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ASSESSMENT OF THE QUALITY OF THE WORK OF TRACTOR AGGREGATES DURING BASIC TILLAGE

SUMMARY

A plow is a tool used to perform basic cultivation of soil in order to restore the arable soil layer. The quality of its execution is one of the most important factors that ensures the stable production of plant crops. With a well-executed basic tillage, the same plot is of the appropriate structure, which implies minimal energy consumption for pre-sowing preparation.

The research was conducted in field conditions, and it included basic parameters that were an indicator of the productivity of machine and human work. The Zetor Forterra tractor has an installed power of 100.02 kW and is in operation for the first time.

The goal of the research is to examine the possibility of adjusting basic parameters in order to increase the quality and productivity of work.

The results obtained in this research indicate that despite the good conditions of exploitation of tractor aggregates, the effects that should be provided by new, modern mechanization during intensive production have not been achieved in practice.

It is necessary to pay special attention to parameters such as: coefficient of utilization of the work scope, shift efficiency, and productivity of machine and human work.

Keywords: Plow, basic tillage, tractor, productivity, application in practice

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INTRODUCTION

As with other agrotechnical operations, more efficient use of resources is necessary during basic tillage. Plowing is done with ploughs, which can be: field plows, disc plows, rotary plows, vibration plows, etc. The most widely used in practice is the field plow, which cuts and crushes the soil horizontally and vertically with the help of a plowshare and colter.

When using a field plow, the cut strip (furrow or plastic) moves along the plow board and twists due to the movement of the plow, and eventually falls due to its own weight, causing the soil to overturn, mix and crush. Of all agrotechnical measures, plowing consumes 50-55% of total energy and time, which makes basic tillage the most demanding operation, both in terms of the required power and the resources invested (Fanigliulo et al. 2016; Jugovic et al. 2020). The increased resistance of the plow is influenced by negative resistance components whose forces often lead to deviations from the linear movement of the tractor and changes in its trajectory (Troyanovskaya et al. 2017).

Key technological changes in today's global agriculture include: mechanization, seeding, and increased use of synthetic fertilizers and pesticides (Gathorne-Hardy 2016). According to statistical estimates, 792,000 hectares of agricultural land, 576,000 hectares of arable land could potentially be cultivated in Republika Srpska, and the rest consists of orchards, vineyards and meadows (RS development strategy, 2021). There are around 377,819 ha of agricultural land in the Republika Srpska, of which 201,428 ha or 53.31% are under arable land (SGRS, 2022). From the above mentioned, the need arises for the maximum optimization of the operating parameters of the plow unit in order to maximize performance and quality of work.

A prerequisite for optimal use of the tractor user has both economic and technical foreknowledge. Emphasis on the tractor is given for a reason since the tractor is main source of energy for working with attachment machines and tools and also has great universality of application, so that economic justification depends on it (Nadykto et al. 2016). Tractor fuel consumption is a significant parameter which shows performance of the tractor in a plowing operation (Troyanovskaya, 2014).

One of the problems of using a tractor in modern agricultural production is the lack of research and scientific results that are related to the way of optimal utilization of traction energy potential of the tractor in the conditions of exploitation (Nadykto et al. 2017). Optimization of the necessary power in a plowing operation can be achieved by improvement of adhesion of the tractor to the soil which is achieved by adjusting the plow aggregate using the „push-pull" principle (Bulgakov et al. 2017).

Although the development of plows has been going on for hundreds of years, there is still room for improvement in exploitation. The goal of the research was to determine and show the basic operating parameters of the plow unit which consists of a tractor „ZETOR Fortera 135/13441.23" and rotary plow „Akpil KM 80".

MATERIAL AND METHODS

The plowing was done on 21st March of 2022 on the plot of the experimental-educational center of the Faculty of Agriculture in Aleksandrovac, which is located between the Banja Luka-Gradiška highway and the M16 road. The size of the plot was 16,83 ha, and geographical location coordinates (44°58′21,17″ N i 17°18′09,44″ E). Corn was used as a previous crop on the plot, there were not many harvest residues on the surface. The soil was moderately moist, the average temperature was 4oC and did not drop bellow 0 °C and wind gusts reached 8 m/s.

