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## CURRENT STATE AND PROSPECTS OF LENTIL PRODUCTION

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*Lentil is an important grain legume crop of food, feed, industrial, and agronomic significance. The global areas under its cultivation fluctuate from year to year but have a stable tendency to increase. The largest areas under cultivation are concentrated in Asian and American countries, while the smallest are in Europe. From 2000 to 2022, there was a significant increase in lentil cultivation areas in American, Oceanian, and European countries, indicating a strengthening position of lentils in the international agricultural market. Analysis by individual countries shows that the largest areas under lentil cultivation are in India and Canada. Up until 2016, India held the leadership position in this indicator among countries worldwide, but since 2016, Canada has taken over. From 2000 to 2022, the share of India and Canada in the global lentil cultivation areas structure ranged from 50% to 66%, with Turkey (5–13%), Australia (2–11%), and the USA (2–7%) following. In Ukraine, lentil cultivation areas did not exceed 500 hectares until 2011. In 2012, they increased to 2,100 hectares with subsequent significant fluctuations from 300 hectares in 2015 to 24,500 hectares in 2018, which had a corresponding impact on the production volumes of this crop. Global lentil production volumes were 18.44 million tons for the period 2006–2010, 24.44 million tons for 2011–2015, and 32.57 million tons for 2016–2020, indicating a steady growth trend. This applies to all regions of the world except the African continent, where lentil production remains stable. The highest production volumes come from Asian countries (47.8%) and American countries (40.2%). The lowest lentil production is in European countries, accounting for only 2.0% of global production. Analyzing individual countries globally, during the period of 2000–2022, 78.1% of the world's lentil production comes from five leading countries: Canada – 34.5%, India – 22.8%, Turkey – 9.0%, Australia – 6.8%, USA – 5.0%. Australia and Canada achieve the highest lentil yields among the leading countries, while India has the lowest. Ukraine has a relatively low level of lentil yield, although starting from 2011, it exceeded India in most years and only lagged behind Australia and Canada in 2021. Expanding cultivation areas and increasing production volumes of this grain legume crop could be an important step in the development of agriculture in Ukraine, ensuring a stable supply of this high-protein crop to the domestic market and strengthening Ukraine's position in the international agricultural market.*

**Key words:** lentils, grain legume crops, production volumes, cultivation areas, yield.

### **Сидякіна О.В. Сучасний стан та перспективи виробництва сочевиці**

*Сочевиця – важлива зернобобова культура продовольчого, кормового, промислового та агротехнічного значення. Світові площі її посівів коливаються за роками, але мають стійку тенденцію до зростання. Найбільші площі посівів зосереджені в країнах Азії та Америки, найменші – в Європі. За період 2000–2022 рр. відбулося їх суттєве зростання в країнах Америки, Океанії та Європи, що переконливо свідчить про посилення позицій сочевиці на міжнародному ринку аграрної продукції. Аналіз у розрізі окремих країн світу засвідчує, що найбільші площі посівів під сочевицею зосереджені в Індії та Канаді. Причому, до 2016 р. лідерство за даним показником серед країн світу належало Індії, а з 2016 р. – Канаді. За період 2000–2022 рр. частка Індії та Канади у структурі світових площ посівів сочевиці становила 50–66%, на третьому місці – Туреччина (5–13%), далі Австралія (2–11%) та США (2–7%). В Україні площі посівів сочевиці до 2011 р. не перевищували 500 га. У 2012 р. відбулося їх збільшення до 2100 га з подальшим дуже сильним варіюванням за роками – від 300 га у 2015 р. до 24500 га у 2018 р., що відповідним чином позначилося і на обсягах виробництва цієї культури. Світові обсяги виробництва сочевиці за період 2006–2010 рр. становили 18,44 млн тонн, 2011–2015 рр. – 24,44, 2016–2020 рр. – 32,57 млн тонн зерна, тобто можна відзначити стійку тенденцію до їх зростання. Стосується це всіх регіонів світу, за виключенням африканського континенту, де виробництво сочевиці носить сталий характер. Найбільші обсяги виробництва*

