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USAGE OF FERMENTED CHICKEN MANURE AS A BIOFERTILIZER IN AN APPLE ORCHARD

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Abstract

Effects of fermented chicken manure on soil nutrient availability, leaf nutrient status and fruit quality parameters were studied in an apple plantation from Eastern Hungary. Beside control, three fermented chicken manure products (BIO-FER Natur Extra, Nitro vit and 7-9-7) were used in a field experiment trial at the Horticultural Experimental Farm of University of Debrecen in 2020. In this trial, soil and leaf analysis were made to check the effects of applied treatments on the nutrient supply of the soil and the nutrient status of the leaves. Beside soil and leaf analysis, yield and some fruit quality parameters were investigated. The products were applied at the beginning of April in 2020. Each treatment consisted of 5 trees.

Soil pH has slightly decreased during the trial. The organic carbon content of the soil has not significantly changed during the experiment. Chicken manure treatments could not affect considerably the soil P, K, Mg, Mn, Cu and Zn content compared to the control. All applied treatments increased the N content of leaves compared to the control, but the effect was not significant. Leaf P content was the same in all treatments, while the leaf K content was slightly higher where chicken products were used. Leaf Ca and Mg were not affected significantly by the treatments compared to the control.

The usage of chicken manure increased yield, fruit weight and fruit flesh hardness compared to the control, but significant effect was observed only in certain treatments. Moreover, all applied treatments decreased the Brix value of apples compared to the control.

Key words: soil organic matter, organic fertilization, fruit nutrition, chicken manure

INTRODUCTION

In 2002, the European Commission pointed out that the reduction of soil organic matter content indicated the continuously increasing soil degradation processes in Europe that is an increasing problem for farmers. Maintaining soil health is essential for the sustained productivity of food, wastes decomposition, heat storage, carbon sequestration, and gas exchange. Soil degradation and/or changes in soil quality that result from wind and water erosion, salinization, losses of soil organic matter (SOM) and nutrients, or soil compaction are of great concern in every agricultural region from the world (Liu et al., 2006; Zacháry et al., 2018).

Soil organic matter is important to improve the physical properties of the soil. Especially, it improves water holding capacity, soil temperature and performance of soil microbiota at the sandy soil. Moreover, soil organic matter affects not only soil health and food production, but also climate change.

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The agricultural sector conducts researches and develops methods to ensure food safety by protecting the environment and human health, while increasing the yield in more environmentally friendly ways. The modern perspective of the agriculture sector is based on applying organic matters, including different manures. This type of fertilizers are mostly made of organic based wastes. As such, it is the most important type in sustainable agriculture practices due to its low cost, easy supply, richness in nutrients for plants and improving soil productivity. Moreover, they re-participate in the material cycles from nature (Tamás et al., 2017).

During recent years, poultry industry has become widespread worldwide due to supplying low-cholesterol meat production and high economically protein sources (Manu et al., 2013). Moreover, manure production is expected to increase in the coming decades due to the growing demand for livestock populations as a result of the ever-increasing human population and shifts in diet structure with more meat consumption (Herrero and Thornton, 2013). Correspondingly, the producing of poultry manure has grown as a result of the economic boom from the poultry industry.

Nowadays, organic manures (e.g. poultry manure) are preferred because of their ability to improve soil fertility and plant growth (Haga, 1999; Bolan et al., 2010; Ravindran et al., 2017). Furthermore, application of them is low-cost. Based on the high content of organic matter, pellets improve the soil's structure and moisture-absorbing capacity, and ensure a fertile balance of natural soil systems as well as the natural enrichment of soils. Poultry manure is also less detrimental to the environment compared to inorganic fertilizers. Manure is an ideal source of important crop nutrients such as potassium, nitrogen and phosphorous. It also improves the physical conditions and characteristics of the soil, as well as crop productivity and plant nutrient uptake.

