International Journal of Horticultural Science 2010, 16 (3): 69–74.
Agroinform Publishing House, Budapest, Printed in Hungary
ISSN 1585-0404

Nutritional aspects of producing fruits organically

Nagy, P. T.[1], Nyéki, J.[2], Szabó, Z.[2]

[1]*Department of Agricultural Chemistry and Soil Science, University of Debrecen, Centre of Agricultural and Applied Economic Sciences, Faculty of Agricultural and Food Sciences and Environmental Management, Böszörményi st. 138. Debrecen, H-4032, Hungary nagypt@agr.unideb.hu*
[2]*Institute for Research and Development, University of Debrecen, Centre of Agricultural and Applied Economic Sciences, Debrecen, Hungary*

Summary: Recent interest to avoid use of agrochemicals in fruit growing to safeguard environmental and human health has stimulated interest in organic fruit production (OFP) all over the world. Organic production requires a holistic approach to agricultural ecosystem management. Because of the perennial nature of orchards, this is not a great departure from conventional orchard management, except that corrective techniques are limited primarily to naturally derived materials. Organic mineral nutrition management hinges on two principles: 1) practices that lead to the build up and maintenance of soil that is biologically active and high in organic matter; 2) supplementing the mineral nutrients provided by the soil with fertilizers from approved sources. Organic orchards should be sited on land with superior soils and preplant soil preparation to increase organic matter and correct any sub-optimal soil characteristics. For successful organic fruit growing the following statement should be considered: Weed management is critical to reduce competition for nutrients and water. Soil and leaf analysis provide the basis for correcting mineral nutrient deficiencies or imbalances in organic production. It may be necessary to use a number of strategies to supply mineral nutrients over the life of the orchard. The slower, natural methods applied require a management approach that is simultaneously patient and dynamic.

Key words: nutritional management, nutrient diseases, organic growing

Introduction

Public concerns about food safety and the environment have stimulated an increasing interest in producing fruits organically. Organic production is widely embraced as a means to better health and environmental quality because of total avoidance of synthetic fertilizers and pesticides in growing. This is not to imply that organic pesticide or fertilizer sources are completely safe and thus do not require precautions governing their use in agriculture and food production (*Sauls* et al., 2005).

Although there are differences in the standards between various organic bodies and across national boundaries, these clearly defined standards represent a foundation on which debate can be based. There is no real dispute that sustainable agriculture and organic farming are closely related terms (*Rigby & Cáderes*, 2001, *Holb,* 2005).

The principle aims of organic production and processing to:

- produce food of high quality in suffcient quantity,
- interact in a constructive and life-enhancing way with natural systems and cycles,
- consider the wider social and ecological impact of the organic production and processing system,
- encourage and enhance biological cycles within the farming system, involving micro-organisms, soil flora and fauna, plants and animals,
- develop a valuable and sustainable aquatic ecosystem,
- maintain and increase long term fertility of soils,
- maintain the genetic diversity of the production system and its surroundings, including the protection of plant and wildlife habitats,
- promote the healthy use and proper care of water, water resources and all life therein,
- use, as far as possible, renewable resources in locally organised production systems,
- give all livestock conditions of life with due consideration for the basic aspects of their innate behaviour,
- minimise all forms of pollution,
- process organic products using renewable resources,
- produce fully biodegradable organic products.

Source: IFOAM, 1998.

This publication does not debate the issues of environmental quality or food safety, nor does it discuss the controversies of organic versus commercial production methodologies. Rather, this publication describes nutrition principles and practices which can be used in organic fruit production. Moreover, it summarizes the major limitations of fertilization and points out the potential nutritional disorders in organic fruit growing.

