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PRACTICAL CONSIDERATIONS REGARDING THE WORK CAPACITY OF STIHL BT 121 MOTTO-BORER, EQUIPPED WITH A 150MM DRILL, FOR DRILLING HOLES FOR PLANTING SAPLINGS

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Abstract

The present research displays the results obtained after the digging of holes for planting saplings in a previously unprepared soil, following the steps to carry them out according to some physical-mechanical properties of the soil. The research was carried out on a horizontal ground in the O.S. Iuliu Moldovan, in two arranged unities (parcels) 31 C and 32 A, in a previously unprepared ground, on two types of soil: gley-soil (the muddy subtype) and alluvial soil (the vertical-gleyed subtype), and in O.S. Radna, u.a. 74, on a brown typically luvic soil, using the Stihl BT 121 motto-borer with a 150 mm drill. The objectives of the research were to make a comparative determination, on different types of soil, of the qualitative parameters, among which the most important ones are: degree of loosening of the soil taken and left in the hole, resistance to penetration, resistance to shearing, timing of drilling holes, degree of scattering of the soil taken out from the hole, degree of evacuation of the soil from the hole, gas consumption for the drilling of the hole, using the Stihl BT 121 motto-borer in order to establish its technical efficiency. In order to observe the influence which the drilling of holes has on its walls, we measured the resistance to penetration and resistance to shearing every 10 cm at a 30cm depth, the proper depth for planting small-sized saplings, on two opposing sides, so that we could get the most probable values of these physical-mechanical properties of the soil. After taking the measures in order to establish the compaction degree of the wall and of the bottom of the hole by the borer in that interval, it was judged that in conditions of normal humidity, if the borers have sharp knives and are well conceived and executed from a technical point of view, there are no big values of the resistance to penetration which could affect the subsequent development of the saplings. The usefulness of the present paper stays in the research data collected, processed, analyzed and valorized in order to offer a pertinent study material, which could indeed be used by specialists in designing the process for obtaining, through a mechanized means, the holes for planting small-sized saplings on a horizontal ground, using the Stihl BT 121 motto-borer.

Key words**:** *motto-borer, resistance to penetration, average time of drilling, degree of scattering, degree of evacuation.*

INTRODUCTION

There is a general concern for introducing and extending the motto-borers for drilling holes in the sylvan field even in other countries. In our country, people tried several types of motto-borers without being extended in the production [11].

The designing and construction of some borers with adequate parameters for the requirements of the sylvan field need continuous scientific research which can establish the optimal types from a technical and economical point of view.

The objectives of the research carried out were to comparatively determine on different types of soil, the qualitative parameters, among which the most important ones are: degree of loosening of the soil taken and left in the hole, resistance to penetration, resistance to shearing, time of drilling holes, degree of scattering of the soil taken out from the hole, degree of evacuation of the soil from the hole, gas consumption for the drilling of the hole, using the Stihl BT 121 motto-borer in order to establish its technical efficiency.

In order to obtain pertinent results, the research was done according to a complex methodology, with a novelty character in this domain, which gave the possibility to study different technical aspects of usage of the motto-borer.

The soil represents the material subjected to the processing by tools and equipment according to

the agro-technical requirements. As material, the soil has different mechanical properties which differ according to the type of soil, its texture and its state [1].
Because of the compaction, while digging holes for planting saplings, there are several phenomena of friction occurring which increase the resistance to penetration through the walls of the hole. For the same reason, the soil offers resistance to some mechanical, exterior forces, presenting resistance to compression, shearing and penetration [8].
During the drilling of the holes with a motto-borer, there are two categories of friction forces. The first category is represented by the friction forces which occur among the soil particles, which come in contact with them, and the second one by the shearing forces given by the soil particles with the metallic part (the drill) [3].
At the mechanized execution of holes for planting saplings, one needs to act to reduce the friction forces between the soil and the active organs, because, if on the contrary, there is registered a supplementary consumption of energy [6].

MATERIAL AND METHOD

The research was carried out on a horizontal ground in the O.S. Iuliu Moldovan, in two arranged unities (parcels) 31 C and 32 A, in a previously unprepared ground, on two types of soil: gley-soil (the muddy subtype) and alluvial soil (the vertical-gleyed subtype), and in O.S. Radna, u.a. 74, on a brown typically luvic soil, using the Stihl BT 121 motto-borer with a 150 mm drill.
The technical characteristics of the motto-borer used in our research are given in Table 1, and its photography appears in Fig. 1.
The present research displays the results obtained after the digging of holes for planting saplings in a previously unprepared soil, taking into consideration the following aspects: time needed to dig holes according to some physical-mechanical properties of the soil, degree of aeration of the soil taken out and left in the hole, the degree of scattering of the soil taken from the hole, the degree of evacuation of the soil in the hole, the gas consumption for digging holes.

