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Assessment of the economic efficiency of scientific-technical progress in dairy cattle breeding

The article evaluates the economic efficiency of scientific-technical progress (STP) in dairy cattle breeding. A set of indicators for estimating the economic efficiency of milk production is described. The system of network planning and management on the basis of network graphs is used for scientific substantiation of the efficient milk production model. In order to ensure the comparability of production system elements, it is proposed to use the unified energy indicators to determine the ratio of energy contained in the manufactured products to the amount of energy spent on their production. The article provides the algorithm and results of economic and energy analysis of cow housing types efficiency on the reconstructed dairy farms in the Vologda Oblast.

Labor costs, metal consumption, energy consumption, reduced costs, energy content, reduced energy consumption, economic and energy efficiency.

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Grave problems in dairy cattle breeding include low productivity and deplorable working conditions of cattle-raisers due to obsolete technologies and equipment, significant physical and moral depreciation of the whole production base of milk cattle breeding, acute shortage of qualified personnel. Increasing the efficiency and competitiveness of this sector is possible only through farms modernization on the basis of the latest technologies and technical means. Large-scale work in this direction is conducted in many regions, including the Vologda Oblast. This is evidenced by the following sustainable trend in livestock production: the average milk yield per one cow increased from 4221 kg in 2005 to 5194 kg in 2011. In prospect, dairy cattle breeding should fulfill the task of increasing the livestock population up to 100 thousand head and achieve milk yield up to 6000 kg per a year [5, 6]. All this requires the reconstruction and modernization of farms, establishment of a good fodder base, improvement of the cattle-raisers' working conditions.

In addition to considerable financial costs, the development of modern milk production technologies requires profound knowledge of their peculiarities and comprehensive notion of the economic effect, which can be obtained when acquiring and using the latest technologies and technical solutions with regard to economic management conditions.

Issues of estimating the economic efficiency of STP achievements implementation in dairy cattle breeding are reflected in a number of works insufficiently, which predetermined the aim of the research: the improvement of methodological approa-ches to estimating the efficiency of promising technologies in milk production. To achieve this goal it is necessary to solve the following tasks: on the basis of the analysis, to identify the methods and indicators used in assessing the efficiency of new equipment introduction; to supplement the methodology of assessing the efficiency of new technologies implementation in dairy cattle breeding with the indicator of a minimum of reduced costs and economic and energy indicators; to assess the economic efficiency of implementing the tethered and loose cow housing options on the basis of the proposed methodology.

The problem of assessing the economic effectiveness of equipment and technology is highlighted in the research in the form of methodology guidelines and standards [1, 4] approved by the RF Government, the works of scientists [3, 12].

Methodological principles for assessing the economic efficiency of new equipment are revealed in the "Methodology of assessing the economic efficiency of using new equipment, inventions and rational suggestions in agriculture" (1998) [4]. In accordance with this methodology, the annual economic effect is determined by comparing the reduced costs of basic and new equipment in compliance with the comparability of the options:

$$E_a = \left[C_1 \cdot \frac{B_2}{B_1} \cdot \frac{P_1 + E_n}{P_2 + E_n} + \frac{(U_1 - U_2) - E_n \cdot (K_2 - K_1)}{P_2 + E_n} - C_2 \right] \cdot A_2, \qquad (1)$$

C_1 and C_2 – reduced costs per a production unit, produced with the use of basic and new equipment;

A_2 – annual output of production produced with the use of new equipment in a target year in physical units;

$\frac{B_2}{B_1}$ – coefficient of assessing the increase in the performance of the new equipment as compared to the basic one;

B_1 and B_2 – production output when using the unit of the basic and new equipment respectively in physical units;

$\frac{P_1 + E_n}{P_2 + E_n}$ – ratio indicating the coefficient of assessing the change in service life of the new equipment as compared to the basic one;

P_1 and P_2 – share of depreciation charges from the initial price of the basic and new equipment;

E_n – normative coefficient of capital investments efficiency;

$\frac{(U_1 - U_2) - E_n \cdot (K_2 - K_1)}{P_2 + E_n}$ – customer's cost advantage in the current expenses and deductions from attending capital investments for the whole service life of the new equipment, rubles;

K_1 and K_2 – customer's attending capital investments when using the basic and new equipment calculated for production output when using the new equipment, rubles;

U_1 and U_2 – customer's annual operation costs when using the basic and new equipment calculated for production output when using the new equipment, rubles.

