SOIL POROSITY INVESTIGATIONS IN TRUFFLE ORCHARDS

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Abstract

Those who are engaged in the production and research of the truffle as a special ecological trait agree that beside of the climatic attributes , the soil circumstances play important role in the sucessful production. Thank to the extensive investigations large amount of the information is available about this fungus, but there are still questions remaining. One of these questions is the importance of the air in the soil in truffle production.

The amount of soil air is one of the most important thing of the soil life, which is in centre of interest. The aim of the investigation was to find out what kind of effect has the air permeability of soil pores to the production of truffle.

The investigation of aggregate composition has shown the structure of the genetical soil layers, which is in close connection with the air permeability of the soils.

We have investigated basic soil parameters to learn the physical and chemical properties of soil which determine the life conditions of truffle.

Water retention capacity and –indirectly– the differential porosity of the investigated soils were characterized by pF-measurements.

The in situ measurement of air permeability of the soils is a rather new technology in our country, and one of our aims was to get acquainted with the method itself. The great advantage of the in situ measurements is that the soils can be investigated in their original structure without disturbance and in this way we can get more exact data about the examined parameter. At the same time the disadvantage is that the measurement cannot be repeated (at the same place). A well-planned measurement protocol can minimize the possibility of the potential mistakes.

Our investigations revealed that advanced truffle growing technology should focus not only on nutrient and water supply but on soil air permeability in order to satisfy special needs of these unique fungi.

Key-words: soil porosity; truffle; truffle orchard; air in the soil in truffle production

Összefoglalás

A szarvasgomba termesztésével és kutatásával foglalkozó szakemberek egyetértenek abban, hogy a klimatikus jellemzők mellett a talajtani viszonyok is meghatározó szerepet játszanak a termés eredményessége szempontjából. A kiterjedt kutatásoknak köszönhetően mára a legtöbb ismeret a rendelkezésünkre áll, de sok kérdésre még nincs kielégítő és egybehangzó válasz. Ezen kérdések egyike a talajlevegő jelentősége a szarvasgomba termesztésben.

A szarvasgomba tenyésztestek, és termőtestek légzésintenzitását nagymértékben befolyásolja a talaj levegőgazdálkodása. A légcsere minőségét, és mennyiségét közvetlenül a talajok szerkezete, fizikai félesége, közvetve pedig a mésztartalom, és a talajok víztartalma határozza meg. Az összefüggések megismerése céljából kielemeztük az említett tényezőket, és megkerestük a köztük fennálló összefüggéseket, melyek befolyásolják a talajok légáteresztő képességét.

Az aggregátum összetétel vizsgálat megmutatta az egyes genetikai szintek szerkezetét, ami szoros összefüggésben áll a talajok légáteresztő képességével.

A talajtani alapvizsgálatok során megismertük a vizsgált talajok fizikai és kémiai tulajdonságait, melyek meghatározzák a szarvasgomba életfeltételeit.

A pF mérések a talajok víztartó-képességének, illetve közvetve a talajok differenciált porozitásának megismerését tették lehetővé.

Légáteresztő-képesség helyszíni mérése egy viszonylag új technológia hazánkban, melynek megismerése egyik fő célja vizsgálatunknak. A helyszíni mérések legnagyobb előnye, hogy a talajokat eredeti szerkezetükben vizsgálhatjuk, azok bolygatása nélkül, így sokkal pontosabb képet kaphatunk a vizsgált paraméterről. Hátránya viszont, hogy egyazon mérés ismételt elvégzésére nincs lehetőség. A jól megtervezett metodika, és annak betartása azonban jelentősen szűkíti a hibalehetőségek körét, és számát.

Vizsgálataink bizonyították, hogy a jövőben a szarvasgomba termesztés élvonalában azok sorakoznak majd, akik a hangsúlyt nemcsak a tápanyag, és vízellátásra helyezik, hanem ezt a talaj levegőellátásának vizsgálatával kiegészítve igyekeznek megismerni a földalatti gombák egyedülállóan speciális igényeit.

Introduction

The culture of truffle consumption seems to revive in Hungary. The evidence of is the growing number of special food on the market made with truffle. The possibility of the growing mycorrhiza mushrooms is examined for a long time, in fact, the growing of so called „early mycorrhiza mushrooms" is solved in French, in Italy, and Spain (Chevalier et al., 2005).

Beside of the climatic features, pedological relations are determined for the successful growing. Thanks to the wide-spread research, most of the knowledge about the growing is available, but there are some questions which are not answered yet. One of these questions is the importance of soil air in the truffle growing.

