Resource-saving by choosing methods of tractors maintenance

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Abstract. Currently, the actual task of resource-saving by choosing methods of tractors maintenance does not take into account particularities, use tractors and a working condition of the operator. The research objective is to determine the resource-saving methods of maintenance tractors. The technique has been developed for determining the unit cost of maintenance of tractors in the implementation of various methods. Resource-saving methods of maintenance of tractors are possible even with a minimum value of the unit cost of maintenance. The upper confidence limits by the decentralized and combined maintenance methods are smaller than the upper confidence limits by the centralized method. All these indicators can be calculated both with and without accounting for the working conditions of the operator in the field. When combining the graphs of the differential distribution functions, the areas of the highest and the lowest unit cost of maintenance are formed (S1 and S2). When they are replaced, the possibility of resource saving is ensured, when choosing methods for maintenance of tractors.

1. Introduction
Currently, the actual task of resource-saving by choosing methods of tractors maintenance do not take into account particularities of use of tractors and a working condition of the operator. The specialists of tractors exploitation often choose intuitively methods of maintenance. Consequently resource-saving by choosing methods of tractors maintenance and improvements of conditions to working are missed. Therefore the research is directed to justification of a technique of the choice of methods of tractors maintenance with resource-saving and social significance for agriculture [1-4].

2. Materials and methods of a research
The technique for determining the unit cost of tractors maintenance is developed. It provides for the process for obtaining the numerical values of this indicator. The method allows determining the output parameter of the mathematical model into account the additional costs. It’s based on the theories: probabilities and mathematical statistics, measurements and errors, analysis and synthesis, as well as the theory of experiment planning. The processing of experimental data is provided on a personal computer using the program “Statistica” [1].

3. Results and their discussion
The possibility of resource-saving by choosing methods of tractors maintenance can be explained by confidence limits (Table 1) [5, 6].

The upper confidential limits by the centralized, decentralized and combined methods have the following meanings, rub/engine hour:

a) taking into account working conditions – \( m_{BC1} = 546, m_{BC2} = 460, m_{BC3} = 518; \)
b) without working conditions – \( m_{BC1} = 546, m_{BC2} = 356, m_{BC3} = 496 \).

**Table 1.** The results of processing the experimental data of the specific cost for the methods of tractors maintenance (centralized, decentralized and combined)

| Parameters                      | Values by maintenance methods (in a numerator and a denominator – with and without working conditions): |
|---------------------------------|---------------------------------------------------------------------------------------------------|
|                                 | centralized, \( C_1 \) | decentralized, \( C_2 \) | combined, \( C_3 \) |
| Population means \( X \), rub/engine hour | 133                                      | 166                                      | 161                                      |
|                                 | 147                                      | 147                                      | 157                                      |
| Standard error \( \delta \), %  | 1.1                                      | 1.3                                      | 1.3                                      |
|                                 | 1.0                                      | 1.0                                      | 1.2                                      |
| Goodness-of-fit test \( \chi^2 \) | 0.21                                     | 0.14                                     | 0.18                                     |

It follows that along “Specific Cost of Tractors Maintenance” parameter, the upper confidence limits by the decentralized and combined methods are less than the upper confidence limits by the centralized method. The calculation was made with and without consideration of the working conditions of the operator. It causes a possibility of resource-saving by choosing methods of tractors maintenance. Besides, this conclusion is confirmed by the curves (differential functions) of the distribution of the specific cost of tractor maintenance. They are obtained as a result of processing statistical data by the example of the distribution of this indicator in the implementation of the centralized and combined methods (Figure 1).

From figure 1 it can be seen that the distribution curves of the specific cost of maintenance for these methods intersect at point A with the formation of two areas. One of them is shown by hatching S_1 to the right; the other is to the left of S_2. The areas with allowance for errors in the construction of curves are approximately equal. More precisely, S_1 and S_2 can be calculated by integrating differential functions within and before point A. In the process of selecting methods of maintenance, the S_1 area (with the highest unit cost) may be replaced by the S_2 area (with the lowest value of this indicator). This provides the possibility of resource-saving.

Let us note that the law of the distribution of unit costs by the maintenance of tractors in accordance with Pearson’s agreement \( P(\chi^2) \) is usual (Table 1). The standard error to definition of this indicator does not exceed 1.3% with confidential probability 0.95.

In each of the 43 agricultural enterprises of the Irkutsk Region taken under observation, three methods of maintenance were implemented. For each of them, the corresponding value of the indicator
of the choice methods of maintenance was obtained taking into account resource-saving (Table 2) - the unit cost of maintenance. With the availability of these data (Table 2), the solution of the selection problem was reduced to finding the method by which the specific cost of tractor maintenance is of minimal value ($C_{\text{min}}$).

