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METHODS FOR SEEDBED PREPARATION IN FORESTRY NURSERIES

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Abstract

This paper presents the results of our research regarding the six methods for seedbed preparation in nursery of the West of Romania. This method are: Vibrocombinator equipped with Gama type active organs (Vibro_Gama), Vibrocombinator equipped with Delta1 type active organs (Vibro_Delta1), Vibrocombinator equipped with Delta2 type active organs (Vibro_Delta2), Disc harrow (Disks), Cultivator (Cultivator) and Rotary harrow (Rotary harrow). In order to evaluate the most efficient method of preparing the germination bed, the following physical-mechanical properties of the soil were determined: moisture, bulk density, total porosity and soil compression degree and water retention. In order to carry out the research, we settled a nursery of the West of Romania so that we could have six methods for seedbed preparation. From each profile was collected soil samples in three steps of 5, 10 and 15 cm. For each sample six repetitions were performed (N = 6). We started by measuring the particle size distribution (granulometric composition) and the main physical properties of the soil. The advantages of using vibro-combinators are: perfect preparation of seedbed in difficult working conditions and preservation of soil moisture. Such important factors can ensure fast, uniform and early germination of seeds, these requirements standing at the basis of abundant harvests. The research investigated the soil tillage performances and the environmental impact of several active elements, at certain soil depths.

Key words: *Vibro-combinator, disc harrow, rotary harrow, cultivator, bulk density, total porosity, compression degree.*

INTRODUCTION

Seedbed structure directly or indirectly affects crop establishment by modifying seed-soil contact, acting as mechanical obstacles or modifying temperature, moisture and oxygen contents of seedbed as well as the dynamic of pests, pathogens and weeds. However, very few detailed descriptions of seedbed's structure of major field crops exist to date, in terms of precise aggregate size distributions in relation to different factors including the cropping system, soil and climatic conditions and their interactions (Lamichhane et al., 2021).

Seedbed structure can significantly affect early growth and development of the crop, by altering abiotic components of the seedbed including soil-plant contact, mechanical forces exerted on plant or plant parts, soil aeration, thermal regime and water balance (Dexter, 1988; Dexter, 2004a; Dexter, 2004b; Boja et al., 2012; Boja et al., 2013).

In addition, seedbed structure can also affect the impact of early biotic stresses and the effectiveness of weed control (Glen et al., 1989; Bale et al., 1992; Otten et al., 2006; Finney et al., 2008; Melander et al., 2011; Boja et al., 2018a).

A seedbed containing a high proportion of large soil aggregates not only leads to a poor seed-soil contact but it also cools down more rapidly thereby slowing down the seed imbibition and germination process (Brown et al., 1996; Håkansson et al., 2002; Boja et al., 2016; Boja et al., 2020).

Consequently, the time interval between the seed germination and seedling emergence phase in a seedbed comprising bigger soil aggregates is longer, due to the increased tortuosity of the seedling path before reaching the soil surface (Boiffin et al., 1992).

Likewise, the risk of seedling death before emergence is higher in coarser seedbeds as seedlings can be trapped under the soil aggregates encountered during its elongation from the sowing depth (Dürr et al., 2000).
Delayed emergence also increases the risk of seedling death in an indirect way; for example, by increasing the probability of attacks due to soil-borne pests and pathogens owing to longer heterotrophic phase or topsoil crust formation impeding the emergence (Gallardo-Carrera et al., 2007).
A previous study (Boizard et al., 2002), based on a field experiment, investigated cumulative effects of cropping systems on the structural state of the tilled layer, in particular the proportion of compacted zones in a loamy soil that is characteristic of northern European soils. The authors showed that the compaction level of a soil was dependent on the soil moisture at the time of field operations as well as the characteristics of the machinery used and that there was no indication of irreversible cumulative degradation.
Another study (Boizard et al., 2013; Boja et al., 2016; Boja et al., 2018b), compared the impact of conventional versus reduced tillage on the soil structure evolution and showed that the soil structure in the untilled layer mainly depends on the soil compaction intensity and that regeneration of this compacted layer over time was slower compared with that of the tilled layer.
Nursery seedbed characterization is not only time consuming and resource intensive but also difficult to perform due to limited field access, especially under rainy seasons and high moisture conditions.
Only little knowledge is available to date concerning precise numerical data characterizing seedbed structure and its variations (Braunack et al., 1989; Braunack et al., 1991; Aubertot et al., 1999; Hammer et al., 2001; Gallardo-Carrera et al., 2007).
Together with the action of climatic nature, the soil, as a system, suffers from the influences of mechanical nature, related on one hand to the tillage process and, on the other hand, to the passing of equipments. According to the characteristics of the tools used and of the exploitation conditions, the first ones are extremely diverse, being conceived to fragmentize and break up the superior part of the soil.
The passing of the equipment represents another way of destroying the texture of the soil, and to favour the apparition of the compaction phenomenon, at some point, in unfavourable climactic conditions, imposed by the cultural calendar (Boja et al., 2018c; Vidrean et al., 2018).

