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NUTRITIONAL STATUS OF SOIL AFTER EIGHT YEARS OF FERTILIZING WITH ORGANIC PRODUCTS

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Abstract

The study was conducted in a fruit-bearing peach plantation on the site of the Fruit-Growing Institute – Plovdiv Bulgaria. In 2019 the influence of bio-products Biohumus, Agriful and Humustim on the basic soil characteristics pH, Ec, N-NO_3^-, N-NH_4^+, K_2O, P_2O_5 has been studied. Eight years of fertilization was carried out. At the dose of 120 kg/da Biohumus, is achieved a very high degree that of available phosphorus and potassium, respectively: 80.93 mg P_2O_5/100 g and 43.13 mg K_2O/100 g soil. Fertilization with Biohumus and Agriful results in an increase of ammonium and nitrate nitrogen in the top soil layer to a depth of 30 cm. For Agriful, ammonium nitrogen values increased from 32.15 mg/100 g (0.5 L/da) to 46.93 mg/100 g (1.0 L/da). The nitrate nitrogen increase is from 39.49 to 66.34 mg/100 g soil. Continuous application of Biohumus and Agriful creates a favorable supply of nutrients in the soil (P_2O_5, K_2O, N-NO_3^-, N-NH_4^+), optimal for nutrition of peach plants.

***Key words**: fertilization, biofertilizers, agrochemical parameters of soil (pH, K_2O, P_2O_5, NO_3^-, NH_4^+), peach.*

INTRODUCTION

The soil is fertile only when it contains all the mineral nutrients of vital importance for the plants in sufficient quantities and in the best ratio.

The chemical analysis of soil is used as a diagnostic tool for assessing soil nutritional status (Stoilov, 1977; Marx et al., 1996; Roy et al., 2006). Soil analysis can be a useful indicator of the relative nutritional status of fruit orchards, especially if changes are followed for a longer period of time.

Soil fertility is maintained mainly by the use of natural products, such as green fertilization, fertilization with organic phosphates and glauconites, and other natural products that provide nutrients to soil or improve its agrochemical properties (Gorbanov, 2006).

The ecological approach in organic fertilization comprises predominantly the use manure extract, a soil nutritional substance derived from the activity of California worms, natural resources rich in biologically active substances, compost derived from wood waste, soil amendment extracted from paper waste and the use of certified fertilizers for organic production (Yadav et al., 2000; Fliebach et al., 2007). The application of organic waste can increase nitrogen and phosphorus content in soil (Jakobsen, 1995), improve soil structure and water retention capacity (Johansson et al., 1999). Other authors (Dutta et al., 2003; Kaur et al., 2005) compare the use of organic and chemical fertilizers. The application of organic fertilizers has a higher positive effect on microbial biomass and therefore on soil status and the total NPK content in soil. Compost is a good source of nutrients for fruit trees, but the time of mineralization and release is difficult to predict. A many-year study in Italy evaluated the impact of organic fertilization on soil fertility, the level of nutrient supply for the nectarine fruit trees and the export of nutrients from the trees (Toselli et al., 2013). The effect of manure applied at the time of planting at a rate of 10 t per ha and of compost at 5 and 10 t per ha was studied. It was found that nitrate nitrogen content in soil increased with the application of a higher rate of compost. Biofertilizers are microbial preparations containing living cells of various microorganisms that have the ability to mobilize nutrients in soil, promote the restoration of micro flora and improve soil fertility (Rozpara et al., 2014). Soil properties are constantly changing in time and space (Rogerio et al., 2006).

The aim of the present study was to evaluate the effects of some bioproducts (Biohumus, Agriful and Humustim) on the major soil characteristics of pH, NO_3^-, NH_4^+, P_2O_5, K_2O after eight years of fertilization in a fruiting peach plantation of 'Glohaven' cultivar.

MATERIALS AND METHODS

The trial was carried out in a fruiting peach orchard on the territory of the Fruit-Growing Institute in Plovdiv. 'Glohaven' cultivar grafted on the vegetative rootstock GF677 was used in the experiment. The soil is alluvial-meadow. Over a period of eight years, from 2011 to 2019, the bioproducts Humustim, Agriful and Biohumus obtained from California worms were applied to soil.

