CONTRIBUTIONS REGARDING KNOWLEDGE OF SOIL AERATION PROCESSES TO PLANT GROWTH AND DEVELOPMENT

Petre VOICU[1], Irina CALCIU[1], Olga VIZITIU[1]

e-mail olga_gate@yahoo.com

Abstract

In this paper, the potential aeration conditions of the soils are studied, which are particularly important in establishing their fertility status necessary for optimal plant development. The indicators that define the air content of the soil, different forms of porosity are thus analyzed, with emphasis on aeration porosity, pore size distribution, air content at different suction stages, but also some measured indicators (such as air permeability), which define air movement by convection (mass flow). Within the current agricultural technological systems, the different ways of working the soil significantly influence the state of aeration. This process takes place by damaging the soil matrix, by changing the movement of water in the porous space, by the dynamics of biological processes in the soil or by the combined effect of these phenomena. In order to obtain the information necessary for the study and research of soil aeration processes, we approached different methods, namely: direct measurement methods on soil samples collected in experiments with controlled traffic and in expeditionary studies, as well as indirect assessment methods using the existing information in the network of monitoring.

Key words: soil; air; permeability

Technological components of cultivation systems of the soil, especially tillage and all interventions from surface caused by harvesting, harvest transport, maintenance cultivation, have a great impact on soil condition in general, but especially on the physical state of soil, and also have a great impact regarding aeration conditions from the surface and from soil profile.

Intensity effects on soil depend on the one hand of the natural conditions in which the soil formed and weather conditions from crop growing season and on the other hand depend on anthropogenic factor generated by the technological system (Canarache A., 1990).

Because changes in soil aeration are extremely dynamic, determinations regarding characterization of air movement and air content should be made in dynamic during the entire period of air stress. The data obtained are useful in establishing optimal conditions for application tillage systems.

LUSMS Also, knowing aeration conditions specific for different cultivation allows to set necessary need for drainage and to use appropriate agricultural works (Dumitru E. *et al*, 1999).

Therefore, especially in irrigated areas were more strongly manifested physical processes of soil degradation at surface.

MATERIAL AND METHOD

The experiments were performed in the southern part of the Romania Plain, in Tancabesti area, on Preluvosols using an apparatus for determining permeability named Eijkelkamp model.

Air permeability measurements were performed in ICPA with permeameter Eijelkcamp on cylinders harvested from all four types of compaction intensity (0, 2, 5 and 10 crossings), the same cylinder which were subjects to different levels of water retention (pF_1, $pF_{1,6}$, pF_2). It was trying to present the correlation between water content and air from samples, knowing that the two phases are complementary in the soil. Moments of induced of soil compaction were chosen to highlight the possible changes that would occur in the soil, especially in the upper layer, in the autumn (determined mainly by the specific work of harvesting and transport, and the preparation soil for sowing) and spring.

Stages of sampling were performed to separate the effects of anthropogenic from natural factors. Thus, we were able to study the possible effects of natural factors (precipitation and temperature) that acts mainly in winter, with mechanical role in natural processes (wetting and drying, heating and cooling, inflation and contraction) of recovery physical condition of soil (Horn R., 1997).

[1] National Research and Development Institute for Soil Science, Agrochemistry and Environment, Bucharest, Romania

RESULTS AND DISCUSSIONS

The obtained results refer at two stages from agricultural year: immediately after compaction induced (spring and fall) and after completion of mechanical maintenance works. Results are given for the first 40 cm of soil profile, on four layers from 10 to 10 cm, correlated with the depth of the main types of tillage.

Induced moments of compaction in soil were chosen to highlight the possible changes that would occur in soil, especially in the upper layer, in the autumn (determined mainly by the specific work of harvesting and transport, but also determined by the soil preparation for sowing crops) and spring.

The two stages for sampling were performed to separate the effects of the natural factors from anthropogenic factors. Thus, we were able to study the possible effects of natural factors (precipitation and temperature) that acts mainly in winter, with have a great role in mechanical natural processes (wetting and drying, heating and cooling, inflation and contraction) of recovery physical condition of the soil.

