



UDC 631.56:338.43(477.44)

DOI <https://doi.org/10.15673/gpmf.v23i3.2754>**A. Kats**, PhD of Technical Science, Associate Professor, *E-mail: anfisakats20@gmail.com*<http://orcid.org/0000-0002-7292-0792>, Researcher ID: F-8743-2016**G. Stankevych**, Dr. Tech. Science, Professor, *E-mail: georgii.stn@gmail.com*<http://orcid.org/0000-0002-0583-8174>, Researcher ID: F-8557-2016**U. Tupytsia**, master's student of the Faculty of Grain Technology and Grain Business, *E-mail: ulyana2601@ukr.net**Department of Grain and Feed Technology,**Odesa National University of Technology, 112, Kanatna Str., Odesa, Ukraine, 65039*

VINNYTSIA REGION: STATUS AND TRENDS OF PRODUCTION, PROCESSING AND STORAGE OF GRAIN

Abstract

The article is devoted to the study of the state of production, processing and storage of grain in the Vinnytsia region. The objectives of the research were to monitor the collected areas and gross harvests of the main crops in 2011-2021, establish the trends of their changes, analyze the capacities of transport and technological equipment and granaries of the region. The analysis was conducted on the basis of data from the State Statistics Service of Ukraine for 2011-2021. The analysis of harvested areas and gross harvests of grain of the main crops at agricultural enterprises of the region in 2011–2021 showed their tendency to increase. During this period, harvested areas increased by 1.42 times, and annual volumes of gross grain harvests had a wave-like growth pattern. Linear trend equations are proposed for forecasting harvested areas and gross grain harvests, which are characterized by coefficients of determination R^2 of 0.79 and 0.65, respectively. The largest gross harvests were given by corn, wheat and sunflower, and smaller – by barley, soybeans and rapeseed. In 2018-2021, the gross harvest of these crops was within the following limits (thousand tons): corn 2015-2620, wheat 1200-1691, and sunflower 755-1001. 66 enterprises receive grain from vehicles, and 65 forward it. The average capacity of receiving grain is 3032.41 t/day, and forwarding 1183.61 t/day. There are 21 railway transport enterprises hiring, and 55 enterprises offering leave. The average capacity of receiving devices from the railway is 949.52 t/day, and the output capacity is 1448.69 t/day. 111 grain dryers from 11 producing countries are installed at the considered 53 enterprises of the region. Of them, 18.9% of enterprises have dryers of Ukrainian production only, 20.8% of enterprises have both domestic and foreign ones, but the majority of enterprises have dryers of foreign production only, which are 1.85 times more than the number of Ukrainian-made dryers. It was established that 82 separators are used for grain cleaning at 37 elevators, most of which (63%) are domestically produced, which outnumber imported ones by 1.73 times. The total capacity of simultaneous storage of grain in 67 elevators of agricultural enterprises is 3554.35 thousand tons, of which 2449.41 thousand tons have harvesting elevators and 1104.94 thousand tons – production elevators. Their simultaneous storage capacity is less than the forecast values of gross grain harvests in 2022 – 6354.2 thousand tons, which requires the expansion of the elevator network of the Vinnytsia region.

Keywords: Vinnytsia region, harvested area, grain production, transport and technological equipment, post-harvest processing of grain, capacity of elevators.

Formulation of the problem

The production and storage of grain in all countries is of strategic importance. This is especially felt in the current war conditions in our country, Ukraine. In 2022, an increase in gross grain harvests and an increase in its export were expected, which would increase foreign exchange earnings for our country, strengthen it, and improve the welfare of the population.

However, everything went according to a different scenario, which was imposed on our country by the war. The sown and harvested areas of agricultural land began to decrease, the volume of gross grain harvests decreased, and in some periods the export of grain completely stopped, and even the "Grain Corridor" could not ensure its stable functioning. These problems did not bypass the central part of our state, Vinnytsia region.

The yield of most crops in Vinnytsia in 2022 was significantly lower than last year [1]. For all categories of farms, grain and leguminous crops were collected on an area of 408.2 thousand hectares (50.8%) and 1.768 million tons of grain were threshed with an average yield of 4.3 t/ha, which is 3.0 t/ha less than last year. From the area of 31.9 thousand hectares (9.7%), 64.8 thousand

tons of sunflower seeds were threshed with an average yield of 2.0 t/ha (in 2021 – 3.2 t/ha).

Buckwheat from an area of 4.4 thousand hectares (51.2%) threshed 5.77 thousand tons with a yield of 1.3 t/ha (in 2021 – 1.5 t/ha). In 2022, it was sown on 8.7 thousand hectares, which is 1.8 thousand hectares more than in the past. Millet from an area of 1.1 thousand hectares (100%) was threshed to 2.65 thousand tons with a yield of 2.4 t/ha (in 2021 – 3.1 t/ha). Soybeans from an area of 1.6 thousand hectares (1.5%) were threshed 2.53 thousand tons with a yield of 1.6 t/ha (in 2021 – 2.8 t/ha). Corn for grain from an area of 0.7 thousand hectares (0.2%) was threshed 1.7 thousand tons with a yield of 2.4 t/ha (in 2021 – 9.4 t/ha). The yield of soybeans and sunflowers in Ukraine is inferior to last year [1].

Taking into account the favorable conditions for growing grain in the Vinnytsia region, the presence of a certain number of elevators and equipment to ensure reliable storage of grain, it is necessary to explore the potential capabilities of the region in the production and delivery of grain by various modes of transport to grain-procuring agricultural farms, the possibility of bringing the collected grain to the standards for reliable grain storage in elevators.



Review of literary sources

By geographical location, Vinnytsia region (Vinnytsia) is a region in Central Ukraine. The population is 1.6 million people (2018). In the west it borders with Chernivtsi and Khmelnytsky, in the north with Zhytomyr, in the east with Kyiv, Kirovograd and Cherkassy, in the south with Odesa regions of Ukraine and the Republic of Moldova, including part of the border falling on the unrecognized Transnistria. The administrative center of the region is the city of Vinnitsa. The region occupies about 4.5% of the territory of Ukraine [2].

A brief overview of the climatic conditions, soils and topography of the Vinnytsia region shows that the climate of the Vinnytsia region is moderate continental, that is, it has moderate and sufficient heat supply and sufficient moisture. The average amplitude of temperature fluctuations throughout the year does not exceed +25°C. The average annual precipitation in the region is 440–590 mm [3].

The soils are mainly silted (about 65%). In the northeast of the region, chernozems predominate, in the central part – gray, dark gray, light gray, in the southeast and in Transnistria – chernozems and silted soils. More than 70% of the region's territory has been plowed [4].

Vinnytsia region has a favorable geographical position. The relief of the region is high. The region is located within the forest-steppe zone. It is characterized by soils, vegetation, fauna, and landscapes typical of this zone. In the Vinnytsia region there is a dense network of rivers, the main river being the Southern Bug [4].

Characterizing the transport and communication networks of the Vinnytsia region, it can be noted that the M12 and M21 highways pass through the region, and there are also a number of regional roads. All settlements in the region are connected to regional centers via paved roads. That is why, due to the fact that the roadway is gradually being repaired, road transport in this area is very developed [2].

In terms of railway density per thousand square kilometers of territory, the region ranks fifth in Ukraine. The main railway junctions of the region are Kazyatyn, Zhmerynka, Vinnitsa, Vapnyarka, Kalinovka I, Rudnitsa, Pogrebyshe, Ziatkovtsy [2]. The rivers carry cargo and passenger navigation over short distances. But grain transportation by river transport is not developed for a number of reasons.

