MECHANISATION TECHNOLOGY IN MEDIUM SOIL SACRIFICATION AT 35 CM

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Abstract. *The mechanization technology in medium soil scarification at 35 cm was done with an aggregate made up of a Challenger MT 765B tractor and a Horsch Tiger 8 AS scarificator. Scarification is done by moving the aggregate after the swing method. Minimum parcel size should ensure working for at least one shift. Technical, technological, and economical performances of the agricultural aggregates are assessed through technical indicators (also called use indicators or operation indicators) such as cultivation depth, cultivation width, cultivation speed, traction force resistance, operation power, operation capacity, energy source load degree and fuel consumption. The mobile aggregate moves at a certain speed determined by the cultivation technology requirements of the cultivation quality and by the agricultural machine traction and operation possibilities. Real operation speed influences the quality of the cultivation. To achieve high quality cultivation, we need to observe specific operation speed (called technological speed). Soil specific resistance influences the operation capacity of the aggregates and fuel consumption per ha. On heavy soils, the operation capacity of the ploughing aggregates is 15÷30% lower than that on medium soils and 25÷30% lower than that on light soils.Scarificator coulter and chisel sharpness has a great influence on traction resistance force. Thus, changing coulter or chisel sharpness from 1 to 3.5 mm makes traction force resistance increase with up to 45%. Other factors also influence traction resistance in soil cultivation agricultural machines, such as technical state, proper assemblage of operating organs, tractor coupling, etc. Specific soil resistance influences the aggregate operation capacity and fuel consumption per ha. On heavy soils, the operation capacity of the ploughing aggregates is 15÷30% lower than that on medium soils and 25÷30% lower than that on light soils. Scarificator coulter and chisel sharpness has a great influence on traction resistance force. Thus, changing coulter or chisel sharpness from 1 to 3.5 mm makes traction force resistance increase with up to 45%. Scarification is done by moving the aggregate after the swing method. Minimum parcel size needs to ensure at least one shift. The land to be scarified needs to be divided into parcels.*

Keywords: *mechanization technology, tractor, scarificator*

INTRODUCTION

The Challenger MT-765B tractor with Challenger Powershift transmission has 16 speeds forwards ad 4 speeds backwards. Operation parameters of the Challenger MT-765B tractor are: nominal power P_m = 320 CP = 238 Kw; nominal engine speed n_m = 2100 rot/min (ω_m = 220 rad/s); nominal engine moment M_e = 108 daNm; hourly fuel consumption G_h = 46,4 kg/h =54 l/ha; specific fuel consumption g_s = 195 g/kWh; weight G = 11800 daN; engine wheel radius r = 0.762 m. *The Horsch Tiger 8 AS scarificator* is meant to aerate the soil up to 35 cm. It operates in aggregate with the Challenger MT-765B tractor. The technical features of the Horsch Tiger 8 AS scarificator are: cultivation width: 7.5 m; length: 7.95 m; maximum cultivation depth: 35 cm; weight: 7800 kg; number of aeration chisels: 33; chisel cultivation width: 23 cm; number of coulter rows: 4; coulter row distance: 23 cm; coulter distance per row: 91 cm; size of roller tire: 7.50-16; tire air pressure: 2,8 bar; pendulum traction bar; axle load: 5,100 kg; operation power: 275-385 CP.

MATERIAL AND METHOD

Machine scarification resistance force is:

