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## RESEARCH OF QUANTITATIVE CHARACTERISTICS OF GRAIN RAILWAY ON GRAIN TERMINAL

### Abstract

An important component of the production and export of grain is the system of transportation of grain from its producers to grain reloading terminals. Among the means of transportation of grain the leading place is occupied by the railway, which is able to provide uninterrupted multi-tonnage transportation of grain from producers to the places of its accumulation and shipment to sea vessels. However, there are some problems in the internal and external operation of grain terminals, which has necessitated these studies.

The purpose of the study was to investigate the quantitative and qualitative characteristics of the flow of grain from the railway to the grain terminal to improve its efficiency. The object of the study was the technological process of receiving grain from the railway at the grain terminal; The subject of the research was grain crops, as well as data on daily revenues of grain by railway transport at the grain reloading terminal of LLC «Ukrelevatoprom» for three calendar years — from January 1, 2012 to December 31, 2014.

The studies were conducted on the basis of the processing of the data of the invoice logs for each year of the research, which summed up the amount of daily transported grain (net). Further processing of the obtained was performed by the combined graphoanalytical method, for which on the basis of tables for each investigated year the corresponding histograms were constructed and the necessary indicators were determined.

It was found that maize had the highest volumes of grain coming from the railways in 2012–2014, followed by wheat in 2012 and rapeseed in 2013–2014. Barley was the third, except for 2013, in which its volumes were the smallest among the main crops that came to LLC «Ukrelevatoprom» in the years studied. It is shown that the major share was occupied by cereals (67.1... 78.1%), followed by oilseeds (15.1...26.7%), and the smallest was occupied by legumes (2.77...6.8%).

The duration of the annual grain intake periods, which amounted to 315, 331 and 333 days, respectively, was determined for 2012–2014. Annual, daily average and maximum grain yields were determined, as well as daily and annual irregularity coefficients of grain supply. The actual coefficients of the daily irregularity of the grain input from the railway in the period 2012–2014 were respectively  $K_{daily} = 1.62; 1.86; 1.79$ , and monthly irregularities respectively  $K_{mont.} = 1.31; 1.40; 1.35$ . According to the standards such coefficients have values  $K_{daily} = 2.5$  and  $K_{mont.} = 2.0$ , which allows to use them for design and verification calculations of grain terminal equipment in technological processes of grain acceptance from railway transport.

**Key words:** cereals, grain acceptance, rail transport, dynamics of grain flow, uneven coefficients.

### Formulation of the problem

Now Ukraine takes a leading position among world producers and largest exporters of grain, and its grain sector is a strategic sector of the state economy. An important component of the production and export of grain is the system for transporting grain from its producers in grain transshipment terminals. Among the appliances of transporting grain, a prominent place is occupied by the railway, which is able to ensure uninterrupted multi-ton transportation of grain from producers to the places of its accumulation and shipment to sea vessels.

By 2020, Ukraine plans to increase production up to 100 million tons, and exports - up to 50 million tons. In this regard, the problem of increasing the efficiency of the railway grain transportation system is very relevant for Ukraine today [1]. The grain export infrastructure includes a transport system, an accumulation and storage system for the required grain volumes and

port transshipment capacities for dispatching the formed grain consignments to water transport.

Ukraine has a well-developed transport infrastructure, and the basis of its transport system is railways. Railway transport provides about 82% of the country's cargo turnover. As for the delivery of agricultural goods by land, the main place is taken by railway (61%), the share of road transport is 32%, and river transport is 3%. The main carrier, which ensures the delivery of more than 60% of export grain from linear elevators to ports, is railway. Considering that the country's grain and oil markets have become export-oriented, and most of the export (91.2%) is carried out through ports, it is advisable to consider the efficiency of the transport system in terms of the delivery of bulk cargo from granaries to ports [2, 3]

According to experts from railway transportation, among the main problems of grain transportation is the insufficient capacity of the railway infrastructure in



ports and port sections, the shortage and deterioration of the grain fleet, and the inefficient logistics [3]. However, there are certain problems in the internal and external work of the grain terminals themselves, which necessitated the conduct of certain studies, in particular, studies of quantitatively-qualitative regularities of the flow of grain by railway to grain terminals.

**The purpose and objectives of the study**

The aim of the study was to study the quantitative and qualitative characteristics of the flow of grain from the railway to the grain terminal of LLC «Ukrelevatorprom», which will help increase its efficiency.