Data obtained for samples collected after the autumn compaction is presented in *Figure 1* only for extreme variants (C0 and C10).

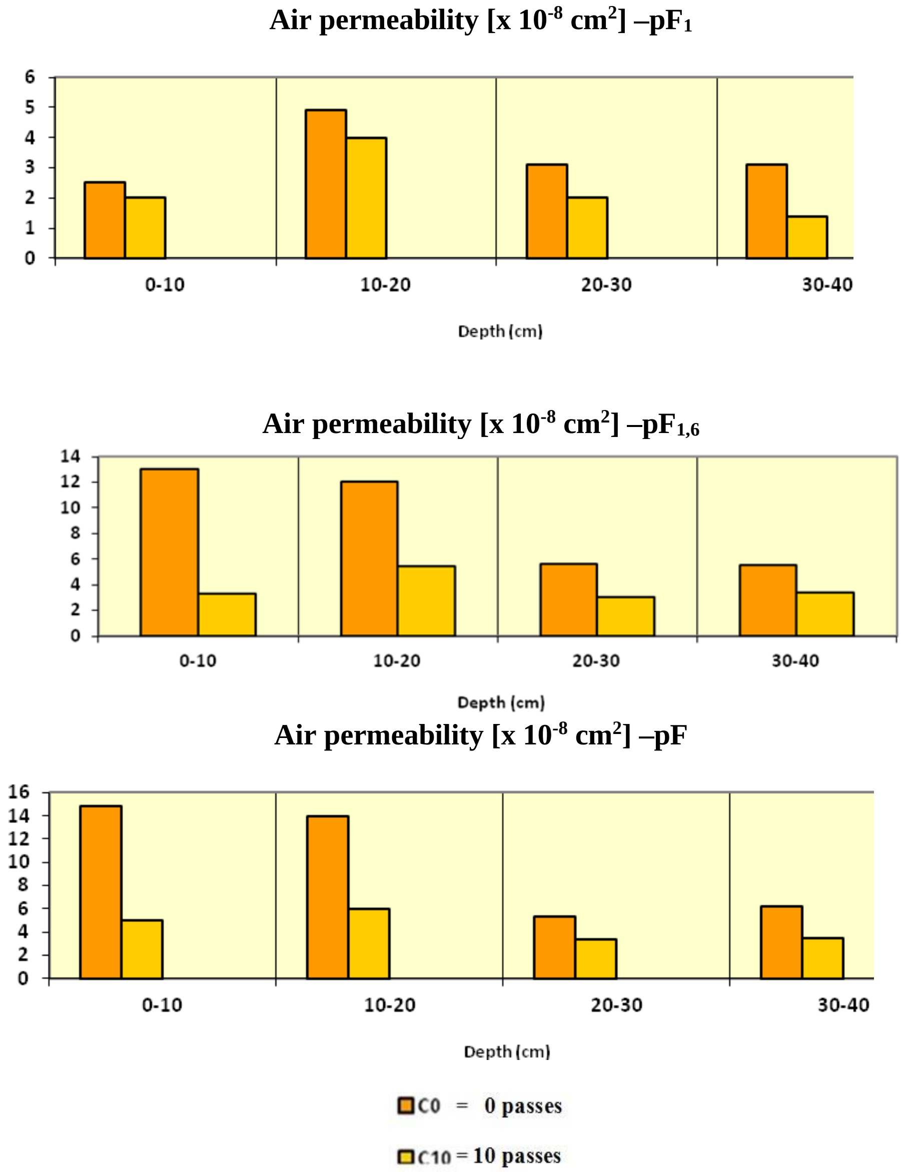

Figure 1 **Effect of anthropic compaction on air permeability at different stage of water retention (Tancabesti).**

Into the version “maximum compacted”, it was found that air permeability is extremely low throughout the soil profile, especially in surface horizons. These results were expected, given that samples were collected immediately after compaction, so the soil had not sufficient time to achieve stability through natural processes, processes like freeze-thaw or wetting-drying, or by anthropogenic processes determined by technological factors. If we look deeper in the profile, air permeability increased slightly in the second depth, reaching a minimum at depth of 40 cm, being in the same range of variation (low air permeability).

