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RESEARCH ON INCREASING WORK EFFICIENCY IN THE MECHANISATION OF GERMINATION BED PREPARATION WORKS

Anișoara DUMA COPCEA[1], Nicoleta MATEOC-SÎRB[1], Casiana MIHUȚ[1], Lucian NIȚĂ[1], Simona NIȚĂ[1], Teodor MATEOC[1], Adalbert OKROS[1], Natalia MOCANU[2]

[1]University of Life Sciences "King Mihai I " fromTimisoara, 300645, 119, Calea Aradului, Timisoara, Romania, Phone: +40256277001, Fax:+40256200296, Emails: anisoaradumacopcea@usab-tm.ro, nicoletamateocsirb@usab-tm.ro, casiana_mihut@usab-tm.ro, lucian_nita@usab-tm.ro, simona_nita@usab-tm.ro,teodormateoc@usab-tm.ro, adalbertokros@usab-tm.ro
[2]Technical University of Moldova, 168, Ștefan cel Mare Boulevard, Chișinău, Moldova, MD-2004, Phone:+37379809816, E-mail: mocanunatalia@gmail.com

Corresponding author: teodormateoc@usab-tm.ro; casiana_mihut@usab-tm.ro

Abstract

The aim of this work is weed control by cutting, pulling from the ground and covering with a thin layer of ground, where they can regenerate. The good preparation of the germination bed allows the seed to be covered with a well-aerated, heated soil layer and stand on a more stable and favourably humid soil. The lack of weeds and vegetable residues on the surface of the soil and on the depth of the germination bed gives it the appropriate quality to be sown. The preparation works of the germination bed were carried out at the "December 3, 1990" commercial company from Periam, Timiș County, Romania. The main methods utilized to optimize the use of agricultural aggregates are mathematical programming, direct calculus solutions, and operating nomograms. The purpose of the secondary works performed after ploughing consists in the crushing of soil clogs and of structural soil macro-aggregates in order to carry out the sowing. For the execution of the mechanised scarification works, the preparation of the germination bed and of maize sowing, the types of tractors are chosen according to the technological process of the works and to the biological properties of the crops, depending on the following indicators: light, gauge, size of equipment, plot size, energy consumption of agricultural machines, state of the land, humidity, and manoeuvrability. Soil works have been an integral part of agriculture since the beginnings of farming and they have served several important goals: the preparation of the germination bed, the reduction of soil compaction to increase aeration and allow the root system to develop optimally, the reduction of weeding, the incorporation of fertilizers and amendments, and the management of plant debris. Following the study, we can conclude that the optimization of the use of agricultural aggregates in operation contributes to the reduction of the production expenses, of the specific fuel and material consumption, and of the labour requirement.

Key words**:** *economic efficiency, germination, soil*

INTRODUCTION

The efficiency of the work depends primarily on the degree of mechanization in agriculture, because the use of agricultural machines and equipment increases the productivity of the work, relieves physical work, and reduces production expenses, thus contributing to the obtaining of increased agricultural productions [20].
The purpose of the secondary works performed after the ploughing consists of the fragmentation and crushing of the structural clogs and macro-aggregates, in order to carry out the sowing [7], [2].For the execution of mechanized works in the preparation of the germination bed, the types of tractors are chosen according to the technological process of the works and the biological properties of the crops, according to the following indicators: light, gauge, size, plot size, energy consumption of the agricultural machines, land state, soil moisture and manoeuvrability [17, 22].
Machines in agriculture, as well as in the other fields of activity, are mobile assets whose use determines a significant increase in labour productivity and a reduction in living expenses. The specific character of the use of the land as the main means of production in agriculture has a particular impact on the use of agricultural machines [3], [9], [14].

Agricultural machines need to meet the following requirements:
-provide qualitative working indices according to the requirements of modern agriculture
-execute as many technological work operations as possible
-have a multifunctional character (i.e., allow different working equipment to be adapted to the basic machine)
-be highly reliable
-be able to perform high precision works without loss of materials or crop
-ensure the mechanization of all operations within the technological production processes at a high coefficient of safety in operation and at a low production cost [6], [8].

