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RESEARCH OF THE EFFICIENCY OF THE GRAIN RECEPTION LINE OPERATION FROM AUTO TRANSPORT AT THE PROCUREMENT PRODUCTION GRAIN ELEVATOR

Abstract

The results of the study of the characteristics of the technological line for grain reception from auto transport at the procurement production grain elevator of LLC "Agricultural Enterprise "Vesna 21" are presented. In the process of research, the quantitative and qualitative composition, volumes and duration of the harvesting periods of early and late crops, the quantitative and qualitative composition and characteristics of auto transport delivering grain to the enterprise were determined; the most intensive supply of early and late crops, as well as the actual coefficients of daily irregularity of their supply by auto transport.

It is shown that the enterprise in 2017-2019 traditionally received such early crops as wheat of 2-6 classes and rapeseed of the highest and 1st class. Late crops were represented by corn (3rd class and non-class) and soybeans (non-standard and extruded). The volumes of harvesting of the corn and wheat (main crops) for the indicated years correlated, respectively (%) 49.2:41.2; 60.1:24.9 and 66.1:17.1, which indicates a tendency for a significant increase in the supply of late crops, especially corn grain. The ratio between early and late crops for 2017–2019 was 45:55, 24:76 and 20:80, respectively (%).

The monthly grain flow to the grain elevator was rather irregular. Most of the grain was received from July to December, when the periods of harvesting of early and late crops coincide, and especially in the autumn months, in September, October and November, up to 32.9 %, less – in the off-season from January to June, to 12.3 %. All the same, a lot of grain in percentage terms was received in November 2017 and October 2018 – 32.9 % each.

An analysis of the quantitative and qualitative composition of cars that delivered grain to the procurement and production elevator in 2017-2019 showed that the carrying capacity of the vehicles ranged from 3 ... 51 tons. In 2017, 80.9% of all grain received by the enterprise was delivered by 2771 vehicles (cars) with a carrying capacity of 20 ... 40 tons, which amounted to 82.4 % of their annual quantity. In 2018, these indicators were as follows – 87.2 % of grain was delivered by 84.5% of vehicles of the same carrying capacity, and in 2019 – 93.4 % of grain was delivered by 93.0 % of the same vehicles. In the years studied, there was a tendency to an increase in the share of more heavy-duty vehicles (35...40 t). However, the number of vehicles with a carrying capacity of more than 40 tons, delivering significant volumes of grain, has significantly decreased, which is associated with the legislative limitation of the vehicles weight. The optimal carrying capacity in terms of the ratio of the mass of the delivered grain: the number of vehicles, taking into account legal restrictions, can be recommended 35...40 tons.

The main characteristics of the reception of an early and late crops at the procurement and production elevator, respectively, for 2017-2018 were the following values: the duration of the arrival of early crops, days - 126, 119 and 97, late – 142, 145 and 240; harvesting period of early crops, days – 73, 88 and 68, late crops – 86, 78 and 57; the most intensive supply of early crops, t/day – 8378, 596 and 1428, late crops 1966, 1576 and 1909; actual coefficients of grain reception irregularity by auto transport of early crops – 6.3; 2.2 and 3.6, late – 2.5, 2.4 and 2.9, which exceeds the standard values of 1.6 and should be taken into account when improving the operation of the grain reception line.

Key words: procurement and production elevator, grain and oilseeds, grain reception line by auto transport (vehicles), coefficients of irregularity.

The formulation of the problem

The grain sector of Ukraine is a strategic sector of the state's economy. Ukraine occupies a leading position among the world's producers and exporters of the grain crops. An important component of the production, procurement, processing and grain's export is the logistics of its storage and transportation. According to experts, by 2022 the volume of grain production in Ukraine will grow to 100 million tons, and exports will reach 70 million tons [1]. The infrastructure supporting the production, processing, storage, processing and export of

grain is quite complex. It includes two large components – a logistics and transport structure and the grain storage system. The task of the first of them is usually the grain delivery from producers to grain-receiving enterprises, procurement or procurement-production elevators for processing grain to the required conditions, storage and subsequent transfer for further use.

The main transport operation at the procurement elevators is the grain reception from the auto transport. It depends on the correct organization of this operation whether enterprises will be able to receive, place and



process all grain of different quality and purpose, coming from producers, within a specified timeframe, with minimal losses and downtime for the auto transport [2].

As noted by foreign researchers, over the past two decades, the volume of transported grain has increased by almost 70%. In particular, the share of the auto transport of grain has increased significantly, since auto transport usually has the advantage of grain delivering over shorter distances. In addition, it has great flexibility with respect to when, where and how much grain is delivered [3].