Fig. 1 Stihl BT 121 motto-borer
Motoburghiul Stihl BT 121, [12]

Table 1. Technical data of the Stihl BT 121 motto-borer

Cylindrical capacity	30.8 cm³
Weight	9.4 kg
Power	1.3/1.8 kW/CP
Level of vibrations left/right	2.2/2.5 m/s²
Speed of rotation	190.0 1/min
Level of acoustic pressure	103.0 dB(A)
Level of acoustic pressure	109.0 dB(A)

The physical-mechanical properties were determined by using the method of cylinders with a constant volume of 100 cm^3, carrying out five repetitions at different depth, from 10 to 10 cm until the depth of 30 cm. The determination of the resistance to penetration was made with the aid of a penetrometer and that of the resistance to shearing was made with the aid of the equipment for shearing through rotation.
The methods of analysis and interpretation of the results as well as the work procedure for the determination of the physical – mechanical properties are those indicated in the specialized literature [2].
In order to observe the influences which the digging of holes have on their walls, we measured the resistance to penetration and the resistance to shearing on the holes' walls from 10 to 10 cm until the depth of 30 cm, on two opposing sides, so as to get the most probable values for these physical-mechanical properties of the soil, depth sufficient enough for the planting of small-sized saplings.

The placement of samples for the resistance to penetration and shearing on the walls of the holes is given in Fig. 2.

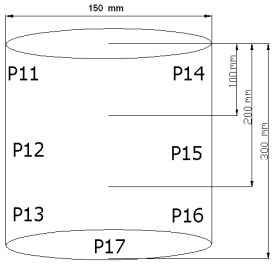

Fig. 2. Placement of samples for the resistance to penetration and shearing on the walls of the holes

The degree of scattering of the evacuated soil from the hole was expressed by the ratio of the maximum diameter of scattering or of the diameter at which is deposited most of the quantity of soil, at the diameter of the hole. The degree of evacuation of the soil from the hole was expressed by the ratio between the volume of the soil evacuated from the hole and the volume of the soil left in the hole at a 30 cm-depth. The elements measured for the determination of these qualitative indexes are given in Fig. 3.

In order to accomplish the objectives we have dug 50 holes for each type of soil chosen for the experiment, placed on a horizontal ground, previously unprepared, using the Stihl BT 121 motto-borer with a 150 mm drill.

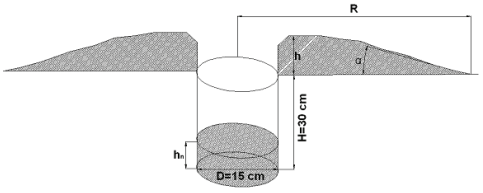

Fig. 3. Determination of the degree of scattering and degree of evacuation of the soil in the hole
(H – depth of digging, hn – height of the un-evacuated soil, h – height of the soil bed evacuated, D – diameter of the hole, α - angle of setting of the evacuated soil, R – radius of scattering of the evacuated soil.

RESULTS AND DISCUSSIONS

To establish the quality of the work carried out with the Stihl BT 121 motto-borer with a 150 mm drill, we made the following measurements:

a) Degree of aeration of the soil taken and left in the hole;
b) Resistance to penetration and shearing of the walls and of the bottom of the hole;
c) Average time for the digging of a hole;
d) Degree of scattering of the soil taken out from the hole;
e) Degree of evacuation of the soil from the hole;
f) Gas consumption for the execution of a hole.

a) Physical properties

The state of aeration of the processed soil and in the natural setting can be expressed through specific issues: apparent density and total porosity [9].

The three types of soil on which the research was carried out are: gley-soil (the muddy subtype), alluvial soil (the vertical-gleyed subtype), and a brown typically luvic soil. The physical properties determined during the execution of the holes like the granulometry of the soil are presented with average values in Table 2 and 3.

b_1) Resistance to penetration

The results of the research carried out, [5] demonstrate that the resistance to compression and cutting of the soil increase while the humidity of the soil is reduced to under 14% and goes even lower while its humidity increases to values over 28%.

