

## TECHNICAL EQUIPMENT WITH MECHANIZATION ON MEDIUM-SIZED FAMILY FARMS

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**Abstract.** *The work investigated the equipment of tractors, attachments and combines in a medium-sized family farm. The research was conducted on the registered family farm "Đurković" in the village of Cestin in the municipality of Kruš. The farm cultivates arable and forage crops for feeding dairy cows and fattening oxen on an area of 44 ha. In the sowing structure, meadows are the most represented with 20 ha (45.45%), alfalfa 5 ha (11.36%), silage maize 3 ha (6.83%) and perko 0.4 ha (0.91%). The farm also grows barley on 2 ha, wheat on 1.5 ha, soybeans on 0.7 ha, oats on 0.4 ha, and peppers for processing on 40 ares. The production process is carried out with three tractors, 22 implements, a self-propelled combine for small grains and a combine for silage. One tractor with an average engine power of 41.4 kW works 14.67 ha of available land with 7.33 attachments. The total available power of the tractor engine is 129.43 kW, and the energy equipment of the farm is 2.94 kW/ha, which is the average of family farms in Serbia. If the combine engine power for small grain and silage were added, the energy equipment would increase to 7.85 kW/ha. Combines are underutilized because they are used only for subsistence. The average age of mechanization is over 40 years, so replacement and purchase of new agricultural machinery is not possible.*

**Key words:** *Family farming, sowing structure, equipment and mechanization level.*

### 1. INTRODUCTION

The development of agriculture in Serbia, the economically successful production of arable crops, especially in the hilly areas, depends largely on the equipment of productive farms with modern means of mechanization. According to data from the Register of Agricultural Holdings, maintained by the Agricultural Payments Directorate of the Ministry of Agriculture, there are 466,000 agricultural holdings in Serbia, of which 462,000 are family farms. Agricultural production takes place on an area of 2,816,424 ha of usable land. According to research [1, 2], most of the production of basic agricultural products is realized in family farms. The high percentage of small family farms, low use of agricultural technology, outdated mechanization and low percentage of irrigated land

have a strong impact on the economic results of these farms. From the point of view of rational use of agricultural mechanization and successful organization of agricultural production, land holdings are considered small if they are less than 30 ha, and medium if they are 30 to 200 ha [2, 3].

The registered farm "Đurković" is engaged in agricultural production for livestock needs and cultivates 44 ha. According to the cultivated area, it is one of the medium-sized farms in Serbia. The 20 ha of land they own is not enough to provide enough fodder for domestic animals, so they are forced to lease another 24 ha of land. Out of a total of 1,513 selected farms in Vojvodina, 31% produce on an area of more than 40.01 ha [4]. The aim of the study is to show the sowing structure, technical equipment with mechanization and to analyze the energy equipment and labor input in a medium-sized farm.

## 2. MATERIALS AND METHODS

The research was conducted using the case study method on the example of a medium-sized registered family farm from the village of Čestin, 12 km from Knić and 20 km from Kragujevac, which belongs to the Šumadija region. Four generations with a total of eight household members aged 2-72 years live on the farm in the family house. All work related to fodder production and livestock breeding on the farm is performed by five family members. The basic income of the farm is generated not only by farming, but also by the additional work of three family members.

Basic data about the farm were collected on site, based on which the following were determined: the existing level of mechanization, the available land and the sowing structure. Other data mentioned in the paper were obtained from the official data of the Institute of Statistics of the Republic of Serbia and from the book of the Agricultural Census 2012 of the Republic of Serbia. Based on the above statistical data, the average area of agricultural land available to a family farm in Serbia was calculated, as well as the number of tractors and implements. In addition, data from literary sources published by domestic and foreign authors were used.

