SATBAYEV UNIVERSITY

Journal of Energy, Mechanical Engineering and Transport

Volume 2 (2025), Issue 2, 49-53

https://doi.org/10.51301/jemet.2025.i2.08

Improving the efficiency of transportation of threshed rice

A.T. Kamysbaeva[1*], S.E. Bekzhanova[1], A. Tazhibayuly[2], S.A. Marat[2]

[1]*Satbayev University, Almaty, Kazakhstan*

[2]*Kyzylorda «Bolashak» University, Kyzylorda, Kazakhstan*

**Corresponding author: ayzhan_kamysbaeva@mail.ru*

Abstract. This article addresses the issue of optimizing crop transportation in rice crop rotation to enhance the efficiency of agricultural operations. The relevance of this research is underscored by the need to reduce harvest time and minimize equipment downtime, thus promoting more effective resource use. The main subject of the study is the performance of combine harvester and transport vehicle units involved in grain transportation. The goal of the research is to develop methodologies and tools that improve rice harvest efficiency through rational planning. The research objectives include analyzing factors affecting equipment productivity, designing a graph-nomogram to optimize unit loading, and performing nomographic calculations to minimize time expenditure. Methods applied include transportation process modeling and statistical analysis of equipment operation data. Findings reveal that the developed graph-nomogram reduces equipment downtime by 20–25% and increases productivity by up to 18%. The conclusions confirm the effectiveness of the proposed approaches and methods in organizing rice harvesting within the shortest timeframe. Finally, recommendations are provided for implementing this methodology in agricultural enterprises.

Keywords: *rice fields, combines, transportation organization, graph-nomogram, motor vehicles, rolling stock.*

1. Introduction

The organization of grain transportation on rice crop rotation ensures inconsistency in the work of combines and vehicles, so that there are no downtime of combines while waiting for unloading and loading of rolling stock. This is achieved with the correct calculation of the re-quired number of rolling stocks for the maintenance of combines, the development and strict observance of the timetable for the movement of rolling stock between com-bines with a hammer and the creation of integrated teams consisting of combine harvesters, drivers, as well as during the operation of tractors and tractor drivers [1].

The schedule of movement of rolling stock when working on the site of a group of combine harvesters is formed in such a way that by the time the combine bunkers are filled, the required number of units of rolling stock is re-turned, ensuring a single emptying of the bunkers of all combine harvesters with full use of the load capacity of all returned rolling stock [2].

During the rice harvest, it is essential to deliver the threshed crop to the grain yard in a short period of time. Changes in weather, increased humidity, or delays in transportation may result in spoilage or decreased grain quality. Therefore, the efficiency of transportation is a critical part of the overall harvesting process.

To prevent loss and spoilage of grain during transportation of bodies, trailers and semi-trailers, vehicles must be equipped with seals at the side joints, equipped with tarpaulins or other materials that protect grain from precipitation and pollination. The sides should be increased to a height that ensures the fullest use of the rolling stock's carrying capacity, but not more than the established norm.

If the capacity of the car body is greater than the capacity of the hopper, it is necessary to load several times, in this case, the double operation method is used, 2 combines are moved in parallel across the field at a distance that allows loading.

Grain is loaded into cars and trailers separately, trailers are loaded directly from the combine hopper during tractor transportation, and then delivered to the place of formation of road trains (field edge/ unloading highway) [3].

Low level of technical equipment – Outdated transport machinery with insufficient capacity affects transportation speed and reliability.

Poor road infrastructure – The quality of roads be-tween fields and the grain yard is often poor, slowing down the transport process.

Low level of organization – Lack of a well-developed logistics system, poor route planning, and long wait times at delivery points hinder efficiency.

2. Materials and methods

To transport grain coming from the combine's hopper to harrows, GA3-53b, KamAZ, etc. vehicles and tractor trailers wheeled TK -82 «Belarus», T-150K, etc. are used. To ensure uninterrupted uninterrupted operation of combine harvesters and conveyor machines, it is necessary to organize a group of pre-harvest vehicles, secure the transportation equipment in common work areas and properly arrange their productive and efficient operation. He. to do this, the following conditions must be met.

1. Conveyor equipment needs to create passages between the gates so that it can move freely and cross the field.

2. It is necessary that transportation equipment and facilities arrive on schedule in a timely manner, preventing unauthorized maintenance of vehicles.