Methodologies of capital investments efficiency calculation are based on the integrated approach to economic development, and the criterion is the produced national revenue increase. The economic efficiency of production, which is one of the most important indicators of economic development, is defined as the ratio of the useful result (effect) to the cost of its obtaining.

Economic efficiency indicators are conditionally divided into 3 groups.

The first group includes generalizing indicators of economic efficiency. First of all, it is the growth of the social productivity of labour, quantitatively expressed in the growth of production output, as well as in the absolute cost savings of living and materialized labour input (in price and physical measurements).

The second group comprises the main indicators of the economic efficiency of production resources usage: direct labour, basic production assets, material costs and capital investments. These include the direct labor productivity (labor intensity), fixed assets turnover ratio (capital-output ratio), materials consumption (materials-output ratio), return on capital investments (capital intensity).

The third group includes technical and economic indicators of the resources usage efficiency. They are used for the specific analysis and planning of individual sides of production process, considering the factors of its growth at the enterprises, industry branches, in agriculture. These indicators are: output per worker; working equip-ment usage coefficients, equipment capacities; the specific raw materials, fuel and energy consumption, a unit of capital investments, payback period, reduced costs [4, 12].

In most cases, the efficiency of investments in equipment is estimated by using the so-called dynamic indicators, which characterize the object of research for the whole period of its use. Such indicators are calculated by discounting (bringing payments, effected at different times, to the particular point of time).

To determine the current value of future payments, it is necessary to conduct the discounting of payments, i.e. to compare future cash flows with their present value.

The formula for discounting the one-off payments is given below:

$$E_0 = E_n \frac{1}{q^n}, \text{ or } E_0 = E_n \frac{1}{(1+i)^n}, \quad (2)$$

E_0 – current value of payments, i.e. the sum of payments reduced to the present moment;

E_n – payments at the end of the n-period;

$\frac{1}{q^n}$ – discount multiplier;

i – interest rate on the invested capital (or the discounting interest rate).

In case of periodical payments:

$$E_0 = e\frac{q^n - 1}{q^n(q-1)}; E_0 = e\frac{(1+i)^n - 1}{i(1+i)^n}, \frac{q^n - 1}{q^n(q-1)}, (3)$$

e – annual payment;

$\frac{q^n - 1}{q^n(q-1)}$ – discount multiplier.

When investing the financial resources in equipment and technology, the optimal indicator is the internal rate of return. A measure of the investments efficiency for this indicator is an internal rate of return r, that is, the interest rate at which the discounted sum of cash flows is equal to zero.

The basic formula for calculating the internal rate of return r is as follows:

$$E_0 = -S_I + \sum_{t=0}^{n} (K_e - K_a) \frac{1}{(1+r)^t} = 0, \quad (4)$$

S_I – sum of capital investment into equipment and technologies, in monetary units;

K_e – revenues, in monetary units;

K_a – payments, in monetary units.

To determine the value of r, the equation of n-th degree should be solved. For $n > 4$ the solution can be only approximate. Therefore, in practice, the simplified approximate calculation methods are used. The solution can be carried out both graphically and analytically.

The obtained value of r is compared with the minimum rate of return r_{min} established at the enterprise. If $r > r_{min}$, the investment is appropriate.

All of these indicators can be successfully used when assessing the present-day equipment and technologies, but with appropriate adjustments considering the time factor (inflation) and the peculiarities of the studied object. These indicators are given in the methodologies by modern authors [5, 10, 12], these methodologies contain various additions, reflecting the peculiarities of the area in which they are applied.

