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MINERAL CONTENT OF NECTARINES FRUITS IN RELATION TO SOME FERTILIZATION PRACTICES

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Abstract

Fruits nutritional quality at the harvest moment and their storage capacity is directly or indirectly affected by multiple factors, including fertilization practices. The aim of this study was to evaluate soil organic and chemical fertilization, also foliar spray treatments on fruits mineral content of two nectarines [Prunus persica L. Batsch var. nectarina (Ait) Maxim] cultivars: Cora and Delta. The following fertilization treatments were applied: V1. Control: No fertilization; V2. Organic fertilizer in mid-May; V3 and V4 Chemical fertilizer in the first part of June; for variant 4 there were applied also two treatments with foliar fertilizer in the second part of May and early June. The experiment was carried out in 2008 at the Research and Development Fruit Growing Station Constanţa, Romania. Nectarine fruits were picked at commercial maturity stage from each tree of various replicates and mineral content was determined at the Plant Physiology Laboratory of the Faculty of Horticulture Bucharest, by using an Inductively Coupled Plasma Spectroscopy (ICP-AES IRIS INTREPID). The results were expressed in mg 100 g^{-1} fresh weight. Our preliminary results indicated a change in the fruits minerals composition in relation with the applied fertilizer, with significantly differences among the treatments. The organic fertilization and foliar sprays impact were found to be the most significant ones for all mineral elements studied in this work.

Key words: *fertilization, fruits, nectarine orchard, minerals*

INTRODUCTION

Peach and nectarine fruit [*Prunus persica* (L.) Batch] are the second most important fruit crop in the European Union after apple [18, 23].
Stone fruits contain significant levels of biologically active components with physiological and biochemical functions which benefit human health [30, 9, 17]. Generally, mineral compositions of plants show a lot of variation [8, 26], also the phytochemical content of fruit tissues is influenced by numerous pre-harvest factors (including genotype, rootstock, climatic conditions, agronomic practices and harvesting time), but also by post-harvest factors, including storage conditions and processing procedures [30]. Many studies through the world have focused on the beneficial effects of nutrient elements, especially calcium and boron on fruit quality.
So, mineral nutrients are essential for normal growth and development of plants [29]. During the time, there have made remarkable progress on the knowledge of mechanism of ions absorption, their physiological role at the cellular and molecular level, as well as those related to the fruits nutritional value [16, 26 etc.]. The relative health promoting potential is also very important, even if from the view point of bile acid binding on a dry mass basis nectarines are on the last place (bananas > peaches > pineapple > grapes > pears > apricots > nectarines) as indicated results obtained by Kahlon and Smith (2007). Recent studies are focused also on new investigation techniques, as for instance Ecological Footprint Analysis (EFA). This is an environmental accounting system, in physical unit, able to quantify the total amount of ecosystem resources required by a region or by a production process [10]. The authors presented a detailed application of EFA to an experimental trial in a commercial nectarine orchard in Piedmont (Italy). Related to different fertilization, in the manure fertilized

systems the fertilizer contribution goes from 0.9% to 1.2% of the total ecological footprint. In the mineral nutrition system the fertilizer contribution is 6.6% of the total ecological footprint. Results support the hypothesis that internal recycle and connections among different systems increasingly resulted in high system benefit and sustainability.

Fertilizer is an important tool used by the most farmers in order to boost crop yield, but the increasing of the public concern about environment aspects caused by over fertilization renew the interest on evaluating the adequate fertilization recommended on field to maintain productivity and fruit quality with less environment impact [13].

According to Olivos et al. (2012) low phosphorus and nitrogen fruit concentrations were associated with biochemical browning reactions in fruit flesh at harvest and with fruit browning during storage, signs of a shorter market life and lower consumer quality. Currently recommended leaf and fruit nutrient critical values are based only on production and do not addresses post harvest quality. In fact, recent results [27] include also proteomic analysis of peach fruit mesocarp softening and chilling injury using difference gel electrophoresis (DIGE). This technique allowed us to identify proteins that showed stage-specific changes in their accumulation pattern. Thus, comparative proteomics has proven to be a valuable tool for understanding fruit softening and post harvest behavior.

