VOL. 16, NO. 21, NOVEMBER 2021 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

APPLIED SOFTWARE OF PLANNING OF MECHANIZED WORKS IN AGRICULTURAL ENTERPRISES

Kudrynetskyi Rostyslav[1], Dnes Viktor[1], Krupych Stepan[1], Skibchyk Volodymyr[2], Krupych Oleh[3] and Sharybura Andrii[3]
[1]National Scientific Center, Institute for Agriculture Engineering and Electrification, Glevakha, Ukraine
[2]National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
[3]Lviv National Agrarian University, Dubliany, Ukraine
E-Mail: kudsl@ukr.net

ABSTRACT

Modern processes of agricultural production are characterized by a high level of mechanization and automation and are aimed at creating favorable growth and development of plants as well as soil microorganisms. The machinery used to mechanize these processes is science-intensive, its cost is constantly growing. The high level of agricultural production technologies, technical excellence and high cost of machinery require a high level of management of the technical base, finding ways to reduce the share of material and energy costs in the cost of agricultural products. The search for rational solutions in the acquisition and use of machine-tractor fleet (MTF) of agricultural enterprises is one of the most difficult tasks, because in its solution it is necessary to take into account a large number of factors, most of which are probabilistic and unmanageable. The article presents the possibilities of using application software for planning mechanized works in agricultural enterprises allows to form a rational composition of MTF, determining the need for machinery based on the structure of sown areas, technologies for growing crops and operating conditions of machine-tractor units (MTU) by scheduling their use. Taking into account the value of direct operating costs. The use of the proposed algorithm in the application software allows you to choose the appropriate MTU, the use of which ensures the implementation of technological operations in the optimal agricultural terms with minimal energy consumption, which in turn reduces the cost of cultivated products.

Keywords: software, planning of mechanized works, model, factors and algorith.

INTRODUCTION

This article is devoted to the description of the applied software of planning of mechanized works in the agricultural enterprises. Software for planning mechanized works in agricultural enterprises, designed to form the rational use of MTF, determining the need for machinery based on the structure of sown areas, technologies for growing crops and operating conditions of MTU by building schedules for their use based on direct operating costs.

In recent years, the technologies of agricultural production are undergoing radical changes, the innovative concept of agricultural technology is to reduce energy and resource consumption of technological operations, bipolarization of agriculture, optimizing the timing of the planned set of operations, ensuring environmental friendliness.

Given the great variety of climatic and organizational and economic conditions for the functioning of agricultural enterprises, the high cost of energy resources and equipment - the search for optimal, for each business entity, solutions for the acquisition of MTF is an extremely important task, the solution of which is basis for the creation of energy-saving and competitive industries.

The idea of this work is to harmonize the parameters of technical support of agricultural enterprises with production programs for growing crops, which will reduce the cost of growing crops.

The result of the application of this application software are the schedules of loading equipment and the structure of the reduced operating costs for each field of the agricultural enterprise.

LITERATURE REVIEW

Improving food and labor safety requires the replacement of outdated technologies and equipment with machines with higher environmental and ergonomic performance. Research on the main problems of mechanization of agricultural production requires new approaches, which based on the principles of systematization using large arrays of information to optimize the choice of technologies. Production technologies and machine complexes have a great influence on the economic performance of agricultural enterprises. Therefore, the decision on which machines should be used to complete the material and technical base of agro-industrial production, MTF of agricultural enterprises, is one of the most important. The wrong decision will negatively affect the production economy and product competitiveness.

The set of machines and technologies form the machine-technological base of agro-industrial production. Machine-technological base is a defining production system that affects the volume, quality and economic characteristics of the final product. The current state of this base does not provide innovative development of agro-industrial production.

Modern trends in technological development involve the implementation of technological operations in a clearly defined time, which provides favorable

conditions for growth and development of plants and crop formation.

To perform the whole complex of works in a short time, it is necessary to provide a differentiated approach to each operation and select for their implementation MTU that will ensure high quality work and the minimum possible fuel consumption.