Agricultural machines are fundamentally distinguished from machines used in other branches of the economy and especially those used in the processing industry since they work with living organisms (plants), with non-homogeneous materials in which different physical, chemical and biological processes take place [11], [16].

This needs certain requirements, specific only to agricultural machines, namely, that the technological processes executed by them create optimal conditions for plant development according to agro-biological requirements for agricultural production [1], [10], [18].

MATERIALS AND METHODS

The preparation works of the germination bed were carried out at the "December 3,1990" commercial company from Periam, Timiș County. The germination bed or the soil layer to be sown corresponds qualitatively if the following conditions are met:
-it has an adequate depth in relation to the species to be sown
-it is shredded, without large bulges and the surface is levelled
-it is aerated and moist on the depth of sowing
-it is devoid of weeds and vegetable residues on the surface.

The optimum depth of the germination bed is equal to the sowing depth or to maximum 1-2 cm deeper, but never less.

With the increase of the moving speed of the aggregate, the working depth decreases. At the first passage over the land, the working depth is uneven; it increases significantly at the second passage, when a uniformization of the surface occurs.

The degree of soil shredding when preparing the germination bed must be normal, i.e., no more than 5-7% bulges below 5 cm on the surface of the soil: 5% of them can even exceed this size if they do not prevent the seed incorporation into the soil and if they allow keeping row distance, for example in cereals. Soil shredding should not be exaggerated; if it can be sown under optimal conditions and the seed does not remain on the surface of the soil and the remaining bulgedo not prevent the emergence, we can appreciate that the shredding was good.

A good preparation of the germination bed allows the seed to be covered with a well-aerated, heated soil layer and stand on a stable soil with favourable humidity.

The lack of weeds and vegetable residues on the surface of the soil and on the depth of the germination bed gives it the appropriate quality to be sown.

Through the works that are done when preparing the germination bed, the weeds must be destroyed by cutting, detached from the ground and not only covered with a thin layer of ground, from where they can regenerate.

When preparing the germination bed on land with rich vegetable debris, the disc harrow should not get clogged and from place to place to be raised to not accumulate the vegetable debris.

In addition to the strict quality elements of the germination bed, depth, levelling, humidity, lack of weeds, some general agrotechnical rules should also be respected, which compete both to improve the quality of the germination bed and to increase the productivity of the aggregates used.

Generally, land surfaces have a series of greater or smaller bumps, which prevent the incorporation of the seeds at the same depth, resulting in an uneven crop with holes. There are a series of cultures that require a perfect levelling such as: clover, alfalfa, rapeseed, sugar beet, soy, etc.

The levelling can be done after the autumn ploughing, so that in spring, with less soil works, a good germination bed is ensured for the early spring sowing.

Larger bumps are removed with the help of machines with a more complex construction. In our country, they experienced with good results two traction levels: one with a working width of 2.80 m and another one with a working width of 4.25 m.

The easiest levelling or smoothing is made with a simple machine, which is a heavy iron or wood bar with a square or rectangular section. The levelling work with such simple machines is executed in aggregate with the coulter harrow, before the sowing.

In the time interval from ploughing to sowing, a significant amount of water is lost by evaporation that needs to be completed by irrigation; otherwise, there will be crop losses. The preservation of water in the soil can be achieved by its superficial mobilization, the shredding of the bulges and the interruption of the capillarity between the 2-3 cm-surface layer, which dries, and the rest of the soil that retains its water. The soil layer from the surface prevents soil drying over a greater depth.

In the interval from harvest to sowing, the weeds are destroyed by the processing of the fields and the preparation of the germination bed. The effect is maximum when the weeds are still young, barely rising, and the soil is dry. In wet soils, the weeds remain in the soil, even if it has been mobilized, the roots are quickly restored and the plant continues to vegetate.