забезпечують країни Азії (47,8%) та Америки (40,2%). Найменше сочевиці виробляється в країнах Європи – 2,0% від світового виробництва. Якщо провести аналіз за окремими країнами світу, то за період 2000–2022 рр. 78,1% світового виробництва сочевиці припадає на 5 країн-лідерів: Канада – 34,5%, Індія – 22,8%, Туреччина – 9,0%, Австралія – 6,8%, США – 5,0%. Найвищу врожайність сочевиці серед країн-лідерів одержують в Австралії та Канаді, найнижчу – в Індії. В Україні спостерігається досить низький рівень урожайності сочевиці, хоча, починаючи з 2011 р., він у більшості років перевищував показники Індії, а в 2021 р. – поступався лише Австралії та Канаді. Розширення площ посівів та збільшення обсягів виробництва цієї зернобобової культури може стати важливим кроком у розвитку сільського господарства України, забезпечити стабільне постачання цієї високобілкової культури на внутрішній ринок та посилити позиції України на міжнародному ринку аграрної продукції.

**Ключові слова:** сочевиця, зернобобові культури, обсяги виробництва, площі посівів, урожайність.

**Problem statement.** The modern agricultural sector is focused on restructuring the sowing area to cultivate crops that will adapt to global climate changes, particularly increasing aridity. Agricultural producers are increasingly emphasizing the selection of drought-resistant crops, which not only address food shortages but also consider geopolitical, economic, and natural factors. Leguminous crops are an important group of plants capable of addressing food shortages. Among them, lentils hold a special place as one of the most important leguminous crops in the world [1, 2]. In Ukraine, the area of lentil cultivation is currently insignificant. However, considering the increasing aridity due to climate change, water supply issues due to the destruction of the Kakhovska Hydroelectric Station, high nutritional value, and significant agronomic importance, this leguminous crop is attracting increasing attention from producers [3, 4]. Therefore, the analysis of the beneficial properties, current state of production, and the feasibility of expanding lentil cultivation areas is a relevant issue today.

**Analysis of recent research and publications.** Lentils contain a large amount of protein, essential amino acids (Fig. 1), vitamins B<sub>1</sub>, B<sub>3</sub>, B<sub>5</sub>, B<sub>6</sub>, C, folic acid, and vital macro- and microelements. One of its valuable characteristics is the presence of up to 50% carbohydrates that do not convert into fats in the human body [5].

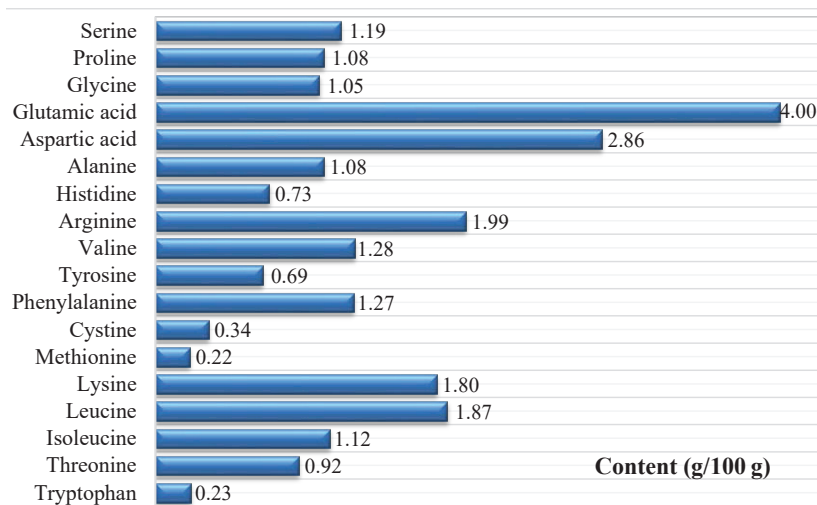


Fig. 1. Amino acid composition of raw lentil seeds (source: USDA, 2022)

Important microelements found in lentils include iron (Fe) and zinc (Zn). Currently, 20% of the world's population suffers from iron deficiency, and 33% suffer from zinc deficiency. Consuming lentils can fully meet a person's daily needs for these microelements [6].