MATERIALS AND METHODS

This paper presents the results of our research regarding the six methods for seedbed preparation in Iarac forestry nursery (Figure 1 and Table 1) of the West of Romania. This methods are: Vibrocombinator equipped with Gama type active organs (Vibro_Gama), Vibrocombinator equipped with Delta1 type active organs (Vibro_Delta1), Vibrocombinator equipped with Delta2 type active organs (Vibro_Delta2), Disc harrow (Disks), Cultivator (Cultivator) si Rotary harrow (Rotary harrow) (Figure 2).
In order to evaluate the most efficient method of preparing the germination bed, the following physical-mechanical properties of the soil were determined: moisture, bulk density, total porosity, soil compression degree and water retention. In order to carry out the research, we settled a nursery of the West of Romania so that we could have six methods for seedbed preparation.
From each profile was collected soil samples in three steps of 5, 10 and 15 cm. For each sample six repetitions were performed (N=6). We started by measuring the particle size distribution (granulometric composition) and the main physical properties of the soil.
There were taken samples in the natural settlement with metallic cylinders of 100 cm^3, in order to determine the physical properties at three levels in depth (0-10; 10-20; 20-30 cm); for each sample, the sampling was repeated six times, after the execution of each technical work.

Figure 1. The placement of the Iarac nursery

Table 1. The description of the nursery included in the experiment

Nursery	Altitude (m)	Zone of vegetation	Climate province		Average annual rainfall (mm)	Soil type
			Köppen	Stoenescu		
Iarac	100	Forest steppe	C.f.a.x.	I.B.p.1	500-600	Alluvial (vertic-gleyed)

Vibro_Gama

Vibro_Delta1

Vibro_Delta2

Disks

Cultivator

Rotary harrow

Figure 2. Methods for seedbed preparation in nursery

RESULTS AND DISCUSSIONS

The bulk density is one of the main indicators of the settlement of the soil and also one of the determining factors of some of the properties of the soil. High values of the bulk density signify the decrease of the capacity to retain water, of the permeability, of aeration and the increase of the mechanical resistance opposed by the soil at works and moreover at the penetration of the roots; low bulk density can reduce sometimes the bearing, making difficult the traffic and the execution of the processing works of the germination bed (Boja et al., 2012).

The porosity (the lacunar space) registers higher values while the content of the soil grows in organic matter and offers some important indications in relation with some of the properties of the soil. Thus, high values indicate a high capacity to retain water (Boja et al., 2018a).

The absolute values of the bulk density or of the total porosity cannot be interpreted accordingly in order to appreciate the state of settlement of the soil, because their practical significance is very different from soil to soil according to their texture (Boja et al., 2016).

The determination of the settlement of the soil is well taken by using a synthetic indicator which shows that the compression level and the deficit of total porosity are met. The indicator which includes the bulk density (total porosity) and takes into account the soil texture is the compression degree (Vidrean et al., 2018).

Apart from its significance as general indicator of its state of settlement, the compression degree practically reflects the state of breaking up and compression of the soil. In certain situations, the elimination of the soil compaction is difficult to be carried out, but it is possible to minimize it through the proper soil management. It is easier to avoid the compaction rather than to eliminate it after its installation, because the correction measures can be expensive and cannot totally solve the problem.

The results of the research are presented though average values according to the granulometric analysis in Table 2. When analysing the granulometric curves, one can notice the fact that there was a sandy-dusty-clay-like texture.