Horticultural principles and practices

Naturally, fruit nutrition is a part of horticultural technology (principles and practices) which is strong connection with other parts (e.g. plant protection, pruning,

Table 1. Differences in nutritional management among growing systems

	Traditional	Integrated	Organic
Fertilization			
	Artificial fertilizers	Artificial fertilizers and manures	Organic manures*
N fertilization	Economic optimum Correct to the maximum yield	Extract by plants Low doses, (regarding to the environmental consideration) Site orientation	Extract by plants Correct to the extraction by plants (highly regarding to the environmental consideration) Site orientation
P and K fertilization	Extract by plants Quick soil filling with nutrients Excessive nutrient supply Annual	Extract by plants Slow soil filling with nutrients Medium nutrient supply Not always annual	Extract by plants Correct to the extraction by plants Stable soil productivity
Micronutrient fertilization	Not charachteristic*	According to the plant demands	Organic manuring
Green fertilization	Grass	Grass and trifolium mixture**	Grass and trifolium mixture**
Manuring	Not characteristic	Frequently	Alone
Biodynamic product	–	–	Several
Irrigation	Legal	Legal	Legal
Philosophy of fertilization			
Yield level	Maximum	Profitable	Incomplete
Target area of fertilization	Soil	Plant	Plant
Doses	Excessive over fertilization	Slight over fertilization	Fertilization adjusted to the soil productivity
Nutrient supply values	Uniform	Depend on species of plant	Depend on species of plant
Nutrient contents (% or mg/kg d.m.)	High Independent of yield	Lower Depend on yield	Lower Depend on yield
Consideration of parameters of growing site	Not specific soil fertilizers	Specific soil fertilizers	Strict regulations according to the site

Legend: *– with rare exceptions; **– mainly
Source: own edition based on *Füleky et al*. (1999)

thinning, irrigation) and essential to the growth, development and fruiting of healthy, vigorous orchard trees.

Although mineral nutrition is an important component of organic orchard management, there are other factors (site and plant selection, spacing, pruning, irrigation, fertilization, weed control) that are also critical to the success of an organic orchard to reduce or eliminate the plant stresses which can often catalyze increased nutritional disease.

Moreover there are some, but very important differences in nutrient management among traditional (conventionally), integrated and organic (ecological) systems (*Soltész*, 1997).

Main differences are showed in *table 1*.

Organic regulations

Commission Regulation (EC) No. 889/2008 of 5 September 2008 laying down detailed rules for the implementation of Council Regulation (EC) No. 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control.

Organic production is an overall system of farm management and food production that combines best environmental practices, a high level of biodiversity and the preservation of natural resources. Organic plant production involves varied cultivation practices and limited use of fertilisers and conditioners of low solubility, therefore these practices should be specified. In particular, conditions for the use of certain non-synthetic products should be laid down.

Site selection & preparation

Orchard sites are typically selected for climatic conditions, slope, elevation and location. Orchards require fertile soils having good surface and internal drainage, ability to nutrient supply and sufficient nutrient resources.

Fruit trees, like most crops, respond to good soil with vigor and productivity. Trees can successfully produce economic yields on hillsides, rocky soils, and other sites not suitable for frequent tillage. Look carefully at your site and take stock of its soil, slope, and aspect, water infiltration and drainage, frost patterns, maximum and minimum temperatures, length of growing season, distribution of annual precipitation, availability of water for irrigation, proximity of the water table, and wind and air circulation patterns. Most of these are beyond your control, and your planting plan must suit the natural conditions of the site. While growers may be able to improve the soil over time, they cannot change the subsoil layers, influence the prevailing wind, or modify temperatures to any significant extent (*Kuepper* et al., 2004).

All the factors of site suitability for conventional fruit plantings apply – even more so – to organic operations. While conventional growers may fall back on chemical fertilizers and pesticides to compensate for some poor site decisions, organic growers cannot. Good drainage and air circulation are essential for disease control.

An assessment of physical and environmental factors will help the grower determine whether a crop can be grown easily, marginally, or not at all (*Kuepper* et al., 2004).

According it, the primary component of organic mineral nutrient management is building and maintaining a soil that is biologically active and high in organic matter.

In spite of these soil characteristics of a prospective orchard site are often a secondary consideration of growers nevertheless selecting an orchard site with good soil properties is essential when planning an organic plantation.

