VARIATION OF SOIL COMPACTION IN FOREST NURSERIES

N. BOJA [1], F. BOJA [1]

[1] "Vasile Goldiş" Western University of Arad, Faculty of Engineering &
Cocorilor Street nr. 57 Arad
E-mail:bojanicu@yahoo.com

Abstract: *Soil compaction assumes volume compression of the soil under the action of external factors. As solid particles can not be compressed, the air pockets between them reduce and therefore through compaction the dimensions of the pores is modified, their distribution and also the soil durability. The degree of compaction of the soil can be estimated thru apparent density, total porosity and degree of settling. The ground compaction in the forestry nurseries is characterized by the increase of the apparent density, the reduction of the total porosity, of the hydraulic conductivity and of the air permeability. These modifications influence the air and water mobility in the soil. The processing of the soil can produce or avoid the soil compaction. The excessive processing can favour the pulverization of the structure of the soil with effects on the compaction at the surface. The repeated tillage with a disc harrow at the same depth can lead, on certain soils, to the formation of compacted strata under the working depth. In general, the capacity of the soil to resist to compaction reduces itself while its humidity increases. When the soil is too humid, its plasticity and adherence are high and thus, the structural aggregates can be easily deteriorated. The result is the soil compaction. The research in cause has as a purpose the identification of the technical means of optimal mechanisation used in the forest nurseries, which are meant to lead to an decrease degree of compaction, a rise of the qualitative level of the processing. The purpose of the research is scientifically motivated through the necessity of introducing new tools for the execution of the works implied for soil preparation about activity settlement. The research has been carried out in three forest nurseries Forestry Department Arad, during 2006-2009, on different soil types. In the present paper, we display the results obtained after the working of the soil in the classical tillage system and minimum tillage system on the physical and mechanical properties. The work systems applied have been: classical tillage system (plough + disc 2X) and minimum tillage system (paraplow + harrow). The usefulness of this paper lays in the research data gathered, processed, analyzed and exploited in order to provide a pertinent study material, which could be effectively used by the specialists in the design of obtaining saplings in the forestry nurseries and the choice of the tillage system for the optimal soil.*

Key words**:** *compaction, technical work, compression degree*

INTRODUCTION

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 equipments 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.

In the last decades, an enormous quantity of energy was spent at a global level to reduce the negative influences of the soil compaction caused by the influence of the anthropogenic activities. This research is justified in the context of the existence of some compressed soils, with weak aeration and weak development of the root of the forestry saplings. (BOJA N., et al., 2010)

The soil compaction occurs at a certain degree of soil deformation. This fact can be noticed in the mass of the soil through the diminution of the structural pores, and thus the structural aggregates take the form of continuous storage.

The soil degradation is influenced by a series of factors of mechanical, physicochemical and biological nature. The numerous and inappropriate mechanical works contribute to the destruction of the soil structure (RUSU T., GUȘ P., 2007).

The soil structure and, implicitly, the properties which derive from it, represent both a morphological index, characterizing different genetic types of soil, and an agronomic index, determining, in an indirect way, its fertility. The agronomic value of the structure is given by its influence on the settlement, of the rule of water and air (POPESCU I., 1984).

The degradation consists in the elongation and flattening of the aggregates, the apparition of the edges and corners, through a stocky settlement, the increase of the ratio of dusty material which, through the rain action, forms mud and passes through different states of plasticity, to finally harden and crack (BOJA N., et al., 2009).

The ground compaction in the forestry nurseries is characterized by the increase of the apparent density, the reduction of the total porosity, of the hydraulic conductivity and of the air permeability. These modifications influence the air and water mobility in the soil.

The soil compaction presupposes the compression of its volume because of external factors. As the solid particles can not be compressed, the porous spaces are reduces and consequently, the compaction modifies the dimension of the pores, their distribution and the soil durability. The soil compression degree can be estimated through apparent density, total porosity and compression degree.

Firstly, the compaction is due to the mechanical forces created by the traffic of the layouts and/or operations of soil processing with a high rate of humidity. The traffic of the layouts on the arable surfaces represents the main factor which contributes to the severe compaction of soils, more often in the last 10-20 years when the weight and dimension of the layouts grew considerably. When the potential of compaction of a layout is evaluated, one must take into consideration the contact pressure created by the wheels of the tractors on the soil and the total upload on the axis (RUSU T., GUȘ P., 2007).

