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MAIN TRENDS OF INCREASE IN PRODUCTIVITY OF BEEKEEPING

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Abstract

A big number of entomophilous plants are cultivated in Russia. These plants need a cross-pollination which is effected by bees only. Beekeeping is a quite specific branch and in a lot of countries it is automated and mechanized. For estimation of the level of labour productivity as well as the level of mechanization and automation in the branch, it is proposed to implement a ROL index. In our work the estimation of ROL across the countries — leaders in bee-keeping — was done. It is proposed to implement the expenditure index which is inverse to the profitability. The objective function of ROL optimization is proposed. The objective function considers the level of mechanization and automation of the output. Optimization of objective function parameters was carried out based on example of Krasnodar region for 4 threshold values of ROL: $ 10 000 per person, $ 20 000 per person, $ 30 000 per person, $ 40 000 per person. These are the main levels of automation and mechanization of technological processes in beekeeping. It was stated that it is possible to increase the ROL up to the advanced countries level by means of increase of automation level. In this case the service norm also increases up to values of USA and Canada. The search of optimal solution of objective function and optimal values of its parameters gave the possibility to establish the rational value of bee-families service norm related to a beekeeper for all levels of automation and mechanization.

Keywords: Labour productivity, profitability, beekeeping, productivity, automation, mechanization.

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1. Introduction

The labour productivity is the consistence part of gross domestic product (GDP) which is related to a unit of country population and defines, on a whole, the level of state competitive-ness. The first place - in respect to the mentioned indicator — belongs to USA: $ 28 000 – 30 000 of production per a population unit. In Russia this indicator is only $ 6 000 - 7 000 per a population unit (Oskin & Ovsjannikov, 2015). The level of development of agricultural branch is defined by the share of GDP produced by a full-time worker. In all countries including Russia agricultural goods are produced not only by big enterprises employing full-time workers, but also small farmers, seasonal workers, etc. In the bee-keeping branch the latter are the main working power (Chen et al., 2019). To make the picture more clear: in all countries the number of workers is related to the number of full-time workers, i.e. to 8 hours per day (or 2000 hours per year).

2. Problem Statement

In bee-keeping the productivity, mainly, is estimated as quantity of marketable honey related to a bee-family. The indicator "quantity of honey to a bee-family" in Russia is ultimately low in comparison with another countries: USA – 36 kg, China – 27 kg, Mexico – 22 kg, Russia – 10 kg. The average figures of high-productive beekeeping in USA in 2000:

- Annual honey after-sale income - $ 125 Million;
- The amount of state donations - $ 46 Million;
- 600 professional bee-keepers produced 75 % of marketable honey;
- The average profitability of bee-keepers – 20 %;
- Each professional bee-keeper keeps 1 500 - 2 500 bee-families;
- The total number of full-time workers – 24 00, part-time workers – 5 000.

3. Research Questions

In spite of big number of applicable economical criteria of agricultural modernisation efficiency (Oskin & Oskina, 2006), the most part of them are hard to apply in beekeeping. It is caused by the mentioned specific of the bee-keeping branch and interconnection with ecology factors (Korzh, 2008; Oskin, 2011; Oskin, 2013). In some countries, e.g. USA and Canada, the level of automation and mechanization of technological processes in beekeeping is quite high. Nevertheless, in some other countries (China, Russia) the majority of processes are realized manually in spite of high value of gross product. It is required to establish the adequate index of labour productivity in beekeeping, and, based on this index, to define the main trends of its increase through modernization of production process (Anand, Raj, Ullas, & Srivastava, 2018).

4. Purpose of the Study

In agricultural production the profitability, or ROL, is one of complex indicators of labour productivity. The equation for estimation of ROL in bee-keeping branch is obtained. The equation considers the price and prime cost of the unit of production, the average number and honey productivity of bee-families, the average number of workers at a production cycle, all types of donations and costs (Krepper, Pistonesi, & Di Nezio, 2019). The ROL in the top-10 countries with high rates of labour productivity and gross honey harvest is calculated. It is defined that, according to the mentioned parameters, Russia occupies the 7th place in this rating. We do not have the equation for computation of ROL in bee-keeping branch is proposed (Singh & Singh, 2018). The equation has to con-siders the number of honey harvestings, established price for a honey variety, number of bee-families, an average honey productivity of a bee-family during the honey harvesting period at the certain honey plant, constant and variable production costs.

