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MECHANISATION OF GRAIN MAIZE HARVESTING WITH SELF PROPELLED COMBINES

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Abstract

The paper aimed to analyze the mechanization of grain maize harvesting using self propelled combines. The John Deere combine of the W series are highly powered, easy to maintain, effective from the point of view of fuel consumption, and available for a wide range of crops and working conditions. The main technical and functional features of John Deere combines of the W series are: Quick cutting, low height sowing platform. Working width between 4.3-10.7 m. Thresher equipped with a beater with 10 beating rails (Ø = 650 mm) ensuring full threshing and low grain breaking percentage. The shaker has a large separation area conferring full recovery of kernels and grains from the straws. The separation system is fed by helix converters avoiding the gliding of matter when harvesting on slope lands. Maize harvesting needs a large amount of labour and it needs to be done in the shortest time, particularly on the plots on which we cultivate winter cereals. There are three phases of ripening in the process of formation and maturation: Milk ripening; Yellow ripening; Full ripening with below 30% moisture. The calculus and making up of grain maize harvesting aggregates led to the conclusion that to ensure maximum working capacity and minimum fuel consumption, the combines must be ensured with the proper means of transport of the crop. The number of transportation should be correlated with hourly productivity and crop transport distances.

Key words: *mechanisation, combine, John Deere, maize, exploitation*

INTRODUCTION

Maize is one of the most important cereals and Romania. Maize cropping requires mechanized agricultural works.

Maize is harvested upon complete ripening when the grains contain below 30% moisture [3].

The process of formation and maturation of the maize gain lasts for about 50% of the vegetation period in maize and it covers three distinct phases: milk ripening, wax ripening, and full ripening. [1]

In this context, the purpose of this paper was to analyze the mechanization of grain maize harvesting using self propelled combines.

MATERIALS AND METHODS

The American company John Deere produces a wide range of self-propelled cereal harvesters for a wide range of farmers. [2]

Exploitation features of the John Deere W 550 combine features of the John Deere W 550 combine are shown in Table 1 below. [3]

Table 1. Exploitation features of the John Deere W 550 combine

THRASHER	
Beater diameter (mm)	660
Beater width (mm)	1400
Beating rails (N)	10
Standard range beater speed (rot/min)	450-980
Counter-beater size (mm)	750x1400
Post-beater diameter (mm)	400
Total thresher separation area (m^2)	1.50
Feeding flow of the thresher (kg/sec)	10
Beaters (N)	5
Beater length (m)	4.6
Shaker separation area (m^2)	6.4
Cleaning system	Dual-Flo
Ventilator speed (rot/min)	700-1525
Bunker volume (l)	8000
Worm download tipping (grades)	105
Bunker download flow (l/sec)	88
Straw chopping knives (N)	56 rotating, 54 stationary
ENGINE	
John DeerePowerTech Plus with 6 cylinders, turbo-compressor, air-air auxiliary cooling, Diesel	
Engine type	6068HZ482
Displacement (l)	6.8
Nominal speed	2400
Nominal power (kW/CP) ECE R120	202/275
Maximum power (kW/CP)	224/305
Maximum downloading auxiliary power (kW/CP)	22/30
Fuel tank capacity (l)	800
GEAR BOX	
Manual transmission 3 speeds	3 speed changes and mechanic break
Push Button Shift Transmission	3 speed changes and electric break

Source: Data sheet

Grain maize harvesting can be done when grain moisture is below 28%. [6]

After harvesting, maize grains dry down to 14-15% moisture. It is recommended to

harvest grain maize when grain moisture is below 17%. [5]
Harvesting is done with the straw cereal harvester. The header is replaced by a corn collector, and the wheat counter-beater in the thresher is replaced with a grain maize counter-beater.

RESULTS AND DISCUSSIONS

Maize was harvested as maize grains with a John Deere W 550 series combine equipped with a Capello 846 cob collector.
The technical features of the Capello 846 cob collector are:
Number of detachment sections – 8;
Distance between detachment sections – 75 cm;
Working width – 6 m;
Number of stem choppers – 8;
Number of chopping knives – 24 (8x3 per stem chopper);
Number of drawing rolls – 16;
Number of detachment plates – 16 (with hydraulic adjustment);
Number of conveyors – 16. The Capello 846 cob collector is operated by the cardan transmission of the John Deere W550 combine. The distance between the detachment plates is adjusted hydraulically depending on the thickness of the maize stems and of the cobs so that the stems may easily go through the plates and the cobs be prevented from passing and be detached from the stems. The stems are drawn by the rolls and chopped, while the cobs are carried by the conveyors to the thresher.
The hourly working capacity of the combine is determined with the formula:

$$W_h^r = \frac{3{,}600 \cdot q \cdot K_s}{m_b \cdot \left(1+\delta_p\right)} \, [ha/h]$$

where:
q - feeding flow of the thresher, given that the theoretical flow is $q = 10\, kg/s$ under normal working conditions and minding loss reduction, the real feeding flow is $q = 8\, kg/s$;
K_s - the time use coefficient $K_s = 0.80$;
m_b - grain volume per ha $m_b = 8000$ kg/ha;
δ_p - ratio between stalk volume and grain volume.
By replacing the data in the formula above, we get:

$$W_h^r = \frac{3{,}600 \cdot q \cdot K_s}{m_b \cdot \left(1+\delta_p\right)} = \frac{3{,}600 \cdot 8 \cdot 0{,}8}{8{,}000 \cdot \left(1+0{,}44\right)} = 2\; ha/h$$

