THE INFLUENCE OF TILLAGE SYSTEM ON SOIL COMPACTATION

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Abstract: *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. In the last decades at a worldwide level a large quantity of energy was used to reduce the negative influences of soil compaction, because of the human activity influence. This research is justified in the existence of compacted soil, with a poor settling and a poor development of the roots of forest samplings. 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. So as to trigger the achievement of the purpose mentioned-above, there were established the following main objectives: - The determination of the influence of different methods of soil processing on some physical and mechanical properties as describe soil bearing (apparent density, total porosity and degree of settling); - The parallel analysis of the influence of the processing system on the soil compaction. The researches were made in the forest nursery of Iarac, following the influence of the tillage system over the soil bearing. The tillage systems that were applied were classic system (classical plough + 2X disks) and a minimal system (paraplow + rotary harrow). Samples were taken in their natural setting with metallic cylinder of 100 cm3, to determine some physical characteristics on four depths, for each sample there were completed six repetitions, harvested after each technical finished work. The degree of novelty resides in the fact that the soil bearing can be characterized with the help of some physical and mechanical properties of the samples taped from different depths after each technical tilling made, observing concurrently the influence of the soil preparation system over the compaction. The utility of this paper is justified by the research data collected, processed, analyzed and made valuable in order to offer a pertinent material for study, which could be thus used by the specialists in the projection of the process of preparation of the germination bed according to the chosen processing system. From the analysis of the results obtained during the research carried on and presented here, we may distinguish some original contributions in the domain of soil processing and in the way of determining the soil bearing in the process of preparation of the germination bed. This paper is important because it offers concrete values of some physical and mechanical properties, which direct influence about soil bearing, resulted after each technical work of preparation of the soil in a classical tillage system and in a minimum tillage system.*

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

INTRODUCTION

The continuous increase of the ratio of soil compaction in the forestry nurseries has imposed the usage of tractors with higher and higher power and with a continuously increasing weight. As the soil represents both the place where the saplings grow and develop and the route on which the wheels of the tractors and of the used cars pass, it is obvious that its physical-mechanical properties are modified in this process which directly influences in a great extent the dimension of the saplings.

The soil is a complex environment, but to make it simple, one can see it as a combination of solid mineral particles, organic matter and porous spaces. The porous spaces

allow the air penetration, the accumulation and the movement of the water 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., GUŞ P., 2007)

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 possible variations caused by the subsidence take place at the level of the air porosity which creates less favourable or totally unfavourable conditions for the growth of the saplings. The adjustment of these conditions is one of the main objectives of the agro-technical works. (POPESCU I., 1984)

The weak aeration of the soil negatively influences the development of the root system and decreases the permeability for the water.

MATERIAL AND METHODS

The research has been carried out in the Iarac forestry nursery and consisted in the observation of the influence of the systems of soil processing on the state of settlement. The processing systems applied were: classical tillage system (plough and disc 2X) and minimum tillage system (paraplow and rotary harrow).

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; for each sample, the sampling was repeated six times, after the execution of each technical work.

The degree of novelty consists in the fact that the settlement of the soil could be characterized with the aid of some physical-mechanical properties at different depth levels of sampling and after the execution of each technical work, by observing at the same time the influence of the system of preparation of the soil on the compaction.

The soil compaction has as an effect the growth of the apparent density and the reduction of porosity and of the index of pores.

Causes of compaction:

- 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.

RESULTS AND DISCUSSIONS

The physical state at which the soil reaches under the effect of the mechanical interventions caused by the processing system is best appreciated through the soil compression

degree, indicator which includes both the apparent density and the total porosity, but in correlation with its texture. (BOJA N., et al., 2009)

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 tillage system of the soil influences the main physical factors of fertility: mechanical resistance, aeration, water accessibility and permeability. The favourable physical state of the soil is that in which none of the four physical factors do not represent limitative values. (BOJA N., et al., 2009)

By observing the compression of the soil after the execution of the technical works for the preparation of the germination bed, it can be inferred that: in the case of the equipments which leave behind particles of variable forms, dimension and display in the soil profile, the soil compression is present with positive and negative values.

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., 2009)

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.

The results of the research are presented through 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. The graphic representations of these values appear in figures 1-3.