$R_m = K_0 \cdot a \cdot b \cdot n = 5 \cdot 10^3 \cdot 0{,}2 \cdot 0{,}23 \cdot 33 = 8250$ daN, where: K_0 - soil resistance to scarification (on medium soil $K_0 = 5 \cdot 10^3\ daN/m^2$); a - cultivation depth ($a = 0{,}2\ m$); b - chisel cultivation width ($b = 23\,cm$); n - number of scarificator chisels ($n = 33\ buc$). *Cultivation speed.* Comparing aggregate resistance to scarification R_m and traction force F_t of the Challenger MT-765B tractor, we choose the 7th speed to scarify. Cultivation speed is: $v_l = v_t(1-\delta) = 2{,}3(1-0{,}1) = 2{,}07\ m/s = 7{,}4\ km/h$. *Operation capacity of the scarification aggregate.* Real hourly operation capacity is calculated with the relation: $W_h^r = 0{,}1 \cdot B_l \cdot v_l \cdot K_s = 0{,}1 \cdot 7{,}5 \cdot 7{,}4 \cdot 0{,}8 = 4{,}44\ ha/h$; where: B_l - operation width ($B_l = 7{,}5\ m$) v_l - operation speed ($v_l = 7{,}4\ km/h$); K_s - operation time use coefficient ($K_s = 0{,}8$). Real operation capacity per shift is calculated with the relation: $W_{sch}^r = W_h^r \cdot T_s = 4{,}44 \cdot 8 = 35{,}5\ ha/sch$. *The number of scarification aggregates* is calculated with the relation: $n_a = \dfrac{S}{W_{sch}^r \cdot n_z \cdot n_s} = \dfrac{100}{35{,}5 \cdot 3 \cdot 1} = 0{,}94$. To cultivate in 3 days, we need to use a scarification aggregate. The area to be scarified (100 ha) is 1,000 m long and 1,000 m wide. Scarification is done by moving the aggregate after the swing method. Minimum parcel size needs to ensure at least one shift. The land to be scarified needs to be divided into parcels.The number of parcels n_p is calculated with the relation: $n_p = \dfrac{S}{W_{sch}^r} = \dfrac{100}{35{,}5} = \approx 3$ parcels. The width of a parcel is: $l = \dfrac{S}{L \cdot n_p} = \dfrac{1000000 m^2}{1000\,m \cdot 3} = 333\,m$; where: L - parcel length (1,000 m). Width of turning area E is calculated with the relation: $E = 3 \cdot R = 3 \cdot 15 = 45\ m$ .where: R - aggregate turning radius. Medium length of useless move L_g is calculated with the relation: $L_g = 3 \cdot R = 3 \cdot 15 + = 45\ m$. Considering $v_l = v_g$, the duration of a cycle is: $T_c = \dfrac{L_l \cdot n_l}{v_l} + \dfrac{L_g \cdot n_g}{v_g} = \dfrac{(910+45) \cdot 2}{2{,}07} = 922\,sec.$ Theoretical area cultivated after a cycle is calculated with the relation: $W_c = \dfrac{L_l \cdot n_l \cdot B_l}{10^4} = \dfrac{910 \cdot 2 \cdot 7{,}5}{10000} = 1{,}36 ha/ciclu$.

Theoretical hourly operating capacity is: $W_h = 3600 \cdot \dfrac{W_c}{T_c} = 3600 \cdot \dfrac{1{,}36}{922} = 5{,}3\ ha/h$. Fuel consumption per ha is: $C_{ha} = \dfrac{C_h}{W_h} = \dfrac{54\,l/h}{5{,}3\ ha/h} = 10\ litri/ha$.

RESULTS AND DISCUSSION

Calculus of economic indicators. Economic indicators suppose knowing both consumption per area unit and costs per ha per cost elements.

Consumption of h/aggregate is calculated with the relation: $C_a = \frac{T_s}{W_{sch}^r} = \frac{8}{35{,}5} = 0{,}23$ aggregate-h/ha. The coefficient C_m is calculated depending on the coefficient C_a and the number of labourers m, with the relation: $C_m = C_a \cdot m = 0{,}23$ man-h/ha. *Production costs* of a mechanised operation consist in indirect and direct costs. *Indirect costs* are for several mechanised operations or in the general interest of the company. They are recorded separately and then, depending on certain criteria, they are divided per mechanised operation. *Direct costs* are determined directly and they are included in the cost of each mechanised operation. In assessing economic efficacy off an agricultural aggregate, we use only direct costs because it represents the reduction of labour and material costs necessary to use the agricultural aggregate. Direct costs are calculated in RON/ ha. Direct costs C_d is calculated with the relation: $C_d = C_S + C_c + C_A + C_{dt}$; where: C_S - wage costs; C_c - fuel costs; C_A - amortisation costs; C_{dt} - aggregate technical maintenance costs. Wage costs are calculated depending on the hourly wage tariff S_h and on the coefficient C_m. A mechanic's salary is about 2,000 RON/month for 22 weekdays/month (i.e., 176 h/month), which corresponds to an hourly tariff of 11 RON/h. Wage costs per ha are: $C_S = C_m \cdot S = 0{,}23 \cdot 11 = 2{,}5$ RON/ha. Fuel costs C_c depend on fuel consumption G_{ha} (l/operation unit) and on fuel price p_l (RON/l): $C_c = G_{ha} \cdot p_i = 10 \cdot 6{,}5 = 65$ RON/ha. Costs for aggregate amortisation C_A are calculated for both the tractor and the scarificator taking into account the initial aggregate value V_i and the residual aggregate value V_r,de operation capacity per shift W_{sch}^r, the number of shifts n_s, the number of weekdays per year n_z and the operation duration D in years:

