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INFLUENCE OF THE SOIL ON THE DURATION OF HOLE DIGGING FOR PLANTING SAPLINGS BY USING A GROUND AUGER

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Abstract
This paper presents the results of our research regarding the usage of ground augers in the forestry sector for drilling holes in order to plant saplings.
In order to carry out the research, we settled in two forest divisions in the plains of the West of Romania (Arad, Lipova) so that we could have four different types of soils which are representative for that specific area.
All our trials were conducted on previously unprepared (non-processed) soils. We started by measuring the particle size distribution and the main physical properties of the soil (moisture, bulk density and total porosity) and then, we determined the duration of drilling holes, split times (duration of movement from one hole to the other) when using a Stihl BT 121 auger equipped with a 200mm-diameter drill.
The average values for the duration of digging for each type of soil was as follows: 1st type of soil – timing 11.7±3.09 sec.; 2nd type of soil – timing 12.0±3.76 sec.; 3rd type of soil – timing 12.06±1.99 sec.; 4th type of soil – timing 9.83±2.52 sec. (mean±SD).
Keywords: ground auger, physical properties, timing of drilling holles

INTRODUCTION

The mechanization of the sylviculture works is a modern, complex and an enhancing form of what the human being produces in a limited time, using perfected manufacture means (tools, devices, prime movers, working movers etc.) (Popescu I., et al. 2013)

Machineries that realize digging holes to plant seedlings are part of the large group of ground working machines whose active components have a moving rotation generated by a power source. The specific of these machineries is the fact that the soil is prepared by chipping, action from which the soil mobilization and aeration is carried out with or without putting out the soil from the hole.

The principle of this action is not exclusively reserved to machineries digging holes for seedlings. This principle exists in other machineries whose destination is to prepare the soil to be a germinating bed, to maintain crops along rows gap, a.s.o. The same principle has applicability on a large scale in the wood and metal industries. (Popescu I., et al. 2006; Boja N., et al. 2011)

The interest regarding soil preparation machineries started 130 years ago. The year 1875 was an important one; in this year a machinery for soil preparation

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having a blade borer mounted on vertical rotor driven by two steam engines was fabricated in England.

Afterwards during the 1920's and the 1930's, researchers constructed different mill types, especially experimental models, in the U.S.A. and in Germany. (Chiru V., et al. 1963)

In our country, the first systematic research regarding soil mills were made by Prof.Ph.D. Gheorghe Dragan, who experimented different motor – mill types in the frame of the Agronomical Research Institute of Romania. (Popescu I., 2006)

In the forest field, some preoccupation regarding the use of machineries with driven rotary tools could be mentioned after 1960. It started with digging holes machineries and machineries to plant seedlings, made in Germany and Italy. These were experimented in different relief conditions in our forest found (Popescu I., et al. 1966).

Mills to prepare the soil to be a germinating bed in forest nurseries then attracted attention. In the field of mills, the first preoccupations are remarkable for their thoroughness in the theoretical basis of the soil mill process. Systematic and ample researches on mills for germinating bed preparation were made after 1969, following the influences of the works regarding physical-chemical soil properties, and regarding seedlings emergence, growth, and soils quality for some important forest species (Popescu I., 1984; Boja N., et al. 2011).

Nowadays, as a result of the impetuous development of the machine industry fitted out with driven rotary tools for soil preparation, the existence of some distinguished types easily leading 100 should be noted. From these, approximately 20% are made up of digging holes machineries having different destinations. (Popescu I., et al. 1966; Popescu I., 1984; Boja N., et al. 2011)

The soil is the environment of the growth and development of the saplings, because in it and through it there are the nutritive elements and the activity of the micro-organisms in the context of a normal thermo-aero-hydro regime. It can be penetrated by the roots of the plants, it is stirred, it contains water, air and living matter (flora and fauna) and it represents the necessary support for the growth and development of the saplings. (Boja F., et al. 2012; Biris S. ST., et al. 2015; Boja N., et al. 2015)

The characteristic of the soil as a growth and development environment for the plans is given by a series of properties (texture, structure, porosity, compaction, reaction, humus content and nutritive elements), expressed globally through the notion of fertility. (Boja N., et al. 2010; Boja N., et al. 2011; Onet A., et al. 2016).