Organic amendments added to manure enhances soil properties by increasing the soil's organic matter content. This consequently improves the soil's aggregate stability and structure hence enhancing the soil's water holding capacity, soil aeration, microbial activities and cation exchange capacity. Organic matter positively influences the hydraulic conductivity of soils, the soils' porosity and aggregation of heavy soils. Incorporation of poultry manure in soil improves the rates of water infiltration in soil hence allowing the easy movement of water in horizontal and lateral gradients from the soil profile (Amanullah et al., 2010).

However, poultry manure may be used in land applications as fertilizer in order to achieve a quick disposal of poultry manure, prevent the loss of nutrients from the manure and avoid environment pollution (Szabó et al., 2019). Mature compost can improve soil fertility and plant growth (Haga, 1999), nutrients and organic carbon content and total exchangeable bases (Kobierski et al., 2017). However, application of immature compost would cause N starvation (Bernal et al., 2009; Moral et al., 2009), can have phytotoxic effects, and alerts to the presence of harmful microbes (Fang et al., 1999; Tiquia and Tam, 2000).

The EIP-AGRI Focus Group pointed out in its final report from 2015 to produce new data to fill the identified gaps of agronomic references about proper rates and types of manures that can be applied (incl. slurries and composted manures) (EIP-AGRI, 2015).

The main objective of this study was to evaluate the effect of fermented chicken manure products with different additives (https://bio-fer.hu/termekeink/) on the nutrient uptake of trees, yield and fruit quality from an apple orchard.

MATERIAL AND METHOD

Experimental design

The study was performed in 2020 at the Horticultural Experimental Farm of University of Debrecen. Type of the soil is light sandy loam. The pH of soil is slightly acidic (pH 6.1 - 7.0). Humus content varies between 1.1 and 1.9 %, the plasticity index according to "Arany" is approximately 27 - 30. The apple orchard was planted in the spring of 2011. Trees were grafted on M9 rootstock and designed with a 4 x 1 meter spacing. Trees were trained to slender spindle with the height of 3.5 m. The study was performed on 'Pinova' cultivar. The orchard has a drip irrigation system. Plant protection refers to integrated pest management principles.

The trial consisted in four treatments (control, Bio-fer Natur Extra (NEX), Bio-fer Nitro vit (Nitro vit) and Bio-fer 7-9-7 (macronutrient contents of the products are presented in Table 1). The treatments were applied at the beginning of April 2020. Each treatment plot consisted of 5 trees while 2.5 kg/plot products were applied at 20 cm depth along the trees, on both sides.

Table 1

Active ingredients of BIO-FER products

Macronutrient content	**NEX**	**Nitro vit**	**7-9-7**
N content (w/w%)	5.0	10.0	7.0
P_2O_5 content (w/w%)	3.0	3.0	9.0
K_2O content (w/w%)	2.5	5.0	7.0

In the trial 'Pinova' cultivar was used. 'Pinova' is a German apple cultivar, a hybrid of 'Clivia' and 'Golden Delicious'. It has high fruit yield, with little tendency towards biennial bearing. It is tolerant to scab, but sensitive to powdery mildew. The fruit is juicy and crisp, with a red skin colour of about 50 – 70 % (Fischer et al., 2000).

Soil sampling, preparation and results

Soil samples were taken from 0-30 cm layer of the soil by using manual soil sampling equipment as described by the relevant Hungarian standard method (MSZ-08 0202-77). Sampling was performed before the experiment was set up (April) as well as at the end of the experiment (September). Samples were dried, sieved, homogenized and stored in plastic boxes until the examination. Three extractants were used for the soil analysis (KCl, AL and EDTA). Soil samples were prepared and measured in the Agrarian Instrument Centre according to Hungarian standards (MSZ 20135:1999; MI-08 0468-81).

Leaf sampling and preparation

Apple leaves were taken from all trees of treatment plots at the standard sampling time (at the beginning of August). For sampling, healthy, well-developed, mature leaves (fifty leaves per treatment) were taken from the mid-third portion of extension shoots of the current year as described in the international and Hungarian plant sampling guidelines for fruit orchards (Hungarian standard MI-08 0468-81).

