



Tree growth, yield, fruit quality attributes and leaf nutrient content of ‘Roxana’ apricot as influenced by natural zeolite, organic and inorganic fertilisers



Tomo Milošević^{a,*}, Nebojša Milošević^b, Ivan Glišić^a

^a Department of Fruit Growing and Viticulture, Faculty of Agronomy, University of Kragujevac, Cara Dusana 34, 32000 Cacak, Serbia

^b Department of Pomology and Fruit Breeding, Fruit Research Institute Cacak, Kralja Petra I/9, 32000 Cacak, Serbia

ARTICLE INFO

Article history:

Received 9 December 2012

Received in revised form 1 April 2013

Accepted 2 April 2013

Keywords:

Acidic soil

Cultivar

Fertilization

Fruit physical–chemical traits

P. armeniaca L.

Productivity

ABSTRACT

Apricot tree growth, productivity, fruit quality attributes, and nutritional status of leaves of cv. ‘Roxana’ were evaluated under different fertilization treatments from the first to the fifth year after planting on acidic soil in Western Serbia. Treatments including applications of cattle manure, complex NPK (15:15:15) mineral fertiliser, multi-nutrient fertiliser commercially named Multi Comp Base (NPK + MgO + Me + humic acids), two types of N (calcium ammonium nitrate and urea) mineral fertilisers, natural zeolite (type ‘Agrozel’) and control (no fertilization). Results showed that both N fertilisers promoted tree growth, precocity, yield performances and soluble solid content, whereas Multi Comp Base fertiliser, in general, provoked the best values of the most fruit physical attributes, ripening index, total phenolic and total flavonoid contents. Also, respectable values of some physical traits, total phenolic contents and yield efficiency were provided by Agrozel and manure, respectively. Differences among fertiliser treatments for leaf macro- and micronutrients content at 120 days after full bloom (DAFB) were significant, except for leaf B. In general, all fertiliser applications and control promoted excessive leaf P and insufficiency of N, K, Ca, Mg, Fe, Zn and B. Leaves Mn and Cu status were not consistent. High imbalances among macronutrients were promoted by NPK and Agrozel, while the best balances among micronutrients were induced by NPK.

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1. Introduction

Apricot (*Prunus armeniaca* L.) is an important fruit tree of temperate world regions, where it is highly appreciated for its delicious edible fruit. It was first domesticated in China and then spread to the Near East region, which is considered to be a secondary centre of domestication (Vavilov, 1992). Domesticated apricots were introduced later from Iran or Armenia into the Mediterranean region (Zohary and Hopf, 1993), although more recently new introductions were made from the Middle East, especially into Southern Europe (Faust et al., 1998). Today, the greatest world apricot production is supplied by Mediterranean countries, i.e. Turkey, Italy, France, Morocco, Spain, Greece, etc. (FAOSTAT, 2013). There are many different uses of apricots. It is enjoyed as fresh fruit, but a large portion of the worldwide production is preserved primarily by

drying (Faust et al., 1998). Apricots are also utilized as canned, dried, frozen, and baby food. Other products include wine, brandy, jam, marmalade, nectar, pulp, jelly, etc. (Jannatizadeh et al., 2008). Generally, apricot has an important place in human nutrition. Owing to their contents of several nutritious and health-promoting bioactive and nutraceutical compounds such as sugars, organic acids, phenolics, flavonoids, anthocyanins, carotenoids, dietary fibre, minerals and vitamins, apricots are considered as a functional food beneficial to consumer health and disease risk reduction (Dragovic-Uzelac et al., 2007; Drogoudi et al., 2008; Hegedüs et al., 2010, 2011; Leccese et al., 2008, 2012).