MATERIAL AND METHODS

The experimental research was conducted in two forest divisions in the plains. For this purpose, we chose the soils which are most frequently spread in those areas. In this respect, we made measurements in order to determine the moisture, the bulk density, the total porosity and the particle size analysis of the soils. The particle size analysis of the soils was carried out in a specialized laboratory.

We determined the digging duration for each hole, but also the split times (duration of movement from one hole to the other). The digging duration and the split times were determined by using a timer.

The technical characteristics of the ground auger used in our research are given in table 1, and its photography appears in figure 1.

Fig. 1. Ground auger Stihl BT 121 (www.stihl.ro)

The technical characteristics of the ground auger Stihl BT 121 are given in Table 1.

Table 1

Technical data of the ground auger Stihl BT 121 (www.stihl.ro)

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 1/min
Level of acoustic pressure	103,0 dB(A)
Level of acoustic pressure	109,0 dB(A)

In this paper, we presented the results gathered after digging the holes for planting saplings in the previously unprepared ground, taking into account: the durations implied by digging holes according to the physical-mechanical properties of the soil.

The physical-mechanical properties were determined by using the method of the cylinders with a constant volume of 100 cm^3, carrying out five repetitions at different depth, from 10 to 10 cm until

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the depth of 30 cm. 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. (Boja N., et al., 2012a; Boja N., et al., 2013a; Boja N., et al., 2013b; Boja N., et al., 2013c; Boja N., et al., 2013d)

In order to reach our objectives, we have dug n holes for each type of soil chosen for the experiment, placed on a previously unprepared horizontal ground, using the Stihl BT 121 auger with a 200-mm drill, until exhausting the whole quantity of fuel placed in the tank (500 ml). (Boja N., et al., 2012c; Boja N., et al., 2012d; Boja N., et al., 2012e)

RESULTS AND DISCUSSIONS

a. Physical properties

The state of aeration of the processed soil in the natural setting can be expressed through specific issues such as: bulk density and total porosity. (Boja N., et al., 2012b, Boja N., et al., 2013)

The types of soil on which the research was carried out are: gley-soil the muddy subtype (soil 1), alluvial soil the vertical-gleyed subtype (soil 2), brown typically luvic soil (soil 3) and a alluvial soil-typical (soil 4). The physical properties determined during the digging of the holes and the particle size distribution of the soil are presented with average values in Tables 2 and 3.

Table 2

The values of physical properties of the soils analyzed (mean±SD)

Type of soil	Physical properties	Depth 0-10 cm	10-20 cm	20-30 cm
SOIL 1 gleysoil – muddy	Soil moisture, %	24.11 ± 1.2	22.73 ± 1.0	20.09 ± 0.8
	Bulk density, g/cm^3	1.62 ± 0.23	1.69 ± 0.19	1.72 ± 0.06
	Total porosity, %	37.89 ± 2.51	37.43 ± 2.24	36.45 ± 1.15
SOIL 2 alluvial soil – vertical gleyed	Soil moisture, %	20.75 ± 0.9	19.46 ± 0.7	17.38 ± 0.5
	Bulk density, g/cm^3	1.70 ± 0.02	1.75 ± 0.01	1.73 ± 0.00
	Total porosity, %	36.97 ± 1.32	35.73 ± 1.11	35.19 ± 0.92
SOIL 3 brown typically luvic	Soil moisture, %	22.43 ± 0.8	21.10 ± 0.5	8.74 ± 0.3
	Bulk density, g/cm^3	1.69 ± 0.05	1.71 ± 0.03	1.73 ± 0.01
	Total porosity, %	37.43 ± 1.05	36.31 ± 0.96	36.09 ± 0.53
SOIL 4 alluvial soil – typical	Soil moisture, %	23.35 ± 0.5	21.68 ± 0.3	19.54 ± 0.1
	Bulk density, g/cm^3	1.64 ± 0.01	1.58 ± 0.01	1.51 ± 0.00
	Total porosity, %	35.54 ± 2.52	33.28 ± 2.01	31.25 ± 1.85

We could notice the fact that the holes were dug when the values of soil moisture were ranging from 20.75 to 24.11 % for the 0-10 cm depth, 19.46-22.73 % for 10-20 cm depth and 8.74-20.09 % for the 20-30 cm depth.

In order to show the influence of the soil type (particle size distribution) and of the physical properties of the soils included in the experiment on the digging duration, all the holes were dug on a previously unprepared ground, which can be noticeable in the values of total porosity that vary as follows: for 0-10 cm between 35.54-37.89 %; for 10-20 cm between 33.28-37.43 % and for 20-30 cm between 31.25-36.45 %.

