

RESEARCH ON DEVELOPMENT OF TRACTOR FLEET IN LATVIA

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Abstract. The article contains an analysis of the research results on the development of the tractor fleet in the country during 2014-2023. The age structure and technical condition of the tractor fleet has been clarified. More than 100 thousand tractors have been registered in the country of which 32.2% are in technical order, 71% of tractors are older than 30 years, only 10.8% belong to the age group up to 15 years, which is usually taken as the amortization period. The existing tractor equipment registration procedure does not give an objective picture of the technical condition of the tractor fleet and the energy supply for agriculture. During the period an average of 462 new tractors with a power exceeding 74.5 kW were purchased annually. Using the available register data on tractor capacity and the year of registration, the total capacity of the tractor park was calculated by year. In order to ensure the amortization of tractors that have been working for 15 years, the calculated capacity is reduced by 15% but is increased by 10%, which roughly corresponds to the area cultivated by tractors that are more than 15 years old. The calculated total capacity is compared with the sown area during the period. It has been established that the total capacity of the tractor park increases by 35%, and the sown area by 13%, so the increase in capacity is significantly greater than the increase in the sown area, which allows to accomplish operations in shorter agrotechnical terms. During the period the specific power also increased by 20% ($3.0\text{--}3.6\text{ kW}\cdot\text{ha}^{-1}$), which is considered by several authors as a criterion for evaluation of the adequacy of tractors. Since the rate of growth of the cultivated areas will decrease in the future, the issue of the amount of subsidies for the purchase of new tractors is debatable.

Keywords: sown area, fleet of tractors, technical condition, power supply reliability.

Introduction

The areas of agricultural and arable land in the country, and, therefore, the areas sown for agricultural crops are increasing every year at the expense of the reclaimed overgrown areas. In the period 2014-2023 the area of agricultural land increased by 5.3%, while the sown area – by 13.0%, and at the end of the period it was 1303.0 thousand ha. Among the agricultural crops, the fastest growth is for cereals, rapeseed and legumes. In the period mentioned their total area increased by 33.3%, and in 2023 it was 1022.4 thousand ha. [1]. The production of several other kinds of crops is also growing. It is important that in 2022 the crop production accounted for almost two-thirds (65.5%) of the total value of the final production of agricultural goods, produced in the country [2]. The number of farms continues to decrease but the average size of farms is increasing – in 2020. There were 69 thousand farms with an average area of 41.0 ha, including the average area of agricultural land of 28.5 ha. The number of large farms (with an area of land, used for agriculture, over 500 ha) is increasing significantly – in 2020 the number of such farms was 0.6 thousand, or about 1%; yet they coped with 610.4 thousand ha, or about 30% of the land [1]. Such expansion and intensification of production requires also the development of the tractor fleet as the main means of technical production. Many scientists have focused on the survey of farmers of the EU countries on the research of the tractor park structure, labour costs, performance, optimal working modes, fuel consumption and other characteristics [3]. It has been established that in the period from 2014 to 2020 the most investments (40.3%) would likely to be invested in machinery, and 39.2% of the total investments in machinery – in the purchase of tractors. A methodology for determining the reduction of the greenhouse gases, emitted as a result of the modernization of the tractor fleet, was developed in study [4]. It has been estimated that the total emissions by the tractor fleet as a result of modernization in Latvia in 2010, compared to 1996, decreased by approximately 47%. The authors of study [5] found out the most popular brands of tractors in the Czech Republic, the age structure of the tractor fleet, and determined also the cyclicity of the number of tractors sold over the years. The age structure of the tractor fleet in Estonia, the operating and repair costs, depending on the age and brand of tractors, are discussed in studies [6; 7]. A characteristic of Polish farms and the tractor fleet is shown in articles [8; 9], where it was stated that in 2018 the average farm area was 9.8 ha and the average tractor power was 45.3 kW. There are shown also changes in these indicators by region and year. The age structure of the Latvian tractor fleet, the technical condition, energy supply of farms of various sizes in $\text{kW}\cdot\text{ha}^{-1}$ are discussed in publication [10]. In article [11] it has been stated that in Australia farmers often choose too large tractor power, a similar trend is often observed in Latvia.

