OPTIMAL MECHANIZATION TECHNOLOGY FOR GRAIN MAIZE HARVESTING

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Abstract *The harvesting of agricultural products is the completion and conclusion of agricultural production process; it is the point of convergence of all human actions, all the material and spiritual efforts invested by the company in the labour process for the production of material goods so necessary for its existence and development. Historically, the action of harvesting and storing the fruits of the Earth has a long and rich past: it has emerged in the Stone Age, many thousands of years before the beginning of the practice of agriculture, and it is one of the primordial activities of man. In its long, but glorious evolution, the harvesting act experienced fall and rise; it was still celebrated with fast and overwhelmed, more glorified with the emergence and development of industry, but the balance sheet time remained "the moment of the truth" for the global activity of a particularly important production branch of the world economy. In order to ease their work, in order to increase labour productivity and efficiency in harvesting agricultural products, man has created and applied, over the years, an unparalleled diversity of work and work techniques, from the simplest tools and devices to complex machines – the self-propelled combines of today – and especially maize harvesters. Maize harvesting is a particularly important work to be executed in time and with minimal losses. The dynamics of agriculture with mechanical means is continuously ascending, current concerns being aimed at increasing the number of agricultural machinery and equipment, as well as their improvement. The modern technical endowment of agriculture claims a thorough training and a high professional level of all those using this endowment.*

Keywords*: mechanization, harvesting, grain maize, combines*

INTRODUCTION

Because the process of harvesting maize as, in fact, all production processes in agriculture, is carried out under direct and permanent influence of natural (mainly climate) factors, which varies greatly in time and space, organization of work is necessary to adapt at all times to these conditions. [L.NIȚĂ, D. ȚĂRĂU, GH. ROGOBETE, D. DICU, LAȚO K.I., NIȚĂ SIMONA, 2018, SIMONA NIȚĂ , L. NIȚĂ , LILIANA PANAITESCU , GH.DAVID , A. OKROS , A. BORCEAN , Ș. BĂTRÂNA, MARIA CRISTA, 2021]Unlike empirical organization (household), in which the operation of the production activity takes place by duty according to tradition, through trials and essays or by sudden, unprepared changes, intensive farming necessarily requires a scientific organization of production to focus on the thorough, prerequisite and multilateral preparation of each activity of each step of the production process. [ANIȘOARA DUMA COPCEA, R. ILEA., CASIANA MIHUȚ,2017, DUMA-COPCEA ANIȘOARA CLAUDIA, MIHUȚ CASIANA, ILEA RADU NICOLAE, SÎRBU CORINA, SCEDEI DANIELA NICOLETA, POP VALER, CUȚUI MIHAELA CARMEN, 2019]The attention granted in countries with advanced agriculture, the specific organization of production and labour is the natural consequence of the great advantages, of the importance of achieving increased production, of high labour productivity and of low-cost price – effects that are usually obtained without investment or with insignificant expenses. The scientific organization of maize harvesting can result in a shortening of the harvesting period and in an increase in labour productivity. In order to achieve these objectives, as well as for rational combine use, a number of organizational measures is to be taken: preparation of the harvesting field, choosing the methods of traveling of the combine in the field, providing means of transport, etc. [V. POP, R.NICULA, ANIȘOARA DUMA COPCEA, CASIANA MIHUȚ, NICOLETA ŢIGRIȘ ,R. ILEA, 2018, I.TRUȚAN, ANIȘOARA DUMA-COPCEA, CASIANA MIHUȚ, DANIELA SCEDEI, 2020]

Self-propelled combines are intended for full harvest in the form of grain cereals and other crops. For harvesting grain maize, the header is replaced by a knotter mounted on the shredder. In the mechanized harvest of grain maize, a large amount of energy is consumed, which is why the problem of determining, on scientific grounds, constructive and exploitation parameters at which energy consumption is minimal. [R. ILEA, ANIȘOARA DUMA COPCEA, R. MILOȘ, 2017, P., ȘERAN, C. CREȚ ANIȘOARA DUMA COPCEA, CASIANA MIHUȚ, 2019].Optimizing all the parameters of self-propelled combines for grain maize harvesting in order to reduce consumption of materials and energy in operation is an essential objective for all agricultural units using harvesters. Mechanization technology is a set of production processes, technological processes, works and agricultural operations justified from an economic and technical point of view. [C. CREȚ, P.ȘERAN, ANIȘOARA DUMA COPCEA, CASIANA MIHUȚ, NICOLETA ŢIGRIȘ [2] , R.ILEA, 2018, GOGA ANA – MARIA, DUMA-COPCEA ANIȘOARA, MIHUȚ CASIANA, ROBU VIORICA, 2016].They must be carried out in a particular order, observing certain conditions established and using a well-defined range of agricultural machinery. Mechanization technology is determined by the specificity of the production branch, framed in a precise mechanized execution formula of agricultural works, optimal times related to the phases of the biological process with the specification of their execution for maximum production with minimum expenses per product unit. When developing a mechanization technology, the following aspects will be taken into account: what is produced, how it occurs, with what it is produced and how much it costs. [POPA D., ILEA R., BUNGESCU S., ALEXANDRA BECHERESCU, 2015, BUNGESCU S., 2016]The organization of industrial flow production ensures increasing labour productivity, reducing production costs, obtaining high crops, and contributing to diminishing losses.