Biohumus was introduced into soil around the stems of the experimental trees at three rates of 40, 80 and 120 kg/da.

Agriful was applied as water solution. Two rates of 0.5 and 1.0 L/da were studied. Humustim was applied as a leaf fertilizer at three rates of 100, 120 and 150 ml/da. Treatment at the studied rates was performed five times during vegetation, every 15-20 days. The control was untreated. Another control variant was also included in the study for the period 2016 to 2019, applying fertilization with ammonium nitrate at a rate of 22 kg/da.

Soil samples for the analysis were collected in 2011 and in 2019 from the studied variants in three replications. The content of mineral nitrogen ($N{-}NH_4^+$ and $N{-}NO_3^-$) in the soil samples was determined by the distillation method after extraction with 1% KCl.

Mobile phosphorus (P_2O_5) was determined in a lactate extract (DL method) colorimetrically, with a hydrazine sulfate reducer and that of potassium (K_2O) - with a flame photometer. Soil reaction (pH) and electrical conductivity (Ec) were determined potentiometrically in water extract (1:2.5). The results were statistically processed with the Duncan test.

RESULTS AND DISCUSSIONS

The agrochemical soil properties at the beginning of the experiment are presented in Table 1.

Table 1. Soil supply in the peach plantation with the major nutrients in 2011

Depth, cm	pH (H_2O)	P_2O_5	K_2O	$N{-}NH_4^+$	$N{-}NO_3^-$
		mg/100 g	mg/100 g	mg/kg	mg/kg
Control					
0-30 cm	7.16	19.80	23.00	21.73	15.55
30-60 cm	7.13	30.00	20.00	25.40	15.03
Biohumus					
0-30 cm	7.10	26.00	32.60	13.24	19.23
30-60 cm	7.30	31.00	23.00	11.14	18.14
Agriful					
0-30 cm	7.05	22.00	30.00	12.96	16.07
30-60 cm	7.43	155.00	20.00	13.22	15.81
Humustim					
0-30 cm	7.24	66.00	27.40	16.33	20.99
30-60 cm	7.28	160.00	21.00	11.92	19.18

The soil in the experimental plot is alluvial-meadow, with a soil reaction from neutral to slightly alkaline (Table 1). There are significant differences in the supply of soil with phosphorus. According to the margin levels of supply (20-30 mg P_2O_5/100 g), all the samples fall under the category of highly supplied. Very high supply was reported for the rows fertilized with Agriful and Humustim at a depth of 30-60 cm. The amount of mineral nitrogen varied by variants of fertilization. The potassium content in the experimental plot varied from 20 to 32.6 mg/100 g of soil. The control falls under the category of moderately supplied. The results of the analyses show that the soil in the plantation is well supplied with the basic macronutrients.

The results obtained for the concentrations of nitric nitrogen, ammonium nitrogen, phosphorus, potassium, conductivity values (Ec) and soil reaction (pH) in water extract and in KCl, after eight years of fertilization with the bioproducts Biohumus, Ariful and Humustim, are presented in Tables 2 and 3.

Table 2. Phosphorus and potassium content and soil reaction in water extract and in 1n KCl after eight years of fertilization with bioproducts

Fertilization rate	**pH (H_2O)**		**pH (KCl)**		**P_2O_5** mg/100 g		**K_2O** mg/100 g	
Biohumus	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
40 kg/da	7.19 ab	7.83 a	6.40 ab	7.15 ab	29.33 ab	51.00 a	25.13 bc	16.93 bcd
80 kg/da	6.70 b	7.19 bc	6.04 b	6.13 b	41.00 ab	69.13 a	26.00 bc	15.80 cd
120 kg/da	7.40 a	7.94 a	6.79 a	7.13 ab	75.80 a	80.93 a	43.13 a	17.93abcd
Agriful	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
0.5 L/da	7.07 ab	7.37 ab	6.29 ab	6.22 b	44.6 ab	62.07 a	31.30 abc	18.47abcd
1.0 L/da	6.73 ab	7.60 ab	6.06 ab	6.74 ab	16.67 b	54.00 a	22.47 c	18.00abcd
Humustim	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
100 ml/da	6.65 b	7.67 ab	5.97 b	7.04 ab	8.93 b	58.13 a	23.47 c	13.00 d
120 ml/da	6.64 b	7.41 ab	5.78 b	6.50 ab	14.0 b	91.00 a	27.67 bc	18.50 abc
150 ml/da	6.86 ab	7.74 ab	6.24 ab	7.24 ab	15.13 b	52.33 a	40.67 a	21.67 ab
Ammonium nitrate	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
22 kg/da	4.89 c	6.72 c	4.30 c	6.33 ab	7.27 b	27.97 a	27.33 bc	19.00 abc
Control	6.72 b	7.71 ab	6.06 b	7.46 a	19.23 b	88.00 a	36.27 ab	22.83 a