Methods for determination of the operation and repair costs of tractors are analysed in publication [12]. A calculation methodology of the tractor fuel consumption for various load modes is presented in study [13]. The authors of publication [14] have conducted experiments in 13 fields throughout the territory of Italy for four years; then by collecting and analysing the extensive material they developed an innovative method how to determine the operating costs of the machinery. All the studies mentioned are topical, they tackle questions about the structure and technical condition of the tractor fleet in the region, the tractor selection criteria for specific conditions, a methodology for calculation of the fuel consumption and operating costs, the greenhouse gas emissions, etc. operating parameters. However, these studies do not cover the issue of the performance and adequacy of the country's total tractor fleet for timely agricultural work in the context of the increase in the sown area and the amount of production, mentioned at the beginning of the chapter. Therefore, it would be useful to assess whether the development of the tractor fleet is appropriate for timely performance of the increased field work. Several authors [15, 16] believe that a criterion for the assessment the adequacy of the performance of the tractor fleet can be the ratio of the total power of the engines of the tractor fleet to the area to be harvested, or the specific power in $\text{kW} \cdot \text{ha}^{-1}$, but the increase in the total power of the tractor fleet should precede the increase in the sown areas. To determine these indicators, the capacity of each registered tractor, the age structure of the tractor fleet, the technical condition, the most common tractor brands, as well as the sown area in each year of the period must be ascertained. The authors also analyse the total capacity changes of the tractor fleet over the period by years. The aim of the study is to find out the dynamics of the total and specific power growth of the tractor fleet over a ten-year period, and, in comparison with the growth dynamics of the sown areas, to evaluate the sufficiency of the power of the tractor fleet for timely treatment of the areas. By analysis of the obtained data one can predict the possibility of timely execution of operations and the necessity to renovate the tractor fleet.

Materials and methods

The trade of tractors manufactured in the European countries began in the second half of the nineties with granting state subsidies for purchase of machinery, yet intensive modernization of the tractor fleet took place after joining EU in 2004 – due to the availability of structural funds the purchase of modern tractors increased significantly. The sale of the machinery produced in the Commonwealth of the Independent States (CIS) practically ended at the beginning of the 2000s, with the exception of the Belarus tractors, manufactured in Belarus, certified in accordance with the EU requirements, sold in Latvia until 2022. The purchase of new tractors by year is shown in Table 1.

Table 1

Purchase of new tractors in a period of ten years

Brand of the tractor	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
John Deere	28	57	105	113	91	70	62	74	110	83	793
Valtra	41	51	62	78	84	83	64	71	112	96	742
Claas	14	33	41	61	89	84	86	117	111	102	738
Belarus	91	70	69	78	89	88	19	24	3	-	531
New Holland	53	21	20	81	67	48	55	47	64	69	525
Case IH	13	20	31	42	50	39	40	50	49	51	385
Fendt	6	18	23	28	36	18	30	26	51	36	272
Massey Ferguson	11	28	30	36	29	37	34	16	34	16	271
Deutz-Fahr	4	14	16	33	39	27	31	27	22	16	229
The rest over 74.5 kW	5	4	7	11	11	18	17	14	18	25	132
In total	266	316	404	561	585	512	438	466	574	494	4617

As evident in the table, 4617 new tractors were purchased during ten years, or an average of almost 462 new tractors per year. The table comprises data only about tractors with a capacity of more than 74.5 kW because tractors of the companies shown in the table with a smaller capacity are practically not purchased for agriculture (except for Belarus); besides, the tractors with a smaller capacity are used only for auxiliary work on the commodity-producing farms. As evident, the most popular tractors,

manufactured in the EU countries, are John Deere, Valtra and Claas. They are purchased by about half of the total. Tractor purchases by year depend mainly on the amount of subsidies granted. The brand, model, number and engine power of all the new tractors purchased each year can be found in the register of the State Technical Supervision Agency (STSA) [17]. When processing these data, the total power of all the tractors of one brand is initially calculated, then by summing the power of all brands – the total power of the tractor park. The calculations assume that the amortization period of tractors is 15 years and that all the tractors purchased since 2014 are working. The total capacity of the fleet of tractors was reduced by 7.5% to allow replacement (depreciation) of the worn-out tractors, and it was increased by 10%, which could roughly describe the working capabilities of the worn-out tractors, manufactured in the CIS countries and still used on small farms or for auxiliary work in the commodity-producing farms. Similar calculations were made for the used tractors purchased in the respective years. The performance impact of the large number (about 77,000) of aging tractors, manufactured in the CIS countries in the STSA register, the youngest of which are about 30 years old, was evaluated, as mentioned above, by increasing the total capacity of the tractor fleet by 10%. In order to be able to carry out timely the field work, the increase in the total capacity should outpace the increase in the sown areas. The specific capacity of the tractor park is obtained by applying the total capacity of the fleet of tractors to the sown area. As already mentioned, several authors [15; 16] propose to use the specific power as a criterion to evaluate the adequacy of the performance of the tractor fleet. By analysing the obtained data, it is possible to judge about the renovation sufficiency of the tractor fleet.

