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EdTech information support for the study of the quality of agricultural products in Ukraine

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Abstract. The article is aimed *at analyzing the information support for the study of rapeseed quality in Ukraine, including export dynamics, problems with information, the formation of a metadata system and the assessment of yield stability to strengthen*

export positions. The ultimate goal is substantiation of measures to strengthen Ukraine's position in the world rapeseed markets by improving the quality and stability of production processes. ***Results:*** *The analysis of the global rapeseed market for 2023 revealed that Ukraine, ranking third in terms of export volumes, has the lowest average cost per kilogram of products (0.3853 USD), which is significantly inferior to the prices of other leading exporters, for example, France (0.8907 USD/kg). ISO international standards, which complicates standardization and information exchange. In response, a conceptual metadata system was developed and presented, including key quality indicators such as glucosinolate and chlorophyll content (according to ISO/TS 12788:2022). The application of statistical control maps to rapeseed yield data in Ukraine for 2000-2022 showed that the yield process is not in a state of statistical control, as evidenced by the exit of individual points beyond the established control limits. This indicates the presence of special causes of variations that require detailed examination and elimination.* ***Conclusions:*** *The study highlights the critical need to improve information support and quality control to stabilize the export position of Ukrainian rapeseed. The methodology of statistical control maps is an effective monitoring tool. Systemic measures, including investments in technology and compliance with international standards, are vital to ensure product quality and increase competitiveness in the global market.*

Keywords: *rapeseed, algorithm of data collection, methodology of control maps, statistical support of management.*

АКТУАЛЬНІ ПИТАННЯ ЕКОНОМІЧНИХ НАУК

EdTech інформаційного забезпечення дослідження якості агропродукції в Україні

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Анотація. ***Метою*** *статті є аналіз інформаційного забезпечення дослідження якості ріпаку в Україні, включаючи динаміку експорту, проблеми з інформацією, формування системи метаданих та оцінку стабільності врожайності для зміцнення експортних позицій. Кінцевою метою є обґрунтування заходів для зміцнення позицій України на світових ринках ріпаку шляхом підвищення якості та стабільності виробничих процесів.* ***Методи:*** *Використано методи системного та статистичного аналізу, зокрема дані UN Comtrade (2023) для експорту та Державної служби статистики (2000-2022) для врожайності. Ключовим інструментом статистичного аналізу стала методологія контрольних карт (зокрема, контрольні карти середнього ($\bar{X}$) та розмахів (R), що дозволила візуалізувати та оцінити стабільність процесу*

врожайності ріпаку, виявивши точки, які вийшли за межі статистичного контролю. Використання цієї методології є особливо цінним в умовах обмеженого доступу до інформації, спричиненого воєнним станом. ***Результати:*** *Проведений аналіз світового ринку ріпаку за 2023 рік виявив, що Україна, посідаючи третє місце за обсягами експорту, має найнижчу середню вартість за кілограм продукції (0,3853 дол. США), що значно поступається цінам інших провідних експортерів, наприклад, Франції (0,8907 дол. США/кг). Це вказує на потенційні проблеми з якістю або маркетингом українського ріпаку. Дослідження також підтвердило відсутність уніфікованих структурних метаданих для товарної категорії "ріпак" у міжнародних стандартах ISO, що ускладнює стандартизацію та обмін інформацією. У відповідь на це було розроблено та представлено систему концептуальних метаданих, що включає ключові показники якості, такі як вміст глюкозинолатів та хлорофілу (згідно з ISO/TS 12788:2022). Застосування статистичних контрольних карт до даних врожайності ріпаку в Україні за 2000-2022 роки показало, що процес врожайності не перебуває у стані статистичного контролю, про що свідчить вихід окремих точок за встановлені контрольні межі. Це вказує на наявність особливих причин варіацій, які потребують детального обстеження та усунення.* ***Висновки:*** *Дослідження підкреслює критичну потребу в покращенні інформаційного забезпечення та контролю якості для стабілізації експортних позицій українського ріпаку. Методологія статистичних контрольних карт є ефективним інструментом моніторингу. Системні заходи, включаючи інвестиції в технології та відповідність міжнародним стандартам, є життєво важливими для забезпечення якості продукції та підвищення конкурентоспроможності на світовому ринку.*

