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RESEARCH ON THE INFLUENCE OF ORGANIC FERTILIZERS ON THE AGROCHEMICAL INDICATORS OF THE SOIL

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Abstract

The aim of this study was to evaluate the influence of organic fertilizers on some soil agrochemical indicators, such as: soil reaction (pH), content of soil in organic carbon, humus, total nitrogen, total phosphorus and total potassium. Research was carried out in an apple demonstrative plot established in 2010 at Maracineni, in a private farm from Arges County. In 2022 the following fertilization variants were applied: V1 - Unfertilized; V2 - Biohumus – 0.5 l/tree, soil application + Macys BC 28 – 2 l/ha, foliar application + Cifamin BK – 1 l/ha, foliar application; V3 - Biohumus – 0.7 l/tree, soil application + Macys BC 28 – 2 l/ha, foliar application + Cifamin BK – 1 l/ha, foliar application; V4 – Biohumus – 0.9 l/tree, soil application + Macys BC 28 – 2 l/ha, foliar application + Cifamin BK – 1 l/ha, foliar application; V5 – manure – 20 t/ha. The following determinations were carried out: pH in aqueous solution mix soil:water = 1:2.5 (potentiometric method); organic carbon according to the Walkley Black method, respectively the humus by calculation; the total nitrogen was determined by the Kjeldahl method; the total phosphorus was determined spectrophotocolorimetric, the Egner-Riehm-Domingo method; the total potassium was determined flamphotometrically from the same extract obtained when determining the phosphorus. Fertilization with manure in a dose of 20 t/ha (V4), has led to an improvement of soil acidity, increased soil content in humus, nitrogen, phosphorus and potassium compared to the unfertilized variant and with the other fertilization variants.

Key words*: humus, nitrogen, phosphorus, potassium, soil reaction.*

INTRODUCTION

Apple is an important fruit crop in many countries, including Romania. The area cultivated with apples in 2022 was 54,070 ha, which ensured a production of 543,380 tons (Faostat, 2024). This fruit production ranks apple on the 2nd place in Romania, after plum. However, Romanian apple production is lower than other countries like the USA, New Zealand and China etc. due to the cultural practices. Some authors report that low productivity is closely related to low soil fertility (Krishna, 2014; Kai & Kubo, 2020; Kai & Adhikari, 2021). The culture of the apple in the ecological system can reduce the amount of chemical fertilizers that damage the structure of the soil. Organic fertilizers application improved both plant growth and soil conditions (less acid soil and more soil carbon) (Kai & Adhikari, 2021). Kai & Kubo, in 2020, conducted a study in organic apple orchards in Japan and reported high levels of carbon, nitrogen, phosphorus and potassium in the soil, which can improve bacterial biomass and leading to enhanced N and P circulation. In conclusion, organic fertilizer management system can improve soil nutrient contents.

In Romania, ecological apple production is still quite limited (Butac et al., 2021), due to the lack of organic fertilizers, which limits profitability of ecological apple orchards. McArtney & Walker, in 2004 also reports a lack of organic fertilizers in Oceania. In previous articles it is specified that production can be lower by about 30% in the situation of using organic methods (Reganold et al., 2001; de Ponti et al., 2012).

The aim of this study was to evaluate the influence of organic fertilizers on some soil agrochemical indicators, such as (soil reaction - pH, content of soil in organic carbon, humus, total nitrogen, total phosphorus and total potassium in an apple orchards managed under ecological system in Maracineni – Arges area.

MATERIALS AND METHODS

Field trial

Research was carried out in an apple demonstrative plot established in 2010 at Maracineni, in a private farm from Arges County.

Fertilization variants

In 2021-2022 the following fertilization variants were applied: V1 – Unfertilized; V2 – Biohumus – 0.5 L/tree, soil application + Macys BC 28 – 2 L/ha, foliar application + Cifamin BK – 1 L/ha, foliar application; V3 – Biohumus – 0.7 L/tree, soil application + Macys BC 28 – 2 L/ha, foliar application + Cifamin BK – 1 L/ha, foliar application; V4 – Biohumus – 0.9 L/tree, soil application + Macys BC 28 – 2 L/ha, foliar application + Cifamin BK – 1 L/ha, foliar application; V5 – Manure – 20 t/ha.

