to increase the production of biomethane to 35 billion cubic meters (bcm) by 2030 from 3 billion cubic meters in 2020 (Mirzoieva et al. 2022). The production and use of biofuel from millet will allow replenishment of the energy balance of rural enterprises and regions, significantly reducing Ukraine's energy dependence on imported fossil fuels.

Experts note that demand for millet is gradually reviving, primarily in regions where it was historically consumed as a staple grain. Along with this, there is also a global trend towards adopting cereals that have undergone minimal genetic modification over the years. Millet-based products are now viable options for people following a plant-based or gluten-free diet. Breakfast cereals and plant-based dairy substitutes are the two main categories for which millet is considered a possible alternative (Baloni & Choudhary 2023).

Thus, growing millet provides access to a reliable food source, has significant ecological and economic advantages, and is also characterized by significant agricultural importance (Table 1).

Millet has been known to Ukrainians since Neolithic times (III-II millennia BC). If, in the countries of Africa and Asia, in the structure of consumption, the use of millet for food purposes prevails, then in Ukraine, it is used mainly for fodder purposes. Therefore, in Ukraine, millet is not only a valuable grain crop but also a valuable source of fodder for livestock, mainly poultry. Practical experience shows that introducing green mass, silage, or millet monoforage into the diet of cattle helps to increase milk yield and improve milk taste. The green mass of millet is superior in quality to the green mass of corn and sorghum; 1 kg contains 0.2-0.4 feed units and 17-25 g of digestible protein. In Ukraine, millet for green mass is harvested at the end of July, when corn for green fodder has not yet been harvested.

Thus, it allows for filling the "window" between perennial grasses and corn. Millet hay is better than oat, sorghum, or corn hay. It contains 0.52 f.u. (feed units) in 1 kg of feed. Millet straw, which can occupy 50% of fodder mixtures' structure, contains, on average, 0.4 f.u. in 1 kg. During harvesting for grain, the leaves and stems remain partially green, suitable for ensiling, which also improves the quality of straw. Millet husk is mixed with mixed fodder, and millet chaff is slightly inferior to oat chaff in terms of nutrition, but it is superior to wheat, barley, and rye chaff. Tall fodder millet varieties are capable of producing 30-37 t/ha of green mass and 7-9 t/ha of hay, which is 50-80% more than ordinary millet varieties and 40-50% more than, for example, oats. The above proves the perspective of using millet as a fodder crop to meet the needs of animal husbandry. The use of millet products may become waste-free from the point of view of resource-saving and environmental friendliness. Also, in Ukraine, millet can be an insurance crop for replanting lost winter and spring crops, which, even with late sowing dates, can provide high and stable grain yields at the level of 3.5-4.0 t/ha due to economical use of moisture, drought resistance, and salt tolerance (Horbachova 2014).

Table 1. The main characteristics of millet and the product of its processing, which determine the prospects of its production in the conditions of modern risks

Nutritional value	Economic opportunities	Agricultural significance
Millet is rich in dietary fiber, vitamins (B vitamins), minerals (iron, calcium, magnesium) and antioxidants	Increasing market demand: Millet has become increasingly popular in recent years due to its health benefits and sustainability. This has led to increased market demand for millet, which can help increase farmers' income.	Drought tolerance: millet is able to tolerate long periods of drought owing to its deep roots that have access to water from the soil.
Millet is gluten-free and has a lower glycemic index than some other grains, making it suitable for people with gluten sensitivity and diabetes	Reduced production costs: Millet is a relatively inexpensive crop to produce because it can be grown with low water, fertilizer and pesticide use. This can help reduce farmers' production costs and increase their profits.	Heat resistance: millet can withstand high temperatures. This makes it an optimal crop for growing in hot climates.
Regular consumption of millet can help reduce the risk of chronic diseases due to its high nutrient content. It promotes a varied and balanced diet and improves overall food intake	Job creation: Millet cultivation can create employment opportunities for farmers, laborers and processors. This can help reduce poverty in rural areas and improve living standards.	Pest and disease resistance: Millet is relatively pest and disease resistant, making it a good choice for sustainable agriculture.
Millet can be used to prepare a wide range of dishes	Reducing rural-urban migration: Millet cultivation can help reduce rural-urban migration by providing farmers with a viable source of income. This is important, as the growing migration from the countryside to the city aggravates social and environmental problems.	Short growing cycle: Millet has a short growing cycle, which means it can be grown in a shorter period of time than other crops. This determines the expediency of its choice by farmers with limited land or water resources.
Millet helps in the prevention of many non-communicable diseases, such as diabetes, hypertension and cardiovascular diseases (thanks to magnesium and polyunsaturated fatty acids, which help lower blood pressure and reduce the risk of heart disease).	Growing millet using sustainable agricultural practices allows: - to develop more profitable organic agriculture; - apply crop rotation, which increases the productivity of agricultural land in the long term.	The ability to grow millet with low consumption of water, fertilizers and pesticides makes it a good choice for sustainable agriculture.