MATERIAL AND METHODS

To establish optimal mechanized harvesting technology of grain maize, self-propelled grain harvester combines with various types of knotters. These combines were analysed as follows: the energy base study, the calculus of the operating indices, the calculus of economic indices. To do so, an area of 100 ha, with an average production of 6,000 kg/ha, measuring 1,000 x 1,000 m was taken into account. Below, the exploitation technology of a CLAAS self-propelled combine is presented. The CLAAS-MAXI 98 SL self-propelled combine is equipped with a CS-6 knotter for six rows. [, BUNGESCU S., 2016]

The working capacity of grain maize harvesting combines is given by the amount of maize or the surface harvested per time unit, according to agrotechnical requirements, expressed in t/h or in ha/h and by the conditions in which they work. The working speed of the combines will be chosen according to the production of maize per ha and the flow of the thresher, so that the combine be not loaded over optimal flow.

It is recommended that all aggregates in the maize harvesting working formations carry out constant work on the same plot, thus ensuring the possibility of organizing technical assistance and operative remediation of operating failures.

As previously shown, to achieve high productivity, low fuel consumption and loss reduction, particular attention should be paid to soil preparation, establishing the direction of movement of the machines and access roads so that the idle movements be minimal.

RESULTS AND DISCUSSIONS

Energy base study. The CLAAS-MAXI 98 SL self-propelled combine is equipped with a MERCEDES Diesel engine with a nominal power of 147 kW. The regulator feature for this engine shows the following operating indices: nominal power $P_{n\,=}$ 147 kW = 197 hp; nominal engine speed of the n_m = 2100 rpm (ω_m = 220 rad/s); nominal motor time M_e = 68 daNm; hourly fuel consumption G_h = 34 kg/h = 40 l/h; specific fuel consumption g_s = 195 g/hph. The CLAAS-MAXI 98 SL combine is characterized by the following parameters: work width is B_l = 6 x 0.7 = 4.2m; power flow of the thresher is q = 10 kg/sec.

The actual working capacity of the combine is calculated with the relation: $W_h^r = \dfrac{3600 \cdot q \cdot K_s}{m_b \cdot \left(1+\delta_p\right)}\ [ha/h]$

$$W_h^r = \frac{3600 \cdot 10 \cdot 0{,}75}{6000 \cdot (1+1)} = 2{,}25\, ha/h = 13{,}5\, t/h\ .$$

Working capacity per shift is calculated with the relation:

$$W_{sch}^r = W_h^r \cdot T_s\ [ha/sch];$$

$$W_{sch}^r = 2{,}25 \cdot 8 = 18\, ha/sch = 108\, t/sch.$$

Calculus of operating indices

For the preparation of the technological system for the exploitation of self-propelled grain maize harvesters, the following indices are determined: land characteristics, agrotechnical requirements, combine features and adjustments, indices for organizing work.

The area to be harvested is 100 ha.

The area to be harvested is 1,000 m x 1,000 m.

The number of plots = 5.

Number of CLAAS-MAXI combines = 5.

The width *l* of a plot will be:

$$l = \frac{S}{L \cdot n_p} = \frac{1000000\, m^2}{1000\, m \cdot 5} = 200\, m$$

The width of the return area is *E* = 29.4 *m*, which corresponds to a number of 42 rows sown in each end of the parcel.

The length of the movement L_l is calculated with the relation:

$$L_l = L - 2 \cdot E = 940\, m.$$

The average idle length L_g is calculated with the relation:

$$L_g = 3 \cdot R + 0{,}5 \cdot l = 3 \cdot 10 + 100 = 130\, m$$

Working speed is calculated with the relation:

$$v_l = \frac{10000 \cdot q}{m_b\left(1+\delta_p\right) \cdot B_l} = \frac{10000 \cdot 10}{6000(1+1) \cdot 4{,}2} = 2\, m/s = 7{,}2\, km/h$$

Considering the working speed equal to the idle speed $v_l = v_g$, the duration of a cycle will be:

$$T_c = \frac{L_l \cdot n_l}{v_l} + \frac{L_g \cdot n_g}{v_g} = \frac{(940+130) \cdot 2}{2} = 1070 \; sec.$$

The theoretical area worked after a cycle is determined with the relation:

$$W_c = \frac{L_l \cdot n_l \cdot B_l}{10^4} = \frac{940 \cdot 2 \cdot 4{,}2}{10000} = 0{,}94 \; ha / ciclu$$

Theoretical hourly working capacity will be:

$$W_h = 3600 \cdot \frac{W_c}{T_c} = 3600 \cdot \frac{0{,}94}{1070} = 3{,}16 \; ha / h$$

The theoretical working capacity is greater than real working capacity.