The choice of methodology for the analysis depends, as it was already noted, on the object of the study: the introduced new and replaced old technologies and equipment for agricultural production, implementation of separate technological processes, agricultural machinery usage and repair.

At the present time, for scientific substantiation of the optimum model of milk production, the network planning and management system is widely used, it is based on network graphs [7].

The methodological basis of network planning and management is presented by the methods of operations research, the theory of directed graphs and some sections of the probability theory. A distinctive feature of the network planning and management system is the use of the specific information-dynamic model of the process, the so-called network model of a complex of operations. The dynamism of the process manifests itself in the constant change of its state, the constant change of composition and parameters of its elements – works and their relations.

The criterion of options assessment shall be the labor content per unit of output, metal consumption, energy intensity. Capital and operating costs in the market conditions are changeable, at the same time, they are proportional to the cost of labour, metal consumption and energy intensity.

The labor content per unit of output (man-hours per head) is defined by the formula:

$$C_u = \frac{n \cdot q}{W_r}, \quad (5)$$

n – the number of employees, performing this operation, pers.;

q – production (milk) output per one head, tons/head;

W_r – efficiency of the equipment at the given operation per an hour, tons/hour.

Specific metal consumption (kg/head) is calculated according to the formula:

$$M_s = \frac{M}{n}, \quad (6)$$

n – the number of cows, head;

M – weight of machines and equipment, kg.

Energy intensity per unit of output (kW*h/head) is calculated according to the formula:

$$E_u = \frac{N_{dm} \cdot q}{W_r}, \quad (7)$$

N_{dm} – power of a drive mechanism, kW.

In order to determine the sequence of operations, ensuring the lowest labour costs, specific metal consumption and energy intensity, it is necessary to choose the optimal path. The task is formulated as follows: find the shortest path from point 1 to point C, moving only at the direction of the arrows.

Let L_{opt} be the optimal distance between the two vertices of the network graph, l_{i_{n-1},i_n} is the distance between two adjacent vertices. Then the principle of optimality of network planning (minimization of the sum of the distances) can be expressed by the following relation:

$$L_{opt} = \sum_{i=1}^{n} l_{i_{n-1},i_n} \rightarrow \min. \qquad (8)$$

The optimality principle leads to the rule of sequential selection of options: if in the process of finding the shortest distance between any two vertices of the network graph there are several edges of different length connecting one of these vertices with some intermediate vertice, the shortest path in the given vertice will be the edge, which length if added to the sum of the lengths of preceding edges produces the smallest sum. All other options can be dismissed.

The optimal path from the starting event to the ending one is easily traced by the generalized criterion, i.e. on average value of technical and economic indicators per unit of output: the cost of labour, metal consumption, energy intensity:

$$n_{av} = \frac{1}{i}\sum_{1}^{k} n_i, \qquad (9)$$

n_{av} – generalized criterion;

n_i – technical and economic indicators per unit of output (head/day).

Thus, carrying out the appropriate calculations, we obtain the optimal path, which will correspond to the optimal technical and technological scheme of milk production on a milk farm.

When conducting the economic assessment of equipment and technologies of livestock maintenance, the important indicators of activity include the physical indicators, which characterize the quantitative and qualitative state of manufactured products. Physical indicators reflect the level of resources used in production: labor costs, energy and fodder consumption, material costs.

The necessity of using physical indicators in determining the economic efficiency of created and used technologies and technical solutions in dairy cattle breeding is conditioned by the requirements of market economy, when it is important to identify the main directions of reducing production costs by saving on fodder, energy, working hours, eliminating the losses of resources and products.