The conclusion of Kader (1999) that continue efforts aimed at developing of new genotypes with better flavor and nutritional quality in all major fruits is valuable in our country too. For nectarines, at Valu lui Traian there is The Peach National Collection, which contents 855 genotypes. Annually, the breeders selected the best genitors and made hibridations, self pollinations and clonal selections, in order to obtain new cultivars [14].

Taking into consideration the importance of trees mineral nutrition and fruit mineral level, both from the view point of nutritional quality and post harvest storage capacity, the aim of this study was to evaluate soil organic and chemical fertilization, also foliar spray treatments on fruits mineral content of two nectarines [*Prunus persica L.* Batsch var. *nectarina* (Ait) Maxim] cultivars: Cora and Delta, recommended as fresh consumption.

MATERIAL AND METHOD

The study was carried out on two nectarines [*Prunus persica* L. Batsch var. *nectarina* (Ait) Maxim] cultivars: Cora and Delta, grown in the fruit tree orchards located at Valu lui Traian, Constanţa, Romania (latitude 44°10 'longitude 28°40' and an altitude of 40-80 m). Mature trees (14-year old-) (grafted on seed propagated rootstock) spaced 4 and 3 m between and along the rows, respectively grown in semi arid conditions and irrigated regime, on calcaric chernozem (CZka), with a clay texture and a slightly alkaline pH (8.2) on the entire profile, have been used in the experiment.

To evaluate soil organic and chemical fertilization, also foliar spray treatments on fruits mineral content, the following fertilization treatments were applied: V1. Control: No fertilization; V2. Organic fertilizer/ manure (30 t ha^{-1}) in mid-May; V3 and V4 Chemical fertilizer (NPK- 15:15:15) – 0.6 kg pom^{-1}) in the first decade of June; for variant 4 there were applied also two treatments with foliar fertilizer (Murtonik – NPK- 20:20:20: and microelements) (2 kg Murtonik in 150 L water/treatment/] well bathe crown trees, in the second part of May and early June.

Fruits were harvested at commercial maturity stage at the end of June 2008. At least 30 nectarines fruits were harvested from at least four different trees for each cultivar. Samples were placed into polyethylene bags and stored at 4 °C until the analysis (analyzed after two days). Two replicates of each variety were selected and analyzed.

Dry matter content was determined in the entire nectarines fruits (peel and flesh) according to the AOAC 1990. Ash content of samples was determined at 550 C [1] After cooling the resulting white ash was dissolved in 1 mL HNO_3 conc., adjusted to a volume of 50 mL with ultra pure water obtained by using a Milli –Q system. Monoelemental containing stock solutions were used for preparing reference solution for the calibration curve, then the elemental analysis was carried out in an inductively coupled with plasma (ICP-AES) IRIS INTREPID. All determinations were carried out in triplicate and expressed as mass on a fresh weight basis. Using Statgraphics software there were compared the obtained data.

RESULTS AND DISCUSSIONS

Dry matter content of the nectarines cultivars and studied variants varied from 8.42 % of the fresh weight (Delta V4 – including foliar fertilization) to 9.92 % (Delta V2 – organic fertilizer). This parameter was not significantly different between variants. Ash content ranged from 3.44 % of the dry matter (Cora – manure fertilization) to 8.52 % (Delta - manure fertilization), with statistically significantly differences between these variants (Figure 1). These data are slightly higher as compared with those synthesized by Kahlon and Smith (2007) (3.9 % of the dry matter). Cora and Delta were licensed as the earliest in the Romanian nectarine assortment [35]. Generally, accumulation of the dry matter is also reflected into the obtained yield. In a such context, according to the multiannual data obtained at the Fruit Growing Station Constanţa, there are no significantly differences between the two cultivars (Cora 21 t ha^{-1}; Delta 22.55 t ha^{-1}) [14].