Fruit analysis

Fruit yield (kg/tree) was measured at harvest. Fruit quality parameters were assessed based on 20 fruits/treatments. Fruit length (mm) and fruit diameter (mm) were measured by mortise gauge. The shape index (length/diameter) was calculated from these data. Fruit weight (g) was measured by analytical balance, while fruit flesh hardness by hand held force gauge (PCE - FM 200). The soluble solid content of fruits (SSC) was measured by Brix handle refractometer (MT - 032ATC, detection limit: ± 0.20 %) (MSZ EN 12143:1998).

Statistical analysis

All the obtained data were tabulated and statistically analysed according to Svab, 1981, using the L.S.D. test at a 5% level to recognize differences between various treatment methods. The effects of the different treatments were assessed within ANOVA, while Fisher's least significant differences were calculated following a significant F test ($P \leq 0.05$).

RESULTS AND DISCUSSION

Results of soil analysis at the beginning of the experiment

The results of soil analysis at the beginning of the experiment are showed in Table 2. Orchard soil type was slightly acidic, non-calcareous (lime content < 0.1 w/w %) sandy soil with low organic carbon content. The soil pH was near neutral but significant differences were not observed among treatments. The texture grade of soil was sandy, according to the soil plasticity index (K_A). The N-supply of the soil was low and the inorganic form (nitrate) dominated. Soil P and K contents were excessive according to the regular significant P and K fertilization management. Micronutrient concentrations (Zn, Cu) are medium with a significant Mn content in the upper soil layer (Table 2).

Table 2

Results of soil analysis at the beginning of the experiment (May, 2020)

	Control	**Nitro Vit**	**NEX**	**7-9-7**
pH (KCl)	6.09	6.38	6.61	6.59
Plasticity index according to Arany (K_A)	27	29	28	30
Organic carbon (m/m) %	1.12	1.48	1.35	1.10
Phosphor pentoxide (mg/kg) (AL)	413	442	456	433
Potassium-oxide (mg/kg) (AL)	338	353	418	388
Nitrate (mg/kg) (KCl)	9.23	20.00	12.00	41.30
Magnesium (mg/kg) (KCl)	186	209	146	140
Manganese(mg/kg) (EDTA)	273	344	372	244
Zinc (mg/kg) (EDTA)	17.3	12.06	9.33	17.6
Copper (mg/kg) (EDTA)	13.20	11.10	13.00	9.48
Organic Nitrogen (m/m)%	0.094	0.135	0.127	0.115

KCl – potassium-chloride solution, AL – ammonium lactate solution, EDTA – Ethylene-diamine-tetra-acetic acid solution

Results of soil analysis at the end of the experiment

The soil analysis results from the end of the experiment are showed in Table 3. Soil pH has slightly decreased, compared to the initial results. Applied NEX and 7-9-7 treatment increased while Nitro Vit treatment decreased the soil pH. Furthermore, significant treatment effects were not observed when compared to the control. Similarly to soil pH, soil organic carbon content has not changed significantly during the experiment.

Treatments did not affect the soil organic carbon content compared to the control. Soil P was excessive in all treatments and has not changed during the experiment. Al soluble K of the soil has not changed at the control and at 7-9-7 treatment but its amount decreased significantly at the Nitro Vit and NEX treatment during the trial. Soil Mg was lower at the end of the experiment in all treatments. Moreover, significant differences were not measured among treatments. A similar conclusion can be drawn for the manganese content of the soil. Lower concentrations were measured at the end of the experiment in all treatments. However, significant differences could not be established among treatments. Soil Zn content decreased in all treatments. Soil Zn content dramatically decreased at the control and the Nitro Vit treatment during the trial. Soil Cu content decreased to the end of the experiment, but significant differences were not observed among treatments.