5. Research Methods

For bee-keeping branch the return on labour – ROL – is the most suitable indicator. In analogy to the common expression for labour profitability, the equation for estimation of ROL in bee-keeping branch P_T was obtained as follows (Oskin & Ovsjannikov, 2015):

$$P_T = \frac{(Q-C)\times N\times M}{n_{np}} = \frac{(Q+D-Z_m-Z_{zn}-Z_{np})\times N\times M}{n_{np}}, \quad (1)$$

here Q - the cost per production unit, m.u./t; C - prime cost of production, m.u./t; N - the average number of bee families, pcs.; M - the average honey productivity of the one bee family, t; n_{np} - the average number of workers involved in honey production; D - all types of donations, m.u./t; Z_m - resources costs, m.u./t; Z_{zn} - salary of workers, m.u./t; Z_{np} - other costs, m.u./t.

Considering the fact that financial flow units are expressed through monetary units (m.u.), then the measure unit for labour productivity will be expressed as m.u./person.

The ratio N / n_{np} is, in fact, a service norm, then the equation (1) could be written as follows:

$$P_T = (Q+D-C)\times H_{ob}\times M. \quad (2)$$

In financial and economical activity the index of ROM p_{np} is also used. This index is counted as a ratio of income to the full prime cost of production and selling of goods. Then the expression in brackets in the Eq. (2) is the profit, and then the Eq. (2) could be written as:

$$P_T = p_{np}\times C\times H_{ob}\times M, \quad (3)$$

Nevertheless, mostly the prime cost of production and selling are unknown, but ROM as well as production procurement price are known. Based on this, it is worth to write the Eq. (3) as:

$$P_T = \left(Q - \frac{Q}{p_{np}+1}\right)\times H_{ob}\times M = Q\times\left(1-\frac{1}{p_{np}+1}\right)\times H_{ob}\times M = Q\times\frac{p_{np}}{p_{np}+1}\times H_{ob}\times M, \quad (4)$$

Labour profitability in top-10 countries with high indicators of labour efficiency and total honey harvest was counted, and data presented in the Tables 01 and 02 were acquired.

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Table 01. Rating of countries in aspect of labour profitability of private apiaries

№	Country	Average honey production, kg/bee-family	Quantity of bee-families per 1 bee-keeper (private)	Procurement price, $/kg	ROM, r.u.	ROL, $/person	Gross honey harvest in a country, thousand tons
1	Canada	64	92	4.52	0.5	8871.25	33-40
2	Turkey	16	67,4	4.65	0.5	1671.52	80-95
3	Denmark	18	30	5.29	0.5	952.2	2.5
4	USA	25.2	26	4.19	0.5	907.83	70-100
5	Ukraine	20	40	1.94	0.5	517.33	70
6	Argentina	40	78	0.48	0.5	499.2	60
7	Russia	19.2	31	1.94	0.5	380.89	50-60
8	China	33	35	0.19	0.5	73.15	400-450
9	Mexico	27	5	0.77	0.5	34.65	55-60
10	India	8.5	4	0.97	0.5	10.99	50-60

Source: authors.

Table 02. Rating of countries in aspect of labour profitability of professional apiaries

№	Country	Average honey production, kg/bee-family	Service norms at professional apiary	Procurement price, $/kg	ROM, r.u.	ROL, $/person	Gross honey harvest in a country, thousand tons
1	USA	25.2	1500-2500	4.19	02	26400-44000	70-100
2	Canada	64	750	4.52	0.25	43392	33-40
3	Turkey	16	280	4.65	0.25	4166	80-95
4	Denmark	18	140	5.29	0.25	2666	2,5
5	Mexico	27	200	0.77	0.25	832	55-60
6	Argentina	40	180	0.48	0.25	691	60
7	Ukraine	20	80	1.94	0.25	621	70
8	Russia	19.2	50	1.94	0.25	369	50-60

Source: authors.

As follows from the Tables 01 and 02, Russian indicators of ROL are sufficiently lower in comparison with countries-leaders in beekeeping. At the same procurement price as at the other regions of Russia, using the Eq. (4) the ROL will be $ 1940 per person. In fact, it is 5 times higher than the average value all over Russia.

