Scientific Papers. Series A. Agronomy, Vol. LXIV, No. 2, 2021
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

RESEARCH ON SOIL FERTILITY IN THE EXPERIMENTAL FIELD AT THE MOARA DOMNEASCA EXPERIMENTAL STATION

Mihaela DOGARU, Damian DRAGOMIR

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author email: cooperwoman67@yahoo.com

Abstract

A basic requirement in the development of modern fruit growing, that should be characterized by economic and ecological efficiency, is the detailed knowledge of the factors which are influencing the crop development, namely: environmental conditions and culture methods. Both aspects must have as final goal the maintenance and permanent improvement of the soil fertility. The rational, economically and ecologically efficient application of fertilizers can be achieved only by knowing in detail the physico-chemical conditions of the soil, considered as a means of living production necessary for plant growth. Thus we can determine the technological links in which we must intervene to obtain sustainable production both in terms of environmental protection and economically. It is also important to remember that by knowing these characteristics, we can identify the ecological methods of disease and pest control, given that the health of plants is directly influenced by the health and fertility of the soil. In 2019, before planting, soil samples were collected from depths of 0-20 cm and 20-40 cm. The samples were analyzed from the point of view of the main soil fertility indicators, respectively: pH, humus content, degree of saturation in bases, nitrogen index, mobile phosphorus, sum of bases and hydrolytic acidity, in order to determine the favorable cultivation of fruiting shrubs. The paper makes recommendations on the need to apply fertilizers in order to optimize the conditions for setting up a new orchard in an intensive system.

Key words*: substrate, humus content, nitrogen index, fertilizers, orchard.*

INTRODUCTION

The soil is an essential resource for all cultivated plants, being not only a support for plant roots, but also a reservoir of essential nutrients needed for plant growth. Due to the increasing practice of intensive agriculture, the soil is threatened by a number of factors, such as: erosion, loss of nutrient reserves, pollution, aridization, decreased fertility, etc. Overall, soil fertility has declined in the last fifty years, not only in our country but also worldwide.

Romania's geographical position and climate have always offered particularly favorable conditions for the cultivation of fruit trees and shrubs (Branişte, 2000). In this regard, Romania brings its contribution to the European Union through a valuable heritage, with many species of plants and animals, some endemic and relics, including medicinal plants and those with high sanogenic and nutritional value.

In this context, lately the attention of researchers and growers has increased towards these species (Jerecki, 2012), registering an expansion of cultivated areas and an increase in fruit production in fruit bushes.

The humanity is facing a global process in terms of environmental protection, namely Climate change. The effects of these changes are already being felt. These changes have already had a considerable impact on ecosystems, the economy, and human health, as well as on well-being in Europe (according to the report "Climate change, impacts and vulnerability in Europe 2016").

The global and European temperatures reach new highs, at the same time the rainfall regime is changing, by increasing rainfall in the wetlands and the decreasing of rainfall in the arid regions.

At the same tine, extreme climatic phenomena (heat waves, heavy rainfall, and periods of drought) are increasing in frequency and intensity in many regions of Europe, including Romania. All countries are vulnerable to climate change, but some regions are more exposed than others to the negative effect, with