$$C_{Atractor} = \frac{V_i - V_r}{W_{sch}^r \cdot n_s \cdot n_z \cdot D} = \frac{500000}{35{,}5 \cdot 250 \cdot 10} = 6 \text{ RON/ha}$$

$$C_{Aplug} = \frac{V_i - V_r}{W_{sch}^r \cdot n_s \cdot n_z \cdot D} = \frac{200000}{35{,}5 \cdot 250 \cdot 8} = 3 \text{ RON/ha}; \quad C_A = 6 + 3 = 9 \text{ RON/ha.}$$

Costs of technical maintenance of the aggregate C_{dt} are technical service costs, technical reviews costs, and repair costs. These costs are calculated for the entire service assistance for both tractors and aggregating machines.

Technical service per tractor are calculated with the relatio $C_{dttractor} = \frac{V_i \cdot G_{ha}}{C_n} = \frac{500000 \cdot 10}{900000} = 5{,}5$ RON/ha where: V_i - inventory value in RON; C_n - standard consumption per operation in l; C_{ha} - fuel consumption per ha in l.

Technical service per plough are calculated with the relation: $C_{dtplug} = \frac{V_i}{W_n} = \frac{200000}{70000} = 3$ RON/ha; where: V_i - inventory value in RON; W_n - volume of operations per shift in ha.

The values G_n and W_n were calculated experimentally and they appear in maintenance technologies, reviews, and repairs of tractors and agricultural machines. Costs for aggregate technical service are: $C_{dt} = 5{,}5 + 3 = 8{,}5$ RON/ha. Direct costs per scarified ha are: $C_d = C_S + C_c + C_A + C_{dt} = 2{,}5 + 65 + 9 + 8{,}5 = 85$ RON/ha. *Auxiliary costs* C_{ac} are costs for main and auxiliary materials, costs for the storage and conservation of the tractors and agricultural machines. They represent percentages (15-20%) of direct costs: $C_{ac} = 0{,}2 \cdot 85 = 17$ RON/ha. *Total costs* of a scarified ha are: $C_T = C_d + C_{ac} = 85 + 17 = 102$ RON/ha.

CONCLUSIONS

In practical operation calculus, traction force resistance of the plough and scarificator is calculated with the formula: $R_{plug} = K_0 \cdot a \cdot b \cdot n$; where: K_0 - specific soil resistance to ploughing; a - cultivation depth; b - operation width of an operation organ; n - number of operating organs. Specific soil resistance to ploughing K_0 is used as a basic criterion in the classification of soils depending on resistance, a classification necessary to organise agricultural operations, to purchase fuel and spare parts, etc. to avoid errors in the classification of soils, calculus need to be made according to rigorous methodologies with a standard plough ploughing 20 cm deep in the soil at an operating speed of 1.2-1.4 m/s (4.3-5.0 km/h), and on a land that has been cultivated for a longer period of time. Depending on their specific resistance K_0, soils on arable lands in Romania can be grouped into:Light soils, with specific resistance $K_0 < 4 \cdot 10^3$ daN/m^2;Medium soils, with specific resistance $K_0 = 4 \cdot 10^3 \div 6 \cdot 10^3$ daN/m^2;Heavy soils, with specific resistance $K_0 = 6 \cdot 10^3 \div 9 \cdot 10^3$ daN/m^2;Very heavy soils, with specific resistance $K_0 > 9 \cdot 10^3$ daN/m^2.

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