Some problems of improving engineering and technical support for crop production

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Abstract. In the article the results of a statistical analysis of the effectiveness of using modern technical equipment in crop production are presented. The analysis of data of Federal State Statistics Service on the technical condition of the agro-industrial complex of the Russian Federation (APK RF) and agricultural organizations of the regions and republics of North-Western Federal District (SZFO) indicates that, against the background of an increase in the power support for labor in agriculture, a constant decrease in its energy supply with appropriate technical equipment is observed. An increase in quality of crop products is largely determined not only by the agricultural technologies used, but also by domestic technical resources that are in service in the agricultural sector of the Russian Federation and whose quality parameters and after-sale service need to be cardinally improved.

1. Introduction

Production of high quality crop products is largely determined by the level of engineering technological support which should be given much importance in modern conditions. At the same time, the main regulators of the quality of products and services are machines and equipment, technical services for maintaining machines in working condition, technologies for machines production [1, 2]. Of great importance are also logistic services for providing agricultural manufacturers with material and energy resources, as well as services for the implementation of technological, technical, transport, reclamation, agro-chemical, and other manufacturing processes. In turn, each of these parameters has many aspects of influence on the quality of products, and consists of a variety of criteria which can be used as primary tools to manage them [3].

It is impossible to implement modern manufacturing technologies without an integrated approach to the introduction of advanced achievements in the field of crop production mechanization. Thanks to the most advanced achievements in the field of mechanization of crop production it is possible to perform complex operations in such areas as cultivated land reclamation, land general chemical treatment, including the application of organic and mineral fertilizers, means of plants protection.

The implementation of tasks on general mechanization of crop production processes during planting and harvesting is inextricably linked to the efficient use of modern agricultural machinery and equipment to minimize losses in agricultural production. With the effective use of technology, it is possible to increase the duration of the interrupted service of machine-tractor fleet (MTP) and decrease the costs of its repair and restoration [4, 5].
The research purpose is to assess engineering technological support as the most effective resource of economic growth of highly productive agriculture and a means to improve the quality of products.

2. Research objects and methods
Data of Federal State Statistics Service served as the research material. In the work we used an analytical method to compare and evaluate the current condition of engineering technical support for crop production in the North-West Federal District (SZFO) [6, 7].

3. Research results
The most effective way of organizing works in crop production is to mechanize them which allows using modern machinery and equipment instead of labor-intensive manual labor, this significantly increasing the labor productivity, reducing the time of crop production, improving quality, and reducing its costs [8, 9]. At the same time, the technological factor is not only a more effective source of development of economics of high profit agriculture, but also a way to improve the quality of products. Violation of technological factors leads to significant losses. So, for example, while violating agro-technological processes during the preparation of grassy feeds, the losses of nutrients can reach up to 50 %, which negatively affects the productivity of animals [10]. Similar results are also observed in grain production, where, when systemic technological processes fail, the losses of harvest can reach up to 49%.

In addition, the amount of harvest losses is affected by the quality of technical means used. A comparative analysis of the technical level and quality of domestic and foreign technologies shows that the Russian agriculture is in many ways inferior to the corresponding foreign enterprises, especially, in the efficiency of internal combustion engines and the quality of technological processes [11].

The analysis of the data of the Federal Statistics on the technical condition of agro-industrial complex of the Russian Federation (APK RF) shows that, against the background of an increase in the power support for agricultural labor, a constant decrease in its energy supply with appropriate technical means is observed (table 1).

**Table 1.** Energy-labor ratio and energy supply of agricultural enterprises (SHO) of the Russian Federation.

| Indicators                                      | 2000 | 2015 | 2016 | 2017 | 2018 | 2018 in % to 2000 |
|------------------------------------------------|------|------|------|------|------|-------------------|
| Availability of energy capacities in agricultural enterprises per 1 worker, hp | 51   | 74   | 77   | 75   | 80   | 156.9             |
| Availability of energy capacities in agricultural enterprises per 100 ha of sown area, hp | 329  | 197  | 200  | 198  | 200  | 60.8              |

So, if in 2000, the energy-labor ratio per 1 worker was 51 hp, in 2018 this indicator reached 80 hp, i.e. increased by 156.9%. However, at the same time, energy capacities per 100 ha of sown area decreased by 129 hp (or by 60.8%), and in 2018 they amounted to 200 hp against 329 hp in 2000.

When analyzing similar indicators for the energy supply of agricultural enterprises in the regions and republics of North-Western Federal District (SZFO), the following similar patterns are observed (table 2).