According to the authors' research [17], the timely execution of all work in the best agronomic terms and the associated crop yields largely depend on providing the farm with all the necessary machinery. Therefore, in all farms much attention is paid to determining the most rational composition of the park in relation to the specific operating conditions of equipment.

The methodology of planning mechanized works and optimization of MTF in the role of initial data is based on: technologies of growing crops, technical parameters of machines, operating conditions of MTU, technical-operational and economic indicators of MTU, agrometeorological factors, sown areas of crops in crop rotation. crops, fertilizer application rates, current production, fuel consumption and wage rates [1-5].

Basically, to solve the problem of "planning of mechanized work and optimization of MTF" a mathematical model is set, which is solved by the method of linear programming [1, 12]. Solving this problem allows you to optimize the MTF by the criteria of minimum specific operating costs. Increasingly, the method of dynamic programming is used in solving this problem. The essence of this method is that it does not require the linearity of the objective function and allows you to take into account the cost of performing operations and the costs caused by the loss of products due to delays in the execution of works.

Effective technical means on the basis of which it is expedient to complete MTF of economy, define on the basis of technical and economic calculations [7-13]. To implement them, scientists have developed a number of computer programs based on methods of linear or dynamic programming [14, 15].

Information technology is increasingly used in agricultural enterprises [16], which help current activities, such as financial and reporting programs that allow you to keep track of procedures, purchased means of production and products.

In [17-19], the authors propose programs that can be used to determine the state of crops in real time, a kind of automated assistants to agronomists.

Software for production planning and design are covered in [20-25], the developed programs are based on the latest economic and mathematical methods and software-algorithmic complexes that provide automation of mechanized work planning.

METHODOLOGY

The need of agricultural enterprises in technical means is determined on the basis of the plan of mechanized works.

The initial data for determining the annual plan of mechanized work, the composition of the MTF and its loading are the following data:

- structure of sown areas (in the form of crop rotation);
- technological regulations for growing crops [8];
- information about the system of machines for mechanized work;
- characteristics of natural production conditions of the economy (natural-climatic zone, type of soils, distances of transportation of technological materials and products, etc.).

The main document for determining the composition and planning of the MTF are technological maps for growing crops.

The technological map is made on the basis of technological regulations from which the list and sequence of performance of operations, terms of the beginning of works and agropermissible duration of their performance are taken. After that, the composition of the MTU is determined to perform the corresponding technological operation.

At the time of compiling the process map, the distribution of MTU on operations performed simultaneously is still unknown. Because of this, the each is conditionally written for each operation. Finally, the composition of the unit is determined after analysis and adjustment of the loading schedule of the MTU.

The need for units to perform technological operations (n_a) is determined by dividing the volume of work by the product of the unit's operating time per day and the number of working days, [13] ie:

$$n_a = \left\lceil \frac{Q}{W_g \cdot t_p \cdot D_p \cdot K} \right\rceil, \quad (1)$$

where Q - volume of work, ha, t, tkm; W_g - productivity of the MTU for an hour of variable time, ha/h, t/h, tkm/h; t_p - duration of work of AIT during the day, hours; D_p - duration of agrotechnical term of performance of works, days; K - correction factor that takes into account the influence of agrometeorological factors (K_m), level of labor organization (K_o), reliability of machines in the MTU (K_T) [13].

$$K = \frac{K_m}{1 + K_o + K_T}. \quad (2)$$

The values of the coefficient K_o are: for continuous tillage - 0.14… 0.25; for inter-row tillage - 0.25… 0.30; for sowing - 0.24… 0.27; for mowing grasses, cereals and silage crops - 0.21… 0.28; for harvesting crops with simultaneous loading into vehicles - 0.28… 0.34. The approximate values of the K_T coefficient are equal to 0.004… 0.060 [11].

The actual need for MTU n_a^F is accepted by rounding the obtained value of n_a to a larger integer.