An analysis of the grain sector of the agro-industrial sector (AIS) of the Vinnytsia region showed that industrial production has the following structure (in% of the total volume of the region): food industry – 53; electric power industry – 23; mechanical engineering and metalworking – 12; light industry – 3; chemical and petrochemical industry – 3; construction materials industry – 2.5; woodworking and pulp and paper – 1; other industries – the rest [2].

More than 850 agricultural units operate in the agro-industrial complex based on private land ownership. In addition, there are 1,240 farms. The area of agricultural land is more than 2 million hectares. The average soil fertility in the region is 60-65 units (on a 100-point scale). The region occupies a leading place in Ukraine in terms of gross agricultural output. The share of crop production is 61%. Every year the area under grain crops

increases, primarily winter wheat, barley, sunflower, corn, buckwheat, millet and sugar beets. The gross grain harvest has increased by almost a quarter over the past two years, the average annual harvest is 1650 tons [2].

There are more than 300 industrial enterprises in the region. The region's agriculture is represented by 718 agricultural enterprises, 1,280 peasant farms, and 525.9 thousand personal peasant farms. The area of agricultural land is 1960 thousand hectares, of which arable land is 1694 thousand hectares. About 2 million tons of grain, 2 million tons of sugar beets, 1.3 million tons of potatoes, 90 thousand tons of fruits and berries are produced annually. The region's agriculture is grain and beet production with developed meat and dairy farming. The number of small enterprises per 10 thousand population in the region is 46.8 units [5].

Vinnytsia region is one of the leaders in the amount of grain harvested. Among the plant industries of the agro-industrial complex, the grain product complex is one of the largest and most important entities. It covers the production, procurement, storage of grain, its industrial processing at enterprises of the flour-grinding, baking, pasta, feed milling industries, etc. The processing sector of the agro-industrial complex of the Vinnytsia region includes the following industries: flour-grinding, pasta, baking and feed production. In total, there are 59 processing industry enterprises in the region (excluding auxiliary industries) [6].

Based on the scale of production in the grain product complex, flour milling production stands out, the main product of which is wheat flour of the first and highest grade. Bakery production is also important. The region has enormous cereal production capacity. The main types of products are: buckwheat, semolina, peas, millet, wheat, pearl barley, barley, oatmeal, and corn grits. The production of compound feed is also an important link. However, the reduction in livestock numbers and the insolvency of potential consumers have negatively affected the state of the feed industry and require solutions to problems at the national level. It is necessary to develop a program for a stable increase in grain production, a radical improvement in its use, and the creation of export-oriented models of grain farming [6].

According to [1], as of October 2021, the harvest of grain and leguminous crops in Ukraine amounted to 49.4 million tons, of which 2.4 million tons were collected by farmers in the Vinnytsia region. At the same time, crop yields in the region are among the highest in the country. The TOP-3 regions of Ukraine in terms of grain and leguminous crop yields include: Khmelnytskyi region – 5.95 t/ha; Cherkasy region – 5.92 t/ha; Vinnytsia region – 5.3 t/ha. In particular, farmers in the Vinnytsia region harvested 118.7 thousand tons of soybeans from an area of 3.93 thousand hectares (46.7% of the forecast) with an average yield of 3.02 t/ha (this is 1.58 t/ha higher than last year). 38.7 thousand tons of corn for grain were harvested from an area of 4.5 thousand hectares (1% of the forecast), the average yield is 8.6 t/ha (3.29 t/ha higher than in 2020). Sunflower was collected on an area of 165.9 thousand hectares (53.2% of the forecast), 486.0 thousand tons were threshed with an average yield of 2.93 t/ha, which is 0.25 t/ha higher than in 2020.

Currently, across all categories of farms, out of



359.0 thousand hectares, winter grains are sown on an area of 276.7 thousand hectares (77.1% of the forecast), including: winter wheat from a projected area of 320.0 thousand ha, sown – 246.2 thousand ha (76.9% of the forecast); winter barley from a projected area of 36.0 thousand hectares, sown – 27.5 thousand hectares (76.4% of the forecast); winter rye from a projected area of 3.0 thousand hectares, 3.0 thousand hectares sown (100% of the forecast). In addition, sowing of winter rapeseed has been completed on an area of 60.0 thousand hectares (100% of the forecast) [1].

If we consider the development trends of the Vinnytsia region, then the agro-industrial complex is one of the most developed sectors of the economy of this region, because it is it that demonstrates trends of stable growth. Favorable climatic conditions in the region allow grain to be grown efficiently. The region's agricultural sector maintains a leading position in terms of gross agricultural output. Vinnytsia region ranks second in terms of gross agricultural output per person. As for the share of the region in national agricultural production for January-September 2021, this figure was almost 8% [7].

For the 2022 harvest, winter grain crops were sown in the region on an area of 360 thousand hectares, which corresponds to the level of 2021. In 2021, 10.2 thousand tons of such a niche crop as buckwheat, were produced across all categories of farms. Meanwhile, the state supports buckwheat producers to provide the Ukrainian population with their own products. In 2021, the production of such industrial crops as rapeseed increased significantly, by almost 60%. The region maintains high production rates of sunflower seeds – more than 950 thousand tons, which is the highest gross harvest in the region for the entire period of cultivation of this crop. In addition, soybean production increased by almost 65% in 2021. Its yield is twice as high as in 2020 [7].

Considering the above, we can conclude that the grain sector of the agro-industrial complex of the Vinnytsia region is promising and worthy of attention. The annual increase in production volumes of various crops indicates the need of the Vinnytsia region to expand granaries for reliable grain storage, the volumes of which tend to grow.

Program, objects and research methods

The purpose of the work is to study the state of production, delivery, separation, drying and storage of grain in the Vinnytsia region, which will allow us to establish trends in changes in gross yields and their compliance with the capacities of its simultaneous storage.

Research objectives:

- conduct monitoring of the harvested areas and gross yields of the main crops grown in the Vinnytsia region during 2011-2021 and establish trends in their changes;
- conduct an analysis of the existing capacities of transport and technological equipment for the delivery, drying, cleaning and distribution of grain at enterprises in the Vinnytsia region.
- conduct an analysis of elevators available in a given area: by quantity, capacity, form of ownership and types;
- conduct a comparative analysis of gross grain harvests and total simultaneous storage capacity in the Vin-

nytsia region to determine the size of the capacity shortage.

Materials and methods of research

The research was carried out on the basis of statistical data from the State Statistics Service of Ukraine for 2011-2021 by harvested areas, gross yields and yields of agricultural crops, taking into account their types. Moreover, in 2011-2019, data from the collected areas and gross yields of various crops were considered as of November 1, and in 2020 and 2021 as of December 1 of the indicated years [8].

The analysis was carried out for agricultural enterprises that (according to the “Methodology...” of the State Statistics Service of Ukraine [9]) carry out agricultural activities, regardless of subordination, forms of ownership and management. As a category, they include state farms, other state enterprises, business societies, cooperatives, private, subsidiary agricultural enterprises and farms. At the same time, the results of the activities of households were not taken into account.

Information about the elevator park of the Vinnytsia region, their types, capacities, volumes of simultaneous grain storage, forms of ownership, availability of transport and technological equipment, their characteristics and other data were taken from various sites and open sources [10, 11, 12].