MATERIAL AND METHODS

The research has been carried out in three forest nurseries Forestry Department Arad, during 2006-2009, on different soil types (Iarac: alluvial vertic - gleyed; Agrisul Mare: luvisol; Iosasel: eutricambosol). In the present paper, we display the results obtained after the working of the soil in the classical tillage system and minimum tillage system on the physical and mechanical properties. The work systems applied have been: classical tillage system (plough + disc 2X) and minimum tillage system (paraplow + harrow). The usefulness of this paper lays in the research data gathered, processed, analyzed and exploited in order to provide a pertinent study material, which could be effectively used by the specialists in the design of obtaining saplings in the forestry nurseries and the choice of the tillage system for the optimal soil.

There were taken samples in the natural settlement with metallic cylinders of 100 cm^3, in order to determine the physical properties, (apparent density, total porosity and soil compression degree), 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. 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. (CANARACHE A., 1990).

RESULTS AND DISCUSSIONS

The apparent 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 apparent 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 apparent density can reduce sometimes the bearing, making difficult the traffic and the execution of the processing works of the germination bed.

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.

The absolute values of the apparent 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.

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 apparent density (total porosity) and takes into account the soil texture is the compression degree (BOJA N., et al., 2010).

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 can not totally solve the problem (BOJA N., et al., 2009).

The results of the research are presented though average values according to the physical-mechanical factor analyzed, for the three sampling depths as it follows: the apparent density in table 1, the total porosity in table 2, and the compression degree in table 3.

Table 1

Average values of the apparent density in comparison with the sampling depth and the technical works done

Nursery	Apparent density		0-10	10-20	20-30
Iarac	Witness sample		1.76	1.75	1.73
	Classical tillage	classical plough	1.44	1.35	1.38
		2X disks	1.43	1.40	1.38
	Minimum tillage	paraplow	1.64	1.57	1.56
		rotary harrow	1.77	1.81	1.84
Agrisul Mare	Witness sample		1.77	1.73	1.72
	Classical tillage	classical plough	1.60	1.38	1.38
		2X disks	1.39	1.44	1.56
	Minimum tillage	paraplow	1.37	1.38	1.40
		rotary harrow	1.56	1.64	1.82
Iosasel	Witness sample		1.56	1.59	1.70
	Classical tillage	classical plough	1.23	1.15	1.07
		2X disks	1.25	1.35	1.44
	Minimum tillage	paraplow	1.38	1.39	1.41
		rotary harrow	1.58	1.59	1.69

Table 2

Average values of the total porosity in comparison with the sampling depth and the technical works done

Nursery	Total porosity		0-10	10-20	20-30
Iarac	Witness sample		34.67	35.01	35.76
	Classical tillage	classical plough	46.75	50.07	48.71
		2X disks	47.05	48.21	48.82
	Minimum tillage	paraplow	39.44	41.91	42.26
		rotary harrow	34.53	31.95	30.44
Agrisul Mare	Witness sample		34.33	36.08	36.34
	Classical tillage	classical plough	40.82	49.02	49.03
		2X disks	48.49	46.52	42.21
	Minimum tillage	paraplow	49.3	48.89	48.05
		rotary harrow	42.27	39.10	32.47
Iosasel	Witness sample		42.05	41.18	37.05
	Classical tillage	classical plough	54.34	57.33	60.50
		2X disks	53.71	49.95	46.71
	Minimum tillage	paraplow	48.88	48.47	47.62
		rotary harrow	41.56	41.07	37.41

Table 3

Average values of the compression degree in comparison with the sampling depth and the technical works done

Nursery	Soil compression degree		0-10	10-20	20-30
Iarac	Witness sample		28.40	28.30	27.20
	Classical tillage	classical plough	3.39	-1.96	0.78
		2X disks	2.64	0.92	0.63
	Minimum tillage	paraplow	18.50	14.10	13.90
		rotary harrow	28.60	34.50	33.20
Agrisul Mare	Witness sample		28.40	25.00	24.90
	Classical tillage	classical plough	14.80	-1.36	-1.14
		2X disks	-1.19	3.81	12.90
	Minimum tillage	paraplow	1.03	1.61	3.24
		rotary harrow	15.10	21.30	34.60
Iosasel	Witness sample		28.36	28.27	27.19
	Classical tillage	classical plough	-14.54	-20.43	-26.42
		2X disks	-13.05	-3.92	2.33
	Minimum tillage	paraplow	-3.02	-1.95	-0.02
		rotary harrow	0.49	1.65	3.01

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. The results obtained are given in tables 4…6, having as a purpose to underline the variance of soil compression degree, comparative with the tillage system (minimum/classical systems).