Due to the fact that honey harvesting takes place several times per season, the Eq. (1) and (2) could be modified and the following expression is obtained:

$$P_T = \sum_{i=1}^{n} \left[\left(Q_i - I_i \right) \times H_{ob} \times M_i + P_i \right], \tag{5}$$

Here ***n*** – the quantity of honey harvestings with goods selling; Q_i - the price for the goods unit (variety of honey) at the i^{th} honey harvesting, m.u./kg; I_i - production costs at the i^{th} honey harvesting (costs for materials, energy, transportation, medicine, etc.), m.u./kg; M_i - the average honey production

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of a bee family at the i^{th} honey harvesting, kg; P_i - additional profit obtained though the selling of side products (wax, propolis, extra bee-families), m.u.

The costs could be constant $I_{i\,const}$ - independent on the level of mechanization and automation of the labour, and variable $I_{i\,\text{var}}$ - dependent on the certain level of mechanization and automation and influencing on the service norm and honey production. Based on the herein above, the Eq. (5) will be modified as follows:

$$P_T = \sum_{i=1}^{n} \left(Q_i \times H_{ob} \times M_i - I_{i\,const} \times H_{ob} \times M_i - I_{i\,\text{var}} \times H_{ob} \times M_i + P_{i\,m}\right). \quad (6)$$

Thus, the ROL of beekeeping depend on:

- The quantity of honey harvestings ***n*** **-** the more often a bee-keeper will change his location, the higher is profitability;
- The established price for the exact variety of honey Q_i;
- Number of bee-families H_{ob};
- Average honey productivity of a bee-family at the honey harvesting at the certain melliferous plant M_i;
- Constant and variable costs $I_{i\,const}, I_{i\,\text{var}}$,
- Additional profit obtained after selling of side products of bee-keeping $P_{i\,m}$.

All these dependencies could be performed as a common functional:

$$P_T = f(n, Q, H_{ob}, M, I_{const}, I_{\text{var}}, P_m). \quad (7)$$

If profitability will converge to the maximal value at the certain parameters of the Eq. (6), then it will be an objective function for the considered case:

$$P_T = \sum_{i=1}^{n} \left(Q_i \times H_{ob} \times M_i - I_{i\,const} \times H_{ob} \times M_i - I_{i\,\text{var}} \times H_{ob} \times M_i + P_{i\,m}\right) \Rightarrow \max. \quad (8)$$

Lets analyse the obtained expression and define the directions for increasing of ROL of bee-keepers. Due to division of costs, the equation for definition of profitability will be modified as follows:

$$p_{np} = \frac{P}{I} = \frac{P}{I_{const} + I_{\text{var}}}. \quad (9)$$

Lets carry out the further modifications of the obtained expression:

$$p_{np} \times I_{const} + p_{np} \times I_{\text{var}} = P, \quad (10)$$

Both parts of the expression will be divided by P:

$$\frac{p_{np}}{p_c} + \frac{p_{np}}{p_{am}} = 1 \Rightarrow p_{np} = \frac{p_c \times p_{am}}{p_c + p_{am}}. \quad (11)$$

The following parameters are introduced: $P/I_{const} = p_c$ - profitability at the constant costs , $\mathrm{P/I_{var}} = p_{am}$ - profitability at the variable costs connected with automation and mechanization of labour.

Considering the implemented designations lets carry out the further modification of the Eq. (11):

$$\frac{p_{np}}{p_c} + \frac{p_{np}}{p_{am}} = 1 \Rightarrow p_{np} = \frac{p_c \times p_{am}}{p_c + p_{am}}. \tag{12}$$

In the case of division of costs onto more constituents, the general equation for ROM could be obtained:

$$\frac{1}{p_{np}} = \sum_{i=1}^{n} \frac{1}{p_i}, \tag{13}$$

here p_i - profitability at $\boldsymbol{i}^{\text{th}}$ constituent of costs.

Lets designate the inverse value of profitability as g and call it expenditure index. Then the Eq. (13) could be written as follows:

$$g_{np} = \sum_{i=1}^{n} g_i \text{ , for the case with automation } g_{np} = g_c + g_{am} \tag{14}$$

Considering all designations done the Eq. (4) could be written as follows:

$$P_T = Q \times \frac{p_{np}}{p_{np}+1} \times H_{ob} \times M = Q \cdot \frac{1}{1+\sum_{i=1}^{n} g_i} \times H_{ob} \times M. \tag{15}$$

For our case considering automation and mechanization the Eq. (4) will be:

$$P_T = Q \times \frac{1}{1+g_c+g_{am}} \times H_{ob} \times M. \tag{16}$$

The general objective function could be written as follows:

$$P_T = \sum_{j=1}^{m} Q_j \times \frac{1}{1+\sum_{i=1}^{n} g_i} \times H_{ob} \times M_j \Rightarrow \max. \tag{17}$$

The further analysis of the objective function could be done in different ways depending on ways of achievement of result.

