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Early evaluation of use of fermented chicken manure products in practice of apple nutrient management

Florence Alexandra Tóth* – János Tamás – Péter Tamás Nagy

University of Debrecen,
Faculty of Agricultural and Food Sciences and Environmental Management, Institute of Water and Environmental Management,
Böszörményi str. 138, Debrecen, Hungary.
*Correspondence: toth.florence@agr.unideb.hu

SUMMARY

According to the Green Deal efforts, the importance and relevance of organic fertilization will increase in the near future. Therefore, the investigation of the effects of different organic fertilizers on soil productivity and nutrient supply is a priority area of agricultural research. Organic fertilizer experiment was conducted in an eight-year-old apple (Malus domestica Borkh.) orchard at Debrecen-Pallag. In the trial Pinova cultivar was used. In this study, two different fermented chicken manure products were added to the soil (in 20 cm depth) to test their effects on soil nutrient status, plant uptake and fruit quality. It was found that the applied treatments slightly increased the pH and nutrient levels in almost all cases, but significant effect was not observed in all treatments compared to the control. Leaf nutrient contents (N, P, K, Ca and Mg) were measured in the experiment. Leaf nutrient status was not affected by the fermented chicken manure treatments. Ho wever, used treatments had strong effects on the fruit characteristics and inner parameters, such as fruit diameter and Brix value. Moreover, it was established that the applied organic fertilizers increased the yield significantly.

Keywords: *organic fertilization, chicken manure, fruit nutrition*

INTRODUCTION

To achieve adequate and modern plant nutrition in orchards it is necessary to use site-oriented plant growing and nutrient management. The precision fruit nutrition is based on proper soil management and nutrient supply. Unfortunately, several Hungarian soils are lacking soil organic matter. Therefore, adequate organic matter supply is necessary for healthy food production. Over the last three decades there has been a great increase in the production of waste from urban-, industrial- and mainly agricultural activity, that could be recycled as a source of plant nutrients and used to enhance soil quality. The use of these materials could partially offset the need for mineral fertilisers, giving both economic and environmental benefits (Cordovil et al., 2005). Chicken manure regarded as excellent nutrient source due to it is very high in nitrogen and, also contains high amount of potassium and phosphorus. Moreover, manure production is expected to increase in the coming decades due to the growing demand for livestock populations because of the ever-increasing human population and shifts in diet structure with more meat consumption (Herrero and Thornton, 2013).

Nowadays, organic manures as poultry manure are preferred to utilize because of its ability to improve soil fertility and plant growth (Haga, 1999; Bolan et al., 2010; Ravindran et al., 2017) and it is low-cost. Based on the high content of organic matter, the manure pellets improve the structure and moisture-absorbing capacity of the soil and ensure a fertile balance of natural soil systems and the natural enrichment of the soil. Poultry manure is also less detrimental to the environment compared to inorganic fertilisers. The manure is an ideal source of important crop nutrients such as potassium, nitrogen and phosphorous.

To achieve quick disposal of poultry manure and prevent the loss of nutrients from the manure and avoid pollution of the environment, poultry manure may be utilized in land applications as fertiliser. The mature compost can improve soil fertility and plant growth (Haga, 1999). However, immature compost applied to soil would cause N starvation (Bernal et al., 2009; Moral et al., 2009), phytotoxic effects, and presence of harmful microbes (Fang et al., 1999; Tiquia and Tam, 2000).

Proper handling of the manure can be achieved through proper manure composting and appropriate practices of feed management (Bolan et al., 2010). Properly composted poultry manure results in an effective nitrogen mineralization hence reducing nitrate leaching and the harmful environmental effects of excess ammonia (Hwang et al., 2020). Nahm (2005) recommends that poultry manure should be applied to soil at rates that are determined by the level of soil - available N and the amounts of nitrogen required by the crops. The modern perspective of agriculture sector is based on application of organic matters for example different manures. These types of fertilisers are made of mostly organic based wastes. It is the most important in sustainable agriculture practices due to its low cost, easy supply, rich in nutrients for plant and improves soil productivity. Moreover, they re-participate in the material cycles in nature (Tamás et al., 2017).