Source: completed using (A Study of Millets 2023, Six reasons 2023).

The relevance of millet for Ukrainian farmers is also increasing because every year, the climate in the country, as in many regions of the world, is becoming increasingly arid, due to which the most common crops – corn and wheat – often suffer. This especially applies to the south of Ukraine. As millet is a drought-tolerant crop, it is increasingly included in crop rotations to reduce risks due to weather conditions (Lebid & Ovas 2021).

Thus, millet is a grain (cereal), technical and fodder crop. Its cultivation becomes a possible alternative in the face of global food security, malnutrition, agrarian distress, and climate change. In particular, millet is one of the most promising crops from the point of view of adaptation of crop production to climatic changes, especially in arid regions, as well as under conditions of disruption of the agricultural production cycle. The

biological features of millet allow it to be successfully used to correct the grain balance field and irrigated crop rotations disrupted due to extreme weather events and military operations (Rudik et al. 2022).

In addition, millet cultivation supports sustainable and agro-ecological farming practices, contributing to biodiversity, soil health, restoration of degraded soils, soil carbon storage, and overall environmental sustainability. Millet is a good choice for marginal land as it is drought and poor soil-tolerant (A Study of Millets 2023). The more farmers know about the benefits of millet, the more they will promote its cultivation, consumption, and integration into sustainable food systems. Experts point out that millet is a good choice for small farmers because it is relatively easy to grow and costs less to produce than other crops.

In recent decades, Ukraine has been one of the leading players in the global grain market, including niche oats and millet. Nevertheless, despite this, as well as all the advantages of the considered niche grain crops and the growing demand for them worldwide, the situation with their production in Ukraine is quite disappointing. In particular, the analysis of the dynamics of the production of niche grain crops in Ukraine (in the example of oats and millet) proved that unsatisfactory trends characterize it. The analysis of the harvested area of niche crops in Ukraine by the main commodity producers shows that in 2022, in comparison with 2021, the area sown with oats and millet decreased in all categories of farms (Table 2). So, in all categories of farms, the harvested area of oats decreased by 13.8%, including in agricultural enterprises by 26.9%, of them in farms by 30.3%, and in households by 7.8%. The harvested area of millet in all categories of farms decreased by 43.6%, including in agricultural enterprises by 39.6%, among them by 47% in farms and households by 55.1% or more than twice. However, we emphasize that these statistics characterize the production of millet and oats in Ukraine as of 2022 – the year of the full-scale invasion of the Russian Federation.

On the other hand, as early as 2020, Ukraine was the largest exporter of millet worldwide – 25% of the world's volume. The USA and India followed. The leading position in international trade was largely achieved due to the reduction of supply on the world market from the Russian Federation and the USA. If in 2017/18 MR the export of Ukrainian millet amounted to 26.3 thousand tons, then according to the 2020/21 season results, it reached a historical maximum of 181.4 thousand tons. The key importers of Ukrainian millet in the 2020/21 FY were Indonesia, Poland, and Great Britain – their combined share in the total volume of exports was 35%. The decrease in the export rate of agricultural crops was already recorded at the start of the 2021/22 fiscal year. It is worth noting that the export orientation of Ukrainian millet is largely explained by the rather low rate of its consumption per capita in Ukraine. In 2018, it amounted to 0.8 kg. At the same time, the world average indicator of consumption of this culture is at the level of 3 kg/person/year (Lebid & Ovras 2021).

Table 2. Dynamics of production of niche grain crops in Ukraine (on the example of oats and millet), 2020-2022

	Years			% to the previous year	
	2020	2021	2022	2021	2022
<i>Harvested area, thousand hectares</i>					
oat					
All categories of enterprises	199.0	178.0	153.5	89.4	86.2
including agricultural enterprises	68.9	55.4	40.5	80.4	73.1
among them farms	15.7	11.9	8.3	75.8	69.7
households	130.1	122.6	113.0	94.2	92.2
millet					
All categories of enterprises	159.1	87.1	49.1	54.7	56.4
including agricultural enterprises	132.9	64.6	39.0	48.6	60.4
among them farms	38.9	18.1	9.6	46.5	53.0
households	26.2	22.5	10.1	85.9	44.9
<i>Yield, c/ha</i>					
oat					
All categories of enterprises	25.6	26.3	24.7	102.6	93.8
including agricultural enterprises	28.1	27.3	25.1	97.0	91.9
among them farms	26.5	24.0	22.7	90.7	94.2
households	24.3	25.8	24.5	106.3	94.9
millet					
All categories of enterprises	16.1	23.5	18.4	146.2	78.4
including agricultural enterprises	16.4	23.3	19.2	141.4	82.4

among them farms	15.7	22.8	19.6	144.9	86.0
households	14.3	24.4	15.7	170.2	64.4

Table 2. cont.