Changing soil characteristics is a long-term process and correcting soil problems in an established orchard is very difficult and costly. Furthermore, there are only few rapid technical rescue options available to the organic grower to achieve it. Starting out with soil that has adequate depth, drainage, texture, water and nutrient holding capacity, pH and mineral nutrient content is always advisable, but with organic production, it is essential.

So it is very important to have any information about soil of our orchard before planting. Soil analysis is very useful for determining lime requirement and mineral availability in the soil before orchard establishment. Once an appropriate site has been selected, pre-plant soil preparations to correct any deficiencies, and to increase organic matter and biodiversity of the soil begin. Ideally, two years before planting the orchard, site improvement is used, based on soil testing.

For existing orchards, it provides information necessary for interpreting leaf analysis results and modifying fertilization programs. A soil nutrient analysis should be performed before planting a new orchard and every 2 to 3 years after orchard establishment.

Fruits may be grown on a wide range of soil types, from coarse-textured sandy or gravelly soils to fine-textured silty clay or clay loams. Alluvial lands will normally be the most fertile soils which more plentiful and good for specific cultivars (grapevine, apricot). Extremely sandy soils are quite good for orchards, but are normally very low in fertility and organic matter (e.g. Somogy and Nyírség region). Orchards for organic fruit production should be planted on only the most fertile soils available.

Soil pH in Hungary ranges from strongly acidic to slightly alkaline. Choices of fruits are limited by the soil condition. Sites, where the soil pH low (4.5) and high (8.7>) are unsuitable to fruit growing. Alkaline soils may result in micronutrient deficiencies, particularly in stone fruits, pome fruits and berries. Conversely, some crops, such as apple, thrive in slightly acidic soils as well.

Liming to increase soil pH and measures to increase organic matter and mineral nutrients are best addressed prior to planting. In this way lime and organic matter can be incorporated deeply into the soil with cultivation so that soil properties are optimized throughout the root zone. This is also the time to tile poorly drained parts of the site and eliminate existing weeds.

Lime should be added to raise the soil pH.

Besides soil analysis, drainage has essential role in nutrition management of plantations. Surface drainage refers to surface runoff to avoid standing water after heavy rains, while internal drainage is the ability for water to percolate downward through the soil to preclude saturation of the root zone and to remove accumulated salts.

Soil Fertility Management

A healthy soil is one of the fundamental goals of organic farming. Thus, soil fertility receives much attention on most organic farms (*Granatstein*, 2000b).

Fruit crops include various perennial plant types like shallow-rooted herbaceous berries, species of shrubs and vines and deep-rooted deciduous trees. Properties of plant physiology should be regard to soil fertilization. Root length, distribution and nutrient demand are essential for adequate nutrition management.

Soil amendments must contribute to overall soil improvement as well as improve growth and production. Possibility of soil improvement in organic producing is more limited than integrated growing system. As all over the world in Hungary the usable products for soil improvement strictly regulated and limited.

Manures, tillage of residues, compost, green manure crops and nitrogen-fixing intercrops are most frequented and adapted to organic orchard system. Soil improvement is very gradual over time, usually requiring many seasons of intensive management to improve and maintain soil fertility.

Organic growers in the USA consider soil organic matter (SOM) as the foundation for their farms. SOM provides a reservoir of nutrients, which are released slowly over time through mineralization. SOM can be a major contributor to the cation exchange capacity of a soil. SOM also provides the food base for soil organisms, both micro and macro. Soil physical properties, such as structure, aggregate stability, and water holding capacity, all improve with increasing SOM (*Granatstein*, 2000b).

Organic fertilizers are not normally well-balanced in major nutrient content, most being disproportionately high in one nutrient. Consequently, a variety of organic materials may be required to meet the nutritional needs of fruit crops. Nitrogen may be the most commonly limiting fertilizer element in organic farming.