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

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MATERIALS AND METHODS

The study was performed at the orchard of Experimental Station area (Debrecen-Pallag) of Institute of Horticultural Science of University of Debrecen in Hungary. The orchard was planted in 2011. In the trial apple (*Malus domestica* Borkh.) 'Pinova' cultivar was used grafted on M9 rootstock. The trees were spaced at 1 m in rows and 4 m between rows. Orchard was not irrigated. 'Pinova' is a German apple cultivar, hybrid of 'Clivia' and 'Golden Delicious'. It has high fruit yield, with little tendency towards biennial bearing. It is tolerant to the scab, but sensitive to powdery mildew. Fruit is juicy and crisp, red skin color is about 50–70% (Fischer et al., 2000). Orchard soil type was brown forest soil with sandy texture and alternated layer of clay, being relatively poor in macronutrients and humus content (*Table 1*). The experiment was set up at April 2019. Beside control two treatments were applied: Natur Extra and Nitro plus. The treatments consist of five trees. Dosage was 2 kg treatment^{-1}. The fermented chicken manure was applied both sides of trees along in 20 cm depth. Soil samples collected monthly for every treatment separately till October. As root system was most intense in the upper layer of the soil, soil samples were taken from the upper 0–20 cm layer of the soil by using a manual soil sampling equipment according to international and Hungarian soil sampling guidelines for fruit orchards Jackson, 1958; MSZ-08 0202-77). After that soil was pretreated (dried, sieved and purified) all essential nutrients were measured from the soil samples. The soil samples were dried outdoors in an airy place in a 1–1.5 cm layer, then the soil was sieved through a sieve of 2 mm hole size, homogenized, and stored in plastic boxes until the examination. Leaf samples were dried and grinded until the examination. Soil and leaf samples were measured in the Agrarian Instrument Centre according to Hungarian standards (MSZ 20135:1999; MI-08 0468-81). The basic parameters of the Pallag soil were as follows (*Table 1*).

Table 1: **Basic parameters of Pallag soil**

Basic soil parameters	Value
pH (KCl)	5.50
Plasticity index (KA)	35.00
Water soluble salts (m/m%)	0.02
Carbonate (m/m%)	< 0.10
Humus (org. C) (m/m%)	2.05
Phosphor pentoxide (mg kg^{-1}) (AL)	259.00
Potassium-oxide (mg kg^{-1}) (AL)	490.00
Nitrate (mg kg^{-1}) (KCl)	18.20
Sodium (mg kg^{-1}) (AL)	49.80
Magnesium (mg kg^{-1}) (KCl)	114.00
Sulphur (mg kg^{-1}) (KCl)	4.98
Manganese (mg kg^{-1}) (EDTA)	173.00
Zinc (mg kg^{-1}) (EDTA)	4.12
Copper (mg kg^{-1}) (EDTA)	3.40
Organic Nitrogen (m/m%)	0.11

The soil is a slightly acidic brown forest soil with larger humus content. Water soluble salts and carbonate contents are low. Nitrogen availability is medium, but phosphorus and potassium contents of the soil are high according to the regular significant P and K fertilization management. Micronutrient concentrations (Zn, Cu) are medium with significant Mn content in the upper soil layer.

Leaf was taken from all trees of each 5-tree plot in August. At sampling date, 8–10 normally sized, healthy leaves were collected from each tree, following the international and Hungarian plant sampling guidelines for fruit orchards (Stiles and Reid 1966; MI-08 0468-81).

Fruit samples were collected at the end of September (at the ripening stage). All apples were collected from the trees to establish the yield. 100 apples were measured for outer parameters and 1kg was the sample size used for inner parameters. Apples were ground and homogenized before measuring the Brix value.

Statistical analysis

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

RESULTS AND DISCUSSION

Soil analysis

The effects of treatments on different soil parameters are presented in *Table 2*. Two sampling dates were showed: at the beginning of the trial (the first soil sampling was made in May) and in September at the harvest time.

Soil pH was increased significantly by the application of fermented chicken manure (except the Nitro plus treatment in May). Increasing pH means better conditions for microorganisms and for plants to uptake nutrients as well. Organic carbon content of the soil was not affected significantly by the treatments. In May, lower organic carbon content was measured at the treatments compared to the control. In September, chicken manure treatments increased the soil organic carbon, but the increment was not significant. Organic nitrogen content was increased significantly by the treatments, except Natur extra treatment in May. Soil P was not affected significantly in May, but significant differences were found between control and chicken manure treatments in September. At soil K similar results were observed than found at soil P. Soil nitrate content was significantly affected by the manure treatments. Enormous increment was observed from May to September. Soil Mg was not affected significantly after one month, but significant effect of treatments was obtained in September. Soil Mn content significantly increased by the manure treatments from May to September. Soil Zn content significantly

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increased by the treatments at the end of studied period. Soil Cu was increased significantly by the treatments, except Natur extra treatment in May.

Leaf analysis

The effects of treatments on the major leaf nutrient contents are showed in *Table 3*. The applied treatments have not increased the N content of the leaves. Low decrement in leaf P content was observed at used chicken products compared to the control. The highest leaf K content was measured at Nitro plus treatment. Leaf Ca and Mg were not affected significantly by the chicken manure treatments. In summarized, the used chicken manure treatments have not increased the leaf nutrient levels (*Table 3*).