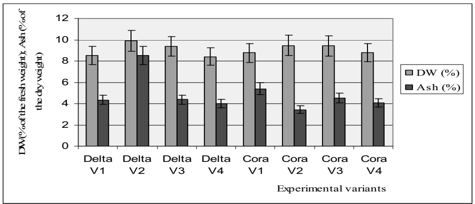

Fig. 1. Nectarines fruits dry matter and ash content

On the other hand, results obtained by Costea and Lăzureanu (2011) emphasized that the different fertilization measures (manure 40 t ha^{-1}; $N_{30}P_{30}K_{30}$; $N_{45}P_{45}K_{45}$; $N_{90}P_{45}K_{45}$) of Delta and Cora cultivars determined an improvement of the yield in the case of Cora (13.6 t ha^{-1} unfertilized; 20.55 t ha^{-1} for the $N_{90}P_{45}K_{45}$).

As Akin et al. (2008) mentioned in the case of apricots, dry matter content is one of the most important parameters that show fruits commercial value. Thus, varieties with high dry matter content are preferred for drying processes while the ones with low dry matter content are consumed freshly. The two studied nectarines cultivars are recommended to fresh consume, so low dry matter content determine fruits to be very sensitive to transportation and handling. Regarding the fruits mineral composition, as we can see in the followings figures (Figure 2, Figure 3 and Figure 4), there were registered significantly cultivars and variants differences.

Potassium, calcium, magnesium, levels were considerably higher and as it is known these are classified as macroelements [26]. On the other hand, natrium, boron, aluminum, iron, cupper have been determined in lower concentration and are classified as micronutrients [26]. So, at harvest the relative order of macronutrients concentration was: K> Ca>Mg (Fig. 2, Fig. 3, Fig. 4) and of micronutrients: Na> B>Al>Fe>Cu (Table 1). First of all it can be mentioned that the mineral content was expressed on the fresh weight, so, the obtained values depends also on fruits water content. This parameter was not so variable, ranging from 90.08 % (Delta V2), to 91.58 % (Delta V4). The highest value was registered for K (204.63 mg 100 g^{-1} F.W.) (Cora V3) and at the opposite pole was Cu 0.01 mg 100 g^{-1} F.W. (Cora V1) (Fig. 2; Table 1).

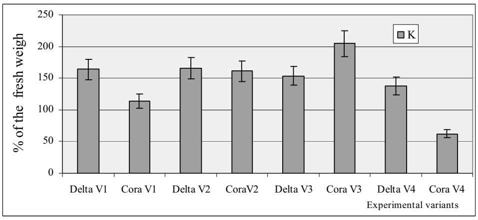

Fig. 2. Nectarines fruits potassium content

From the literature studied, there are no other scientific papers to describe Cora and Delta fruits mineral composition. Our data are close to those obtained by Val et al. (2010) in the case of 'Miraflores' peach trees sprayed at monthly intervals with different concentrations of Ca along the growing season. Mesocarp K^+ content was 128.6 mg $100g^{-1}$ F.W. and 179.9 mg 100 g^{-1} F.W. (control) as compared with skin level: 125.1 mg $100g^{-1}$ F.W., 170.7. mg 100 g^{-1} F.W. respectively (for 1 % Ca^{2+} application). In the case of calcium and magnesium, the mesocarp level was higher for magnesium as compared with calcium (7.01 mg 100 g^{-1} F.W.; 2.66 mg 100 g^{-1} F.W. – control; 7.09; 2.23 in the case 1% Ca treatment).

In our experiment calcium level was higher as against magnesium for both cultivars, with higher values for Delta cv. For Delta cv. organic fertilization fruit calcium level was 17.60 mg $100g^{-1}$ F.W, as compared with 12.09 mg $100g^{-1}$ F.W. Cora cv., the same treatment, as compared with Mg level: 12.92 mg $100g^{-1}$ F.W, 11.94 mg $100g^{-1}$ F.W., respectively. The lowest level was noticed in the case of V4. Chemical fertilizers determined higher fruit Ca^{2+} and K^{+} accumulation in Cora cv. (Figure 3, Figure 4). According to Başar (2006) results, in the case of Redhaven cv., in the fruits flesh samples the highest levels was occupied by K^{+} (1.34 %), followed by Mg^{2+} (0.064 %), Ca^{2+} (0.032%) and microelements values decreased from Fe to, Zn, Cu and Mn (13.46; 8.41; 6.28; 3.23 mg kg^{-1}). The author mentioned that elemental analysis of fruit is not a common practice to estimate sufficiency of a fertilization program and nutritive value of a fruit. Our opinion is that the second part of his affirmation is still disputable.