## 3. RESULTS

The family farm "Đurković" owns a dairy farm with 18 cows of Simmental breed, 5 calves and 8 fattening steers. All the fodder needed for feeding the cattle is produced on the farm on an area of 44 ha. Annually, about 360 bales of meadow and alfalfa hay, 135 tons of corn silage, 42 tons of grain corn, 14 tons of small grain, and about 2 tons of soybeans are processed (Table 1). There are facilities for bulk storage on the farm: two silos for preservation and storage of silage from the whole corn crop, and storage rooms for storage of hay and grain crops. From 2022, the farm started organized production of peppers on an area of 40 hectares. An average farm in Serbia has 4.48 ha of agricultural land divided into 5 plots of 90 ares each. For the production of coarse and grain fodder for livestock feeding, the farm cultivates 44 ha of land. The available arable land is divided into 37 plots, so the average area of a plot is 1.19 ha. The two largest plots of 2.5 ha are planted with corn and meadows. By landholding size, the farm belongs to

the medium size farms in Serbia and is larger than the farms in Montenegro, where the farm size is 4.60 ha, Greece (6.4 ha), Portugal (8 ha), Italy (9.3 ha), Western Turkey (10 ha), Spain (22 ha) and Germany (28.9 ha), and smaller than the farms in Great Britain, where the farm size is 109.7 ha. A similar farm structure of land ownership is found only in France (44.8 ha) [5, 6, 7, 8, 9, 10].

Table 1. Sowing structure and average yields

Crop	Area (ha)	Number of plots	Total production (t)	Participation in crop rotation %
Sown meadows	20	15	100	45.45
Corn for grain	9	5	42	20.45
Alfalfa	5	6	70	11.36
Maize for silage	3	3	135	6.83
Barley	2	2	6	4.54
Wheat	1.5	2	6	3.41
Soy	1.5	1	3	3.41
Oats	0.7	1	2	1.59
Perko	0.4	1	12.5	0.91
Vegetables and economic yard	0.9	1	10	2.04
Total / Average	44	37		100

In the sowing structure, forage crops are the most represented with 65.67% or 28.4 ha, followed by arable crops with 33.41% or 14.7 ha, and vegetable crops the least with 0.4 ha or 0.91% of the total area. For bulk forage production, 20 ha (45.45%) of meadows were sown on 15 plots, followed by 5 ha (11.36%) of alfalfa on 6 plots, 3 ha (6.83%) of silage maize on 3 plots and 0.4 ha or 0.91% of sorghum (Table 1). To ensure a sufficient amount of green bulk, forage peas and sorghum were also sown on the farm during the last production year, in addition to the crops mentioned above. In addition, perko is sown on an area of up to 1 ha each year, which is used as green fodder for the cows. Field crops are grown on an area of 14.7 ha. Grain maize is grown the most on 9 ha, barley on 2 ha, soybeans and wheat on 1.5 ha each, and oats the least on only 0.7 ha. Crop production is a function of animal production, ensuring high quality and cheap food for feeding domestic animals on the farm. In this way, the products of crop production are marketed in the form of milk and meat.

The equipment of the farm with tractors and suitable implements depending on the assortment is determined by many factors: the size of the land, the nature of the terrain, the structure and volume of production, the economic strength of the farm and the machinery available on the market. In order to better compare and assess the level

of agricultural machinery equipment, the tables provide an overview of the number of tractors and implements in the studied area and on the farm.

According to the 2012 agricultural census in the Republic of Serbia [11], the total number of two-axle tractors used on family farms is 410,894 tractors, of which 94.87% are older than 10 years. In addition to tractors, farms own 2,421,065 implements, 93% of which are older than 10 years (Table 2).

In the region of Šumadija and Western Serbia, 262,940 family farms are registered, which have 1,865,957 ha and own 149,401 two-axle tractors (0.56 tractors/farm), of which 95.84% are older than 10 years. In the Šumadija region, there are 26,941 registered farms with an available area of 151,922 ha and 19,198 two-axle tractors (Table 2). In the territory of Knić municipality, there are 3,941 registered farms cultivating 24,211 ha of available land with 3,218 two-axle tractors, of which 3,135 are older than 10 years. In the village of Čestin, there are a total of 174 registered farms and 140 two-axle tractors cultivating a total of 1,276 ha of available land (Table 2).