Analyzing the obtained data, we can say that in the loose version (witness) permeability for air behaviour is the one expected: in the upper layer is lower, permeability for air increases significantly with depth (increasing more evident at higher values of the suction, $pF_{1,6}$, pF_2). By comparison, appears unexpected differences in maximum compacted version, in upper layer at all three levels of water retention, air permeability is very high, they are decreasing with increasing the soil profile. High values of permeability for air for this version may be due because of numerous cracks from the soil, which created preferential paths of water and air circulation.

The cumulative effect of compaction and maintenance of soil is observed at 10-20 and 20-30 cm depths; where at higher suction growth is not as obvious as the witness version, although air permeability increases.

The results led to conclusion that work in the spring and summer (from seedbed preparation, maintenance cultivation) has the greatest importance in the appearance and development of more compact layers in the soil profile, at least in the first 40 cm.

In general, aeration conditions in the upper soil profile are much improved, being in agreement with other physical properties: apparent density, water content at various stages of retention, aeration limit and aeration deficiency index (*table 1*).

Table 1

Main physical attributes in plot maximum compacted (C10) reddish brown soil from Tancabest.

Depth (cm)	Characteristic					
	DA (g cm^{-3})	Water content (% v/v) at different suctions			LA (% v/v)	Ida (%)
		$pF_{1,0}$	$pF_{1,6}$	pF_2		
0-10	1,17	48	41	38	40	-379
10-20	1,46	41	38	36	24	-150
20-30	1,42	45	40	38	26	-205
30-40	1,52	43	40	38	22	-89

To assess air content should be taken into account the aeration limit **- LA** (which indicating maximum humidity that the soil is likely to have without aeration to be poor) and aeration deficiency index **- Ida**, both indicators showing full aeration conditions satisfactory.

Using assessment indicators for the air content in soil, from year 2019 (in year three of experiments) it was calculated total porosity and aeration porosity at three different moments: after compaction in autumn, after compaction in spring and after mechanical maintenance work.

Soil permeability for water is one of the important physical characteristics that it offers a suggestive image regarding changes of air regime in soil because air and water are two additional phases in the soil. Air permeability of soil with low values must be accompanied by a hydraulic conductivity with great values.

From the first stage of making observations, immediately after exercise surface traffic immediately, and until to the next stage, after maintenance work, saturated hydraulic conductivity values decrease sometimes over 3-4 times, especially in witness version, in most cases reaching the middle values (Voicu P., 2008).

High values of this feature, for a soil so tamp, could be explained by improving macro and mezzo-fauna activity, especially with earthworms, activity which determined the continuity improving and growth of macro-pores volume, because increased amount of plant debris that remained on the soil surface after harvesting manual work and have then been incorporated into the soil by ploughing in the autumn.

It is known that during the application of irrigation or rainfall water percolating into the soil, forcing the elimination of an equivalent volume of air. Also, water is very little responsible for increasing the oxygen content in the soil (at a temperature of 20^{0C} a quantity of oxygen bring by a volume of water in soil is about 30 times lower than that of an equal volume air).

The main effect of soil compaction is to reduce the porous volume and redistribution of different size groups of the pores. These changes had direct effects on many physical properties, processes with a higher intensity or less intensity including the aeration capacity, gas exchange, water retention, permeability, resistance at penetration, root penetration and indirectly many chemical and biological processes (especially de-nitrification processes, nodule formations, micro and mezzo-fauna from soil, especially modified because of decreasing soil aeration).

Porosity, total porosity, macro-porosity (pores larger than 50 µm) regarding pores larger than 30 µm and distribution by size for pore presents important changes because of the compaction (*figure 2*).