Truffles are also performing gas exchange with their environment, which is determined by the „air management" of the soil. The quality and quantity of the gas exchange depends on the structure, the physical feature, and indirectly on the amount of lime, and water in the soil (Stefanovits, 1999). We've examined the factors above, and the relationships between them that can influence air permeability od soils.

The aim of our research was the examination of the air permeability of the soil in truffle plantations, and to test an in situ field method. The experimental field was a truffle orchard. Soil investigations were made after planting and before harvesting, which can serve a good basis for further comparisons and well characterize relationship between soil air supplying and truffle growth.

We hypothesized that there is a relationship between the yield of the truffle and the air permeability of the soil. By finding relationship between basic soil examination and the field air permeability investigations we can get fast and precise picture about the soil porosity. With help of this – and with some other investigations – we can draw conclusions on the suitability of the soil for truffle production solely from the soil-air management indices. With a fast and simple measurement we can determine the necessity of the volume of soil improvements and with the help of this we can establish better conditions for the truffle.

Materials and methods

The truffle orchard in Keszthely is situated in the botanical garden of University of Pannonia, Georgikon Faculty. Regarding the hydrological circumstances the field is periodically under influence of water. The causes of this are that the physical type of the upper 35-55 cm layer is clayey loam, which makes the moving of the gravitation water slower; and at 200 cm depth there is a layer, which is impermeable to water. The truffle orchard has on Ramann-type brown forest soil (Haplic Cambisol).

The Szentgál truffle orchard is situated near to the village on a former arable land. In the Szentgál valley there are clayey brown forest soils (Dövényi, 2010). These soils belong to the physical type of loam, and they have favorable water budget. There were two sampling points at the field. The first was at a lower point of the valley and it can be classified as a slope alluvium. The second point was at the upper part of the sample area. The soil of this sampling point is a typically clayey brown forest soil (Haplic Luvisols).

From the genetic layers we collected disturbed samples for the laboratory examinations. The basic tests were made according to the protocol of the Hungarian soil examinations (Buzás, 1993) in the laboratory of University of Pannonia, Georgikon Faculty.

In situ measurements of the air permeability of the soils were also performed which were used for further evaluations. For these measurements, PL300 permeameter from Eijkelkamp Agrisearch were used. This equipment can be used either for field measurements or laboratory measurements. There are two accessories to the equipment: a tensiometer, and a TDR probe with the help of these we can measure the water content of the soil, and the capillary suction force of the soil pores.

We collected undisturbed soil samples from both fields in 100 cm^3 sample rings for the measurements of water capacity and differential porosity from the soil layers where we measured the soil air permeability.

The pF value shows the water retention capacity of the soil against a given pressure. We can fit a function to the measured values in every pressure and with the help of this fitted curve, we can read the water retention value. From the form of the curve and the designated points we can conclude to the ratio of different soil pores (differential porosity) (Várallyay, 1973).

The water retention capacity of the soils were measured at the adequate pressure values: pF: 0.0, 0.4, 1.3, 2.2, 2.5, 4.2, 6.2 with the porous ceramic plate pF measuring equipment type Soil moisture Equipment Corporation LAB 23. After the measurement, the soils were dried at 105°C till permanent weight, and their weight was measured. From the dry weight and from the weight values in different pressures, the water content for each pressure can be calculated.

Results

The results of the basic soil examinations are shown in the Table 1. Comparing our data to the literature (Barna, 1998) it can be stated, that the pH, the lime content, and the humus content of the examined soils are not quite optimal for truffle growing.

Profile/level	Depth (cm)	K_A	Density (g/ cm³)	pH distilled water	pH KCl	$CaCO_3$ (%)	Humus (%)
Szentgál 1/A	0-30	45	2.33	6.63	5.58	Ø	2.49
Szentgál 1/B1	30-55	51	2.28	6.72	5.44	Ø	0.79
Szentgál 1/B2	55-80	52	2.38	7.17	6.35	0.34	0.68
Szentgál 2/A1	0-30	42	2.44	6.83	5.97	Ø	2.39
Szentgál 2/A2	30-60	38	2.57	6.82	5.86	Ø	1.46
Szentgál 2/B1	60-85	40	2.5	6.66	5.24	Ø	0.67
Keszthely /1	0-20	35	2.5	7.63	7.15	1.35	2.14
Keszthely /2	20-40	32	2.57	7.84	7.2	1.05	1.49
Keszthely /3	40-55	38	2.5	8.1	7.35	9.27	0.71
Keszthely /4	55-75	45	2.56	8.16	7.54	20.23	0.41

