INVESTIGATIONS IN SUITABILITY OF FLEET OF COMBINES FOR TIMELY HARVESTING

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Abstract. The article offers an analysis about the suitability of a fleet of grain combine harvesters in the years 2001-2015. There are combine harvesters of the most widespread brands registered in Latvia determined. The age structure of all the registered combine harvesters is analysed dividing them into age groups. The average age of a combine harvester in 2015 was 23.2 years, 18.3 % combine harvesters were less than 15 years old. In 2015 33 % of the registered combine harvesters were in technical order. The registration procedure allows that a great number of the used combine harvesters are still in the register. A methodology has been developed for estimation of the number of combine harvesters that are sufficient for timely harvesting of the areas under cereals and canola. The methodology is based on calculation of the summary capacity of the engines of the fleet of combines by years and its comparison with the increase in the area under crop and the total yield by years. After the mutual dependence had been evaluated, it was established that the increase in the summary capacity of the fleet of combines allows timely harvesting the essentially increased area under crop, achieving twofold increase in the total yield and shortening the harvesting time at the end of the period in comparison with the beginning. The estimate does not consider the climatic conditions during the harvesting period. As the growth in the areas under crop and the total yield is expected also in the future, the renewal of the fleet of combines should be continued at the present rate – by purchasing, on the average, of 80 to 100 new combine harvesters every year.

Keywords: grain combine harvester, engine capacity, areas under crop, harvesting duration.

Introduction

The areas under cereals and canola are growing in Latvia. In the period from the year 2001 till 2015 they have increased from 452.1 to 761.4 thousand ha [1]; there is an essential increase also in the total yield which, on the whole, raises requirements for the harvesting machines, too. Data about the registered combine harvesters by their brands and models, data about the technical inspections of combine harvesters, as well as data about the new combines purchased during a year by their brands and models have been registered every year by the State Technical Supervision Agency (STSA) [2]. In Latvia and the East European countries investigations are conducted about the age structure of tractors and capacities needed for timely completion of operations on the farms of various size [3-6]. However, there are no up-to-date studies and data about the age structure of the fleet of combines, their development dynamics and use on the farms, as well as about the capacity of combines sufficient for harvesting the growing areas under cereals. The purpose of the article is to estimate the age structure of the fleet of combines, to work our a methodology, and to compare the dynamics of the growth of the areas under cereals and canola with the dynamics of the growth of the capacity of the fleet of combines in order to judge about the sufficiency of the capacity of the fleet of combines for timely harvesting, and about the sufficiency of the renewal rates of the fleet, or the need to increase them.

Materials and methods

Trade in the agricultural machinery produced in the European countries started in Latvia since 1996 when subsidies were established for agricultural production, including for the purchase of the machines. At the beginning of the 1990-ties, machines, made predominately in the CIS countries, were purchased, though at a gradually diminishing rate, including the grain combine harvesters. At that time a certain part of agricultural machines were manufactured by the local enterprises as well as within the framework of the Regional Machine Building Programme, the Ministry of Agriculture. Yet, before the beginning of the second millennium the number of the combine harvesters released in the countries of Europe was small. Table 1 shows the changes in the number of the most widespread brands of combine harvesters registered in Latvia in a 15-years' period. Niva SK-5, Jenisej-1200 and Don-1500 are combine harvesters made in the CIS countries, which were sold in Latvia up to the year 1992, whereas Claas, John Deere and New Holland are the most popular combine harvesters produced in the European countries. Their ratio in the total number of the registered combines, which are made in the European countries in various years, is 74-87 %.