	Years			% to the previous year	
	2020	2021	2022	2021	2022
<i>Gross harvest, thousand tons</i>					
oat					
All categories of enterprises	510.0	467.9	378.5	91.7	80.9
including agricultural enterprises	193.9	151.3	102.0	78.0	67.2
among them farms	41.6	28.6	19.0	68.8	65.7
households	316.1	316.6	277.0	100.2	87.4
millet					
All categories of enterprises	256.1	205.0	91.0	80.0	44.2
including agricultural enterprises	218.5	150.2	75.0	68.7	49.8
among them farms	61.1	41.2	18.8	67.4	45.6
households	37.5	54.8	15.9	146.1	28.9

Source: State Statistics Service of Ukraine.

The yield of oats in Ukraine during 2020-2022 decreased in all categories of farms – by 6.2%, and in agricultural enterprises, farms, and households – by 8.1, 5.8, and 5.1%, respectively (Table 2). The millet yield in Ukraine during the studied period in all categories of farms also decreased by 21.6%, and in agricultural enterprises, farms, and households by 17.6, 14 and 35.6%, respectively. The highest millet yield was recorded in 2021, we assume that this is largely due to favorable weather conditions. The analysis of the gross harvest of the studied crops shows that due to the decrease in the sown areas and their productivity during the analyzed period, their gross harvest also decreased. Thus, in all categories of farms, the gross harvest of oats and millet in 2022, compared to 2021, decreased by 19.1 and 55.8%, respectively. The gross harvest of millet decreased by more than two times. This is likely to be partly because millet is cheaper than staple crops and offers lower margins, making it less attractive to farmers up to 2022. Starting from 2022, the situation was affected by military actions.

Factors restraining oats production in Ukraine are the decline of animal husbandry, insufficient processing capacity, and farmers' fear of being at a loss. The latter is related to the fact that the main reason for the decline in oat production in the past was its low yield, which did not contribute to the profitability of the culture. Accordingly, one of the reasons for the decrease in the attractiveness of oats for Ukrainian farmers was its rather low profitability compared to other crops (Mirzoieva & Tomashevskiy 2023). However, the situation is changing now. By improving breeding, Ukraine has a huge potential to increase yield by at least 1-1.5 t/ha. It is worth noting that more and more agricultural enterprises in Ukraine are introducing oats into crop rotations, which are becoming a mandatory and strategic crop. Processing, which is slow, but developing, contributes to this in part – primarily, these are factories that produce flakes.

Analysis of the structure of production of niche crops by the main commodity producers of the agricultural sector of Ukraine in 2022 shows that the production of oats is mainly concentrated in households, and the production of millet in agricultural enterprises and farms (Fig. 1). We consider the fact that millet in Ukraine is produced mainly by specialized enterprises as one of the facts that determined the country's leadership in the export of culture in the 2020/21 marketing year.

Based on the study of the production of niche grains in Ukraine, particularly oats and millet included in them, the following was found in a regional section. Oat production is mainly concentrated in seven northern and north-western regions, which provide 75% of all crop production (Fig. 1). Thus, in 2021, the Volyn, Zhytomyr, Rivne, and Chernihiv regions had the largest specific weight in total oat production, the share of which was 19.1, 15.9, 11.4, and 11.1%, respectively. Oats were produced less in the Sumy and Kyiv regions – 6.2% and 4.1%, respectively. In the rest of the regions of Ukraine, oats were grown in very small quantities or not at all.

As of 2021, millet production in Ukraine was mainly concentrated in seven regions, which provided 67.6% of the crop's gross harvest (Fig. 2). These seven regions are located in the south and east in the Steppe zone. Thus, the Odesa, Kharkiv, and Kherson regions had the largest specific weight in total oat production in 2021, the share of which was 12.2, 11.7, and 10.6%, respectively. Less millet was produced in Dnipropetrovsk, Donetsk, and Zaporizhzhia regions – 8.7, 8.5, and 6.9%, respectively. The location of millet crops in the southern and eastern regions of Ukraine is determined by the fact that the culture, as already noted, is heat-loving, drought-resistant, and heat-resistant. Accordingly, it was grown mainly in the Steppe zone of Ukraine. At the same time, in Ukraine, millet can be grown in the conditions of the Forest Steppe and Polis-

sia, where it is one of the most promising forage crops. Millet is practically not grown in Ukraine's central, northern and western regions. Thus, the geography of the location of millet crops in Ukraine indicates the risks caused by the state of war since the crops are mainly concentrated in the occupied territories and in the zone of active hostilities. We consider this fact as a threat to the production of millet in Ukraine and to a certain extent to the food security of Ukraine and the world.