most regions and sectors experiencing a negative impact.
In the climate of the Moara Domneasca Research Base, water losses through plant perspiration and evaporation from the soil are high. These losses are also influenced by strong winds that increase soil erosion. The organic matter content of the soil is generally low because the biomass production is low, which means that the availability of plant nutrients is very low. Under these conditions, the key to increasing crop productivity is to protect the soil from the sun, wind and increase the amount of organic matter and water in the soil.
The organic matter content of the soil can be improved by applying manure or compost. In the case of compost application, the challenge is to increase the production of plant biomass, which is needed for compost production. In hot and humid climates, high above-ground biomass production and rapid decomposition of soil organic matter make nutrients easily accessible to plants. But it also involves a high risk of nutrients loss by being washed away and thus lost. Under these conditions, it is important to keep a balance between the production and decomposition of organic matter, so soil depletion is avoided.
The interaction between soil chemical, physical and microbiological properties define a specific soil's "quality" and influence how effectively the soil carries out ecosystem function such as: a) retain and release nutrients and other chemicals, b) distribute rainfall at the soil surface into run off and infiltration, c) hold and release soil water to plants, stream and groundwater, d) with stand wind and water erosion, and e) buffer against the concentration of potentially toxic materials (Pryce, 1991).
In the present research, the effects of the application of different technologies for cultivating fruit shrubs are studied (blackberry and raspberry), respectively planting on different culture substrates (compost used by mushrooms, mulberry, forest compost, etc.).
The most important to study as a culture substrate is the used compost of mushrooms, which is in fact the material left after finishing a mushroom culture. Used mushroom substrate (SMS) can be used in a wide variety of applications SMS is available in huge quantities underlined by the fact that 1 kg of fresh mushrooms results in 5 kg of substrate consumed (ie 2 kg dry weight) (Finney et al. 2009). SMS has long been considered a waste stream. However, it can be used for production to produce high quality compost (Uzun, 2004) or other fungi to feed animals and for their health (Nasehi et al., 2017), to streamline the production of biofuels (Phan and Sabaratnam 2012), to produce materials (Jones et al., 2017; Islam et al., 2017; Appels et al., 2018), and to extract enzymes for industries (Phan and Sabaratnam, 2012).
The studied territory is part of the Moara Domneasca Farm, located N-E of Bucharest (in the Vlasiei Plain, a subunit of the Roman Plain), in Ilfov County at approx. 17 km from Bucharest. The farm belongs to the Fruit Research and Development Station Baneasa and is characterized by a humid climate, with hot summers and harsh winters.
Extreme temperature values range from 41.1°C in August to -30°C in January. The average annual rainfall is 580 mm, with a maximum average reached in June (92 mm) and a minimum average reached in February (31 mm).
The climate, the depth of the groundwater, the loessoid deposits and the vegetation contributed to the formation of soils belonging to the luvisols class, the reddish luvosols being predominant. In the depressed areas and in the crevices there are reddish luvosols and stagnosols.
The reddish luvosol from the Moara Domneasca, has the following characteristics:

- granulometric analysis for determination the soil content in clay, dust and sand revealed a high percentage of clay ranging from 40.5% in the upper horizon 0-40 cm, 41.6% at a depth of 41-53 cm and 47.4% at depths greater than 54 cm;
- the clay-clay texture determines a low mobility of nutrients and a poor permeability of water in the soil;
- apparent density on depth 0-20 cm 1.53 g/cm^3 medium, high at 20-40 cm 1.50 g/cm^3.
- low total porosity over the entire depth of the profile.
- the degree of compaction has values between 16%, the soil is moderately compacted

and 18% at a depth of more than 40 cm, strongly compacted.

The morphological characteristics of the soil are:

In the horizon of humus accumulation

• Ao 0-19 cm, dusty clay, colors of 10YR 5/ 3.5 in dry state, loamy-clayey, poorly developed grainy-glomerular structure, (weak) - moderately compact, cracks to the base of the horizon, fine grassy roots, with rare point separations of iron and manganese hydroxides, gradual transition.

• Ao 20-40 cm, dark brown, with a slight reddish tinge, loamy-clayey, macro-microprofous, kneaded, angular, stable, loose, rare grassy roots, light, compact, with separations of iron hydroxide and manganese in the form of dots and spots.

In the transition horizon

• Ao / Bt 41-53 cm, clayey clay, dry colors 10 YR 4/3, grainy and small polyhedral angular and subangular, jilav, compact, with more separations of iron and manganese hydroxide more numerous, the transition is made gradually textural horizon B.