Due to a significant amount of amino acids, mineral compounds, and vitamins, lentils have the ability to remove toxins and products of their metabolism from the human body. Like other leguminous crops, lentils are considered environmentally friendly products that do not accumulate nitrates, nitrites, and radionuclides. Another advantage of lentils is the presence of a significant amount of isoflavones in the seeds – plant-derived substances of the phytoestrogen class, which are characterized by metabolic and anticancer properties and have important medical significance and practical applications [7, 8].

Lentils are used in the preparation of soups, salads, sausages, coffee substitutes, and certain types of chocolate. Flour made from lentils is added to wheat flour during the baking of bakery products. Young lentil pods are consumed as vegetables, easily absorbed by the body, which is especially important for individuals with digestive issues. Lentils are also a crucial food product for vegetarians who use them as a meat substitute [9, 10]. With a protein content of up to 35%, lentils surpass other leguminous crops and meat in protein content [11].

Like all leguminous crops, lentils have significant agronomic importance. Through symbiosis with nodular bacteria, plants fix nitrogen from the atmosphere, partially providing themselves with this essential element and contributing to its accumulation in the soil. Introducing lentils into crop rotations allows for a 30–40% reduction in nitrogen fertilizer usage and significantly lowers the cost of production [4].

Lentils serve as an excellent precursor in crop rotations, increasing the yield of cereal crops grown after them by 0.3–0.6 tons per hectare. Due to their short growing period, lentils are also suitable as a cover crop for fallow land [12].

In addition to their nutritional value, lentils are a valuable source of raw materials for industrial production. Starch from lentil seeds is widely used in the textile and printing industries [13].

Ground grain as a valuable concentrated feed, green mass, straw, and lentil husks are used in the feed industry. The characteristic feature of lentil feeds is high protein content and digestibility of nutrients [11, 14]. Stems, dried leaves, husks, and screenings of lentils can also be used as feeds. For example, according to Ahmad N. et al. [13], lentil screenings contain 50% carbohydrates, 21.4% fiber, 12.2% ash, 10.2% moisture, 4.4% protein, and 1.8% lipids. The same authors note that in some Middle Eastern countries, due to low availability of animal feed, lentil screenings are priced equally with the grain of the crop, and sometimes even higher.

The analysis of practical use of the crop, natural factors related to global climate warming, water supply issues due to the destruction of the Kakhovska Hydroelectric Station reveal significant prospects for expanding lentil cultivation areas in Ukraine. This highlights the relevance of conducting research on this crop and the feasibility of its wider implementation in production.

**Problem statement.** The aim of the scientific research was to analyze the current state of lentil production in Ukraine, various regions of the world, and leading producing countries. Comparative-analytical, graphical, and abstract-logical methods were used during the scientific work. The information material for the scientific research consisted of data from the international FAOSTAT database (Food and Agriculture Organization of the United Nations), scientific publications by domestic and foreign authors, results of own analytical studies and calculations.

**Presentation of the main material of the research.** Lentils are grown in all regions of the world. The largest areas of cultivation are concentrated in countries in Asia and America, while the smallest are in European countries. In Asia, starting from 2000, the areas allocated for lentil cultivation each year have remained stable at 2.201–2.895 million hectares (Table 1) [15]. In American countries during the period of 2000–2008, the areas under lentil cultivation fluctuated between 0.469–0.987 million hectares, with a significant increase occurring thereafter, reaching maximum values in 2016 at 2.621 million hectares. The areas under lentil cultivation in European countries significantly increased from 2016, but prior to this period, they were minimal at 0.037–0.106 million hectares. Significant growth in lentil cultivation areas, especially in recent years, is also observed in Oceanian countries. The global areas under cultivation of this leguminous crop vary annually but show a consistent trend towards growth.

On average for the years 2000–2010, Asia accounted for 68.8%, America for 22.5%, Oceania for 3.8%, Africa for 3.6%, and Europe for 1.3% of the total lentil cultivation areas worldwide. From 2011 to 2022, the situation changed due to a significant expansion of lentil cultivation areas in American, Oceanian, and European countries, as demonstrated vividly in Fig. 2. The average share of Asian countries in the global lentil cultivation areas decreased from 68.8% to 51.2% over the study periods, although there was no decrease in cultivation areas in this region. This convincingly indicates the strengthening position of lentils in the international agricultural produce market.