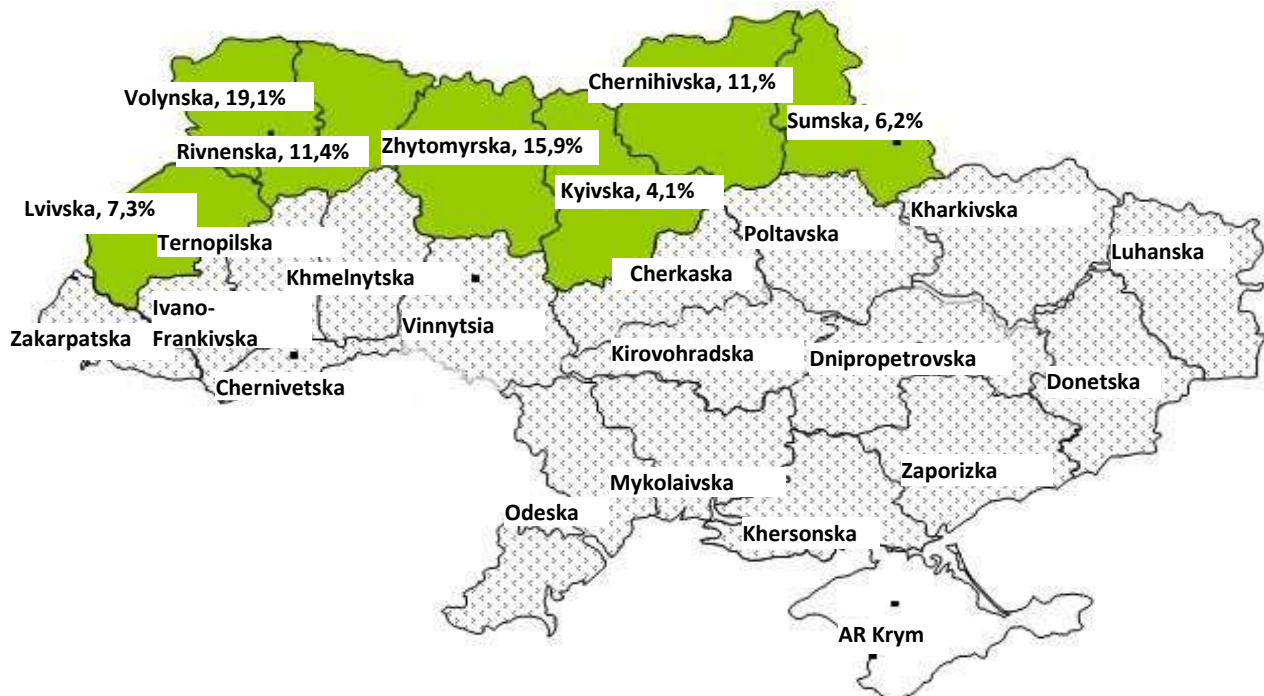


Fig. 1. The main regions of oat production in Ukraine, 2021
Source: State Statistics Service of Ukraine.



Fig. 2. The main regions of millet production in Ukraine, 2021
Source: State Statistics Service of Ukraine.

Taking into account the economic importance of oats and millet in today's conditions, as well as the role of Ukraine in the world grain market, highlighted above and supported by several arguments, as well as the role of Ukraine in the world grain market, the competitiveness of niche crops in agricultural enterprises was calculated separately for each type and region of Ukraine. For this, we used a rating assessment, the general direction of which is express diagnostics and which is quite common in the field of economics. Regional rating assessments were performed according to the following algorithm. First of all, the indicators that determine the competitiveness of crops were chosen:

- yield, t/ha,
- production cost, UAH,
- price of 1 ts, UAH,
- profitability ratio (ratio of price to full cost price),
- revenue of 1 ha, UAH.

Then, the ratio (indices) of each indicator of the regions to the average in Ukraine was calculated using the following formulas:

- to evaluate indicators, the increase of which has a positive value (yield, price, profitability ratio, revenue per 1 ha), i.e., stimulants:

$$I_{ij} = \frac{x_{ij}}{x_i}, \quad (1)$$

- for the evaluation of indicators – destimulants, the increase of which has a negative value (production cost of 1 centner):

$$I_{ij} = \frac{\overline{x_i}}{x_{ij}}, \quad (2)$$

where:

x_{ij} – the absolute value of the i-th indicator of the j-th region,

$\overline{x_i}$ – the average value of the i-th indicator for Ukraine.