Table 1

Changes in the number of the most widespread brands of registered combine harvesters in a 15-year period

Brand of the combine	2001	2005	2010	2015
Niva SK-5	2208	1935	1852	1658
Jenisej1200	1116	1108	1106	1042
Don1500	197	185	179	170
Claas	108	323	476	668
John Deere	37	127	212	290
New Holland	17	89	162	258
Other combines	1632	1905	2273	3420

As it is evident from the data of the table, there is gradual increase in the number of combine harvesters released in the European countries, yet the number of the combines made in the CIS countries, the newest of which have run more that 20 years, has not essentially changed (except NIVA SK-5). Besides, most of the registered combine harvesters produced in the European countries are purchased as new, therefore, they are in technical order, and it can be supposed that they are harvesting absolutely most of the areas under cereals and canola during the recent years. In their turn, the contribution to harvesting of the combine harvesters produced in the CIS countries annually decreased in this period due to their aging, and it is insignificant in the recent years, although they are not excluded from the register. This creates a situation that the number of the registered combine harvesters was 7506 in the year 2015 but in technical order there are only 33 % of them. The age structure of the combine harvesters, using the STSA register data, is analysed in the following section.

As some authors [7; 8] state, an indicator of the sufficiency of combine harvesters for timely and quality harvesting might be the specific capacity $kW \cdot ha^{-1}$ of their engines. Yet, in order to find out the specific capacity, one should know the summary engine capacity of all the combine harvesters operating in a particular year. It is not possible to clarify this figure from the available register data because it is not known how many of almost 3000 registered combine harvesters, made in the CIS countries, are in technical order and are running. Along with the 1445 new combines, there are also purchased approximately 1000 used combine harvesters in the considered period, which are released in the European countries and the technical condition and operational capability of which are unknown as well. However, it is possible to detect from the STSA data the brand, model, number and the engine capacity of the combine harvesters purchased every year. Therefore, it is also possible to estimate the summary capacity of the yearly acquired combine harvesters. It is further assumed that all the new combine harvesters purchased since 2001 are in working order and operating, i.e. their depreciation period is 15 years. Knowing that in the year 2001 all the area under crop was harvested, the capacity of the annually acquired new combine harvesters should ensure that at least the annual increase in the area under crop is harvested and even surpassed by 7-8 % in order to replace the combine harvesters worn out during 15 years with new ones.

As 80.5 % (on the average) of the nine brands of the new combine harvesters bought in a 15-years' period are combines of three brands – Claas, John Deere and New Holland, then, in order to diminish the amount of work, the STSA register data are used to determine the capacity of these three brands, assuming that the capacity of the remaining brands is similar. The quantity and capacity of every brand and model of the combine harvesters mentioned here is recorded for each year, the total capacity of the new combine harvesters of the corresponding brand is calculated, as well as the average estimated capacity of one new average combine in the respective year. Multiplying the average estimated capacity by the quantity of the new combine harvesters purchased in a year, we obtain the summary capacity of all the new combine harvesters acquired in the country in the corresponding year. The estimated summary capacity is reduced by 7.5% to ensure replacement (depreciation) of the combines which have been in operation for 15 years but increased by 10%, which characterises approximately the area harvested by the unregistered combine harvesters. As already mentioned, this summary capacity should ensure harvesting of at least the annually increased area under cereals and canola.

Results and discussion

The number of combine harvesters in the years 2001-2015 has increased from approximately 4.5 to 7.5 thousand. In this period the agricultural farms have bought altogether 1445 new combine harvesters of various brands and capacities, or, on the average, 96 combine harvesters a year. But during the last seven years there are acquired 111 new combines, as well as a certain number of used combines every year [2]. Approximately 77.2 % of the combines registered in the STSA database are older than 20 years because, as evident in Table 1, exclusion of the worn-out combines (Niva SK-5, Jenisej-1200, Don-1500) from the register takes place at a minimal rate – much slower than registration of the new combine harvesters. Distribution of combine harvesters by age groups in the years 2011 and 2015 is shown in Fig. 1.