The important apricot-growing area in Serbia is the region of Cacak, located in the Western Serbia. This region accounted for approximately 10% of the Serbian apricot production. However, there are many negative factors that limit its growing under Serbian conditions, such as blossoms killed by spring frosts, sudden (premature) wilting – Apoplexy, winter killing of flower buds prior to bloom, *Plum pox virus* infection in apricot trees and the absence of quality rootstock and modern growing technologies (Milošević et al., 2010). Moreover, in the Cacak region, the most limiting factors are shallow and excessively acidic soils with a low pH that causes numerous problems and physiological disturbances in

Abbreviations: CAN, calcium ammonium nitrate; NPK, complex NPK mineral fertiliser; MCB, multi-nutrient fertiliser commercially named Multi Comp Base; TPC, total phenolic content; TFC, total flavonoid content; TAC, total antioxidant capacity.

* Corresponding author. Tel.: +381 32 303400; fax: +381 32 303401.

E-mail address: tomomilosevic@kg.ac.rs (T. Milošević).

apricot trees, resulting from nutritional imbalances of soil macro- and micronutrients, which are caused by inadequate fertilization. These degrade the normal tree growth, yield characteristics, quality of the fruit and increase the cost of apricot growing technology (Milosevic et al., 2011). From this point, fertiliser is an important tool used by the most Serbian apricot growers in order to boost apricot yield and fruit quality attributes. However, excessive fertilization has been verified, especially on the horticultural enterprises, where the fertiliser costs represented less than 10% of the variable crop costs (Huett and Dirou, 2000). Beside economic aspects, excessive fertilization has been associated to ground and stream soil and water contamination, as well as causing an increment of pest (Marschner, 1995) and by disease occurrence (Bussi and Amiot, 1998; Bussi et al., 2003). 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.

The most commonly used fertilisers in the Serbian apricot orchards are complex NPK mineral fertilisers, N fertilisers, i.e. calcium ammonium nitrate and urea, and farmyard manure. Manure, P and K fertilisers are given after the leaf fall and N in early spring. Micronutrients are given when there are deficient. Recently, natural zeolite alone or when mixed with N, P, K and/or farmyard manure is considered and important tool to enhance the yield, fruit quality and leaf nutritional status of different fruit crops, and it becomes, as positive alternative to chemical fertilisers (Torii, 1978; Reháková et al., 2004; Milosevic and Milosevic, 2009). It is safe for human and environment and using them was accompanied with reducing the great pollution occurred on our environment as well as for producing organic foods.

It is well known that the fertiliser amount applied by growers influences the apricot tree growth, yield, fruit quality (Dimitrovski and Cvetkovic, 1981; Bussi and Amiot, 1998; Bussi et al., 2003; Radi et al., 2003; Asma et al., 2007), leaf mineral composition (Leece and van den Ende, 1975; Eryuce et al., 2004; Bošković-Rakočević et al., 2012), etc. Since acidic soils are predominant in Serbian fruit orchards, fertilization of fruit trees, including apricot, requires a new management practice (Milosevic and Milosevic, 2009). From these reasons, the objective of the present study was to detect the effect of the soil application of natural zeolite-type “Agrozel”, cattle manure, complex NPK mineral fertiliser, multi-nutrient fertiliser commercially named Multi Comp Base and two nitrogen mineral fertilisers (calcium ammonium nitrate and urea) on tree growth, precocity, yield, fruit quality attributes and leaf chemical constituents of ‘Roxana’ apricot trees grown on sandy-loam and acidic soil under Western Serbian conditions.

2. Materials and methods

2.1. Plant material, field trial and experimental procedure

The Afgan apricot cultivar named ‘Roxana’, from Irano-Caucasian eco-geographical group, was evaluated from 2008 (first) to 2012 (fifth year after planting). This choice was due to the possible interest in this cultivar in the region of Cacak, because of their low tree vigour, maturity time and good fruit quality. Cultivar was grafted on Myrobalan seedlings (*P. cerasifera* Ehrh.) rootstock at 60 cm above ground level.