Then, the actual duration of work on this operation is determined by the expression:

$$D_p^F = \left\lceil \frac{Q}{W_g \cdot t_p \cdot K \cdot n_a^F} \right\rceil. \quad (3)$$

In performing many jobs, different MTU work simultaneously.

Therefore, the daily productivity and the number of operations to perform parallel operations must be determined in the following sequence:

- select the main or dependent operation;
- calculate the operational performance of the MTU on the main operation per day;
- determine the required number of MTU and the actual duration of work;
- determine the amount of work that can perform a given number of MTU per day;
- depending on the daily volume of work on the main operation, the daily volume of work on dependent operations is determined;
- according to the established volume of work, similarly to the main operation, the required number of service units and machines is determined.

The number of technical means necessary for execution in agrotechnical terms of the plan of mechanized works in an economy, is defined on the basis of the schedule of their use [7, 12, 26].

To build a schedule of use on the abscissa axis, the deadlines for work are postponed, and on the ordinate axis - the number of technical means of a particular brand that perform this type of work in this period. The use of a tractor in each operation on the chart is built in the form of a rectangle. If the works coincide in terms of execution, the rectangles are placed one above the other. In the process of plotting a significant number of "peaks" and "failures", which indicate the uneven need for tractors during the year [40].

You can align the "peaks" in the following ways:

- increasing the number of working days within the agro-technical period of the operation;
- increasing the number of changes in the operation of units during the day;
- redistribution of technical means between different works ;;
- change of technology (if possible, replace one operation with another).

The volume of work for transport operations is defined as the product of the volume of cargo to be transported, the distance of transportation. The average distance of transportation within the farm is taken depending on the natural and climatic zone in which it is located, so for the conditions of Ukraine - in the Steppe it is 8 km, for the Forest-steppe - 5 km and for Polissya - 3 km [4]. And outside the farm, the distance of transportation is indicated on the technological map. The need for energy is calculated by dividing the daily volume of work by the daily productivity of one vehicle.

Direct specific operating costs (DSOC) of agricultural enterprises to perform the required amount of work are determined by the expression [3, 26]:

$$DSOC = C_1 + C_2 + C_3 + C_4, \quad (4)$$

where C_1 - specific wages of employees, UAH/ha; C_2 - specific cost of fuels and lubricants, UAH/ha; C_3 - specific deductions for depreciation of technical equipment involved, UAH/ha; C_4 - specific deductions for current repairs and maintenance of the involved technical means, UAH/ha.

According to the volume of work actually performed by the unit, the specific costs of remuneration of employees are determined [3, 26]:

$$C_1 = \sum_r \frac{(m_1 P_1 + m_2 P_2 + ... + m_n P_n)}{W_r^h}, \quad (5)$$

where $m_1, m_2,...,m_n$ – the number of workers who service the unit, separately for each qualification (category); $P_1, P_2,...,P_n$ – wages of the worker of each qualification for the hourly rate of production, UAH/hour; W_r^h - hourly productivity of the machine-tractor unit, ha/hour.

The specific cost of fuels and lubricants is determined by the formula [3, 26]:

$$C_2 = \mathrm{Pr}_f \cdot q, \quad (6)$$

where Pr_f – complex price of one kilogram of fuel, UAH/kg; q – consumption of fuels and lubricants, kg/ha [7].

The specific depreciation deductions are determined by a known expression [3, 26]:

$$C_3 = \sum_i \frac{Bv_i \cdot n_i \cdot a_i \cdot k_i}{100 \cdot Q}, \quad (7)$$

where Bv_i - book value of the i-th machine in the unit, UAH; n_i - the number of i-th machines in the unit, pcs; a_i - the rate of deductions for depreciation of the i-th machine, %; k_i – coefficient that takes into account the degree of loading of the i-th machine in the composition of this unit.