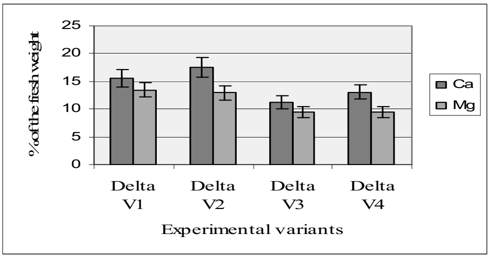

Fig. 3. Delta cv. calcium and magnesium level

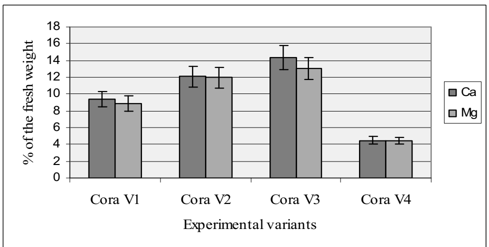

Fig. 4. Cora cv. calcium and magnesium level

These remarkable differences in minerals are most likely due to differences in fertilizer use and soil quality. So, differences in the soil fertility management affect soil dynamics and plant metabolism. The induced results are emphasized in differences in plant composition and nutritional quality [38]. Technological advances in genomics, plant breeding, bioengineering, and biotechnology now make it possible to create foods which will have maximal nutritional content, by manipulating field growing conditions [37].

For instance, although K^{+} not enter into the composition of organic molecules and is not an element of a mineral structure, it is involved in many physiological and biochemical processes essential for plant growth, to achieve a quality crop and plant response to stress factors etc. [24]. As regard as organic fertilization, Bravo et al. (2012) studied the effect of organic fertilization on carbon dioxide fixation, carbon partitioning and growth of potted nectarine trees (*Prunus persica* L. Batsch), cv. 'Orion'. The addition of compost at the highest rate was effective in increasing CO_2 fixation, promoting root and shoot growth, with no effect on fruit biomass, compared to the unamended control. Also, Baldi et al. (2010) noticed that organic fertilization practices can have strong influences on root production. This work helps to clarify the complex ways the shifts in fertilization practices may affect fruit tree root function and dynamics.

If we refer to calcium foliar application, as Crisosto et al. (2000) noticed, the lack of Ca^{2+} uptake in the fruit flash suggest that the calcium mobility is extremely limited in peach and nectarine fruit tissue under California orchard condition. In fact, generally, Ca^{2+} is an element that differs from others by being imported into fleshy fruit only in small amounts, much less than into leaves. Although Ca^{2+} is sufficiently available in the soil of most orchards, localized Ca^{2+} deficiency may become a problem in several fruits and vegetable crops, with the risk of large economic losses [31].

Excess Ca^{2+} in the growth medium induces premature shedding of fruit and buds. Also, excess Ca^{2+} interferes with Mg^{2+} absorption. Possibly in our experiment, with a slightly alkaline pH, there was induced a precipitation of many micronutrients, and in turn these were undisponible to the plant. After Marschner (2012), the high concentration of Ca^{2+} in the peel and the low concentration in the pulp can be attributed to the low mobility of Ca^{2+} in phloem. Calcium sprays to peach fruits as an aqueous solution had no effects on the fruit quality parameters and on ion content in the peach skin or mesocarp. On the contrary, the treatment of $CaCl_2$ incorporated in Tara gum to the fruits and these bagged following the application resulted in a great increase in the absorption of Ca^{2+}: up to a 261% in the mesocarp and 247% in the skin for the greatest concentration of Ca^{2+} applied. However, the 1% level determined a great increase in pre-harvest fruit drop [36].