To achieve this goal, it was necessary to solve the following tasks:

- study the quantitative and qualitative characteristics of annually received crops by railway;
- determine the duration of the periods, the volume of daily, average daily and maximum grain receipts by railway;
- calculate the coefficients of daily and monthly irregularity of grain supply by railway.

**Object and subject of research**

The object of the study was the technological process of receiving grain from the railway at the grain terminal. The subject of the study was grain crops, as well as data from daily grain receipts by railway at the grain transshipment terminal of LLC «Ukrelevatorprom» for three calendar years - from January 1, 2012 to December 31, 2014.

**Research Methods**

To determine the patterns of quantitative and qualitative grain supply to the terminal from the railway, statistical material was collected, it based on the processing of data from the consignment notes for each year of research for 2012-2014. There was calculated a summed amount of grain (net) daily transported by railway. Summary results were entered in the table for each year of the grain supply.

Processing of the obtained tabular data was carried out by a combined grapho-analytical method, for which, on the basis of the tabular values of the daily grain supply for each studied year, the corresponding histograms were constructed, which gave a visual representation of the dynamics of grain inflow.

The irregularity coefficients of daily  $K_{daily}$  and monthly  $K_{month}$  of grain supply to the enterprise were determined according to the following procedure. From the total annual period of grain supply, three days of its maximum supply were selected (digital data are shown on the histograms below), according to which the maximum average daily and monthly average values of grain supply for each year and each type of transport were calculated according to the formula

$$A_{aver.daily}^{3max} = A_{3daily} / n, \text{ t/day}, \quad (1)$$

$A_{3day}$  – total amount of grain received in 3 days

of its maximum receipt, t;

$n$  – number of days of maximum grain intake ( $n=3$ days).

The average daily intake of grain for a certain year  $A_{aver.day}$  was calculated by the formula

$$A_{aver.day} = A_{sum.year} / \Pi_H, \text{ t/day}, \quad (2)$$

де  $A_{sum.year}$  – the total amount of grain coming in a year, t;

$\Pi_H$  – grain supply period, days.

The coefficient of daily irregularity of grain intake is calculated by the formula

$$K_{month} = A_{aver.day}^{3max} / A_{aver.day} \quad (3)$$

The determination of the coefficient of monthly irregularity of grain supply was calculated according to the formula

$$K_{month} = A_{aver.month}^{3max} / A_{aver.month} \quad (4)$$

де  $A_{aver.month}^{3max}$  – maximum grain supply per month of the three maximum months of the year, t/month.;

$A_{aver.month}$  – average monthly grain supply in each month of the three maximum months in a year, t/month.

According to the given methodology, the coefficients of daily and monthly irregularity of grain supply by railway were determined.

**Research results**

At the first stage of the study, the qualitative composition of grain that was delivered by railway to LLC «Ukrelevatorprom» from 01/01/12 till 12/31/14 was analyzed. The results are presented in the form of histograms, which show the distribution of the volumes of main crops according to the years studied (Fig. 1), as well as their ratio by the main groups of crops (Fig. 2).

From Figure 1 it is seen that the largest volumes of grain received by railway in 2012-2014 was corn, the second place was occupied by wheat in 2012, and in 2013-2014 it was taken by rapeseed. Barley was the third, except in 2013, in which its volumes were the smallest among the main crops, received by LLC «Ukrelevatorprom» during analyzed years.

If we consider the main groups of crops that arrived at the enterprise by railway in the indicated period (Fig. 2), then it can be noted that the main share was occupied by cereals (67.1...78.1 %), including wheat, corn,

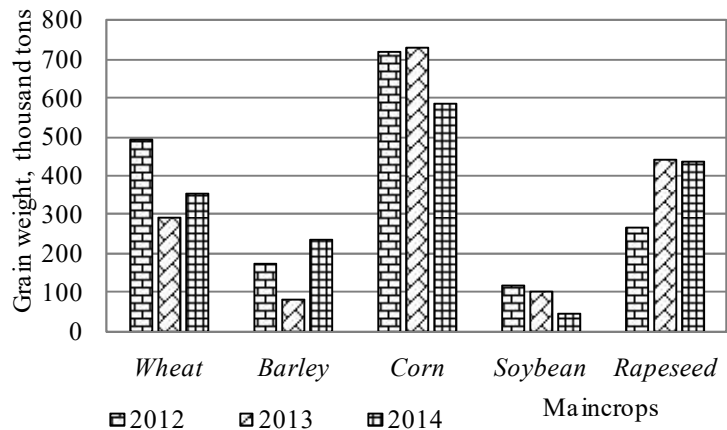


Fig. 1 – Histogram of railway supply of some crops to the enterprise

barley and in 2012 slightly sorghum. In second place



were oilseeds (15.1...26.7 %), such as rapeseed and insignificantly in 2013 sunflower, and the lowest was oc-