The rate of deductions for depreciation a_i by the straight-line method of depreciation determined by the formula [3, 26]:

$$a_i = \frac{100}{t_m}, \quad (8)$$

where t_m – service life of the machine, years.

The load factor of the machine in the unit determined by the formula [3, 26]:

$$k_i = \frac{T_r}{T_{sum}}, \quad (9)$$

where T_r - operating time of the i-th machine in the composition of the r-th unit, hours; T_{sum} – total operating time of the machine on the farm for a year, hours.

Deductions for current repairs and maintenance are determined by the formula [3, 26]:

$$C_4 = \sum_i \frac{Bv_i \cdot n_i \cdot p_i \cdot T_r}{10^4}, \quad (10)$$

where p_i - rate of deductions for current repairs and maintenance of the i-th machine in the composition of the unit per 100 operating hours, %.

The above technique implemented in application software. This program written in Microsoft Visual Studio 2005 in the object-oriented C # programming language. The program uses a Microsoft Access database, which stores the following information: technological regulations; list of operations and requirements to them; characteristics of tractors; characteristics of agricultural machinery; characteristics of combines; car characteristics; characteristics of stationary machines; complete machine-tractor units and their characteristics.

The program works according to the algorithm shown in the Figure-1.

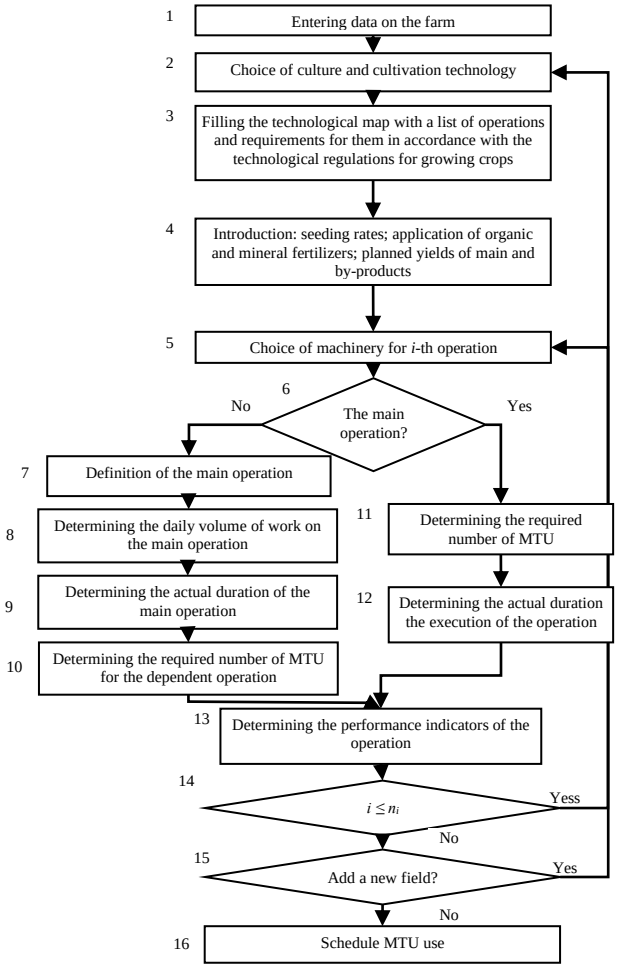

Figure-1. Generalized block diagram of the algorithm of the computer program for planning mechanized works.

RESULT AND DISCISSIONS

To start working with the program, you need to create a new farm file, where you specify the name of the farm, climatic zone and state.

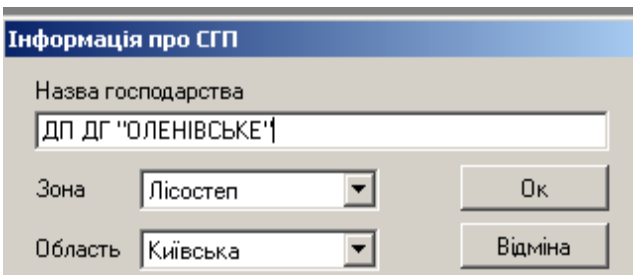

Figure-2. Dialog box for entering information about the farm.

