THE EFFECT OF SOIL AERATION ON THE CHEMICAL AND BIOLOGICAL PARAMETERS OF THE SOIL

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Abstract: *In Hungary, climate change has brought about an extreme increase in temperatures in the summer months and a decrease in the amount and intensity of precipitation. An in direct consequence of climate change is soil degradation. The increasingly intensive use of agricultura ltechniq ues also promotes the soil degradation process. The physicald eterioration and compaction of the soil impedes the permeability of air and water. Soil compaction also reduces the biological activity of the soil. With the soil aeration process, the harmful processes that occurcan be stopped and reversed. We have previously reported on the effect of soilaeration on the physical parameters of the soil (compaction, permeability). This study presents the results of soil biological tests of a soil aeration intervention carried out in the spring of 2024. Our studies follow the change in soil moisture, which was carried out using in situ and ex situ methods. Furthermore, biologicalactivitytests (FDA, glomalin BCA) werecarried out using ex situ methods. The testswerecarried out twice before aeration and once after. The results obtained are presented along side the current meteorological results. The results obtained do not show significant differences, which could have been influenced by wea ther extremes. The tests will be performed again nex tyear.*

Keywords: *soil aeration, soil moisture, measure of soil moisture, in situ, ex situ methods, activity tests (FDA, glomalin BCA)*

INTRODUCTION

Extreme climate events in Hungary danger to the fertile soil. It was typical of the summer months that their average temperature always exceeded the same month of the previous year. The lack of precipitation also affected the extreme category. These meteorological factors lead to soil damage. First, the literature reports on the lack of soil moisture, and then on the drastic reduction of deep groundwater. This leads to a decrease in soil structure and organic matter supply (Gelybó et al, 2018). Nearly 35% of Hungarian soils are especially sensitive to compaction (Várallyay 2005). According to Hakansson and Voorhees (1997), as a result of mechanical stress, part of the air is displaced from the three-phase system of the soil and the volume of the soil decreases, resulting in a compacted soil. In addition to natural factors, this unfavorable soil condition can also be caused by anthropogenic effects (Birkás et al. 2017, Dekemati et al. 2017).

The spatial and temporal extent and extent of congestion can be influenced by many factors: – geological properties (grain composition, soil moisture, organic matter content, soil structure, physical type, bedrock, grain fraction composition and pore size distribution) (Lipiec et al. 2003, Gómez 2017).

One of the most common and most appropriate methods of on-site examination of clogging is the measurement of the mechanical resistance of the soil (in short: soil resistance), which is carried out with a penetrometer (Szőllősi 2003). Soil resistance means the force (MPa used) that the soil layer exerts against the probe tip of the vertically penetrating 60º conical penetrometer (Búzás 1993). The soil resistance is mainly influenced by the current moisture content of the soil. Therefore, soil resistance and moisture content must always be examined at the same time at the same time (Rátonyi 1999). Along with the increase in moisture content, the tendency for soil compaction also increases (Birkás et al., 1996). In the case of a soil resistance of 1.5–2.5 MPa, we can speak of a favorable degree of compaction, but if this value is 3.0 MPa or more, the soil layer is considered highly compacted (Birkás 2010, Sinnett et al. 2008).

A soil's vulnerability to compaction is largely a result of biological aspects: Living plants with active root systems, along with mycorrhizal hyphae, and the glue-like secretions of each, will significantly reduce compaction susceptibility (Reeder et Westermann, 2006).

Glomalin is a high molecular weight, insoluble glycoprotein that is stored in large quantities in the cell wall of fungal hyphal filaments. The amount of glomalin strongly determines the structural properties of soils, including their friability and soil properties related to water retention and water conservation (Rilling, 2004). The production of this material shows a certain degree of seasonality.The produced glomalin can be detected in soils for 6–42 years. The condition for the production of glomalin is the cooperation between plants and mycorrhizal fungi, the establishment and functionality of symbiosis. Mycorrhizal fungi need stable environmental conditions, so they develop and survive better in conditions without tillage. Since glomalin has many positive effects on the soil and also increases the stability of the aggregates, a positive correlation with soil use is expected (Rilling et Steinberg, 2002). The extensive plots yielded an average of three times as much, 1.07 mg, which in this case showed the positive effect of abandoning disturbance in line with expectations (Hoorman et al., 2011).