Table 2. Condition of tractors and harvesters in the researched area

Area	Total number of farms	Available area	Number of two-axle tractors	Number of grain harvesters	Number of silage harvesters
Republic of Serbia	631,552.00	5,346,596.52	410,894.00	19,474.00	10,788.00
The Šumadija region and Western Serbia	262,940.00	1,865,957.69	149,401.00	4,943.00	5,573.00
Šumadija region	26,941.00	151,922.74	19,198.00	967.00	955.00
Municipality Knić	3,941.00	24,211.40	3,218.00	168.00	200.00
The village Čestin	174.00	1,276.01	140.00	5.00	4.00

From the above statistical data, it can be concluded that in the Šumadija region family farms own 0.71 two-axle tractors/farm and that one tractor cultivates 7.92 ha of available land. The situation is similar in the area of Knić municipality: 0.83 tractors/household and 7.52 ha per tractor. In Čestin municipality, the average household owns 0.80 tractors and thus cultivates 9.11 ha of available land.

In terms of the number of tractors per farm, this is more than in Hungary (0.25), Kosovo (0.43), Portugal (0.51), Italy (0.59), Serbia (0.64), Poland (0.77) and less than in Montenegro (0.84), Turkey (0.99), Austria (1.32), Slovenia (1.47), France (1.58), United Kingdom (2.05), and Croatia-Osijek Baranja County (3.3) [5].

The farm has full mechanization for the production of forage and field crops, so the processes of forage production are fully mechanized. The farm has 3 two-axle tractors: IMT 539, IMT 558 and FIAT 78. It can be seen that domestically produced tractors of Belgrade IMT factory dominate (66.66%), which produced these tractors in the eighties of the last century. The factory has very old tractors and machines that are over 40 years old. The tractors IMT 539 and IMT 558 were purchased in 1979 and have been in use on

the farm for more than 43 years, while the tractor FIAT 78 from 1989 was purchased used in 2015 (Table 3).

Table 3. Numerical condition and age of tractors on the Farm

Serial number	Manufacturer	Number of pieces	Engine power kW	Year of production	Age of the tractor (years)
1.	IMT-539	1	29.5	1979	43
2.	IMT-558	1	42.6	1979	43
3.	FIAT-780	1	57.33	1989	33
Total average	-	3	129.43/41.14	-	119/39.67

In Serbia, more than 95% of tractors are older than 10 years [8]. In comparison, 91.8% of registered tractors in Croatia are older than 10 years, and the average age of tractors in Slovenia is 21 years. In Hungary, the average age of tractors was 18.3 years by 2013 and 12 years in 2016. In Turkey, 54% of tractors are older than 24 years, and in Western Turkey, only 12% of tractors are older than 20 years. In Montenegro, 52% of tractors are older than 20 years, and 8.4% are younger than 10 years [5, 12].

Table 4. Numerous condition and age of self-propelled harvesters

Serial number	A type of harvester	Combine harvester manufacturer	Engine power kW/HP	Year of production	Age of the machine (year)
1.	Combine harvester	DRAGON-133	55	1978	44
2.	Silo combine	CLASS JAGUAR 70 SF	161	1981	41

In addition to the tractors, the farm also has a Zmaj-133 self-propelled universal forage harvester for harvesting small grains with its own 55-kW engine and a Klass Jaguar 70 self-propelled silage forage harvester SF with a 161 kW engine. As for the tractors, the age of the Zmaj-133 harvester is over 44 years and the age of the silage harvester is 41 years (Table 4). The Class Jaguar 70 SF self-propelled silage harvester, manufactured in 1981 and acquired in 2021, worked only on 3 ha on its own property when preparing silage from the entire corn crop. Until last year, a single-row Lipham 30 silage chopper was used for processing silage from the entire corn plant on the farm, but due to the low output, a self-propelled chopper with a larger capacity was purchased.