Table 3

Average values of the granulometric analysis at different depths of prelevation

Type of soil	Depth of prelevation	Values of the granulometric analysis: Sand (Coarse+Fine)	Dust (I+II)	Clay
SOIL 1 gleysoil – muddy	0-10	36.78	33.88	29.54
	10-20	47.78	25.08	27.34
	20-30	41.18	30.38	28.64
SOIL 2 alluvial soil – vertical gleyed	0-10	40.78	38.78	20.64
	10-20	39.38	37.18	23.84
	20-30	41.98	33.08	25.24
SOIL 3 brown typically luvic	0-10	38.78	36.33	25.09
	10-20	43.58	31.13	25.59
	20-30	41.58	31.73	26.94
SOIL 4 alluvialsoil – typical	0-10	40.36	38.36	21.28
	10-20	40.63	36.08	23.29
	20-30	41.2	33.95	24.85

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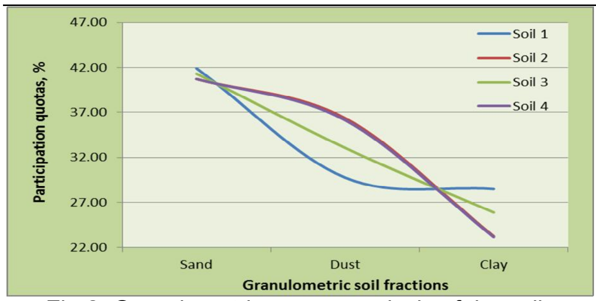

Fig.2. Granulometric curves analysis of the soils

When analysing the granulometric curves presented in figure 2, one can notice the fact that there was a sandy-dusty-clay-like texture in all the soils encompassed in the experiment at a participation quota that scarcely varies, with the exception of the 1st soil where the particle size distribution is slightly different: sandy-clay-like-dusty texture.

b. Duration of hole digging

In order to simplify the highlight of the main characteristics regarding the variation of the duration, at different depth and on different soils, we passed on to the stratification of the values according to these requirements. Then, we proceeded to the determination of statistical indexes that allow us to intrinsically evaluate the structure of the analysed data. These values are given in Tables 4 and 5.

Table 4

Statistical indexes regarding the duration of hole digging

Statistical indexes	SOIL 1	SOIL 2	SOIL 3	SOIL 4
Mean	11.70	12.00	12.06	9.83
S.E.M.	0.29	0.40	0.19	0.24
Standard deviation	3.09	3.76	1.99	2.52
Coefficient of variation	0.26	0.31	0.17	0.26
Minimum	7.01	8.19	7.41	6.04
Maximum	19.5	26.8	19	16.78
The number of feature values	116	87	105	111
Skewness	0.37	2.20	1.41	0.96
Curtosis	-0.56	5.02	2.36	0.03
Mean Deviation	2.58	2.56	1.42	2.03
Median	11.84	11.08	11.54	8.99
Range	12.49	18.61	11.59	10.74
Confidence Level (0,95)	0.57	0.80	0.39	0.47
Lower Confid. Limit	11.41	11.59	11.86	9.59
Upper Confid. Limit	11.99	12.40	12.25	10.07

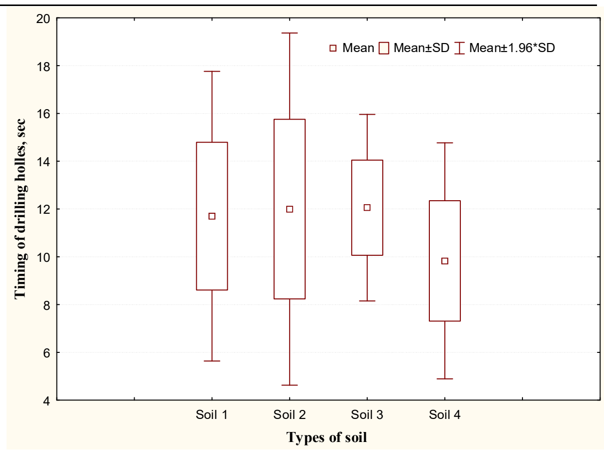

Fig.3. Variation timing of drilling holles

The average values of the digging time of holes vary between 9.83±2.52 and 12.06±1.99 seconds (mean±SD). Even though the soils chosen for this experiment have an almost identical particle size distribution, there is a noticeable difference among them in terms of drilling time, which can reach up to 13.36 seconds (the mean between the difference of maximum and minimum values). These differences appear as a result of physical properties of the soil while digging, which are different in terms o moisture, bulk density and total porosity.