On the horizon of colloquial illuviation

- Bt 54-83 cm, reddish-brown, clay-clay, compact structure, shades of 10 YR 3/3.5, the transition from one sub-horizon to another is done gradually.
- Bt 84-125 cm clay clay, the shade of the material becomes reddish-reddish (5YR 3.5/4) in undisturbed structure.
- Bt 126-154 cm, clayey clay, prismatic-columnoid, very compact.
- Bt 155-200 cm clay clay, 5YR 4/4 in undisturbed structure and 5YR 4/4.6 in cut, compact, clear passage.
- About 200 cm depth, clay and loessoid clay material, under 2 m depth appear flowers and concretions of $CaCO_3$.

MATERIALS AND METHODS

At the Experimental Base Moara Domneasca, an agrochemical study of the soil at depth of 0-40 cm was carried out, in order to observe the main agrochemical soil fertility indicators which are directly influencing the quantity and quality of crops.

In 2019, after plots were plowed and harrowed, samples were taken by the personnel of the Agrochemistry Laboratory. The samples were taken from plots that are to be planted with fruiting shrubs (different varieties of raspberries and blackberries). Sampling was done with a soil sampler, observing the provisions of the STAS 7184/1-84.

The samples were brought to the laboratory under normal conditions and processed according to the standard STAS 7184 .

The samples collected in the field phase were analyzed, according to the "Methodology for elaboration of pedological studies" - I.C.P.A, in the Agrochemistry Laboratory within the Fruit Research and Development Station Baneasa, using the following methods:

- soil reaction - pH - SR 7184-13 was determined in aqueous extract, soil: water ratio = 1: 2.5, with the CONSORT 933 analyzer using the pH electrode;
- humus content. STAS 7184/21-82 humus was determined by wet oxidation, according to the Walkley Black-Donut method, and titrimetric dosing;
- degree of saturation in bases - V% - STAS 7184/12-88;
- nitrogen index - IN = H x Vah / 100 - STAS 7184/12-88;
- mobile phosphorus (assimilable) - Pppm - STAS 7184/19-82 were determined colorimetrically easily soluble phosohates in ammonium lactate acetate extract by the Egner-Riehm method, the values being read at UV spectrophotometer VIS CAMSPEC M 330;
- sum of bases - SB -. STAS 7184/12-88;
- hydrolytic acidity - Ah.

The determination of the hydrolytic acidity and the sum of the exchangeable bases was performed according to the Kappen method. In order to correct the soil reaction, the degree of base saturation, VAh, was determined, which represents the ratio between the sum of the basic cations, SB, and the total cation exchange capacity, SB + Ah. To estimate the amount of mineralized organic matter in the soil and the amount of mineralized N in it, the nitrogen index was determined, IN = H * VAh/100.

After determining the values of agrochemical indicators, it can be identified the ecological methods to control diseases and pests, given that plant health is directly influenced by soil health and fertility.

The basic fertilization must take into account the results of the agrochemical analysis and bring a contribution in macroelements balanced with the needs of the species. Any supply of organic matter at orchard establishment will bring positive impact on plants growing rate. Also, an organic fertilizer will improve the soil structure and texture and will actively support the microbiological life of the soil surface.
Thus, we developed a experiment in which different organic substrates have been used in order to identify which of these are more beneficial for the cultivation of fruit bushes.

RESULTS AND DISCUSSIONS

In the Moara Domneasca soil profile there are biogenic neoformations, especially in the upper part of the profile (coprolites, larval sites, etc.), and iron oxides and hydroxides are on the crack walls like films, usually continuous in the Bt horizon. In horizon C we find neoformations of calcium carbonate. The granulometric composition of the soil shows that the clay content increases from the soil surface to the Bt horizon, from 40.55% to 47.39%, and the fine sand decreases with depth (Table 1).

Table 1. The granulometric composition of the reddish luvosols soil at the Moara Domneasca

Horizon	Depth cm	Clay %	Coarse sand %	Fine sand %	Dust %	Texture
Ao	0-40	40.55	0.36	34.33	24.75	Clay loam
Ao/Bt	41-53	41.63	0.52	21.54	56.28	Clay loam
Bt	54-200	47.39	0.37	27.59	30.34	Clay loam
C	Over 200	36.18	0.42	32.04	32.04	Clay loam

The soil content in humus is good in the first 40 cm of profile, where most of the roots of young trees are located, reaching 3.26%, then suddenly decreases in profile up to 1% in the Bt horizon (Table 2). The pH is slightly acidic at the soil surface (6.4), reaching alkaline in the C horizon (8.3).