Table 1

**Dynamics of sown areas under lentil by world region (source: FAOSTAT, 2023)**

Year	Regions of the world										World crop area, million hectares
	Asia		America		Africa		Europe		Oceania		
	million hectares	% of world crop area	million hectares	% of world crop area	million hectares	% of world crop area	million hectares	% of world crop area	million hectares	% of world crop area	
2000	2.790	71.9	0.807	20.8	0.125	3.2	0.043	1.1	0.118	3.0	3.882
2001	2.895	72.2	0.767	19.1	0.146	3.6	0.043	1.1	0.159	4.0	4.009
2002	2.856	77.8	0.469	12.8	0.131	3.6	0.050	1.4	0.166	4.5	3.670
2003	2.697	75.5	0.619	17.3	0.116	3.2	0.058	1.6	0.085	2.4	3.574
2004	2.699	69.7	0.871	22.5	0.116	3.0	0.058	1.5	0.129	3.3	3.874
2005	2.789	67.2	0.987	23.8	0.136	3.3	0.060	1.4	0.180	4.3	4.151
2006	2.768	70.8	0.742	19.0	0.146	3.7	0.046	1.2	0.208	5.3	3.909
2007	2.699	72.5	0.717	19.2	0.141	3.8	0.037	1.0	0.130	3.5	3.725
2008	2.201	66.0	0.828	24.8	0.154	4.6	0.037	1.1	0.118	3.5	3.337
2009	2.222	60.4	1.150	31.2	0.154	4.2	0.050	1.4	0.105	2.9	3.681
2010	2.331	53.3	1.628	37.2	0.132	3.0	0.064	1.5	0.220	5.0	4.375
2011	2.456	59.6	1.207	29.3	0.190	4.6	0.092	2.2	0.175	4.2	4.119
2012	2.479	59.6	1.219	29.3	0.191	4.6	0.106	2.5	0.167	4.0	4.162
2013	2.379	58.3	1.262	30.9	0.198	4.8	0.076	1.9	0.170	4.2	4.084
2014	2.271	55.7	1.363	33.4	0.161	3.9	0.074	1.8	0.209	5.1	4.080
2015	2.404	51.0	1.869	39.7	0.160	3.4	0.090	1.9	0.186	3.9	4.710

Continuation of table 1

2016	2.340	42.8	2.621	48.0	0.144	2.6	0.124	2.3	0.235	4.3	5.463
2017	2.812	45.7	2.227	36.2	0.190	3.1	0.262	4.3	0.665	10.8	6.157
2018	2.816	51.1	1.829	33.2	0.175	3.2	0.272	4.9	0.419	7.6	5.511
2019	2.440	50.2	1.720	35.4	0.167	3.4	0.137	2.8	0.401	8.2	4.865
2020	2.305	46.4	1.965	39.6	0.150	3.0	0.132	2.7	0.413	8.3	4.965
2021	2.517	47.6	1.954	37.0	0.148	2.8	0.167	3.2	0.502	9.5	5.287
2022	2.542	46.2	2.020	36.7	0.146	2.7	0.220	4.0	0.576	10.5	5.504

An analysis of individual countries worldwide showed that the largest areas under lentil cultivation are concentrated in India and Canada. As clearly seen from the data presented in Fig. 3, up to 2016, India surpassed Canada in terms of lentil cultivation areas, but starting from 2016, Canada took the lead among countries in the world in this indicator. The share of India and Canada in the global lentil cultivation areas for the period 2000–2022 fluctuated between 50–66%. Turkey held the third position, but with a significant gap, at 5–13%, followed by Australia and the USA at 2–11% and 2–7%, respectively.

