Studia Universitatis "Vasile Goldiş", Seria Ştiinţele Vieţii
Vol. 21, issue 4, 2011, pp. 761-765

NUTRITIONAL ASPECTS OF ORGANIC APPLE GROWING IN EAST HUNGARY

Péter Tamás Nagy[1*], Marianna Sipos[1], József Nyéki[2], Zoltán Szabó[2]
[1] Department of Agricultural Chemistry and Soil Science, Centre of Agricultural and Applied Economic Sciences, University of Debrecen, Hungary
[2] Institute for Extension and Development, Centre of Agricultural and Applied Economic Sciences, University of Debrecen, Hungary

ABSTRACT
Nowadays, there is an increasing interest in environmental friendly growing systems and attention has also been paid to the environmental impacts of fertilizations. Most frequented environmentally-benign fruit production systems is the organic system.
Numerous studies have published about phytotechnique and plant protection of organic growing but considerably less information is available about the soil, leaf nutrient status and fruit quality of organic apple orchards.
In this study, the nutrient status of apple cultivars in organic production system was investigated to establish the nutritional conditions of ecological fruit growing.
Soil, leaf and fruit analysis was used to realize the effect of this environmental sound production system on environment and fruit quality.
Keywords: organic growing, apple, nutritional management

INTRODUCTION

Worldwide demand for organic food products continues to expand rapidly, because the consumer demand for organically grown produce has increased dramatically over the past decade, most likely because of the perceived benefits to the environment and human health. Accordingly in recent years consumers demand is continuously increasing in Hungary as well. More and more consumers are thus prepared to pay premium prices for organic fruits thanks to the perception that organic products are safe, clean, more nutritious, healthy better-tasting and environmentally friendlier than conventional fruits. It also means that nowadays there is an increasing interest in environmental friendly growing systems and attention has also been paid to the environmental impacts of natural and artificial fertilizations in fruit growing.

A major component of organic production is providing organic sources of nutrients to promote plant growth as well as sustain soil quality. Organic **nutrition** of plants can present opportunities and challenges to the grower (Rosen and Allan, 2007).

Contributing to the increasing consumer demand for healthier and more environmentally sustainable agricultural products, there has been a great expansion in the number of growers and the total land area utilizing organic farm management systems in apple (*Malus domestica* Borkh.) orchards around the world.

Moreover, organic production system strives towards sustainability by minimizing environmental degradation and improving soil quality, while maximizing productivity as well as economic returns (Reganold et al., 2001).

Organic agriculture has gained international attention and the number of organic farms and the area of organic fruit production has been increased starting the nineties mostly in USA (Granatstein, 2000).

In other countries, particularly New Zealand and many European Union (EU) member-states, integrated farm management has become the standard agricultural practice, while conventional management is largely being phased out, with the belief that an integrated agricultural system represents the middle ground between the constraints of certified organic production and the negative impacts of conventional agriculture (Sansavini, 1997; Morris and Winter, 1999).

According to increasing costumer demand, efforts of healthy lifestyle within the last decade there have been a number of excellent reviews about contrasting organic with integrated or conventionally grown fruits for quality claims (Lester, 2006).

I think a common thread to compare these growing systems is the huge variability in the available data. In most cases, differences in location, climatic conditions, fruit nutrition, water management, pest practices, varieties, fruit maturity and harvest dates, pre- and postharvest handling can individually and collectively contribute to the observed variability and opposing conclusions.

In spite of the enormous number of publication, there are only few publications about nutritional aspects of organic orchard management.

Therefore, the purpose of this study was to measure the effects of organic and integrated apple production systems on fruit quality among Hungarian conditions.