Ключові слова: *ріпак, алгоритм збору даних, методологія контрольних карт, статистичне забезпечення управління.*

Problem statement. At the present stage of development of the world economy, especially in the context of global instability and military conflicts, ensuring food security and stability of the agricultural sector is of paramount importance. Ukraine, as one of the world's leading exporters of agricultural products, faces unique challenges that affect the quality and competitiveness of its agricultural products in international markets. In particular, rapeseed, which plays a significant role in the country's economy and is an object of export to the countries of the European Union, requires a systematic approach to quality control and information support.

The key unresolved problem is the lack of a comprehensive and effective information support system that would allow for operational monitoring of the quality of agricultural products, in particular rapeseed, at all stages of its production and sale. This includes problems with access to systematized data on yields, qualitative characteristics, as well as the lack of unified metadata in international standards, which complicates the transparency and efficiency of trade operations. The existing gaps in information support lead to a decrease in the competitiveness of Ukrainian products in world markets, as evidenced, in particular, by the lower export value of Ukrainian rapeseed compared to other countries.

The connection of this problem with important scientific tasks lies in the need to develop and adapt modern methodologies of statistical analysis for assessing and controlling the quality of agricultural products in the context of dynamic changes. This requires the integration of advanced analytical tools, such as statistical control maps, to identify and address factors of instability in production processes. From a practical point of view, solving this problem is critical for ensuring the compliance of Ukrainian agricultural products with international standards, increasing their export potential and strengthening the country's economic resilience. In addition, the introduction of modern educational technologies (EdTech) plays a key role in training qualified personnel who are able to work effectively with large amounts of data, apply the latest quality control methods and contribute to the digitalization of the agricultural sector,

which is an important scientific and practical task for the development of the industry as a whole.

Analysis of recent research and publications. The study of the quality of agricultural products, the efficiency of their production and export, as well as the role of information support in these processes, is the subject of constant attention of the world and domestic scientific community. A review of the latest publications for the period 2020-2025 indicates a growing interest in the stabilization of the agricultural sector in the face of global challenges, in particular the impact of climate change, economic crises and geopolitical conflicts.

The works of many scientists around the world are devoted to the study of the rapeseed market. Considering the theoretical aspects of the development of the rapeseed market, the works of O. V. Maslak were of scientific interest to us [1], Bardina Y. B. [2], Golikova A.P. [3], Kovalchuk G.M. [4]. The practical aspects of the rapeseed market were dealt with by Kostenko N. P. [5], Melnyk A. V. [6], Chekhov S. A. [7] and others. However, the works of most of the above-mentioned scientists reveal only narrow aspects related to the rapeseed market and are not aimed at a systematic comprehensive study of this product category.

A significant number of works are devoted to the analysis of world markets for agricultural products, in particular oilseeds. Researchers are actively studying the dynamics of prices, production and export volumes, as well as factors affecting the competitiveness of products of different countries. Research on the impact of the war in Ukraine on global food markets and logistics chains is relevant, emphasizing the need to adapt and find new ways to ensure export potential.

A separate block of research focuses on methods of assessing and controlling the quality of agricultural products. Modern publications actively consider the application of statistical methods, such as Statistical Process Control (SPC), for monitoring and quality management at all stages of production, from sowing to storage. In particular, control maps, as an SPC tool, are increasingly being used to detect anomalies and

inconsistencies in production processes, which is critical to ensuring sustainable product quality.

At the same time, considerable attention is paid to the issues of information support of the agricultural sector. Publications in recent years emphasize the importance of digitalization, the development of data collection and analysis systems, as well as the formation of metadata to increase the transparency and efficiency of agricultural process management. More and more studies are looking at the role of educational technologies (EdTech) in training specialists for the agricultural sector, improving their skills in the field of working with data, applying the latest technologies and understanding international quality standards. This includes the development of online courses, interactive learning platforms, as well as the use of simulation models to put knowledge into practice.