A short description of fertilizers and application period

Biohumus is a 100% organic fertilizer, produced with the help of earthworms, which stimulates the yield, growth and health of trees (Butac & Chivu, 2020). In the apple experimental filed, soil fertilization with Biohumus was carried out in increasing doses, from 0.5 L/tree, 0.7 L/tree to 0.9 L/tree in two moments: in spring before the start of vegetation and in autumn after the fall of the leaves (in 2022).

Macys BC 28 is a fertilizer based 100% on the algae *Macrocystis integrifolia*, which stimulates root development, vegetative growth, flowering and fruiting, and also the fruits size and quality (Butac & Chivu, 2020). Macys BC 28 fertilizer was applied foliar in doses of 2 L/ha, in two moments: after flowering and in the young fruit phase (in 2022).

Cifamin BK is a special fertilizer based also on the algae *Macrocystis integrifolia*, very rich in organic components, indicated for improving the size and fruits quality, keeping fruit and firmness unaltered, ensuring optimal shelf-life (Butac & Chivu, 2020). Cifamin BK fertilizer was also applied foliar in doses of 1 L/ha, also in two moments: after flowering and in the young fruit phase (in 2022).

Foliar fertilizers, Macys BC 28 and Cifamin BK were dissolved in 500 L water.

Manure from cattle is a natural fertilizer aerobically fermented for 12 months. It was applied in November 2021.

Agrochemical indicators of the soil

In autumn 2021, before the applied the fertilization, soil samples were collected from the depth of 0-20 cm and 20-40 cm and chemical analyzes were carried out (acidity, content in humus, organic carbon, nitrogen, phosphorus and potassium). It was concluded that the respective soil, on which a conventional technology was applied, has a weak acid reaction, low humus content in the arable horizon, low nitrogen and phosphorus and moderate potassium content (Table 1).

Table 1. Agrochemical indicators of the soil

Depth (cm)		0-20	20-40
Acidity Indicators	pH	6.37	6.14
Fertility indicators	Total nitrogen (%)	0.08	0.07
	Phosphorus P_2-P_2O_5 (ppm)	7-15	6-10
	Potassium K-K_2O (ppm)	130	85
	Organic carbon (%)	0.95	0.83
	Humus (%)	1.64	1.43

Soil sampling and analysis of chemical properties

Soils were sampled in November 2022 using a boring stick. Soil samples of the top 20 cm were taken from around the base of three trees for analyzing the chemical properties. The soil chemical properties were analyzed using the methods described by Florea et al. (1987). The following analyses were carried out on the fresh soil samples: soil pH was measured in a soil:water suspension (ratio 1:2.5 w/v) by the potentiometric method; organic carbon with wet oxidation method followed by titrimetric dosing by Walkley – Black method modified by Gogoașă, respectively the humus calculated with the formula: humus %= C org x 1.724 (Rusu & Mărghitaș, 2010); the total nitrogen was determined by Kjeldahl method (Kjeldahl, 1883); the total phosphorus was determined spectrophotocolorimetric by Egner-Riehm-Domingo method by which the phosphates are extracted from the soil sample with a solution of acetate - ammonium lactate at pH=5.75, and determined colorimetric phosphate anion extracted as molybdenum

blue (Egnér et al., 1960); the total potassium was determined flamphotometrically by which the hydrogen and ammonium ions of the extraction solution replace by exchange the exchangeable potassium ions in the soil sample which are thus passed into the solution (Egnér et al., 1960).

Statistical analysis

Results were processed by Excel (Microsoft Office 2010) and SPSS Trial Version 14.0. Data were subjected to analysis of variance (One-way ANOVA; $p \leq 0.05$), and Duncan's Multiple Range Test (DMRT) post hoc tests were used to measure specific differences between sample means.

RESULTS AND DISCUSSIONS

***Reaction of the soil* (pH)**

In general, most cultivated plants prefer soils with neutral, slightly acidic or slightly alkaline pH (6.3-7.5). The consumption of nutrients by fruit trees depends on the pH. For example, calcium and magnesium are easily assimilated by fruit trees at pH 7-8.5, nitrogen at pH 6.0-6.8, phosphorus at 6.5-7.5 and potassium at higher pH of 6 (Nagy et al., 2022).