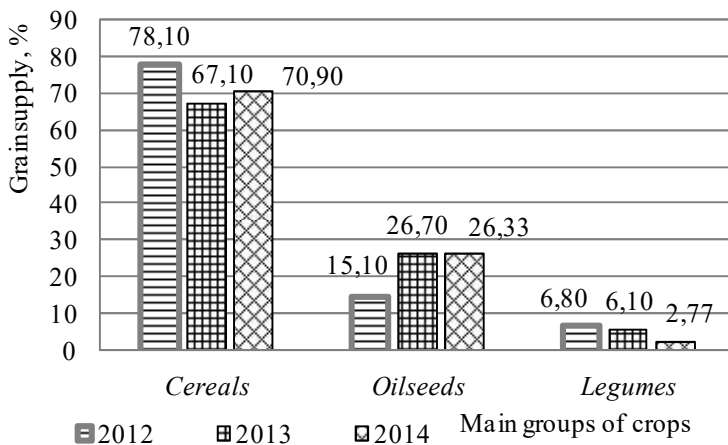


Fig. 2 – Consolidated histogram of grain delivery of main crop groups at the enterprise by railway

cupied by legumes (2.77...6.8 %), represented by soybean and in 2012 slightly by peas. A significant share of cereal crops can be explained by their high demand in the international grain market, in which Ukraine occupies a leading position.

If we compare the total volumes of grain received by railway with its delivery by road to LLC «Ukrelevatoprom» in 2012-2014, which we studied earlier [4], we can see that the ratio between them was two to one (2:1), which explained by the most practical use of hoppers for transporting grain than conventional grain carriers.

At the next stage of the work, the dynamics of the course of daily grain supply for the annual periods of grain supply by railway was studied. For this, on the basis of tabular values of daily grain supply for each of the studied years, histograms were constructed; they are shown in Fig. 3.

From the above histograms it is clearly seen that LLC «Ukrelevatoprom» receives grain by railway from the beginning of the year to June, and then from July to the end of December, and the grain arrival period lasted

for 315, 331 and 333 days over the years (an average of 326 days). According to the same histograms, it can be seen that the supply of grain by railway over the studied years was almost uniform. If we compare the intensity of grain inflow in the first and second half of the year, then in the first half of the studied years it was 5601, 3581 and 3941 t/day, respectively, and in the second half of the year in accordance with 4109, 5949 and 5580 t/day, that is, their ratio was by years, respectively 0.7, 1.7 and 1.4. These data show that in 2012 the first half of the year was more stressful in terms of grain reception by railway, and in the second half in 2013 and 2014.

If we compare the results of grain supply by railway with the dynamics of grain supply by road to LLC «Ukrelevatoprom» in the same 2012-2014 (the results of which were partially published by us in [4]), then in the first half of the year, the intensity of grain intake by motor transport was 1466 324 and 741 tons/day, respectively, and in the second, 2569, 2690 and 2664 tons/day, respectively, that is, it grew by 1.8; 8.3 and 3.6 times depending on the year and, especially, this difference was noticed in 2013-2014.

Thus, unlike the railway, grain delivery by automobile transportation has differed at the enterprise by about 2-8 times in the first and second half of the calendar year in the period 2012-2014. In this sense, the use of railway transport is more justified, since it provides a large uniform and stable operation of the grain terminal.

The dates and the largest volumes of grain received by railway, which were noted in the studied years, are given in table 1.

