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STUDIES ON MECHANIZATION OF MINIMUM WORK IN CORN CULTIVATION

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Abstract. *The purpose of this work is the detailed technical and economic analysis of the sowing operation using the aggregate formed by the John Deere 6190R tractor and the Gaspardo MT 12 seed drill, on an area of 100 ha. The conventional system is characterized by annual energetic loosening of the soil carried out by ploughing with furrow turning, which is then followed by other secondary works. In relation to the intensity and frequency of soil work, three major categories of methods are distinguished within this system, namely: loosening by ploughing with furrow turning, loosening by discing and reduced loosening. This soil loosening system is the one that also defines the type of conventional agriculture. The primary soil loosening work aims mainly to combat weeds by deeply incorporating seeds and roots, as well as to create a soil surface free of plant debris to facilitate the preparation of the seedbed for sowing. The absence of plant debris on the surface leaves the soil completely uncovered for a long period of time, thus being exposed to the aggressive action of degradation factors, becoming susceptible to destructuring, crusting, erosion, etc., as well as to water loss through direct evaporation from the soil. Technological tillage systems have evolved a lot, both in Romania and worldwide, an evolution both conceptually and in terms of the practical extension of conservative tillage methods. The practical extension of unconventional tillage methods differs from one country to another depending on the possibilities of mechanization and increases with the increase in the capacity of tractors and agricultural machinery and the diversification of loosening, soil processing and sowing equipment.*

Keywords*: minimal work, technological systems, corn cultivation*

INTRODUCTION

In the specialized literature in our country it is shown that, in the conventional system, soil cultivation requires 35-60% of the fuel necessary for the establishment and maintenance of a crop. Research and expansion of minimum tillage systems has become important with the need to reduce production costs and the risks of soil degradation, compaction and erosion. (V POP, ET AL 2018).

The application of variants of the unconventional soil cultivation system, according to research carried out in our country, leads to significant reductions in fuel consumption both per unit area and per unit of production. (ȘARPE, N, ET AL 2004).

The concept of soil conservation encompasses a set of activities, measures and technologies that contribute to maintaining the state of soil fertility without significantly reducing yields or without high costs. (AUNGURENCE N., ET AL 1997). This concept arose from the consideration that land is the most important means of human existence that ensures the production of agri-food products, raw materials for industry, energy, etc. and consequently maintaining biological capacity is a necessity imposed by the existence of social life. (GOGA ANA–MARIA, ET AL 2016).

Sustainable agriculture implies that it must not only ensure uninterrupted food supplies but must also accept and recognize the socio-economic impact on the environment and human health. (DERPSCH, R., 2001)

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Currently, unconventional soil tillage defines extremely varied procedures, from direct sowing in uncultivated soil to deep loosening without turning the furrow. Between these two extremes, there are variants such as: reduced tillage (classical rationalized), minimal tillage (with coverage below 30%), minimal tillage with vegetable mulch (with coverage above 30%), sowing on ridges, partial or strip tillage, etc. (PANTELIMON BOROZAN, ET AL., 2022) This terminology highlights the specific character that defines that procedure applied at a given time, in a given area, in accordance with local specifics. (DUMA COPCEA, ANIȘOARA, ET. AL.2024)

AGROTECHNICAL REQUIREMENTS FOR SOWING CORN

The main agrotechnical requirements that must be achieved through the work system for spring crops are. (M.A DRĂGAN, 2024).

- the soil must be mobilized to a minimum of 30 cm, optimally 25 - 35 cm;
- soil works must ensure the accumulation of sufficient moisture for seed germination;
- the soil for spring sowings must not be too finely ground because it can be too easily blown away by the wind; soil that is too finely ground on the surface forms a crust during heavy rainfall, preventing the germination of seeds germinated under the crust; (NIȚĂ, LUCIAN ET AL, 2004)
- through the work system practiced, the soil must be cleaned of weeds, so that sowing can be done under normal conditions and after the plants have emerged, they will not be competed by other species. (MATEOC-SÎRB NICOLETA, ET.AL. 2022; MATEOC-SÎRB, NICOLETA, ET.,AL. 2024).