3.It is better to fill the boxes of cars and trailers with the hopper of the second combine so that they fill up quickly, preventing the combine from getting stuck in most cases.

4. In order not to stop and quickly unload grain machinery arriving at Kurgan, it is necessary to equip grain-carrying machinery in crates.

The study was conducted by calculating the inflow between threshing machines and rice threshing machines, determining the yield of rice products, and determining the productivity of the combine [4,5].

A stable-shift approach is a rational method of transporting grain from combine to combine. With interchangeable trailer trucks, one tractor can provide 3 combines at a distance of 3-4 km, and two combines at a distance of 5 km. A tractor with a trailer truck and the combines it provides make up the harvesting link. The combined group, working in one row, consists of 2-3 links.

A stable shift method is a two-system conveyor, in which the work on grain management and transportation takes place individually, rather than depending on each other.

The first system is a combine harvester trailer located in the center of the trailer pen, into which grain is loaded. The second system is a rake trailer. Even due to the constant location of grain loading, waiting for the combine by the grain loading machine and free movement on the belly are lost. The efficiency of tractor uses increases (a trailer with grain loading pulls a tractor).

This development allows you to reliably and correctly calculate the harvested grain, fill out the calculation documents correctly, so that there is no unnecessary work done in the work of combine harvesters.

The use of this method makes it possible to harvest rice along the production line and use other machines available on the farm that are convenient for this approach.

Along with the effective organization of the harvesting and transportation group and planning the order of loading on machines, methods of loading and unloading grain by machines and trailers on the harrow, as well as the organization of work on counting grain on the harrow, informing about the progress of harvesting and transportation work, etc. they allow you to shorten the cleaning time.

3. Results and discussion

The main condition for the smooth operation of combines and conveyors is a sufficient quantitative ratio between them. This is determined by the following formula:

$$T = \frac{K \cdot V}{P \cdot C}$$

Where:

T – the number of transport vehicles carrying grain from the field to the threshing floor;

K – the number of operating combines;

V – the return time of the transport vehicles (in hours);

C – the time it takes to fill the combine’s grain tank (in hours);

P – the number of fully loaded combine grain tanks equal to the carrying capacity of the transport vehicles.

The return time of the transport vehicle is determined based on previous years' experience or calculated using the following formula.

$$V = \frac{L + M}{S} + T$$

Where:

L – the distance from the combine to the threshing floor along the route taken by loaded transport vehicles, in kilometers;

M – the distance from the threshing floor back to the combine along the route taken by empty transport vehicles, in kilometers;

S – the technical speed of the transport vehicles, in km/h;

T – the time required to load the vehicle, in hours (0.05 h);

R – the time required to unload the grain at the threshing floor, in hours (0.1 h for mechanical unloading, 0.17 h for manual unloading).

The time required to fill the combine's grain tank is determined based on previous years' experience or calculated using the following formula:

$$C = \frac{1.2 \cdot V}{3600 \cdot P} + B$$

Where:

C – the capacity of the grain tank, in kilograms;

V – the ratio of straw weight to grain weight (equal to a multiplier of 1.5–2.0);

P – the throughput of the threshing machine, in kg/sec;

B – the time required to unload the grain tank, in hours (0.05 h).

When the number of combines in a group changes significantly, or when the distance from the combine to the threshing floor, the length of the furrow, or the grain yield in the harvested area changes, the number of vehicles assigned to each combine must be recalculated.

During rice harvesting, 3 to 8 groups of combines may operate within one field plot. Each group may have 2 to 4 combines working in separate furrows.

According to past experience, a specific vehicle is not permanently assigned to any particular combine or group of combines working in the same area. Vehicles are not fixed to any one combine or group—they can be loaded from any combine. Since the order of loading is decided by the combine operators themselves, this leads to a loss of working time for the entire complex.

To ensure the smooth operation of combines and transport vehicles, the following conditions must be met:

Calculate the number of combine groups working in one furrow so that the total capacity of their grain tanks is equal to the load capacity of one transport vehicle.

Divide the combines into groups based on the capacity of their grain tanks—this makes it easier to record the weight of the delivered grain under each combine operator’s name.

Assign transport vehicles to groups of combines, rather than to individual operators.

Instruct combine operators to load grain from their tanks into partially filled vehicles.