The average indices of indicators were calculated separately for each group according to the formula:

$$I_j = \sqrt[n]{\prod I_{ij}}, \quad (3)$$

where:

I_{ij} – index of the i-th indicator of the j-th region,

n – the number of indicators.

As a result of the calculations, it was established that the highest level of competitiveness of oats in 2021 was held by the enterprises of Kharkiv (1.14), Khmelnytsky (1.11), Poltava (1.09), Ternopil (1.09), Lviv (1.06), Vinnytsia (1.04), Sumy (1.03) regions (Fig. 3).

Calculations indicate that the production of oats in Ukraine can potentially be competitive even in those regions that are currently not leaders in its production.

In the course of the rating assessment of the regions of Ukraine for the competitiveness of oats in agricultural enterprises, it was found that the agricultural enterprises of the Odesa region had the lowest place in the ranking of the competitiveness of enterprises engaged in the cultivation of oats in Ukraine (Fig. 4).

In turn, the agricultural enterprises of Poltava (1.22), Cherkasy (1.20), Khmelnytsk (1.19), Vinnytsia (1.18), Kharkiv (1.10) had the highest level of millet competitiveness) regions (Fig. 5).

The rating assessment of the regions of Ukraine according to the competitiveness of millet in agricultural enterprises proved that the agricultural enterprises of the Luhansk and Zhytomyr regions had the lowest place in the ranking of the competitiveness of enterprises engaged in the cultivation of millet (Fig. 6).

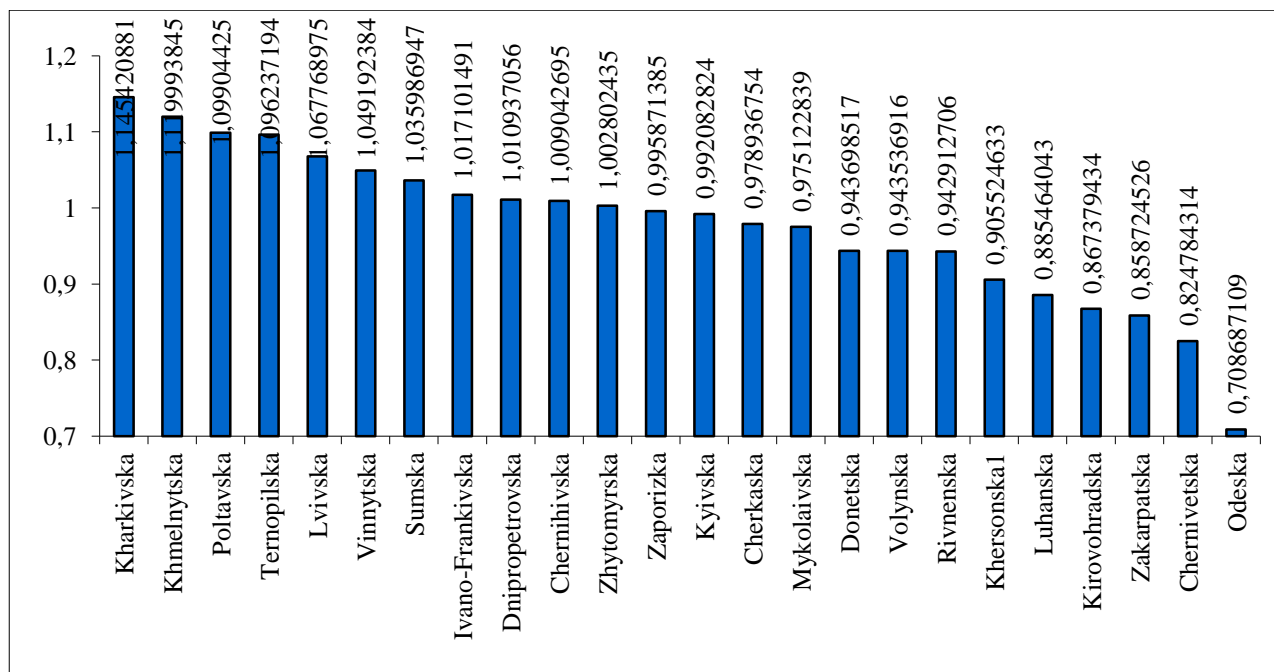


Fig. 3. Ranking of regions of Ukraine according to the competitiveness of oats in agricultural enterprises
Source: developed by the authors.