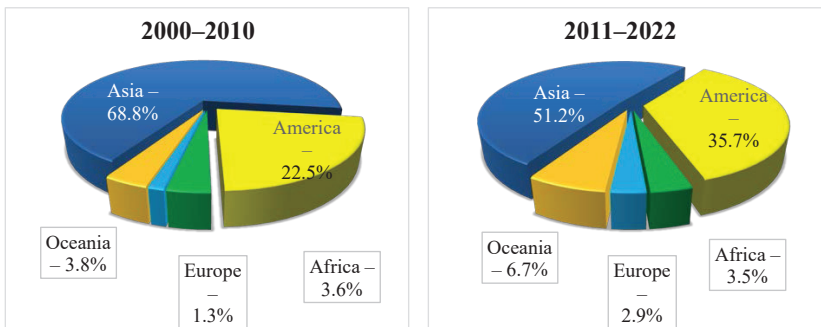


Fig. 2. The average share of regions in the global lentil cultivation areas from 2000 to 2022 (source: FAOSTAT, 2023)

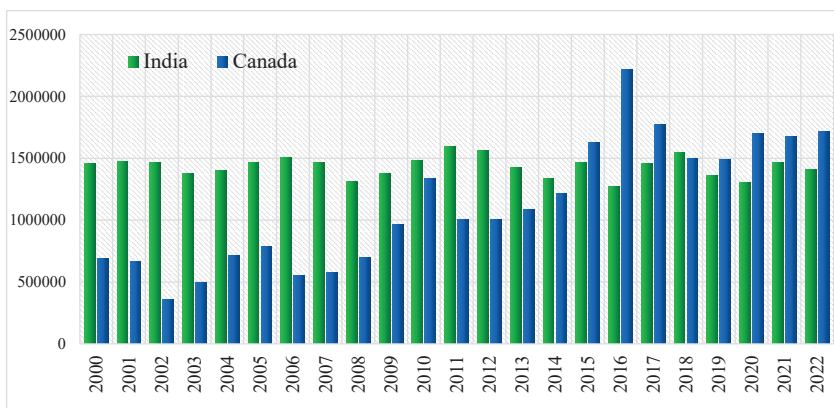


Fig. 3. Dynamics of lentil cultivation areas in leading producing countries (source: FAOSTAT, 2023), ha

In Ukraine, until 2011, the areas under lentil cultivation did not exceed 500 hectares (Fig. 4). In 2012, there was an increase to 2,100 hectares with subsequent significant fluctuations in cultivation areas – from 300 hectares in 2015 to 24,500 hectares in 2018. The increase or decrease in cultivation areas corresponded to the respective production volumes of this leguminous crop, which was relatively niche for Ukraine until recently (Fig. 5).

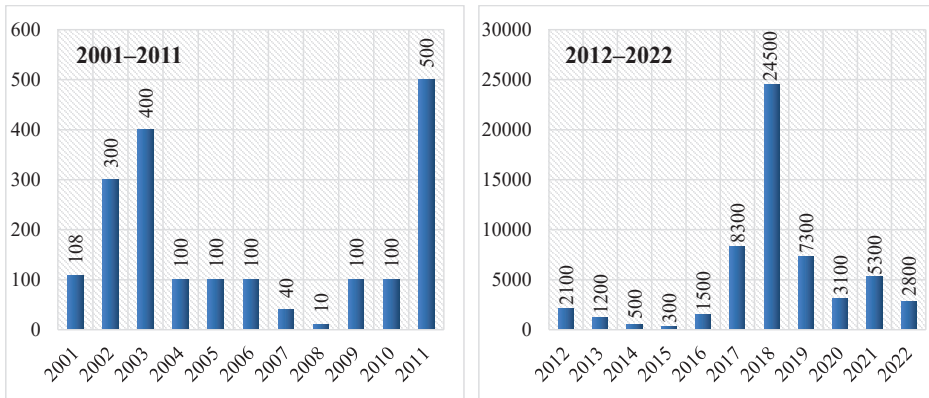


Fig. 4. Dynamics of lentil cultivation areas in Ukraine (source: FAOSTAT, 2023), ha