Compiling tables based on collected statistical data, constructing histograms and graphs, determining average and weighted average characteristics, coefficients of determination R^2 [13] and other calculations were carried out using Microsoft Excel and Word programs with their subsequent analysis.

Due to the fact that the productivity of receiving and releasing devices of various enterprises on the websites is given in different units of measurement (t/hour, t/day, wagons/day) and this significantly complicated their comparative analysis, they were recalculated into t/day taking into account the standards design. For this purpose, the capacity of grain wagons (hoppers) was taken on average as 70 tons. When converting the productivity of acceptance and release operations with wagons from units of measurement t/h to t/day, the duration of unloading or loading of wagons was taken into account design standards, according to which per day the enterprise receives a maximum of 2 wagons with an interval of 2 hours, that is, the duration of transactions is 20 hours. The same daily duration (20 hours) was also adopted for unloading (loading) road transport when recalculating productivity per ton/hour in t/day, which takes into account the reduction in the productivity of elevators and conveyors in receiving and releasing operations with vehicles to 80% of their rated values.

It should also be noted that the term “grain” in the studies was used as a generalized concept of cereals, seeds of legumes, oilseeds and other plants.

Research results

At the first stage of the research, an analysis was carried out of the areas collected at agricultural enterprises and the gross volumes of production of grains, legumes and oilseeds. For this, open statistical data from the State Statistics Committee of Ukraine were used [8], on

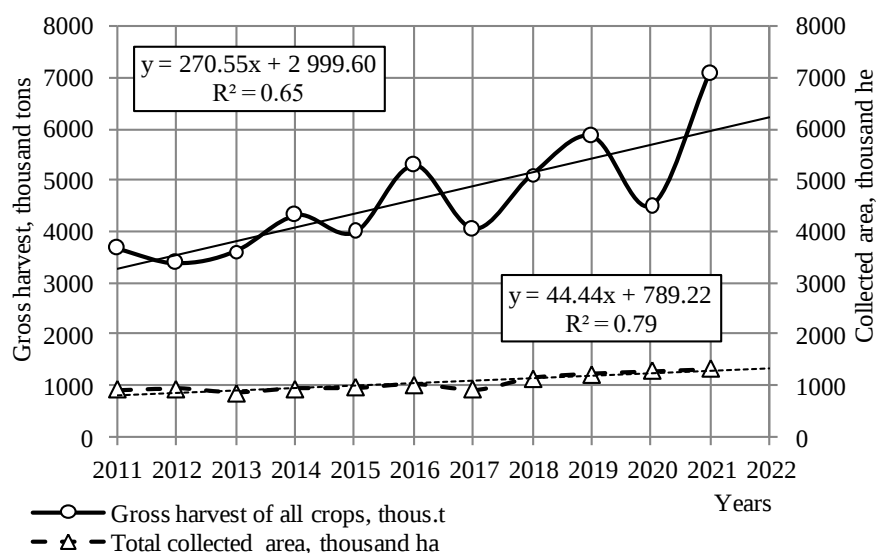


Fig. 1. Annual changes in harvested areas and gross volumes of grain production of various crops in 2011-2021

the basis of which tables were compiled for the Vinnytsia region and graphical dependences of changes in harvested areas and volumes of gross grain production of different crops were constructed for the years 2011-2021 (Fig. 1).

Analysis of the results shows that the collected areas increased slightly every year (with the exception of 2013 and 2017). From 2011 to 2021, the collected areas increased from 932.6 to 1328.8 thousand hectares, that is, 1.42 times.

The annual volumes of gross grain harvests from the harvested areas, as can be seen from Fig. 1, had a wave-like character, when high gross yields were interspersed with their decrease. We can note the years of decrease in gross grain harvests – 2012, 2015, 2017 and 2020. The highest gross harvest was observed in 2011, 2014, 2016, 2020 and 2021. 2021 was a record year, when 7075.16 thousand tons of grain from various crops were harvested on agricultural farms. Despite the complex nature of changes in gross grain volumes over the years, the general trend of these changes tends to grow.

Figure 1 shows with straight thin lines the trends in the year-to-year changes in harvested areas (solid line) and volumes of gross harvests (dashed line). The equations $y=f(x)$ and the coefficients of determination R^2 of the indicated trend lines are given – upper left for gross

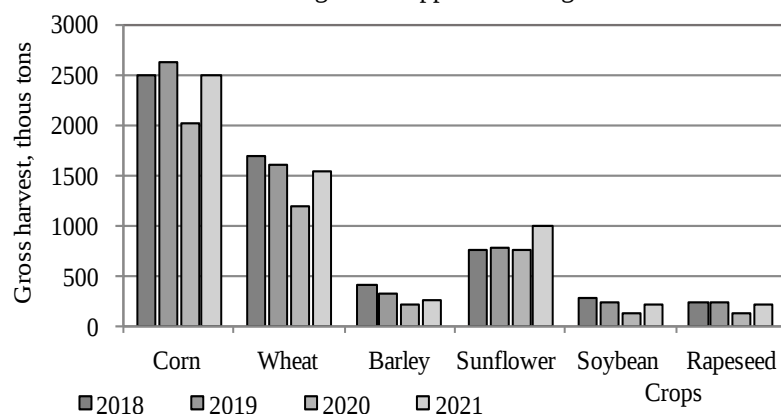


Fig. 2. Volumes of gross harvests of main crops in 2018–2021

volumes of grain and lower right for collected areas. In the given trend line equations, the following notations are used:

y – calculated (predicted) value of the volume of gross grain production (thousand tons) or harvested area (thousand hectares) in a particular year;

x – serial number of the year (2011 – 1; 2012 – 2, etc.).

It can also be seen that the linear trend for the collected areas according to the coefficient of determination $R^2=0.79$ has a strong (close) connection with the actually collected areas in 2011-21, and the linear trend for gross volumes of grain with the coefficient of determination $R^2=0.65$ has a moderate connection with the actual volumes of grain collected in the

same years.

Calculations carried out using the given equations of trend lines showed that in 2022 in the Vinnytsia region it could be possible to predict an increase in harvested areas from 1,278.06 to 1,322.50 thousand hectares and an increase in the gross volume of harvested grain from 6,074.65 to 6,354.20 thousand tons. However, due to the war that started in 2022, it is currently impossible to verify real information about harvested areas and gross grain harvest.

Analysis of State Statistics Service data [8] showed that among those grown in Vinnytsia region during the period studied there were grains, legumes and oilseeds, in particular such as wheat, corn, barley, rye, oats, millet, buckwheat, peas, soybeans, sunflowers, rapeseed, soybeans and others. However, the largest volumes of gross harvests are primarily from corn, wheat and sunflower, and smaller amounts from barley, soybeans and rapeseed (Fig. 2). The remaining cultivated crops occupy a significantly smaller share of the gross grain harvest.

From the given histograms it is clear that for the crops under consideration, despite the increase in harvested areas (Fig. 1), they are characterized by a significant decrease in the gross volumes of their collection in 2020, which was caused primarily by unfavorable climatic conditions. Thus, gross harvests of grain and seeds in 2020 decreased significantly compared to 2019: corn by 23.1%, wheat by 25.2%, barley by 32.9%, soybeans by 46.3%, rapeseed by 43.0%. And only sunflower seeds remained virtually unchanged – the decrease was only 3.0%.

Next year, 2021, the gross volumes of harvested grain and seeds increased for all crops (Fig. 2): corn by 24.2%, wheat by 29.0%, barley by 18.8%, sunflower by 31.6%, soybeans by 73.7% and rapeseed by 57.0%.