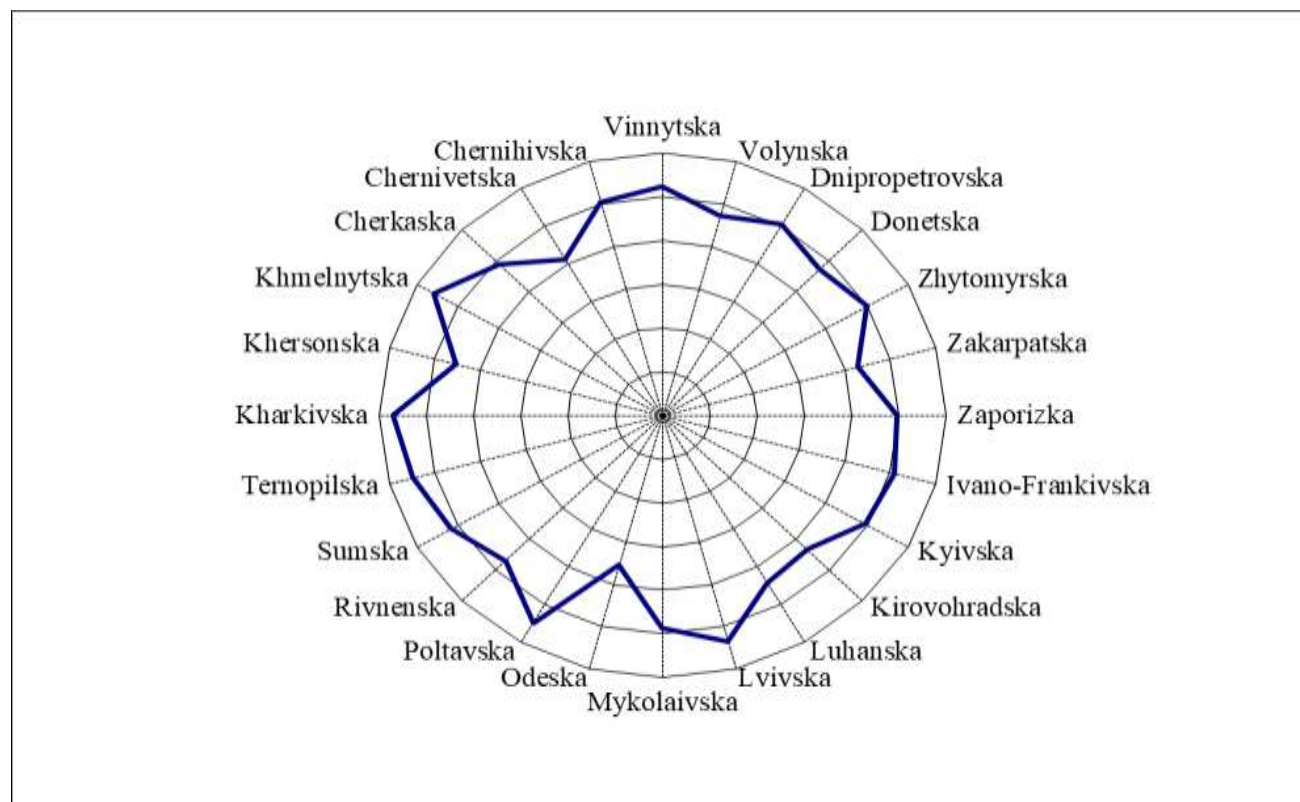


Fig. 4. Rating of regions of Ukraine according to the competitiveness of oats in agricultural enterprises
Source: developed by the authors.