However, despite the significant amount of research carried out, there are unresolved issues that require further in-depth analysis. In particular, the aspects of integrating EdTech tools directly into the processes of information support for quality control of agricultural products in times of crisis are not sufficiently studied. There is also a gap in research on the specific application of statistical control maps to analyze rapeseed yields in Ukraine, taking into account regional characteristics and the influence of external factors, as well as the lack of national standards for the recommended yield level. Existing studies often focus on general aspects without providing detailed analysis of specific metadata for individual product categories, which is critical for harmonization with international requirements.

Selection of previously unresolved parts of the general problem. Despite significant scientific achievements in the field of agrarian economics, product quality and information support, a number of aspects of the general problem remain insufficiently studied or require additional in-depth research, especially in the context of modern challenges for Ukraine. In particular, the following key issues remain unresolved:

- instability of the rapeseed yield process and the lack of scientifically based methods of its control in Ukraine;
- the impact of EdTech on the formation of information quality assurance of agricultural products in wartime.

These unresolved parts of the problem are critical for understanding the general state of information assurance of the quality of agricultural products in Ukraine and its competitiveness. Their study will allow not only to identify hidden factors affecting quality and export potential, but also to develop specific recommendations to improve the efficiency of the agricultural sector.

Formulation of the objectives of the article (statement of the task). On the basis of the selected unresolved parts of the general problem, **the purpose of the article** is to develop theoretical and methodological foundations and practical recommendations for improving the information support for the study of the quality of agricultural products, in particular rapeseed, in Ukraine, taking into account modern challenges and opportunities of educational technologies. The objectives of the article reflect the relevance of the research as it is aimed at solving urgent problems of the agricultural sector of Ukraine in the conditions of war and global economic instability. The sequence of tasks provides a logical structure of the study, starting from the general market analysis, moving on to the specifics of metadata and statistical quality control, and ending with the development of practical recommendations. The formulated goals are objective and scientifically grounded, emphasizing the importance of a new contribution to the development of the theory and practice of information quality assurance of agricultural products.

In the context of war and global economic instability caused by the aggression against Ukraine, the effective functioning of the agricultural sector is the key to food security. This requires not only adaptation of the rapeseed market to new conditions, but also strengthening information support and product quality control. In this context, educational technologies (EdTech) are of particular importance, which can contribute to the rapid dissemination of knowledge about new quality standards, data analysis

methods and innovative approaches to the cultivation and processing of agricultural products. EdTech is a key tool for training specialists who are able to work effectively with metadata and ensure compliance of products with international requirements, which is critically important for maintaining Ukraine's competitiveness in the global market.

Rapeseed is one of the oldest agricultural crops, which became known 4 thousand years ago. Studying the origin of rapeseed, it was found that the most common theory to which most scientists are inclined is the origin of rapeseed from the northwest coast of Europe. The peak of the distribution of rapeseed in Europe occurred in the middle of the XIX century, where this crop, together with other oil cruciferous plants, was used for the manufacture of technical oils. The area under it in Germany alone at that time reached 300 thousand ha [2]. It was from Germany at the beginning of the twentieth century that rapeseed came to Western Ukraine, where it quickly spread and gained popularity as a cheap fodder crop.

With the development of technologies for the production of cheap mineral technical oils at the beginning of the XX century, the popularity of rapeseed began to decline, which led to a significant reduction in the area for its cultivation in Europe. However, it was the development of technology that gave impetus to the filtration of rapeseed oil and its use in the food industry, which literally saved Europe during the First World War. By the early 1950s, rapeseed production in Ukraine was almost completely curtailed. The main reason was the intensive expansion of sunflower production, with which rapeseed could not compete economically. This decision was also influenced by the lack of methodological support for the conditions of sowing and harvesting rapeseed, which led to the fact that rapeseed was sown in territorial zones with significant temperature fluctuations throughout the year. According to the Harmonized Commodity Description and Coding System (HS), the code of this product at level 4 HS 2017 is 120510 [8].