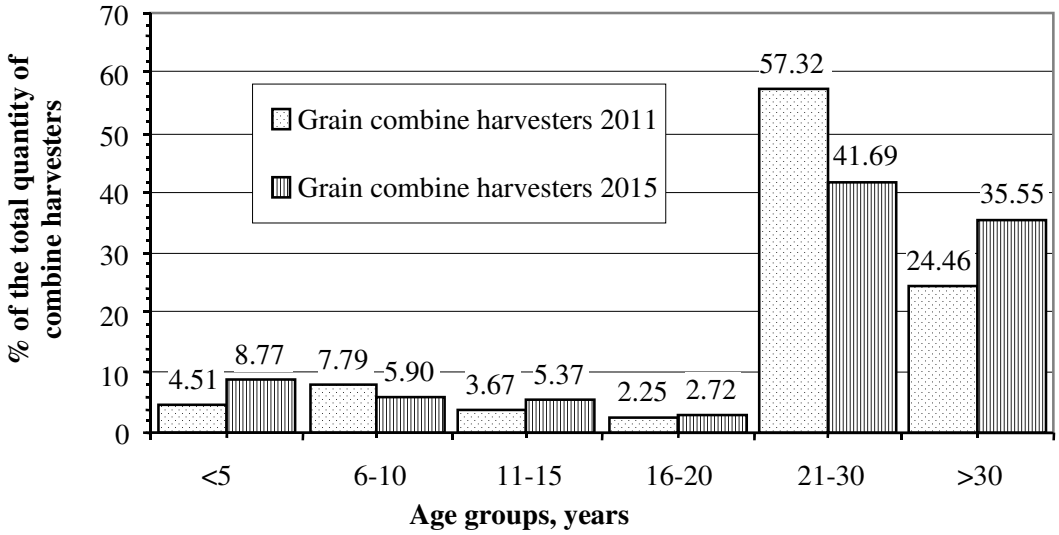

Fig.1. **Distribution of combine harvesters by the age groups**

As it is evident, the age structure has changed minimally during five years in connection with more intense acquisition of new combines during the recent years. In 2015 the number of combines has increased a little in the age group to five years, as well as in the groups altogether – to 20 years. In 2015 only 18.3 % of the registered combine harvesters were newer than 15 years, which would be considered as the depreciation period of the combines. In 2015 the average estimated age of the combines was 23.1 years. Apparently a similar situation will continue – by buying new combines the quantity of the combines will gradually grow but their average age will also increase because for the owner of the combine its exclusion from the STSA register will be connected with a certain waste of means and time whereas its being in the register does not impose any liabilities.

Alongside with the age structure of the fleet of combines, it is important to estimate the suitability of the summary capacity of the engines for harvesting the areas under cereals and canola. As it was mentioned in the previous section, in some publications the specific capacity $kW \cdot ha^{-1}$ of the engines is considered as an indicator for the sufficiency determination of combines for timely and quality harvesting, which is calculated dividing the summary capacity of the engines of the fleet of combines by the summary area under cereals and canola in the respective year. Some authors [6] are of the opinion that in the East European countries a sufficient specific capacity of the engines of the fleet of combines is 0.18 $kW \cdot ha^{-1}$, in the industrially developed countries of Europe with small farms it is 0.32-0.40 $kW \cdot ha^{-1}$. [7], in his turn, has found out that on the farm of Latvia the average specific capacity of the fleet of combines in the years 1982-1985 was 0.80 $kW \cdot ha^{-1}$. In considering this indicator, one should take into account the fact that the quality of the combine harvesters produced at that time was low, and there were frequent technical failures.

In order to establish changes of the specific capacity $kW \cdot ha^{-1}$ of the fleet of combines within the discussed period, the total engine capacity of the combine harvesters, existing in the year 2001 in technical order, was established according to the above described methodology, and the total engine capacity of the new combines acquired from 2001 till 2015 was registered every year. Summing these capacities in ascending order, we obtain the summary capacity of the fleet of combines by years,

which, divided by the summary area under cereals and canola, produces the specific capacity kW· ha^{-1} of the fleet of combines in the specific year. In a graphical form the changes of the specific capacity in a 15 years' period are shown in Figure 2.