Correspondence: *Péter Tamás Nagy, University of Debrecen, Faculty of Agricultural and Food Sciences and Environmental Management, Department of Agricultural Chemistry and Soil Science, Centre of Agricultural and Applied Economic Sciences, Debrecen, Hungary, Tel. +36-(52)-508444, Fax. +36-(52)-413385, email: nagypt @agr.unideb.hu*

MATERIAL AND METHODS

Characteristics of examined apple orchard

The study was performed at the orchard Fruit Research Station (University of Debrecen), at Debrecen-Pallag during 2002-2004. The 1 ha orchard was planted in 1997 with 39 apple cultivars, grafted on M26 rootstock. Spacing between and within rows was 4 x 1.5 m. Cultivars were planted in 7-tree plots and replicated three times in organic management system, which consists of 8 rows, labelled from A to L per line. Selected seven cultivars (cv. 'Jonagold', 'Mutsu', 'Idared', 'Red Elstar', 'Egri piros', 'Remo' 'Reka') were positioned by randomize way.

Only organic manuring was used in the organic orchard part. Stable manure, 30 t ha^{-1} were applied to the soil in 2001 and 2003.

Soil sampling

Soil was sampled from each 7-tree plot of examined apple cultivars from both the integrated and the organic orchard blocks. Three samples were taken from each plot, one from the middle and one from both edges of the plots by leaving 1 m at both sides. As the root system was most intense in the upper layer of the soil, soil samples were taken from 0-20 cm layers 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). Sampling was performed at the beginning and the end of the vegetation period on 16 April and 23 October and 29 April and 16 October in 2002 and 2003, respectively.

Sampling was performed at the end of the vegetation period, on 16 October in 2008.

Soil sample as an untreated control were also taken from the neighbouring arable field.

Quantification of soil parameters

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. Soil pH was determined from soil solution made by 0.01 M $CaCl_2$. Plasticity index (K_A) and humus content was measured according to Hungarian guideline (MSZ 20135:1999). Nitrogen forms of each soil sample were quantified according to Houba et al., 1986. Briefly, 5 g soil in a 50-ml 0.01 M $CaCl_2$ extractant was shaken for 2 hrs and then NO_3^--N, $NH4^+$-N, organic-N and total soluble-N were determined by the CFA method. For extracting the available phosphorus and potassium content of soils, ammonium-lactate solution (so called AL extractant) was used, then the amount of phosphorus was quantified colorimetrically with the phospomolybdovanadate method (MSZ 20135:1999) using a spectrophotometer (Metertech VIS SP-850 Plus; Metertech Inc., Taipei, Taiwan). Potassium was quantified by flame atom emission spectrophotometry method (MSZ 20135:1999), using an Unicam SP90B Series 2 Atomic Absorption/ Emission Spectrophotometer (PYE Unicam, England). For determining Ca, Mg, Mn, Cu and Zn contents of soil Lakanen-Erviö solution (LE) was used (Lakanen Erviö, 1971). Soil Ca, Mg, Mn, Cu and Zn contents were quantified by flame atomic absorption spectrophotometry using a SpectrAA-10 Plus spectrophotometer (Varian Australia Pty Ltd. Mulgrave, Australia) (MSZ 20135:1999).

Plant sampling

The same seleted cultivars form the same 7-tree plots were used for plant sampling as for soil sampling. Leaves were taken from all trees of each 7-tree plot at the stage of full blooming and later at the standard sampling time (second half of July). At each sampling date, 8-10 healthy leaves were taken from the mid-third portion of extension shoots current year were collected in each selected tree, following the international and Hungarian plant sampling guidelines for fruit orchards (Stiles and Reid, 1966; MI-08 0468-81).

Quantification of leaf samples

Leaf samples were dried firstly outdoors in an airy place then in a well-ventilated drying oven for 6 hrs at 70 °C, the whole sampled material was finely grounded and homogenized. Samples were then stored in paper bags in a dark and dry place until use.

Nitrogen content of leaves was determined from homogenized samples directly using the dry combustion method according to Nagy (2000) using an Elementar Vario EL analyser (Elementar Analysensysteme GmbH, Hanau, Germany). For determining phosphorus and potassium contents of leaves, first homogenized leaf samples (0.5 g each sample) were digested with cc. 5 ml H_2SO_4 and 5 ml H_2O_2 in a heating block digestor, at 220 °C for 2 hrs. Then phosphorus was quantified colorimetrically with the phospomolybdovanadate method using a spectrophotometer (Metertech VIS SP-850 Plus; Metertech Inc., Taipei, Taiwan).