A user interface has been developed to work with the information of the "Machinery" and "Technology" databases.

The dialog box for selecting machinery has 4 tabs that allow you to select the following types of machine: machine-tractor units; self-propelled units; transport; stationary machines.

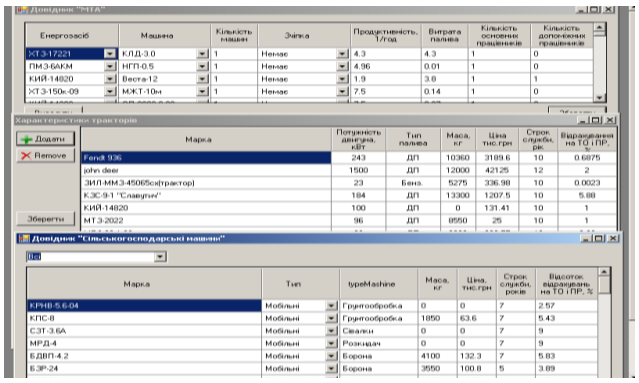

Figure-3. Dialog boxes for working with the database "Machinery".

Using the "Technology" dialog box, the user has the opportunity to edit the technological regulations of production, as well as add new ones. The window is divided into two parts: the top presents a list of existing technologies and a tool for adding new ones, and the bottom - a list of operations of the selected technology and the ability to edit them.

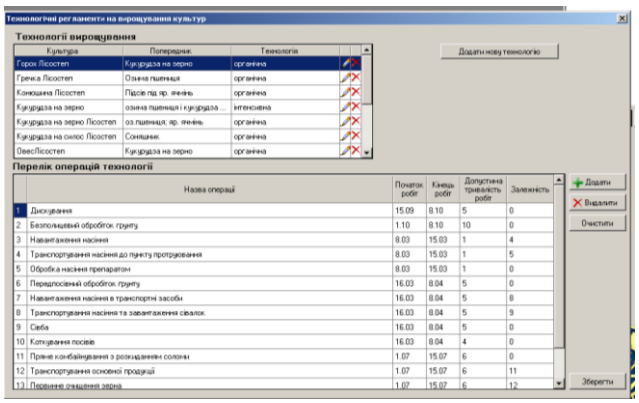

Figure-4. Dialogs boxes for working with the database "Technology".

The next step is to select the crop, predecessor, cultivation technology from the list in the appropriate dialog box, as well as to specify the field area. Because of these actions based on technological regulations, we will receive the list of operations and agro requirements to them at cultivation of the set culture.

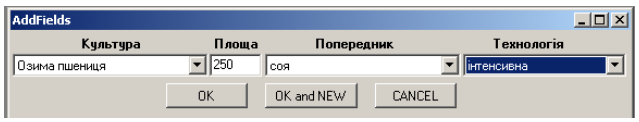

Figure-5. Dialog box for entering information about the type of crop grown.

In the dialog box, you must select from the list the crop, predecessor, cultivation technology, as well as specify the field area. Because of these actions based on technological regulations from a DB we will receive the list of operations and agro requirements to them at cultivation of the set culture.

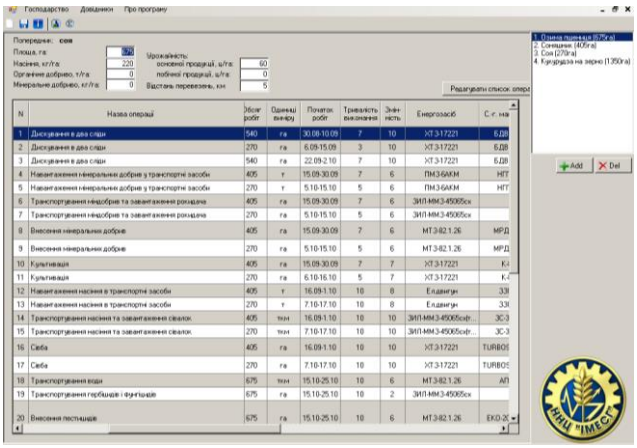

Figure-6. Dialog box for entering information about the type of crop grown.