We will use the data from UN Comtrade to conduct a study and review the volumes of rapeseed exports in the world and in Ukraine for 2023 (Table 1).

In total, for the period of 2023, 51 countries are exporters of rapeseed. Moreover, Canada became the largest exporter in the world in 2023, both in terms of trade value and export volume. The most expensive rapeseed was exported by France - $ 0.8907. per kilogram, and in terms of export volumes it is in 5th place. Speaking about Ukraine, it is possible to notice that with a significant volume of exports, the average cost per 1 kg is the lowest (0.3853 US dollars), which is more than two times cheaper than French rapeseed. These data clearly confirm the analysis of foreign trade of group 12 in subsection 1.2.

Table 1

Top rapeseed exporting countries on the world market for 2023

№	Exporting country	Trade value, USD USA	Weight net, kg	Cost, USD USA /kg
1	Canada	4461122054	7087518225	0,629434
2	Australia	3334578758	5752467650	0,579678
3	Ukraine	1100897063	2857426224	0,385276
4	Romania	697894621	1404986793	0,496727
5	France	528994324	593867383	0,890762
6	Netherlands	298019272	556093439	0,535916
7	Latvia	248304997	504923145	0,491768
8	Poland	278627751	504855288	0,551896
9	Belgium	214152719	373583668	0,573239
10	Hungary	220199771	367057964	0,599905

Source: built by the author based on materials UN Cometrade Database (product code HS (as reported) – 120510) [9].

The high demand for Ukrainian rapeseed determines the relevance and urgency of studying the quality of yield of the commodity category, for the development of the economy as a whole. Research and planning of rapeseed yield currently faces a number of problems related to obtaining information:

- during the war and economic instability, access to some information about

strategic institutions of the agricultural sector may be limited (partially or completely);

- lack of systematized information on the volume of consumption and production of rapeseed in the regions;

- lack of complete information on the yield of rapeseed grown in different regions of the country.

Solving existing problems related to obtaining information and introducing modern technologies in the cultivation, processing and transportation of rapeseed can help strengthen Ukraine's position in the world market. Investing in the agricultural sector, improving logistics infrastructure, and ensuring that products meet international quality standards are key steps to achieve these goals.

To conduct an analytical assessment, we analyzed the results of rapeseed yield (winter and spring) depending on the types of enterprises (Table 2).

Table 2

Dynamics of rapeseed yield in Ukraine for 2000-2022

Sample Number	Year	Yield (c per 1 ha),Xi				Amount	Average $\bar{X}$	Scope R
		X_1*	X_2	X_3	X_4			
1	2000	9,7	8,4	7,4	6,7	32,2	8,05	3
2	2001	14,1	12,4	11,8	12,9	51,2	12,8	2,3
3	2002	8,3	8,7	8,6	9,1	34,7	8,675	0,8
4	2003	11,5	9,4	7,6	9,9	38,4	9,6	3,9
5	2004	14,2	13,9	12,9	13,8	54,8	13,7	1,3
6	2005	13,3	14,7	13,8	11,6	53,4	13,35	3,1
7	2006	13,7	15,7	14,8	16,8	61	15,25	3,1
8	2007	12,4	13,1	11,6	13,8	50,9	12,725	2,2
9	2008	16,3	21,0	18,6	22,2	78,1	19,525	5,9
10	2009	13,5	18,7	15,8	19,9	67,9	16,975	6,4
11	2010	-	17,0	15,0	17,5	49,5	12,375	2,5
12	2011	-	17,4	15,7	14,6	47,7	11,925	2,8
13	2012	-	22,1	19,5	15,8	57,4	14,35	6,3
14	2013	-	23,7	22,4	18,5	64,6	16,15	5,2
15	2014	-	25,6	23,2	18,8	67,6	16,9	6,8