Table 2. Average values of the granulometric analysis

Depth of prelevation		Values of the granulometric analysis				
		Sand, %		Dust, %		Clay, %
		Coarse	Fine	I	II	
		>0.2	0.2-0.02	0.02-0.01	0.01-0.002	<0.0002
cm		%				
NURSERY IARAC						
Depth	0-10	1.7	39.0	14.5	24.2	20.6
	10-20	1.8	37.5	14.1	23.0	23.8
	20-30	2.4	39.5	14.5	18.5	25.2
Average on profile		**2.0**	**38.7**	**14.3**	**21.9**	**23.2**

To synthesize more efficiently the data taken and to be able to describe completely the intrinsic characteristics of the sample, it was chosen a statistic processing with the aid of the program KyPlot (http://www.kyplot .software. informer.com). The results obtained are given in Tables 3-6, having as a purpose to underline the variance a six methods for seedbed preparation in nursery. Thus, for each nursery were included in the experiment resulted in fifteen statistical indicators for each technical work, but also witness sample. For example we present the determination of statistical indicators for the depth of 5 cm.

Table 3. Statistical indexes of variation of moisture, depth 5 cm

Statistical indicator	Witness sample CTRL	Methods for seedbed preparation					
		Vibro_ Gama	Vibro_ Delta1	Vibro_ Delta2	Disks	Cultivator	Rotary harrow
Mean	20.04	21.52	21.75	23.83	23.70	19.52	18.53
S.E.M.	0.95	0.06	0.08	0.11	1.39	0.70	0.57
Standard deviation	2.32	0.15	0.19	0.28	3.40	1.70	1.40
Coefficient of variation	0.12	0.01	0.01	0.01	0.14	0.09	0.08
Minimum	16.50	21.30	21.50	23.45	19.84	17.71	17.08
Maximum	23.19	21.70	22.00	24.20	27.72	22.18	20.29
The nr. of feature values	6	6	6	6	6	6	6
Skewness	-0.20	-0.31	0.00	0.00	0.19	0.47	0.12
Curtosis	-0.82	-1.15	-1.27	-1.27	-1.54	-1.11	-1.78
Mean Deviation	2.10	0.14	0.18	0.27	3.30	1.68	1.49

Statistical indicator	Witness sample CTRL	Methods for seedbed preparation					
		Vibro_ Gama	Vibro_ Delta1	Vibro_ Delta2	Disks	Cultivator	Rotary harrow
Median	20.12	21.55	21.75	23.83	23.23	19.28	18.40
Range	6.69	0.40	0.50	0.75	7.88	4.47	3.21
Confidence Level (0,95)	2.43	0.15	0.20	0.29	3.57	1.79	1.47
Lower Confidence Limit	19.09	21.46	21.67	23.71	22.31	18.82	17.96
Upper Confidence Limit	20.99	21.58	21.83	23.94	25.09	20.21	19.10

Table 4. Statistical indexes of variation of bulk density, depth 5 cm

Statistical indicator	Witness sample CTRL	Methods for seedbed preparation					
		Vibro_ Gama	Vibro_ Delta1	Vibro_ Delta2	Disks	Cultivator	Rotary harrow
Mean	1.44	1.39	1.35	1.31	1.43	1.60	1.74
S.E.M.	0.01	0.00	0.01	0.02	0.05	0.10	0.04
Standard deviation	0.02	0.01	0.03	0.06	0.12	0.24	0.10
Coefficient of variation	0.01	0.01	0.02	0.04	0.08	0.15	0.06
Minimum	1.41	1.38	1.31	1.23	1.21	1.31	1.62
Maximum	1.47	1.40	1.39	1.38	1.54	1.84	1.87
The nr. of feature values	6	6	6	6	6	6	6
Skewness	0.24	0.00	0.00	0.00	-1.03	-0.34	-0.01
Curtosis	-0.68	-1.50	-1.50	-1.27	-0.08	-1.61	-1.27
Mean Deviation	0.02	0.01	0.03	0.05	0.10	0.24	0.09
Median	1.44	1.39	1.35	1.31	1.45	1.67	1.75
Range	0.06	0.02	0.08	0.15	0.33	0.53	0.25
Confidence Level (0,95)	0.02	0.01	0.03	0.06	0.13	0.25	0.10
Lower Confidence Limit	1.43	1.39	1.34	1.28	1.38	1.50	1.70
Upper Confidence Limit	1.45	1.39	1.36	1.33	1.48	1.69	1.78