Table 2. Physico-chemical properties of reddish luvosols soil at the Moara Domneasca (on profile)

Factor	**Ao**	**Ao/Bt**	**Bt**	**C**
Humus (%)	3.26	1.87	1.0	1.0
Ca soluble (mg/100 g sol)	55	32	32	30
Hydrolytic acidity(m.e.)	2.8	2.04	1.72	0.18
Amount of exchangeable bases (m.e.)	22.6	23.62	26.28	-
Total cation exchange capacity (m.e.)	28.65	28.04	30.01	-
Degree of saturation in bases (%)	78.94	84.28	87.53	-
pH	6.4	6.6	6.8	8.3
Total nitrogen (%)	0.144	0.102	0.075	0.07
Soluble phosphorus (mg/100 g sol)	50	40	40	30
Soluble potassium (mg/100 g sol)	2	2	2	2

Soil preparation for planting

Table 3. The results of the soil samples at the Moara Domneasca, 2019

Date	**2019**		
Lot no.	**SHRUBS (plowed soil)**		
Depth	**0-20**		
pH	6.26	6.39	6.35
SB: Ca(2+)+Mg(2+)+K(+)+Na(+)	7.94	15.68	16.27
Ah	6.17	6.17	4.46
H, % (105 C)	3.14	2.94	3.02
C org (105 C)	5.42	5.08	5.21
T - cation exchange capacity	14.11	21.85	20.73
Degree of saturation with bases (%)	56.26	71.75	78.49
IN (105 C)	1.77	2.11	2.37
P, mg/kg	50.45	56.57	46.86

After planting, before substrate application, the results of soil analysis were:

Table 4. The results of the soil samples at the Moara Domneasca before substrate aplication, 2020

Date/lot no.	FEBRUARY 2020				Normal values allowed by Order no. 756/1997	
Lot no.	raspberry		blackberry		raspberry	blackberry
Sample no.	13	14	15	16		
Depth	0-20	20-40	0-20	20-40		
pH	7.07	6.74	7.3	6.99	5.6-6.5	5.8-7.0
U, % humidity	18.37	15.71	18.15	17.12		
SB: Ca(2+)+Mg(2+)+K(+)+Na(+)	12.23	12.15	12.29	12.2		
Ah	2.74	2.56	2.77	2.34		
H, % (105 C)	4.1	2.47	4.46	3.98	3.5-4.5	3.5-4.5
C org (105 C)	2.38	1.43	2.59	2.31		
T - cation exchange capacity	21.34	23.56	23.57	20.34		15
V_{Ah}, % - degree of saturation with bases	98.37	98.71	98.35	99.23	76-92	80-98
IN (105 C)	4.03	2.44	4.39	3.95	4.1-6	4.1-6
P, mg/kg	101.9	62.6	60.1	88.4	>72	>72

Experimental design

In March 2020, the most appropriate options for these crops were fixed.
The randomized experimental design was Randomized Complete Block with 2 species (blackberry and raspberry) on different variants of organic substrate (V1-garden soil, V2-used mushroom compost, V3-forest compost, V4-mixture V1 + V2 + V3 + V5, V5-semi-fermented compound and M-control).
Planting distance between rows - 3m and planting distance between plants (blackberry - 1m and raspberry - 0.5 m).
As varieties, for blackberries, have been used Triple Crown, Chester and Dar 24.

Figure 1. Planting the plants

Figure 2. Soil substrate

As varieties, for raspbaries, have been used Tulameen, Przehyba and Citria.
In order to supply plants with water a drip irrigation system was used. For weed protection mulching has been done with Agrotextile foil.
For each substrate variant I will use 7 blackberry plants of each variety and 7 plants/ variety as control and 14 raspberry plants of each variety and 14 plants/variety as control.