Soil reaction was neutral to moderately alkaline. A significant decrease in pH values was observed as a result of fertilization with ammonium nitrate. The pH values in H_2O were 4.89 for the layer 0-30 cm and pH 6.72 at 30-60 cm depth. In KCl salt extract those values were 4.30 (0-30 cm) and 6.33 (30-60 cm). The imported ammonium nitrate led to an acidification of the soil reaction in the surface soil layer. The results obtained correspond to the studies of other authors (Sas et al., 2003; Sas Paszt & Żurawicz, 2005; Wójcik, 2000). On the other hand, the acidification also affected the content of ammonium and nitrate nitrogen (Table 3). Ammonium nitrogen in the 0-30 cm layer reached values of 181.93 mg/kg and nitrate nitrogen up to 187 mg/kg of soil, those values exceeding the untreated control many times. The differences are statistically significant.

In all the other treated variants, the soil reaction in water extract ranged from 6.64 to 7.7, which is the optimal soil acidity for the peach crop. A slight increase in pH (H_2O) was observed after the application of Biohumus - 7.19 (40 kg/da) to 7.4 (120 kg/da), as the organically bound nitrogen is mineralized and then transformed into ammonia, leading to a slightly alkaline soil reaction. The electrical conductivity ranged from 244 μS to 811 μS for the 0-30 cm layer and from 124 μS to 250 μS for the 30-60 cm layer in the different variants of fertilization. Soil electrical conductivity was relatively high, although below the threshold for damage to the peach trees (Table 3).

Table 3. Ammonium nitrogen and nitrate nitrogen content and soil electrical conductivity after eight years of fertilization with bioproducts

Fertilization rate	Ec, µS		$N{-}NH_4^+$ mg/кg		$N{-}NO_3^-$ mg/кg	
Biohumus	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
40 kg/da	305.33 ab	163.33 b	6.40 c	26.84 b	37.85 c	7.91 b
80 kg/da	811.33 a	211.33 b	133.45 ab	6.04 ab	146.00 ab	28.97 ab
120 kg/da	244.33 b	181.00 b	19.87 c	6.79 ab	16.90 c	5.79 b
Agriful	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
0.5 L/da	292.67 ab	124.67 b	32.15 bc	13.90 ab	39.49 bc	9.27 b
1.0 L/da	402.00 ab	207.33 b	46.93 bc	18.83 ab	66.34 bc	16.02 b
Humustim	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
100 ml/da	297.67 ab	184.33 b	36.69 bc	14.09 ab	44.80 bc	7.72
120 ml/da	177.33 b	135.00 b	22.79 c	15.93 ab	16.99 c	11.68 b
150 ml/da	224,67 b	200.00 b	19.79 c	14.87 ab	15.06 c	13.79 b
Ammonium nitrate	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
22 kg/da	655.67 ab	539.00 b	181.93 a	33.22 a	187.34 a	56.10 a
Control	262.33 b	250.33 a	29.26 c	20.28 ab	40,56 bc	11.78 b

Eight years of fertilization of the alluvial-meadow soil shows that with increasing the rate of Biohumus the phosphorus uptake by the plants also increases. At the highest rate of 120 kg/da the soil has sufficient reserves of absorbable phosphorus - 80.93 mg P_2O_5/100 g of soil. There is a linear relationship between the introduced rate of Biohumus and the amount of mobile phosphorus in soil, which can be expressed by the linear equation of the type y = b*x (Figure 1).