Table 3

Results of soil analysis at the end of the experiment (September, 2020)

	Control	Nitro Vit	NEX	7-9-7
pH (KCl)	6.18	5.24	6.43	6.33
Plasticity index according to Arany (K_A)	30	30	29	29
Organic carbon (m/m) %	1.08	1.47	1.39	1.27
Phosphor pentoxide (mg/kg) (AL)	490	460	415	421
Potassium-oxide (mg/kg) (AL)	339	230	252	354
Nitrate (mg/kg) (KCl)	13.4	17.7	38.5	41.2
Magnesium (mg/kg) (KCl)	123	135	134	114
Manganese(mg/kg) (EDTA)	162	202	183	139
Zinc (mg/kg) (EDTA)	5.81	3.91	6.12	10.7
Copper (mg/kg) (EDTA)	8.90	7.34	7.22	6.40
Organic Nitrogen (m/m)%	0,091	0,147	0,108	0,118

KCl – potassium-chloride solution, AL – ammonium lactate solution, EDTA – Ethylene-diamine-tetra-acetic acid solution

Results of leaf analysis

The results of plant (leaf) analysis at the standard sampling time are showed in Table 4.

Table 4

Results of the leaf analysis (August, 2020)

	Control	Nitro Vit	NEX	7-9-7
Nitrogen (w/w %)	2.16a	2.34a	2.37a	2.26a
Phosphor (w/w %)	0.16a	0.17a	0.17a	0.17a
Potassium (w/w %)	0.98a	1.11a	1.13a	1.14a
Calcium (w/w %)	1.73a	1.79a	1.83a	1.84a
Magnesium (w/w %)	0.44a	0.49a	0.44a	0.46a

In each column, means followed by the same letter are not significantly different ($P<0.05$).

All applied treatments increased the leaves N content when compared to the control, but the effect was not significant. Leaf P content was the same in all treatments. The leaf K content was slightly higher where chicken products were used. The highest leaf K content was measured for the 7-9-7 treatment. Leaf Ca and Mg had not been significantly affected by chicken manure treatments. As a summary, the used chicken manure treatments did not increase leaf nutrient levels (Table 4).

Results of fruit analysis

The effects of treatments on the yield are presented in Figure 1. Our results pointed out that the treatments increased the yield (except Nitro vit), but a significant effect was observed only for the 7-9-7 treatment.