Thus, for each nursery were included in the experiment resulted in fifteen statistical indicators for each technical work performed in the two systems (minimum/classical), but also witness sample.

Table 4

Statistical indexes of variation of soil compression degree in Iarac nursery

Statistical indicator	Witness sample	Soil compression degree			
		Classical system		Minimum system	
		classical plough	2X disks	paraplow	rotary harrow
Mean	27.940	0.737	1.397	15.523	32.130
S.E.M. (Average standard error)	0.376	1.545	0.627	1.484	1.787
Standard deviation	0.651	2.675	1.086	2.571	3.095
Coefficient of variation	0.023	3.632	0.778	0.166	0.096
Minimum	27.190	-1.960	0.630	13.940	28.640
Maximum	28.360	3.390	2.640	18.490	34.540
The number of feature values (N)	3.000	3.000	3.000	3.000	3.000
Skewness	-0.692	-0.030	0.651	0.702	-0.563
Curtosis	-1.500	-1.500	-1.500	-1.500	-1.500
Mean Deviation	0.750	2.697	1.243	2.967	3.490
Median	28.270	0.780	0.920	14.140	33.210
Range	1.170	5.350	2.010	4.550	5.900
Confidence Level(0,95)	1.617	6.646	2.699	6.387	7.688
Lower Confidence Limit	27.564	-0.808	0.769	14.039	30.343
Upper Confidence Limit	28.316	2.281	2.024	17.008	33.917

Table 5

Statistical indexes of variation of soil compression degree in Agrisul Mare nursery

Statistical indicator	Witness sample	Soil compression degree			
		Classical system		Minimum system	
		classical plough	2X disks	paraplow	rotary harrow
Mean	26.083	4.100	5.177	1.960	23.690
S.E.M. (Average standard error)	1.135	5.350	4.127	0.662	5.746
Standard deviation	1.965	9.267	7.149	1.146	9.952
Coefficient of variation	0.075	2.260	1.381	0.585	0.420
Minimum	24.860	-1.360	-1.190	1.030	15.130
Maximum	28.350	14.800	12.910	3.240	34.610
The number of feature values (N)	3.000	3.000	3.000	3.000	3.000
Skewness	0.700	0.707	0.338	0.509	0.411
Curtosis	-1.500	-1.500	-1.500	-1.500	-1.500
Mean Deviation	2.267	10.700	7.733	1.280	10.920
Median	25.040	-1.140	3.810	1.610	21.330
Range	3.490	16.160	14.100	2.210	19.480
Confidence Level(0,95)	4.881	23.021	17.758	2.846	24.722
Lower Confidence Limit	24.949	-1.250	1.049	1.298	17.944
Upper Confidence Limit	27.218	9.450	9.304	2.622	29.436

Table 6

Statistical indexes of variation of soil compression degree in Iosasel nursery

Statistical indicator	Witness sample	Soil compression degree			
		Classical system		Minimum system	
		classical plough	2X disks	paraplow	rotary harrow
Mean	27.940	-20.463	-4.880	-1.663	1.717
S.E.M. (Average standard error)	0.376	3.430	4.466	0.878	0.728
Standard deviation	0.651	5.940	7.735	1.520	1.261
Coefficient of variation	0.023	-0.290	-1.585	-0.914	0.735
Minimum	27.190	-26.420	-13.050	-3.020	0.490
Maximum	28.360	-14.540	2.330	-0.020	3.010
The number of feature values (N)	3.000	3.000	3.000	3.000	3.000
Skewness	-0.692	-0.010	-0.224	0.334	0.097
Curtosis	-1.500	-1.500	-1.500	-1.500	-1.500
Mean Deviation	0.750	5.957	8.170	1.643	1.293
Median	28.270	-20.430	-3.920	-1.950	1.650
Range	1.170	11.880	15.380	3.000	2.520
Confidence Level(0,95)	1.617	14.756	19.214	3.777	3.133
Lower Confidence Limit	27.564	-23.893	-9.346	-2.541	0.988
Upper Confidence Limit	28.316	-17.034	-0.414	-0.786	2.445

Measures to prevent the soil compaction:

- The reduction of the traffic on the field because it represents the main cause of compaction.
- The reduction of the works applied on the soil through the usage of different minimum systems together with an efficient management of the vegetal remains.
- The usage of equipments of small weight and of the small and medium-seized tractors.
- The usage of tyres with big outer surface and radial section which operate at a low pressure, leaves behind a wider, vaster and more stable rut due to the better distribution of the pressure on the soil.