Table 5. Statistical indexes of variation of total porosity, depth 5 cm

Statistical indicator	Witness sample CTRL	Methods for seedbed preparation					
		Vibro_ Gama	Vibro_ Delta1	Vibro_ Delta2	Disks	Cultivator	Rotary harrow
Mean	32.22	46.54	48.17	49.81	44.81	39.97	35.68
S.E.M.	4.11	0.14	0.51	0.88	1.25	4.12	1.47
Standard deviation	10.07	0.34	1.24	2.16	3.06	10.09	3.61
Coefficient of variation	0.31	0.01	0.03	0.04	0.07	0.25	0.10
Minimum	22.10	46.15	46.54	46.92	40.88	28.36	30.56
Maximum	45.22	46.92	49.81	52.69	48.36	51.53	40.06
The nr. of feature values	6	6	6	6	6	6	6
Skewness	0.54	-0.02	0.00	0.00	0.10	0.16	-0.06
Curtosis	-1.48	-1.50	-1.32	-1.27	-1.44	-1.63	-1.22
Mean Deviation	10.12	0.31	1.19	2.08	2.98	10.29	3.38
Median	28.29	46.54	48.17	49.81	44.39	38.31	35.34
Range	23.12	0.77	3.27	5.77	7.48	23.17	9.50
Confidence Level (0,95)	10.57	0.36	1.31	2.27	3.22	10.59	3.79
Lower Confidence Limit	28.10	46.40	47.67	48.93	43.56	35.85	34.21
Upper Confidence Limit	36.33	46.68	48.68	50.69	46.06	44.09	37.15

Table 6. Statistical indexes of variation of soil compaction degree, depth 5 cm

Statistical indicator	Witness Sample CTRL	Methods for seedbed preparation					
		Vibro_ Gama	Vibro_ Delta1	Vibro_ Delta2	Disks	Cultivator	Rotary harrow
Mean	23.19	8.07	4.84	1.61	2.64	18.50	26.87
S.E.M.	6.16	0.28	1.00	1.74	3.79	6.13	3.17
Standard deviation	15.08	0.68	2.46	4.27	9.27	15.01	7.77
Coefficient of variation	0.65	0.08	0.51	2.65	3.51	0.81	0.29
Minimum	3.79	7.31	1.61	-4.09	-14.28	-0.02	17.22
Maximum	40.61	8.83	8.07	7.31	10.72	35.09	37.32
The nr. of feature values	6	6	6	6	6	6	6
Skewness	-0.36	0.00	0.00	0.00	-1.04	-0.13	-0.07
Curtosis	-1.44	-1.50	-1.32	-1.27	-0.06	-1.72	-1.31
Mean Deviation	14.64	0.61	2.36	4.10	7.71	15.77	7.29
Median	27.49	8.07	4.84	1.61	4.07	20.59	28.03

Statistical indicator	Witness Sample CTRL	Methods for seedbed preparation					
		Vibro_ Gama	Vibro_ Delta1	Vibro_ Delta2	Disks	Cultivator	Rotary harrow
Range	36.82	1.52	6.46	11.40	25.00	35.11	20.10
Confidence Level (0,95)	15.83	0.71	2.58	4.48	9.73	15.75	8.16
Lower Confidence Limit	17.03	7.79	3.84	-0.13	-1.14	12.38	23.69
Upper Confidence Limit	29.34	8.35	5.84	3.35	6.43	24.63	30.04

Analyzing the average values of the six variants of seedbed preparation, for the five physical-mechanical properties of the soil, for the sampling depth of 5 cm, the best values were obtained when using the Vibrocombinator equipped with active organs of Delta2 type (Vibro_Delta2).

The mechanical processing of the soil through traditional and modern methods is currently put under question due to the high energy consumption and the continuous degradation of the arable horizon through erosion and excessive compaction.

Analyzing the variation of soil moisture on the three sampling depths, it is noted that at 5 cm depth was recorded the maximum soil moisture after processing with Vibro_Delta2 and at 10 and 15 cm depth the maximum soil moisture accumulated was obtained after processing with Vibro_Delta1 (Figure 3).

The lowest bulk density were recorded after processing with Vibro_Delta2 (5 cm) and Disks (10-15 cm) (Figure 4).