This system of indicators can be supplemented by indicators, which provide choosing the most efficient production option [2]. Firstly, it is a well-known indicator of the minimum of reduced costs. Reduced costs is an indicator of the best option of the comparative efficiency of production. It is calculated by the formula:

$$R_i = C_i + E_n \cdot K_i \rightarrow min, \qquad (10)$$

C_i – self cost (operating expenses) of a unit of production, rub.;

E_n – normative coefficient of capital investments efficiency (established on the level of the current refinance rate of the RF Central Bank);

K_i – capital investments in equipment and technology as calculated per a unit of production, rub.

Current expenditures and capital investments in equipment and technology are reduced to a common scale through the normative coefficient in the amount of reduced costs.

Secondly, it is the economic and energy indicators, which, at present, are widespread due to the fact that they most fully correspond to the economic functions of production efficiency criterion, reflect the cost of living and materialized labour in energy units. The increase in energy consumption for obtaining one unit of production, the scarcity of fossil fuels and steady growth of investments in their extraction point to the fact that agriculture has turned into an energy-intensive sector. As V.I. Dragaytsev and A.V. Shpilko [12], V.V. Kalyuga [3] and other researchers of this issue [2, 9, 11] point out, the necessity arises to develop the methodology of economic and energy analysis of the technical and technological level of production development in agriculture. The existing methodologies are primarily developed for pig-breeding and beef cattle-breeding farms. The novelty of the economic and energy assessment indicators used in this paper consists in the fact that the methodology, on the basis of which they are calculated, is developed for dairy farms and takes into account the peculiarities of their activities [9, 11].

Therefore, it is possible to compare the elements of the production system in the unified energy indicators, i.e. to estimate the economic efficiency of the production by using the indicator, which characterizes the ratio of the amount of energy contained in the manufactured products to the amount of energy spent on its production.

Total energy intensity (total energy consumption) for the production of milk is calculated as follows:

$$E_t = E_d + E_m, \tag{11}$$

E_t, E_d, and E_m – total, direct and materialized energy consumption, MJ.

Direct energy consumption is based on the consumption of electric power, heat energy and fuels and lubricants:

$$E_c = E_{ce} + E_{cf} + E_{ch}, \tag{12}$$

E_{ce}, $E_{cf,}$ and E_{ch} – consumption of electric power, fuel and heat, MJ.

Energy intensity of the consumed electric power is calculated by the formula:

$$E_{cp} = A_{cp} \cdot I_{de}, \tag{13}$$

A_{cp} – amount of consumed electric power, kW*h;

I_{de} – energy equivalent of 1 kW*h of direct expenses, MJ.

Energy intensity of the liquid fuel is calculated by the formula:

$$E_{clf} = Q_{clf} \cdot I_{clf}, \tag{14}$$

Q_{clf} – fuel consumption, kg;

I_{clf} – energy equivalent of 1 kg of consumed liquid fuel of direct expenses, MJ.

Energy intensity of the consumed heat is calculated by the formula:

$$E_{ch} = S_u \cdot I_{uh}, \tag{15}$$

S_u – useful area of production facilities, required for producing 1 centner of milk per year, m^2;

I_{uh} – energy equivalent taking into account the heat consumption per 1 m^2 of the useful area of production facilities per year, MJ.

Materialized energy consumption is calculated by the formula:

$$E_o = E_{mf} + E_{mfp} + E_{mlf} + E_{me} + E_{mh} + E_{mb} + E_{mem} + E_{mw} + E_{ml}, \tag{16}$$

E_{mf} – energy consumption, materialized in fodder, MJ;

E_{mfp} – energy consumption, materialized in fodder over the past years, MJ;

E_{mlf} – liquid fuel energy intensity, MJ;

E_{me} – electric power energy intensity, MJ;

E_{mh} – heat energy intensity, MJ;

E_{mb} – energy intensity of the buildings, MJ;

E_{mem} – energy intensity of equipment and machinery, MJ;

E_{mw} – energy consumption for water, MJ;

E_{ml} – consumption of living labour, MJ.

Energy consumption in the consumed fodder is calculated by the formula:

$$E_{of} = q_f \cdot I_{of}, \qquad (17)$$

q_f – fodder consumption for producing 1 centner of milk;

I_{of} – energy equivalent of 1 centner of fodder unit, MJ.