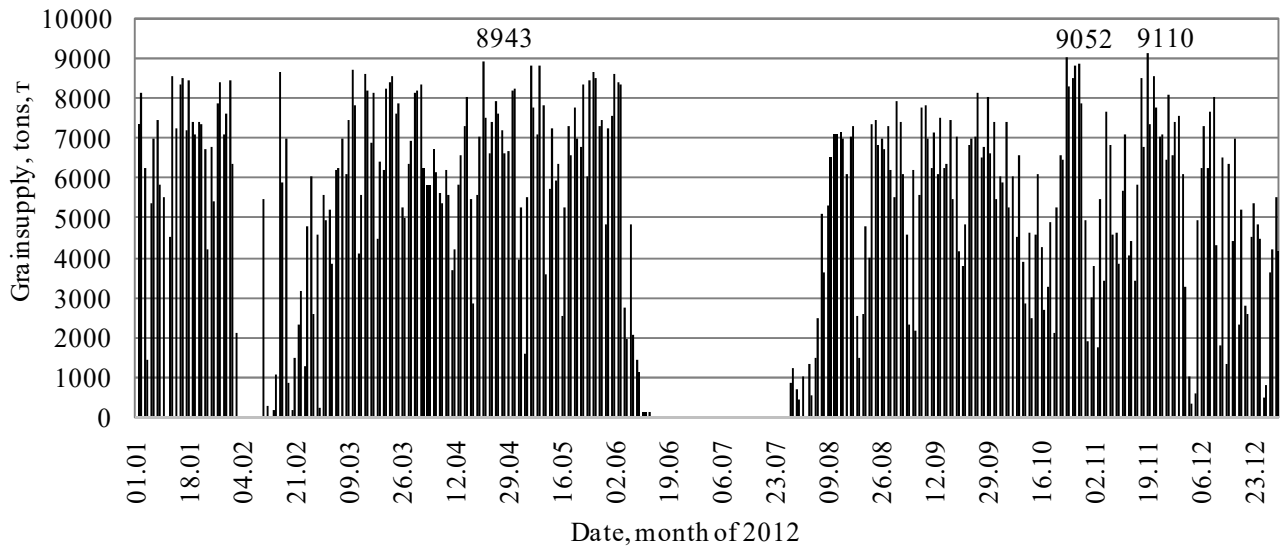
According to the data and the research methodology obtained from the histograms constructed, for each of the years under consideration there were certain periods of grain arrival by automobile transportation, the volume of average daily grain supply, the maximum grain supply for the periods of the most intensive reception and for the day of maximum work of the grain terminal, which are given in table. 2.

Table 1 – Determination of the maximum grain supply by railway

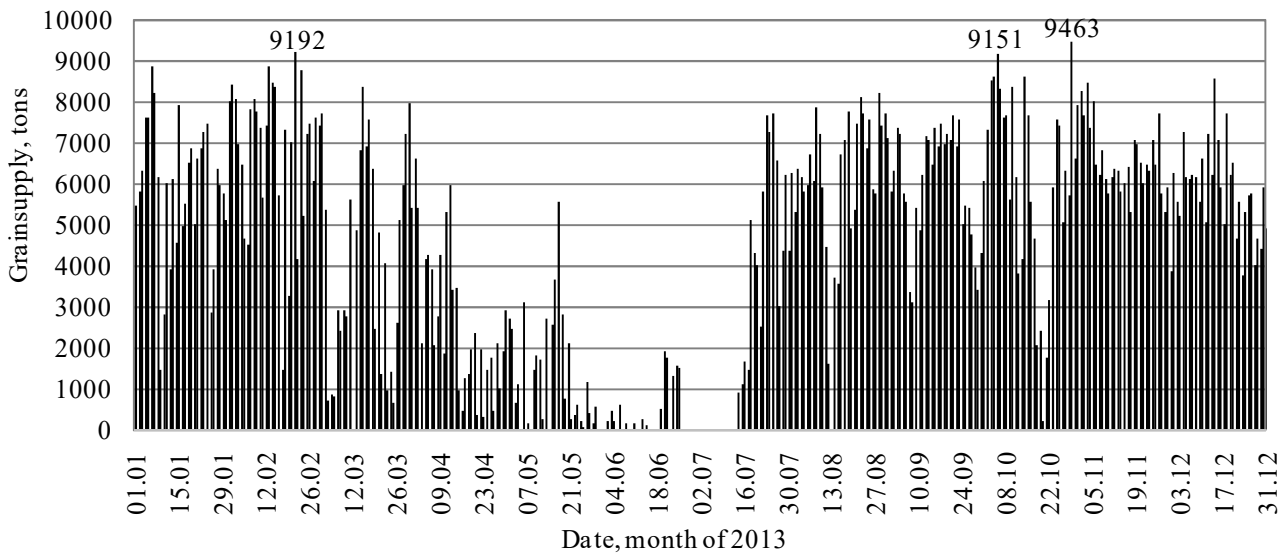
2012 year		2013 year		2014 year	
Date	Volumes, t/day	Date	Volumes, t/day	Date	Volumes, t/day
21 April	8942	21 February	9192	12 April	8997
24 October	9052	5 October	9151	23 March	8673
19 November	9110	29 October	9463	25 September	8771
$A_{g, day} = 9035$		$A_{g, day} = 9269$		$A_{g, day} = 8814$	