According to the State Statistics Service of Ukraine, in 2019, the volume of grain crops transportation by auto transport increased by 16.1 % - to 22.4 million tons, excluding the activities of individuals. According to the company Pro-Consulting, which conducts marketing research of the markets, the volume of transportation by auto transport is 1.5... 2.0 times higher and can range from 33 million to 40 million tons [4].

Successful grain reception from auto transport depends on the composition, quantity and performance of equipment and devices that must correspond to the nature of the receipt from auto transport: its type and carrying capacity, the number, volume and quality of grain lots of various crops, which are delivered to the grain elevator.

Over the past decades, the dynamics of grain supply to all elevators has changed significantly. Currently, grain producers are in no hurry to hand over grain to grain-receiving enterprises and procurement elevators, placing it in their own storages for the temporary storage, since this saves on transport costs, on payment for grain processing and storage services of an elevator and makes it possible to sell grain later with higher purchasing prices than during the harvest season.

At the same time, many production elevators begin to engage in procurement activities and, on the contrary, procurement elevators are expanding their activities by completing the construction of production buildings for processing grain into various products. With such an expansion of enterprises, certain logistical and transport problems often arise associated with the coordination of auto transport flows with the operation of grain receiving lines at elevators. This, in fact, prompted research into the operation of lines for receiving grain from vehicles at a procurement elevator, which acquired procurement and production functions.

The purpose and objectives of the study

The purpose of the study was to study the characteristics of a technological line for receiving grain by auto transport at a procurement and production elevator, which will increase the efficiency of grain procurement.

To achieve this goal, you need to solve the following *tasks*:

- to determine the quantitative and qualitative composition, volumes and duration of harvesting periods of early and late crops at the enterprise;

- to determine the quantitative and qualitative composition and characteristics of road transport delivering grain to the enterprise;

- to determine the maximum and average daily supply of early and late crops, as well as the actual coefficients of daily irregularity of their supply by auto transport.

Object and subject of research

The object of the research was the technology of grain receiving from auto transport at the procurement and production elevator; the subject of research was cereals, legumes and oilseeds, a receiving grain line from auto transport, as well as data on daily reception operations of LLC “Agricultural Enterprise “Vesna 21” (form No. 28) for three calendar years – from January 1, 2017 to December 31 Dec 2019.

Limited Liability Company “Agricultural Enterprise “Vesna 21” is located in the Khmelnytsky region. The procurement elevator was built in 2011-2012. The grain storage facilities consist of ten flat-bottomed silos with a total capacity of 55 thousand tons of grain; there are 2 grain dryers with a total capacity of up to 140 t/h and two grain cleaning machines. The line for receiving grain at the elevator includes an autoloader of the U-ARG-16 brand for two passages, the transport equipment has a capacity of up to 120 t/h.

At first, the elevator was operated as a procurement (linear), and after the construction and commissioning of a feed mill on the territory of the enterprise in 2015, the elevator changed to a procurement-production type, with the subsequent transfer of grain to production. However, due to the large capacities for storing grain, the possibility of its completion, shipment to road and rail transport, the elevator is now partially used as a procurement one. The company has the ability to sell products both on the domestic market and for export.



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Research methodology

To determine the regularities of the quantitative and qualitative of grain supply to the procurement and production elevator by auto transport, we used the data of Form No. 28 on the amount of grain transported by vehicles daily for 2017-2019. Summary results were entered into tables for each year of grain supply. Further analysis was carried out using histograms and graphs, it was done on the basis of the specified statistical data of the enterprise, and it has given the visual representation of the patterns and characteristics of grain supply. During the research, we used the guidelines developed at the Department of grain storage technology [5].

The quantitative and qualitative composition, volumes and duration of the annual harvesting periods (the most intensive supply) of early and late crops at the enterprise were carried out according to the logs of the daily intake of cereals, legumes and oilseeds (form No. 28), for each year their volumes and ratio were determined for individual crops. The duration of the periods of the most intensive intake of early and late crops was determined according to the generally accepted method described in the scientific and methodological literature [5, 6], by constructing and analyzing the integral curves of the intake of these crops. In more detail, the essence of the graphical definition of harvesting periods and volumes of grain reception for these periods is discussed further in the research results.

Since harvesting and production elevators are characterized by the supply of early and late crops not only during the harvesting period (early crops, as a rule, in June-July, late crops in September-November), but practically throughout the year, in our studies the period of harvesting should be understood as the period of the most intensive supply of these crops to the enterprise.