6. Findings

Lets analyse the objective function using as an example bee-keeping at Krasnodar region (Russia). All beekeepers could be divided onto two groups: first group – bee-keepers as amateurs for whom the income from this activity is not crucial, second group – bee-keepers as professionals for whom the income from this activity is the main income source. For the first group the usual production process is – 2-time honey harvesting per season. For the second group – 3-time honey harvesting per season. For this purpose the Eq. (17) could be used and, taking into account the constant values of service norm and ROM, for 3-time honey harvesting:

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$$P_T = Q_1 \times \frac{1}{1+2} \times H_{ob} \times M_1 + Q_2 \times \frac{1}{1+2} \times H_{ob} \times M_2 + Q_3 \times \frac{1}{1+2} \times H_{ob} \times M_3 = \\ =6 \times \frac{1}{1+2} \times 50 \times 15 + 8 \times \frac{1}{1+2} \times 50 \times 15 + 1.5 \times \frac{1}{1+2} \times 50 \times 30 = 1500 + 2000 + 750 = \\ =4250 \ \ \$/person \tag{18}$$

Lately, the part of beekeepers is focused on the certain varieties of honey which let them sell their production at the highest price, but with the certain share of losses in honey productivity. In such cases the number of honey harvestings per season could be increased. Nevertheless, it is efficiently to carry out four-time harvesting per season – a harvesting per a honey variety. Lets carry out a calculation of labour productivity considering four-time harvesting and, at the same time, divide the first harvesting, in accordance with honey productivity, onto two parts. One of this parts will be sold at a price of ***12 $/kg***. The value of ROL will be:

$$P_T = Q_1 \times \frac{1}{1+2} \times H_{ob} \times M_1 + Q_2 \times \frac{1}{1+2} \times H_{ob} \times M_2 + Q_3 \times \frac{1}{1+2} \times H_{ob} \times M_3 + \\ +Q_4 \times \frac{1}{1+2} \times H_{ob} \times M_4 = 6 \times \frac{1}{1+2} \times 50 \times 7 + 12 \times \frac{1}{1+2} \times 50 \times 8 + \\ +8 \times \frac{1}{1+2} \times 50 \times 15 + 1.5 \times \frac{1}{1+2} \times 50 \times 30 = 700 + 1600 + 2000 + 750 = 5050 \ \ \$/person \tag{19}$$

The following circumstance should be taken into account: if a beekeeper increases the level of automation then the financial investments in new equipment will be done - with the high probability - in a lump, and it would be better to share its reimbursement onto whole season, in accordance with income. Thus, in the equation for profitability in each period (17) the equal value of expenditure index for all honey harvestings will be included. Depending on the level of automation and mechanization, the service norm will be also changed. Considering the earlier carried computations, in accordance with ROL in other countries as well as the fact that beekeepers in Krasnodar region at the existing number of bee-families related to a bee-keeper have the certain equipment for reduction of laboriousness, the following equation for ROL at the certain period was obtained:

$$P_T = Q \times \frac{1}{1+g_c+g_{am}} \times 200 \times g_{am} \times M , \tag{20}$$

here $200 \times g_{am} = H_{ob}$ - the empiric equation for service norm.

Then for beekeeping of Krasnodar region at the rate of $H_{ob} = 50$ the value of expenditure index will be equal to $g_{am} = 0.25$.