The last work of preparing the germination bed must be performed on the day of the sowing or no more than 1-2 days before sowing for several considerations, one of which is the destruction of weeds to avoid their competition during the rising period with the cultivated plant [19], [21].

The rational use of the power of the tractor is one of the means of reducing energy consumption in agricultural works.

The loading coefficient of the tractor (the ratio between the actual power developed by the engine and its nominal power) need to range between 0.8-0.9.

In tractors that develop power, only in traction there is a direct connection between this coefficient and the use of the tractor.

The coefficient of use of the power developed by the tractor engine (the ratio between the power developed by the engine to perform the useful work and the total developed power) must be maintained within 0.9-0.95. This is obtained by the composition of dynamically balanced aggregates with reduced masses in the rotational movement and with its own reduced mass [4], [5].

Equipping tractors with technical means for their use in optimal parameters (additional weights, double wheels, semi-caterpillars) mechanical and hydraulic devices for increasing adherence

The composition of aggregates with optimal operating parameters is also an important way to reduce diesel consumption.

One can choose an optimal ratio for the work speed and the width of the aggregate, considering that, at high working speeds, the energy consumption is higher, and at increased work widths, consumption is lower.

The composition of complex aggregates, which will perform several works on a single passage

Aggregates with which three or five works can be performed at a single passage. These aggregates are energetically advantageous and, with them, one can perform good quality agricultural works during optimal agrotechnical periods.

Fuel consumption in agricultural works with complex aggregates is lower by 20-50% compared to the consumption registered with the works performed with individual agricultural aggregates [12].

The realization of organs of agricultural machines and machines with which agricultural works with low energy consumption can be performed

Use of vibrations when processing the soil, processing of work organs to reduce friction

Promoting, in production, of technologies with low energy consumption and eliminating some intensive energy works:

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-higher by 15-20%, it turns out that the gliding exceeds 15%; it is necessary to reduce the working depth or itswidth.
-lower by 15-20%, it turns out that the gliding is lower; the depth or width can increase. [13], [15], [1].

RESULTS AND DISCUSSIONS

For the work of preparing the germination bed, a John Deere tractor with 60 HP engine was used in good working condition.
The tractor was provided with a device for determining fuel consumption, as well as two weights of 47.5 kg each, mounted on the engine wheels.
The mass of the tractor prepared for trial was 3,750 kg.
The air pressure was regulated and kept constant during the experiments at 1.2 atm (1.18 bar). Initially, the engine regulator feature was also raised.
The data and regulator characteristics are presented in Table 1.

Table 1. Data on the John Deere 60 hp engine regulator feature

Values measured				Values calculated			
Motor shaft turation n, (rot/min)	Break force F, (daN)	Fuel consumed a v, (g)	Trial duration t, s	Real engine power HP	Hourly fuel consumption C, kg/h	Specific fuel consumption g_5, g/HPh	Engine moment M_m, m, daN
1950	1.10	39.60	50	3.00	2.85	950	1.10
1918	8.40	80.80	60	22.50	4.85	218	8.30
1900	15.45	88.00	44	41.00	7.20	176	15.45
1865	24.00	191.72	68	62.00	10.15	163	23.90
1850	24.19	137.50	45	62.50	11.00	176	23.20
1825	25.40	230.40	70	64.70	11.85	183	25.40
1800	25.80	262.16	78	64.85	12.10	186	25.90
1795	25.85	79.33	24	64.80	11.90	184	25.90
1705	26.88	80.55	25	64.00	11.60	181	26.90
1605	27.84	190.00	60	62.40	11.40	18-2	29.90
1440	28.60	151.50	54	57.50	10.10	176	28.60

Source: Own determination.

The actual work for establishing the optimal working regime was executed on a plot with an area of 1.5 ha.
The soil was a chernozem, the land has a 3° slope in the NW direction.
The previous culture was winter wheat.
The stubble was ploughed 30 cm deep.
The ploughed land remained totally devoid of weeds, to be sown with the 2nd crop.