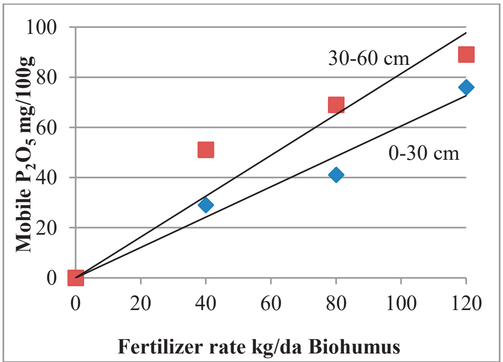

Figure 1. Relationship between the rate of fertilization with Biohumus and the mobile phosphorus content

The relationship between the amount of introduced fertilizer and the content of mobile phosphorus achieved in the 0-30 cm layer is expressed by the linear equation y = 6054*x and for the layer 30-60 cm -i by the equation y = 8143*x, where y is the mobile phosphorus in soil in mg/100 g and x is the fertilizer rate, kg/da of Biohumus.

Potassium uptake by plants gradually increases with increasing the rates of Biohumus, but the increase is not so clearly expressed as with phosphorus. At a fertilization rate of 120 kg/da of Biohumus, the potassium content in soil reached 43.13 mg K_2O/100 g of soil, showing very high supply with the nutrient. The mineral nitrogen content varied in the studied variants. Monitoring the nitrogen dynamics in soil to a depth of 60 cm with increasing fertilization rates showed a significant difference in the content and distribution of ammonium nitrogen and nitrate nitrogen in depth. Fertilization with Biohumus led to an increase in ammonium and nitrate ions only in the surface soil layer. The highest values of the ammonium (133 mg/kg) and nitrate (146 mg/kg) forms of nitrogen were observed at the rate of 80 kg/da at a depth of 0-30 cm. The nitrate form of nitrogen increased at the expense of the ammonium due to mineralization. Further to that, the application of 120 kg/da had a negative effect on the nitrogen content in soil: 19.87 mg/kg $N{-}NO_4^+$

and 16.90 mg/kg $N-NO_3^-$, the values obtained being commensurable with those in the control (Table 3).

After treatment with Agriful, there was a tendency to higher values for the phosphorus and potassium contents in the surface soil layer 0-30 cm, when applying the rate of 0.5 L/da. The increased rate of 1.0 L/da had a negative effect on the values of those nutrients. However, this is not the case with nitrogen. The introduction of the higher rate of Agriful – 1.0 L/da resulted in higher values of $N-NH_4^+$ and $N-NO_3^-$, the tendency being reported only for the 0-30 cm layer. Ammonium nitrogen values increased from 32.15 mg/kg (at the rate of 0.5 L/da of Agriful) to 46.93 mg/kg (at 1.0 L/da of Agriful). For nitrate nitrogen, the increase was from 39.49 to 66.34 mg/kg, the differences to the untreated control being statistically significant (Table 3).

It should be noted that soil application of Agriful and Biohumus products resulted in better soil parameters for the 0-30 cm layer. The most active part of the roots of the peach trees grown on a vegetative rootstock, are located at that depth.

The values obtained for the studied soil characteristics after the application of Humustim were close to those of the control variants. The bioproduct did not affect the basic soil characteristics, since its application is foliar and it does not significantly affect the studied soil parameters.

CONCLUSIONS

Fertilization of alluvial-meadow soils with high rates of Biohumus led to an increase in the mobile forms of phosphorus in the soil, with a close relation between the rate of fertilization and the amount of the mobile forms of phosphorus, expressed by a linear equation.

Despite the high rates of Biohumus and Agriful fertilizers applied, deep penetration into the soil was not observed.

The long-term application of the bioproducts contributed favorably to the soil characteristics of pH, Ec, NO_3^-, NH_4^+, P_2O_5, K_2O in the peach plantation and contributed to a favorable supply of nutrients (potassium, phosphorus and nitrogen), optimal for the nutrition of peach trees.

Continuous application of ammonium nitrate led to acidification of soil, which is unfavorable to the peach crop.

The application of bioproducts to soil confirmed the positive impact on its nutrient supply and hence, increases its productivity.

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