Table 1 – Production of grain and leguminous crops in enterprises by district of Vinnytsia region as of December 1, 2021

Districts Vinnytsia region	Collected area, th ha	Gross col- lection in initial mass, th tons	Productivity, t/ha
Vinnytsia	140.35	1209.23	8.62
Haysynskiy	116.36	926.71	7.96
Zhmerinsky	55.91	479.25	8.57
Mohyliv-Podilskiy	57.96	439.85	7.59
Tulchynskiy	71.94	619.69	8.61
Khmilnytskyi	86.57	734.74	8.49
All region	529,10	4409.48	8.35

According to the new administrative structure, Vinnytsia region has 6 districts [14, 15]. Volumes of harvested areas, gross harvests of grain and leguminous crops (excluding oilseeds) and their average yield in enterprises in the regions of Vinnytsia region as of December 1, 2021 are shown in table 1 (the given data relate to enterprises that own and/or use 200 hectares of agricultural land or more) [16]. It can be seen that large volumes of grain production are produced by Vinnytsia and Haysynskiy districts.

Analysis of transport and technological operations.

Grain of various crops from the harvested areas must be delivered to grain procurement enterprises for its processing to the required standards and subsequent storage. Road and rail transport are usually used to transport grain. We note that not a single elevator in the Vinnytsia region receive or unload grain by water transport.

Automobile transport. All enterprises in the Vinnytsia region, without exception, receive grain by road transport; the productivity of the receiving streams of four of them is unknown. Therefore, for further research and construction of histograms presented in Fig.3, only elevators with known characteristics of receiving and unloading devices were used.

The number of elevators with known data of receiving devices is 64 pcs. The productivity of their receiving streams ranges from 500 to 9000 t/day. Enter-

prises with the largest receiving capacities are, accordingly, one of the most simultaneous storage capacity elevators: “Vinnitsa Elevator” – 9000 t/day, “Vapnyarsky Elevator” – 8000 t/day; “Voronovitskoye HPP” – 7000 tons/day; “Gnivansky elevator” – 6500 t/day and “Ladyzhynsky elevator of Vinnitsa poultry farm” – 6000 t/day. The largest number of enterprises (22 elevators) has a capacity for receiving grain from vehicles from 1000 to 2000 t/day, which is 34.4% of their total number (Fig. 3-a). If we consider a group of elevators with a receiving capacity of up to 4000 thousand tons per day, then their number reaches 53 units, which is 82.8%. The average productivity of receiving devices for road transport is 3032.41 t/day.

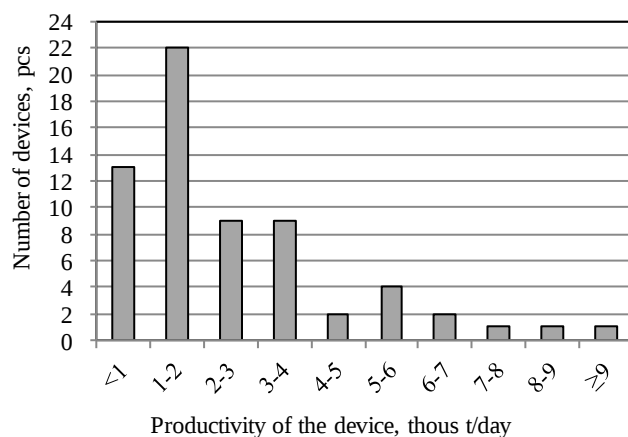
Of all the enterprises studied, one does not supply grain to road transport, and for 3 there is no information on grain supply, so the entire analysis was carried out only for known data from 61 elevators.

As can be seen from Fig. 3-b, the productivity of grain unloading to road transport ranges from 120 to 5000 t/day. The most powerful enterprises for the supply of grain to road transport are “Voronovitske KhPP” – 5000 t/day, followed by “Vinnitsa Elevator” and “Sorchansky Melnik” with a value of 4800t/day, and the lowest level is occupied by “Kotyuzhany grain” t/day due to the fact that this is a production elevator.

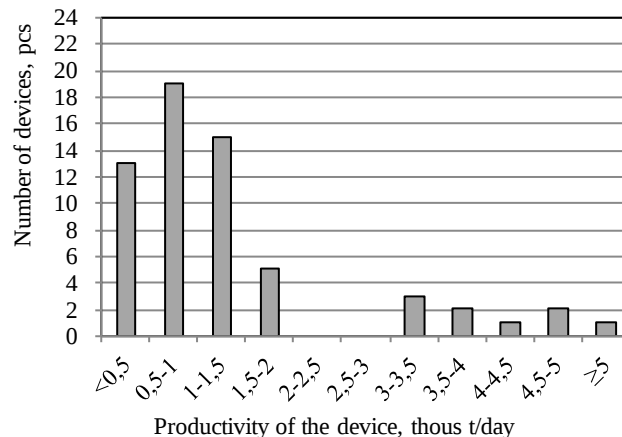
The average productivity of unloading devices in road transport is 1183.61 t/day.

Railway transport. Reception of grain from railway transport is provided at 21 enterprises in the Vinnytsia region, which is 31% of their total number. Due to the discrepancy in the units of measurement of the productivity of receiving and unloading operations in railway transport at various enterprises (t/day, wagons/day and t/hour), they were all listed according to the method described above up to one thousand t/day. Based on the data obtained, histograms of the productivity distribution of receiving (Fig. 4-a) and unloading (Fig. 4-b) railway transport devices were constructed.

It is clearly seen that when receiving grain from the railway (Fig. 4-a), the productivity of receiving devices has in the range of 0.5–3.5 thousand t/day (more precisely, 120–3780 t/day). At the same time, the majority of enterprises (18 units), accounting for 85.71 %,



a) receiving devices



b) unloading devices

Fig. 3. Summary data on the productivity of grain receiving and unloading by road transport, thousand t/day



have a capacity of receiving devices in the range of 1.0–1.5 thousand t/day. And only one enterprise has the highest productivity of 3781 t/day – the Vinnitsa elevator. There are no receiving devices with productivity in the ranges of 1.5–2.0 and 2.5–3.5 thousand t/day under consideration at enterprises at all.

The average productivity of receiving devices for railway transport of agricultural enterprises is 949.52 t/day. If we take into account the reception of grain from vehicles, then together they can receive 3981.93 t/day, and per month – 119.5 thousand tons of grain.

Railroad communication is very common throughout the Vinnytsia region, so most enterprises, in addition to receiving grain from the railway, also supply grain to railway transport. The research results showed that 55 enterprises, that is, 82% of all 67 elevators, also have unloading to railway transport. And only 12 enterprises (18%) do not ship grain to the railway.

Analysis of those shown in Fig. 4-b data shows that in addition to a larger number of grain unloading devices at enterprises, they also have a higher productivity of grain dispensing from railway transport, which has in the range of 0.5–7.5 thousand t/day (more specifically 100–7560 t/days). At the same time, the majority of enterprises (45 units), accounting for 81.82%, have a capacity of dispensing devices in the range of 0.5–2.0 thousand t/day. And only one enterprise has the highest productivity of 7565 t/day – Bogdanovskiy Elevator. Receiving devices from the railway with productivity in the ranges of 2.5–3.0; 4.0–4.5 and 5.5–8.0 thousand t/day are not available at the enterprises. It can also be noted that there are 4 enterprises that have supply devices for the railway with a capacity of 3.5–4.0 thousand tons/day.