The machines in the aggregate (GD 3,4 harrow, levelling blade) were in good condition, being checked and adjusted.
The angle of tilting of the batteries with discs from the GD-3,4 harrow was 15°.
After the aggregates were checked and regulated, 1.5 ha was worked, after which the appropriate adjustments were corrected.
Working parameters
The average working depth for the four speeds, for which the measurements were made is shown in Table 2.
The working width is 3.4 m. This value resulted in that the tilting angle of the batteries from GD-3,4 was maximum 15°.
The degree of soil breaking up was determined with the relationship:

$G_{ms}= M_{sc}/M_{st} x\ 100\ (\%)$..........................(1)

where:
M_{sc} = mass of clogs larger than 5 cm
M_{st} = total mass of aerated soil
The values of the degree of breaking up for the four speeds are shown in Table 2.
It is found that, at higher work speeds, its values increase and vice versa, as the speed of the aggregate decreases, the degree of shredding decreases.
The degree of soil aeration was determined with the relationship:

$G_{as} = h_m/a_m\ x\ 100\ (\%)$...............................(2)

where:
h_m = height of soil level after the passage of the aggregate
a_m = average work depth
The values determined for the four speeds are shown in Table 2. It is found that the values of the aeration are raised due to the maximum angle of tilting of the discs, as well as the existence of the harrows in the aggregate.
The degree of soil levelling was determined with the relationships:

$G_ns = h_{md}\text{-}hc_{li} x\ 100\ (\%)$..........................(3)
$G_{ms}= (h_{md}\text{-}h_{mi})/h_{mi} 100\ \%$.........................(4)

where:

h_{mi} = average distance from soil surface to rule before the passage of the aggregate (cm)
h_{md} = average distance from soil surface to rule after the passage of the aggregate (cm)
The values of the levelling degree calculated following the measurements performed are shown in Table 2. An increase in the levelling degree is observed with the decrease of the speed of advancement of the aggregate. However, the high values of the levelling degree are due to the presence in the aggregate of the levelling blade.
The degree of weed destruction was not determined, as the land was deprived of weeds, its preparation for the sowing being done immediately after the ploughing.

Table 2. Values of qualitative working indices

Gear	Average work depth of the J.D. 60 CP + GD 3,4 Level. + 2 GCR 1,7 cm	Aggregate working width B1(m)	Soil aeration degree (G_{ms}%)	Soil breaking up degree (G_{ns}%)	Soil levelling degree %	Weeds control degree Gas (%) x
lll.F	9.70	3.35	32.50	62.30	40.10	-
IV.	9.72	3.35	32.90	62.40	40.30	-
lll.î	9.87	3.35	33.20	60.10	41.40	-
II.R	9.84	3.35	34.00	60.20	41.53	-

x) The land was prepared immediately after the ploughing for the second crop and therefore it was deprived of weeds
Source: Own determination.

Energy indices
The working speed was established by timing the time to travel the distance of 100 m for the four speeds, with the relationship:

V = 3.6 x S/T (km/h)..................................(5)

where:
S = distance covered =100 m
T = time in sec.
The gliding of the motor wheels was established with the help of the relationship, where we determined the skating for the four speeds (III.R, IV. î., III. Î., II.R):

$\delta = (n_s - n_g)/n_s$...(6)

where:
n_s = average number of rotations in operation
n, = average number of rotations at rest
It is found that the values of the gliding fall between the limits allowed (15-20%), the highest value being in the speed IV.î.