To study the qualitative and quantitative composition of vehicles (cars) delivering grain to the enterprise, we have analyzed the vehicles that delivered grain to the enterprise in 2017-2019, established the range of their carrying capacity, which was divided into classes with an interval of 5 tons. Further, in each year, the numbers of vehicles of a certain class of a carrying capacity, the amount of grain delivered by them, as well as the weighted average carrying capacity were determined.

Determination of the irregularity coefficients of the daily grain intake K_{daily} to the enterprise by auto transport was carried out in the following sequence [5,6].

The average daily grain supply for a certain year was calculated using the formulas:

$$A_{aver.daily} = A_{total.ann} / P_d, \tag{1}$$

where $A_{aver.daily}$ – average daily grain supply, t/month, t/day;

$A_{total.ann}$ – total annual grain supply, t;

P_d – the number of days of grain supply to the enterprise in a particular year, days.

Further, from the total annual period of the grain supply, we have selected three months of the most intense (maximum) supply of early and late crops. In each of these months, three days of maximum grain supply were also chosen. Based on the data obtained, the maximum daily mean value of the early and late crops supply for each year was calculated using the formulas:

$$A_{aver.daily}^{3\ max} = A_{3\ daily} / n, \tag{2}$$

where $A_{aver.daily}^{3\ max}$ – maximum average daily supply of early and late crops, t/day;

$A_{3\ daily}$ – the amount of early or late crops, for 3 days of its supply, t/day;

n – the number of days of maximum intake of early or late crops (respectively, $n = 3$ days).

The coefficients of daily irregularity of grain supply separately for early and late crops were determined by the formula:

$$K_{daily} = A_{aver.daily}^{3\ max} / A_{aver.daily}, \tag{3}$$

where $A_{aver.daily}$ – average daily income of early and late crops for a specific year, t/day.

Research results

We processed the initial data from the enterprise on the supply of legumes and oilseeds by auto transport for three years – for the period from 01/01/2017 to 12/31/2019.

The studied enterprise traditionally received such early crops as wheat of 2-6 classes and rapeseed of the highest and 1st class. Late crops are represented by corn (3rd class and non-class) and soybeans (non-standard and extruded).

At the first stage, the quantitative and qualitative spectrum of crops (Table 1) supplied to the enterprise was investigated. It can be seen that over three years, from 2017 to 2019, most of all corn grains (3 class) were received, most of all in 2019, namely more than 66 % of the total volume of grain received for the specified year. The gross harvest of corn in 2019 amounted to 35.2 million tons from 4.9 million hectares with a yield of 71.4 kg/ha. In 2018 and 2017, the largest share of grain was also corn of the 3 class, it was received 59.39 % and 48.36 %, respectively. This is due to the fact that the enterprise belongs to the procurement and production enterprises that receive grain, including and for a feed mill.

Table 1 - Reception of cereals, legumes and oilseeds to the enterprise in 2017-2019 (%)

Crop	2017	2018	2019
Corn 3 class	48.36	59.39	66.14
Corn without class	0.38	0.74	–
Wheat 2 class	0.30	4.86	0.06
Wheat 3 class	17.09	6.95	8.11
Wheat 4 class	–	–	6.19
Wheat 5 class	0.09	–	–
Wheat 6 class	22.63	8.10	–
Wheat without class	0.58	–	–
Wheat non standard	0.49	4.94	2.69
Rapeseed the highest class	2.78	–	–
Rapeseed 1 class	1.05	4.06	5.33
Soybean	0.25	10.97	–
Soybean non standard	5.54	–	11.48
Soybean extruded	0.02	–	–



Among other crops in 2017, wheat took the second place in terms of supply – 17.09 % of the 3 class and 22.63 % of the 6th class (total 29.72 %), other crops were in the range of 0.02...5.54 %.

In 2018, other crops, except for corn, arrived in the range of 4.06...8.10 %, and in 2019 – in the range of 0.06...11.48 %. In the same years, the supply of soybeans has increased, including non-standard, up to 10.97...11.48 %.

During studied years wheat of different classes, non-class wheat and non-standard wheat was also received irregularly – from 0.1 to 22.6 %, and in some years some classes (4, 5 and 6) and non-class wheat did not arrive at all (see Table 1).

Rapeseed of the highest class (2.78 %) was only in 2017, and rapeseed of the 1st class also was supplied in insignificant quantities – 1.05...5.33 %.

Such small volumes of grain supply also apply to soybeans – in 2017 it was 5.81 %, of which 5.54 % were non-standard and 0.02 % extruded. In 2018, the supply of soybeans increased to 10.97 %, and in 2019 it increased to almost the same limits (11.48 %) of the intake of non-standard soybeans. Note that extruded soybeans in a scanty amount (0.02 %) appeared only in 2017.