The average productivity of dispensing devices for railway transport is 1448.69 t/day, which allows enterprises in the region to unload almost 0.5 million tons of grain per year.

Grain unloading of grain to processing plants. Among the studied elevators, there are 18 production ones, which amounts to 27% of their total number. They supply grain to various processing plants for the production of compound feed (the most common), flour, cereals, vegetable oil, etc. The largest of these enterprises is the Vinnitsa Poultry Farm, located in the town of Ladyzhin, Gaysinsky district, and in need of feed for its own production of meat products. Therefore, this enterprise built for its own needs a large grain storage facility, the Ladyzhinsky Elevator, the largest in terms of simultaneous storage capacity in the Vinnytsia region.

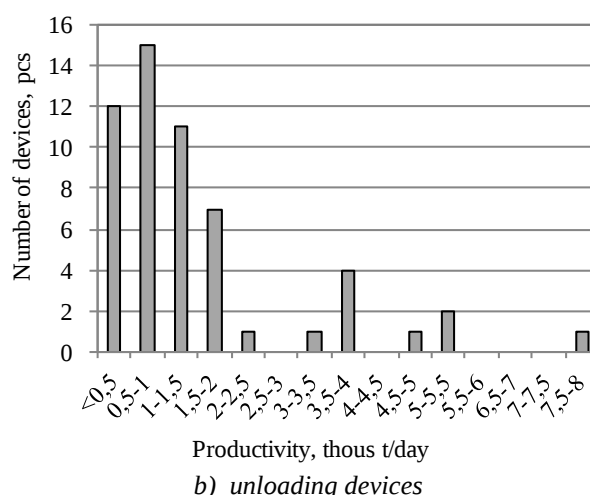
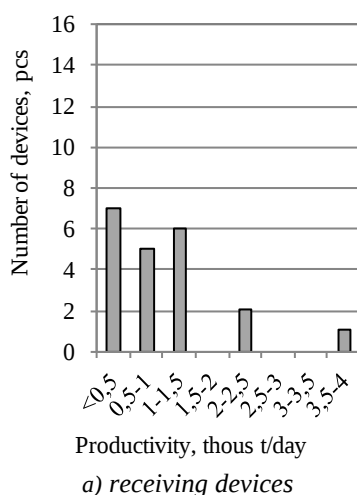


Fig. 4. Productivity of receiving and releasing devices of railway transport, thousand t/day

Analysis of equipment for grain processing

Grain drying equipment. To ensure high-quality storage conditions at the stage of put the harvested crop and storing significant volumes, the grain must be dried. Grain drying is the most important stage in the procurement and storage of grains, legumes and oilseeds. The reliable safety of the harvest depends on it. A grain dryer performs a very important job: it reduces the moisture content of the grain to certain values at which it is stored for a long time. In addition, drying completes post-harvest ripening processes, which have a significant impact on grain quality. Therefore, more and more enterprises are installing or replacing grain dryers – old ones with new ones, or more productive ones.

During the study, it was found that the total number of grain dryers at 53 enterprises in the Vinnytsia region is 111 pieces. At the same time, 12 enterprises were not taken into account, which did not provide any data regarding the availability of grain dryers, as well as two enterprises that did not indicate which dryers they have installed.

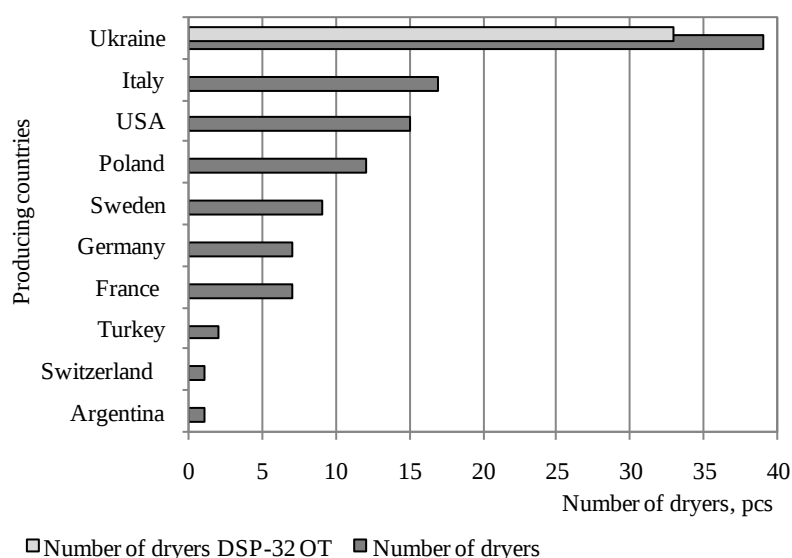
Analysis of the grain dryers in Vinnytsia region showed that 10 enterprises have only Ukrainian-made dryers, 11 enterprises have both domestic and foreign ones, however, the majority of enterprises in the region (32 units or 60.4%) have only foreign-made grain dryers. Among the grain dryers there are all types – shaft, modular column, and tower.

Brands of grain dryers and their distribution by country of origin are given in table 2 and fig. 5. Analysis of these data shows that the number of foreign grain dryers is 1.85 times higher than the number of Ukrainian-made dryers, which account for 35% of the total number in the Vinnytsia region. After them, Italians predominate in number, accounting for 15%, followed by the USA – 14%, Poland – 11%, Sweden – 8%, Germany – 6%, France – 6%, Turkey – 2% and one each (1%) grain dryers made in Switzerland and Argentina.

In table Figure 2 shows a wide variety of brands of grain dryers at enterprises in the Vinnytsia region. The most common Ukrainian-made grain dryers are those from the Karlovsky Machine-Building Plant (now KMZ

**Table 2 – Brands of grain dryers from different countries of manufacture**

Country	Brands of grain dryers
Ukraine	DSP-32 OT, A1- DSP-50, Brice-Baker
Italy	Bonfanti XL 265 PC, L175, L 150C, L110 CE, STRAHL 10000FR/8, 8000FR/8, 5000FR/6, MECMAR RT175/8
USA	SukupU1812, 3180, 3518U, BEM-NG Mathews Company, Handler, GSI 3426, DELUXE DPSL, DPX8T, Farm Fans CMS 500 (CIF)
Poland	FTD 4/28 FEERUM, ArajS440, M-819
Sweden	TORNUM TK 8-28-4, TK6-24-3
Germany	Schmidt Seeger, Petkus, RIELA GDT440, GDT 300/28/2
France	CFCAI LAW SBC24LE, SATIG SMT CFCAI, SBC 22 LE , SATIG
Turkey	UGT 6213
Switzerland	Bühler (Schmidt Seeger)
Argentina	Mega T3 280

**Fig. 5. Distribution of grain dryers by producing countries**

Industries). Among them, the largest share is occupied by grain dryers DSP-32 OT (32 pcs.), which account for 30% and are quite outdated designs. There are more advanced dryers from the same plant A1-DSP-50 (5 pcs.), as well as two of the latest modern designs – Brice-Baker grain dryers – at the enterprises of the Vinnytsia region. Grain dryers made in Italy are represented by the brands Bonfanti, STRAHL, MECMAR; USA – Sukup, Mathews Company, Handler, GSI, DELUXE, FarmFans; Polish – FEERUM, Araj, M-819; German – Schmidt Seeger, Petkus, RIELA; Sweden – TORNUM; France – CFCAI LAW, SATIG; Turkey – UGT; Switzerland – Bühler (Schmidt Seeger); Argentina – Mega.