Leaf K was determined by flame atom emission spectrophotometry and Ca, Mg, Mn, Cu and Zn contents of leaves were quantified by flame atomic absorption method as described for soil samples.

Qualification of fruit samples

At ripening stage from each studied cultivars 100 medium-sized apples was used for harvest measurements.

For consuming quality of fruits the following parameters were measured:

Diameter (mm) was measured by digital calliper.

Weight (g) was measured by analytical scale with 0,0001g punctuality.

Firmness (N/cm^2) was measured by hand penetrometer (Bishop). Dry matter (%) was measured by analytical scale with 0,0001g punctuality. Vitamin C (mg/100g fresh weight) in fruit was determined by HPLC. For determination Spherisorb ODS C18 (15×4,6, 5 μm) column was used (eluent was: 0.01%-os K_2SO_4 (pH=2.6); flow rate was: 1 ml/min) and UV-VID DAD detector with wavelength at 245 nm for identification.

Health (%) manually selected and controlled healthy fruits from 100 fruits.

RESULTS AND DISCUSSION

Results of soil examination

Orchard soil type was brown forest soil with alternated layer of clay ("Kovárvány"[1*]), being relatively poor in colloids, macronutrients and humus content (Table 1).

The plasticity index according to Arany (K_A) was 28. Total carbon and nitrogen content was 0.34 and 0.043 % (dm.) Salinity of soil was approx. 0.002%. The pH of soil was slightly acidic.

Table 1.Soil analytical results of examined organic orchard part (2002-2004, average)

K_A*	28
pH (0,01 M $CaCl_2$)	5.13
Humus (%)	0.75
NO_3^--N (0,01 M $CaCl_2$) (mg/kg)	1.00
NH_4^+-N (0,01 M $CaCl_2$) (mg/kg)	0.81
Organic N (0,01 M $CaCl_2$) (mg/kg)	2.90
PO_4^{3-} (0,01 M $CaCl_2$) (mg/kg)	4.76
K (0,01 M $CaCl_2$) (mg/kg)	168
Ca (LE) (mg/kg)	451
Mg (LE) (mg/kg)	87.4
Mn (LE) (mg/kg)	62.3
Cu (LE) (mg/kg)	3.48
Zn (LE) (mg/kg)	1.78

* Plasticity index according to Arany

Humus content and nitrogen forms, like nitrate nitrogen, ammonium nitrogen and soluble organic nitrogen in the soil were low, which was accordance with the results of yields. Significant amount of easily soluble organic nitrogen fraction was pointed out that organic production can be use in sandy soils provided that the efficiency of nutrients should be increased by improving soil properties.

Easily soluble and available phosphorus and potassium content of soil were low also due to the soil properties (Table 1). Micronutrient contents were very low in the soil of organic orchard except copper. This is probably due to more frequent copper uses (as a fungicide) in an organic orchard than in integrated one.

Our data indicated that highly significant differences between the two management systems ($P < 0.001$) for magnesium, copper, and zinc; while significant differences between the two management systems was at $P = 0.007$ for calcium. Years had no significant effect for any soil elements and manganese data indicated no significant differences among years, management systems.

Results obtained indicated that seasonal variability of available elements in the soil was high in the organic orchard (data not shown). The obtained data on micronutrient contents correspond to the values characteristic to sandy soil with low humus content and pH value.

Soil analytical results corresponded to the nutrient maintaining of organic fruit production. Data obtained pointed out that organic farming under unfavourable conditions could not based on simply organic fertilization. Required yield can be received only soil improving nutritional management.

Results of leaf examination

Based on leaf diagnostic results established that studied growing ways not affected the dynamics of macro and microelement uptake of examined seven cultivars (data not shown).

Nitrogen and potassium contents of leaves were slightly lower than optimal values (Table 2).

Whereas leaf phosphorus, calcium and magnesium contents were near optimal.