The total number of vehicles used to transport grain from the combine to the threshing floor depends on the crop yield, the distance between the threshing floor and the grain delivery point, the time required to fully load the truck bed with grain and to unload it at the threshing floor, the load-carrying

capacity of the equipment used, the speed of the transport vehicles, and the throughput of the access routes within the rice field system. This relationship can be analyzed and calculated using the following formula.

$$C = \frac{E \cdot Q \cdot R}{K \cdot 60}$$

Where:

C – the number of transport vehicles;

E – the yield per hectare, in centners per hectare (c/ha);

Q – the productivity of the combine per hour, in kg/hour;

R – the total round-trip time of the transport vehicle, including the time for loading and unloading, in hours;

K – the load-carrying capacity of the vehicles, in kilograms.

When calculating the combine's productivity using this formula, a work time utilization coefficient of 0.3 to 0.6 is typically used. The average speed of grain transport vehicles traveling to and from the combine in rice fields is assumed to be 25–30 km/h, while for tractors such as the MTZ-82 «Belarus» or T-150K with trailers, a speed of 12–15 km/h is used. Based on this, the working hours per day of the grain transport vehicles and the time required for grain transport are estimated in advance to determine the required number of vehicles.

An efficient and practical method of transporting grain from the combine to the threshing floor using wheeled tractors is the fixed rotation method. For example, in rice farming, if the yield is 60 centners per hectare and the distance to the threshing floor is 4 km, two TRION 750 combines can be serviced by one MTZ-82 «Belarus» tractor with a single interchangeable trailer. The trailer-equipped tractor and the grain-harvesting combines are part of the same harvesting unit. A harvesting team working across multiple furrows typically consists of 2 to 3 units.

This technology enables accurate grain accounting, proper completion of settlement documents, fair evaluation of combine operators' work, and accurate tracking of fuel and lubricants usage.

A new method that significantly simplifies the calculation of how many transport vehicles are needed to deliver grain from the combine is the use of a graph-nomogram, which has proven effective for use in agricultural operations. This method allows farms to quickly and accurately determine the optimal composition of harvesting and transport groups based on their specific conditions. With the help of the nomogram, it is possible to select the appropriate number of combines and vehicles for a given group with high precision and minimal time investment.

For example: as shown in Figure 1, the nomogram (via the arrow) indicates how many vehicles are required.

1. When directly harvesting and threshing rice, TRION 750 combines are used. The rice yield is 80 centners per hectare, and the distance between the rice field and the central threshing floor is 10 km. In this case, five MTZ-82 «Belarus» tractors or GAZ-53B trucks are needed to transport the grain to the central threshing floor.

2. For separate harvesting and threshing of rice, the TRION 750 combine is used. The crop yield is 70 centners per hectare, and the distance between the field and the central threshing floor is also 10 km. In this situation, three KAMAZ trucks are required to transport the grain to the central threshing floor.

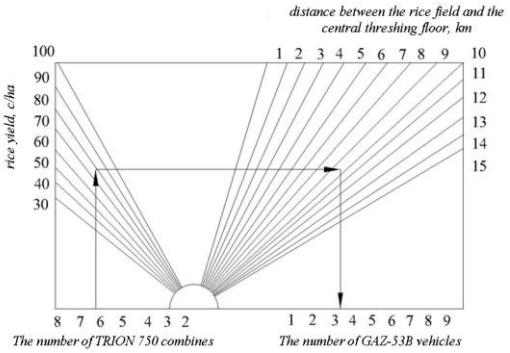

Figure 1. Graph-nomogram for transporting threshed rice from the combine's grain tank to the threshing floor

This method depends on the proper and efficient organization of the work of combine–transport unit groups. If the harvesting process is well supported with sufficient grain transport equipment and properly organized, idle time of machinery can be reduced by 20–25%, and the productivity of transport vehicles and equipment can be increased by up to 15–18%. Thus, nomogram-based calculations help complete the rice harvesting and collection process in the shortest possible time.

Ways to Improve Efficiency

Upgrading machinery and mechanization. The use of modern trucks and tractors with higher load capacities. GPS-based route optimization can also improve transportation planning.

Improving road infrastructure and temporary setups Constructing temporary hard-surface roads during harvest seasons or repairing existing roads to facilitate quicker transport.

Enhancing logistics Automating grain receiving systems at the grain yard, reducing wait times. Planning transportation schedules based on distance and expected volume.

Efficient use of labor resources Introducing multi-shift work systems and better coordination between drivers and machine operators.

a) Insufficient Technical Equipment

Worn-out machinery: Much of the agricultural transport equipment is outdated and has been in use for many years, leading to frequent breakdowns, repair needs, and workflow interruptions.