Equipment for grain cleaning. Any modification of post-harvest processing of grain is associated with its purification from various impurities, the presence of which negatively affects the efficiency of grain storage and its technological features, which leads to a decrease in the yield and quality of processed products. Therefore, grain cleaning operations occupy a central place in grain processing. Technological processes for the production

of flour, cereals, alcohol, feed, and malt also begin with grain cleaning operations. Most of the impurities enter the grain mass during harvesting in the form of various anatomical components of cultivated plants and weeds, pieces of soil, insects, etc. When carrying out operations with grain, various random objects can get into its composition – stones and sand from current platforms and concrete structures of elevators, metal components of transport and grain processing machines. Any movement of grain is associated with intense friction of the grains among themselves, as well as the working bodies and other surfaces of the machines, which causes the appearance of dust, which is always an integral part of the grain mass.

In the course of the research, it was found that the total number of grain cleaning equipment at elevators in the Vinnytsia region is 82 pieces at 37 enterprises (excluding 29 that did not provide any data regarding the presence of separators, as well as one more enterprise where this equipment is not available). Brands of grain cleaning equipment (separators) and their distribution by country of origin are given in table. 3 and Fig. 6.

A study of the capacity of the technological operation for grain cleaning in the Vinnytsia region showed that the majority of enterprises choose domestic separators. From the table figure 3 shows the variety of brands of grain cleaning machines. The most common Ukrainian-made separators are BSH, BTSS, LUCH ZSO; separators Horizont-K, UTSS, IBP, SKO, DSF, SPO are also used.

The brands of separators from foreign manufacturers are given in table 3, and their number can be seen in Fig. 6. The same figure clearly shows the relationship between the number of separators from different countries operated in the Vinnytsia region. Among them, Ukrainian-made separators (52 pcs.) occupy leading positions, accounting for 64% of the total number at enterprises. Separators from foreign producing countries are presented in proportions: Germany 13%, France 11%, Switzerland 10% and one separator (1%) and Poland 1%. The data shows that the number of separators made in Ukraine exceeds imported ones by 1.73 times.

To avoid misunderstandings and confusion, as a note, we point that Schmidt Seeger grain dryers and TAS and SMA grain cleaning separators are manufactured in Germany, but since 2011 they have been labeled under the Bühler brand (Switzerland). In tables 2 and 3, this equipment is assigned to Germany or Switzerland as indicated on the elevator reference sites.



Analysis of existing grain storage tanks in Vinnytsia region

In total, in Ukraine there are about 1000 elevators of various types and capacities [17, 18], of which 67 (6.7% of the total) are in the Vinnytsia region, but they are quite powerful in terms of capacity [5]. The total simultaneous storage capacity of these 67 elevators is 3554.35 thousand tons, of which 2449.41 thousand tons are provided by procurement elevators and 1104.94 thousand tons by production elevators.

To better understand the relationship between the number of elevators and their simultaneous storage capacities, histograms shown in Fig. 7.

The histograms clearly show that most elevators (21 units, accounting for 31%) have a capacity in the range of 20-40 thousand tons, which allows simultaneous storage of 612.29 thousand tons of grain. But the largest simultaneous storage capacity (858.84 thousand tons) is provided by elevators with a capacity of 40-60 thousand tons, of which there are 17 units (25%).

The fewest elevators – one enterprise each within the range of 200-300 thousand tons (1.5%) – is the Ladyzhynsky elevator Vinnitsa Poultry Farm, with a capacity of 230 thousand tons and more than 300 thousand tons (1.5%) with a total capacity of 375 thousand tons of simultaneous storage.

In terms of total storage capacity, the above-mentioned elevators in the range of capacities of 40-60 thousand tons prevail, simultaneously accommodating a total of 858.84 thousand tons (25% of the total capacity), in second place are elevators in the range of 100-200 thousand tons with a capacity of 600 thousand tons (6%), in third place are elevators in the range of 60-80 thousand tons, holding 471.6 thousand tons (10%), as shown in Fig. 6. The smallest total volume of grain, namely 145.32 thousand tons (19%), supplies elevators with a storage capacity of up to 20 thousand tons, corresponding to the type of mini-elevators.

Of the largest elevators in the Vinnytsia region, the following can be distinguished: Vinnytsia elevator (Vinnytsia district), the simultaneous storage capacity of which is 375 thousand tons, Ladyzhynsky elevator "Vinnitsa Poultry Farm" (Gaisinsky district) – 230 thousand tons (included in the TOP-3 elevators in the country), Vapnyarsky elevator (Tulchinsky district) – 200 thousand tons (included in the TOP-15 elevators in the country), Rakhyansky elevator (Zhmerinsky district) – 159 thou-

Table 3 – Brands of separators by producing countries

Country	Brands of separators
Ukraine	BSH (16, 100, 200, 300), BTSS (50, 100), LUCH ZSO (200) Olis, Horizont-K, UTSS, KBS 1270, SKO (100, 200), DSF, SPO
Germany	TAS-206A6 TAS-204A-4, TAS-154A, SMA-203, RIELA Prof-Seed 1006-2A, 1003-A, Petkus
France	Marot, DENIS NR 304
Switzerland	Bühler (TAS)
Poland	Araj

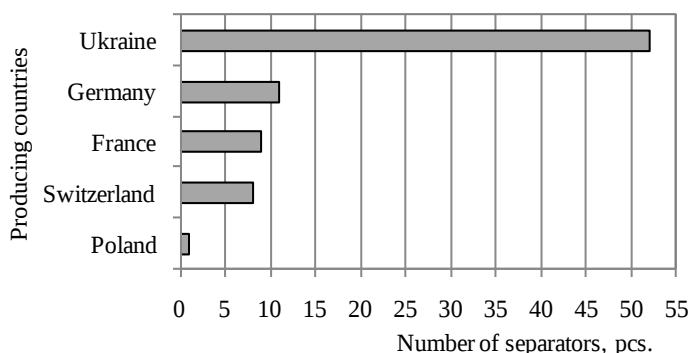


Fig. 6. Distribution of separators by producing countries

sand tons. The smallest ones are the Agro-Dar and Life-Invest elevators, only 5.5 thousand tons of simultaneous grain storage capacity.

Ownership form of elevators. During the study, it was found that none of the known elevators in the Vinnytsia region are state owned; absolutely all are private enterprises. The companies that own several elevators in the study area are as follows: TESSLAGROUP – 6 enterprises with a total storage capacity of 340 thousand tons, located in different areas; Vioil – 6 with a capacity of 195.75 thousand tons; Epicenter Agro – 5 with a capacity of 669.2 thousand tons (largest capacity); MHP – 4 with a capacity of 293.02 thousand tons; Agroprosperis – 4 with a capacity of 195 thousand tons; Louis Dreyfus Ukraine – 3 with a capacity of 204.6 thousand tons;