Table 2: **Effects of the treatments on the soil nutrient contents**

Parameters	May			September		
	Control	Nitro plus	Natur Extra	Control	Nitro plus	Natur Extra
pH (KCl)	5.50a	5.08a	6.02b	5.47a	6.20b	6.18b
Organic carbon (m/m %)	2.05a	1.88a	1.91a	1.33a	1.52a	1.60a
Phosphorous as P_2O_5 (mg kg^{-1}) (AL)	259a	311a	296a	317a	532b	496b
Potassium as K_2O (mg kg^{-1}) (AL)	490a	502a	513a	546a	659ab	733b
Nitrate (mg kg^{-1}) (KCl)	18.2a	74.8c	41.6b	24.6a	115c	71.6b
Magnesium (mg kg^{-1}) (KCl)	114a	146a	140a	135a	196b	211b
Manganese (mg kg^{-1}) (EDTA)	173a	271b	262b	230a	321b	301b
Zink (mg kg^{-1}) (EDTA)	4.12a	6.73a	6.45a	4.74a	12.0b	16.6b
Copper (mg kg^{-1}) (EDTA)	3.40a	5.41a	6.19b	4.38a	7.49b	9.72c
Organic Nitrogen (m/m%)	0.109a	0.152b	0.121a	0.109a	0.169b	0.133b

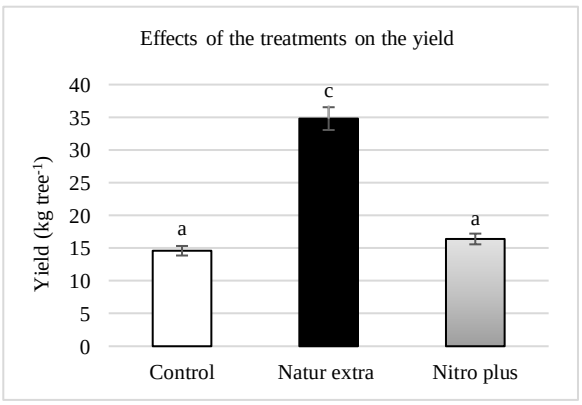
Table 3: **Effects of the treatments on the major leaf nutrients**

Nutrients (m/m%)	Control	Nitro plus	Natur Extra
N	2.090a	1.970a	2.090a
P	0.167a	0.159a	0.153a
K	0.856a	0.965a	0.817a
Ca	1.810a	1.600a	1.800a
Mg	0.366a	0.356a	0.367a

Fruit analysis

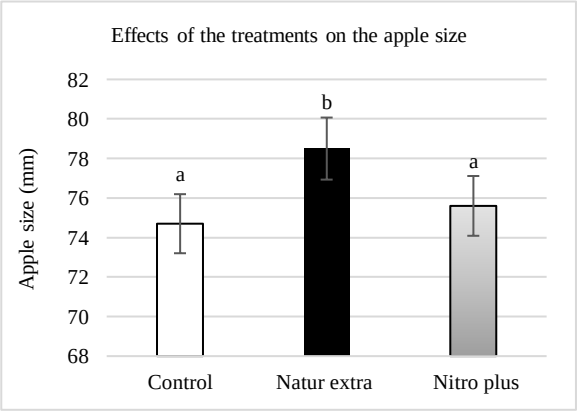
The effects of treatments on the yield are presented in *Figure 1*. Our results pointed out that the treatments increased the yield, but significant effect was observed at the Natur Extra treatment only. This treatment more than doubled the yield per tree.

Figure 1: **Effects of the treatments on the yield**



The effects of treatments on the fruit diameter are presented in *Figure 2*. Our results pointed out that the treatments increased the fruit size, but significant effect was only observed at the Natur Extra treatment (more than 4mm increment).

Figure 2: **Effects of the treatments on the apple size (diameter)**



The effects of treatments on the Brix value are presented in *Figure 3*. Our results pointed out that the treatments increased the Brix values significantly compared to the control.

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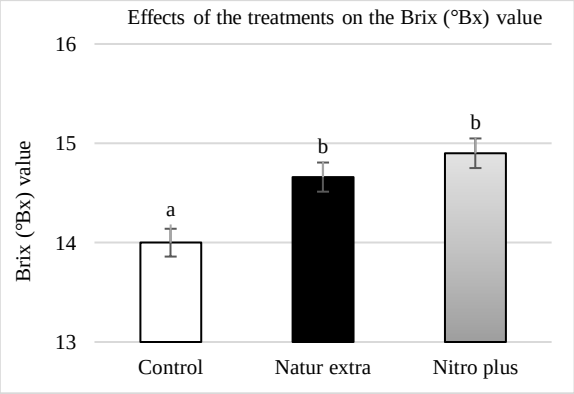
Figure 3: **Effects of the treatments on the Brix value**



CONCLUSIONS

Soil pH was increased significantly by the application of fermented chicken manure. Organic carbon content of the soil was not affected significantly by the treatments. Organic nitrogen content was increased significantly by the treatments, except Natur extra treatment in May. Soil P, K, Mg and Zn values were not affected significantly in May, but significant differences were found between control and chicken manure treatments in September. Soil nitrate content was significantly affected by the manure treatments. Enormous increment was observed from May to September. Soil Mn content significantly increased by the manure treatments from May to September. Soil Cu was increased significantly by the treatments, except Natur extra treatment in May.

The used chicken manure treatments have not increased the leaf nutrient levels at all due to the "one year effect".

Our results pointed out that the treatments increased the yield, but significant effect was only observed at the Natur Extra treatment. It was found that the treatments increased the fruit size, but significant effect was only observed at the Natur Extra treatment. It is established that the treatments increased the Brix values significantly compared to the control. Obtained results showed a positive effect of the applied treatments, but further studies are needed to explore the mechanism of used products.

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