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.

The soil processing in the classical tillage system leads to an excessive break-up through repeated interventions, leaving it without vegetal remains through the reversal of the clods in the ploughing process, thus being strongly eroded under the action of the water and wind.

Worldwide, there is the tendency to replace the classical tillage system of the soil, through the extension of the minimum work system, method recommended both from the point of view of the preservation of the soil and for the reduction of energy consumption (BOJA N., et al., 2008).

In our country, the extension of these systems of soil processing in the forestry nurseries is slow because of the lack of unitary strategies to sustain the technology, the lack of unitary strategies to correspond to the biological requirements of each culture, the lack of specialized knowledge related to the new system.

CONCLUSIONS

From the compression degree, from all nurseries included in the experiment, the following conclusions can be inferred:

- during the experimental cycle, the values of the compression degree at a depth of 0-30 cm indicate a weakly or moderately fragmentized soil, vaguely or moderately compressed.
- at the level of asymmetries, there is a very strict, the experimental distributions are right, for the soil compression degree values in the minimum system and the left for soil compression degree in the classical system.
- the kurtosis of the experimental distributions are, in general, platykurtic for the minimum tillage system and the classical tillage system.
- the values of the compression degree registered in the classical tillage system are by far superior to the sample (undisloquated soil), where high values of this indicator were obtained.
- if taking into consideration the coefficient of variation, all the primary data belong to relatively homogeneous amounts both in the case of the witness sample and in that of the data obtained after the preparation of the germination bed in the classical tillage system and in the minimum tillage system.

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 equipments 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: apparent 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 estompate the negative effects which appeared after the impact produced by its processing with mechanical means. Several research 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 stabilize.

This research attempted to emphasize the fact that the process of compaction plays a negative role on the physical-mechanical properties both in the classical and minimum tillage system. In the case of the minimum tillage system, the state of compaction of the soil is expected to reduce considerably in at least one year, without doing activities of fragmentations. An important role in the soil compaction is also played by the agricultural equipments, through their weight and traffic.

BIBLIOGRAFY

1. BOJA N., BOJA F., TEUŞDEA A., CARŢIŞ MIHAELA., 2008, Influence of minimum tillage systems upon the soil physical properties and the reduction ratio, International Symposium Trends In European Agriculture Development, Publishing House Agroprint, Timişoara, Vol 40 (2) p. 25-30.
2. BOJA N., BOJA F., TEUŞDEA A., CARŢIŞ MIHAELA., 2009, The variation of the ratio level of the soil after its processing in a classical tillage system and in a minimum tillage system, International Symposium Trends In European Agriculture Development, Publishing House Agroprint, Timişoara, vol. 41 (1) p. 385-390.

3. BOJA N., BOJA F., CARȚIȘ MIHAELA., 2009, Determination of soil reduction ratio level after its processing in classical tillage system and in minimum tillage system, International Symposium „Studia Universitatis", Engineering Sciences and Agrotourism Series, 4/2009, University Press „Vasile Goldiş" Arad, p. 27-34.
4. BOJA N., BOJA F., 2010, The influence of tillage system on soil compactation, International Symposium Trends in European Agriculture Development, Editura Agroprint, Timişoara, vol. 42 (1) – 908 (2010) p. 31-37.
5. BOJA N., BOJA F., 2010, Aspects regarding the soil compaction in the forestry nurseries: Requirements, Means, Technology, Engineering Sciences and Agroturism Series „Studia Universitatis", vol. 5, issue 1, University Press „Vasile Goldiş" Arad, p. 11-16.
6. CANARACHE A., and colab., 1990, Tutorial for the study of the soil on the spot and in the laboratory, Publishing House Agro-Silvică, Bucharest.
7. POPESCU I., 1984, Mechanization of the forestry processing, Publishing House Ceres, Bucharest.
8. RUSU T., GUȘ P., 2007, Compaction of the soils– processes and consequences, Publishing House Risoprint, Cluj-Napoca.