It is essential to ascertain the nutrient content of the fertilizer being used so as to guide relative application rates. In addition, soil test samples should be collected and analyzed each summer to determine the status of essential elements in the soil. Although the soil test measures the available nutrients, tissue analysis should also be performed each summer to determine the actual nutrient status of the trees. Thus, the nutrient content of the fertilizer(s), soil and tree will provide an accurate nutritional program for the orchard to assure optimum growth and production.

Nitrogen. Nitrogen is readily leached from the root zone and is the most likely nutrient to be limiting to growth. Several authors pointed out that the limited N availability causes problems for organic growers (*Holb,* 2002, 2006; *Rosen & Allen*, 2007; *Peryera & Dunley*, 2008; *Holb* et al., 2009; *Nagy* et al., 2009). Many of the trees in the organic orchards showed strong visual symptoms of nitrogen (N) deficiency, including small pale leaves, poor shoot extension, and reddish bark. Nitrogen deficiencies are common in the first years of organic management (*Granatstein*, 2000b).

Leaf mineral analyses in organic apple orchards (Pallag, Újfehértó) in 2002–04 and 2008- showed that the organic had consistently lower leaf N concentrations than did the integrated and conventionally managed trees. Low leaf N in the organic orchards is associated with weed competition and inadequate N availability from manures and composts. High leaf N in the integrated orchards is consistent with application of ammonium- and urea-containing fertilizers that supply readily available N and consequent soil acidification due to nitrification of these fertilizers (*Holb* et al., 2009; *Nagy* et al., 2009).

Furthermore, limited N availability and varied supply of other nutrients from organic sources may contribute to the differences sometimes observed in dry matter content, tissue NO_3 and mineral concentration, vitamin C and other phytochemicals, and taste (*Rosen & Allen*, 2007).

Common sources of supplemental nitrogen include various animal manures, green manures, cover crops, nitrogen-fixing intercrops and microbes and compost. From these the animal manures the most important because for centuries farmers have spread animal manures on the land to increase soil productivity. Manure nitrogen is in both unstable and stable organic forms, and either must be decomposed by microorganism to inorganic nitrogen before it can be used by trees. The organic N sources provide a combination of readily available N (ammonium and nitrate) and slow-release organic N.

Therefore it is essential to use mature animal manures and the conditions of mineralization in soil is favourable. Soil conditions (pH, water capacity, humus content, temperature etc.) determine effectiveness of animal manures.

Vegetable meals, animal hides, fish emulsions, blood meal or meals made of other animal by-products are used in organic product. The list of usable products is regulated by order of 12. and 16. sections of 834/2007/EC and 3. section of 889/2008/EC (1. suppl.).

It is very important when making fertilizer calculations based on nitrogen, growers need to credit the estimated contributions made by legume cover crops and/or mulches. A cover crop of subterranean clover, properly fertilized and inoculated, can fix from 50 to 100 kilograms of nitrogen per acre annually in a "living mulch" system. Other legume cover crops may produce as much or even more, depending on things such as planting date, weather, and mowing (*Kuepper* et al., 2004).

Phosphorous. Although the uptake of phosphorous is determined several factors (pH, clay content) rarely limiting in Hungarian soils. Natural phosphorous sources are available for P fertilization. Hard-rock, soft-rock and colloidal phosphate, bonemeal and guano are common organic sources of phosphorous. Moreover, food-grade orthophosphoric acid, fish emulsions, soap phosphates, basic slag and at alkaline soils aluminium-calcium-phosphate are also considered for organic production.

Consider the overall fertilizer analysis; basing application rates solely on nitrogen content can cause problems when the fertilizers are not balanced to meet the needs of the fruit crop. For example, repeated use of poultry manure, which is very high in phosphate, can lead to zinc deficiency in the crop. These problems can be avoided by regularly monitoring and adjusting fertilizer selection and rates.