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16	2015	-	26,1	23,1	17,0	66,2	16,55	9,1
17	2016	-	25,8	25,4	22,5	73,7	18,425	3,3
18	2017	-	28,0	27,3	23,8	79,1	19,775	4,2
19	2018	-	26,5	25,5	21,6	73,6	18,4	4,9
20	2019	-	25,7	24,8	21,3	71,8	17,95	4,4
21	2020	-	23,0	21,8	19,9	64,7	16,175	3,1
22	2021	-	29,3	28,5	23,8	81,6	20,4	5,5
23	2022	-	28,7	28,7	22,4	79,8	19,95	6,3

**In the period from 2000 to 2009, the category of rapeseed yield of state-owned enterprises was presented in the annual statistical collection "Crop Production of Ukraine", in the collections after 2009 this category is not presented.*

Source: developed by the author based on the State Statistics Service [10,11,12,13,14,15,16,17].

Taking into account all the above-mentioned vulnerabilities, in our study on statistical provision of the necessary information, we followed the path of using such a methodology as statistical control maps[18, Pp. 207-209].

A control map is a graphical representation in the Cartesian coordinate system of a set of points, each of which is a value of a quality control parameter. The control map is built in order to identify points that have come out of a stable (controlled) state, for further study and elimination of the reasons for their exit.

According to the State Statistics Service, the following categories of enterprises are distinguished:

- ✓ X_1 (state-owned enterprises);
- ✓ X_2 (agricultural enterprises);
- ✓ X_3 (farms);
- ✓ X_4 (households).

There are different types of control maps, based on the available quantitative data, we decided to build control maps of mean ($\bar{X}$) and swing (R).

In the course of collecting information, we did not find any national standards for the recommended level of rapeseed yield, therefore, we decided to take the average

productivity data of rapeseed varieties and hybrids and make an analysis based on the average productivity of the most common variety in Ukraine [5].

According to the methodological provisions, the crops of the DK Extorm hybrid, which is one of the most common hybrids for sowing, the highest average yield was obtained at a sowing rate of 0.6 million germinating seeds per 1 ha. In the DK Exprit hybrid, the yield was slightly reduced compared to the DK Extorm hybrid. Thus, on the August variant (0.6 million germinating seeds), the yield was at the level of 3.01 t/ha. The highest average yield was obtained when growing the DK Extorm hybrid with a seeding rate of 0.6 million germinating seeds per 1 ha – 3.24 t/ha (32.4 c/ha) [5]. Let's take the value of the average yield of rapeseed hybrids at the level of 2.915 t/ha (29.15 c/ha) and determine the deviation compared to the lowest indicator,
namely 2.73 t/ha (27.3 c/ha). That is, (X_0 = 29.15, σ_0 = 1.85). Let's present below formulas for determining the upper control limit, lower control limit and center line of the control map:

$$UCL\ (\bar{X}) = \mu + A\sigma \quad (1)$$

$$LCL\ (\bar{X}) = \mu - A\sigma \quad (2)$$

$$CL\ (\bar{X}) = \mu \quad (3)$$

where: $\bar{X}$ – average;

μ – true average of the process;

σ – true group mean deviation;

A – the coefficient is a constant for calculating control limits.

To construct the control boundaries of the maps, we will find the data of the coefficients of the constants A, d2, D1 and D2 in the table for calculating the lines of the control maps, provided that the sample size (the number of studied categories of enterprises) is n = 4 [18, Pp. 275-276].

Let's calculate the indicators for building average and scale maps below:

X-map:

$$CL = X_0 = 29{,}15;$$

$$UCL = X_0 + A\sigma_0 = 29{,}15 + (1{,}500 \times 1{,}85) = 31{,}9$$

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$$LCL = X_0 - A\sigma_0 = 29{,}15 - (1{,}500 \times 1{,}85) = 26{,}375$$

R -map:

$$CL = d_2\sigma_0 = 2{,}059 \times 1{,}85 = 3{,}80915;$$

$$UCL = D_2\sigma_0 = 4{,}698 \times 1{,}85 = 8{,}69913;$$

$$LCL = D_1\sigma_0 = 0 \times 1{,}85 = 0.$$

Let's present the control maps that are built according to the data in Table. 2. and draw conclusions about finding these indicators within the control limits:

According to the visualized data in Fig. 1 and 2 we see that certain points of selective survey of rapeseed yield are placed outside the control limits, so we have reason to believe that the process is not in a state of statistical control.