Results and discussion

The total number of registered tractors is increasing every year since in the recent years 450-550 new and several hundred used tractors are purchased annually. At the end of 2023., according to STSA data [17], there were 103,706 tractors in the inventory. The existing registration procedure allows a large number of used tractors to be in the register, without imposing any obligations or liabilities on the owner. The distribution of registered tractors by age groups is shown in Figure 1.

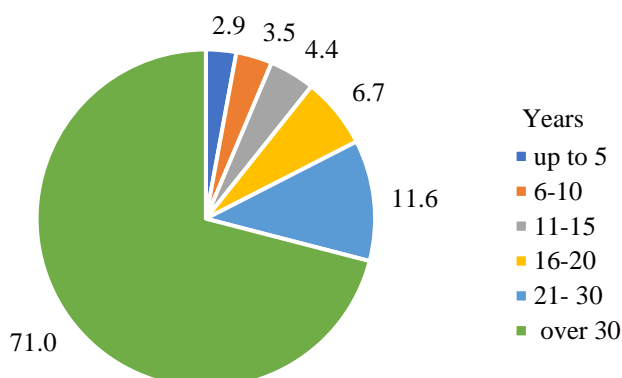


Fig. 1. Distribution of registered tractors by age groups, %

71% of the tractors are older than 30 years, most of them in this age group are up to 1994 produced obsolete MTZ, T-40, T-25 and similar low-powered brands. The performance of these tractors is not essential, some of them are used on small backyard farms or for auxiliary work on larger farms. The performance of this group and other tractors with high wear and tear is evaluated in the following calculations with a 10% increase in the total power, justified by the methodology. The age group up to 30 years includes 29.1%, up to 20 years – 17.5%, up to 15 years, which is most often accepted as the amortization period of the tractor, – 10.8% or 11,200 tractors. Taking into account the sown area [2], the cultivated area for one tractor in the age group up to 15 years in 2023 was 116.5 ha, The tractors of this set, equipped with modern machinery, ensure the production of most goods. The existing registration procedure – not excluding obsolete tractors from the register – does not give an objective picture of agricultural energy supply and makes it difficult to compare the characteristics of the Latvian fleet of tractors with the data of the Czech Republic, Estonia, Poland [5; 7; 9] and other countries. As a result of the existing tractor registration procedure the number of tractors has already exceeded 100 thousand. As a result, the average age of the fleet increases and the technical condition deteriorates,

creating a wrong idea about the energy supply of agriculture. In 2023 in technical order there were 32.2% of the registered tractors, including 90.6% in the age group 1-5 years, and in the age group over 30 years – 18.9%. These indicators have not changed significantly over a ten-year period.

Along with the age structure and technical condition of the tractor fleet, the performance of the fleet is also characterized by the total power of its engines. According to the methodology this indicator may be viewed together with the sown area of agricultural crops in the corresponding year. Changes in the total capacity of the tractor fleet, the sown area of agricultural crops and the specific capacity over a period of ten years are shown in Figure 2.

