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THE USE OF TRACTOR AGGREGATES ON A MEDIUM-SIZED FARM IN ARABLE PRODUCTION

Ranko Koprivica[1], Biljana Veljković[1], Radmila Žugić[2], Marija Gavrilović[1], Goran Dugalić[1], Bojana Milenković[3], Dragan Terzić[4]

Abstract: The intensity of use and work output of tractors and implements were investigated using the example of a medium-sized family farm. The farm is located in central Serbia and cultivates 44 ha of arable land for livestock farming. The farm has 3 tractors, 22 attachments, a self-propelled combine harvester for harvesting small grains, and a combine harvester for silage preparation. In the 2021/22 production year, the tractors were used for a total of 376.92 hours, namely 170.58 hours for the FIAT 78 tractor, 144.17 hours for the IMT-539, and 62.17 hours for the IMT-558. Tractors and attachments were most frequently used to produce wheat (10 h ha^{-1}), silage maize (9.94 h ha^{-1}), soybeans (9.72 h ha^{-1}), oats (9.17 h ha^{-1}), barley (8.58 h ha^{-1}) and grain maize (8.17 h ha^{-1}).

The greatest engagement of mechanization was in basic tillage 31%, pre-sowing preparation with a rotary harrow 25%, and the least in spreading mineral fertilizers, protecting plants from diseases, and pests, and destroying weeds 8% of the total working time.

Keywords: family farm, engagement, tractors, attachment machines

Introduction

The high cost of purchasing modern agricultural machinery and the low intensity of use on small plots of land affect their economic profitability. In Serbia, many family farms use tractors, attachments, and harvesting machines that are technically over 30 years old. A two-axle tractor with an average engine power of 32.27 kW (43.52 hp) is used for 421 hours per year to cultivate 6.99 ha of land with 5.89 attachments (Radivojević 2014, Tot and Nikolić 2016, Koprivica et al. 2021, Koprivica et al. 2023).

Rational use of tractors and attachments can be achieved through a greater scope of use, planned sowing, harmonized agricultural techniques, and the

[1]University of Kragujevac, Faculty of Agronomy, Cara Dušana 34, Čačak, Serbia (biljavz@kg.ac.rs)
[2]University of Kragujevac, Faculty of science, Radoja Domanovica 12, Kragujevac, Serbia
[3]University of Pristina Kosovska Mitrovica, Faculty of Agriculture, Kopaonicka bb, Lešak Serbia
[4] University of Niš, Faculty of Agriculture, Kosančićeva 4, Kruševac, Serbia

organization of work on the farm. One of the ways is to join machine groups, rings, and cooperatives, as proposed by Veljković et al. (2020), Tot and Nikolić (2016).

The research aims to show the intensity of the use of mechanization in agricultural production and to calculate the impact of the use of tractors and attachments on a medium-sized family farm. On this basis, a recommendation can be made for the purchase and further equipment with new machines.

Materials and methods

The family agricultural farm "Đurković" is located in the village of Čestin in the municipality of Knić, and in terms of the size of the cultivated land, it belongs to medium-sized farms. It cultivates a total of 44 ha of land, divided into 37 plots with an average size of 1.12 ha. Agricultural production is organized on an area of 14.7 ha in 14 plots with an average size of 1.05 ha. The most common crop is maize on an area of 12 ha, of which 9 ha are used for grain and 3 ha for silage, followed by barley (2 ha), wheat (2 ha), soybeans (1.5 ha) and oats (0.7 ha). Forage crops include fodder turnip on an area of 0.4 ha, alfalfa on 5 ha, and artificial meadows on 20 ha. Crop production is tailored to the needs of livestock farming and the feeding of 18 dairy cows and 13 fattening steers. In terms of sowing structure, 33.41 % or 14.7 ha is devoted to arable crops, 65.67 % or 28.4 ha to forage crops (silage maize is classified as a forage crop), and 0.4 ha or 0.92 % of the total area to vegetable crops.