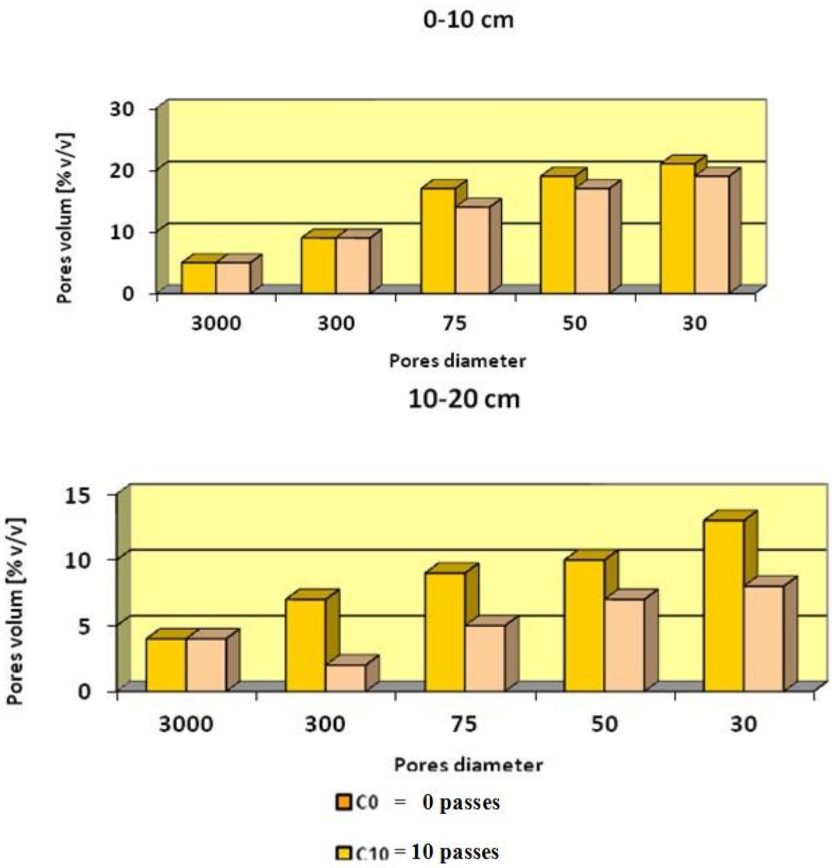

Figure 2 - Effect of compaction intensity on distribution by pores size (depth 0-10 and 10-20 cm).

The maximum compacted version, total porosity reaches minimum values, falling below 50% (the middle value domain), while the aeration porosity is situated with domain of low values, between 7 and 12% v/v. The only depth where aeration porosity is good is the surface layer (PA 20%).

Distribution after size of different categories of pores suffers important changes under the influence of compaction, especially in the uppers and lowers tilling layer, as well as water content at different levels of water retention.

As expected, when we advance on the profile, macro-pores volume transmission (those with diameter > 50 µm, which have active role in the processes of aeration of the soil) greatly decreases, reaching values even below the minimum of 10% v/v which represents deficient aeration conditions for plant development.

Results confirmed the effect of aerations of the soil to different chemical and biological process in soil (*table 2*).

Table 2

Microbiological activity under the influence of compaction

Biological activity indices	Un-compacted (0 passes)	Compacted (10 passes)
Number of bacteria (x 10^6 viable cells x g-1 d.s.)	163	30
Number of fungi (x 10^3 viable cells x g-1 d.s.)	2231	79
Soil respiration (mg CO_2 x g-1 d.s.)	3.5	1.2

CONCLUSIONS

Air from soil is with water and nutrients, one of the most important factors affecting soil fertility. The purpose of this paper was to study the soil aeration, which is a complex subject, including air movement and content, using a wide range of indicators which are determined and/or calculated and/or estimated by various methods for understanding many factors which determines the state of aeration and its influence on soil processes and plant response.

From obtained data you can be seen, as expected, that in witness version, after compaction and after maintenance, aeration porosity does not present restrictive values, it is in small to medium value (between 10 and 20% v/v), and total porosity is about 50% v/v. These data show favourable conditions for normal development of various processes in the soil. We should note that from all the mechanisms regarding air movement in the soil, it was study the convection one, although it participation in air movement has not very high proportions. Unlike the diffusion mechanism for assessing indicators (coefficients of diffusion of gases) are strongly dependent on the nature of each component of soil air, air permeability (pointer of movement by convection) is independent of the gas circulating in the soil. Despite these advantages of air permeability, this indicator has not been determined so far in Romania, this research is a first.

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