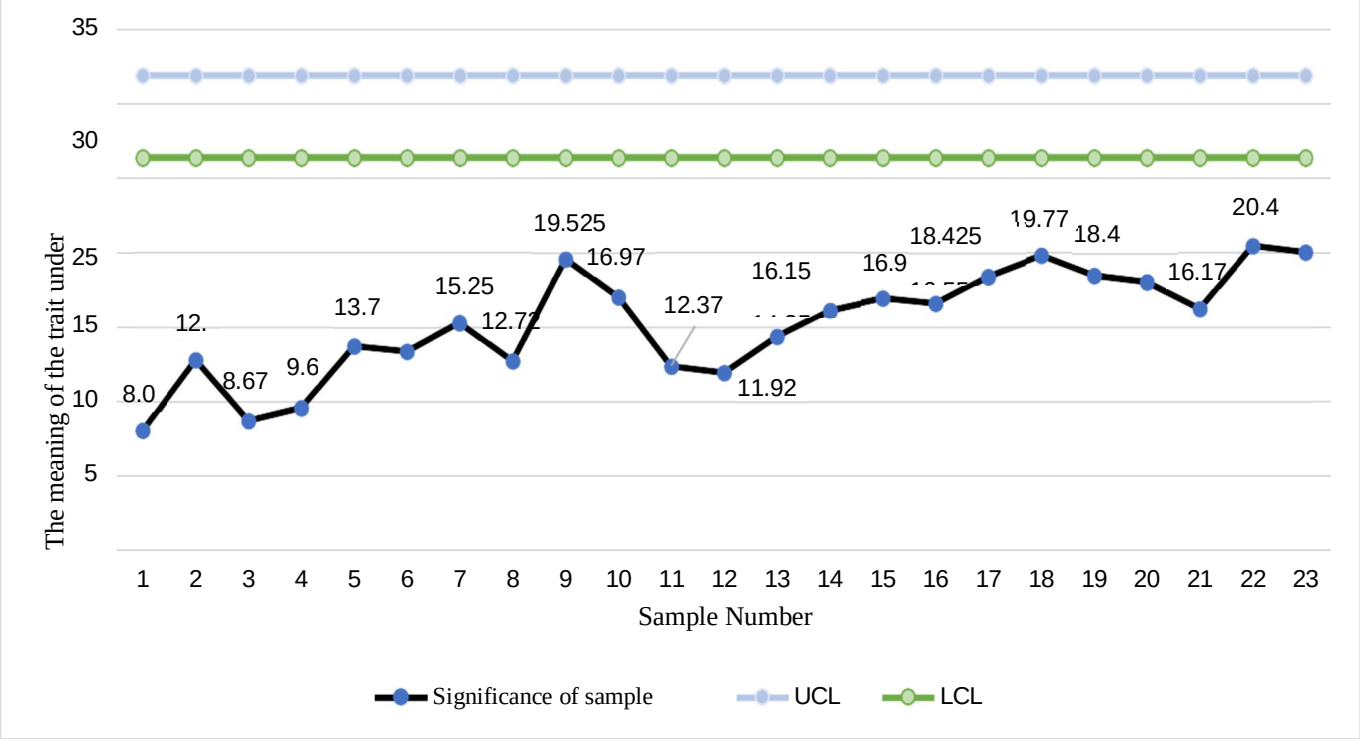

Fig. 1. Control map of average rapeseed yields

Source: built by the author on the basis of data analytics in Table. 2.