In the situations in which the humidity is reduced under the minimum threshold shown, the active organs of the equipment take out clods and the aggregates are being highly stressed, which leads to the increase of specific consumption for materials (gas and metal). If humidity goes above the threshold of 28%, the soil begins to lose its organs. Consequently, it is recommended that the mechanic execution of the holes for planting to be done when its humidity is found in an optimal state (18-24%) [7].

Another important aspect is related to the resistance to penetration in connection with the study of the development and penetration in the

soil of the root system of the saplings. The experimental research shows that at values under 10-15 kgf/cm^2 the resistance to penetration does not influence negatively the penetration in the soil of the roots, while at values over 35-50 kgf/cm^2 it is almost null [10].

Table 2. Average values of the physical properties of the soil analyzed

Depth of prelevation of the sample, cm	**Natural humidity, %**	**Apparent density, g/cm^3**	**Total porosity, %**
SOIL 1: GLEYSOIL – MUDDY (u.a. 31 C, O.S. IULIU MOLDOVAN)			
0-10	24.11	1.62	37.89
10-20	22.73	1.69	37.43
20-30	20.09	1.72	36.45
SOIL 2: ALLUVIALSOIL– VERTICAL GLEYED (u.a. 32 A, , O.S. IULIU MOLDOVAN)			
0-10	20.75	1.70	36.97
10-20	19.46	1.75	35.73
20-30	17.38	1.73	35.19
SOIL 3: BROWN TYPICALLY LUVIC (u.a. 74, , O.S. RADNA)			
0-10	22.43	1.69	37.43
10-20	21.10	1.71	36.31
20-30	18.74	1.73	36.09

Table 3. Average values of the granulometric analysis at different depths of prelevation

Depth of prelevation of the sample	Sand		Dust		Clay
	Coarse	Fine	I	II	
SOIL 1: GLEYSOIL – MUDDY (u.a. 31 C, , O.S. IULIU MOLDOVAN)					
0-10	0.74	36.04	16.94	16.94	29.54
10-20	2.34	45.44	12.54	12.54	27.34
20-30	1.84	39.34	16.54	13.84	28.64
SOIL 2: ALLUVIALSOIL– VERTICAL GLEYED (u.a. 32 A, O.S. IULIU MOLDOVAN)					
0-10	1.74	39.04	14.54	24.24	20.64
10-20	1.84	37.54	14.14	23.04	23.84
20-30	2.44	39.54	14.54	18.54	25.24
SOIL 3: BROWN TYPICALLY LUVIC (u.a. 74, , O.S.RADNA)					
0-10	1.24	37.54	15.74	20.59	25.09
10-20	2.09	41.49	13.34	17.79	25.59
20-30	2.14	39.44	15.54	16.19	26.94

The resistance to penetration was also measured on the walls of the hole from 10 to 10 cm until de 30 cm-depth, on two opposing directions, (at the depth from 0 to 10 we obtained the values P11 and P14), but also at the bottom of the hole after the soil had been totally evacuated. The values obtained are given in a graphic in Figure 4 to 6.

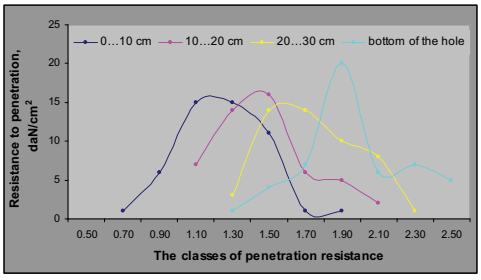

Fig. 4. Variance of resistance to penetration for soil 1

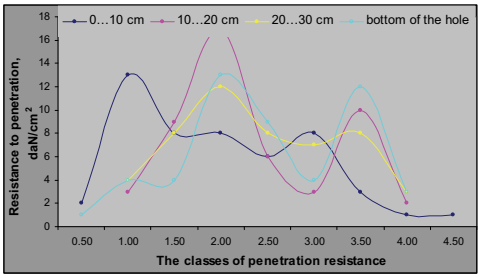

Fig. 5. Variance of resistance to penetration for soil 2

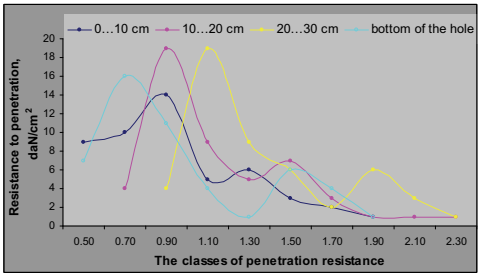

Fig. 6. Variance of resistance to penetration for soil 3

b_2) Resistance to shearing

The existence of the points of compliance in the mass of earth determines the redistribution of the surplus of unitary efforts to the neighbouring material points, thus generating a progressive breakage. Once the value of the tangential unitary efforts increase, these points multiply and group, allowing for a certain compliance zone called gliding zone or breakage zone. This zone, being reduced in dimensions as compared to the mass of earth, may be approximated with a surface called the breakage surface. Knowing the resistance to shearing allows avoiding the apparition of the breakage phenomenon [4].