Considering all above, the ROL will be:

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$$
\begin{aligned}
&P_T = Q_1 \times \frac{1}{1+1.67+0,25} \times 200 \times 0.25 \times M_1 + Q_2 \times \frac{1}{1+1.67+0.25} \times 200 \times 0.25 \times M_2 + \\
&+Q_3 \times \frac{1}{1+2.5+0.25} \times 200 \times 0.25 \times M_3 + Q_4 \times \frac{1}{1+2.5+0.25} \times 200 \times 0.25 \times M_4 = \\
&6 \times \frac{1}{1+1.67+0.25} \cdot 50 \times 7 + 12 \times \frac{1}{1+1.67+0.25} \times 50 \times 8 + 8 \times \frac{1}{1+2.5+0.25} \times 50 \times 15 + \\
&+1.5 \times \frac{1}{1+2.5+0.25} \times 50 \times 30 = 719 + 1644 + 1600 + 600 = 4563\ \$ / person
\end{aligned}
\tag{21}
$$

It is well known that the higher level of automation and mechanization in bee-keeping branch, the lower the honey production of a bee-family. It is connected with impossibility to maintain an individual approach towards each bee-family: it is impossible to cut with high quality the wax frames before harvesting at the automated installations, at the installations with electric drive the damages of the wax frames and wax itself could happen, etc. All above leads to additional energy consumption of a bee-family targeted on reconstruction of damages. Also increase in the level of automation leads to increase in number of bee-families, and a beekeeper is forced to focus on the gross sales of honey. At the same time, at the small number of bee-families a beekeeper sells a part of honey by retail at a higher price per kilogram of the product. Thus, at the highest level of automation and mechanization (the 4th level, in accordance with the proposed classification) the result of production of honey production of a bee-family and price of the one kilogram of honey will be less at a rate of 20-25 % in comparison with the lowest level. The mentioned decrease was divided at four intervals and approximated by the most appropriate mathematical expression. As a result, the following object function was obtained:

$$
\begin{aligned}
P_T &= \sum_{j=1}^{m} H_{ob} \times \frac{1}{1+\sum_{i=1}^{n} g_i} \times Q_j \times M_j \times k_{c\,am} = \\
&= \sum_{j=1}^{4} 200 \times g_{am} \times \frac{1}{1+g_c+g_{am}} \times Q_j \times M_j \times 0.9 \times g_{am}^{-0,074} \Rightarrow \max
\end{aligned}
\tag{22}
$$

here $k_{c\,am}$ - coefficient of price- and honey production decrease at the certain level of automation and mechanization of technological processes, $0.9 \times g_{am}^{-0,074}$.

At the optimization at the first level of automation and mechanization the following boundary conditions were implemented:

- The market price of honey and honey production do not increase at the rate exceeding 10% (because a bee-keeper, practically, cannot influence on it or keep it under control);
- The expenditure index of main production g_c is a constant value equal to the value from the previous example;
- A service norm could be calculated as a result of optimization in accordance with equation. $200 \times g_{am} = H_{ob}$.

Then, the objective function and a result of optimization will be as following:

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$$P_T = \frac{200 \times g_{am}}{1 + 1.67 + g_{am}} \times Q_1 \times M_1 \times 0.9 \times g_{am}^{-0,074} + \frac{200 \times g_{am}}{1 + 1.67 + g_{am}} \times Q_2 \times M_2 \times 0.9 \times$$
$$\times g_{am}^{-0,074} + \frac{200 \times g_{am}}{1 + 2.5 + g_{am}} \times Q_3 \times M_3 \times 0.9 \times g_{am}^{-0,074} + \frac{200 \times g_{am}}{1 + 2.5 + g_{am}} \times Q_4 \times M_4 \times \quad (23)$$
$$\times 0.9 \times g_{am}^{-0,074} \Rightarrow 10000$$

Search of optimal solution was realized with the help of software MS Excel by iterative method based on Newton method. The results of search of optimal solution are represented at the Table 03.

Table 03. Results of optimizing for the first level of automation and mechanization

Periods of honey harvestings												General indicators		
1			2			3			4					
Q_1	M_1	P_{m1}	Q_2	M_2	P_{m2}	Q_3	M_3	P_{m3}	Q_4	M_4	P_{m4}	$H_{об}$	$g_{ам}$	P_m
6.01	7.01	1549	12.02	8.03	3542	8.03	15	3542	1.55	30	1367	132	0.66	10^4

Source: authors.

In the same way the search of optimal decision is done for the rest levels of automation and mechanization. All results are represented at the Table 04.

Table 04. Results of optimizing for 4 levels of automation and mechanization

Levels of automation	Components of ROL in periods				General ROL P_m	Service norm H_{ob}	Expenditure index, g_{am}
	1	2	3	4			
1	1549	3542	3542	1367	10000	132	0.66
2	3003	6867	7253	2878	20000	375	1.88
3	4385	10047	11231	4336	30000	891	4.46
4	5865	13405	15534	5196	40000	1576	7.88

Source: authors.