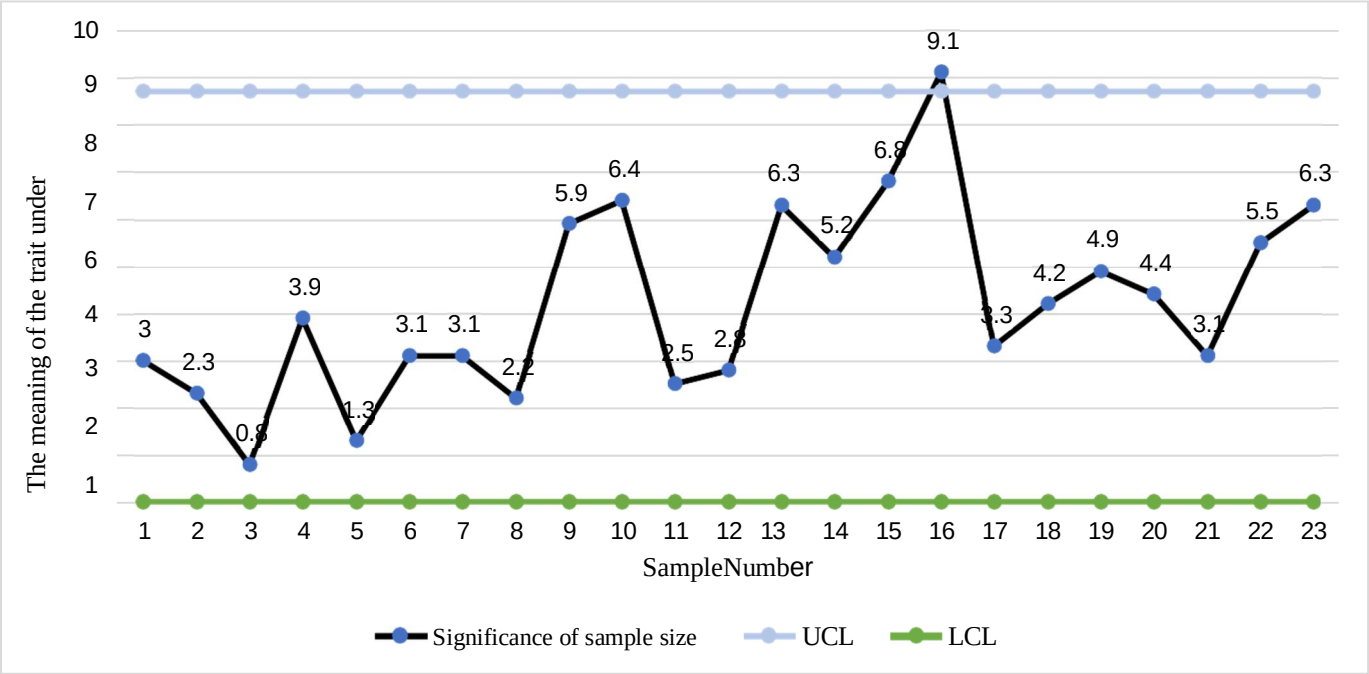

Fig. 2. Control map of the range of variation in rapeseed yield

Source: built by the author on the basis of data analytics Table. 2.

Conclusions. The study convincingly proved that the provision of reliable information support and effective quality control of agricultural products, in particular rapeseed, is a fundamental factor in the economic stability of Ukraine in the face of military challenges.

The identified significant problems, including the abnormally low export value of Ukrainian rapeseed compared to the world's leading exporters, the critical lack of unified international metadata for this commodity category and the statistically uncontrolled yield process, require urgent, systematic and scientifically based solutions.

The proposed methodology of statistical control maps has confirmed its effectiveness as an effective and indispensable tool for continuous monitoring and prompt detection of deviations in yield dynamics, which allows timely identification and correction of special causes of variations. To increase the competitiveness of Ukrainian rapeseed in the world market and ensure its consistently high quality, it is imperative to implement an integrated approach, which includes:

- targeted investments in the agricultural sector;
- systematic modernization of logistics infrastructure;
- active introduction of the latest technologies at all stages of production;
- significant strengthening of control over the quality of seed material;
- continuous work on full compliance of products with international quality standards.

Further scientific research should be focused on an in-depth analysis of the root causes of the identified deviations and the development of adaptive strategies for effective stabilization, control and sustainable improvement of the quality of agricultural products in the face of modern dynamic challenges, which will contribute to strengthening Ukraine's position in the international market.

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