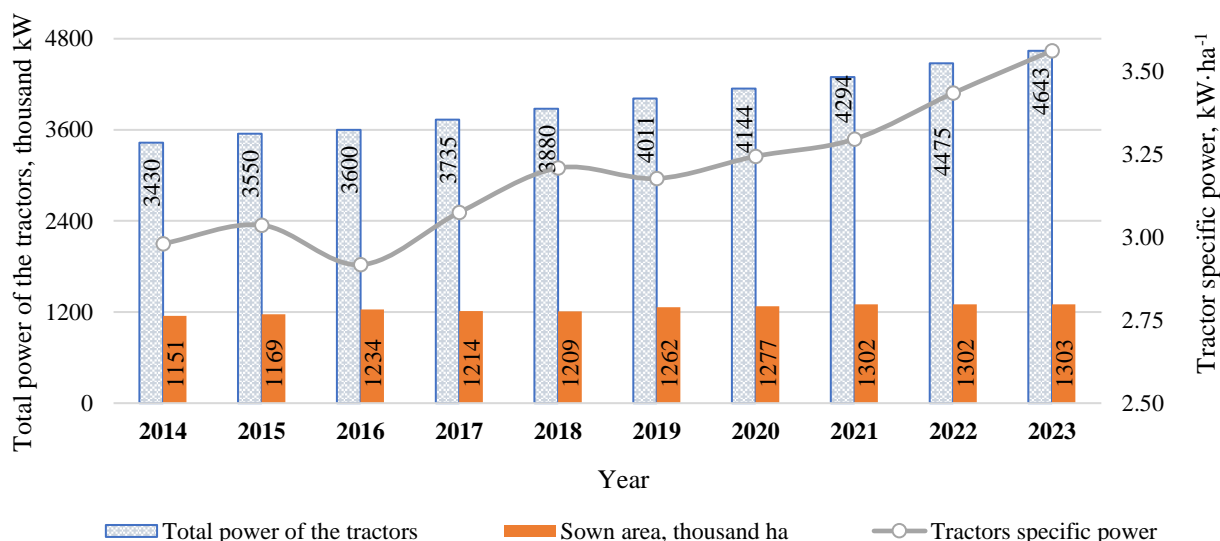


Fig. 2. Changes in total capacity, specific capacity and sown area of agricultural crops of the tractor fleet in 2014-2023

During the period the sown area has increased by 13%, while the total capacity of the tractor fleet has increased by 35%. A pre-emptive increase in the total capacity, compared to the increase in the sown area, allows the work to be carried out in shorter agrotechnical terms, which is important in the increasingly extreme climatic conditions. In contrast to the previous period - 2005-2014, according to the data [16], the growth rate of the total power, compared to the sown area, has increased almost twice. This can be explained by the relatively intensive purchase of new tractors during the period (an average of 462 per year) and the increase in the average power of the purchased tractors. When evaluating these indicators, it should be taken into account that production also increased during the period - the average total harvest of cereals and rapeseed increased approximately 1.7 times in contrast to the previous ten-year period. An increase in the total capacity affects the performance of the tractor fleet less than the performance of combines.

Several authors [15; 16] use the specific power, which is obtained by dividing the total power of the tractor fleet by the sown area of agricultural crops in the corresponding year, as an indicator characterizing agricultural energy supply. This indicator increased from 3.0 to 3.6 kW·ha⁻¹ during the period (see Fig. 2). The indicator is relatively high because in the previous study [10] it was established that in Latvia it is 1.3-4.1 kW·ha⁻¹, depending on the size of the farm. The indicator decreases as the area of the farm increases because on larger farms the machinery is used more intensively. On the other hand, the authors of article [15] indicate that in the European countries this indicator, depending on the size of the farm, is 1.1-8.1 kW·ha⁻¹. High energy security allows shortening the deadlines for work, but at the same time increases the prime cost of products.

Considering the sufficiency of the total capacity of the tractor fleet to process the growing sown areas and production volumes, it can be concluded that the increase in capacity significantly outstrips the increase in sown areas – 35% against 13%. The specific power has also increased by 20% during the period. Consequently, the increase in total and specific capacity exceeds the increase in cultivated areas, which allows to increase the performance of the tractor fleet and shorten the agrotechnical deadlines for carrying out the field work.

Evaluating these results together with publication [18], which examines the development of the tractor park in 2001-2014, it can be found that the growth rates of the cultivated areas gradually decrease over a period of more than 20 years but the growth rates of the total capacity of the fleet of tractors increase. In [3] the established trend - to invest intensively into the purchase of new tractors – indicates that the increase in the total capacity will continue. However, the amount of land that can be used for agriculture is not increasing, so the intensity of the increase in the cultivated areas will continue to decrease in the future, as its use is limited by the requirements of several EU directives in addition to the local conditions. Therefore, an intensive increase of the performance or total capacity of the tractor fleet is not justified; this process can be regulated by the amount of subsidies for the purchase of tractors.

Conclusions

1. The age group up to 15 years includes 10.8% of tractors, 75% of them are in technical order; the tractors of this group, complete with modern equipment, ensure the production of the majority of products.
2. The existing procedure for registration of the tractor machinery – without excluding obsolete and used machinery from the register – does not give an objective picture of the technical condition of the tractor fleet and the energy supply for agriculture.
3. The advanced growth of the total capacity of the tractor fleet, compared to the growth of the sowing area, increases its performance, compensates for the growth of the sowing area and the total harvest, and allows the work to be carried out in shorter agrotechnical terms.
4. Also in the future the total capacity of the tractor fleet is expected to increase at approximately the current pace but the growth rate of the sown areas will decrease; therefore the issue is debatable of the amount of subsidies for the purchase of new tractors.

Author contributions

Conceptualization D.V., methodology D.V. and A.R.; investigation A.R. and D.V., writing – review and editing D.V. and A.R. All authors have read and agreed to the published version of the manuscript.

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