Energy consumption over the past years materialized in fodder is calculated by the formula:

$$E_{mfp} = q_f \cdot I_{mfp}, \qquad (18)$$

I_{mfp} – energy equivalent of 1 centner of fodder unit of materialized consumption over the past years, MJ.

Energy intensity of the liquid fuel is calculated by the formula:

$$E_{mlf} = Q_{fc} \cdot I_{mlf,}. \qquad (19)$$

I_{mlf} – energy equivalent of 1 kg of liquid fuel of materialized consumption, MJ.

Energy intensity of electric power is calculated by the formula:

$$E_{mp} = E_{cp} \cdot I_{mp}, \qquad (20)$$

I_{mp} – energy equivalent of 1 kW*h of materialized consumption, MJ.

Energy intensity of heat is calculated by the formula:

$$E_{mh} = S_u \cdot I_{mh}, \qquad (21)$$

I_{mh} – energy equivalent, taking into account the materialized consumption of heat for 1 m^2 of the useful area of production facilities per year, MJ.

Energy intensity of buildings is calculated by the formula:

$$E_{mb} = A_b \cdot I_{ob}, \qquad (22)$$

A_b – specific total area of a production premise necessary for production of 1 centner of milk per year, m^2;

I_{ob} – energy equivalent of 1 m^2 of buildings and facilities, MJ.

Energy intensity of equipment is calculated by the formula:

$$E_{me} = W \cdot I_{me}, \qquad (23)$$

W – weight of equipment, kg;

I_{me} – energy equivalent of 1 kg of the weight of equipment, MJ.

Energy consumption for water is calculated by the formula:

$$E_{mw} = q_w \cdot I_{mw}, (24)$$

q_w – specific water consumption for pro-ducing 1 centner of milk, l;

I_{mw} – energy equivalent of 1 litre of water of materialized consumption, MJ.

Energy consumption for living labour is calculated by the formula:

$$E_{ml} = C_l \cdot I_{ml}, \qquad (25)$$

C_l – specific labour input for producing 1 centner of milk, man-hours;

I_{ml} – energy equivalent of living labour, MJ.

Energy content of the main production of dairy cattle breeding E_{pr} is equivalent to the energy content of milk E_1, MJ.

Energy content of additional production:

$$E_a = E_2 + E_3 + E_4 + E_5, \qquad (26)$$

E_2 – energy content of calf crop, MJ;

E_3 – energy content of cows body weight gain, MJ;

E_4 – energy content of body weight of culled cows, MJ;

E_5 – energy content of manure, MJ.

Energy content of the whole amount of dairy cattle breeding production when producing milk:

$$E_{wp} = E_{pr} + E_a. \qquad (27)$$

Coefficients of economic and energy efficiency assessment of various milk production technologies are calculated by the formulae:

$$\eta_1 = E_{pr}/E_c \cdot 100, \quad (28)$$

$$\eta_2 = E_{wp}/E_c \cdot 100, \quad (29)$$

η_1 and η_2 – coefficients of economic and energy efficiency assessment of production of main products (milk) and the whole cattle-breeding production of the dairy livestock breeding sector, %.

From the point of view of energy, the technology is profitable, if it ensures the highest energy output in the products per a unit of the total used energy.

The energy intensity of milk production is determined on the basis of the primary source of information – cattle-breeding farm Zarya located in Gryazovetsky District of the Vologda Oblast. The farm uses seven technologies of milk production (the technologies are described in *table 1*).

On the basis of these data, we shall calculate the minimum of reduced costs and economic and energy indicators, then we shall summarize the data in *table 2*.