By performing the sowing process, the seed is placed in the soil at a depth of 5-8 cm, the seed is covered with a layer of soil, the soil is compacted in rows to bring the seed into contact with the soil. (F MLADIN, ET.AL. 2023)

The distance between the rows is 70 cm at a density of 55,000 grains per hectare.

A distance of 25 cm between grains per row must also be ensured. The rows must be straight, to allow mechanization of the crop in terms of crop maintenance and harvesting. Simultaneously with sowing, the fertilizers established in the fertilization plan of 200 kg/ha of complex fertilizers of the 20-20-0 type are applied. (NICOLETA MATEOC SÎRB, ET AL 2013). The application of fertilizers must be uniform on all rows and at a depth of 2-3 cm below the seed and 2-3 cm laterally. (MIHUȚ, CASIANA, ET. AL., 2024).

During sowing work, the unit will move after the bobbin travel, and the control lever of the hydraulic distributor is placed in the floating position. (ILEA, R.; 2017).

MATERIAL AND METHODS

TECHNICAL CHARACTERISTICS OF THE SEEDER GASPARDO MT 12

The Gaspardo MT 12 seeder is designed for precision sowing (grain by grain) of the seeds of threshing plants. Simultaneously with the work of sowing in nests, the machine also performs fertilization by incorporating solid chemical fertilizers into the soil. It is a machine carried and driven from the power take-off shaft of the John Deere 6190R tractor with which it works in aggregate.

The technical characteristics of the Gaspardo MT 12 seeder are:

- working width: 8.4 m;
- number of sowing sections: 12 pcs;
- row spacing: 70 cm;
- seed box volume: 36 cm3-box;

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- seed distribution: pneumatic with vertical disc with holes;
- weight 2270 daN
- coulter type: skid coulter;

CALCULATION AND FORMATION OF SEEDING UNITS

Table 1

Technological operation sheet of the sowing unit John Deere 6190R tractor and Gaspardo MT 12 seeder

No. crt.	Basic indicators	Characteristics of the technological process
1	1 Characteristics of the land	Sowing area S=100 ha Length of the plot L=960 m Terrain relief flat Specific resistance K=80 daN/coulter
2	Agrotechnical requirements	Working depth a=5 cm Row spacing d=70 cm
3	3 Characteristics of the aggregate and preparation for work	Working width Bl = 8.4 m Adjust the working depth a=5 cm Adjust the length of the track markers Lm=2850 mm Adjust the machine flow rate for seed rate N = 60000 grains/ha
4	Land preparation	Plot width l=850 m Number of plots np=4 Width of the turning area E=30m The control line is marked by passing the track marker
5	Indicators regarding work organization	Cycle duration Tc=845 sec. Worked area per cycle Wc=1.3 ha Fuel consumption Cc=6 l/ha Working speed Vl=8.3 km/h
6	Quality control of the work	Respect the working depth a=5 cm Respect the distance between rows Respect the distance between grains in a row

According to the data from the Exploitation Technological Sheet (Table 1) and the additional requirements, here is the calculation of the required economic indices, using standard formulas from agricultural mechanization.

Performance and Working Capacity Indices

1. WORKING SPEED (VL)

The working speed is given directly in the Technological Sheet (Table 1, point 5):

Vl=8.3 km/h

2. THEORETICAL HOURLY WORKING CAPACITY (W_{TEOR}_H)

The theoretical hourly working capacity is calculated with the relationship:

W_{teor}_h=0.1·Bl·Vl

where:

• Bl is the working width of the aggregate (8.4 m - point 3).
• Vl is the working speed (8.3 km/h - point 5).
• 0.1 is a transformation coefficient to obtain the result in ha/h.