The hourly fuel consumption (G) was determined with the speed and skating using the consumer apparatus, using the relationship:

G = 3.6/t x V x g (kg/h).............................(7)

where:
V = volume of fuel consumed (cm)
g = specific weight of Diesel (g/cm^3)
t = trial duration (s).
The determinations were made for the four speeds.
There is a decrease in the hourly consumption of fuel at the lower speed.
The effective power necessary for the aggregate (N_ef) was determined from the engine regulator feature, which equipped the tractor based on the obtained fuel consumption. Also from the regulator characteristic, the value of the nominal power (N_m) was established.
The loading of the engine (I) was determined by reporting the values of the two established powers above N_ef and N_m, with the relationship:

$1 = N_{ef}/N_m$ x l00 (%)................................(8)

The values of the engine loading degree are passed in Table 3.
The traction power (N_t) of the aggregate for each gear was calculated separately with the relationship:

$N_t = (R_{in}$ x V)/270 (CP).............................(9)

where:
R_{in} = resistance to ii action of the aggregate;
V = working speed for each of the four gears
In order to have a clearer image on how to use the nominal power of the engine, the power required to self-deposit the tractor was calculated (N_r).
Operation trials
Analysing the results presented above and taking into account that the tractor engine does not work in overload (lîl.R), it can be established, that the optimal working regime in a heavy soil with soil humidity up to 18-20% on plane or slope of maximum 6° would be:

-working with 9.84 cm
-working speed 5.6 km/h (II.R)
-aggregate resistance 1,128 daN
-gliding 12.9%
-hourly consumption 9.7 kg/h

It can also be seen that, from the point of view of the degree of test of the engine (without working in overload), the optimal working regime previously is appropriate.

The operation of the work aggregate John Deere + GD-3,4 + 2 GCN-1,7 and time element are shown in Table 3.

Table 3. Elements of working time

Symbol and name	Time	Value(min)
Ti = real working time	The time during which the aggregate having the active bodies under load, executes the work process	1,890
T21 = return time	The time during which the aggregate moved in the void, at the ends of the plot, executing the return in charge	188
T31 = time for daily technical maintenance	The time in which the daily technical maintenance operations were performed, in order to maintain the aggregates in working condition	80
T41 = time for technological deficiencies	The time used to remove the clogging of active organs	452
T_{42} = time for technological deficiencies	The time used to diagnose and remove the technical defects that occurred in the group of working machines in aggregate	278
T_4 = time for technological deficiencies	$T_4 = T_4i + T42$	730
T_5 = time for staff	The time used to diagnose and remove the technical defects that occurred in the group of working machines in aggregate	312
T_{61} = time for moving from headquarters to plot and vice versa	The time when the aggregate went away from the mechanization section	468
T_7 = time for technical maintenance at the energy source	The time in which daily technical maintenance operations were performed at the tractor	38

Source: Own determination.

The grouping of working time elements represents the structure of the work time presented in Table 4.

Table 4. Structure of working time

Symbol	Name	Definition	Value (min.)
T02	Operative time	T02 " Ti + T21	2,078
T03	Total operative time	T03 T02 + T31	2,158
T04	Production time	T04 " T03 + T4	2,888
T07	Time of shift	T07 = T04 + T5 + T61 + T7	3,706
T	Performance time	$T = T_1 + T_{21} + T_{\cdot\cdot} + T_5 + T_{61} + T_7$	2,976

Source: Own determination.

The coefficients of time use, which constitute operating indications that characterize the activity during the working time in order to appreciate the aggregate, are represented in Table 5. The working capacity of the aggregate representing the working volume performed in the unit of time is represented in Table 6.

Table 5. Coefficients of time use

Symbol	Name	Definition	Value (min.)
K02	Coefficient of operative time use	K02 = T1/T02	0.910
K03	Coefficient of total operative time use	K03 = T-t/To3	0.877
K04	Coefficient of production time use	K04 = T1/T04	0.645
K07	Coefficient of shift time use	K07 = T1/T07	0.510
K21	Coefficient of return	$K21 = T_1/(T_1+T_{21})$	0.910
K23	Coefficient of technical maintenance	$K23 = T_1/(T_1+T23)$	0.956
K41	Coefficient of technological safety of machine organs	$K41 = T_1/(T_1+T41)$	0.806
K42	Coefficient of technical safety	$K42 = T_1/(T_1+T_{42})$	0.872
K4	Coefficient of operational safety	$K4 = T_1/(T_1+T_4)$	0.722

Source: Own determination.