For culture, the norm is set: sowing seeds, fertilizers, as well as the planned yield of the main and by-products.

For each operation, the MTU selected for its execution. Unit performance and fuel consumption taken from the database with the possibility of adjusting them depending on the specific operating conditions of the AIT. Also in this dialog box, depending on the composition of the unit, the number of employees for its maintenance specified.

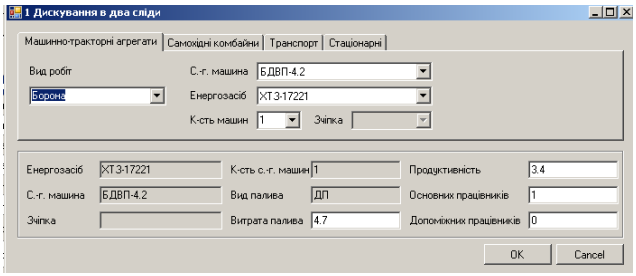

Figure-7. MTU selection dialog box to perform a specific operation.

The result of the program formed in the form of schedules for loading machinery.

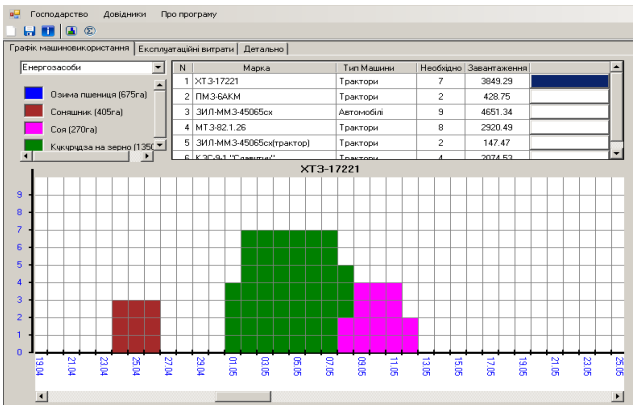

Figure-8. Dialog box to display the schedule of loading machinery.

With the help of the loading schedule, it is possible to analyze the use of machinery during the year, as well as to determine the needs of the farm in machinery. Adjustment of the schedule of loading of technical means carried out in a manual mode by change of coefficient of variability, date of the beginning of performance of works or replacement of one technical means on others.

The user receives the results in tabular form on the structure of the reduced operating costs for each crop grown in the enterprise and a detailed description of the types of costs for technological operations for growing crops.

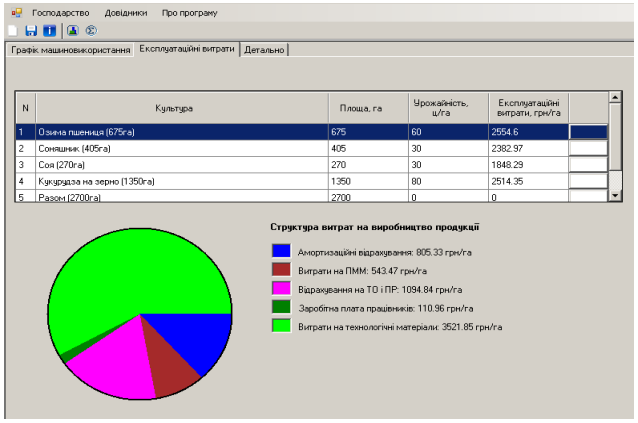

Figure-9. Dialog box displaying the structure of total operating costs for production by the farm.