So, for the period from 2015 to 2018, in five regions and republics of the district, a tendency to reduce energy capacities per 100 ha of sown area is observed. Agricultural enterprises of the Murmansk (59.6%) and Pskov (86.5%) regions have the largest decline in this indicator. At the same time, in the Arkhangelsk, Kaliningrad, and Novgorod regions, as well as in the Republic of Karelia, the energy supply of agricultural enterprises experiences an insignificant increase in this indicator, compared to 2015.
Table 2. Energy supply of agricultural enterprises of the North-Western Federal District (SZFO) (energy capacities per 100 ha of sown area), hp.

| District, republic, region | Years | 2018 in % to 2015 |
|---------------------------|-------|-------------------|
|                           | 2015  | 2016  | 2017  | 2018  |       |
| North-Western Federal District (SZFO) |       |       |       |       |       |
| Arkhangelsk region        | 386   | 384   | 371   | 366   | 94.8  |
| Vologda region            | 545   | 567   | 573   | 563   | 103.3 |
| Leningrad region          | 360   | 353   | 343   | 338   | 93.9  |
| Republic of Karelia       | 635   | 645   | 631   | 595   | 93.7  |
| Komi Republic             | 543   | 712   | 690   | 566   | 104.2 |
| Kaliningrad region        | 786   | 729   | 709   | 711   | 90.5  |
| Murmansk region           | 222   | 219   | 210   | 223   | 100.5 |
| Novgorod region           | 2017  | 1400  | 1317  | 1202  | 59.6  |
| Pskov region              | 192   | 205   | 196   | 235   | 122.4 |
|                           | 230   | 223   | 208   | 199   | 86.5  |

Presented in Table 3, the structure of energy capacities of the Russian Federation and the North-Western Federal District (SZFO) shows that, on the whole, the main capacities of engines belong to tractors, with the range from 21.8% in the Murmansk region to 45.0% in the Kaliningrad region, and automobiles, correspondingly, from 24.2% in the Vologda region to 41.4% in the Murmansk region.

Table 3. Structure of energy capacities of agro-industrial complex (APK) in 2018, %.

| District, republic, region | Engine power: |       |       |       |       |       |
|---------------------------|---------------|-------|-------|-------|-------|-------|
|                           | of tractors (including those on which other machines are mounted) | of harvesters and self-propelled machines | of automobiles | of other mechanical engines | of electrical engines and electrical installations | of working cattle in terms of mechanical power |
| Russian Federation        | 34.3          | 20.3  | 29.1  | 1.2   | 15.0  | 0.1   |
| North-Western Federal District (SZFO) | 33.8          | 12.8  | 27.9  | 2.0   | 23.4  | 0.02  |
| Arkhangelsk region        | 45.0          | 0.7   | 25.7  | 16.9  | 11.6  | 0.1   |
| Vologda region            | 37.8          | 17.9  | 24.2  | 0.9   | 19.1  | 0.01  |
| Republic of Karelia       | 29.6          | 7.1   | 34.5  | 1.9   | 26.8  | –     |
| Komi Republic             | 25.0          | 2.1   | 31.3  | 1.8   | 39.9  | 0.02  |
| Kaliningrad region        | 40.5          | 20.8  | 27.1  | 1.9   | 9.7   | 0.03  |
| Leningrad region          | 27.2          | 9.4   | 27.8  | 2.8   | 32.9  | –     |
| Murmansk region           | 21.8          | 7.2   | 41.4  | 0.7   | 29.0  | –     |
| Novgorod region           | 38.4          | 13.7  | 29.5  | 2.3   | 16.1  | 0.01  |
| Pskov region              | 39.1          | 12.0  | 29.4  | 1.5   | 18.0  | 0.04  |
The North-Western Federal District is much inferior by the powers of harvesters and self-propelled machines to the similar indicators of the Russian Federation, and is on average 12.8% in the area compared to 20.3% in the Russian Federation, and such a decline in the considered indicators is noted, mainly, because of the northern regions of the district.

At the same time, by capacities of electrical engines and electrical installations the North-Western Federal District (SZFO) is significantly superior to those in the Russian Federation, which is associated with the climatic specifics of agriculture in the conditions of the European North of Russia.

Thus, the results of the data analysis on the comparative assessment of energy-labor ratio and energy supply in agricultural enterprises of the Russian Federation from 2000 to 2018 show a significant decrease in the quality of technical means in general over a 5-year period (table 1). Against the background of a significant increase in energy powers per a worker (up to 156.9%), their decrease (by 2.5 times) per 100 ha of sown area is noted. Similar data on the comparative assessment of energy support for agricultural enterprises are noted in the North-Western Federal District as well.

The analysis of the level of technical supply in agriculture using the example of the crop industry indicates the need to assess the quality of agricultural technical means entering the agricultural sector (APK). While assessing their quality, such important criteria of technical equipment as reliability, durability, maintainability, and safekeeping, should be taken into account.

A comprehensive indicator of the quality of products is accepted to be the machinery availability rate which is calculated by the following formula:

$$K_I = \frac{T}{(T-T_0)}^{1/\alpha} \tag{1}$$

where $T$ is MTBF (failure rate); $T_0$ is average recovery time (maintainability indicator).

The integral indicator of the quality of machines is the ratio of the total useful effect of machines to the total costs of their creation and operation:

$$H = \frac{\mathcal{E}(3c+3\bar{y})^{1/\alpha}}{1/\alpha} \tag{2}$$

where $\mathcal{E}$ is a total useful coefficient from operation; $3c$ is total production costs for creation; $3\bar{y}$ is total production costs for operation (maintenance, repair, etc.) [8].