Table 1

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

Apparent density		0-10	10-20	20-30
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

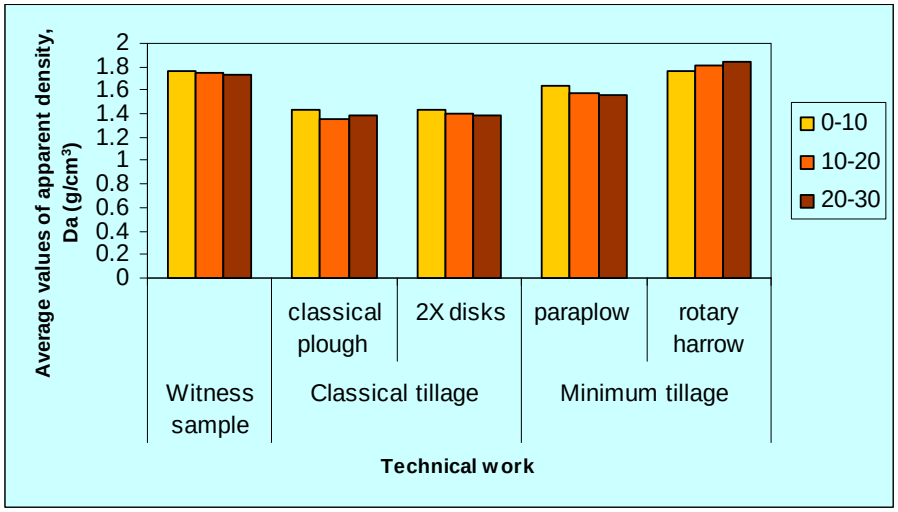

Figure 1: Variation of the apparent density with the sampling depth and the tillage system of the soil

Table 2

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

Total porosity		0-10	10-20	20-30
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

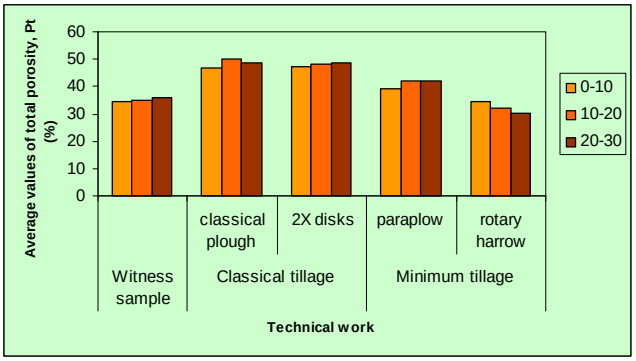

Figure 2: Variation of the total porosity with the sampling depth and the tillage system of the soil

Table 3

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

Soil compression degree		0-10	10-20	20-30
Witness sample		28.4	28.3	27.2
Classical tillage	classical plough	3.39	-1.96	0.78
	2X disks	2.64	0.92	0.63
Minimum tillage	paraplow	18.5	14.1	13.9
	rotary harrow	28.6	34.5	33.2

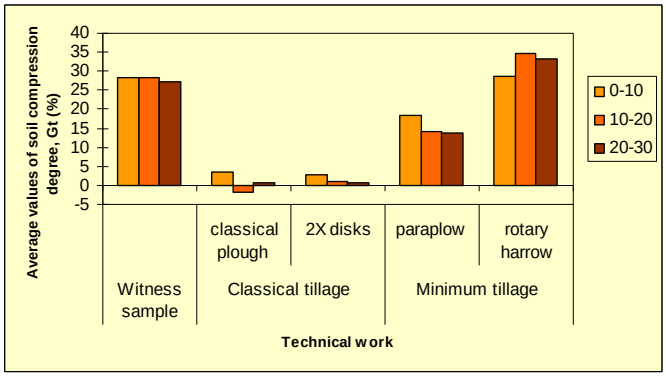

Figure 3: Variation of the compression degree with the sampling depth and the tillage system of the soil

The soil compaction takes place under the influence of two categories of factors: natural factors (natural compaction) which is due to some genetic factors or processes and artificial factors (artificial or anthropogenic compaction). The anthropogenic compaction appears as a result of the exaggerated traffic, carried out on the fields prepared in an intensive system.