Low-capacity machines: Existing vehicles often have limited load capacity, which requires multiple trips to transport large volumes of rice, increasing both time and fuel consumption.

Lack of modern equipment: The absence of automated loading and unloading systems leads to over-reliance on manual labor, which slows down the transportation process.

b) Poor Road Infrastructure

Dependence on weather conditions: Many access roads are dirt or unpaved, becoming unusable after rain or flooding.

Narrow and difficult routes: Some roads only allow one-way movement, leading to traffic congestion and long wait times for transport vehicles.

Additional costs: Poor Road conditions result in higher fuel consumption and increased wear and tear on transport equipment.

c) Organizational and Logistical Challenges

Lack of transport schedules: Routes and transport times are often uncoordinated, causing vehicle clustering in one place and inefficient use of time.

Limited intake capacity at the grain yard: The inability to receive large quantities of rice quickly causes long queues of transport vehicles.

Weak communication and coordination: Poor communication between field operators and grain yard staff prevents real-time coordination of transport processes.

d) Challenges in Human Resource Management

Shortage of skilled personnel: There is often a lack of qualified drivers and technical staff to operate and maintain transport equipment.

Low labor productivity: Many workers lack specialized training, which affects their ability to operate machinery efficiently and manage the transport process effectively.

Lack of shift-based operations: Some farms operate on a single-shift basis, limiting the volume of rice that can be transported in a day.

4. Conclusions

In the rice crop rotation, while providing threshed grain with transportation equipment, organizational work is well established, reducing the waste of machinery by 20-25 percent, increasing the productivity of transporting vehicles and machinery to 15-18 percent. By using a graph-nomogram, it is possible to increase the efficiency of using transportation techniques, thereby contributing to the completion of harvesting and harvesting rice in the shortest possible time.

Improving the efficiency of transporting threshed rice to the grain yard depends not only on technical factors but also on organizational solutions. By implementing modern technologies, improving infrastructure, and optimizing logistics processes, it is possible to significantly increase the success of the overall harvesting campaign.

References

[1] Kainar. (1969). Kazakhstan rice. *Almaty: Kainar*

[2] Tazhibayuly, A. (1985). Methods of harvesting rice crops. *Almaty: Kainar; Kyzylorda*

[3] Tazhibayuly, A. (1999). Improving the use of agricultural machinery in rice crop rotation. *Zharshy*

[4] Alshynbay, M.R. (1999). Theory of agricultural machinery. *Almaty: Kazakh State Agrarian University*

[5] BIKO. (2005). Rules for the transportation of goods by road. *Almaty: BIKO*

[6] Tazhibayuly, A., Kozhakmet, A. & Marat, N. (2022, April 11). Infrastructure for the high-quality transportation of perishable agricultural products. *In Modern Science: Digital Transformation, International Scientific-Practical Conference, Bolashak University*

[7] Doszhanov, M.Zh., Yskak, E., Tasbergenova, G.Zh., Abdilakhatova, A.F. & Raev, S. (2020). The effect of the physical-mechanical properties of arable land soils on the wear of plowshares. *Mechanics and Technologies, 1(67), 26–31*

[8] Tazhibayuly, A., Doszhanov, M. Zh. & Tasbergenova, G. Zh. (2021). A swath turner device for installation on a header for rice harvesting. *Bulletin of Dulaty University, 4(04), 94–99*

[9] Standards Publishing. (2003). OST 10.2.2.-2002. Testing of agricultural machinery: Methods of energy assessment. *Moscow: Standards Publishing*

[10] Koptilyuev, B. Zh., Tazhibayuly, A. & Mustayap, M. B. (2022, March 30). Problems of urban passenger transportation. *In Energy and Resource-Saving Technologies: Experience and Prospects, IV International Scientific-Practical Online Conference, Kyzylorda: Korkyt Ata Kyzylorda University*

[11] Usmanov, A.A., Kozhbanov, K.B., et al. (1976). Mechanization of rice production operations. *Almaty: Kainar*

[12] Iztaev, A.I., & Yermekbayev, S.B. (2014). Fundamentals of crop production in grain farming (Textbook)

[13] Iztaev, A.I., Kizatova, M.Zh., Baybatarov, T.A., Baymuratov, D. Sh. & Iztaev, B. A. (2012). Technology of grain drying and storage (Textbook). *Almaty: Economics*