**Table 2.** The results by choice methods of tractors maintenance in agricultural enterprises of the Irkutsk region, taking into account resource-saving

| Options for determining the unit cost of maintenance | Number of agricultural enterprises in selected methods of maintenance: | $N_X$ | $P_C$ |
|------------------------------------------------------|---------------------------------------------------------------------|-------|-------|
| Taking into account the working conditions            | centralized: 27 (62.8 %) decentralized: 7 (16.3 %) combined: 9 (20.9 %) | 43    | 0.63  |
| Regardless of working conditions                      | centralized: 24 (55.8 %) decentralized: 17 (39.5 %) combined: 2 (4.7 %) | 43    | 0.56  |

Note – in brackets - % from $N_X$.

At the same time we recorded the value of the maximum unit cost ($C_{\text{max}}$) and method of maintenance used in an agricultural enterprise. According to the obtained data, the possibility of resource saving $\Delta C$ was determined by the formula:

$$\Delta C = C_{\text{max}} - C_{\text{min}}.\quad (1)$$

All the described actions were performed in two versions: with and without consideration of the working conditions of the operator in the field. The results of the work are presented: in table 2 and in figure 2 - in a generalized form. In addition, in table 2, another indicator is given for the analysis - the experimental probability of the coincidence of the proposed (selected) method with that used in an agricultural enterprise $P_C$, the value of which is calculated by the formula:

$$P_C = \frac{N_{XB}}{N_X},\quad (2)$$

where $N_{XB}$ – number of enterprises that already use the selected maintenance method; $N_X$ – total number of agricultural enterprises under surveillance. In this case, the number of $P_C$ was calculated at $N_X = 43$, and also based on the fact that in the agricultural enterprises of the Irkutsk region, maintenance of tractors was carried out only by the centralized method. Results show the following (Table 2, Figure 2).

![Figure 2](image-url)
62.8, 16.3, 20.9 and 55.8, 39.5, 4.7. The calculations were made with and without accounting for the working conditions of the operator in the field. It turns out that the centralized method is most demanded. The probability of coincidence of the proposed (selected) method with that used in the agricultural enterprise is 0.63 and 0.56 (on average - not more than 0.60). This indicator was determined accordingly with and without consideration of the working conditions of the operator. Working conditions influence the choice of methods maintenance. The selection results with regard to working conditions differ from the results obtained without taking them into account. By the centralized method it differs by 12.5%, by the decentralized method by 58.8%, and by the combined method they differ 3.5 times.

When determining the unit cost of maintenance for the option “taking into account the working conditions of the operator” versus the option “without taking into account the working conditions of the operator”, the number of agricultural enterprises was redistributed by methods of maintenance towards the centralized method from 24 to 27. This was due to the reduction in the number of agricultural enterprises in which there had to be decentralized and combined methods. As a result, the volume of maintenance works in the field decreased by 12.5%. We count it by the number of agricultural enterprises that are undergoing maintenance, and this leads to a social effect - improving the working conditions of the operator. All this indicates the need to choose the methods of maintenance of tractors in agricultural enterprises of the Irkutsk region. This should be done taking into account the working conditions of the operator in the field.

4. Conclusions
Thus, it is established that the population mean to specific cost of maintenance tractors by the centralized $X_{C1}$ method has the minimum value – 133 rub/engine hour that for 33 and 28 rub/engine hour (or for 24.8 and 21.1%); there are less population means of $X_{C2}$ and $X_{C3}$ – respectively by the decentralized and combined methods. This results from the fact that at the decentralized and combined methods the agricultural enterprises in addition (in comparison with the centralized method) have costs on acquisition to units of maintenance, their contents and use for destination. When accounting working conditions of the operator in the field – in the decentralized and combined methods of maintenance at the expense of additional expenses ($\Delta C_{ASC1}, \Delta C_{ASC2}$ and $\Delta C_{ASC3}$) respectively, there is 3.9 rub/engine per hour (2.2%) and increase by 18.8 rub/engine hour (11.3%). In the combined method ($\Delta C_{ASC1}, \Delta C_{ASC2}$ and $\Delta C_{ASC3}$) additional expenses are 4.8 times less than in decentralized due to carrying out in field conditions only maintenance-1.

Resource-saving on the basis of the choice methods of maintenance tractors is possible in spite of the fact that their specific cost of maintenance by the centralized method has the minimum value from three available. It is used as the upper confidential limits by the decentralized and combined maintenance methods (by an indicator: the specific cost of maintenance) and taking into account and without working conditions of the operator in the field. This is less than upper confidential limits by the centralized method.

Besides, a combination of differential functions of distribution form areas of the greatest and smallest specific cost of maintenance ($S_1$ and $S_2$) provides a possibility of resource-saving during their replacement, and practically, when choosing methods of maintenance tractors.

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