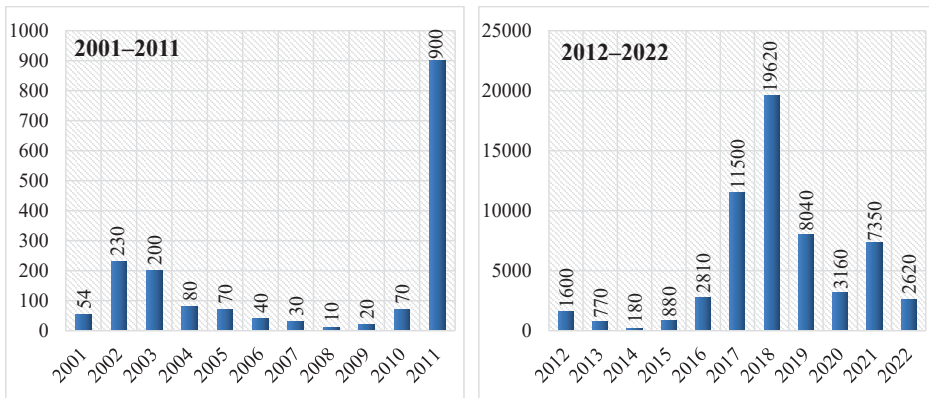


Fig. 5. Dynamics of lentil production volumes in Ukraine (source: FAOSTAT, 2023), tons

Worldwide lentil production volumes show a tendency towards gradual growth. For the period 2006–2010, the world produced 18.44 million tons, 2011–2015 – 24.44 million tons, and 2016–2020 – 32.57 million tons of lentil grain (Table 2). Moreover, an increase in production volumes is observed in all regions of the world, except for the African continent, where lentil production has maintained relatively stable positions since 2011. The largest production volumes of lentils in the world are provided by countries in Asia and America. Over the period 2000–2022, these regions accounted for 47.8% and 40.2% respectively. The least amount of lentils is produced in European countries – 2.0% of global production.

Table 2  
**Dynamics of lentil production by regions worldwide and in leading countries**  
 (source: FAOSTAT, 2023), million tons

Years	Regions of the world					Countries-leaders in production					World production, million tons
	Asia	America	Africa	Europe	Oceania	India	Canada	Turkey	Australia	USA	
2000–2005	13.26	5.41	0.49	0.26	0.97	5.87	4.37	3.09	0.94	0.93	20.37
2006–2010	9.71	7.19	0.59	0.20	0.75	4.65	5.99	2.04	0.74	1.09	18.44
2011–2015	10.61	11.18	0.99	0.40	1.28	5.19	9.90	1.98	1.26	1.08	24.44
2016–2020	12.85	15.27	0.96	0.89	2.59	6.15	13.19	1.87	2.59	1.88	32.57
2021–2022	5.20	4.43	0.34	0.44	1.86	2.76	3.89	0.71	1.85	0.40	12.26
2000–2022	51.63	43.48	3.37	2.19	7.45	24.62	37.34	9.69	7.38	5.38	108.08

78.1% of the world's lentil production volumes for the period 2000–2022 were provided by 5 leading countries: Canada – 34.5%, India – 22.8%, Turkey – 9.0%, Australia – 6.8%, USA – 5.0%, and only 21.9% of the grain of this crop was produced in other countries around the world (Fig. 6).

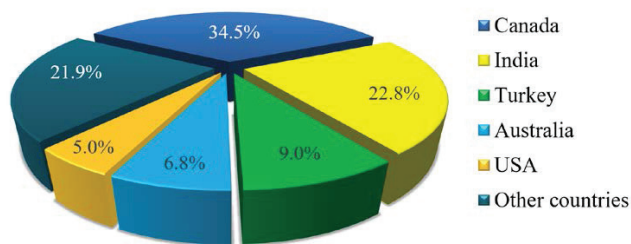


Fig. 6. Share of leading countries in global lentil production volumes for the period 2000–2022 (source: FAOSTAT, 2023), %

The increase in lentil production volumes is not only due to an expansion of cultivation areas but also to the use of innovative agricultural technologies and an increase in yield levels. Sharp fluctuations in lentil grain yields during the study period are notable in Oceania countries, with the highest in American countries (Fig. 7). Countries in Asia and Africa achieve relatively stable yield levels. In Europe, lentil yields are also quite stable but low – ranging from 0.79 t/ha in 2009 and 2018 to 1.19 t/ha in 2022.

Among the leading lentil-producing countries, Australia and Canada have the highest yields, while India has the lowest. A comparative diagram (Fig. 8) shows a relatively low level of lentil yield in Ukraine compared to leading countries, although starting from 2011, it exceeded India's yields in most years and in 2021, it was only surpassed by Australia and Canada.

