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COMPARATIVE EVALUATION OF SOME ENERGY-PERFORMANCE INDICATORS OF AGRICULTURAL UNITS FOR PLOWING

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ABSTRACT: Cultivation of agricultural production is impossible without soil-conducting operations that are associated with rational and proper selection of technological measures concerning the various factors and the specific operating conditions. In the field of agriculture various studies that aim to optimize soil cultivation processes and minimize costs have been conducted. Considering plowing as one of the founding events in almost every technology in the cultivation of crops, we will discuss and compare two agricultural units in terms of power producing. The energy assessment provides an opportunity to determine the correct choice of an appropriate agricultural unit for the specific working conditions. By evaluating the energy-performance indicators an economic assessment of the effectiveness of the process can be made.
KEYWORDS: comparative evaluation, power producing study, plowing

INTRODUCTION

Many years of research conducted in Bulgaria and other countries in the world show that a prerequisite for the creation of optimal conditions for the growth and development of agricultural crops and for obtaining stable yields is the proper implementation of deep tillage technological operation [4]. This can be achieved only when agricultural units with optimal mode of performance are suitably constructed and used, providing the necessary quality of soil treatment in compliance with the agro-technical time requirements and their specific operation at a given depth [3]. It is well-known that with the increase of the plowing depth, the operating width and speed of the soil processing units there is a significant rise of the tractive force of the working machines, as shown by formula (1) [2]:

$$R_t = k\ h\ B_p\ , \qquad (1)$$

where: R_t - is the tractive resistance of the working machine, kN;
h - the depth of the soil-cultivation, m; B_p - the operating width of the working machine, m;
K - the specific tractive resistance depending on the speed, kN/m^2

This specific tractive resistance is approximately defined by the linear dependency:

$$K = K_1\left[1 + (V - V_1)\frac{K_c}{100}\right], \qquad (2)$$

where: K_1 - is the specific tractive resistance of the working machine at speed V_1 = 1,1 till 1,4 m/s;
V - current value of the working speed , m/s; K_c - the mode of the speed increase, % [2].

Tractive resistance is not constant. It depends on the working conditions of the agricultural units and is influenced mainly by three groups of factors: soil and climate conditions (type and mechanical composition of the soil; type and current situation of the cultivated material and macro micro relief of the ground, stone and weed content on the terrain, previously cultivated crop, humidity, etc.) design and technology of the unit (type of machine, working width, number of working units, the type of the system chassis of the tractor), and technical performance of the unit (correct selection of power engine and working machine, types and methods of service and maintenance, etc.) Because of this fact the value K is calculated experimentally by conducting power producing study, using specialized measuring equipment.

The aim of this study is on the basis of the conducted comparative analyses of some power producing characteristics and performance parameters of the current plowing agricultural units in Bulgaria (tractor nominal tractive potential 30 kN T-150K and plough PP-7-25 and P-4-30 PA) and to define their effectiveness in concrete soil and climate conditions.

❖ EXPOSITION

Studies were conducted in 2006 in the experimental field of "Nikola Pushkarov" Institute of Soil Science - Sofia, and in the land of the village of Trastenik, District Rousse, on a stubble field of a previously cultivated corn crops. The soil is carbonate black earth without transverse slope of the terrain. The experiments were performed in layers from 0 to 0.60 m and soil humidity of 20.7% and in layers 0-0.40 m and hardness of 22,7 kg/cm^2, according to the specific agro-technical requirements for conducting the technological operation of deep plowing.

Both agricultural units - T-150K tractor and plough RP-7-25 have been tested (Fig. 1.) and their indicators tractive power, tractive resistance, coefficient of the engine performance load, productivity and fuel consumption per hour described.

Figure 1. Agricultural plowing units T-150K and plough PP-7-25

An ASIT-1 microcomputer system (Fig. 2.) consisting of fuel flow measuring device, a device for measuring the tractive force, a transducer for recording the revolutions of the PTO, a fifth wheel and block keyboard used for conducting tests with tractors and automobiles have been applied. All these devices have been tested before the experimental testing.

Figure 2. Parts of the ASIT-1 microcomputer system used for experimental testing of tractors and automobiles

The achieved results are processed by using the methods of mathematical analyses and the averages described in the tables and diagrams below.

❖ RESULTS AND DISCUSSION

The results of the experimental tests of the power producing indicators of the two plowing agricultural units are shown in table 1 and table 2.