In the Republic of Serbia, family farms are not sufficiently equipped with two-axle tractors, only 0.64 tractors per farm. With a two-axle tractor with an average engine power of 32.27 kW (43.52 HP), 6.99 ha of land are cultivated with 5.89 implements. The power equipment of family farms in Serbia is 2.89 kW/ha, and the average age of tractors is 17.5 years. The average annual use of tractors on family farms is 421 hours [8, 13].

Table 5. Energy equipment of the farm with machinery

Equipment (unit of measurement)	Tractor (pc)	Total engine power (kW)	Cultivated area (ha)	Power equipment (kW/ha)	Number of connected machines per tractor (pc)	Cultivated area per machine (ha)
Tractors	3	129.43	44	2.94	7.33	14.67
Small grain harvester	1	55.00	14.7	1.68	-	14.70
Soybean and corn harvester						
Harvester for corn silage	1	161.00	3.0	53.67	-	3.00
Total/Average	3+2	345.43	44	7.85	22/7.33	

On the studied medium-sized family farm "Đurković", one tractor with an average engine power of 41.4 kW with 7.33 implements cultivates 14.67 ha of available land. It can be seen from Table 5 that the total power of the tractor engine is 129.43 kW and the energy equipment of the farm is 2.94 kW/ha, which is the average for family farms in Serbia. However, if we take into account the combine engine power for small grain and silage, the energy endowment of the farm increases to 7.85 kW/ha. Analyzing the seasonal power and harvested area in the production year 2021/2022, we conclude that the combine harvesters were underutilized, as they were used only on the farm's own land (Table 5).

According to research [14], a medium-sized farm in Vojvodina owns 3.25 tractors with an average engine power of 62.50 kW and energy equipment of 2.2 kW/ha. One tractor manages on average 28.38 ha with 4.46 machines. The data provided by the authors do not match the results presented in this paper.

An overview of the number of attached machines in Serbia as well as in the Šumadija region and western Serbia, the municipality of Knić and the village of Čestin, is provided in Table 6.

Table 6. Number of attached machines in Serbia in relation to the village of Čestin

Area	Republic of Serbia	The region of Šumadija and Western Serbia	Šumadija region	Municipality of Kuis	The village of Čestin
Plows	336,928	118,046	16,379	2,653	125
Subsoilers	14,440	2,697	688	17	0
Crushers	3,364	562	130	8	0
Plows	146,647	51,968	9,273	1,702	76
Harrows	218,161	86,796	12,596	2,021	71
Sowing preparation	60,453	9,042	1,070	241	7
Tillers	36,685	21,797	1,789	149	2
Mineral fertilizer spreaders	95,378	24,206	5,143	906	28
Manure spreaders	13,371	4,334	438	73	2
Liquid manure spreaders	13,629	6,344	519	71	8
Planters	114,710	35,250	4,970	823	25
Sprinklers	138,084	45,890	5,502	944	29
Trailers	298,667	98,560	12,116	1,822	70
Mowers	148,191	74,151	9,119	1,792	76
Hay collectors	92,686	42,758	6,889	1,342	49
Balers	46,706	21,324	3,340	657	26
Total	1,778,100	643,725	89,961	15,221	594

For comparison, in Vojvodina, the energy endowment of the private sector is 3.54 kW/ha, and a tractor with an average power of 40 kW covers 15.83 ha of agricultural land. In America, the use of mechanical tractor power is 0.783 kW/ha, in Europe 0.694 kW/ha, in Turkey 2.42 kW/ha, in Kosovo 2.55 kW/ha, in Poland 4.9 kW/ha [5, 8, 9, 15]. In Serbia, a two-axle tractor with an average engine power of 32.00 kW (43.52 HP) cultivates 6.99 ha of land with 5.89 implements per tractor. In Turkey, one tractor covers 7.26 and in Montenegro 1.85 implements [6,8,10].