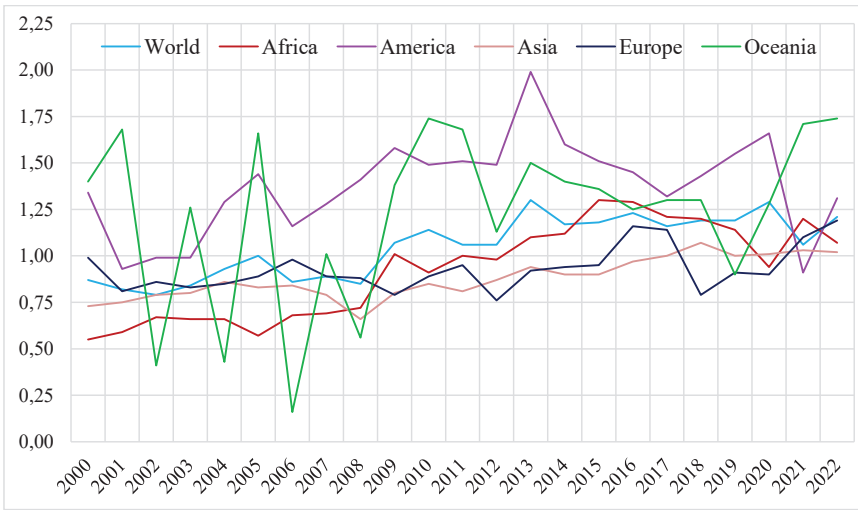


Fig. 7. Dynamics of lentil yields in world regions (source: FAOSTAT, 2023), t/ha

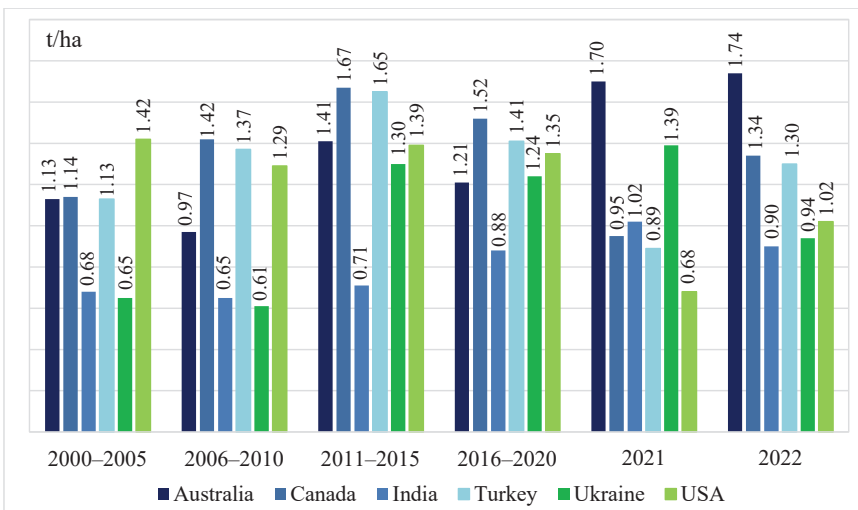


Fig. 8. Dynamics of lentil yield in Ukraine and leading production countries (source: FAOSTAT, 2023), t/ha

Improving lentil cultivation technology in Ukraine will allow to increase yield levels and improve grain quality indicators, especially based on resource conservation principles, which will be quite important during the post-war period of Ukraine's recovery. Expanding cultivation areas and increasing production volumes of this leguminous crop will reduce dependence on lentil imports and ensure a stable supply of high-protein grain to the domestic market. Additionally, increasing lentil yields will enhance the profitability of agricultural producers, which in turn will positively impact the country's economic development. Improving lentil cultivation technology can be a



significant step in the development of agriculture in Ukraine and ensure a stable supply of this valuable crop to the international market.

**Conclusions and recommendations.** Climate change towards global warming and increasing aridity forces agricultural producers to expand the cultivation areas of drought-resistant crops. One such crop is lentils, which contain a significant amount of protein, minerals, and vitamins. Increasing the cultivation areas under lentils in Ukraine and improving the technology of their cultivation will help address food, environmental, and economic issues, as well as ensure a stable supply of valuable high-protein grain to the global agricultural market, strengthening Ukraine's position on the international stage.

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