The combine working capacity for a production of 8,000 kg/ha is 16 t/h, which means that the daily working capacity is 128 t/day or 16 ha/day. An area of 100 ha is harvested in 6 days.
Working speed is correlated with the feeding flow and working width.
Working width is 5.6 m (8 x 0.7). Taking into account the ratio between stalk volume and grain volume, the material weight 0.9 kg/m^2. For a real flow of 8 kg of material per second, the working speed of the combine should be 1.5 m/s, i.e. 5.4 km/h. Therefore, the working speed of the combine ranges between 5 and 6 km/h if we need to maintain the feeding flow constant.
Fuel consumption per ha is determined with the formula:

$$C_{ha} = \frac{\lambda_c \cdot C_{hn}}{W_h^r} = \frac{0.86 \cdot 56}{2} = 24\; l/ha\,.$$

where:
C_{hn} - hourly engine fuel consumption in nominal regime (56 l/h);
λ_c - correction coefficient taking into account engine load (0.86).
Fuel consumption is 3 l/t.
Production costs consist in indirect and direct expenses.
Direct expenses C_d are calculated with the formula:

$$C_d = C_S + C_c + C_A + C_{dt}$$

where:
C_S - remuneration expenses;
C_c - fuel expenses;
C_A - amortization expenses;
C_{dt} - aggregate technical service expenses.
Remuneration expenses depend on hourly wages S_h and on hourly productivity. A combiner's wages is about 4,000 RON/month for 22 working days per month, i.e. 176 h/month, which corresponds to an hourly

tariff of 22 RON/h.
Remuneration expenses per ha are:

$C_S = \frac{22\ lei/h}{2\ ha/h} = 11$ RON/ha, i.e. 1.25 RON/t.

Fuel expenses C_c are established depending on fuel consumption G_{ha} (l/working unit) and on fuel cost p_l (RON/l):

$C_c = G_{ha} \cdot p_i = 24 \cdot 5 = 120$ RON/ha, i.e. 15 RON/t.

Amortization expenses C_A are calculated taking into account the initial value of the combine V_i (546,000 RON), the residual value of the combine V_r (6,000 RON), the shift working capacity W_{sch}^r (20 ha), the number of shifts n_s, the number of working days per year n_z and the use duration D (10 years):

$$C_A = \frac{V_i - V_r}{W_{sch}^r \cdot n_s \cdot n_z \cdot D} = \frac{546{,}000 - 6{,}000}{20 \cdot 1 \cdot 90 \cdot 10} = 30$$

RON/ha, i.e. 3.75 RON/t.

Aggregate technical assistance expenses C_{dt} consist in technical maintenance expense, technical review expenses, and repair expenses. These expenses are determined for the entire use duration of the combine.

Aggregate technical assistance expenses are calculated with the formula:

$C_{dt} = \frac{V_i \cdot G_{ha}}{C_n} = \frac{546{,}000 \cdot 18}{650{,}000} = 15$ RON/ha, i.e. 2 RON/t.

where:

G_n - fuel consumption for the sue duration (650,000 l).

Direct expenses per harvested ha are:

$C_d = C_S + C_c + C_A + C_{dt} = 11 + 120 + 30 + 15 = 176$ RON/ha.

$C_d = C_S + C_c + C_A + C_{dt} = 1{,}25 + 15 + 3{,}75 + 2 = 22$ RON/t.

Auxiliary expenses C_{ac} are expenses for main and auxiliary materials, for the storage and conservation of agricultural machines. They are calculated as percentage (15-20%) of direct expenses.

$C_{ac} = 0.18 \cdot 176 = 32$ RON/ha, i.e. 4 RON/t.

Total expenses for the harvesting of 1 ha of maize are:

$C_T = C_d + C_{ac} = 176 + 32 = 208$ RON/ha, i.e. 26 RON/t.

Calculated technological indices are synthesised in the technological mechanisation chart of the grain maize harvesting operation.

CONCLUSIONS

Well organising grain maize harvesting by completely using the working time, by avoiding useless stops and useless movements, by using machines at their full potential and by observing specific fuel consumption asks for the proper plot working with the best method.

Useless movements of the machines occurs while turning at the end of the plots. Combine bunkers should be downloaded while working to prevent the decrease of daily productivity because of the stops.

To ensure continuous functioning, we need to ensure proper technical assistance (mobile workshop) for maintenance and repairs. It is extremely important to do the maintenance on a daily basis to avoid machine damage and stops. The failures occurring during work should be fixed in the shortest time possible.

It is recommended that the engine work at maximum speed to ensure proper functioning of the thresher.

To use the working time optimally, we need to take into account the correlation of the number of combines and the areas to be harvested, combine productivity and production per ha. This is particularly important during the short harvesting period when we need to avoid combine movement from one plot to another during the day, when harvesting is possible.

To increase the period of combine use, we recommend the cultivation of plant cultivars with different ripening phases; to reduce losses, we recommend the cultivation of fall-resistant crops.

During work, we need to correlate the moving speed with the state of the field so that the thresher be fed at optimum, constant levels to ensure maximum productivity and minimum loss.

To ensure maximum working capacity and minimum fuel consumption, the combines will be ensured with the proper means of transport of the crop. The number of transportation means should be correlated with hourly productivity and crop transport distances.

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