The numerical status of all connected machines owned by the farm is shown in Table 7.

Table 7. Numerous state of attached machines on the Farm

Type of machine	Manufacturer	Required tractor power kW/HP	The year of production	Age of the machine (year)
Plow turners (three furrow)	HUARD 265	57/78	1995	27
Plow turner (double furrow)	IMT 565	29.5/39	1990	32
The saucer	Lemund Leskovac 24	29.5/39	1980	42
A harrow	IMT	29.5/39	1980	42
Rotary harrow	LEMKEN	57/78	1990	32
Artificial fertilizer spreader	Aggres	29.5/39	2017	5
Manure spreader	WELGER LS300	42.6/58	1993	29
Seeder for small grains	IMT 632	29.5/39	1985	37
Pneumatic seed drill for hoes	NODET	29.5/39	1994	28
Rotary mower	KUHN	29.5/39	1998	24
Roller press	WELGER RP12	42.6/58	1999	23
Tedder - hay collector	IMT	29.5/39	1998	25
Tedder - hay collector	Pottinger	29.5/39	2001	12
Singlerow silage harvester	Lipham-30	29.5/39	1986	37
Tank for liquid manure	KAISER	42.6/58	2000	22
Sprinkler system	CROCUS	29.5/39	2019	3
Mixer trailer	Trioliet Gigant 500	IMT 558	2002	20
Tractor front loader for large bales	Calvet	FIAT	1996	27
Trailer for roll bales	Own production	IMT 558	2019	4
Trailer	IMT	IMT 539	1979	44
Hydraulic crane-loader	Donder	IMT 539	2008	15
Tractor rear loader for manure	Ferocoop	IMT 539	2012	11

In Latvia, the average tractor power is 63 kW, and the energy equipment of farms up to 50 ha is 3.1 kW/ha, i.e. 4.3 tractors per 100 ha. The average age of tractors is 23.7 years, with 48% of tractors being 21-30 years old [16].

Based on the number of implements and available power per unit area, the farm is well supplied with tractors. However, considering the age structure of the tractors and the area cultivated by the farm, there is a need to purchase a newer tractor with power greater than 90 kW, a chisel plow with rollers (Germinator), medium-heavy disk harrows, a seeder, and a seedbed.

From the previous analysis, it is clear that the gradual replacement of agricultural machinery and the purchase of new means of mechanization in the farm is necessary, for which significant financial resources are required.



#### 4. CONCLUSION

The "family farm "Đurković" belongs to the medium-sized farms in Serbia, measured by the size of the cultivated area. The main activity of the farm is the production of coarse and granular fodder for feeding cattle on an area of 44 ha, of which 20 ha are owned. On the available land in the production year 2021/22. In 2008 were sown: meadows (20 ha), grain corn (9 ha), alfalfa (5 ha), silage corn (3 ha), barley (2 ha), wheat and soybeans (1.5 ha each), oats (0.7 ha), perko (0.4 ha) and peppers (0.4 ha). Three tractors (IMT 539, IMT 558 and FIAT 78), 22 implements, a self-propelled grain harvester and a silage harvester are used for forage production.

One tractor with an average engine power of 41.4 kW works 14.67 ha of available land with 7.33 implements. The power equipment of tractors on the farm is 2.94 kW/ha, which corresponds to the average equipment of family farms in Serbia. The average age of the machinery is over 40 years.

Considering the age structure of tractors and the area cultivated by the "Đurković" farm, gradual replacement is required. On the farm cultivated area it is necessary to gradually replace and acquire new agricultural machinery, especially tractors with higher power, chisel plows, medium-heavy disk harrows, seeders for planting seedlings and seedbeds.

**Acknowledgement:** This work was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia, Contract No. 451-03-47/2023-01/200088 and 451-03-47/2023-01/200383.

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