Resistance to shearing was measured on the walls of the hole from 10 to 10 cm until the depth of 30 cm, on two opposing directions, (at the depth 0…10 cm the values obtained were R11 and R14), but also at the bottom of the hole after the soil was totally evacuated. The representation of these values under a graphical form is given in Figure 7 to 9.

c) Duration of drilling

In order to establish the economic efficiency of the Stihl BT 121 motto-borer, at the boring of the holes for planting, we registered the number of drilled holes for each variant of work and established the average time of execution of a hole for every type of soil included in the experiment.

For a better representation of the periods of execution of a hole we formed classes from second to second or, in the case of the 2nd soil, from five to five seconds, where we added up the drilled holes which belong to each class.

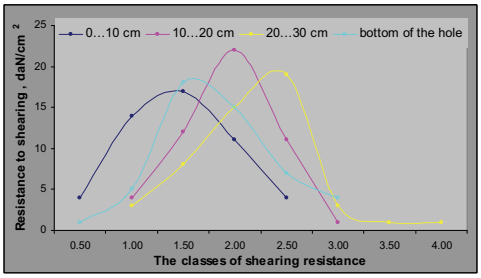

Fig. 7. Variance of resistance to shearing for soil 1

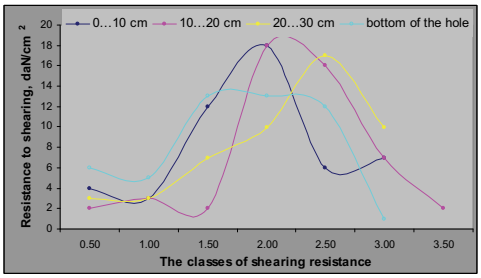

Fig. 8. Variance of resistance to shearing for soil 2

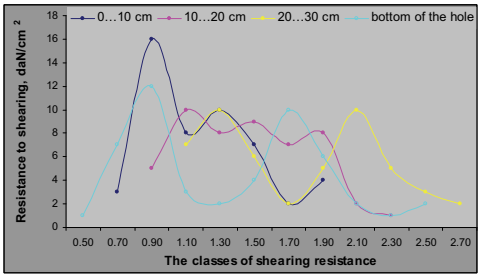

Fig. 9. Variance of resistance to shearing for soil 3

We can notice the enormous periods of execution for the holes in the 2nd soil, this fact being easily explainable because in this case we observed a more frequent presence of the roots, but also of the parental material and, in addition, bigger values of the resistance to penetration in comparison with the other types of soil which were included in the experiment.
The allure of the connection is that of the polynom of II degree and the equations are given in Fig. 10 to 12.

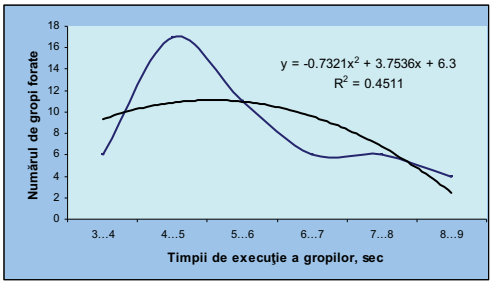

Fig. 10. Variance of the periods of execution of the holes with a 150 mm-drill for the 1st soil

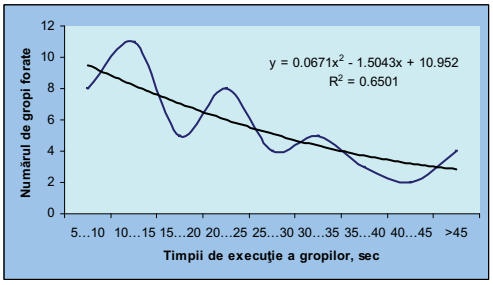

Fig. 11. Variance of the periods of execution of the holes with a 150 mm-drill for the 2st soil