MATERIAL AND METHOD

Test site

The study site is located in the southern part of the Central Hungarian region between the towns of Tápiószele and Abony. The subject of the investigation is a multi-year orchard with traditional management. There are several types of fruit trees in the orchard. Cherry and plum plantations were chosen for the purpose of the study, since they are almost the same age and make up the largest proportion in the orchard. The study area was divided into a treated (aerated, sample area) and a control (non-aerated) area. The extent of which is 4,140m2, the same for both areas. Thus, we can ensure the same number of samples in both cases.

Soil moisture measurement:

Soil moisture was measured three times. Two times before aeration. This was justified by the fact that the aeration process was delayed in time, so we considered it important to indicate the state of soil moisture immediately before it. The third sampling was taken after aeration. The moisture was measured (in situ) with on-site measurements, and after sampling (0-10 cm, 10-30 cm, 30-60 cm deep samples) in the laboratory (ex situ). The on-site soil moisture was measured with the Daróczi-Lelkes PENETRONIK instrument from Szarvas. The instrument provides data for moisture from 300-350 depth points in 4 repetitions during one sampling. The data of the measurement points were averaged according to their depth. Since the instrument records the data every centimeter, in order that its values can be compared with those measured in the laboratory, the first 10 data were averaged for the 0-10 cm part of the soil and so on. Data below 60 cm were ignored. Laboratory (ex situ) soil moisture was measured using the gravimetric method (at depths of 0-10 cm, 10-30 cm, 30-60 cm from an average sample). To test the soil moisture, the samples stored in a refrigerator at 10°C and then thawed to room temperature were dried to a constant weight, and then the water loss value was converted to a percentage

Glomalin determination

Arbuscular mycorrhizal fungi (AMF) produce glomalin-type protein. Because glomalin related soil protein (GRSP) has been linked with AMF, several studies have used this substance to identify AMF presence in greenhouses and cultures (Wright et al., 1996). Currently GRSP is operationally defined, meaningthattheidentification of this protein restsonthemethodsusedtoextractit (citricacidbuffer, autoclavingat pH of either 7.0 or 8.0) and the as says (Bradford method/enzyme-linked immuno sorbentassay (ELISA) with MAb32B11) used for quantification (Rillig, 2004).

Determination of total microbial activity(FDA)

FDA hydrolysis is widelyacceptedas an accurate and simple method for measuring total microbial activity in a range of soils. A sensitive and rapid method for the measurement of total microbial activity using fluoresce indiacetate (FDA) is described here, after Adam and Duncan (2001), modified from Schnurer and Rosswall (1982). Colourless FDA is hydrolysed by both free and membrane bound enzymes, releasing a coloured end product fluorescein which can be measured by spectrophotometry. The advantage of this method is that it is simple, rapid and sensitive.

RESULTS AND DISCUSSIONS

Soil moisture

The results of changes in soil moisture are shown in Table 1. The obtained results are interpreted with the precipitation data of the nearby (Tápiószele) meteorological station. To explain the change in moisture content, we need to know the meteorological events of the study period. In January and February, a total of 41 mm of precipitation fell, which is 42% lower than the multi-year average. The amount of precipitation in the next two months also shows a similar deficit (hungaromet.hu).

Table 1.