Table 1.Technical specifications of tractor

ENGINE	Engine type, stage III A	Zetor 1605
	Power, ISO 2000/25 (*kW/KS*)	100,2/136
	Number of cylinders	4
	Nominal number of revolutions (*o/min*)	2200
	Engine displacement (cm^3)	4156
	Maximum torque (*Nm*)	581
TRANSMISSION	Number of gears (*forward/reverse*)	24/18
	Maximum movement speed (*km/h*)	40
	RPM PVT (*o/min*)	540/1000
HYDRAULICS	Lifting powers on levers (*kN*)	77
	Pump capacity (*l/min*)	70
	Number of connections	6+1
DIMENSIONS	Mass (*kg*)	5950
	Wheel base (*mm*)	2490
	Fuel tank volume (*l*)	180

Figure 1. Tractor ZETOR Forterra 1605

Figure 2. Plow turner Akpil KM80

Table 2. Technical specifications of the plow

Number of plow bodies	3
Type	turner
The distance between the plow bodies (*cm*)	102
Frame height (*cm*)	82
Working engagement of plow bodies (*cm*)	35/50
Mass (*kg*)	1080

The tractor ZETOR Forterra 1605 with 135 horsepower, i.e. 100.02 kW (power according to ISO 2000/25) was used as the traction-drive unit (Fig.1, Tab.1). The tractor is equipped with front 420/70R24 and rear 520/70R38 tires. The weight of the tractor is 5950 kg. A three-bladed plow turner manufactured by Akpil-Poland, model KM80, was used as a working attachment. The plow is set to a working reach of 135 cm, i.e. 45 cm per plow body (Fig.2, Tab.2). The tractor and the plow are owned by the faculty, the tractor was used for the first time (1 MČ), i.e. it was purchased for the needs of the experimental educational center Aleksandrovac. The plot was processed by one worker-operator of the unit in one shift that lasted 10 hours. The compaction of the soil was analyzed based on the collection of data on the resistance of the cone penetration into the soil, volumetric mass and current soil moisture (Molnar et al. 2015, Ćirić et al. 2012, Ćirić et al. 2016). Soil compaction was measured using an electric penetrometer Eijkelkamp Penetrologgers with a diameter of 11.28 mm, the tip of which is at an angle of 60^o. Recording of soil compaction was performed in 10 repetitions at two depths 0.05 m and 0.10 m and was expressed in Pa. Compacting the soil results in an increase in the volume of the soil, which leads to greater resistance of machines during soil cultivation and resistance to the growth of the root system, which absorbs food and water more poorly, which has a negative impact on the yield (Simikić et al. 2018).

The power is expressed according to ISO 2000/25 kW/HP the gearbox is mechanical with Power Shift technology, 24/18 multi-speed synchro -24 forward and 18 reverse speeds.

RESULTS AND DISCUSSION

The productivity of the machine unit largely depends on the coefficient of utilization of the work engagement, so the actual work engagement was measured in three passes. Based on the measurements, the values were obtained, the first passage was 1.59 m, the second 1.33 m, and the third 1.25 m. From the mentioned measurement, the average actual working reach (Br) is obtained, which is 1.39 m, from the set 1.65 m (Bt), it is smaller by 0.26 m, it can be seen that it varies by an average of 0.17 m that is 12.233 %.

The coefficient of utilization of work capacity (β) is 0,903.

The unit operator monitored the working speed during plowing (ν) in the tractor cabin and it is 9.70 km/h. The idle time (Ttp or T21) is 34.988% with a variation of 1.543 %. Turning time (T212) is 5 % with a variation of 15.28 %. Uptime (Tr or T1) is 91 % with a variation of 9.104 %. Downtime (Tto or T22) 4 % with a variation of 200 %. The above data are shown in the Figure 3.