If you look at the ratio between early and late crops, then it was in the years studied, respectively (%) – 45:55, 24:76 and 20:80, that is, over the years, there is a noticeable tendency for a significant increase in the volume of supply of late crops.

Indicators of the monthly supply of different crops in 2017-2019 can be obtained from the histograms shown in Fig. 1.

Most of the grain was received in the autumn months, that is, in September, October and November, the least in May and June (during the off-season). All the same, a lot of grain in percentage terms was received in November 2017 and October 2018 – 32.9 % each. An increased grain supply was observed from July to December, that is, when the periods of harvesting of early and late crops coincide.

Subsequently, we investigated the quantitative and qualitative characteristics of vehicles delivering grain

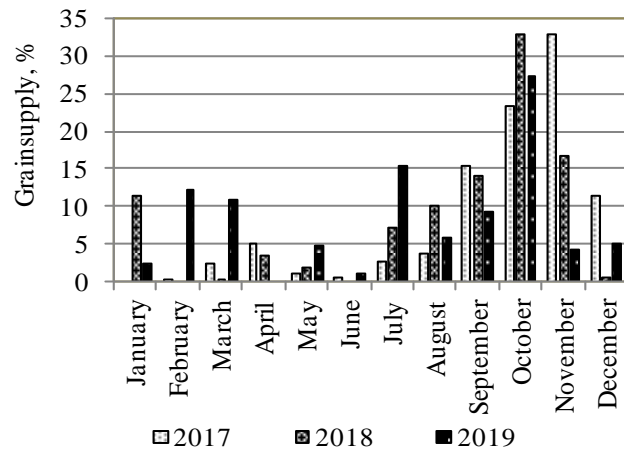


Fig. 1. Monthly shares of different crops supply to the enterprise

to the enterprise. According to the research methodology, the entire range of carrying capacity of vehicles supplied to the enterprise per year was divided into 11 classes at intervals of 5 tons. For each of the studied years, the number of cars included in each class of carrying capacity was counted and the mass of grains delivered by them was determined. Based on the data obtained, the average characteristics were calculated – the number of cars in each class and the mass of grain delivered by them in each of the studied years. The results are summarized in table. 2.

As you can see, the average carrying capacity of the cars delivering grain to the enterprise was in the range of 2.58...50.95 tons. The data also show that most of the vehicles, respectively, delivering the largest volumes of grain, had a carrying capacity of 20 ... 40 tons. Occasionally there were also vehicles of both very small and significantly higher carrying capacity. On the basis of these data, for each class, the weighted average carrying capacity of vehicles received by the enterprise for the studied period was determined, given in the same table.2.

Data analysis in table 2 shows that in 2017 the largest grain volumes (18210.0 tons, 22422.9 tons and 28,063.4 tons) were delivered by vehicles with a carrying capacity of 25...30 tons (665 units), 30...35 tons (683

Table 2 – Quantitative and qualitative composition of vehicles delivering grain to the enterprise

Class	Load capacity, t	Number of vehicles, items			Delivered grain, t			The average load capacity of auto transport, t		
		2017	2018	2019	2017	2018	2019	2017	2018	2019
I	less5	4	39	8	11.1	140.6	20.6	2.78	3.6	2.58
II	5...10	12	139	6	93.9	952	48.6	7.83	6.85	8.10
III	10...15	24	17	20	307.9	207.1	245.5	12.83	12.19	12.28
IV	15...20	171	42	140	3235	785.7	2631.8	18.92	18.71	18.80
V	20...25	677	531	1673	15186.1	11561.0	37808.3	22.43	21.77	22.60
VI	25...30	665	464	557	18210.0	12822.8	15163.1	27.38	27.64	27.22
VII	30...35	683	715	653	22422.9	23409.9	21278.6	32.83	32.74	32.59
VIII	35...40	746	788	782	28063.4	29329.6	28887.7	37.62	37.22	36.94
IX	40...45	382	210	91	16183.4	8738.2	3801.6	42.36	41.61	41.78
X	45...50	–	11	7	–	509.5	324.7	–	46.32	46.39
XI	50...55	–	–	4	–	–	203.8	–	–	50.95
	together	3364	2956	3941	103714	88456	110414	–	–	–



units) and 35...40 t (746 pcs.). In 2018, the largest grain volumes (65562.3 tons or 74.1 %) were delivered by vehicles with a carrying capacity of 25...30 tons, 30...35 tons and 35...40 tons, and in 2019 – vehicles with a carrying capacity of 20...25 tons, 30...35 tons and 35...40 tons, and cars with a carrying capacity of 20...25 tons made up the largest annual share (42.3 %) and delivered the largest volume of grain (34.2 %).