Table 1. Some microelements content in nectarines fruits (mg 100 g fresh weight $^{-1}$)

Experimental variant	Na	B	Al	Fe	Cu
Delta V1	0.88	**0.41**	0.16	0.16	0.02
Delta V2	**3.03**	0.22	0.17	0.17	0.02
Delta V3	2.08	0.26	**0.24**	**0.24**	**0.06**
Delta V4	2.72	0.13	0.16	0.16	ND
Cora V1	1.48	0.14	0.11	0.11	0.01
Cora V2	3.94	0.17	0.19	0.19	0.05
Cora V3	**4.75**	**0.19**	0.19	0.19	0.03
Cora V4	0.14	0.10	0.10	0.08	ND

[1] V1 – Control
[2] ND = not detectable

Iron is a transitional element, and its absorption is regulated to ensure sufficient quantities for optimal growth and ensure prevention of excessive accumulation [22]. Boron is an important microelement that prevents fruits physiological disorders and disease incidence. As we can see in Table 1, the highest level was registered for Delta – unfertilized (0.41 mg 100 g fresh weight $^{-1}$), of about three times higher as compared with Cora cv. (the same variant). As regard as Al, Fe and Cu, the highest levels were noticed in the case of chemical fertilization, also for Delta cv. Field experiment showed that the incidence of peach infections by *Monilinia laxa* was negatively correlated with the content of boron in the leaves [34]. Copper as a transition element and also a heavy metal has been accumulated in small amounts and in the case of foliar fertilization this element was not detected.

It can be mention that our data are agreed with those presented by Mayer (1997) in a synthesis regarding the mineral composition changes during the time (1930s and the 1980s). In the case of nectarines fruits (mg 100g $^{-1}$ F.W.) these data are as followings: Ca old 3.9; Ca new 7.0; Mg old 12.6; Mg new 10.0; Fe old 0.46; Fe new 0.4; Cu old 0.06; Cu new 0.06; Na 9.1 old; Na new 1.0; K old 268.0; K new 170.0; Dry matter old 19.8; Dry matter new 11.1.

Results obtained by Cerutti et al. (2011) support the hypothesis that internal recycle and connections among different fertilization systems increasingly resulted in high system benefit and sustainability. Also, as Olivos et al. (2012) noticed, further research is needed to determine new recommended leaf and fruit nutrient values suitable for both production and maintaining fruit quality during storage. The conclusion of El-Jendoubi et al. (2011) was that it should be always taken into account that the effectiveness of a given Fe-fertilizer will depend on the specific conditions imposed in the particular study. In many cases, a positive result will not grant efficiency in other scenarios or can be valuable for other fertilizers too. Increasing productivity of horticultural production has primarily focused on intensification of fertilizers and water, resulting in high environmental costs. That is why Stefanelli et al. (2010) reviews the link between the nutritional quality of horticultural crops and the environmental and social sustainability of reducing nitrogen and water.

From the view point of nectarines quality, Iordănescu et al. (2010) noticed that the sugars content over passed 10% only for Cora nectarines, while all the other studied varieties had a sugars content value between 6.20% and 8.98%. Also, the highest gluco-acidimetric index (15.60) was registered at Cora even if most of the varieties had similar acidity content. fact, ten years ago, Tagliavini and Marangoni (2002) noticed that about 60% of peach and nectarine orchard in Emilia Romagna (north Italy) follow the guidelines of integrated fruit production. They mentioned that the period trend was for restriction in the amounts of mineral nutrients to be applied in orchards as a consequence of regulation at the European Union.

In addition, recent results indicate that supplementation of food with 4% nectarine is sufficient to promote life span and health span in the *Drosophila melanogaster*. This study carried out by Boyd et al. (2011) is the first to show life span extension by nectarine in an animal model. As the authors mentioned, these results provide a foundation for future research and development of nectarine as an effective intervention to promote life span and health span in mammals, including humans.

The ongoing *Prunus persica* genome sequencing project, together with the development of deep-sequencing technologies (e.g., RNA-Seq), will represent formidable advancements and powerful tools to identify and characterize peach genes and track gene expression changes during the last phase of development and in relation to different postharvest conditions [4].

CONCLUSIONS

Our preliminary results indicated a change in the nectarines fruits minerals composition in relation with the applied fertilizer, with significantly differences among the treatments.

The organic fertilization and chemical fertilization associated with foliar sprays impact was found to be the most significant ones for all mineral elements studied in this work

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