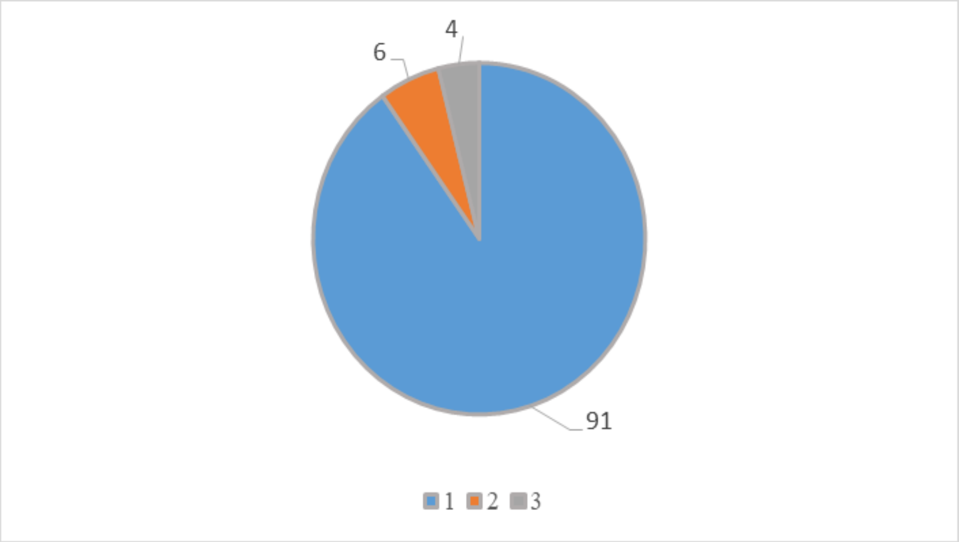

Figure 3. Turning time (1), Uptime (2), Downtime (3)

The results obtained by this research show that the training of the operator of the aggregate can significantly contribute to the improvement of the coefficient of the utilization of working time, throughthe reduction of the time spent for turning the aggregate at the gates of the plot.

Table 3. Research results

	Worth	**Deviation**
Time utilization ratio ($\tau_{pr} ili \tau_{02}$)	0,92	
Shift utilization coefficient ($\tau_{sm} ili\ \tau_{03}$)	0,92	
Shift performance ($W_{t(sm)}$)	12,413 ha/shift	
Daily performance (W_d)	12,413 ha/shift	
Fuel consumption per hour (G_r)	23,45 l/h	
Fuel consumption per area (q_g)	17,325 l/ha	
Productivity of mechanical work (M_{ha})	79.208 kWh/ha	
Productivity of living labor (H_{ha})	1,241 h/ha	
Depth of work (*a*)	0,27 m	0,018 m (7,212 %)
Soil compaction at depth of 0,05 *m*	104 Pa	52,237 (52,817%)
Soil compaction at depth of 0,10 *m*	135 Pa	43,591 (33,891%)

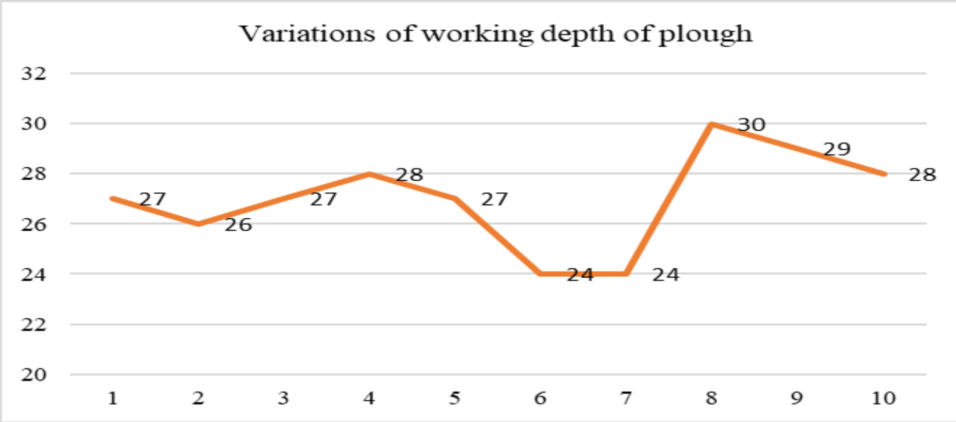

Figure 4. Variations of working depth of plought

Based on the research the results shown in table 3 were obtained. The data were obtained by measuring in three passes, and based on the measurements, the time utilization coefficient is obtained (τpr or τ02) 0.92, shift time utilization coefficient (τsm or τ03) 0.92, shift output (Wt(sm)) 12.413 ha/sm, daily performance (Wd) 12.413 ha/day. Hourly fuel consumption (Gr) was obtained by monitoring the display in the tractor cabin, and it amounted 23.45 l/h. Fuel consumption per unit area is (qg) 17.235 l/ha.