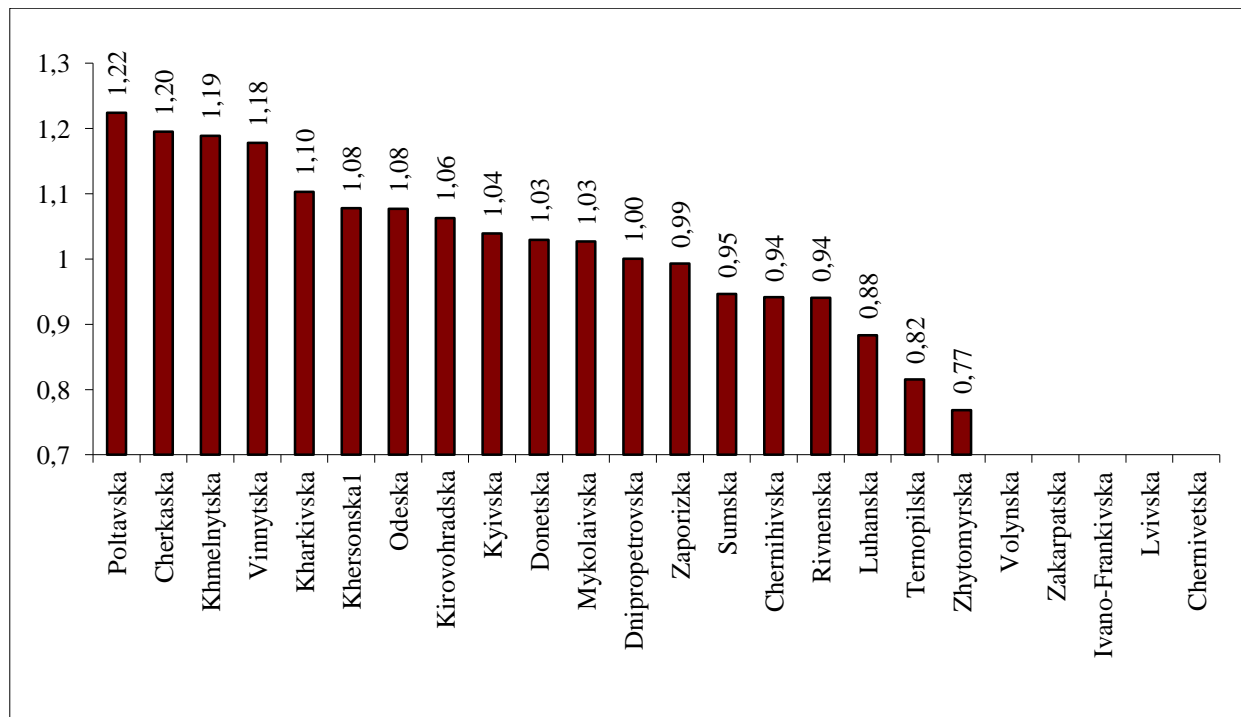


Fig. 5. Ranking of the regions of Ukraine according to the competitiveness of millet in agricultural enterprises
Source: developed by the authors.

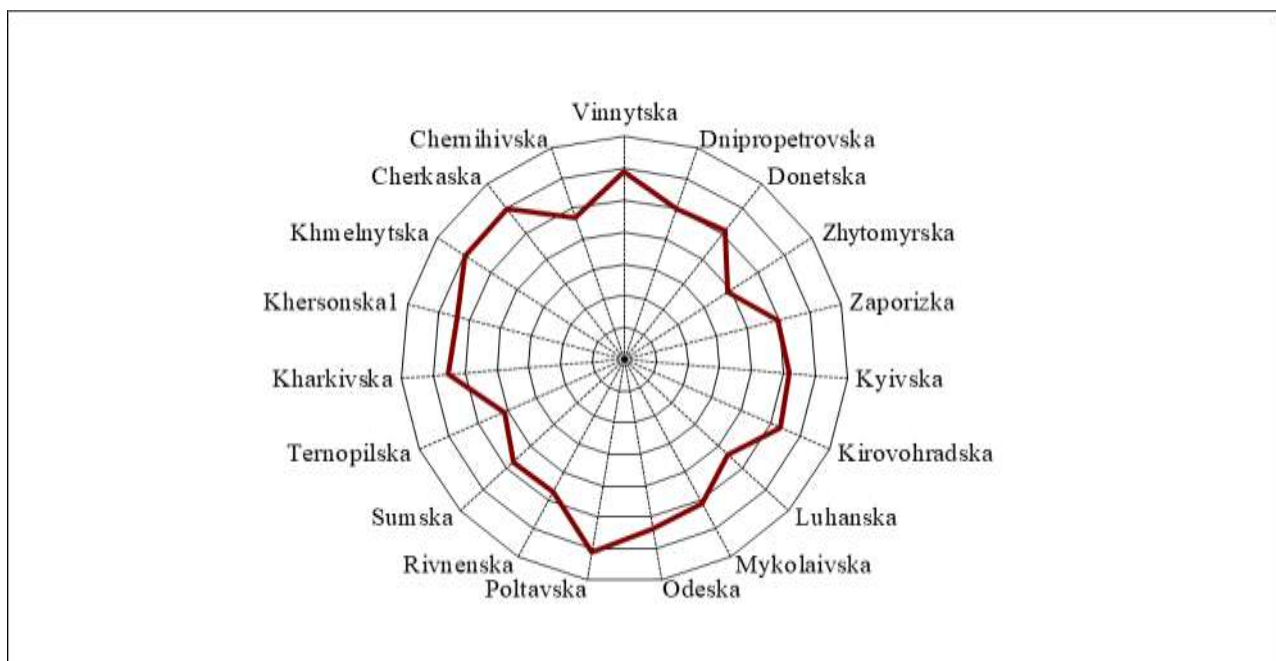


Fig. 6. Ranking of the regions of Ukraine according to the competitiveness of millet in agricultural enterprises
Source: developed by the authors.

