Improvement of transportation of melon crops using increased loading standards

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Abstract: In this paper, the economic efficiency of introducing an increased rate of loading into wagons during the transportation of melons is considered. The relevance of the topic is due to the need to optimize logistics processes and reduce the cost of transporting agricultural products. The study analyzes the current loading standards and their impact on the cost of transportation, as well as assesses the potential benefits of increasing standards. Various factors are considered, such as the possibility of increasing the volume of transported products, reducing transportation costs per unit of goods, and improving trade turnover. The research methodology includes a comparative analysis of existing practices, statistical data on the transportation of melons, and economic modeling. As a result, it was found that the introduction of an increased loading rate can lead to significant cost savings, increase profitability, and improve the competitiveness of agricultural products on the market.

1 Introduction

The static load of wagons is an important indicator of the use of wagons as rolling stock. The increase in static loading leads to a reduction in the demand for wagons, an increase in the throughput of railway sections and the processing capacity of stations, and the optimization of the use of rolling stock and roads, as a result of which it affects the costs of freight transportation. Railway transport and cargo owners will see some benefits from the increase in wagon loading [1, 2].

2 Materials and methods

The savings gained by shippers from the reduced number of wagons shipped result in lower freight rates. The reduction in the number of wagons in a year for the transportation of individual cargo is determined as follows:

$$\Delta N_{sav} = \frac{n_{ac}}{100} \cdot \sum_{i=1}^{k} \alpha_i \left(1 - \frac{q_{sti}}{q_{hi}}\right), \text{ sum} \quad (1)$$

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where ΣN_k is the economy in physical wagons due to the increase in static load;

α_i – the percentage of i-type traffic in the transportation of a given type of cargo;

n_{ac} – actual consumption of all types of wagons for transportation of one type of cargo in one year;

q_{sti} – completed static loading of the wagon, t;

q_{hi} – as a result of the implementation of the recommendations, the achieved static load, t;

i – type of content in motion.

The reduction in tariff costs is determined by the following expression:

$$E_t = \sum_{i=1}^{k} \Delta N_{savi} C_{avi}, \text{ sum} \tag{2}$$

where C_{avi} is the average tariff rate for transportation of the corresponding types of cargo for 1 wagon, sums;

$\sum_{i=1}^{k} \Delta N_{savi}$ – sum of wagons saved in the transportation of the corresponding goods.

The reduction in operating costs consists of two parts:

– reduction of overstaying of wagons at loading and unloading stations;

– reducing the mileage of loaded and unloaded wagons.

The reduction of wagon hours in a year at loading and unloading stations is determined by the following calculations:

$$\sum N_{ek} = \frac{n_{ac}}{100} \div \sum_{i=1}^{k} \alpha_i \left(1 - \frac{q_{cst}}{q_{hi}}\right) \cdot 2t_{c\arg} \text{ sum} \tag{3}$$

where $t_{c\arg}$ is the average parking time of a wagon at a loading and unloading station corresponding to one cargo operation, hours.

The reduction in car-kilometer travel is as follows:

$$\sum NS = \frac{n_{ac}}{100} \sum_{i=1}^{k} \alpha_1 \left(1 - \frac{q_{sti}}{q_{hi}}\right) \cdot l_{c\arg} \left(1 + \alpha_{fr}\right), \text{ sum} \tag{4}$$

where $l_{c\arg}$ is the average loaded flight of the car, equal to the average distance of transportation, km;

α_{fr} – coefficient of free running of the wagon.

The economic efficiency from increasing the loading of the wagon is determined by the following expression in terms of costs:

$$\Delta E_{pr} = \sum t_{\text{sav}} \cdot C_h + \sum NS \cdot C_{pr} + E \cdot \Delta K_{car}, \text{ sum} \tag{5}$$

where C_h is the price of a wagon-hour, sum;

C_{pr} – wagon-km price, sums;

C_h and C_{pr} – 40% of the total price is accepted in the accounts since the expenses related to the amount of movement are taken into account.

E– standard coefficient of efficiency, 0.12 is accepted;

ΔK_{car} – reduction of capital costs for the wagon fleet:

$$\Delta K_{car} = \alpha_{sch} \frac{\sum \Delta N_{ek}}{365} \Theta_{car} \cdot C_{car} \left(1 + \alpha_{c.\kappa.}\right), \text{ sum} \tag{6}$$

where α_{sch} is a coefficient that takes into account the scheduled maintenance of wagons, α_{sch}=1.05;

Θ_{car} – wagon rotation time, day, Θ_{car} = 15 days;

$\alpha_{c.\kappa.}$ – share of expenses for the development of the wagon fleet, $\alpha_{c.\kappa.}$ = 0.1;

$\sum \Delta N_{ek}$ – number of wagons saved in a year;

C_{car} – average price of a refrigerated wagon.