Table 1. Tractive indicators of tractor T-150 K (on stubble terrain)

Tractor	At maximum tractive power Nt				At maximum tractive force		Coefficient of the tractive force x
	Working speed, V_p, km/h	Tractive force Ft, kN	Tractive power Pt, kW	Slipping δ, %	Tractive force Ft, kN	Slipping δ, %	
T-150K	I до 7,3	40	79,2	13,1	44,5	21	1,11

Table 2. Power producing indicators of the tested ploughs

№	Working machine	Tractor	Depth of the plowing, h, m	Number of working units	Working speed, V_p m/s	Tractive resistance, Rt, kN	Tractive power Pt, kW	Tractive force, Ft, kN
1	plough P-4-30PA Bp=1,2m	T-150K	0,26	4	0,95	20,89	71,65	35-38
2	plough PP-7-25 Bp=1,75m	T-150K	0,26	7	1,0	26,1	93,44	35-38

The analyses of the results of these tables show that plowing agricultural aggregate built up of T-150K tractor and plough P-4-30PA working at a depth of 0,26 m, with a working speed 0,95 m/s (3,43 km/h), has a tractive resistance of 20,89 kN at a maximum limits of 35-38 kN obtained by this tractor. In this case the coefficient of the engine load of the tractor does not exceed 60%.

Respectively in the agricultural unit consisting of the same tractor and plough RP-7-25 operating at a depth of 0,26 m with a working speed of 1,0 m/s (3,60 km / h), the existing tractive resistance is 26,1 kN at an engine load factor of 77.1%.

These results indicate that in terms of traction capabilities, T-150K tractor can be suitably assembled with both plowing units.

Judging by the values obtained from the experimental tests it can be noted that the differences in the power producing performance is a result of the difference in the working width of the two ploughs (Table 2).

From the experimental results the tractive power Pt in kW required for the execution of the operation can be calculated (3).

$$P_t = R_t V_p, \quad \text{кW} \tag{3}$$

In calculating the values of the tractive power required when working with plough P-4-30PA (in Table 2.) it is observed that the obtained power exceeds half of the eventual power producing potential of the aggregate, which is a consequence of the fact work that it operates at a smaller working width in comparison with other agricultural unit.

The achieved results of the experimental studies show that the time performance of the agricultural unit with plow RP-7-25 is Wh = 6,32 da/h, while in the second agricultural plow aggregate drawn by P-4-30PA, it is Wh = 4,12 da/h, which is less by 34.8% .

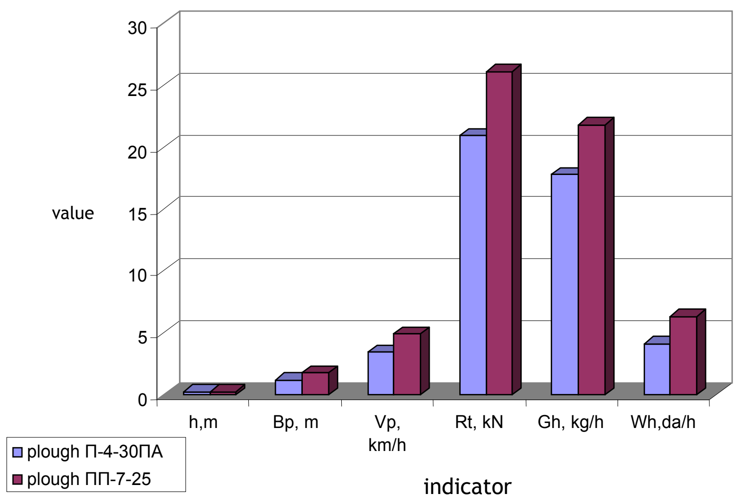

Figure 3. Values of some of the tested power producing and performance indicators

Moreover, it appears that there is a difference in the values of Gh which is fuel consumption per hour and it is accordingly Gh '= 17,8 kg/h for the first agricultural unit and Gh "= 21,82 kg/h. for the second, which indicates that the expenditure in the second unit (with a larger working width) is bigger, but only 18.4%.

The differences in the values of some of the most important power producing and performance indicators are presented graphically in Figure 3.

The main indicator for the performance evaluation of the agricultural units in terms of the amount of work realized by them is productivity, which according to Figure 3 indicates a relatively high difference in the values of the two plowing aggregates, and the advantage in this regard is for the unit combined by - T-150K tractor and plow RP-7-25.

❖ CONCLUSION

- ☐ T-150K tractor is well combined with both model ploughs, and the constructed agricultural units are properly power producing built up and provide the necessary quality of cultivation and good operating performance.
- ☐ When working with agricultural plowing unit consisting of T-150K tractor and plow RP-7-25 the requirements (depth of tillage) for conducting tillage operation on this type of soil (black earth carbonate), embedded in the technology for growing corn and industrial crops have been covered.

- A better time performance of the unit composed of plough PP-7-25 has been achieved which is more than 34.8% compared to that of the unit composed of plough P-4-30PA and tractor T-150K, with a difference in the amount of fuel consumption by 18.4% at the same quality of work.

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