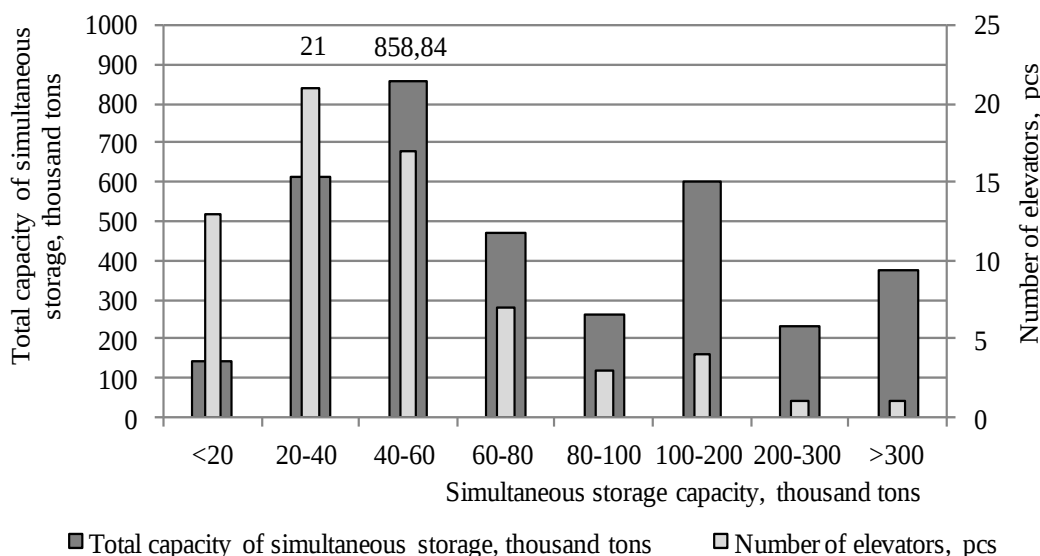


Fig. 7. Distribution of elevators by simultaneous storage capacity, thousand ton



UKZPROMINVEST-AGRO – 3 with a capacity of 171.34 thousand tons; TAS AGRO – 3 with a capacity of 146 thousand tons; Kusto Agro – 3 with a capacity of 90 thousand tons; Regoin Grain Company – 2 with a capacity of 96.5 thousand tons; Kernel – 2 with a capacity of 88.9 thousand tons; There are also well-known companies such as ADM and NIBULON, which each have one elevator with a capacity of 97.3 and 10.5 thousand tons, respectively.

An analysis of elevators according to their purpose [17, 18] showed that in the Vinnytsia region there are the following types: procurement, production, basic and mini-elevators (Fig. 8). Of all the enterprises under study, the most common basic elevators are elevators of the second link (which receive grain that has already undergone primary processing) in the number of 27 enterprises, equal to 40% (Fig. 8) of the total, with a total simultaneous storage capacity of 1429.64 thousand. The next in number are production elevators, amounting to 18 units (27%), with a total capacity of 1077.94 thousand tons. The third place is occupied by procurement elevators in the amount of 12 units (18%), with a total capacity of 949.35 thousand tons. There are fewer mini-elevators – 10 pieces (15%), with a total capacity of 97.42 thousand tons.

In terms of simultaneous storage capacity in the ratio, the elevators considered occupy the following plac-

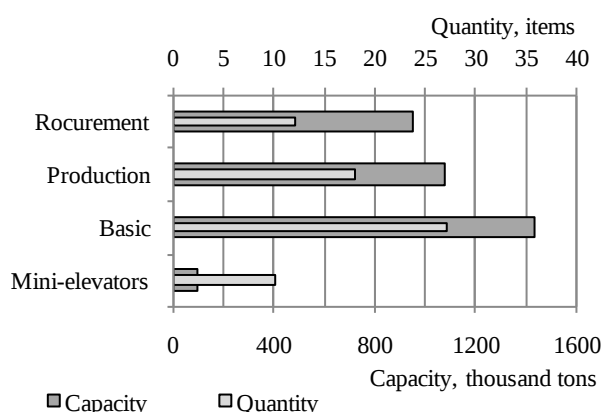


Fig. 8. Characteristics of elevators by purpose

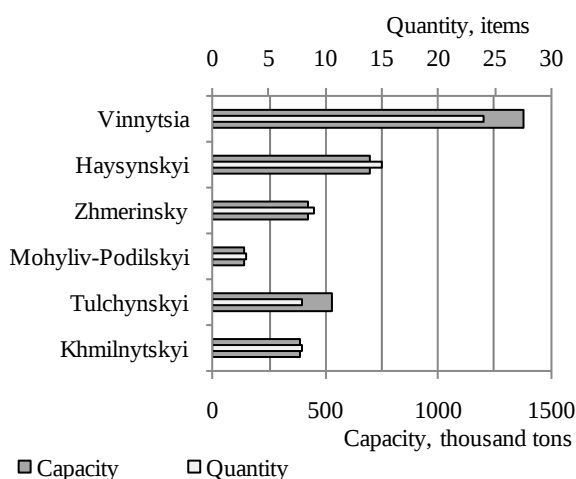


Fig. 9. Distribution of the number and capacity of elevators by district of Vinnytsia region

es: basic 40%, production 30%, procurement 27%, and mini-elevators account for only 3%.

Distribution of elevators by region. The distribution of the number and capacity of elevators by region is shown in Fig. 9. In the Vinnytsia region there are 24 elevators (36% of the total) with a total capacity of 1374.49 thousand tons, which is equal to 36% of the total capacity of all enterprises. Gaysinsky district has 15 enterprises (22%) with a total capacity of 697.84 thousand tons (20%). Zhmerinsky district includes 9 enterprises (12%) with a total capacity of 423.1 thousand tons (12%). The least numerous is the Mogilev-Podolsk region, which has only 3 enterprises (4%) with elevators with a capacity of 141.62 thousand tons (4%). Tulchinsky district has 8 elevators (12%) with a capacity of 527.5 thousand tons (15%). Khmelnytsky district has 8 elevators (12%) with a capacity of 389.8 thousand tons (11%). This discrepancy between the regions can be explained, first of all, by their area, sown areas, productivity and proximity to the regional center. That is why the Vinnytsia region has the largest number and capacity of elevators, and the Mogilev-Podolsk region the smallest (Fig. 9).

The histograms clearly show the ratio of the number of elevators and their grain storage capacity between the regions of the region. Their location is influenced by a number of factors: the total area of the region, the soils located on its territory, proximity to the regional center, as well as to interregional roads, highways and the ramifications of railway traffic in the region.

Conclusions

1. Based on an analysis of the harvested areas and gross grain yields of main crops at agricultural enterprises in the Vinnitsa region, their growth trend has been established. Collected areas in the period 2011-2021 increased from 932.6 to 1328.8 thousand hectares, that is, 1.42 times. The annual volumes of gross grain harvests from the harvested areas during the same period were of a wave-like nature, when high gross harvests were interspersed with their decrease.

To predict the harvested areas and gross grain yields, linear trend equations are proposed. Based on the determination coefficients R^2 , it was established that the linear trend for the harvested areas ($R^2=0.79$) has a strong (close) connection with the areas actually collected in 2011-2021, and the linear trend for gross grain volumes ($R^2=0.65$) has a moderate relationship with the actual volumes of grain collected in the same years.

2. Among the crops grown in Vinnytsia region, during the period studied there were grains, legumes and oilseeds, in particular such as wheat, corn, barley, rye, oats, millet, buckwheat, peas, soybeans, sunflowers, rapeseed, soybeans and others. However, the largest volumes of gross harvests are primarily from corn, wheat and sunflower, and smaller amounts from barley, soybeans and rapeseed. The remaining cultivated crops occupy a significantly smaller share of the gross grain harvest. In 2018-2021, the gross yields of the main crops were within the following limits (thousand tons): corn 2015-2620, wheat 1200-1691 and sunflower 755-1001. It is also shown that the largest volumes of grain production are produced by Vinnytsia and Gaysinsky districts.