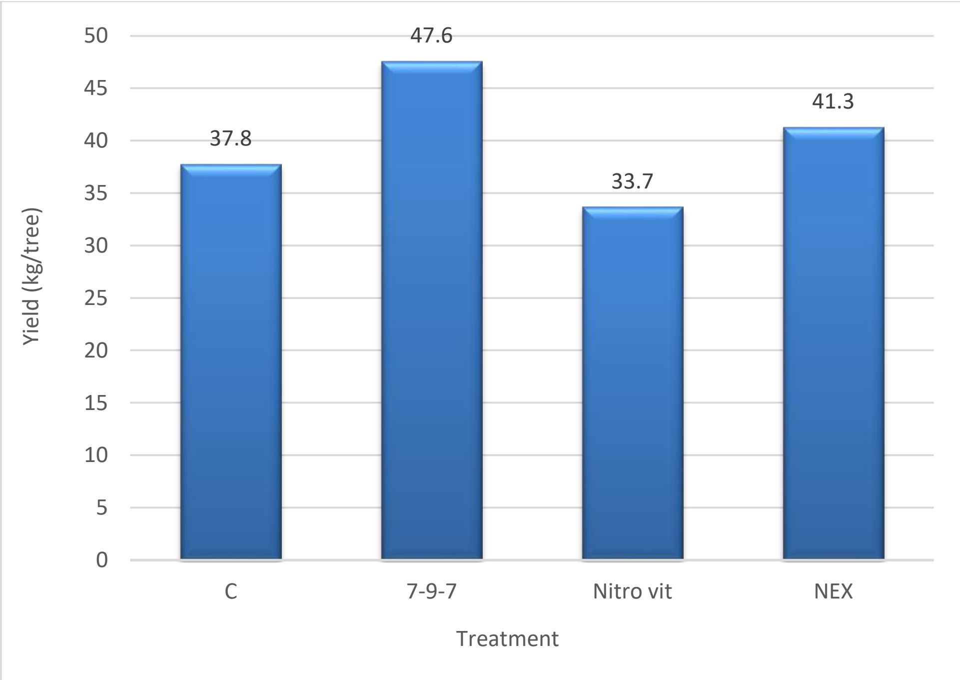

Fig. 1. Treatments effects on yield (kg/tree)

The effects of the treatments on the fruit weight are presented in Figure 2. It was found that the treatments (except 7-9-7) increased the fruit weight compared to the control, but the increment was not significant and the value of the standard deviation was high. This means that the weight distribution of the apples was wide.

The treatments effects on the fruit diameter are presented in Figure 3. The applied treatments (except 7-9-7) increased the fruit weight when compared to the control, but this effect was not significant and the value of the standard deviation was high. This is correlated with what was found for fruit weight. This means that the diameter distribution of the apples was wide, similar to the weight.

The effects of the treatments on fruit flesh hardness are presented in Figure 4. All treatments increased fruit flesh hardness, compared to the control, but this effect was not significant. The largest value was measured for the 7-9-7 treatment.

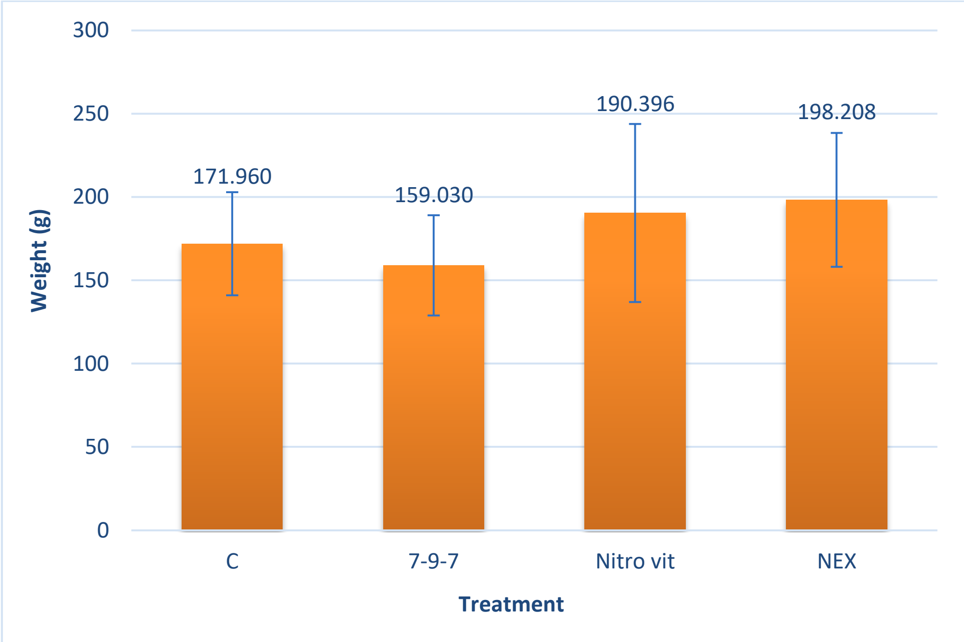

Fig. 2. Treatments effects on fruit weight (g/apple)