Table 2 – The results of the study of the grain supply by railway to the grain terminal

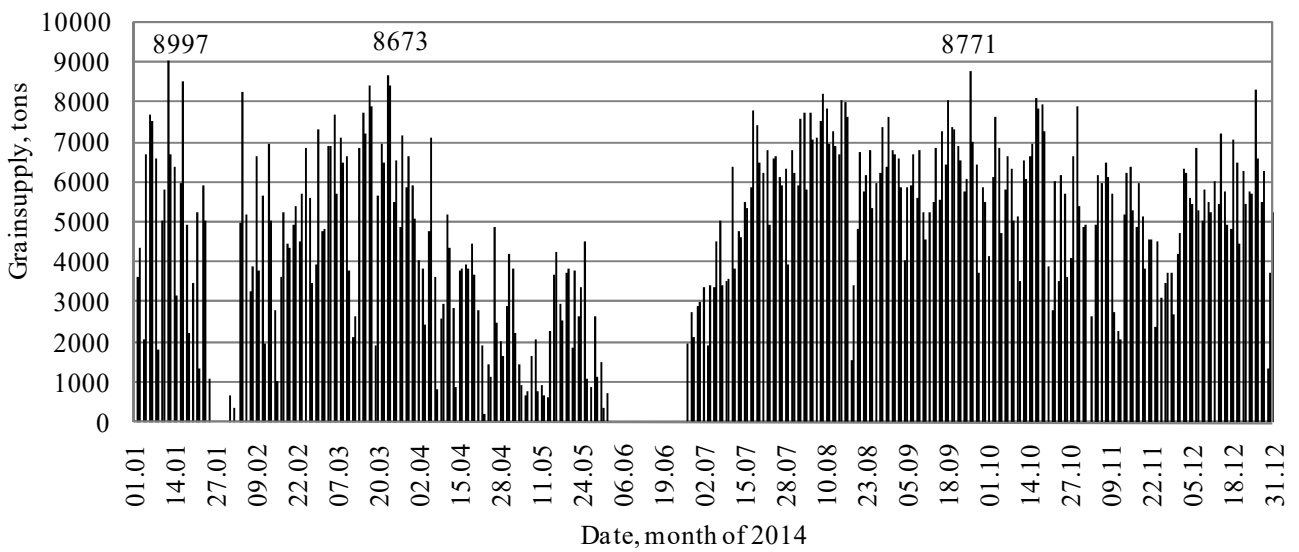
Name of indicators	2012 year	2013 year	2014 year
Grain supply period $\Pi_n$ , days	315	331	333
Volumes of annual grain supply $A_{sum, year, T}$	1750218	1641515	1642530
Average daily grain delivery $A_{average, day, T}$ , t/day	5556	4959	4933
Maximum daily grain delivery $A_{g, day, T}$ , t/day	9035	9269	8814



a)



b)



c)

Fig. 3 – Histograms of daily grain delivery by railway to the terminal in 2012-2014



**Table 3 – Actual and normative meaning of the coefficients of irregularity of grain supply by railway to the grain terminal**

Name of coefficient	According to experimental data			According to regulatory data [5]
	2012 year	2013 year	2014 year	
Coefficient of daily irregularity, $K_{\text{daily}}$	1.62	1.86	1.79	2.5
Coefficient of month irregularity, $K_{\text{month}}$	1.31	1.40	1.35	2.0

When analyzing the work, designing or reconstructing an enterprise, it is necessary to have indicators on the basis of which it is possible to calculate the necessary productivity of technological and transport equipment, as well as receiving devices, which will ensure uninterrupted reception and processing of grain at the terminal. The most important of these indicators when receiving grain from railway transport is the period of the most intensive grain reception at the enterprise, the amount of grain and the rate of its reception in the indicated period, as well as the daily and monthly irregularity coefficients of grain supply.