3. Transport network of road and rail transport in Vinnytsia region is well developed. 66 enterprises out of the 67 studied receive grain from vehicles, and 65 export them to this type of transport. The average productivity of receiving from road transport is 3032.41 t/day, output is 1183.61 t/day. Reception from railway transport is present at 21 enterprises (31% of the total), and vacation – at 55 (82%), which is a good indicator. The average productivity of receiving devices for railway transport of agricultural enterprises is 949.52 t/day, and output devices are 1448.69 t/day. Water transport is not used for grain transportation in the Vinnytsia region.

4. An analysis of 53 enterprises in the Vinnytsia region, which account for 79.1% of the total number and provided information about grain dryers, showed that they installed 111 grain dryers from different manufacturing countries. Of these, 10 (18.9%) enterprises have only Ukrainian-made dryers, 11 (20.8%) enterprises have both domestic and foreign ones, however, the majority of enterprises in the region (32 units or 60.4%) have grain dryers only foreign production. The number of foreign grain dryers is 1.85 times higher than the number of Ukrainian-made dryers, which account for 35% of their total number. The enterprises have all types of grain dryers – shaft, modular column, and tower.

Among domestic grain dryers, the largest share (30%) is made up of rather outdated mine DSP-32 OT, there are 5 A1-DSP-50 grain dryers that replaced them, as well as two of the modern mastered designs – Brice-Baker grain dryers. Of the foreign grain dryers, the dominant ones in terms of quantity are Italian (15%), American (14%), Polish (11%), Swedish (8%), German (6%), French (6%), Turkish (2%) and one (1%) Swiss and Argentinean production.

5. The analysis of grain cleaning equipment was carried out on the basis of data from 37 elevators, which make up 55.2% of the total number of agricultural enter-

prises in the Vinnytsia region and provided information about their existing grain cleaning capacities. It has been established that elevators use 82 separators for grain cleaning, most of which (63%) are domestically produced. Separators from foreign producing countries are presented in the following proportions: Germany 13%, France 11%, Switzerland 10% and Poland 1%. It has been established that the number of Ukrainian-made separators exceeds imported ones by 1.73 times.

6. It has been established that in the Vinnytsia region the total capacity of simultaneous grain storage in 67 elevators of agricultural enterprises (about 6.7% of all elevators in Ukraine) is 3554.35 thousand tons, of which 2449.41 thousand tons are provided by procurement elevators and 1104.94 thousand tons – production.

It is shown that according to established linear trends in 2022 in Vinnytsia region it was predicted that the harvested area would grow from 1278.06 to 1322.50 thousand hectares and the gross volume of the harvested crop would grow from 6074.65 to 6354.20 thousand tons. But due to the war that began in 2022, it was impossible to find real information about the collected area and the gross grain harvesting is currently not possible. However, a comparison of the projected gross grain harvest volumes with existing grain storage capacities shows a shortage of grain storage facilities, which amounts to about 2.8 million tons.

Considering the uneven location of elevators across the regions of the Vinnytsia region, the Mogilev-Podolsky, Zhmerynsky and Khmelnytsky districts are in greater need of storage silos. According to the inserted trend of growth in gross grain harvests, it can be concluded that the Vinnytsia region requires an increase of almost 80% in the number of elevators or warehouses for storing grain from new harvests at agricultural enterprises.

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УДК 631.56:338.43(477.44)

А.К. Кац, канд. техн. наук, доцент, E-mail: anfisakats20@gmail.comГ.М. Станкевич, д-р техн. наук, професор, E-mail: georgii.stn@gmail.comУ. Тушня, магістрант, E-mail: ulyana2601@ukr.net

Кафедра технології зерна і комбікормів

Одеський національний технологічний університет, вул. Канатна, 112, Одеса, Україна, 65039

ВІННИЦЬКА ОБЛАСТЬ: СТАН ТА ТРЕНДИ ВИРОБНИЦТВА, ДОРОБКИ І ЗБЕРІГАННЯ ЗЕРНА

Анотація

Стаття присвячена дослідженню стану виробництва, доробки і зберігання зерна у Вінницькій області. Завданнями досліджень було проведення моніторингу зібраних площ та валових зборів основних культур у 2011-2021 роки, встановлення тенденцій їх змін, аналізу потужностей транспортно-технологічного обладнання та зерносховищ області. Аналіз проводився на основі даних Держстату України за 2011-2021 років. Аналіз зібраних площ та валових зборів зерна основних культур на сільськогосподарських підприємствах області у 2011-2021 рр. показав їх тенденцію до зростання. Зібрані площі в цей період зросли у 1,42 рази, а щорічні обсяги валових зборів зерна мали хвилюподібний характер зростання. Для прогнозування зібраних площ та валових зборів зерна запропоновано лінійні трендові рівняння, які характеризуються коефіцієнтами детермінації R^2 відповідно 0,79 та 0,65. Найбільші валові збори давали кукурудза, пшениця і соняшник та менші – ячмінь, соя і ріпак. У 2018–2021 рр. валові збори цих культур були у таких межах (тис. т): кукурудза 2015-2620, пшениця 1200-1691 та соняшник 755-1001. З автотранспорту зерно приймають 66 підприємств, а відпускають 65. Середня потужність прийому зерна становить 3032,41 т/добу, а відпуску 1183,61 т/добу. Прийом із залізничного транспорту є на 21 підприємстві, а відпуск – на 55-ти. Середня потужність приймальних пристроїв із залізниці 949,52 т/добу, а відпускних – 1448,69 т/добу. На розглянутих 53 підприємствах області встановлені 111 зерносушарок з 11 країн-виробників. З них 18,9% підприємств мають сушарки лише українського виробництва, на 20,8% підприємств є як вітчизняні так і закордонні, але більшість підприємств мають сушарки лише закордонного виробництва, яких в 1,85 разів більше кількості сушарок українського виробництва. Встановлено, що на 37 елеваторах для очищення зерна використовується 82 сепаратора, більшість з яких (63%) вітчизняного виробництва, які переважають імпортні у 1,73 рази. Сумарна місткість одночасного зберігання зерна у 67 елеваторах сільськогосподарських підприємств становить 3554,35 тис.т, з яких 2449,41 тис.т. мають заготівельні елеватори та 1104,94 тис.т – виробничі. Їх місткість одночасного зберігання менше за прогнозні значення валових зборів зерна 2022 року – 6354,2 тис.т, що потребує розширення елеваторної мережі Вінницької області.

Ключові слова: Вінницька область, зібрана площа, виробництво зерна, транспортно-технологічне обладнання, післязбиральна доробка зерна, місткість елеваторів.

Received 02.09.2023

Reviewed 15.09.2023

Revised 25.09.2023

Approved 26.09.2023



Cite as Vancouver Citation Style

Kats A., Stankevych G., Tupytsia U. Vinnytsia region: status and trends of production, processing and storage of grain. Grain Products and Mixed Fodder's, 2023; 23 (3, 91): 22-32. DOI <https://doi.org/10.15673/gpmf.v23i3.2754>

Cite as State Standard of Ukraine 8302:2015

Vinnytsia region: status and trends of production, processing and storage of grain. / Kats A. et al.// Grain Products and Mixed Fodder's. 2023. Vol. 23, Issue 3 (91). P. 22-32. DOI <https://doi.org/10.15673/gpmf.v23i3.2754>