Fuel consumption per hectare C_{ha} is calculated with the relation:

$$C_{ha} = \frac{C_h}{W_h^r} \cdot \lambda_c = \frac{34}{2{,}25} \cdot 0{,}84 = 12{,}7 \; kg / ha = 2{,}2 \; kg / t$$

Taking into account Diesel density (1 l Diesel = 0.86 kg), Diesel consumption expressed in l will be:

$$C_{ha} = \frac{12{,}7}{0{,}86} = 14{,}8 \; litri / ha = 2{,}46 \; litri / t.$$

Calculus of economic indices

Consumption of h/combine is appreciated by the coefficient C_a calculated with the relation:

$$C_a = \frac{T_s}{W_{sch}^r} = \frac{8}{21{,}6} = 0{,}38 \text{ combine-h/ha.}$$

The coefficient C_m for serving the aggregate is calculated according to the coefficient C_a and number of workers *m*, with the relation:

$$C_m = C_a \cdot m = 0{,}38 \text{ hours-human/ha}$$

Production expenses

Production costs for carrying out a mechanized agricultural work consist of indirect costs and direct expenses.

Direct expenditure C_d is calculated with the relation:

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

The salary of a mechanizer is about 2,000 RON/month for a number of 22 working days/month, i.e., 176 h/month, respectively, corresponding to an hourly tariff retribution of 11.4 RON/h. Expenditure on retribution per ha will be:

$$C_S = C_m \cdot S = 0{,}38 \cdot 11{,}4 = 4{,}4 \text{ RON/ha.}$$

Salary per t of grains will be:

$$C_s = 4{,}4 : 6 = 0{,}74 \text{ RON/t;}$$

$$C_c = G_{ha} \cdot p_i = 12{,}3 \cdot 4 = 49{,}2 \text{ RON/t.}$$

i.e., per t of grains:

$C_c = 49{,}2 : 6 = 8{,}2$ RON/t;

$$C_A = \frac{V_i - V_r}{W_{sch}^r \cdot n_s \cdot n_z \cdot D} = \frac{140000}{21{,}6 \cdot 90 \cdot 10} = 7{,}2 \text{ RON/ha}$$

i.e., per t of grains:

$C_A = 7{,}2 : 5 = 1{,}44$ RON/t;

$$C_{dt} = \frac{V_i \cdot G_{ha}}{C_n} = \frac{140000 \cdot 12{,}3}{180000} = 9{,}2 \text{ RON/ha}$$

where:

V_i is the inventory value in RON;

G_n is the normal fuel consumption during service in l;

C_{ha} is the fuel consumption per hectare in l.

i.e., per t of grains:

$C_{dt} = 9{,}2 : 6 = 1{,}5$ RON/t.

Direct expenses per ploughed ha are:

$C_d = C_S + C_c + C_A + C_{dt} = 4{,}4 + 49{,}2 + 7{,}2 + 9{,}2 = 70$ RON/ha.

i.e., per t of grains:

$C_d = 70 : 6 = 11{,}66$ RON/t;

$C_{ac} = 0{,}2 \cdot 70 = 14$ RON/ha = 2.33 RON/t.

The total cost of a ploughed ha is:

$C_T = C_d + C_{ac} = 70 + 14 = 84$ RON/ha = 14 RON/t.

CONCLUSIONS

Given that the technique of the mechanization of maize harvesting has advanced a long time ago, worldwide, the most important aspect to be addressed relates to the choice of optimal operating regimes to increase productivity and quality and reduction costs. For this reason, a major part studied refers to the current state of self-propelled combine harvesters of grain maize. The analysis of specialized bibliographic sources reveals concerns in the field of scientific research for the improvement of self-propelled harvesters for grain maize and knotters in order to bring them to the level of ever-increasing requirements.

The CLAAS-MAXI 98 SL + CS-6 self-propelled combine harvests maize from six-rows with a working width of 4.2 m. The combine is equipped with a 196 hp Diesel engine and has a 13.54 t/h hourly productivity, at a feed rate of the thresher of 10 kg/s. For a 6 t/ha production, fuel consumption is 14.8 l/ha (2.2 l/t) and the total costs of harvesting grain maize are 84 RON/ha and 14 RON/t, respectively.

This paper shows the importance of executing the mechanized harvesting work in grain maize under optimal quality conditions.

In order to obtain high productions per area unit with reduced costs, it is necessary to observe cropping technologies using as high complex aggregates as possible.

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