CONCLUSIONS

The results of the analyzes show that the reddish preluvosol from Moara Domneasca on which the experimental lots of fruit bushes are placed is well provided with nutrients.

The humus content includes this soil in the category of medium soils provided with humus, and phosphorus is also found in the category of medium soil provided with this element.

In order to increase the fertility of this soil, we cultivated fruit bushes on different cultivation substrates (used compost from mushrooms, garden soil, forest compost, semi-fermented compost).

Determinations will be made in plants throughout the vegetation periods to highlight the influence of nutrient substrates on the ripening date of the first / last fruits in the inflorescences and on the growth and fruiting processes.

The aim of the experiment is to apply cultivation technologies targeting reducing soil degradation, by optimizing agrochemical soil properties, maintaining and increasing soil nutritional capacity by using technologies for the balanced application of fertilizers (organic and mineral).

In the given context, the elaboration of soil fertilization recommendations should be based on periodic control of soil fertility status depending on:

- Cropping system, assortment and applied technology;
- Soil maintenance system;
- Biological particularities of the species
- Irrigation method used;
- Integrated control of diseases and pests.

Depending on these considerations, the soil fertilization of experimental plots, must include recommendations for the combined and harmonized use of all nutrient resources (organic, mineral and foliar fertilizers).

The growths that take place will continue to be monitored, depending on the substrate in which the fruit bushes are grown and the variation of the nutrients in the soil in each substrate.

REFERENCES

Appels, F.V.W., Dijksterhuis, J., Lukasiewicz, C.E., Jansen, K.M.B., Wösten, H.A.B., Krijgsheld, P. (2018). Disappearance of the hydrophobic gene and the impact of growth conditions on the mechanical properties of the mycelium by affecting the density of the material. *Sci Rep 8. 4703*.

Braniște, N. (2000). Guide for fruit growers. *Cultivation of fruit species of fruit bushes and* strawberry *in Romania, Bucharest,* pp. 11-120.

Finney, K.N., Ryu, C., Sharifi, V.N, Swithenbank, J. (2009a). The reuse of spent mushroom compost and coal tailings for energy recovery: comparison of thermal treatment technologies. *Bioresource Technology*, *100*. 310–315.

Islam, M.R., Tudryn, G., Bucinell, R., Schadler, L., Picu, R.C. (2017). Morphology and mechanics of fungal mycelium. *Sci Rep 7. 13070.*

Jarecki MK, Chong C, Voroney RP. (2012). Evaluation of compost leachate for growing nursery trees on a waste-rehabilitated field site. *Compost Science & Utilization 20*(3), 171–180.

Jones, M.P., Huynh, T., Daver, F., John, S., (2017). Mycelium Composites: A Review of Engineering Characteristics and Growth Kinetics. *Journal of Bionanoscience, 11*, 241–257.

Nasehi, M., Torbatinejad, N.M., Zerehdaran, S., (2017). Efectul fermentarii în stare solidă cu ciupercă de stridie (Pleurotus florida) privind valoarea nutritivă a unor subproduse agro. *J Appl. Anim. Res., 45. 221–226.*

Pryce, S. (1991). Alternatives to peat. *Plantsman 13*(2), 75–93.

Phan, C.W., Sabaratnam, V. (2012). Potential uses of the substrate used by - fungi and its associated lignocellulosic enzymes. *Appl. Microbiol. Biotechnol.,* 96. 863–873.

Uzun, I., (2004). Use of used mushroom compost in fruit production. *J. Fruits of Ornamental Plants, 12.* 157–165.

***"Climate change, impacts and vulnerability in Europe 2016" from https://www.eea.europa.eu/publications /climate-change-impacts-and-vulnerability-2016

***Methodology of agrochemical analysis of soils in order to establish the necessary amendament and fertilizers (1987) Vol.I, II, III - I.C.P.A Bucharest.

***Operational STAS by ASRO – Romania.