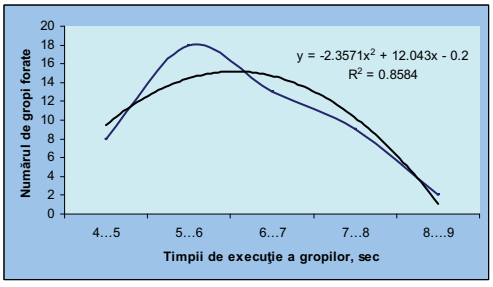

Fig. 12. Variance of the periods of execution of the holes with a 150 mm-drill for the 3st soil

d) Degree of scattering of the soil taken from the hole

The degree of scattering of the soil taken out from the hole can be expressed through the ratio between the maximum diameter of scattering (or the diameter at which point most of the quantity of evacuated soil is scattered) and the diameter of the hole. The registered values for the determination of those qualitative indexes are given in Table 4.

e) Degree of evacuation of the earth from the hole

The degree of evacuation of the soil from the hole is expressed in the ratio between the quantity (volume) of soil evacuated from the hole and the quantity of soil left in the hole at a 30 cm-depth.

f) Gas consumption for the digging of a hole

The measurements regarding the gas consumption were taken in conditions of ground previously unprepared, on a plain country where the study took place and the results are presented in Table 4.
The gas consumption was determined by introducing in the tank a known quantity of gas (0.5 l), with which there were made 106/90/110 holes, according to the type of soil. Relating the quantity of gas introduced in the tank to the number of holes dug we obtained the average quantity of gas for the digging of a hole, until the depth of 30 cm, which has the following values: 4.72 ml for the 1st type of soil, 1, 5.56 ml for the 2nd type of soil and 4.55 for the 3rd type of soil.

Table 4. Data regarding the quality of work with the Stihl BT 121 motto-borer on a horizontal ground

Type of soil	Ratio between the diameter at which point most of the quantity of evacuated soil is scattered and the diameter of the hole	Ratio between the maximum diameter of scattering of the soil and the diameter of the hole	Ratio between the quantity of soil evacuated and the quantity of soil left in the hole	Average gas consumption, ml
Soil 1	1.14	1.21	2.46	4.72
Soil 2	2.29	2.43	3.54	5.56
Soil 3	1.25	1.38	2.85	4.55

CONCLUSIONS

From all of the above, we can infer the following conclusions regarding the qualities and the behavior of the Stihl BT 121 motto-borer with a 150 mm drill in the sylvan field of activity, on a horizontal ground:

- After taking all the measurements for establishing the degree of compaction of the wall and bottom of the hole by the motto-borer during the work, it was inferred that in condition of normal humidity, if the motto-borers have sharp knives and are well conceived and executed from a technical point of view, do not register big values of resistance to penetration which could affect the ulterior development of the saplings.
- During the research, it was inferred that the wall of the hole is also compacted because of the wearing out of the spires of the helicoidal transporter or of the knife placed at the base of the last spire. Another possible cause for compaction occurs when the active diameter of the motto-borers' knife is cut because of the wearing out, which can lead to the exaggerate compaction of the walls or of the bottom of the hole.
- The small values of the resistance to penetration and shearing were obtained also because of the optimal values of the soil humidity during the drilling of the holes, these values oscillating between 19.20 % and 22.31 %.
- Analyzing the granulometric composition of the three types of soil included in the experiment, we can say that the fact that the soils present a sand-dust-clay-like composition, also mentioning that the quotas of participation of the fraction "dust" in the 32 A parcel (2nd soil) is by far superior to the same fraction from the other parcels. Thus, we can explain the average time of execution of the hole as being bigger in this parcel than in the rest of the parcels included in the experiment.
- In the pedological conditions of these three parcels included in the experiment the average time of execution of the holes are: 5.41 sec. for the 1st type of soil (gley-soil-the muddy subtype), for the 2nd type of soil (alluvial soil - the vertical-gleyed subtype) the average time was 23.42 sec, while for the 3rd soil (brown typically luvic soil) the average time was 6.08 sec for the 150 mm drill.
- The ratio between the diameter at which one can find scattered the biggest amount of soil evacuated and the diameter of the hole varies according to the type of soil as it follows: 1.14 for the 1st soil, 2.29 for the 2nd soil and 1.25 for the 3rd soil.
- The ratio between the quantity of soil evacuated and the quantity of soil left in the hole registers values between 2.46 and 3.54.
- The average gas consumption necessary for digging a hole until the 30cm-depth is 4.72 ml for the 1st type of soil, 1, 5.56 ml for the 2nd type of soil and 4.55 for the 3rd type of soil.

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