Table 1. Main technological characteristics of the dairy farms of CJSC cattle-breeding farm Zarya of Griazovetsky District of the Vologda Oblast

Technological characteristics	Farm					
	“Pirogovo”	“Sloboda”	“Palkino”	“Ostanino”	“Gari”	“Stanovishchevo”
1. Housing option	Tethered	Tethered	Tethered	Loose	Loose	Tethered
2. Farm size, head	338	675	352	391	691	161
3. Silo, hay loading option	Ranger-965	Ranger-965	Ranger-965	Ranger-965	Manitou-730	Ranger-965
4. Fodder distributing option (with tractor MTZ-82)	RKT-10, KTU-10A 10 м³	“Bulldog” 8 м³ “Optimix” 12 м³ In the maternity barn – distribu-tion by hand	“Optimix” 12 м³ TVK-80 (delivery room) KTU-10A (young cattle)	“Optimix” 12 м³	“Optimix” 12 м³	RKT-10, KTU-10A 10 м³
5. Type of milking equipment	“Surge” 2×200, milking tube	“Unicala” 4×200, milking tube	“Unicala” 4×200, milking tube	“Europarallel” Milking parlour 2×12	“Europarallel” Milking parlour 2×12	ADM-8 (200), milking tube
6. Milk cooling option	Tank 6 м³, 2 pcs	Tank 4 м³, 3 pcs	Tank 10 м³	Tank 8 м³, “iced water” equipment	Tank 10 м³, equipment for flash cooling of milk	Tank 10 м³
7. Watering equipment	Communicating vessels in water tanks	Communicating vessels in water tanks	Communicating vessels in water tanks	Double-ball thermo drinkers	Double-ball thermo drinkers	Communicating vessels in water tanks
8. Manure removal option	KSN-f-100, 2 pcs Augers	KSN-f-100, 10 pcs	KSN-f-100, 6 pcs	Delta-scrapers 12 pcs Augers	Delta-scrapers 10 pcs Augers	KSN-f-100, 2 pcs.
9. Equipment for manure transportation	2PTS-4 + MTZ-82	RZHT-16 + T-150K, 2PTS-4 + MTZ-82	2PTS-4 + MTZ-82	RZHT-16 + T-150K	RZHT-16 + T-150K	2PTS-4 + MTZ-82

Table 2. Main performance indicators of 2 stock-breeding complexes at CJSC cattle-breeding farm Zarya (during reconstruction)

Indicator	“Sloboda”		“Gari”	
	Before reconstruction	After reconstruction	Before reconstruction	After reconstruction
Reduced costs, rub.	484.37	518.77	485.44	541.47
Indicator of economic and energy efficiency of milk production, %	13.75	10.58	13.85	14.67
Indicator of economic and energy efficiency of total production output, %	27.72	16.27	23.06	21.70

The data in the table show the significant advantages of milk production by using the loose cow housing option and by milking cows in the parlor.

After analyzing the parameters of the minimum of reduced costs criterion, it is possible to make a conclusion that the economic efficiency of milk production at the complex “Sloboda” (tethered housing option) is greater in comparison with that at the complex “Gari” (loose housing option). However, the gap in the values of reduced costs for compared options is insignificant, and if the additional indicators such as gross output volume, labor costs, metal consumption are taken into consideration, the performance of the complex “Gari” is better.

Economic and energy analysis proved, that after reconstruction, the values of the indicators of energy consumption in production reduced, it is especially noticeable at the complex with the tethered cow housing option (from 27.72% to 16.27%), and as a result, the value of the economic and energy indicator for the complex with loose cow housing option increased (21.70% at the “Gari” in comparison with 16.27% in the “Sloboda”). Besides, at the “Gari” complex, labour costs for production of goods are the lowest (from 1.24 to 0.92 man-hours per centner), which indicates the greater efficiency of production and economic activities. Specific indicators of fodder and metal consumption for producing 1 centner of milk also confirm the high efficiency of milk production when using the loose cow housing option. However, the disadvantage of this technology lies in significant electric power consumption – 11.4 kW•h/centner, which is inevitable given the high degree of mechanization and automation of milking process.