Based on the measurement of working time by chronography and chronometry, the total operating time of tractors and attachments as well as the consumption of machine working hours per unit area was calculated for each crop in the 2021/22 production year. In addition, the total seasonal use of tractors and attachments for agrotechnical work in the production process of the above-mentioned crops was determined. The work output of tractors with attachments (h/ha) was also calculated. To compare the results obtained, data from literary sources published by foreign and domestic authors were used. The medium size of the average farm corresponds to the classification of Todorović, (2017).

Results and discussion

In the analyzed period 2021/2022, the following agricultural machinery was used in field production on the farm: 3 two-axle tractors IMT 539 (29.5 kW),

IMT 558 (42.6 kW), FIAT 78 (57.33 kW), 22 attachments, as well as a small grain combine Zmaj 133 and silage combine Klass Jaguar 70 SF, which are over 40 years old, were used.

On the farm, the average power of the tractor engine is 41.4 kW, and with 7.33 attachments, 14.67 ha are cultivated with an energy output of 2.94 kW/ha according to the studies by Koprivica et al. (2023). In crop production, the working hours were determined according to farm size, sowing structure, number, and category of tractors and implements which are shown in Table 1.

Table 1. Total hours of tractor and attachment use during 2021/2022 production year on the farm

Crops	Surface (ha)	Tractor working hours (h)			Total (h)	Tractor operation (h/ha)	Numb. of plots
		FIAT 78	IMT-539	IMT-558			
Wheat	1.5	10.67	3.83	0.5	15	10	2
Barley	2	12.33	4.5	0.33	17.17	8.58	2
Oats	0.7	4.83	1.17	0.42	6.42	9.17	1
Maize for grain	9	43.67	25.83	4	73.5	8.17	5
Maize for sillage	3	16	13.83	27.5*	29.83	9.94	3
Soybean	1.5	10.17	3.66	0.75	14.58	9.72	1
Totals field crops	17.7	97.67	52.83	6	156.5	8.84	14
Fodder turnip	0.4	11.25	4.67	7	22.92**	57.3**	1
Alfalfa	5	14.17	19.17	11.67	45.10	9.23	6
Meadows	20	47.5	67.5	37.5	152.5	7.62	15
Total	43,1	170.58	144.17	62.17	376.92	8.72	37

**Without time to trample the maize silage of the IMT-558 tractor*

***Time spent mowing, collecting, pressing the green mass of fodder turnip, transporting it to the barn and fresh distributing it every day for feeding cattle.*

In the production of field crops in 2021/22, all three tractors worked a total of 156.5 hours on the Farm. The FIAT 78 tractor was used the most for 97.67 hours, followed by the IMT-539 for 52.83 hours, and the IMT 558 for at least 6 hours. In the 2021/22 season, the total engagement of tractors was 376.92 hours, namely: 170.58 hours FIAT 78, 144.17 hours IMT-539, and 62.17 hours IMT 558 (Table 1).

Research by Škaljić et al. (2017) shows that tractors with 38-66 kW are used for less than 100 h in 23 % of cases, for 100-200 h in 43 % of cases, and more than 200 h in 34 % of cases, which is also confirmed by the individual uses of the tractors in Table 1. The use of FIAT tractors 78 is close to the results of 180 operating hours of a 34.8 kW tractor reported by Stojnović et al. (2001).

In the production of 1.5 ha of wheat, the tractors were used for a total of 15 hours or 10 h ha^{-1}, which is more than the results of Janković (1989) 8.12 h ha^{-1}, Bošnjak et al. (1998) 7.03 h/ha, Obradović and Kresović (1988) 6.56 h/ha, Beck et al. (1988) 8.52 h ha^{-1}, Tot and Nikolić (2016) 8 h ha^{-1}, Koprivica et al (2021) 7.41 h ha^{-1}. The total use of tractors on the Farm in the production of field crops on an area of 17.7 ha is 156.5 h or 8.34 h ha^{-1}, which is in agreement with the results stated by Mago (2009) 8-10 h ha^{-1}, and Tot and Nikolić (2016) 8,7 h ha^{-1}.