Potassium. Although the adequate potassium (K) supply is essential for organic fruit production, the K balance on many farms is negative, where more K is removed in harvested crops than is returned to the soil (*Mikkelsen*, 2007). Similarly, as potassium demand of fruits is high, potassium is often limiting in Hungarian soils also, where the soil is acidic and sandy or has high clay content. Although various organic certification agencies have different regulations governing allowable sources of K, the behaviour of soil K is largely governed by its solubility. The slow release of K from soil minerals is generally insufficient to meet the peak nutrient demand of high-yielding crops, but they can contribute to the long-term improvement of soil fertility. There are many excellent K sources allowed for organic fruit production, including soluble minerals such as langbeinite, sylvinite, and potassium sulfate. Potassium sources such as wood ash, feldspar, greensand, seaweed and recycled potassium-rich organic matter can also supply K but require special management because of their low nutrient content, their effect on soil pH, low solubility, or bulky nature. The concentration of K in manures and composts is highly variable, but it is generally quite soluble and available for plant uptake. Some rock minerals may supply a portion of the K requirement of plants, but many are too insoluble to be of practical significance (*Mikkelsen*, 2007).

Calcium. Calcium deficiency in organic fruit orchards in Hungary (Nyírség region) is very commonly problem. Finely grounded limestone and dolomite should be used widely on acidic soils. Natural chalk, marl and beet potash sludge are also usable for organic fruit production. Gypsum, kiln dust, calcified seaweed, corn calcium and calcium oxide are calcium sources useful on acidic or alkaline soils.

Bitter pit of apple is a nutritional problem reported by a number of organic growers (Photo 2.). Thus, they monitor Ca levels and especially the ratio of Ca to N. Some growers subscribe to the cation balance theory, where they want to achieve a base saturation of 65-70% Ca, 10-15% Mg, and 2-5% K. This concept is controversial among soils researchers, and little work has been done on tree fruits (*Granatstein*, 2000a). Furthermore, according to the regulation, calcium chloride can be used

Calcium (Ca) deficiency is often associated with low soil pH, thus lime is the primary material for maintaining soil Ca. Mined gypsum may be applied when it is desired to increase soil Ca without raising pH. Bitter pit is an apple disorder associated with low fruit Ca (see Photo 2.). Nutritional imbalances such as excessive N, K, or Mg, and deficient B, as well as non-nutritional factors, such as variety, excessive fruit size/low crop load, or drought can contribute to low fruit Ca, even when soil Ca is adequate. In such instances, foliar sprays of calcium chloride ($CaCl_2$) are permitted when calcium deficiency symptoms have appeared on leaves to reduce the incidence of bitter pit. Under European (889/2008/EC) and USA regulations, the $CaCl_2$ used in organic orchards must be extracted from brine (*Schupp*, 2004).

Magnesium. Magnesium is rarely deficient in most tree crops in Hungary. Magnesium deficiency appears mostly in the middle of summer, after intensive shoot growing period following a longer droughty period. Direct magnesium fertilization is very rare in Hungary. It may be found in Somogy and Nyírség region where leached, acidic forest soils are found. For supplemental magnesium fertilization in organic orchards similar natural sources can be used than in integrated management. Mostly dolomite (not for use in alkaline soils), kieserite, sulfate of potash-magnesium (langbeinite) and natural magnesium sulfate (Epsom salts) is allowed as a soil amendment if there is a documented soil Mg deficiency.

Sulphur. It is unlikely that sulphur deficiencies would be observed in orchards, but elemental (mineral) sulphur is often applied to the soil in a limited attempt to lower soil pH. Gypsum and pesticides used in organic produce also contains sulphur.

Micronutrients. Micronutrient deficiencies are common in some tree crops in Hungary, including zinc in apples, cherries and peaches and iron in peaches and other stone fruits, pome fruits and blackberries growing in alkaline soils. Seaweed and wort extract, kelp meal and natural rock powders are limited sources of some micronutrients (rock phosphate and other ground minerals can be used as well). For Zn, and B, there are a number of commercial products available that are approved for organic farms. These include zinc sulfate, Solubor, gypsum, lime, and chelated nutrients.

The best way to avoid micronutrient disorders using animal and green manures regularly.