Favorable pH value: 7.0 – 8.3

Optimal $CaCO_3$: 5 - 50 %

Proper organic material %: 1.5 – 8.0 %

Table 1. The most important data of the soils of sample areas (Barna, 1998)

On the Figures 1 and 2 the relationships between air permeability and pF curve are shown. The pF curve is described from the measuring points with the help of a soil expert program (Fodor-Rajkai, 2005). The in situ measured values of the air permeability are shown with the soil moisture content in the pF curve of the same soil sample. The difference of the volumetric soil moisture content at pF 2.5 and pF 0 shows the amount of the gravitation pores in the original structure soil. The braces on the figure (namely the difference between the pF0 and the soil moisture content at the measuring time) shows the pore volume (%), which were filled with air at the moment of the measurement. These pores are responsible for the air supply of the soil organisms and of the soil itself.

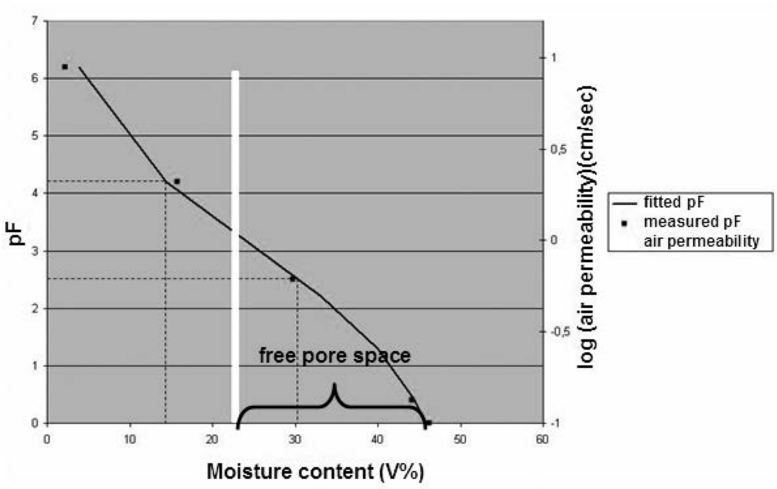

Fig. 1. The connection between soil air permeability and pF curve in large free pore space, measured at actual soil moisture content.

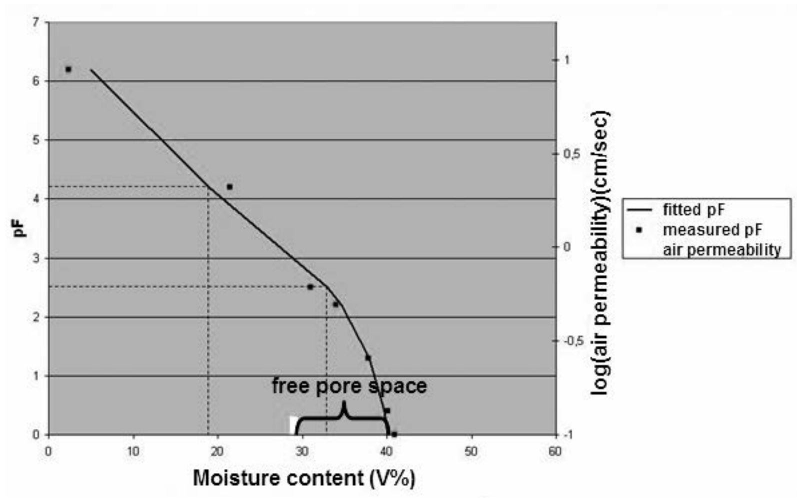

Fig. 2. The relationship between soil air permeability and pF curve in small free pore space, measured at actual soil moisture.

The evaluation of the results of air permeability examinations. Air permeability was made with the statistical program SPSS for Windows 13.1 (Ketskeméty-Izsó, 1996). The connection of air permeability and certain soil features were evaluated with lineal regression method. The received results give information about the connection and it strength between the examined parameters. The strength of relationship between the parameters can be seen well on the figures and on the R^2 value (determination coefficient).