Soil moisture in volume %

<table>
<tr><td colspan="2">Treatments</td><td colspan="4">21.02.2024.</td><td colspan="4">3.04.2024.</td><td colspan="2">25.04.2024.</td></tr>
<tr><td>Method</td><td>Depth</td><td>KSZ</td><td>KM</td><td>LSZ(1)</td><td>LM(1)</td><td>KSZ</td><td>KM</td><td>LSZ (1)</td><td>LM(1)</td><td>LSZ(2)</td><td>LM(2)</td></tr>
<tr><td rowspan="3">ex situ</td><td>0-10</td><td>18,9655</td><td>9,8712</td><td>9,5794</td><td>11,5299</td><td>12,3077</td><td>7,8261</td><td>11,3208</td><td>7,3634</td><td>15,3846</td><td>8,371</td></tr>
<tr><td>10-30cm</td><td>18,22</td><td>9,2457</td><td>15,3846</td><td>11,674</td><td>14,4144</td><td>5,0926</td><td>12,2768</td><td>9,8592</td><td>11,3379</td><td>7,8556</td></tr>
<tr><td>30-60</td><td>17,3397</td><td>9,1549</td><td>17,5926</td><td>10,7579</td><td>17,5926</td><td>5,5422</td><td>15,0121</td><td>6,9212</td><td>11,2644</td><td>8,5575</td></tr>
<tr><td rowspan="3">in situ</td><td>0-10</td><td>18</td><td>14,3</td><td></td><td></td><td></td><td></td><td></td><td></td><td>18,25</td><td>10,5</td></tr>
<tr><td>10-30cm</td><td>20,90</td><td>15,26</td><td></td><td></td><td></td><td></td><td></td><td></td><td>20,6</td><td>12,29</td></tr>
<tr><td>30-60</td><td>21,7</td><td>17,7</td><td></td><td></td><td></td><td></td><td></td><td></td><td>21,5</td><td>14,81</td></tr>
</table>

Explanation: KM - cherry plantation control area KSZ - plum plantation control area, LM (1) - cherry plantation sample area before aeration, LSZ (1) - plum plantation sample area before aeration, LM (2) - cherry plantation sample area after aeration, LSZ (2) - plum plantation sample area after aeration

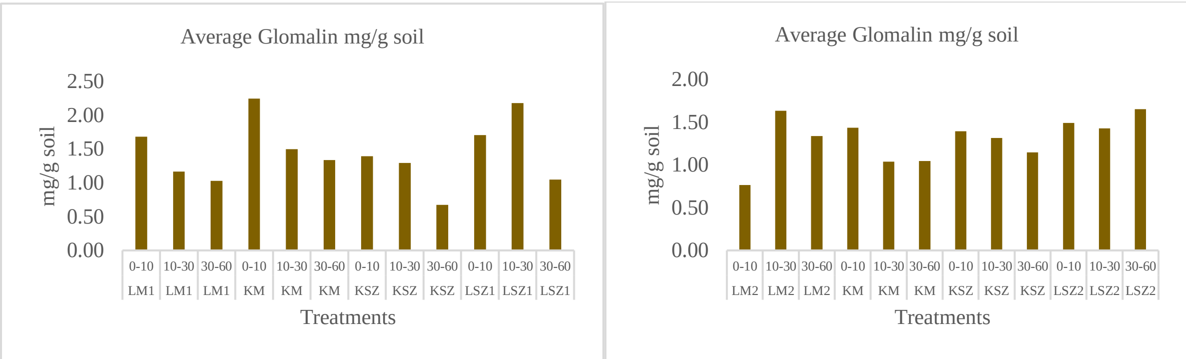
Between the first two sampling times, there is a significant decrease in soil moisture content. This is due to the absence of precipitation during the given period.

Soil moisture varies in the area. In the case of the control areas, it can be established that the soil moisture of the plum plantation is almost 50% higher than that of the county. During sampling, we found that the soil, in the case of the plum plantation, is much tighter. This statement remains valid during the second sampling as well. The difference in soil moisture between the two plantations was also confirmed by the laboratory measurements with a smaller ratio.

After aeration, the difference in soil moisture in the case of in situ (PENETRONIK) measurements shows further confirmation of this large difference. The depth distribution of soil moisture clearly shows the soil's characteristic water retention power. The increase in soil moisture after aeration can be explained by the fact that a total of 16.2 mm of precipitation fell in the two days before sampling. It can be seen that higher values are typical in the upper layer of the soil. Laboratory (ex situ) measurements do not confirm this.