Total porosity recorded maximum values for all depths after the preparation of the germination bed with Vibro_Delta2 (Figure 5).

The soil compression degree recorded the lowest values when preparing the germination bed with Vibro_Delta2 (5 cm) and Disks (10-15 cm) (Figure 6).

The water retention reached maximum values when preparing the germination bed with the help of Vibro_Delta2 (5 cm) and Vibro_Gama (10-15 cm) (Figure 7).

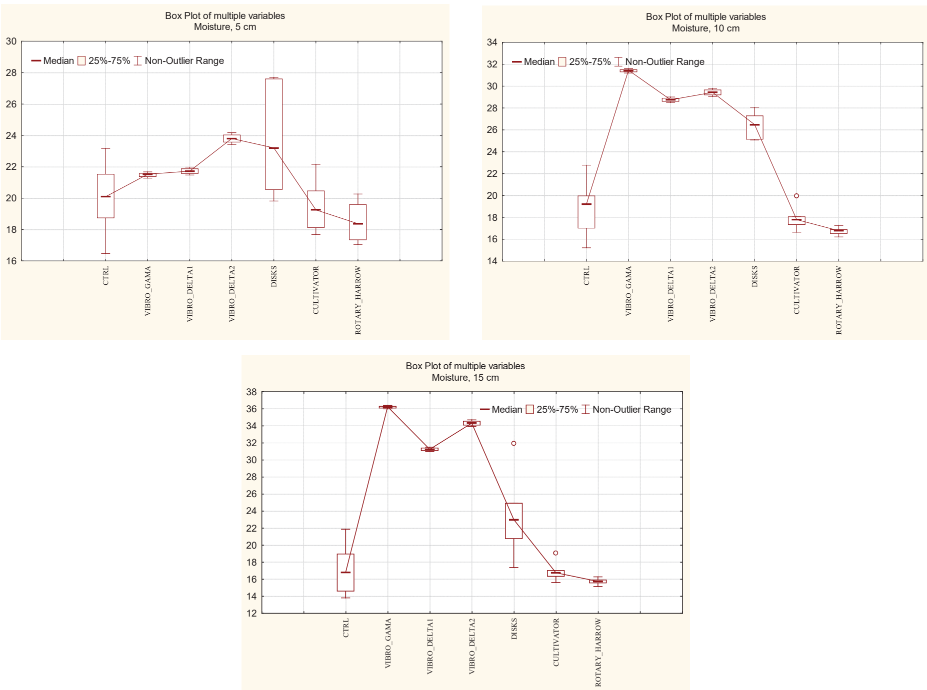