The use of tractors and attachment on the Farm by work operations and their chronological order is given in Table 2. Work processes were monitored from their preparation on the economic yard, execution on the plot, and return to the Farm.

Table 2. The work output of tractors and attachment on the Farm by field crop operations in 2021/2022. year

Work operation	Total working time (h)	Work output (h ha^{-1})	Tractor used
Plowing	47.83	2.69	FIAT 78
Soil preparation with rotary harrow	38.67	2.17	
Application of mineral fertilizers	12.42	0.35	IMT-539 Basic fertilization and feeding
Application of pesticides	12.75	0.36	
Sowing	24.83	1.40	
Transportation of grain and silage	8.83	0.74	IMT-539 IMT-558
Pressing, loading, transport, unloading, stacking of roll bales	11.17	0,63	FIAT 78 IMT-558
Total	156.5	8.34	All tractors

In the 2021/2022 production year at the farm, the FIAT 78 tractor was predominantly engaged in basic tillage, specifically using a three-furrow rotary plough for 47.83 hours, accounting for 30.56% of the total operational time. Notably, various studies by Obradović and Kresović (1988), Barać et al. (2013), Kovačev et al. (2013), and Koprivica et al. (2021) indicate that tractors are commonly employed in basic tillage operations. The work output of 2.70 hours

per hectare in ploughing, surpassed the findings of Kovačev et al. (2013) but fell short of the results reported by Barać et al. (2013), Obradović and Kresović (1988), and Koprivica et al. (2021). It's important to note that these variations may stem from the distinction between effective work and total work.

In the pre-sowing soil preparation phase, the FIAT 78 tractor utilized a Lemken rotary harrow for 38.67 hours, representing 24.71% of the total operational time. The work output was 2.17 h ha^{-1}, slightly below the reported by Kovačev et al. (2013).

For sowing maize and soybeans, a four-row pneumatic Nodet seeder was employed, while small grains were sown using a mechanical seeder IMT 632. The IMT 539 tractor was engaged for a total of 24.83 hours (15.86%), producing an output of 1.4 h ha^{-1} which is more compared to research by by Obradović and Kresović (1988), Barać et al. (2013), Kovačev et al. (2013), Tot and Nikolić (2016).

The IMT 539 tractor, equipped with the Agrex spreader, operated for 12.42 hours (7.94%) and achieved an output of 0.35 hours per hectare. It's worth noting that this output exceeds the effective work reported by Obradović and Kresović (1988).

The IMT 539 tractor and Crocus sprayer were used for plant protection and weed destruction for 12.75 hours or 8.15% of the total working time. The stated results are lower than the results reported by Koprivica et al. (2021) and higher than the results of Obradović and Kresović (1988).

The results of the research in the paper differ from the results of other authors due to: different technical and operational characteristics of attached machines, tractor power, applied agrotechnics in the production of field crops, distance from the farm, size of the plot, conditions of clima, and type of soil, as well as applied research methods. It can be concluded that the family farm is equipped with agricultural machinery, but the problem is their age and insufficient utilization.

Conclusion

The tractors were used on the farm for a total of 376.92 hours in the 2021/22 production year. The FIAT 78 tractor worked a total of 170.58 hours for the seasonal tasks of plowing, tilling, baling, collecting, unloading, and stacking bales. The IMT-539 (144.17 hours) and IMT-558 (62.17 hours) tractors were used for simpler tasks such as sowing, fertilizer application, transport, hay preparation, and protection against diseases, pests, and weeds. The work output of the tractor is 10 h $ha^{-1}$for wheat production, 9.94 h ha^{-1} for silage

maize, 9.72 h ha^{-1} for soybeans, 9.17 h ha^{-1} for oats, 8.58 h ha^{-1} for barley, and 8.17 h ha^{-1} for grain maize.

The analysis of the use of mechanization on the Farm showed that tractors and attachment achieved lower effects than potential due to the size of the property. The increased scope of use is possible by increasing the holding, buying, or leasing land, as well as providing mechanization services to other users.

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