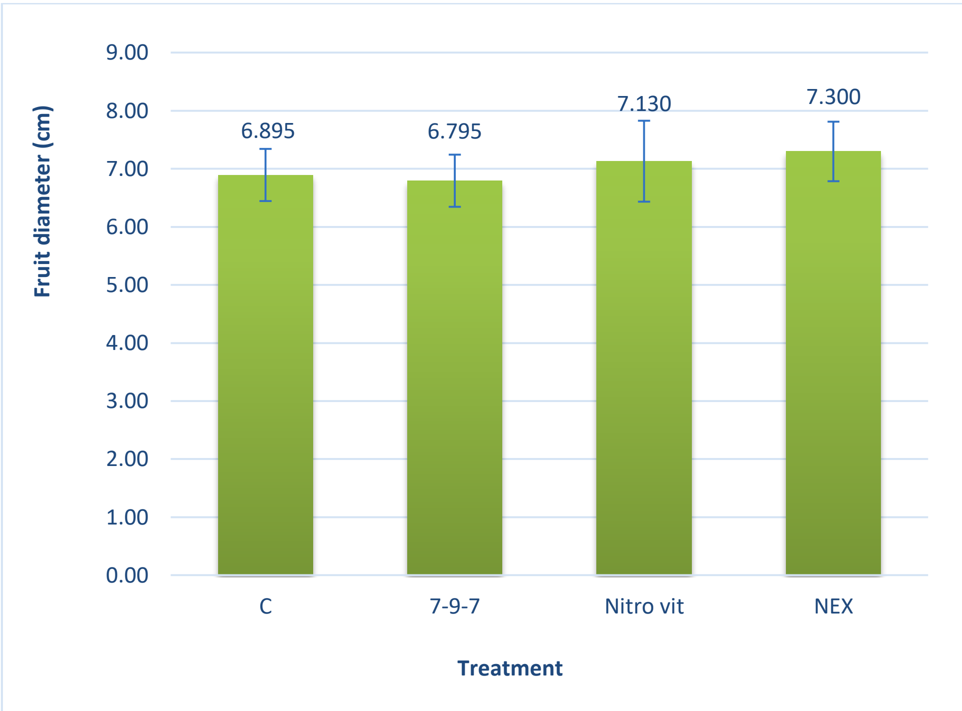

Fig. 3. Treatments effects on fruit diameter (cm/apple)

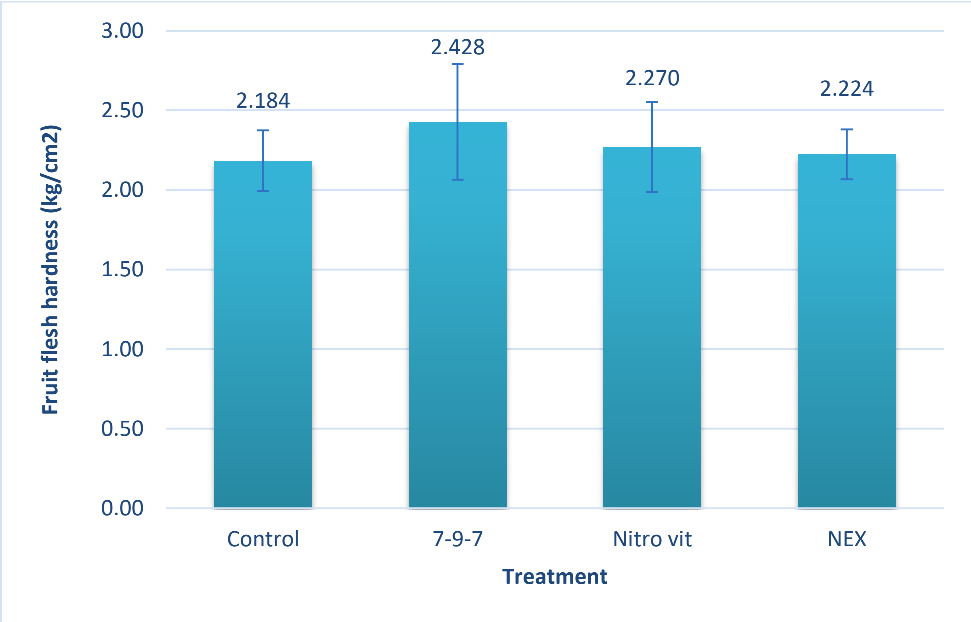

Fig. 4. Treatments effects on fruit flesh hardness (kg/cm^2)

The effects of the treatments on the fruit Brix value are presented in Figure 5. It was found, that all applied treatments decreased the Brix value of apples compared to the control. This means that the apple sugar content was decreased by treatments.