Sulphur and copper content of leaves was in the 'optimal' range of nutrient supply category which can be explained by the relatively high Cu content of soil follows from the frequent use of copper sprays ($CuSO_4$) against diseases and pests (Holb et al., 2009).

Table 2. Nutrient contents in apple leaves *(Pallag, 2002-2004, averages of cultivars at standard sampling time)*

Nutrient content	*Organic*
N (%)	2.14
P (%)	0.20
K (%)	1.14
Ca (%)	1.46
Mg (%)	0.41
S (%)	0.21
Mn (mg/kg)	73.12
Zn (mg/kg)	23.23
Cu (mg/kg)	6.88

Beside absolute element concentrations binary ratios of them were also investigated. Our assumption is that these ratios can provide a better indication of nutritional status than conventional sufficiency range approaches. It has been suggested that using these ratios minimize the effects of dilution or concentration due to dry matter and age factors and better evaluates possible nutritional interactions. The most frequently used ratios

1 * „Kovárvány" layer: is a clayey silicate strip with high humus and ferro content.

(N/K, N/P, N/Ca, K/ Ca, K/Mg, Ca/Mg and Cu/Zn/Mn) were calculated (Table 3.).

Nutrient ratios were sometimes unfavourable in organic orchard, which pointed out the balanced and harmonic nutrient supply conditions in this orchard part (Table 3.).

Direct evidence was found that the applied plant protection practice have an effect on nutrient uptake and following of this the ratio of nutrient in leaves.

Due to the higher leaf Cu content in organic apple leaves, the Cu:Zn:Mn triple ratio was close to the optimal value.

Table 3. Nutrient ratios in apple leaf
(Pallag, 2002-2004, averages of cultivars at standard sampling time)

Nutrient ratios	*Organic*	*Optimal*
N/K	2.01	1.76
N/P	11.20	14.40
N/Ca	1.56	1.53
K/Ca	0.79	0.87
K/Mg	2.80	3.90
Ca/Mg	3.62	4.50
Cu/Zn/Mn	~1:3:11	~1:3:10

Results of fruit examination

Studied fruit qualifying parameters were shown in Table 4.- 5.

Table 4. Fruit qualifying parameters I. (means of three-year)

System	Cultivar	Diameter (mm)	Weight (g)	Firmness (N/cm²)
Organic	Jonagold	79.57	203.4	72.11
	Mutsu	82.54	223.0	64.42
	Idared	80.76	162.1	59.70
	Red Elstar	76.31	163.3	74.31
	Egri Piros	70.39	153.4	55.60
	Reka	70.71	133.6	67.42
	Remo	65.40	126.9	69.83
	Mean	*75,10*	*166,53*	*66,20*
	SD	*6,38*	*35,13*	*6,75*
	$LSD_{5\%}$	*4,73*	*26,03*	*5,00*

Diameter data showed that the size of apples strongly depended on cultivars and organic apples were larger than integrated ones. It can be explained by fruit loaded of trees. Few but high sized fruits are got in the organic orchard.

Obtained data of fruit weight confirmed this statement. Moreover, the effect of year and species strongly affected the apple diameter, size and weight. Measured data of firmness were good agreement in data of diameter and weight. Larger fruits have lower values of firmness due to the structure of fruit flesh.

Table 5. Fruit qualifying parameters II. (means of three-year)

System	Cultivar	Dry matter (%)	Vitamin C (mg/100g fresh weight)	Health (%)
Organic	Jonagold	14.62	5.64	44.9
	Mutsu	14.92	9.16	57.4
	Idared	13.83	6.34	60.1
	Red Elstar	17.29	5.99	49.7
	Egri Piros	12.87	5.64	49.6
	Reka	15.75	6.34	65.9
	Remo	17.10	7.75	84.2
	Mean	*15.20*	*6.69*	*58.83*
	SD	*1.63*	*1.30*	*13.29*
	$LSD_{5\%}$	*1.21*	*0.96*	*9.85*

Dry matter content of apples varied between 12.87 and 17.29 in organic apples according to cultivars. Values were affected by years (data not shown) and cultivars. From results it was evident that the dry matter content of apples affected by production system.