The values of pH are between 5.83 (V4) and 6.96 (V5), with a mean value of 6.17 (Figure 1). Fertilization with Biohumus in doses 0.5 L/tree (V2), 0.7 L/tree (V3) and 0.9 L/tree (V4) (soil application), associated with Macys BC 28-2 L/ha and Cifamin BK - 1 L/ha (both fertilizers with foliar application) has led to a significant decrease in pH values compared with unfertilized variant.

Fertilization with manure in a dose of 20 t/ha (V5), has led to an improvement of soil acidity. Significant increases, statistically insured, are observed, from 6.27 in the V1 – unfertilized variant, to 6.96 in the fertilized variant with manure (V5) (Figure 1).

In previous studies performed in apple orchards managed in the organic system, more or less close values of the pH have been obtained. The effect of cattle manure on the improvement of the soil reaction was reported in Romania by Borlan & Hera many years ago (1973). Recent, in Romania, in an apple orchard in which compost from urban sludge was applied, the pH values between 6.5 and 7 were obtained (Nagy et al., 2022). In Japan, Kai & Ahikari, reported values of soil pH of 6.9 in organic apple system. In Italy, Bona et al. (2022) reported high values of soil pH in apple orchard fertilized by matured manure (about 8.8).

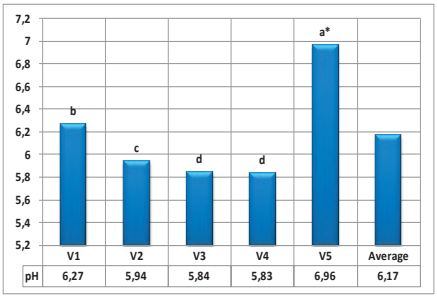

Figure 1. The influence of organic fertilization on the pH of the soil

*Duncan multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

***Content of soil in organic carbon* (%)**

As expected, the content of soil in organic carbon increased significantly with the increase of doses of fertilizer.

There are significant differences between all fertilized variants. In the fertilization variant with manure (V5), the value of the carbon organic has registered the highest increases compared to all other variants.

It is noted that the dose of manure is much higher than the doses of Biohumus, Macys BC 28 and Cifamin BK applied in the other fertilization variants (Figure 2).

Similar results were reported by Kai & Adhikari in 2021.

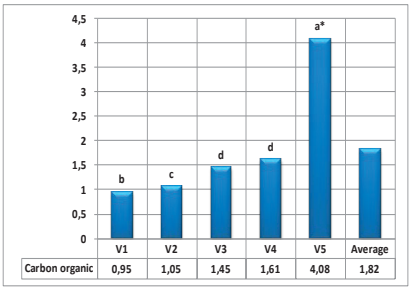

Figure 2. The influence of organic fertilization on the content of soil in the organic carbon

*Duncan multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

***Content of soil in humus* (%)**

Humus has a sedimentation effect on the soil (Belopukhov et al., 2023).

In our experiment we observed a tendency of increases of humus content in the soil. Similar results are reported by the other authors (Kopytko et al., 2017; Elkhlifi et al., 2022; Belopukhov et al., 2023; Butkevičienė et al., 2023).

The values of humus were between 1.64 (V1) and 7.04 (V5), with a mean value of 3.15 (Figure 3).

It can be seen from Figure 3 that, in the case of fertilization with manure (V5), content of soil in humus was much higher than in the other fertilization variants (7.04% versus 1.64% in V1 – unfertilized, 1.81% in V2, 2.50% in V3, respectively 2.78% in V4 (Figure 3).

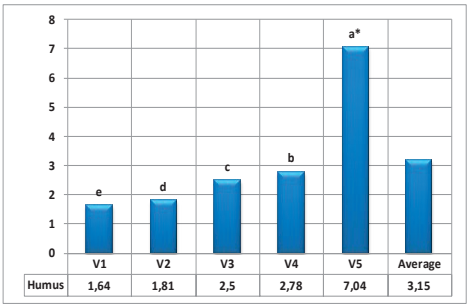

Figure 3. The influence of organic fertilization on the content of soil in the humus

*Duncan multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

***Content of soil in total nitrogen* (%)**

Also, the content of soil in the total nitrogen was higher in the case of fertilization with manure (V5). The differences are significantly much higher than all the other variants, including the unfertilized variant (Figure 4).

The positive effect of the manure on the content of the soil in nitrogen has been reported by the Khusaynov et al. in 2019 in Russia, the dose of manure being 30 t/ha.