W_{teor}_h=0.1·8.4 m·8.3 km/h

W_{teor}_h =6.972 ha/h

2. Real Hourly Working Capacity (Wreal_h)

The real hourly working capacity is calculated with the relation:

W_{real}_h=W_{teor}_h·ηo

-where ηo is the coefficient of use of the operative time, which can also be determined by the ratio between the area worked per cycle (Wc) and the theoretical area worked after a cycle (W_{teor}_c), divided by the duration of a working cycle (Tc).

A more direct method is to use the values in the table (pt. 5):

W_{real}_h=TcWc·3600

where:

- Wc is the area worked per cycle (1.3 ha).
- Tc is the duration of a cycle (845 sec).
- 3600 is the number of seconds in an hour.

W_{real}_h=845 sec1.3 ha·3600 sec/hWreal_h≈0.001538·3600Wreal_h≈5.538 ha/h

4. OPERATING TIME UTILIZATION COEFFICIENT (HO)

It can be calculated as the ratio between the actual and theoretical capacity:

ηo=Wt_{eor}_h

W_{real}_hηo=6.972 ha/h5.538 ha/hηo≈0.794 or 79.4%

5. REAL SHIFT CAPACITY (WSHIFT)

The real shift capacity is calculated with the relationship:

W_{shift}=W_{real}_h·Tshift·ηu

Since the shift duration (Tshift) or the time utilization coefficient per shift (ηu) is not specified, the duration of a standard 8-hour shift will be used and, in the absence of other data, ηu≈0.9 - 0.95 is considered (usually, ηu=1 is used to calculate the maximum shift capacity, but more realistically ηu≈0.92 can be used).

Assuming a shift of Tshift=8 hours and ηu=1 (for the theoretical/real maximum shift capacity without breaks), or directly using Tshift·ηu as the effective shift duration (Tef) - which is not given.

We will use Texchange=8 hours and ηu=1:

Wexchange=5.538 ha/h·8 h/exchange

Wexchange=44.304 ha/exchange

If Tschimb is implicitly given as operative time (without long breaks), the result is the above.

6. DURATION REQUIRED TO PERFORM THE WORK IN THREE DAYS (TTOTAL)

The total area to be sown is S=100 ha. The real working capacity per hour is Wreal_h≈5.538 ha/h. The number of days given is D=3 days. The total time required, in hours, is:

T_{total}=W_{real}_hS=5.538 ha/h100 ha

T_{total}≈18.058 hours

The number of working hours per day required:

Tzi=DTtotal=3 days18.058 hours

Tzi≈6.02 hours/day

7. FUEL CONSUMPTION PER HECTARE (CC)

The fuel consumption per hectare is given directly in the Technological Data Sheet (Table 1, point 5):

Cc=6 l/ha

8. THEORETICAL AREA WORKED AFTER ONE CYCLE (WTEOR_C)

The theoretical area worked after one cycle is determined with the relationship:

Wt_{eor}_c=10000Bl·L

where:

• Bl is the working width (8.4 m).

• L is the length of the plot (960 m).

• 10000 is a transformation coefficient to obtain the result in ha.

W_{teor}_c=100008.4 m·960 mW_{teor}_c=100008064W_{teor}_c=0.8064 ha

There is a discrepancy between the calculated Wtheor_c (0.8064 ha) and the Wc given in the table (1.3 ha). The value of 1.3 ha in the table is probably a real measured value or a normalized value that also includes the preparation/turnaround time. For further calculations (such as Wreal_h), Wc=1.3 ha from the table was used.

RESULTS AND DISCUSSIONS

The calculation of economic indices in agricultural mechanization is an essential process for evaluating profitability and planning operations. These notions are based on the quantification of costs and technical performance.

I. CALCULATION OF TIME AND LABOR CONSUMPTION

1. Consumption of hours/aggregate (Mechanical work time)

Consumption of hours/aggregate per hectare (Taggregate) is the inverse of the real hourly work capacity (Wreal_h).

Consumption of hours/aggregate=Wreal_h1=5.538 ha/h1

Consumption of hours/aggregate≈0.1805 hours-aggregate/ha

2. Coefficient for servicing the aggregate (Manual labor time)

Since the aggregate requires a single operator (the tractor driver), the consumption of man-hours per hectare is equal to the consumption of man-hours.