Glomalin values

Glomalin content was measured three times. Between the first two measurements, we only observed an increase in glomalin content due to the air temperature. Regarding the state before soil aeration, the highest amount can be seen in the warmest part of the soil (0-10 cm). This layer heats up the fastest. This layer is the richest in the air. The glomalin content before aeration ranges from 0.67 to 2.25 mg/g.



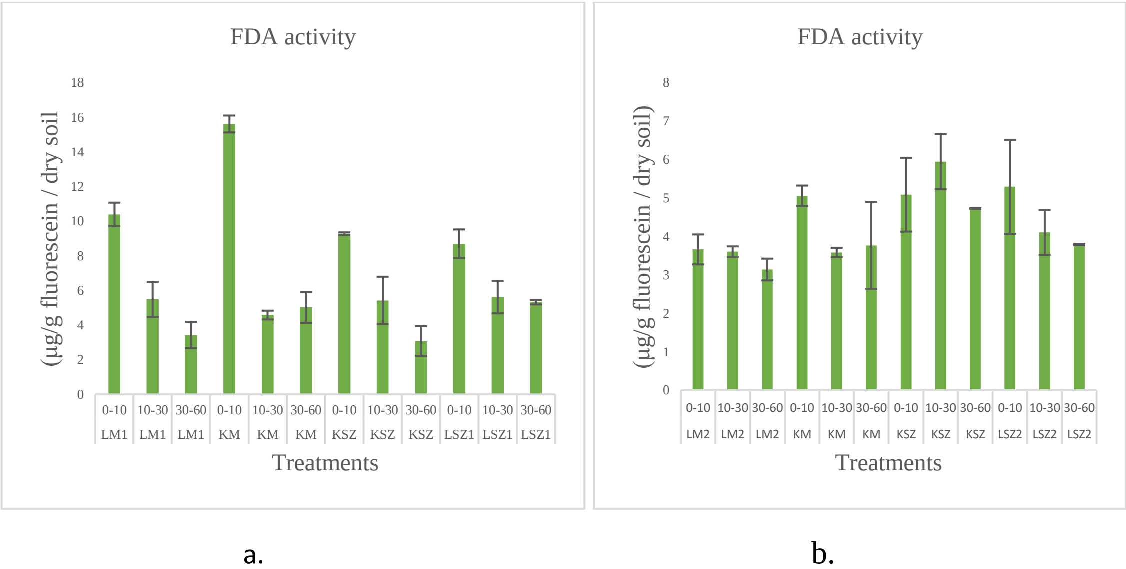
a. b.

1. Figure: Change in glomalin level before (a) and after (b) soil aeration

After aeration, we expected an increase in the amount of glomalin, but we observed a decrease, the range of which is 0.77-1.63 mg/g. So many changes can be observed that it increased in the 10-30 cm depth (LM2, LSZ 2). So the biological life of the soil increased at a depth of 0-30 cm.

Total microbiological activity values (FDA)

The values of all microbiological activities were also examined in the laboratory (ex situ). The results of the condition before aeration and the condition after aeration are illustrated due to the significant difference. The results show the overall microbial deterioration of the soil as a result of aeration.



2 Figure: Total microbiological activity values are the results of the first (a) and second (b) sampling

This test did not produce the expected result, so a repetition will be necessary. We do not yet know the nature of the error in the result. We only have assumptions. We will continue the investigation in the spring of 2025 and repeat the measurements.

CONCLUSIONS

Soil aeration is one of the effective procedures for soil compaction. Our research is in the initial stages in a multi-year orchard. We carried out these initial soil resistance tests, as well as soil moisture tests. In this study, we wanted to show the changes in the biological properties of the soil in addition to changes in soil moisture. Our results show no significant difference in the case of glomalin. The results of all microbiological activity tests showed no increase due to aeration.

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