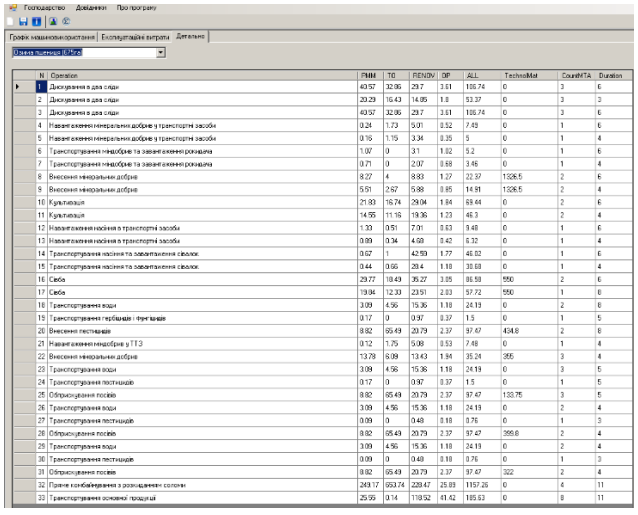

Figure-10. Dialog box displaying a detailed description by type of costs for the implementation of technological operations at production of products by the farm.

In the process of calculations, along with the choice of a rational plan for the use of MTF will determine the duration of each type of MTU for a particular type of work, the number of machine operators and support staff involved in production processes, and labor costs.

CONCLUSIONS

The optimal structure of the MTF of the farm should take into account the structure of sown areas, crop rotation system, technology of growing crops, as well as natural-climatic conditions. It found that not every saturation of farms with technical means contributes to reducing the cost of production. Therefore, one of the most important tasks is to determine the minimum sufficient number of technical means to ensure the implementation of the production process with minimal labor costs and funds.

The main functions of the application software for planning mechanized work in agricultural enterprises: forecasting performance; substantiation of the composition of the MTF according to the schedule of loading of the MTU; calculation of economic efficiency of MTF use.

During the substantiation of the rational composition of the MTF with the help of the developed software it possible to get information about: the number of technical means that need to be used for growing crops (as well as in terms of individual operations, crops and crop rotations); their actual annual load; detailed analysis of the use of mechanization.

REFERENCES

[1] Gudz V. P., Primak I. D., Budyonny Yu. V., Tanchik S.P. 2010. Agriculture: textbook, 2nd ed. remake and ext. Center for Educational Literature. p. 464. (in Ukrainian).

[2] Stetsenko I. V. 2010. Modeling of systems: a textbook. Ministry of Education and Science of Ukraine, Cherkasy State Technological University. Cherkasy: ChSTU, p. 399. (in Ukrainian).

[3] Zholnin E. V. 2013. Discussion on the methodology for assessing the economic efficiency of agricultural machinery. Agricultural machines and technologies. (3): 3-9. (in Russian).

[4] Tabashnikov A. T. 1985. Optimization of harvesting of grain and forage crops. Agropromizdat. p. 159. (In Russian).

[5] Zavalishin F. S. 1973. Basics of calculating mechanized processes in plant growing. Moscow. Kolos, p. 319. (In Russian).

[6] Melnyk I. I., Grechkosiy V. D., Marchenko V. V. 2001. Optimization of machine complexes and structure of machine-tractor fleet and planning of technical service. Kiev. NAU Publishing Center, pp. 5-47. (In Ukrainian).

[7] Finn E. A., Warsaw M. L., Chervatyuk I. E. 1989. Manning of the machine-tractor fleet of collective farms and state farms. p. 176. (in Ukrainian)

[8] Adamchuk V. V., Gritsishin M. I. 2012. System of technical and technological support of crop production. Agrarian science, 416 p. (in Ukrainian)

[9] Repetov A. P. 1984. Optimization of MTF composition and its operability. Tractors and agricultural machines. (2): 8-10. (In Russian).

[10] Mininzon V. I., Tyulenev A. V., Vechernin B. V. and others. 1986. Determination of optimal composition of engine-tractor fleet depending on weather conditions. Tractors and agricultural machines. No. 3. pp. 7-9. (In Russian).