Organic manuring. Organic manure applications, like stable or chicken manure can also be beneficial for increasing organic matter and adding mineral nutrients to the soil. Horse manure should be avoided, as it is low in nutrient value relative to other animal manures. Furthermore, weed seeds often survive the inefficient digestion of a horse's gut and can contribute to the introduction of new weed species.

Animal manure must not be stockpiled prior to use, as it can cause severe problems with neighbouring residences due to both odour and flies. Manure should be tilled in promptly after spreading to incorporate it and prevent loss of N due to volatilization.

Moreover, there are several benefits of animal manuring practise. Using of manures similar advances can be realized than growth regulators and activators (see below) due to the same active ingredients.

Organic fertilizers – especially uncomposted animal manures – should be incorporated into the soil to avoid nitrogen volatilization and to comply with organic standards. Use shallow tillage to prevent damage to plant roots and to minimize the potential for soil erosion. Manures should be incorporated into the soil at least three or four months before harvest (depending on the crop type).

Growth regulators, activators and soil conditioners. Although growth regulators, activators and soil conditioners have any inconsistent impact in fruit production using them is continuously increasing all over the world. Sources that may be used include:

- seaweed extracts
- natural enzymes
- herbal preparations
- rhizobial inoculants
- nitrogen-fixing microbes
- bluegreen algae
- cellulolytic bacteria
- natural root hormones
- humates
- adjuvants.

Most of plant growth biostimulants made from beneficial bacteria (nitrogen fixing bacteria, hormone producing bacteria, phosphorus solubilizing bacteria and other living micro-organisms), humic extracts, cold water sea kelp extract, essential amino acids, vitamins, root growth stimulants and sugars.

Bacteria play an indispensable role in the sustainability of soil fertility as they fix the nitrogen of air and turn it into a form that is absorbable by plants. They also help the uptake of phosphorus and potassium of soils and they take care of the decomposition of organic substances that get into the soil (*Kincses* et al., 2008; *Kincses & Sipos*, 2008).

Furthermore, soil conditioners stimulate the life of the soil by promoting humus development it helps the soil to keep its biological balance.

Moreover they effects on the plants summarized as follows:

- make the fertilization more effective
- improve the physical-chemical state of the soil
- stimulate roots development and soil microorganisms
- increase speed of composting processes, water holding capacity and organic matter content of soil
- help in nutrient mobilization processes
- make the plants more stress-resistant.

Nutrient diseases. The most reliable means for determining whether fertilization is adequate is to combine field observations with soil or tissue testing. Poor yields, unusual coloration of leaves, early or unusual fall of leaves, deformations on fruits and leaves and poor plant growth are all clues to a possible nutritional imbalance or deficiency. On most fruit trees, slow elongation of branches often indicates a nitrogen deficiency. Purple colouring on leaves is typical phosphorous deficiency symptom. Yellow and brown stripe on the edge of leaves indicates potassium deficiency. Yellowing between the veins and pale colouration of new leaves usually means the tree is suffering an iron deficiency. Corky bark on certain apple varieties can indicate an over-availability of manganese in the soil.

External and internal cork symptoms (with brown tissue concentrated around the core) may also have a bumpy appearance and following from insufficient boron or calcium uptake (*Figures 1 and 2*).

Foliar analysis measures the nutrient content of the leaves and can identify a nutrient deficiency or excess well in advance of visible symptoms. It is more helpful than a soil test because the foliar analysis is a measure of what the plant is actually taking up, while a soil analysis only measures what is in the soil – which may or may not be available to the plant. Annual foliar analysis generally provides the best guide for adjusting supplementary nitrogen or other fertilization (*Kuepper* et al., 2004).

Figures 1. and 2.: Boron (left) and calcium (right) deficiency symptoms on apple (P. T. Nagy)

Figure 3. Iron deficiency symptom on apple shoot (P. T. Nagy)

Acknowledgements

Thanks to OM-00042/2008, OM-00265/2008 and OM-00270/2008 projects for financial assistance.