Unfortunately, modern methods of using technical means in crop production do not possess a variety of effects on the manufacturing process, and the criteria used for these purposes do not reflect real results. Potential manufacturing opportunities are not always implemented.

The comparative analysis of the technical level and quality of domestic and imported equipment shows that Russian agricultural machinery is in many ways inferior to machines of leading foreign companies. Besides, the low reliability of agricultural machinery is related not only to serious violations of technological and labor discipline at enterprises of agricultural machinery, but also the low responsibility of enterprises for the quality of their products. Defects of machines, detected in the process of testing and inspection at farms, show that up to 19% of them are due to not only the low quality of spare parts and components, but also the inappropriate technical characteristics. So, for example, the engine used in the MTZ–82 tractor develops a power 58.8 of kW, while most of the time it idles, i.e. remains underloaded, which in turn leads to economically unjustified fuel consumption [12].

A significant part of the deviations of machines from the requirements of technical specification (TU) in terms of performance is also due to the fact that the equipment manufactured is borrowed from foreign counterparts, without taking into account soil, climatic and other zonal features of application in Russia, and scientific support for the production of equipment is either weakened or absent.

In order to ensure the production of competitive equipment, domestic agricultural machine-building plants need to take radical measures to improve the quality of products in accordance with the requirements of international standards ISO 9000 series, with the creation and organization of production of equipment of the fourth and fifth generations. The main part of the modern material and technical base of the crop industry should be a reliable competitive agricultural machinery, without...
which it is impossible to conduct a work process. At the same time, the mechanization of works in the field must provide acceleration of the complex process of automation and mechanization of all stages of a production chain due to the implementation of advanced technologies and technological solutions [13].

It is also necessary to take into account the modern level of applied agricultural technologies in the crop industry which is based on the use of high-yielding varieties of crops of a new generation, adapted to the conditions of cultivation, healthy seed material with high sowing and varietal quality indicators. Of great importance are also the rational use of effective systems of mineral and organic fertilizers, and environment-friendly ways of plants protection with the use of productive and high quality technical means.

4. Conclusion

Thus, an increase in the quality of crops is largely determined by not only the applied agricultural technologies, but the available domestic technical resources that are in service in the agro-industrial complex (APK), which requires the radical improvement of their quality indicators and after-sale service in accordance to international standards of ISO 9000 series.

References

[1] Popov V D, Minin V B and Maksimov D A 2018 Principles and foundations of the development of intellectual experimental fields Bulletin of the International Academy of Agricultural Education 41 (2) 56–60

[2] Villa-Henriksen A, Edwards G T C, Pesonen L A, Green O and Sorensen C A G 2020 Internet of things in arable farming: implementation, applications, challenges and potential Biosystems engineering 191 60–84 DOI: 10.1016/j.biosystemseng.2019.12.013

[3] Trevizan B, Chamby-Diaz J, Bazzan A L C and Recamonde-Mendoza M A 2020 A comparative evaluation of aggregation methods for machine learning over vertically partitioned data Expert systems with applications 152 113406 DOI: 10.1016/j.eswa.2020.113406

[4] Jian C 2018 Agricultural mechanization in southwestern China during transitional period: a case study Ama-Agricultural mechanization in Asia Africa and Latin America 49 (1) 7–12

[5] Lang P V, Hay N, Tam D T and Han N T 2019 The role of agricultural mechanization in the process of modernization of agriculture in Vietnam - Contribution of agricultural engineering to production after years of conducting renovation Ama-Agricultural mechanization in Asia Africa and Latin America 50 79–88

[6] Electronic resource of the Federal State Statistics Service Available at: http://gks.ru/ folder /11186 (accessed: 10.07.2020)

[7] Agriculture in Russia 2019: Statistical Digest Russian Statistical Yearbook 2019 (Moscow) p 91

[8] Chernoivanov V I, Ezhovsky A A, Krasnoschekov N V and Fedorenko V F 2011 Quality management in agriculture (Moscow: Federal State Scientific Institution “Rosinformagrotekh”) p 344

[9] Borisova L V, Nurutdinova I N, Dimitrov V P and Tugengold A K 2020 Selecting a strategy for determining the combine harvester parameter settings Engineering technologies and systems 30 (1) 60–75 DOI: 10.15507/2658-4123.030.202001.060-075

[10] Eryomin M A, Erokhin I V and Sukhoparov A I 2017 Patterns of grass drying depending on the type of mowing Young scientist 7 (141) 180–84

[11] Saritas O and Kuzminov I 2017 Global challenges and trends in agriculture: impacts on Russia and possible strategies for adaptation Foresight 19 (2) 218–50 DOI: 10.1108/FS-09-2016-0045
[12] Rakov V A and Litvinov V I 2019 Determination of the required engine power of a combined tractor power plant *News of St. Petersburg State Agrarian University* 3 (56) 145–51

[13] Rodionov A V, Kozin M N and Pripoten V Y 2019 Innovative development of grain products subcomplex as the driver of national food security provision *Scientific papers-series management economic engineering in agriculture and rural development* 19 (3) 493–98