The calculated meanings (according given methodology) of the coefficients of daily and monthly irregularity of grain supply by railway to the grain terminal compare to the standard (literary) data are given in table. 3.

Our studies show that the values of the daily and monthly non-uniformity coefficients determined by us differ by years, but do not exceed the normative ones, according to which the necessary equipment for grain

terminals is usually calculated. The use of actual coefficients makes it possible to calculate the minimum necessary equipment to ensure the uninterrupted operation of the enterprise.

### Conclusion

The results of studies of the grain supply by railway to the grain terminal made it possible to determine the duration of the annual periods of grain reception, the annual, average daily and maximum volumes of grain reception, as well as the coefficients of daily and monthly irregularity of grain supply. The actual coefficients of diurnal irregularity of grain receipts from the railway in the period 2012-2014 were determined, respectively, amounted to  $K_{\text{daily}} = 1.62; 1.86; 1.79$ , and monthly irregularities, respectively,  $K_{\text{month}} = 1.31; 1.40; 1.35$ . According to the standards, such coefficients have the values  $K_{\text{daily}} = 2.5$  and  $K_{\text{month}} = 2.0$ , which allows them to be used for design and verification calculations of the equipment of grain terminals in technological processes of grain reception from railway transport.

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## ДОСЛІДЖЕННЯ ЗАКОНОМІРНОСТЕЙ ПРИЙМАННЯ ЗЕРНА ІЗ ЗАЛІЗНИЦІ НА ЗЕРНОВОМУ ТЕРМІНАЛІ

### Анотація

Важливою складовою виробництва та експорту зерна є система транспортування зерна від його виробників до зернових перевантажувальних терміналів. Серед засобів транспортування зерна чільне місце посідає залізничний, який в змозі забезпечити безперерйне багатотоннажне перевезення зерна від виробників до місць його накопичення та відвантаження у морські судна. Однак є певні проблеми у внутрішній та зовнішній роботі зернових терміналів, що і викликало необхідність проведення даних досліджень.



Метою роботи було дослідження кількісно-якісних характеристик надходження зерна із залізниці на зерновий термінал для підвищення ефективності його роботи. Об'єктом дослідження був технологічний процес приймання зерна із залізниці на зерновому терміналі; предметом досліджень були зернові культури, а також дані з добових надходжень зерна залізничним транспортом на зерновому перевантажувальному терміналі ТОВ «Укрелеваторпром» за три календарні роки — з 1 січня 2012 р. по 31 грудня 2014 р.

Дослідження проводили на підставі обробки даних журналів накладних для кожного року досліджень, у яких була підсумована кількість щодобово перевезеного залізницею зерна (нетто). Подальшу обробку отриманих проводили комбінованим графоаналітичним методом, для чого на основі табличних для кожного дослідженого року будували відповідні гістограми та визначали необхідні показники.

Було встановлено, що найбільші обсяги зерна, що надходили залізницею у 2012–2014 рр. мала кукурудза, друге місце у 2012 р. займала пшениця, а у 2013–2014 рр. – ріпак. Ячмінь був третім, окрім 2013 р., у якому його обсяги були найменшими серед основних культур, що надходили на ТОВ «Укрелеваторпром» у досліджені роки. Показано, що основну частку займали злакові культури (67,1...78,1 %), на другому місці були олійні культури (15,1...26,7 %), а найменшу займали бобові культури (2,77...6,8 %).

Була визначена тривалість щорічних періодів надходження зерна, яка склала для 2012–2014 рр. відповідно 315, 331 та 333 діб. Були визначені також річні, середньодобові та максимальні обсяги надходження зерна, а також коефіцієнти добової та річної нерівномірності надходження зерна. Фактичні коефіцієнти добової нерівномірності надходження зернових з залізниці у період 2012–2014 років склали відповідно  $K_{доб} = 1,62; 1,86; 1,79$ , а місячної нерівномірності відповідно  $K_{міс} = 1,31; 1,40; 1,35$ . За нормативами такі коефіцієнти мають значення  $K_{доб} = 2,5$  та  $K_{міс} = 2,0$ , що дозволяє використовувати їх для проектних та перевірочних розрахунків обладнання зернових терміналів у технологічних процесах приймання зерна з залізничного транспорту.

**Ключові слова:** зернові культури, приймання зерна, залізничний транспорт, динаміка надходження зерна, коефіцієнти нерівномірності.

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