The further increase of ROL is also possible, but it could be implemented only through increase of honey productivity of bee-families.

7. Conclusion

The objective function of ROL in bee-keeping branch is obtained. The analysis of the function applied to Krasnodar region shows that at the three-time honey harvesting per season the ROL is $ 4250 per person, and at the four-time honey harvesting - $ 5000 per person.

It was offered to implement 4 levels of automation and mechanization of the main production processes. The respective optimal labour productivity for these processes are: $ 10 000 per person, $ 20 000 per person, $ 30 000 per person, $ 40 000 per person. The definition of expenditure index related to automation and mechanization of the technological processes is implemented. This value is the inverse towards profitability.

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Search of the optimal solution of the objective function and its optimal parameters was carried out by means of software MS Excel in iterative way based on the Newton method. The search shows that for the first level of automation and mechanization of the main technological pro-cesses the optimal value of the service norm per a beekeeper is 132 bee-families at the level of expenditure index of production equal to 0.66. At the same way, the optimal values for the other levels of automation and mechanization were obtained:

- 2nd level – service norm is 375 bee-families per a bee-keeper at the expenditure index 1.88;
- 3rd level – service norm is 891 bee-families per a bee-keeper at the expenditure index 4.46;
- 4th level – service norm is 1576 bee-families per a bee-keeper at the expenditure index 7.88.

References

Anand, N., Raj, V. B., Ullas, M. S., & Srivastava, A. (2018). Swarm detection and beehive monitoring system using auditory and microclimatic analysis. In N.V.R. Naidu (Ed.), *3rd International Conference on Circuits, Control, Communication and Computing, I4C*, (pp.1-4). New Jersey: IEEE.

Chen, Y.-L., Chien, H.-Y., Hsu, T.-H., Jing, Y.-J., Lin, C.-Y., & Lin, Y.-C. (2019). A pi-based beehive IoT system design. In C.-N. Yang, S.L. Peng, L.C. Jain (Eds.), *International Conference on Security with Intelligent Computing and Big-data Services. Advances in Intelligent Systems and Computing, 895* (pp 535-543). Cham: Springer.

Korzh, V. N. (2008). *Osnovy pchelovodstva.* Rostov-na-Donu: Feniks. [in Rus.].

Krepper, G., Pistonesi, M. F., & Di Nezio, M. S. (2019). Adsorptive square wave voltammetric determination of amitraz in Argentine honeys with a microwave-assisted sample treatment. *Microchemical Journal, 150*, 104068.

Oskin, S. V. (2011). Povyshenie jekologicheskoj bezopasnosti sel'skohozjajstvennoj produkcii. [Improving the environmental safety of agricultural products]. *Mehanizacija i Jelektrifikacija Sel'skogo Hozjajstva/Mechanization and Electrification of Agriculture, 5,* 21-23. [in Rus.].

Oskin, S. V. (2013). Innovacionnye sposoby povyshenija jekologicheskoj bezopasnosti produkcii. *Zemleustrojstvo* [Innovative ways to improve the environmental safety of products. *Land Management*]. *Kadastr i Monitoring Zemel/Cadastre and Land Monitoring, 8*(104), 75-80. [in Rus.].

Oskin, S. V., & Oskina, G. M. (2006). Tehniko-jekonomicheskaja ocenka jeffektivnosti jeksplu-atacii oborudovanija [Technical and economic assessment of equipment operation efficiency]. *Mehanizacija i Jelektrifikacija Sel'skogo Hozjajstva/Mechanization and Electrification of Agriculture, 1,* 2-3. [in Rus.].

Oskin, S. V., & Ovsjannikov, D. A. (2015). *Jelektrotehnologicheskie sposoby i oborudovanie dlja povyshenija proizvoditel'nosti truda v medotovarnom pchelovodstve Severnogo Kavkaza: Monografija* [*Electrotechnological capabilities and equipment for increasing labor productivity in small-scale beekeeping in the North Caucasus: Monograph*]. Krasnodar: Kron. [in Rus.].

Singh, I., & Singh, S. (2018). Honey moisture reduction and its quality. *Journal of Food Science and Technology*, *55*, 3861-3871.