Thus, in 2017, 80.9 % of all grain received at the enterprise was delivered by 2771 auto-machines with a carrying capacity of 20...40 tons, which amounted to 82.4 % of their annual amount. In 2018, these indicators were as follows – 87.2 % of grain was delivered by 84.5 % of vehicles of the same carrying capacity, and in

2019 – 93.4 % of grain was delivered by 93.0 % of the same vehicles. Apparently, in the years under study, there was a tendency to an increase in the share of more heavy-duty vehicles.

It can also be seen that in 2017-2019 the number of vehicles with a carrying capacity of more than 40 tons, delivering significant volumes of grain, has significantly decreased, which is associated with the legislative limitation of the vehicle's weight. This limitation of the total weight of vehicles forces enterprises to reduce their grain load, which will lead to inefficient use of heavy vehicles when delivering grain to grain processing plants. The situation is further complicated by the fact that the production of medium-duty vehicles has not been established in Ukraine, and a duty has been imposed on imported vehicles [7].

It is known that early and late crops are delivered to grain processing plants and elevators extremely irregularly.

Fluctuations in the monthly number of cars, as well as in the volumes of grain delivered by them, are clearly seen in the ones shown in Fig. 2 histograms of vehicle arrivals and graphs of vehicles delivered by them grain volumes in 2017-2019.

From the histograms (Fig. 2) it can be seen that in 2017-2018 the largest number of cars came as follows: 2017 – in three autumn months (2254), in 2018 in August, October and November (1694) and in 2019 in February, July and October (2096). This number of vehicles delivered 85946 tons, 52320 tons and 61081 tons of grain, respectively, during the months indicated.

During all studied years the smallest number of cars were in the first half of the year, which is usually typical for procurement elevators. So, in 2017, fewer cars arrived in January, February and June, in 2018 – in February, March and June, in 2019 – in January, April and June. Considering that the investigated elevator is a procurement-production one, then in some months of the first half of the year one can observe a certain increase in the grain flow and, accordingly, in vehicles. These months in 2017 were March and April (103 and 192 vehicles), in 2018 it was January and April (324 and 124 vehicles), in 2019 – February, March and May (549, 492 and 194 vehicles). They delivered from 2827 to 13564 tons of grain in the specified months.

During the summer months (June, July, August), when the early crops begin to arrive, there is a gradual increase in the number of cars. Fig. 2 shows that already in July 625 vehicles arrived, which delivered 17176 tons of grain.

When analyzing the work or when designing grain elevators, it is necessary to have indicators on the basis of which the required performance of technological and transport equipment is calculated, as well as devices that ensure uninterrupted reception and processing of grain supply. The most important indicators for carrying out such calculations are the period of the most intensive grain supply to the enterprise (harvesting period), the amount of grain and the rate of its receipt in the specified period, characterized by the coefficients of daily irregularity of grain supply.

Today, in order to determine these data, they use the norms of technological design of grain-receiving en-