Vitamin C content of apples was stronger affected by species and years than production system. Significant differences found in apple total vitamin C content among cultivars. Moreover, our results confirmed earlier results (Weibel et al., 2000) whereas did not find significant differences in apple vitamin C content between the production systems.

Healthy fruits number strongly affected by years, cultivars and production systems also (Table 2.). Among organic conditions approximately 59% of apples were healthy.

CONCLUSIONS

In conclusion, based on our results obtained leaf analytical results depended on cultivars. But the effect of production system was inconsistent sometimes.

Our results suggested that mobility and available of nutrients in studied organic orchard where only natural nutrient sources are allowed was hindered. This study also demonstrated that the lower nutrient content of soil and also the generally poorer uptake of N, P and K nutrients in organic apple orchards resulted in higher production risk in the organic apple orchards compared with conventionally or integrated ones. This indicates that a more efficient nutrient supply is needed for the organic management system to achieve good quality and profitable yield.

Moreover, from results it is very hazardous to state that organic fruits provide greater health benefits than integrated or conventionally ones but we suggest that these comparison studies should be expand. Similar studies have to carry out in more and more orchards, among different conditions (climatic, orchard density, rootstocks, nutritional management etc.).

The real benefit of these comparisons is that they will recognize and establish the production input weakness and strengths that affect nutrition, so that changes can be made to improve both organic and integrated fruit growing produce.

ACKNOWLEDGEMENTS

Thanks to OM-00042/2008 project for financial assistance. Special thanks Mr. István Gonda and Mr. Imre Holb for technical and professional services and advices.

REFERENCES

Granatstein, D. (2000): Tree fruit production with organic farming methods. http://*organic.tfrec.wsu.edu/OrganicIFP/OrganicFruitProduction/OrganicMgt.pdf*

Holb I.J, Gonda I, Vago I, Nagy P T (2009): Seasonal Dynamics of Nitrogen, Phosphorus, and Potassium Contents of Leaf and Soil in Environmental Friendly Apple Orchards. C**ommunications in soil science and plant analysis 40, 1-6: Sp. Iss. SI: 694-705.**

Jackson, M.L. (1958): Soil Chemical Analysis; Prentice Hall Inc.: Englewood Cliffs, UK, 1958; 546 pp.

Lester, G. E. (2006): Organic versus conventionally grown produce:quality differences, and guidelines for comparison studies. Hortscience 41 (2): 296-299.

MI-08 0468-81: *Plant analyses. Orchards. Sampling, preparation of samples, storing of samples.* Hungarian Standards Institution. Ministry of Agriculture. Budapest (in Hungarian)

Morris, C., Winter, M., (1999): Integrated farming systems: the third way for European agriculture. Land Use Pol. 16: 193-205.

MSZ-08 0202-77: Sampling soils for management purposes in agriculture. Hungarian Standards Institution. Ministry of Agriculture. Budapest (in Hungarian)

MSZ 20135:1999: *Determination of the soluble nutrient element content of the soil*. Hungarian Standards Institution. Budapest (in Hungarian).

Nagy, P.T. (2000): Application of an element analyser for soil and plant analyses (dry combustion method). Agrokémia és Talajtan 49: 521-534. (in Hungarian with English summary)

Rosen C. J., D. L. Allan (2007): Exploring the benefits of organic nutrient sources for crop production and soil quality. HortTechnology 17:422-430.

Reganold, J.P., J.D. Glover, P.K. Andrews, H.R. Hinman (2001): Sustainability of three apple production systems. Nature 410:926-929.

Sansavini, S., (1997): Integrated fruit production in Europe: research and strategies for a sustainable industry. Sci. Hortic. 68: 25-36.

Stiles, W.C., Reid, W.S. (1966): Orchard Nutrition Management; Cornell Cooperative Extension: Geneva, NY, Information Bull. 219.

Weibel, F. P., Häseli, A., Schmid, O., Willer, H. (2004): Present status of organic fruit growing in Europe. Acta Hort. 638:375-385.