[14] Sysuev, V.A. & Kazakov, V.A. (n.d.). New technologies for post-harvest grain processing and production of high-quality feed for livestock. *Agrarnaja nauka Evro-Severo-Vostoka*

[15] Fedorova, N.A. (2018). Effective technical solutions for improving grain quality during harvesting and post-harvest processing (doctoral dissertation). *Ryazan*

Бастырылған күрішті қырманға тасу тимділігін жоғарылату

А.Т. Камысбаева[1*], С.Е. Бекжанова[1], Ә. Тәжібайұлы[2], С.А. Марат[2]

[1]*Satbayev University, Алматы, Қазақстан*

[2]*Қызылорда «Болашақ» университеті, Қызылорда, Қазақстан*

**Корреспонденция үшін автор: ayzhan_kamysbaeva@mail.ru*

Аңдатпа. Мақалада күріш ауыспалы егістігінде астықты тасымалдау жұмыстарын тиімді ұйымдастыру мәселесі қарастыры-лады. Зерттеудің өзектілігі – егін жинау уақытын қысқарту және техниканың бос тұрып қалуын азайту қажеттілігі-не негізделген, бұл ресурстарды тиімді пайдалануға ықпал етеді. Зерттеудің негізгі пәні – астық тасымалдауды жүзеге асыратын комбайн және көлік агрегаттарының жұмысы. Жұмыстың мақсаты – күріш жинау тиімділігін арт-тыруға мүмкіндік беретін жоспарлау әдістемесі мен құралдарын әзірлеу. Зерттеу барысында техниканың өнімділі-гіне әсер ететін факторларды талдау, агрегаттарды жүктеу үшін график-номограмма әзірлеу және уақыт шығында-рын азайту мақсатында номографиялық есептеулер жүргізу міндеттері қойылды. Қолданылған әдістерге тасымал-дау процестерін модельдеу және техниканың жұмысына қатысты деректердің статистикалық талдауы кіреді. Зерт-теу нәтижесінде әзірленген график-номограмманы пайдалану техниканың бос тұрып қалуын 20–25%-ға азайтып, оның өнімділігін 18%-ға дейін арттыратыны анықталды. Қорытынды нәтижелер ұсынылған әдістердің күріш жи-науды қысқа мерзімде ұйымдастырудағы тиімділігін растайды. Соңында ауыл шаруашылығы кәсіпорындарына әдістемені енгізу бойынша ұсыныстар берілген.

Негізгі сөздер: *күріштік, комбайндар, тасымалдауды ұйымдастыру, график-номограмма, автокөлік құралдары, жылжымалы құрам.*

Повышение эффективности транспортировки обмолоченного риса

А.Т. Камысбаева[1*], С.Е. Бекжанова[1], А. Тажибайулы[2], С.А. Марат[2]

[1]*Satbayev University. Сатпаева, Алматы, Казахстан*
[2]*Кызылординский университет «Болашақ», Кызылорда, Казахстан*

**Автор для корреспонденции: ayzhan_kamysbaeva@mail.ru*

Аннотация. В данной статье рассматривается проблема оптимальной организации транспортировки урожая в севообороте риса для повышения производительности агротехнических процессов. Актуальность исследования обусловлена необходимостью сокращения времени уборки и минимизации простоев техники, что способствует более эффективному использованию ресурсов. Основной предмет исследования – работа агрегатов комбайнов и транспортных средств, осуществляющих перевозку зерна. Цель работы – разработка методологии и инструментов, позволяющих повысить эффективность уборки риса за счет рационального планирования. В рамках исследования были поставлены задачи: анализ факторов, влияющих на производительность техники, разработка графика-номограммы для оптимизации загрузки агрегатов, а также проведение номографических расчетов для минимизации временных затрат. Примененные методы включают моделирование процессов транспортировки и статистический анализ данных о работе техники. В результате исследования установлено, что использование разработанной график-номограммы позволяет сократить простой техники на 20–25% и увеличить ее производительность до 18%. Полученные выводы подтверждают эффективность предложенных подходов и методов для организации уборки риса в сжатые сроки. В заключение предложены рекомендации по внедрению методики в практику сельскохозяйственных предприятий.

Ключевые слова: *рисовые поля, комбайны, организация транспортировки, график-номограмма, автотранспортные средства, подвижной состав.*

Received: 20 March 2025
Accepted: 15 June 2025
Available online: 30 June 2025