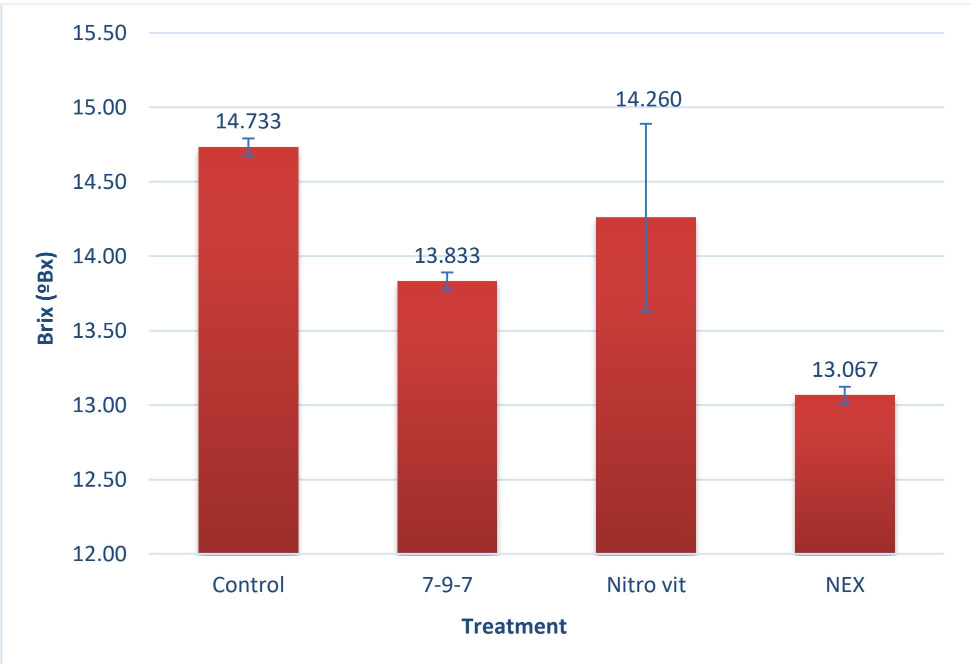

Fig. 5. Effects of the treatments on the fruit Brix value (ºBx)

CONCLUSIONS

The soil analysis results pointed out that the applied NEX and 7-9-7 products slightly increased while Nitro Vit treatment decreased soil pH. Furthermore, significant treatment effects were not observed during the trial. Similarly, the organic carbon content of the soil was not affected significantly by the treatments during the examined vegetation period.

Soil P content was excessive in all treatments. Therefore its amount did not change greatly during the experiment. Soil K did not change at the control and 7-9-7 treatment but its amount decreased significantly at the Nitro Vit and NEX treatment during the trial. Soil Mg, Mn, Cu and Zn contents were lower at the end of the experiment in all treatments. Moreover, significant differences were not measured among treatments. A decrease of these elements followed from seasonal changes.

The results of leaf analysis pointed out that all applied treatments increased the N content of the leaves, compared to the control, but the effect was not significant. Leaf P content was the same in all treatments, while the leaf K content was slightly higher where chicken products were used. Leaf Ca and Mg were not affected significantly by the treatments compared to the control.

Our results of fruit analysis pointed out that the treatments increased the yield (except Nitro vit), but significant effect was observed only at the 7-9-7 treatment. It was found that treatments (except 7-9-7) increased fruit weight when compared to the control. Moreover, all treatments increased fruit flesh hardness, compared to the control, but this effect was not significant. It is established, that all applied treatments did not significantly decreased the Brix value of apples, compared to the control.

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