[11] Fere N. E., Bubnov V. Z., Elenev A. V., Pilshchikov L. M. 1978. Manual on operation of the machine-tractor fleet. Kolos, p. 256. (In Russian).

[12] Kudrynetskyy R. B. 2017. Rationale of parameters of technical support crop production. International scientific journal «Mechanization in agriculture & conserving of the resources». Issue 1/2017. pp. 18-21.

[13] Dnes V. I., Kudrynetskyi R. B., Skibchyk V. I. 2020. Methodical basis of determination of efficiency of use of equipment in soil treatment, application of fertilizers and sowing of spring crops by energy indicator. Bulletin of the Lviv National Agrarian University: agricultural engineering research. No. 24. pp. 77-82. DOI:10.31734/agroengineering2020.24.077. (In Ukrainian).

[14] Kudrynetskyi R., Dnes V., Skibchyk V. 2018. Methodical principles of modeling of subject-agrometeorological events in technological processes growing of grain crops. TEKA. An International Quarterly Journal on Motorization, Vehicle Operation, Energy Efficiency and Mechanical Engineering. Lublin-Rzeszow. 18(3): 129-139.

[15] Skibchyk V. I., Kudrynetskyi R. B. 2019. Structure of automated decision support system in early grain harvesting programs. Mechanization and electrification of agriculture: Interdepartmental thematic collection/RUP NPC NAS of Belarus on agricultural mechanization. Belarusian Science. (52): 137-140. (In Russian).

[16] Mobli H., Rafiee S., Madadlou A. 2012. The use of artificial neural network to predict exergetic performance of spray drying process: A preliminary study. Computers and Electronics in Agriculture. 88: 32-43.

[17] Dimitris S. Paraforos *et al.* 2016. A Farm Management Information System Using Future Internet Technologies. IFAC-PapersOnLine. 49-16 (2016) pp. 324-329.

[18] J. Muangprathub *et al.* 2019. IoT and agriculture data analysis for smart farm. Computers and Electronics in Agriculture. 156(2019): 467-474.

[19] A. P. Kale, S. P. 2019. IoT based Smart Farming: Feature subset selection for optimized high dimensional data using improved GA based approach for ELM. Sonavane Computers and Electronics in Agriculture. 161(2019): 225-232.

[20] Cupiał M., Szeląg-Sikora A. 2014. Komputerowe wspomaganie zarządzania w gospodarstwach ekologicznych. Kraków, ISBN 978-83-64377-11-2.

[21] Jensen A. L., Boll P. S., Thysen I., Pathak B. K. 2000. Pl@nteInfo - a web-based system for personalised decision support in crop management. Computers and Electronics in Agriculture. 25(3): 271-293.

[22] Recio B., Rubio F., Criado J.A. 2003. A decision support system for farm planning using AgriSupport II. Decision Support Systems. 36(2): 189-203.

[23] Konstankiewicz K., Pukos A. 2012. Wykorzystanie technologii informacyjno-telekomunikacyjnych (ICT) w wybranych gospodarstwach rolnych województwa podlaskiego. Inżynieria Rolnicza. 2(136): 121-128.

[24] M. Cupiała, A. Szeląg-Sikora, M. Niemiec. 2015. Optimisation of the machinery park with the use of OTR-7 software in context of sustainable agriculture. Agriculture and Agricultural Science Procedia. 7(2015): 64-69.

[25] Henning T. Søgaard, Claus G. Sørensen. 2004. A Model for Optimal Selection of Machinery Sizes within the Farm Machinery System. Biosystems Engineering, 89(1): 13-28. DOI:10.1016/j.biosystemseng.2004.05.004

[26] Didenko M. K. 1983. Operation of the machine-tractor fleet. Vyshcha shkola, p. 447. (In Ukrainian).

[27] Ilchenko V. Yu., Karasev P. I., Limont A. S. 1993. Operation of the machine and tractor fleet in agricultural production. Urozhay, p. 288. (In Ukrainian).