Figure 3. Variation of soil moisture for seedbed preparation, for three depth

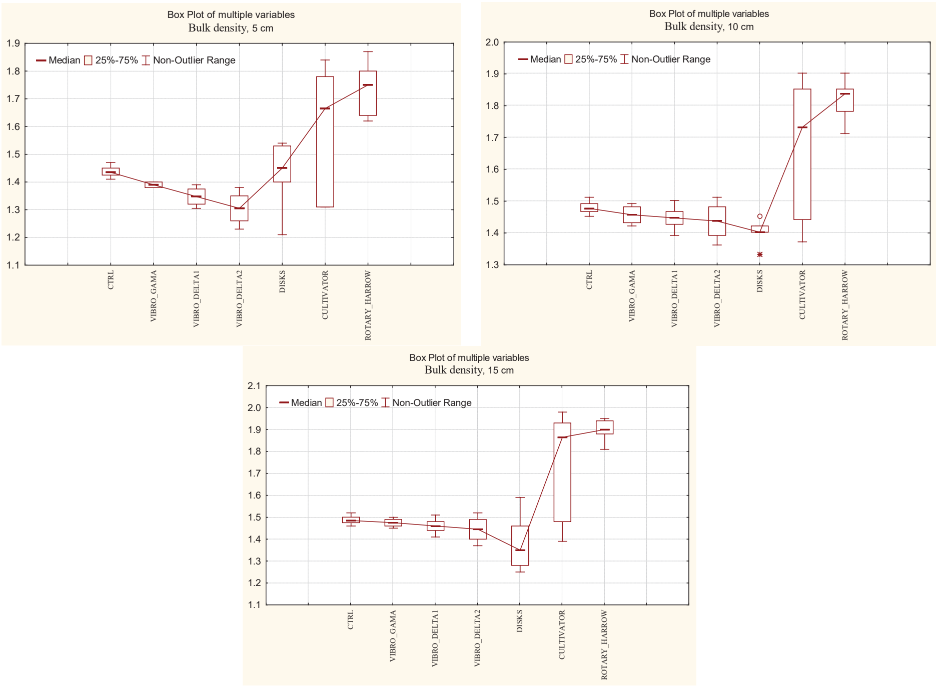

Figure 4. Variation of bulk density for seedbed preparation, for three depth

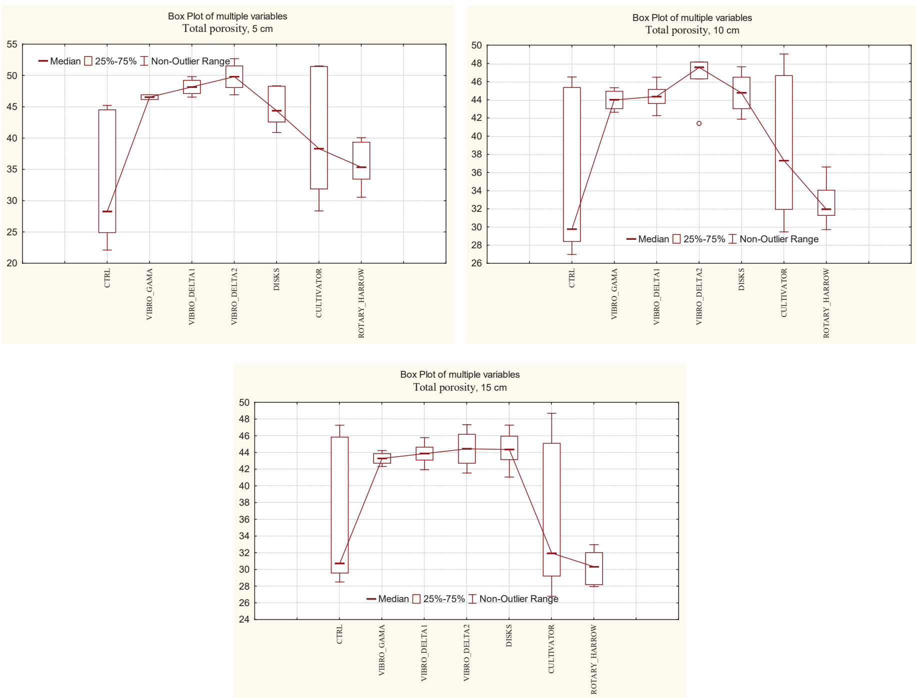

Figure 5. Variation of total porosity for seedbed preparation, for three depth

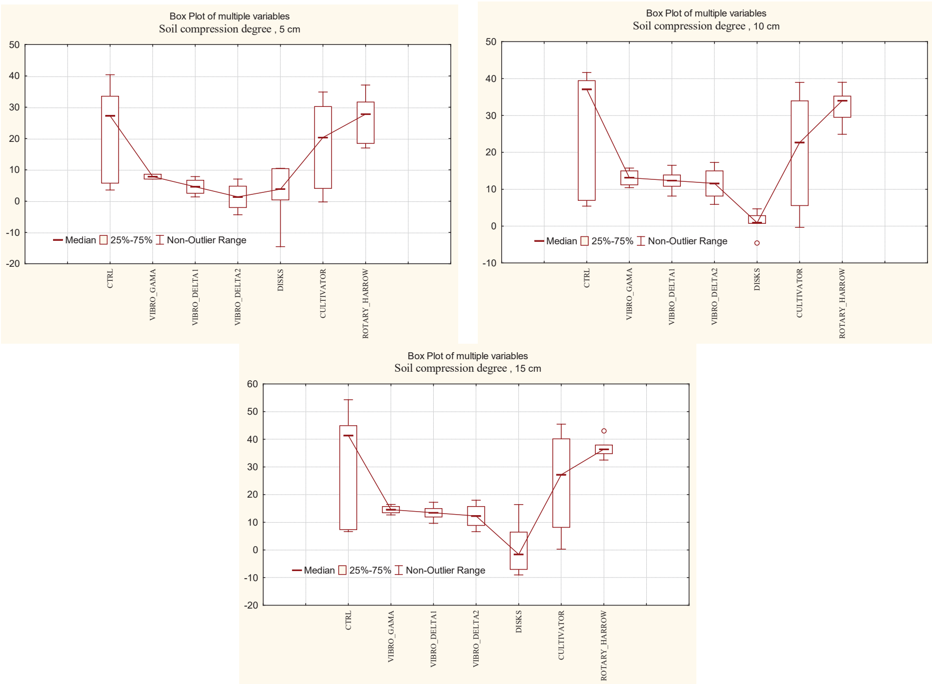

Figure 6. Variation of soil compression degree for seedbed preparation, for three depth