Table 5

The ANOVA analysis duration of hole digging

Anova: SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*	*Std. Dev.*	*Law*	*Height*
Duration soil 1, sec	116	1357.071	11.699	9.563	3.092	8.606	14.791
Duration soil 2, sec	87	1043.703	11.997	14.135	3.760	8.237	15.756
Duration soil 3, sec	105	1265.820	12.055	3.967	1.992	10.064	14.047
Duration soil 4, sec	111	1090.960	9.828	6.349	2.520	7.309	12.348

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	359.706	3	119.902	14.523	0.0000000052	2.626
Within Groups	3426.289	415	8.256			
Total	3785.995	418				

c. Split times for digging holes

Split times represent the duration of movement from one hole to the other, which can be at a distance of 1, 2, 3 or 4 metres. These dimensional values are the most frequently found in the layout used for planting forestry saplings. These split times can be considered auxiliary times or time loss reflected in the fuel consumption, which must be amortized if we want to update the quota of the ground augers in the forestry sector.

In order to simplify the highlight of the main characteristics regarding the variation of the split times, at different distances from one hole to the other, we passed on to the stratification of the values according to these requirements. Then, we proceeded to the determination of statistical indexes that allow us to intrinsically evaluate the structure of the analysed data. These values are given in Table 6.

Table 6

Statistical indexes regarding the split times for digging holes

Statistical indexes	Distances from one holle to another			
	1 m	2 m	3 m	4 m
Mean	2.71	5.42	8.14	10.85
S.E.M.	0.14	0.27	0.41	0.55
Standard deviation	1.41	2.83	4.24	5.66
Coefficient of variation	0.52	0.52	0.52	0.52
Minimum	0.79	1.57	2.36	3.14
Maximum	7.7	15.39	23.09	30.78
The number of feature values	107	107	107	107
Skewness	1.78	1.78	1.78	1.78
Curtosis	3.27	3.27	3.27	3.27
Mean Deviation	0.99	1.98	2.97	3.96
Median	2.44	4.88	7.32	9.76
Range	6.91	13.82	20.73	27.64
Confidence Level (0,95)	0.27	0.54	0.81	1.08
Lower Confid. Limit	2.58	5.15	7.73	10.30
Upper Confid. Limit	2.85	5.70	8.55	11.39

From the analysis of the split times derived by hole digging (time lapse of the auger put on, from one hole to the other, according to the planting layout: 1, 2, 3 or 4 metres), we can infer the fact that the average value of drive for a 1m-distance is 2.71±1.41 sec.; at 2 m - 5.42±2.83sec.; at 3 m - 8.14±4.24 sec. and at 4 m - 10.85±5.66 sec. (mean±SD).

This time lapse starts from the moment the drill was taken out of the hole, moved to the next hole and placed on the spot where the following digging was going to be done.

The values of these split times are directly influenced by the field configuration, the presence of grass, of Rubus species and pioneer species which invade the soil when it is deprived of the protection of a tree. Similarly, the afforestation site significantly hinders the movements of the person in charge of the auger from one hole to the other.

CONCLUSIONS

From all of the above, we can infer the following conclusions regarding the behaviour of the Stihl BT 121 auger with a 200 mm drill in the forestry sector and on a previously unprepared horizontal ground:

- ✓ The average values of duration needed to dig holes (starting from the moment when the drill penetrated the soil, bored until reaching the 30 cm depth and was pulled out of the hole) vary between 9.83±2.52 and 12.06±1.99 seconds (mean±SD).
- ✓ The amplitude of average variation (the mean between the difference of maximum and minimum values) for the duration of digging holes is 13.36 sec., which is a high value. However, in terms of particle size distribution, the soil texture is similar. These differences occur as a result of physical properties of the different soils while digging.
- ✓ The average value of split times derived from hole digging (time lapse of the auger put on, from one hole to the other, according to the planting layout: 1, 2, 3 or 4 metres), is at a 1m-distance, 2.71±1.41 sec.; at 2 m, 5.42±2.83sec.; at 3 m, 8.14±4.24 sec. And at 4 m, 10.85±5.66 sec. (mean±SD).

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