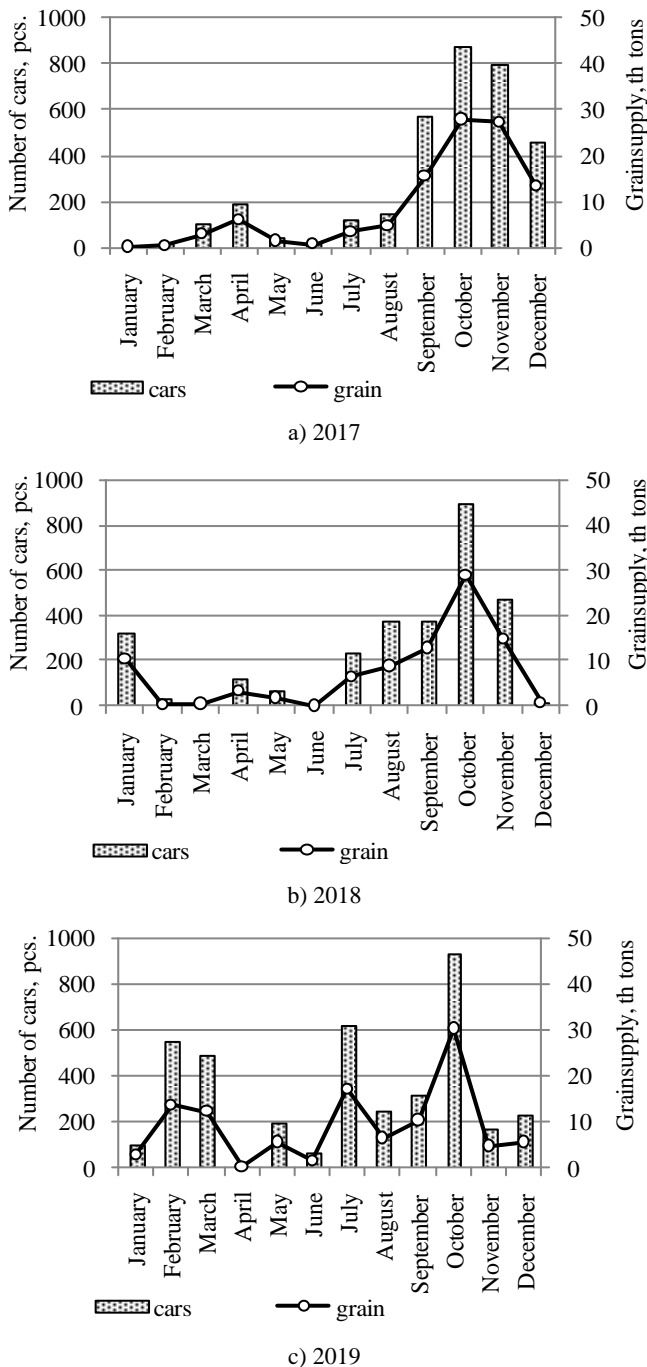


Fig. 2. Histograms of the monthly reception of vehicles and grain at the enterprise, which they delivered in 2017-2019



terprises and elevators or educational literature, which currently do not correspond to the current state of technology and technology of the grain storage system [5, 6]. Therefore, when developing projects for the construction of new or reconstruction of existing enterprises, there is a need to establish the value of the above coefficients for technological research.

Based on this, at the next stage of research, the duration of the harvesting periods of the grain supply of early and late crops, that is, the periods of their most intensive supply, was determined. For this, according to the research methodology, for each year, integral curves of the supply of separately early and late crops were constructed, according to which the duration of their intensive supply was determined by the graphical method.

Figure 3 shows a histogram characterizing the dynamics of the daily supply of late crops (class 3 corn and non-class and soybeans, including non-standard) from January 19, 2019 to December 27, 2019. Also Figure 3 shows that these crops enter the enterprise throughout the year, and not only during the harvesting period when they are harvested. From the analysis of the histograms on the volume of late crops supply, three characteristic periods can be distinguished - the minimum supply within 20...100 t/day (mainly June – July); average supply in the range of 100...500 tons/day (first half of

the year, August – September, November-December); the maximum intake is about 1500...2000 tons/day (end of September – beginning of October). It is in the last period that late crops of the new harvest arrive and the highest intensity of their arrival is observed.

According to the method of graphically determining the period of the most intensive supply of late crops (harvesting period), the following was carried out. Initially, a tangent was drawn to the integral curve at the site of its steepest rise, which characterizes the highest rate of grain inflow (see thin dashed lines in Fig. 3). Vertical lines (top and bottom) were drawn from the points formed at the intersection of this tangent line with the horizontal lines of 0 % and 100 % grain input until the intersection with the integral curve. From the resulting points from the integral curve, horizontal lines were drawn to the left axis ("Grain supply, %"). The distance between these horizontal lines showed the percentage of harvested late crops (in Fig. 3 this was 47 %), and the distance along the date axis between the vertical lines gave the value of the period of the most intense influx of late crops (the period of their harvesting) $P_h = 57$ days.

Similarly to the one described, the procurement periods for the reception of early and late crops for the studied period of 2017-2019 were determined.