Thus, we can conclude that loose cow housing technology (with parlor milking), in spite of the short experience of its use in Russia, has certain technical and technological advantages compared to the tethered cow housing technology and milking with the use of milking tubes. The loose cow housing technology provides the highest labour productivity, low metal and fodder consumption, and as it is known, the cost of fodder and salaries account for the largest share in the self-cost of the final product. Therefore, when reducing these costs, the value of the cost price also reduces, and the producers obtain an actual opportunity to increase their incomes, purchase additional equipment, carry out the necessary modernization of technological equipment, etc.

As it was stated above, any kind of activity is accompanied by certain energy consumption, so it is reasonable to point out the necessity of applying the standards of energy intensity for expanding the opportunities of investment planning, financing, crediting, since these standards meet at least two requirements: they take into account the production potential of agricultural goods producers and reflect the developmental level of individual branches and agriculture in general.

The described methodological approaches to estimating the economic efficiency of STP achievements implementation in dairy cattle breeding provide for establishing the extreme values of the efficiency criteria and, in accordance with them, to forecast and justify the optimal values of economic and energy indicators of compared technologies at designing stages (working out a business plan) and in their implementation.

References

1. GOST R 53026-2008. Agricultural machinery. Methods of economic evaluation. Moscow: Publishing house of the standards, 2008.

2. Dzhabborov N.I., Dobrinov A.V., Dementyev A.M. Classification of the efficiency criteria and their use in optimizing the performance of traction machine-tractor units. Saint Petersburg: North-West Research Institute of Agricultural Engineering and Electrification of the Russian Academy of Agricultural Sciences, 2010.
3. Kalyuga V.V. Methodology of bioenergy assessment of pork. In: Technology and technical means of mechanized production of crop and livestock goods in the North-Western zone of Russia: collection of scientific works. Vol. 70. Saint Petersburg, 1999.
4. Methodology of estimating the economic efficiency of the use in agriculture of new machinery and equipment, inventions and rationalization proposals. Ministry of Agriculture and Food of the Russian Federation. Moscow: Economics, 1998.
5. Bilkov V.A., Legoshin G.P. Main directions of technological progress in dairy farming: recommendations. Vologda: LLC PF "Polygraphist", 2007.
6. Technological schemes of reconstruction and modernization of dairy farms of the Vologda Oblast: recommendations. Saint Petersburg: North-West Research Institute of Agricultural Engineering and Electrification of the Russian Academy of Agricultural Sciences, 2006.
7. Tuvayev V.N., Tuvayev A.V., Selin M.V. Scientific and practical aspects of stimulating the development of STP achievements in dairy cattle breeding. Vologda: Research Centre at the Vologda State Dairy Farming Academy, 2011.
8. Tuvayev V.N., Tuvayev A.V. Feasibility study of promising technologies of milk production on the basis of the network model. Proceedings of higher education institutions. The North-Caucasian region. Technical sciences. 2006. Appendix No. 11. November. P. 125 – 127.
9. Tuvayev A.V., Tuvayev V.N. Economic and energy analysis of dairy cattle breeding production technologies. Collection of scientific papers, devoted to the 100 anniversary of the birth of the Vologda Dairy Institute Rector V.V. Slivko. Vologda – Molochnoye, 2004. P. 213 – 218.
10. Tuvayev V.N., Tuvayev A.V. Evaluation of economic efficiency of dairy cattle breeding. New technologies in production and processing of agricultural products: interacademic scientific works. Vologda – Molochnoye: Research Centre at the Vologda State Dairy Farming Academy, 2005. P. 122 – 129.
11. Tuvayev V.N. Economic and energy assessment of milk production technologies in summer. Collection of scientific papers of the Agriculture Mechanization Department at the Vologda State Dairy Farming Academy. Vol. 1. Vologda, 2001. P. 54 – 57.
12. Shpilko A.V., Dragaytsev V.I., Morozov N.M. et al. Economic efficiency of agricultural production mechanization. Moscow: Russian Academy of Agricultural Sciences, 2001.