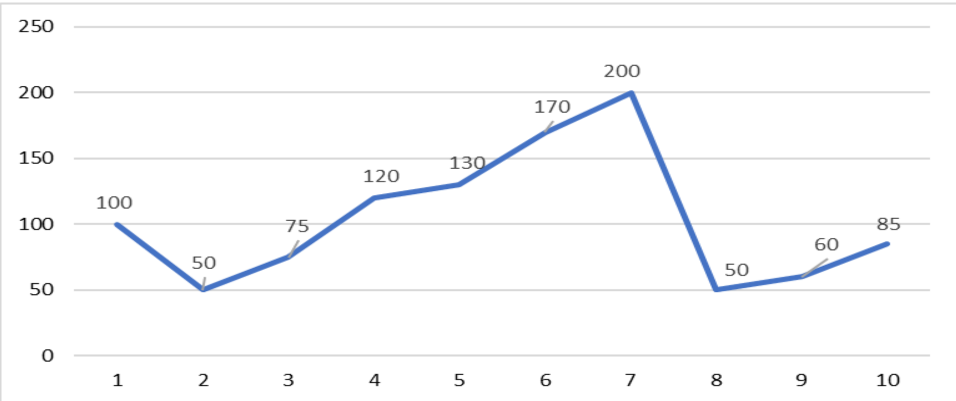

Figure 5. Soil compaction at depth 0.05 m

Based on the measured data shown in Table 3, the productivity of machine work (M ha) was calculated as 79.208 kWh/ha, as well as the productivity of live work (Hha) of 1,241 h/ha.

According to Kovačević et al. (2019) the time utilization coefficient is obtained 0.91, shift time utilization coefficient 0.91, shift output 15.365 ha, daily performance 15.365 ha, which is in line with the results of these researches.

The depth of work (a) was 27 cm, with a variation of 1.827 cm or 7.212 %. Data on the depth of work were obtained by measuring ten values at different locations. Variations of depth work are shown in the Figure 4.

Soil compaction was measured at a total of 20 positions on the plot, including measurements at two depths 5 and 10 cm (10 times each). Soil compaction varied significantly and was 104 Pa with a variation of 52.237 Pa, i.e. 52.817% at a depth of 5 cm.

At a depth of 10 cm, soil compaction is slightly more pronounced and amounts to 135 Pa, and it varied by 43.591 Pa. i.e. 33.891%. The results obtained by measuring on the plot are shown in Figure 5 and 6.

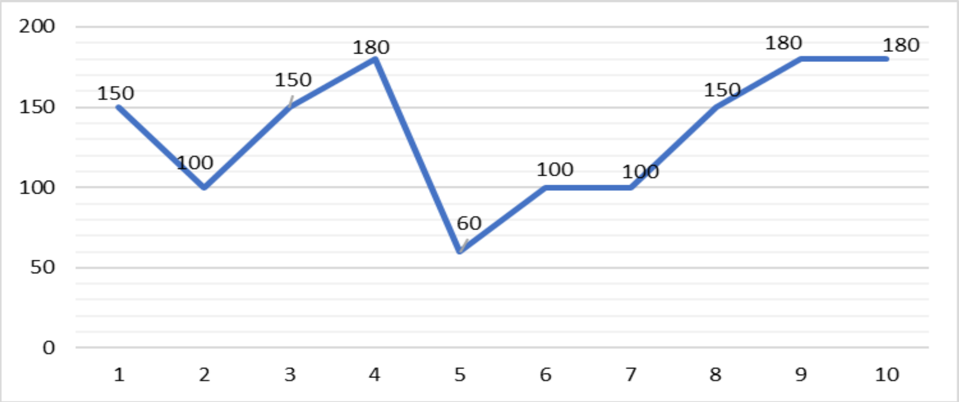

Figure 6. Soil compaction at depth 0.1 m

Soil compaction was measured in 10 repetiotions at two depths, 0,05 m and 0,10 m and was expressed in Pa.

CONCLUSIONS

The use of heavy machinery in agricultural production is necessary due to the use of the power of the tractor on the one hand, while on the other hand it negatively affects the state of soil compaction. One of the indicators of the set-up of the aggregate is the coefficient of utilization of the work engagement, which in this research was 0.903. The achieved performance is significantly affected by the working speed, which during the research is 9.70 km/h. It is to be expected that the fuel consumption tends to decrease according to the cultivated area after a certain number of engine hours, and the data obtained by measurement are 17.325 l/ha.

Examination of the quality of the unit’s operation during the exploitation of the rotary plow showed good results in terms of the shift time utilization coefficient. The obtained results indicate that despite the solid conditions for the exploitation of aggregates, the effects that should be provided by new, modern mechanization during intensive production have not been achieved. The coefficient of utilization of the shift time is significantly influenced by the training of the unit operator, since it is a new tractor, which is in use for the first time, the results achieved can be considered good. Further testing of the unit is recommended in order to optimize the operating parameters and better adapt and train the operator unit.

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