The effects of compaction:

- The consequences of the soil compaction can be approached from different aspects, starting with the variable properties of the soil, continuing with its effects on the saplings, the effects on the limitative, accidental factors on the production, and nonetheless, the implications of compaction on the soil pollution. The intensity of the negative effects of the soil compaction is in direct proportion with the intensity of the phenomenon.
- The most noticeable modifications are registered in the case of the apparent density, the total porosity and the compression degree. These changes affect the movement of the water and of the air in the soil.
- The decrease of the soil capacity to retain water.
- The reduction of permeability.
- The worsening regime of the water in the soil.
- The reduction of aeration.
- The sensible growth of resistance to penetration and, implicitly, of the tillage of the soils by the agricultural equipments.

Measures to prevent the soil compaction

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.

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. (BOJA N., et al., 2008)

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.

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.

In order to establish the co-relational dependence between the indicator and the sampling depth, through the analysis of the carriage, two equations were used as it follows: a linear one and a second degree polynomial. The element of statistical nature which determined

the choice of the corresponding curve was the coefficient of determination R^2. In all cases, the coefficient of determination for the second degree polynomial was higher than that corresponding for the right line.

In order to cuantify the co-relational dependences between the physical-mechanical properties in dependence with the working depth and the tillage systems, and also of the witness sample, a second degree polynomial curve was accepted, like

$$y = ax^2 + bx + c\,, \qquad (1)$$

in which:

y - represents the physical-mechanical indicator researched,

x – the sampling depth, in cm.

The concrete results obtained were gathered in table 4 to which it was also added the value of the coefficient of determination R^2, whose values are presented in table 5.

Table 4

Equations of regression determined in comparison with the physical-mechanical properties analyzed and the sampling depth

The depth of taking	Equations of regression		
	Apparent density	Total porosity	Soil compression degree
0-10	$y = 0.08x^2 - 0.458x + 2.102$	$y = -2.9921x^2 + 17.194x + 21.82$	$y = 6.2029x^2 - 35.651x + 55.026$
20-30	$y = 0.1x^2 - 0.566x + 2.174$	$y = -3.8914x^2 + 21.921x + 18.474$	$y = 7.9714x^2 - 44.965x + 62.39$
20-30	$y = 0.1029x^2 - 0.5771x + 2.178$	$y = -4.015x^2 + 22.381x + 18.22$	$y = 7.4871x^2 - 42.403x + 60$

Table 5

Values of the coefficients of determination R^2, obtained in comparison with the physical-mechanical properties analyzed and the sampling depth

The depth of taking	Coefficient of determination R^2		
	Apparent density	Total porosity	Soil compression degree
0-10	0.8564	0.8585	0.8588
20-30	0.9069	0.9224	0.9304
20-30	0.9627	0.9767	0.9532

CONCLUSIONS

From the compression degree, observed during the soil tillage, the following conclusions can be inferred:

- during the experimental cycle, the values of the compression degree at a depth of 0-30cm indicate a weakly or moderately fragmentized soil, vaguely or moderately compressed.
- 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 inhomogeneous 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.

By interpreting the values of the compression degree of the soil processed in a classical tillage system, as compared to the witness sample, it can be concluded that the soil is much more compressed than in the case of the sample, even if, in the classical tillage system

the number of equipments which pass on the same surface is greater. In the case of the harrow, as it appears in the literature of specialty and in the data obtained in our experiment, the particles of the processed soil are much more uniform and their spacing is much more homogenous. Under this state, the compression degree will be systematically positive.

As it results from the analysis of values of the coefficient of determination shown in table 5, as compared to the physical-mechanical properties and the sampling depth, one can make the following affirmations:

- the higher apparent density is taken at the working of the soil with the harrow, while the lowest value appears in the case of the classical tillage system when processing the soil with a plough;
- globally, the minimum tillage system has a value between that of the witness sample and of the classical tillage system, because the number of the equipments and the passing is much more reduced as compared to the classical one;
- regarding the total porosity, the sampling depth has a much more influence for the minimum tillage system as compared to the classical system;
- the compression degree is less influenced by the sampling depth in the classical system than in the minimum 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.

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 fragmentation. An important role in the soil compaction is also played by the agricultural equipments, through their weight and traffic.

BIBLIOGRAPHY

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., CARŢIŞ 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. POPESCU I., 1984 - Mechanization of the forestry processing, Publishing House Ceres, Bucharest.
5. RUSU T., GUŞ P., 2007 - Compaction of the soils– processes and consequences, Publishing House Risoprint, Cluj-Napoca.