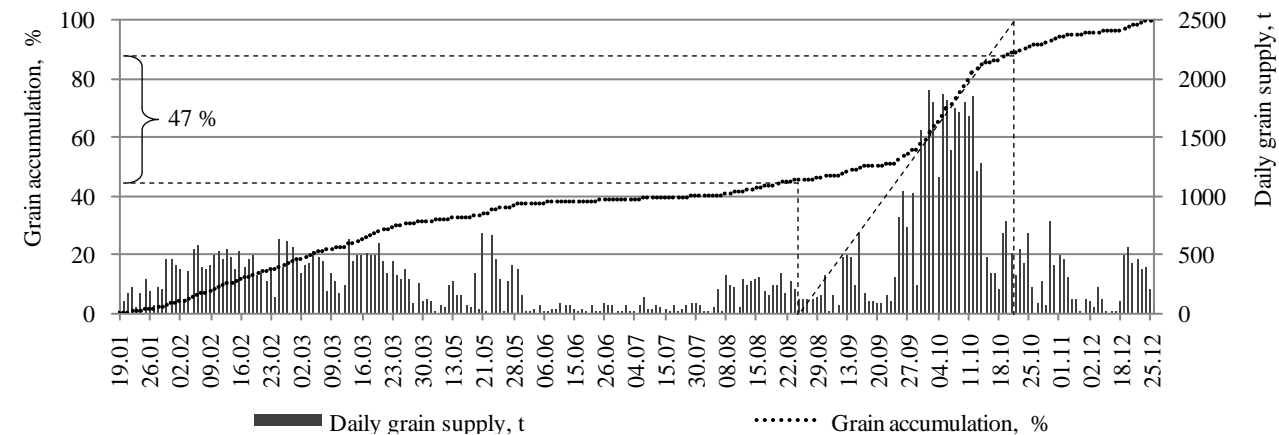


Fig. 3. Histogram of the daily income of late crops and the integrated schedule of their accumulation at the enterprise in 2019

Table 3 – Characteristics of the reception of early and late crops to the elevator

Indicators	2017		2018		2019	
	Crops					
	early	late	early	late	early	late
Duration of grain reception by road per year, days	126	142	119	145	97	240
Estimated procurement period, days	73	86	88	78	68	57
The volume of grain reception in the harvesting period, %	88	83	81	78	84	47
Daily grain reception, t/day						
– maximum	8378	1966	596	1576	1428	1909
– for 3 days of maximum reception	19261	5458	1682	4440	3581	5628
– average for 3 days of maximum income	6420	1820	561	1480	1194	1876
– average daily for the harvesting period	622	716	251	617	328	655
Coefficients of daily irregularity of grain supply	6.3	2.5	2.2	2.4	3.6	2.9
Normative coefficients of daily irregularity [8]	1.6					
The total volume of grain receipts by auto transport per year, tons	103714		88456		110414	

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Analysis of the obtained data on the annual and daily grain reception in 2017-2019 made it possible to determine the actual coefficients of the daily irregularity of grain flow by auto transport to the elevator (according to the research methodology described above). The obtained calculation results are presented in table 3.

From the above research results, it can be seen that the actual values of the harvesting periods of early and late crops and the coefficients of daily irregularity of grain reception by auto transport, compared with the normative ones, significantly exceed the normative ones, especially for early crops. This must be taken into account when further improving the operation of grain reception lines by auto transport.

Conclusions

1. The studied enterprise in 2017-2019 traditionally received such early crops as wheat of 2-6 classes and rape of the highest class and 1st class. Late crops were represented by corn (3rd class and non-class) and soybeans (non-standard and extruded). The volumes of harvesting of the main crops of corn and wheat for the indicated years correlated, respectively (%) 49.2: 41.2; 60.1: 24.9 and 66.1: 17.1, which indicates a tendency for a significant increase in the supply of late crops, especially corn grain. The ratio between early and late crops for 2017-2019 was 45:55, 24:76 and 20:80, respectively (%).

2. The monthly grain flow to the elevator was rather uneven. Most of the grain was received from July to December, when the periods of harvesting of early and late crops coincide, and especially in the autumn months, in September, October and November, up to 32.9 %, the least of all was during the off-season from January to June, up to 12.3 %. All the same, a lot of grain in percentage terms was received in November 2017 and October 2018 – 32.9 % each.

3. Analysis of the quantitative and qualitative composition of vehicles that delivered grain to the pro-

urement and production elevator in 2017-2019 showed that the carrying capacity of auto transport ranged from 3...51 tons. In 2017 80.9 % of all grain received by the enterprise was delivered by 2771 vehicles with a carrying capacity of 20...40 tons, which amounted to 82.4 % of their annual quantity. In 2018, these indicators were as follows – 87.2 % of grain was delivered by 84.5 % of vehicles of the same carrying capacity, and in 2019 – 93.4 % of grain was delivered by 93.0 % of the same vehicles. In the years studied, there was a tendency to an increase in the share of more heavy-duty vehicles (35...40 t). However, the number of vehicles with a carrying capacity of more than 40 tons, delivering significant volumes of grain, has significantly decreased, which is associated with the legislative limitation of the weight of vehicles.

The optimal carrying capacity in terms of the ratio "weight of grain delivered: number of vehicles", taking into account legal restrictions, can be recommended 35...40 tons.