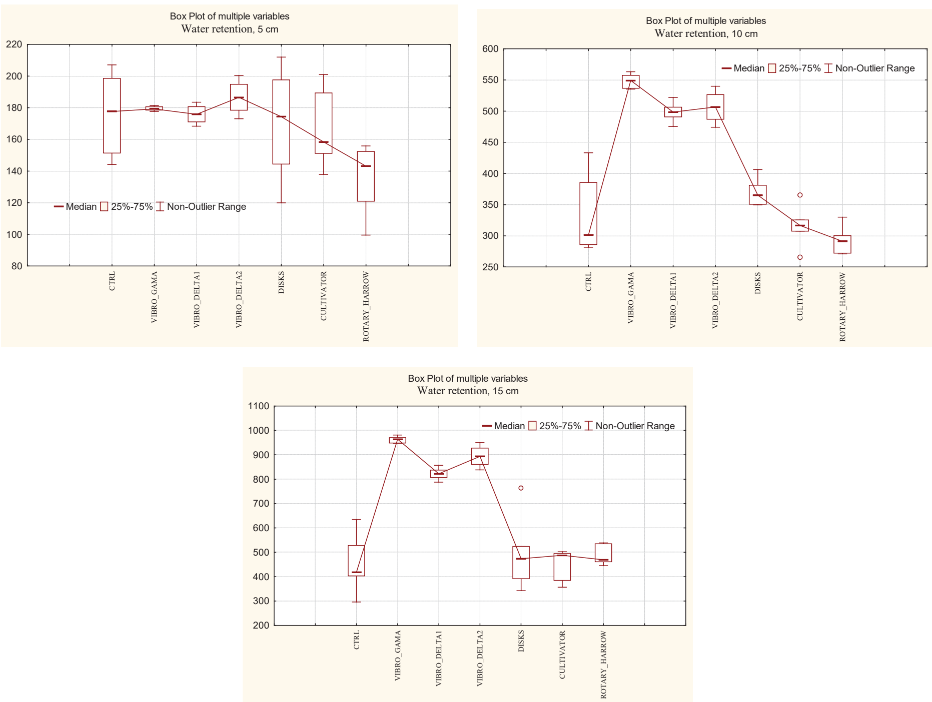

Figure 7. Variation of water retention for seedbed preparation, for three depth

CONCLUSIONS

The process of soil compaction due to natural factors appears under the form of some genetic consolidated horizons. The situations which lead to the occurrence of the phenomenon of soil compaction are divided between the action of natural and anthropogenic factors.

During the action of the wheeling system of the tractors and the agricultural equipment on the soil, it is subjected to some mechanical efforts, which, through their action, make it shift laterally (refulation), vertically (compression) and horizontally (shear). The effect of the compression is transmitted in the layers of the soil in all directions, under the form of a pressure, and thus their propagation is insignificant at depths greater than 80 cm.

The physical characteristics like bulk density, total porosity and compression degree modify according to the soil works. The modification of these properties is hard to notice (except for the compression degree) during a year because the soil has the tendency, in normal conditions, to get back to the initial state and to estimate the negative effects which appeared after the impact produced by its processing with mechanical means.

Several researches show that in a long period of time, the evolution of the physical properties in a certain direction takes place at a slow rhythm, after a short period of time when they start to stabilise. This research attempted to emphasise the fact that the process of compaction plays a negative role on the physic-mechanical properties in the six methods for seedbed preparation.

The research investigated six methods for seedbed preparation in forestry nursery performances and the environmental impact of several active elements, at certain soil depths.

Following the six methods of seedbed preparation, it was found that the most efficient method, following the five physical-mechanical properties of the soil, is when using Vibro_Delta2.

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