References

79/2009. (VI. 30.) FVM rendelet: A mezőgazdasági termékek és élelmiszerek ökológiai gazdálkodási követelmények szerinti tanúsításának, előállításának, forgalmazásának, jelölésének és ellenőrzésének részletes szabályairól.

Daar, S. (1987): Update: Flame weeding on European farms. The IPM Practitioner. March. p. 1.

Füleky, Gy., Rajkainé Végh, K. & Tolner, L. (1999): Tápanyag-ellátási elvek és módszerek. In: Füleky Gy. (szerk.): Tápanyag-gazdálkodás. Mezőgazda Kiadó, Budapest

Granatstein, D. (2000a): Biointensive Management of the Orchard Understory. http://organic.tfrec.wsu.edu/OrganicIFP/OrchardFloor Management/BCOrchardFloor99.pdf

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

Holb, I. (2002): A biotermesztés lehetősége a héjasoknál. In: Radócz, L. (szerk.) A héjasok növényvédelme. Szaktudás Kiadó Ház, Budapest, pp. 227–241.

Holb, I. (2005): Az ökológiai (bio-) és az integrált termesztés és növényvédelem alapelvei és kapcsolatuk. Nemzetközi (IFOAM) növényvédelmi előírások. Európai növényvédelmi előírások In: Holb, I. (szerk.) A gyümölcsösök és a szőlő ökológiai növényvédelme. Mezőgazda Kiadó, Budapest, pp. 11–28.

Holb, I.J. (2006): Effect of six sanitation treatments on leaf decomposition, ascospore production of *Venturia inaequalis* and scab incidence in integrated and organic apple orchards. European Journal of Plant Pathology. 115 (3): 293–307.

Holb, I. J, Gonda, I., Vagó, I. & Nagy, P. T. (2009): Seasonal dynamics of nitrogen, phosphorus, and potassium contents of leaf and soil in environmental friendly apple orchards. Communications in soil science and plant analysis. 40. (1–6): 694–705.

Kincses, I., Filep, T., Kremper, R. & Sipos, M. (2008): Effect of nitrogen fertilization and biofertilization on element content of parsley. Communications in soil science and plant analysis. 40. (1–6): 571–575.

Kincses, I. & Sipos, M. (2008): The effect of bacteria fertilizers on the nitrogen amount extracted by the yield of perennial ryegrass (Lolium perenne) on different soil types. „Risk Factors for Environment and Food Safety" International Symposium Oradea, Romania. Symp. Book: 121–126

Kuepper, G., Ames, G. K. & Baier A. (2004): Tree Fruits: Organic Production Overview Horticulture. Systems guide. http://attra.ncat.org/attra-pub/PDF/fruitover.pdf

Mikkelsen, R. L. (2007): Managing Potassium for Organic Crop Production. Hort Technology, 17: 455–460.

Nagy, P. T., Szabó, Z., Nyéki, J., Gonda, I. & Holb, I. (2009): Organic versus integrated apple growing: I. differences in soil and leaf parameters. Int. J. Hort. Sci., 15 (4) 57–60.

Peryea, F.J. & Dunley, J.E. (2008): Orchard management strategy influences leaf mineral element concentrations of d'Anjou pear. Acta Hort., 800: 577–582.

Rigby, D. & Cáderes, D. (2001): Organic farming and the sustainability of agricultural systems. Agricultural Systems. 68: 21–40.

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

Soltész, M. (szerk.) (1997): Integrált gyümölcstermesztés. Mezőgazda kiadó, Budapest (in Hungarian)

Sauls, J. W., Baker, M., Helmers, S., Lipe, J., Lyons, C., McEachern, G., Shreve L. & Stein, L. (2005): Producing Texas fruits and nuts organically. http://sustainable.tamu.edu/publications /organicfruit.html

Schupp (2004): Mineral Nutrient Management for Organic Fruit Production New York Fruit Quarterly, 12. (2): 31–34.