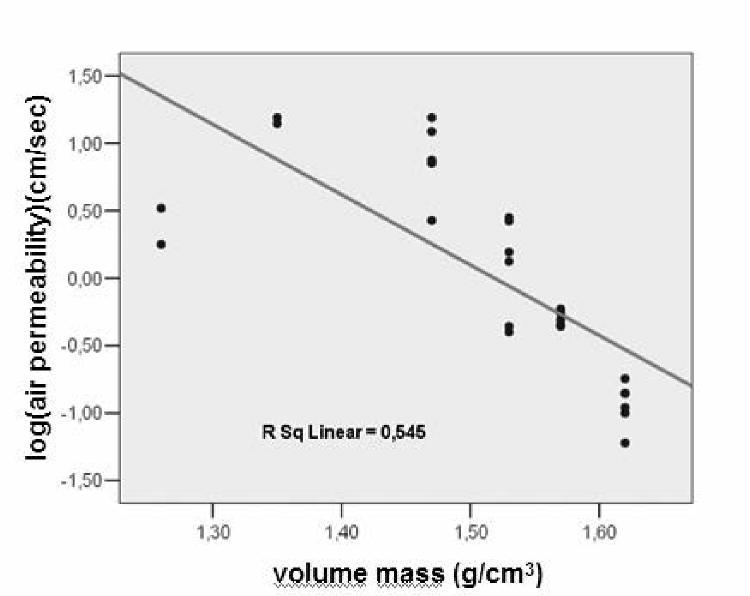

Fig. 3. Relationship between the air permeability and bulk density

The total porosity of the soil can be calculated on the basis of the bulk density, so it can be supposed the relationship between the air permeability and the bulk density. On the Figure 3 can be seen, that in case of the examined soil samples with the growing of the bulk density the air permeability decreasing, the relationship is medium tight.

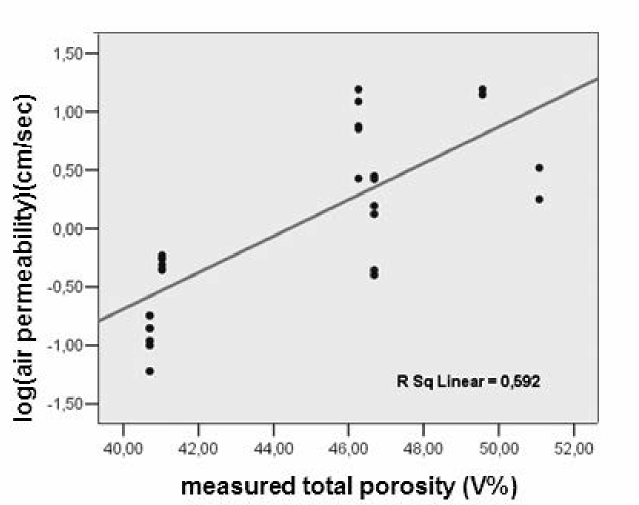

Fig. 4. Relationship between the air permeability and the total porosity

The examination of the correlation between the measured total porosity and the air permeability gave the expected result. On Figure 4 it can be seen, that with the increasing of the pore volume, the air permeability of the soil also increases. . Between the two factors there is a medium tight relationship.

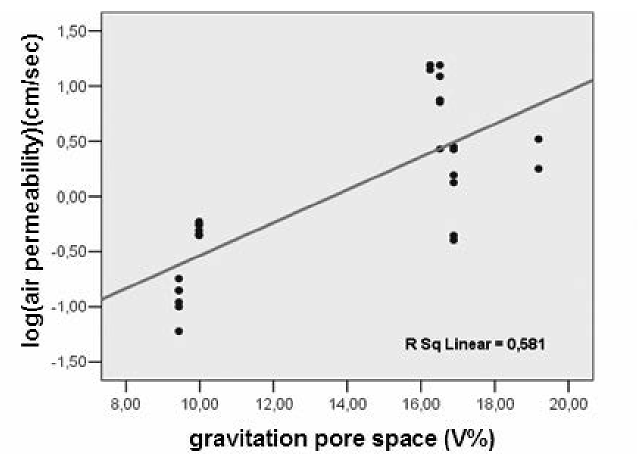

Fig. 5. Relationship between the gravitation pore space and air permeability

Air permeability occurs through the gravitation pore space in the soils. To comparing the pF curves with air permeability data can be seen, that where the proportion of the gravitation pore space was higher, the air permeability of the soil increased (Figure 1, 2). On the Figure. 5 can be seen, that the air permeability of the soil was higher where the volumetric amount of the gravitation pores were higher.

Conclusions

Because of the gravitation pore space, the measured total porosity, the bulk density and the air permeability of the soils are in significant linear correlation with each other, there is a possibility to work out a method, which enables fast diagnosis of aeration and compaction of the soils.

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