Coefficient of man-hours/ha=Taggregate

Coefficient of man-hours/ha≈0.1805 hours-aggregate/ha

II. CALCULATION OF DIRECT EXPENSES

Direct expenses per hectare (Cdirecte) include: remuneration, fuel, depreciation and technical service.

1. Remuneration expenses (Salary)

Remuneration expenses=Coefficient man-hours/ha·Average gross salary/hour

Remuneration expenses=0.1805 man-hours/ha·50 lei/hour

Remuneration expenses≈9.03 lei/ha

2. Fuel expenses

Fuel expenses=Specific consumption·Diesel price/liter

Fuel expenses=6 l/ha·7.5 lei/l

Fuel expenses=45.00 lei/ha

3. Expenses for depreciation of the aggregate (Ca)

According to the established norm (estimated):

Expenses for depreciation of the aggregate≈40.00 lei/ha

This value includes depreciation of the tractor and the seeder (e.g., 30 lei/ha for the tractor and 10 lei/ha for the seeder).

4. Expenses for technical service of the aggregate (Cdt)

Cdt is calculated as a percentage of Ca (depreciation), using the coefficient Kdt=1.25 (125%):

Expenses for technical service=Ca·Kdt

Expenses for technical service=40.00 lei/ha·1.25

Expenses for technical service of the aggregate=50.00 lei/ha

5. Direct costs for a sown hectare

Direct costs=Ctaxation+Cfuel+Depreciation+Ctechnical_service

Direct costs=9.03 lei/ha+45.00 lei/ha+40.00 lei/ha+50.00 lei/ha

Direct costs for a sown hectare=144.03 lei/ha

III. CALCULATION OF TOTAL COSTS (LABOR COST)

1. Auxiliary costs (Caux)

Caux is calculated as 10% of direct costs (the 10% rule is a common simplification for overhead/organization costs).

Auxiliary costs=Cdirect·10%

Auxiliary costs=144.03 lei/ha·0.10

Auxiliary costs≈14.40 lei/ha

2. Total cost of one sown hectare

Total cost=Cdirect+Cauxiliary

Total cost=144.03 lei/ha+14.40 lei/ha

Total cost of one sown hectare≈158.43 lei/ha

Table 2.

Mechanization Technological Sheet (Centralized Economic Indices)

Economic Indicator	Unit of measurement	Calculated value
Consumption of hours/aggregate	hours-aggregate/ha	0,1805
Coefficient man-hours	ha man-hours/ha	0,1805
Expenses for remuneration	lei/ha	9,03
Fuel expenses	lei/ha	45,00
Expenses for depreciation of the aggregate	lei/ha	40,00
Expenses for technical servicing of the aggregate	lei/ha	50,00
Direct costs per hectare sown	lei/ha	144,03
Ancillary expenses	lei/ha	14,40
Total cost of one sown hectare	lei/ha	158,43

CONCLUSIONS

The cultivation of corn using the minimal tillage method is increasingly being studied. The results obtained have demonstrated the possibility of cultivating corn with minimal tillage using herbicides and various special machine systems that can perform several operations in a single pass over the field.

The aggregate formed by the John Deere 6190R tractor and the Gaspardo MT 12 seeder demonstrates high operational efficiency in the analyzed sowing system:

• The actual working capacity is 5.538 ha/h, ensuring a substantial work flow.

• The operational time utilization coefficient is 79.4%. Although good, this indicates that approximately 20.6% of the operational time is allocated to maneuvers, stops and adjustments.

• In order to sow the total area of 100 ha within the agrotechnical term of 3 days, an effort of 6.02 hours of work per day is required. This effort is feasible and sustainable for a single work shift.

Therefore, the aggregate is economically and productively efficient, allowing the work to be done in a timely manner and at a controlled cost. Further optimization points should aim at improving the utilization rate of operational time and reducing maintenance costs.

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