Competitiveness indexes for the studied crops were calculated using individual indicators, the integrated competitiveness index was calculated by types of products (millet, oats), and regional ratings were developed based on the index method. Accordingly, the presented research on the example of the regions of Ukraine allows us to analyze individual competitiveness indices for each indicator, which determine the competitiveness of crops in a certain region and to identify reserves for their improvement. The research results can be useful to agribusiness representatives and other potential investors who plan to develop niche segments in agricultural production. This is especially relevant for Ukraine, considering that, potentially, the production of niche grain crops can be competitive in many regions of the country, which is one of the leading players in the world grain market.

4. Discussion

This study aimed to contribute to the field of studying the value of niche crops by providing empirical evidence of the need to develop their production to ensure food security and contemporary risks. In today's world, the harmful consequences of intensification and specialization of agriculture are becoming increasingly obvious. The focus of agricultural producers on monocultures, a narrow range of varieties, and the intensive use of agrochemicals are the main factors in the reduction of biodiversity, deterioration of soil health and pollution, and climate change, which endangers the food system and food security of mankind in general (Sumets et al. 2022a, 2022b). This requires more rapid and effective testing, implementation and scaling of sustainable approaches to agricultural production, including crop diversification (Dankevych et al. 2021, Denysiuk et al. 2022, Weituschat et al. 2023). There is no objection to the fact that the agricultural market needs niche crops, and the demand for them and their processing products exceeds the world's supply. At the same time, during the research, it was found that, for example, in Ukraine, which is one of the leading players in the global agro-food market, the cultivation of niche crops in general and such valuable niche grain crops as oats and millet is secondary; production based on them of products with high added value is not sufficiently developed; in regions where the production of these crops is potentially competitive, they are not grown at all or are grown in small quantities. We understand that niche crops will never replace traditional crops and that the demand for them, in many cases, is situational, discouraging producers. However, given the worsening food security in the world and several other risks, we believe that diversification of agricultural production through the spread of niche crops is necessary (Dvigun et al. 2022). In our opinion, this necessitates the popularization of this issue, the widest possible familiarization with it of local agricultural producers and society, and the need for its presentation in the international scientific information field.

In contrast to existing studies, this paper presents a complex and substantive approach to determining and substantiating the economic value of individual representatives of the group of niche grain crops, as well as calculating their competitiveness indices across the regions of Ukraine. Future research could gather more empirical examples of the feasibility of developing niche crop production. A systematic comparison of niche production in the agricultural sectors of different countries will contribute to the identification of reasons and factors that prevent the wide spread of innovations based on sustainable development (Rohe et al. 2022). Analysis of the dynamics of niche plant production, the risks faced by their producers in different parts of the world, interactions between different niches, between dominant agri-food systems and niches, as well as the formation of alliances between agribusiness actors, sectors, and countries can be incentives for the diversification of agri-food systems.

5. Conclusions

In the conditions of modern risks and the increased need to ensure food security in global agricultural production, particularly in Ukraine, various transformations are taking place. One of them is the shifting of producers' emphasis on selecting agricultural crops for production. Increasingly, growing some of the traditional crops in some regions of the world is becoming either not profitable or quite problematic due to many objective reasons. Producers are paying attention to crops that, for some time, were in the background and now belong to niches. The relevance of niche crops in general and niche cereals, in particular, and the expediency of expanding their production in recent years is growing rapidly due to many factors: climate changes, the need to increase biodiversity, the unsatisfactory condition of soils and the need for their restoration, the decrease in the profitability of the production of certain main agricultural crops, military conflicts, etc. In the course of the study, it was substantiated that the production of niche grain crops can be one of the tools for diversification of agricultural production in the conditions of modern risks and the aggravation of the problem of food security. We believe that the incentives for mastering technologies for growing niche crops for representatives of agribusiness, primarily small and micro, are: high competition with major players in the market of traditional grain and industrial crops; the need to diversify production to ensure the profitability of economic activity; the trend of healthy food, which is gaining more and more popularity in the world; development of processing in response to consumer requests; multifunctionality of niche cultures, the processing products of which are used in many areas and the production of which is accompanied by high added value. Considering the economic value and potential of niche grain crops, on the example of oats and millet, it was found that the main arguments in favor of the development of their production are their advantages in the economic, ecological, agrotechnical, and social spheres. Considering that Ukraine is one of the significant players in the world grain market, within the framework of the study, the competitiveness of niche crops in agricultural enterprises was calculated separately for each type and region of Ukraine. As a

result, it was found that the cultivation of oats and millet is competitive in many regions of Ukraine. Considering the reasonable economic value and potential of these crops, we believe that the presented arguments confirm the presence of positive prospects for developing their production in response to the need to ensure food security in the conditions of modern risks.

The article was prepared as part of the scientific research work on the topic "Forecasting the development of the market of cereal niche crops in the conditions of challenges and threats to food security of Ukraine (using the econometric model of partial equilibrium AGMEMOD)", state registration no.: 0123U102156.

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