Table 6. Working capacity of the aggregate

Symbol	Name	Definition	Value (ha/h)
W_{ef}	Hourly working capacity in real time	$W_{ef} = U/T_1 \times 60$	1.590
W_{02}	Hourly working capacity in operative time	$W_{02} = U/T02 \times 60$	1.080
W_{03}	Hourly working capacity in total operative time	$W_{03} = U/T_{03} \times 60$	1.390
W_{04}	Hourly working capacity in production time	$W_{04} = U/T_{04} \times 60$	1.040
W_{07}	Hourly working capacity in sift time	$W_{07} = U/T_{07} \times 60$	0.808
w_p	Working capacity	$W_p = U/T \times 60$	1.010

Source: Own determination.

Fuel consumption per ha was established using the formula:

$C_{ha} = Q/U$..(10)

where:
Q = 365 kg – total fuel consumption
U = 1.5 ha – work volume
$C_{ha} = 365/50 = 243.33$ kg/ha

CONCLUSIONS

Following the trials of the aggregate formed by the John Deere tractor and the GD-3,4-disc harrow provided with a levelling blade and two harrows, conclusions and recommendations can be formulated:

- In the 3rd gear, rapid range, the aggregate cannot work because the traction force developed by the tractor is greater than the sum of the traction resistance of the aggregate machines and the resistance to self-deployment of the tractor, which makes the engine operate in overload;

- In the 4th gear, slow range, the aggregate can no longer work because the engine load is 98.5%, very close to the maximum load. In fact, in the operating tests it was not possible to work in this gear because, when larger irregularities of the land appear, the engine enters the overload, reducing the speed and power;
- In the 2nd gear, fast range, the aggregate can work because it performs a 92% engine load and a sliding of 12.9%;
- In the 3rd gear, slow range, the aggregate can work; however, the engine load is only 83%, and the capacity is lower than in the 2nd gear, fast range;
- The preparation of the land for the 2nd crop in heavy soils should be done at the same time with ploughing or immediately after the rain, otherwise the formed clogs become very compact, they can no longer be crushed, producing frequent clogs on the disc harrow (that is why the value of the coefficient K41 is low);
- The levelling blade is useful only under the conditions shown under point 5, otherwise there is a large agglomeration of clogs in front of it, the levelling effect decreases, and the traction resistance of the aggregate and the fuel consumption increase;
- In heavy soils, in general, the adjustable coulter harrows do not resist, many defects appear, and the time for their remediation increases (that is why the value of the coefficient K42 is low). Therefore, we recommend for heavy soils the use of flesh hob fields (GCM);
- The scraping knives from the batteries with discs become inefficient and, in the case of clogging, the clogs attached to the discs stop blocking the entire battery. When the soil humidity does not exceed 20%, we recommend the use of the disc harrow without scraping coulters;
- Productivity at shift time (W_{07}) is low in relation to productivity in real time ($VV_{e}f$).
- The value of fuel consumption per ha is high due to the increase in the resistance to fraction of the aggregate by using the levelling blade and of the deficiencies that appear, as well as the increase of the operating time of the tractor while cleaning and of the returns at the ends of the plot 1, M;
- Finally, we consider that the aggregate formed by the John Deere tractor with GD-3,4-disc harrow provided with levelling blade and two GCR-1,7 harrows can work in heavy soils with a humidity of up to 20%, on plane field or with a slope below 6°, the optimal working regime having the following energy and productivity indices:

* Resistance to traction – 1,128 daN;
* Hourly fuel consumption – 9.7 kg/ha;
* Engine load – 92%;
* Working speed – 5.6 km/h corresponding to the 2nd gear, fast range;
* Gliding – 12.9 %;
* Productivity – 0.808 ha/h (6.64 ha/8 h);
* Fuel consumption per ha – 7.31 kg/ha.

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