As it is evident, the specific capacity has increased from 0.39 to 0.64 kW· ha^{-1}, or more than 1.6 times. Such an increase cannot be explained only by the increased quantity of the acquired new combine harvesters; their number during the last seven years is growing a little more intensely than at the beginning of the period, yet in long term it is relatively stable – the average quantity of combine harvesters purchased a year is 96 combines. The essential increase in the period can be explained by the average estimated changes of the engine capacity of one new combine purchased in the years 2001-2015 (Fig. 2).

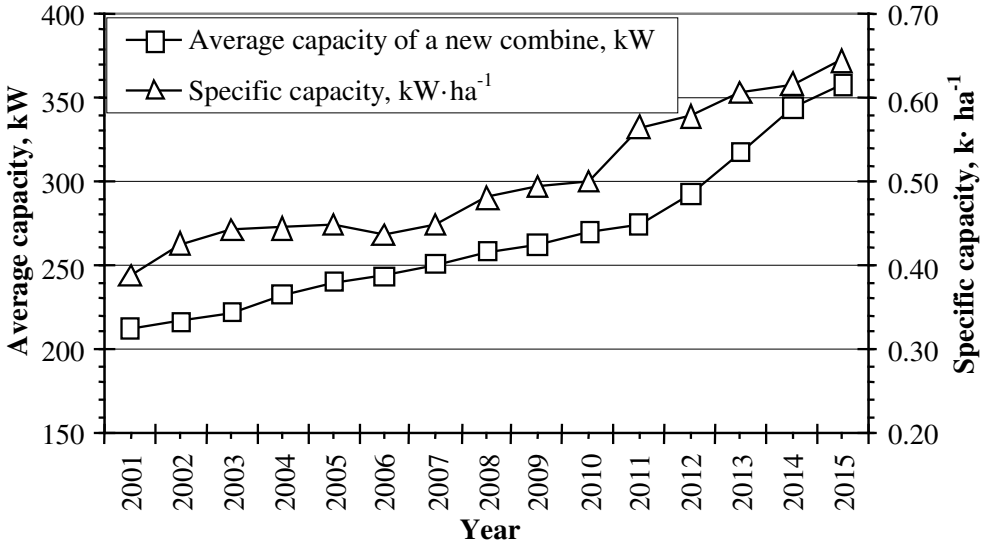

Fig. 2. **Changes of the specific capacity of the fleet of combines and changes of the average capacity of a new combine in the years 2011-2015**

During 15 years this capacity has grown from 212.0 to 358.2 kW, or almost 1.7 times, i.e. the average engine capacity of the new combine harvesters bought in 2015 has been 358.2 kW. Consequently, the increase in the average and the specific engine capacity of a new purchased combine harvester is almost proportional, which explains the increase in the specific capacity. Therefore, analysis of the provision of the specific capacity allows an optimistic prognosis about the possibilities of timely harvesting.

Fig. 3, in its turn, reflects an increase in the areas under cereals and canola as well as an increase in the summary engine capacity of the operating combine harvesters by years.

In the period from 2001 till 2015 the area under cereals and canola has grown from 452.1 to 761.4 thousand ha, or approximately 1.7 times; and, at the same time, the summary engine capacity of the operating combine harvesters has increased from 175.8 to 489.7 thousand kW, or 2.8 times. This points to a possible essentially greater increase in the summary capacity of the combines and, hence, also productivity in comparison with the increase in the areas under crop. Consequently, judging by these indicators, the duration of harvesting at the end of the period should become shorter, which is confirmed also by the increase in the specific capacity mentioned above.

However, it is important that the crop capacity has increased, as well as the total yield of cereals and canola – in the period from the year 2001 till 2005 the average annual yield was 1118.9 thousand tons but in the period from 2011 till 2015 2421.4 thousand tons – had grown more than two times. Such an increase in the amount of the harvested grain, in its turn, diminished the possible efficiency of the fleet of combines approximately 1.5 times [9].