3 Discussion

Studies show that the transportation of some fruits and vegetables according to the differentiated scheme leads to a decrease in the quality of the cargo [1]. For example, in the case of increased loading of melons on a wagon, the number of standard products for different refrigerator wagons is allowed to decrease within the limit of 1.7 to 2.7%. It is necessary to take this situation into account when justifying the effectiveness of the introduction of increased norms of wagon loading. Due to the fact that there is not enough space for air circulation at increased loading, the circulation of air masses is not uniform, and the quality of the product is somewhat lost [3-5].

When transporting melons in refrigerated wagons at increased loading rates, it is necessary to remove a part of the two upper rows of boxes to ensure air circulation. These adjustments ensure complete air circulation as specified in the standards. Also, the distance between rows should be at least 4-5 cm.

Additional costs arising from product damage and loss during transportation with increased loading on wagons can be determined using the following calculations:

$$\Delta A = \frac{n_{ac} \cdot q_{sti} \cdot \psi}{100} \left(C_{c\arg} + \frac{C_{c\arg}}{q_{hi}} \right), \text{ sum} \tag{7}$$

where ψ is a reduction in the transported volume of the standard product, %;

$C_{c\arg}$ – wholesale price of 1 t of product, sum.

As a result of the introduction of slightly higher static loads, the number of wagons extracted is determined by the following expression:

$$\Delta N = Q \left(\frac{1}{q_{sti}} - \frac{1}{q_{hi}} \right), \text{ sum} \tag{8}$$

where Q is the volume of future transportation, t;

q_{sti} – static loading of the wagon before the introduction of measures, t;

q_{hi} – static loading of the wagon after the introduction of measures, t.

For the convenience of subsequent calculations, it is appropriate to write the formula (7) in the following form:

$$\Delta N = Q \frac{\Delta q}{q_c \left(q_c + \Delta q \right)}, \text{ sum} \tag{9}$$

where Δq is the increase of the proposed norms compared to the fulfilled norms.

In this way, it can be seen that the number of wagons saved depends on three parameters:

– volume of transportation;

– existing static load of the wagon;

– volume of the increased loading of the wagon according to the new standards.

As a result of the introduction of a slightly increased static load, the total economy from the reduction in the number of wagons can be determined by the following formula:

$$E = \Delta N \cdot C \text{, sum} \tag{10}$$

where C is the price of transportation of one wagon of policy product by rail transport, sums.

In the transportation of melons, it is necessary to regulate the loading of refrigerated wagons, ensure the complete preservation of the quality of the product with one constant requirement, put the boxes up to 220 cm high (10 boxes in height) and carry out differentiation under the condition of fully using the carrying capacity of the refrigerated wagons [3, 4, 6].

Today, there are no technical loading standards for the transportation of melons. According to statistics, there are large differences in the loading of the same type of wagons. The difference in loading is more than 2 tons, which corresponds to an average of 25,267 kg per wagon (Table 1). Even when the boxes are mounted on the same type of wagons at the same height, there is a difference of several tons. This situation is explained by the non-existence of approved standards for loading wagons at loading points, which encourages shippers to take financial responsibility and leads to different indicators of loading wagons [1, 2, 3].

In order to increase the static load of refrigerator wagons, depending on the parameters of the wagons, it is advisable to transport melons by applying optimal methods of loading.

Table 1. Loading of refrigerated wagons when transporting freshly cut melons (statistics of Chukursoy station in 2020)

Car type	Duration of transportation, day	Cargo mass in the wagon, kg	Loading height, (m)	Quality, %		
				standard	non-standard	waste
1	2	3	4	5	6	7
with refrigerator	14	24848	208	94.7	3.3	2.0
"-"	14	24309	210	93.4	2.6	2.5
"-"	20	26372	206	89.9	5.8	4.3
"-"	20	25540	208	90.5	5.5	4.0
Average		25267	208			

There are three ways to load crates of melons into refrigerated wagons: checkerboard, crosswise, and longitudinally. In order to choose the optimal version of the tax, comparisons were made for all three methods (Table 2).