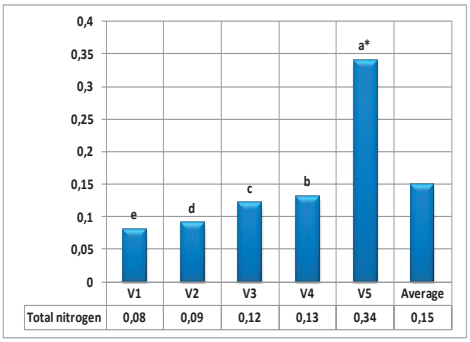

Figure 4. The influence of organic fertilization on the content of soil in the total nitrogen

*Duncan multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

***Content of soil in total phosphorus* P_2-P_2O_5 (ppm)**

The values of phosphorus were between 7 ppm (V1) and 162.33 ppm (V5), with a mean value of 60.26 ppm (Figure 5).

The total phosphorus content has increased with the increase of the doses of Biohumus and also in the variant fertilized with manure.

The differences are significantly higher than the unfertilized variant and the differences are also significant between the fertilization variants with different doses of organic fertilizers (Figure 5).

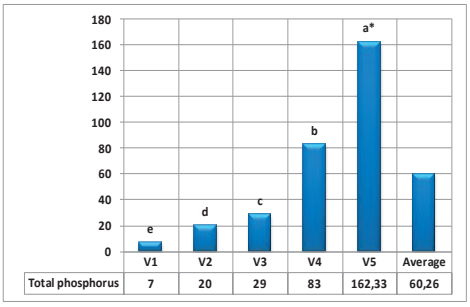

Figure 5. The influence of organic fertilization on the content of soil in total phosphorus

*Duncan multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

Similar results regarding the influence of organic fertilization on content of soil in phosphorus are reported by the other authors (Khusaynov et al., 2019; Belopukhov et al., 2023).

***Content of soil in total potassium K-K_2O* (ppm)**

Information about the content of potassium is important in the agrochemical analysis of soils (Belupukhova et al., 2023).

The values of potassium were between 100 ppm (V1) and 552.33 ppm (V5), with a mean value of 205.26 ppm (Figure 6).

The potassium content increased in soil with increases of organic fertilizers doses applied to the soil. Practically the variant 5 – fertilization with manure cannot be compared to the other organic fertilization variants.

However, there are significantly differences between V3 and V4 variants compared to the unfertilized variant and significantly higher values in V4 compared to V3. The increase of the potassium content in V2 is insignificant to the unfertilized variant (Figure 6).

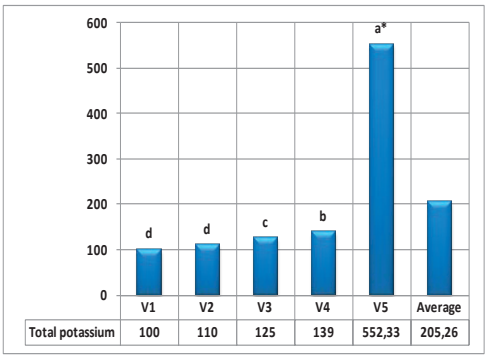

Figure 6. The influence of organic fertilization on the content of soil in total potassium

*Duncan multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

Based on the data obtained in this study regarding content of soil in potassium, we confirmed that the our results are similar with other results obtained by Khusaynov et al. (2019), Kai & Adhikari (2021), Butkevičienė et al. (2023).

CONCLUSIONS

Fertilization with Biohumus in doses 0.5 L/tree (V2), 0.7 L/tree (V3) and 0.9 L/tree (V4) (soil application), associated with Macys BC 28 – 2 L/ha and Cifamin BK – 1 L/ha (both fertilizers with foliar application) has led to a significant decrease in pH values compared with unfertilized variant.

Fertilization with manure in a dose of 20 t/ha (V5), has led to an improvement of soil acidity versus the unfertilized variant and to all other organic fertilization variants.

The organic carbon content has increased significantly with the increase of the fertilizers doses, the highest increase being obtained in the case of fertilization with 20 t/ha of manure.

The contents of soil in N, P, K have increased with the increase of the doses of fertilizer, the highest increases being obtained in the case of fertilization with manure.

The results of our study show that organic fertilization in apple culture had a good effect on the content of soil in humus, carbon, nitrogen, phosphorus and potassium.

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