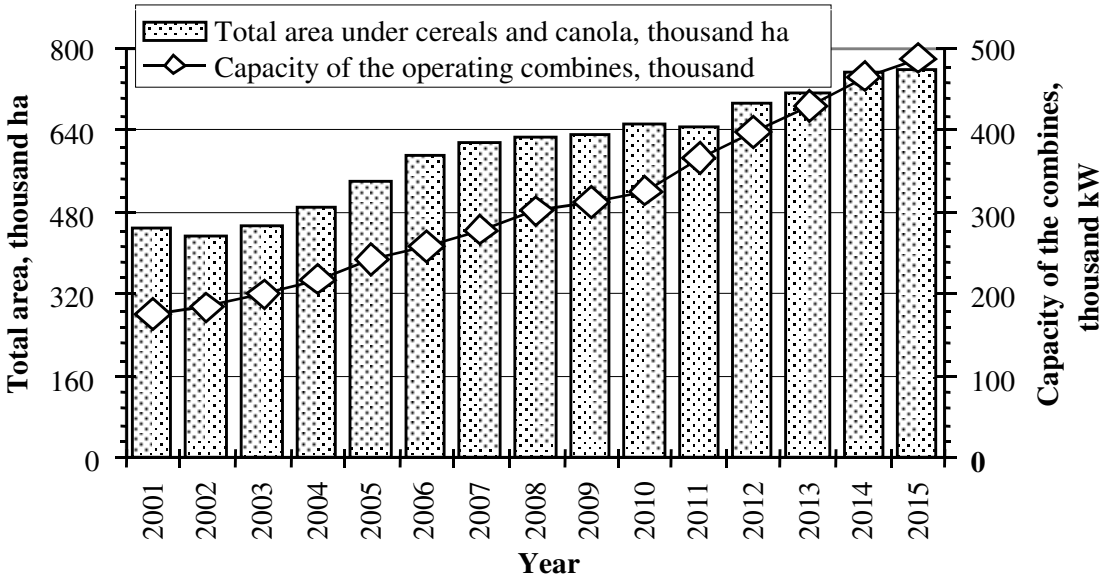

Fig. 3. **Changes of the total areas under cereals and canola and the capacities of the operating combine harvesters in the years 2001-2015**

Judging by the impact of the four analysed factors – the area under crop, the total yield, the increase in the specific engine capacity of the combine harvesters and the summary engine capacity of the fleet of combines – upon the duration of the harvesting period, one can draw a conclusion that the increase in the engine capacity of the fleet of combines compensates the increase in the areas and total yields or provides a possibility to shorten the harvesting time a little in the period from 2011 till 2015 in contrast to the period from 2001 till 2015. Theses estimations do not consider differences in the climatic conditions in the harvesting period in various years. As it is expected that the areas under crop and the total yields will increase still further, the renewal of the fleet of combines should be continued at the present rate – acquiring 80-100 new combine harvesters every year. It is expected that a steep engine capacity increase of the new combines will not go on because the leading manufacturers have updated the most powerful models during the recent years, and their production in the present embodiment will continue five or six years.

Conclusions

1. The average age of combine harvesters is 23.1 years because the registration procedure allows being of a great number of worn out combines in the register.
2. In 2015 there were 33 % of the combine harvesters in technical order, mainly purchased after the year 2000 from the EU countries, which are harvesting absolutely the greatest part of the areas under cereals and canola.
3. The increase in the summary capacity of the combine engines 2.8 times in a period of 15 years provides a possibility of timely harvesting the area under canola and cereals, which has increased 1.7 times in this period and the total yield which has increased more than two times.
4. As an increase in the areas under crop and the total yield is expected also in the future, the renewal of the fleet of combines should be continued at the present rate – purchasing, on the average, 80 to 100 new combine harvesters every year.

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