4. The main characteristics of the grain supply of early and late crops to the procurement and production elevator, respectively, for 2017–2018 were the following values:

- the duration of the intake of early crops, days – 126, 119 and 97, late crops, – 142, 145 and 240;
- the harvesting period of early crops, days – 73, 88 and 68, late crops – 86, 78 and 57.
- the most intensive intake of early crops, t/day – 8378, 596 and 1428, late crops 1966, 1576 and 1909;
- actual coefficients of unevenness of grain flow by auto transport of early crops – 6.3; 2.2 and 3.6, late crops- 2.5, 2.4 and 2.9, which exceeds the standard values of 1.6, especially for early crops, and should be taken into account when further improving the operation of the grain reception line at the enterprise.

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ДОСЛІДЖЕННЯ ЕФЕКТИВНОСТІ РОБОТИ ЛІНІЇ ПРИЙМАННЯ ЗЕРНА З АВТОТРАНСПОРТУ НА ЗАГОТІВЕЛЬНО-ВИРОБНИЧОМУ ЕЛЕВАТОРІ

Анотація

Наведено результати дослідження характеристик технологічної лінії приймання зерна з автотранспорту на заготівельно-виробничому елеваторі ТОВ «Сільськогосподарське підприємство «Весна 21». У процесі досліджень визначено кількісно-якісний склад, обсяги та тривалість періодів заготівель ранніх і пізніх культур, кількісно-якісний склад та характеристики автомобільного транспорту, що доставляє зерно на підприємство; максимальне інтенсивне надходження ранніх і пізніх культур, а також фактичні коефіцієнти добової нерівномірності їх надходження автомобільним транспортом. Показано, що підприємство у 2017–2019 рр. традиційно надходили такі ранні культури, як пшениця 2–6 класів і ріпак вищого та 1-го класу. Пізні культури були представлені кукурудзою (3 клас і некласна) та соєю (нестандартна і екструдована). Обсяги заготівель основних культур кукурудзи та пшениці за вказаними роками співвідносились відповідно як (%) 49,2:41,2; 60,1:24,9 та 66,1:17,1, що свідчить про тенденцію суттєвого збільшення обсягів надходження пізніх культур, особливо зерна кукурудзи. Співвідношення між ранніми та пізніми культурами за 2017–2019 роками склало відповідно (%) 45:55, 24:76 та 20:80.

Помісячне надходження зерна на елеватор було досить нерівномірним. Більше всього зерна надходило з липня по грудень, коли збігаються періоди заготівель ранніх та пізніх культур, і особливо в осінні місяці, у вересні, жовтні та листопаді, до 32,9 %, найменше — у період міжсезоння з січня по червень, до 12,3 %. Однаково багато зерна у відсотковому відношенні надійшло у листопаді 2017 р. та жовтні 2018 р. — по 32,9 %.

Аналіз кількісно-якісного складу автомашин, що доставляли зерно на заготівельно-виробничий елеватор у 2017–2019 рр. показав, що вантажопідйомність автомашин коливалась в межах 3...51 тонн. У 2017 р. 80,9 % всього зерна, що надійшло на підприємство, було доставлено 2771 автомашинами вантажопідйомністю 20...40 т, які склали 82,4 % від їх річної кількості. У 2018 р. ці показники були такими — 87,2 % зерна доставили 84,5 % автомашин тієї ж вантажопідйомності, а у 2019 р. — 93,4 % зерна було доставлено 93,0 % таких же автомашин. У досліджені роки спостерігалась тенденція збільшення частки більш вантажопідйомних автомобілів (35...40 т). Однак, кількість автомобілів вантажопідйомністю понад 40 т, які доставляли значні обсяги зерна, суттєво зменшилась, що пов'язане з законодавчим обмеження ваги автотранспорту. Оптимальною вантажопідйомністю за співвідношенням «маса доставленого зерна : кількість автомобілів» з урахуванням законодавчих обмежень, можна рекомендувати 35...40 тонн.

Основні характеристики надходження зерна ранніх і пізніх культур на заготівельно-виробничий елеватор відповідно за 2017–2018 роками склали такі значення: тривалість надходження ранніх культур, діб — 126, 119 та 97, пізніх — 142, 145 та 240; заготівельний період ранніх культур, доби — 73, 88 та 68, пізніх культур — 86, 78 та 57; максимально інтенсивне надходження ранніх культур, т/добу — 8378, 596 та 1428, пізніх культур 1966, 1576 та 1909; фактичні коефіцієнти нерівномірності надходження зерна автотранспортом ранніх культур — 6,3; 2,2 та 3,6, пізніх — 2,5, 2,4 та 2,9, що перевищує нормативні значення 1,6 та повинно враховуватись при удосконаленні роботи лінії приймання зерна.

Ключові слова: заготівельно-виробничий елеватор, зернові та олійні культури, лінія приймання зерна автотранспортом, коефіцієнти нерівномірності.

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