Table 2. Comparison indicators of the increased standards of loading of refrigerated wagons when packing boxes with fresh melons in different ways

Car type	Schemes of laying cells								
	chess			intersectional			longitudinally		
	Cutting height, (mm)	Number of cells, (piece)	Cargo weight, (kg)	Cutting height, (mm)	Number of cells, (piece)	Cargo weight, (kg)	Cutting height, (mm)	Number of cells, (piece)	Cargo weight, (kg)
Refrigerated wagon	2200	1176	23520	2200	1392	27840	2200	1432	28640

As can be seen, due to the fact that there is a uniform circulation of air, the scheme of laying the boxes longitudinally allows the refrigerator car to accommodate a slightly larger volume of cargo. The scheme of loading boxes into a refrigerated wagon in a longitudinal way is presented. In this case, when the loading height is 2200 mm, the weight of the load reaches 28640 kg.

Compared to the checkerboard method, at the same height of laying, using this method, an additional 5 tons of cargo can be loaded into the wagon (Table 2).

Based on this, the capacity and loading technical norms of the wagons were calculated, and they were compared with the existing loading determined according to the data of experimental transports and statistical data [1,2].

The proposed loading rates are matched with data from pilot runs and existing loading statistics.

The proposed technical standards of loading of refrigerated wagons using the longitudinal method of loading exceed the average statistical standards by 3.37 tons, or 13%.

Based on the above, we calculate the number of wagons saved at the Chukursoy station due to the introduction of a slightly higher statistical load:

$$\Delta N = 142 \cdot 25267 \cdot \frac{3373}{25267 \cdot (25267 + 3373)} = 17 \text{, car}$$

where Q is the volume of transport, Q = 142, car;

q_s – statistical loading of the wagon before the introduction of measures, t, q_s = 25267 t;

q_h – statistical loading of the wagon carried out according to the proposed schemes of loading and increased loading, t, q_h = 28640, t.

Δq - the value of increase compared to the fulfillment of the proposed standards, t, Δq = 28640-25267=3373 t.

So, according to the actual available data of "O'TY" JSC in 2020, the total number of wagons saved as a result of the introduction of high static loads is 17 units, based on the annual volume of melons transported from Chukursoy station to Russia.

The cost of transporting Polish products, especially melons, from the Chukursoy station to the border of Kazakhstan is $9.36 per 1 ton of cargo.

Using the longitudinal method of loading, the average load of a refrigerated wagon is 28.6 tons.

Based on the data, it is possible to calculate the total transportation cost of one refrigerated wagon from Chukursoy station to Cherkizovo station. The transportation distance is 3446 km.

1. From Chukursoy station to Saragach station on the territory of Uzbekistan:

$9.36·28.6, tons = $267.7

2. From Sary-Agach station to Ozinki station on the territory of Kazakhstan - $1601.3

3. On the territory of Russia - from Ozinki station to Cherkizovo station - $4519.5

Total transportation cost from Chukursoy station to Cherkizovo station: $267.7 + $1601.3 + $4519.5 = $6388.5.

As of May 1, 2021, the value of 1 US dollar is 10,523, sums.

Based on this, the cost of transporting one wagon:

$6388.5 · 10,523, sums = 67,226,188.5, sums.

As a result of the introduction of high static loads, the total economy from the reduction of freight wagons sent outside the country (on the Chukursoy-Cherkizovo route) is as follows:

$$E = 17 \cdot 67\,226\,188.5 = 1\,142\,845\,205.5, \text{ sums}$$

where C is the price of transportation of one wagon loaded with policy products in railway transport, C = 67,226,188.5 sums.

Therefore, as a result of the implementation of proposals developed to ensure the preservation of the supply of melons transported from the Chukursoy station to the neighboring countries of the CIS, as a result of the introduction of increased standards for the loading of refrigerated wagons, 1.143 bln. sum economic efficiency can be obtained.

4 Summary

As a result of the introduction of the increased standards of loading refrigerated wagons, the implementation of the developed recommendations on ensuring safe deliveries of melons transported from the Chukursoy station to the CIS countries will provide an opportunity to obtain economic efficiency in the amount of 1,143 billion sums annually.

References

1. S.Yu. Firsova, A.V. Kulikov, B.S. Sovetbekov, Bulletin of the Kyrgyz-Russian Slavic University **14,** 12. 199 - 201 (2014)
2. S.Yu. Firsova, A.V. Kulikova, Energo- i resursosberezhenie: promyshlennost i transport **10**, 113, 86-88 (2013)
3. U. Crisalli, A. Comi, L. Rosati, Procedia – Social and Beh. Sci. **87**, 292-305 (2013)
4. M. Gursoy, Scientific Research and Essays **5(7).** 613-624 (2010)
5. A. Rong, R. Akkerman, M. Grunow, International Journal of Production Economics, **131**, 421-429 (2011). https://doi.org/10.1016/j.ijpe.2009.11.026
6. X. Wang, D. Li, Omega, **40**, 906-917 (2012) https://doi.org/10.1016/j.omega.2012.02.001