The trial was conducted at an experimental orchard located at private orchard in Prislonica village (43°53' N latitude, 20°21' E longitude, 340 m a.s.l.) near Cacak city, Western Serbia. The orchard was established in early spring of 2008 at 5.5 m × 3.0 m planting distance; training system was open vase. This training system controlled tree vigour by pruning in the summer. The orchard

was managed following the usual standard procedures under non-irrigated practice.

The soil treatment involving the application of the organic fertiliser – cattle manure with 0.5% total N (N_{TOT}), 0.3% P_2O_5 , 0.6% K_2O and 25% organic matter on dry weight (5 kg m^{-2}), complex NPK in the form of 15:15:15 (0.05 kg m^{-2}), calcium ammonium nitrate (CAN) with 27% of N_{TOT} (0.03 kg m^{-2}) mineral fertilisers, natural zeolite – “Agrozel” type (Milosevic and Milosevic, 2009) (1 kg m^{-2}), multi-nutrient fertiliser commercially named Multi Comp Base (MCB) (0.04 kg m^{-2}), and urea with 46% N_{TOT} (0.03 kg m^{-2}).

Multi Comp Base is multi-nutrient fertiliser in form NPK + MgO + microelements + humic acids. It contains 14% N, 13% P, 20% K, 2.1% MgO, 0.005% Cu, 0.05% Mn, 0.05% Zn, 0.01% B and humic acid which covers granules and has high biological value. This fertiliser is characterized with synergic activity of K and nitrate, and the absorption of cations and anions are much higher, while nitrification inhibitors contribute to the adoption of a balanced all macro- and micronutrients (personal communications).

Manure, NPK, Agrozel and MCB were given in autumn from 2008 to 2011, while CAN and urea were given in early spring from 2008 to 2012. All fertilisers were applied every year. In the control treatment, orchard soil was not fertilized. The experiment was established in a randomized block design with six trees for each cultivar–fertiliser combination and control in four replicates ($n = 24$).

2.2. Soil chemical analysis and weather conditions

Soil physical–chemical analysis was performed prior to trial establishment. The content of macro- and micronutrients in soil was determined according to standard laboratory protocols and methods. Results revealed that trial was conducted on soil with 1.62% organic matter, 0.16% N_{TOT} , 178 mg kg^{-1} P_2O_5 , 220 mg kg^{-1} K_2O , 0.39% CaO and 6.2 mg kg^{-1} MgO. The soil showed wide variations in the content of available micronutrients, ranging from very high for Fe (78 mg kg^{-1}), high for Cu (1.6 mg kg^{-1}) and B (2.3 mg kg^{-1}), low for Mn (7.8 mg kg^{-1}) to very low for Zn (0.52 mg kg^{-1}) (Ankerman and Large, 1977). Soil texture is sandy-loam with low pH, ranging from 4.86 in the first (0–30 cm) to 4.33 in the second soil depth (31–60 cm). In general, soil conditions were inadequate for normal vegetative and reproductive growth of apricot trees, as previously reported (Son and Küden, 2003; Milosevic et al., 2011).

The climate is maritime temperate, with moderate to strong winters and hot and semi to dry summers, characterized by the average annual temperature of 11.3°C and total annual rainfall of 690.2 mm (long-term average). The average air temperature during vegetative cycle was 17.0°C .

2.3. Measurements of tree growth and yield

For tree growth, trunk circumference at 20 cm above ground level was measured using calliper gauge Sttarret 727 (Athol, MA, USA), and converted into trunk cross-sectional area (TCSA, cm^2). An ACS System Electronic Scale (Zhejiang, China) was used to measure yield per tree and total cumulative yield (kg). The yield efficiency (kg cm^{-2}) was expressed as the ratio of total cumulative yield in kg per final TCSA. All measurements were involved every year.

2.4. Fruit physical and chemical analysis

Samples of 25 fruits per each fertiliser treatment in four replicates ($n = 100$) were hand harvested randomly for experimentation at the commercial maturity stage, on the basis of their skin ground colour, i.e. fully coloured (Ruiz and Egea, 2008). Immediately after

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