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Investigation of Leaf Micronutrient Contents of Some Apricot Varieties Grafted on Different Prunus Rootstocks

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Abstract

Prunus cerasifera, *P. domestica,* and *P. persica* species or their hybrids are mostly used in rootstock breeding studies for stone fruit species. In terms of rootstock features, all three species have their important characteristics, therefore, Estimating which species can be a better candidate as a rootstock is quite complex and not easy. It can be said that the transfer of plant nutrients from the soil to the scion is the most important task of a rootstock. This situation may vary within species as well as between species. This study was carried out in the field and laboratories of the Eastern Mediterranean Transition Zone Agricultural Research Institute. In this study, the content of leaf micronutrients in Mikado, Mogador, and Flopria apricot cultivars grafted on a total of 18 rootstocks obtained by selection breeding of mentioned species, six of each, were investigated. The results showed that the leaf content of Fe and B in *P. persica* (57.75 kg.mg-1 and 86.76 kg mg^{-1}, respectively), the contents of Mn and Zn in *P. cerasifera* (37.21 kg mg-1 and 21.10 kg.mg-1, respectively), the content of Cu in the control rootstock Myrobolan 29C (17.74 kg.mg-1) had the highest values. The data obtained from the study were found to be promising considering the reference values and the values obtained from the control rootstock.

Keywords: Rootstock, prunus, apricot

INTRODUCTION

Apricot, known for its high nutritional value, is one of the most produced fruits in the world and Turkey (Ozdogru et al., 2015). Although the production of fresh and dried apricots in Turkey varies according to the climate, it shows a continuously increasing trend. Thus, Turkey's fresh apricot production, which was 75,800 tons in 1963, reached 685,000 tons as of 2018, according to FAO data. Turkey exported 42,157 tons of fresh apricots and 112,590 tons of dried apricots in 2018, generating a total revenue of 355 million USD. Turkey's share in world fresh and dried apricot exports is 13.6% and 79.7%, respectively (FAO, 2020). There are more than 250 different species of *Prunus spp* (Rosaceae), many of which are not botanically described. Among these, apricot, peach, cherry, almond, sour cherry, and plum are important fruit species produced (Chin et al., 2014). Anatolia, which has a different ecological environment from subtropical to cold climate, is the homeland of many species belonging to the genus *Prunus* (Ercişli, 2004). Among these species, *P.domestica, P.cerasifera, P.divaricata, P.spinosa, P.microcarpa, P.scoparia, P.amygdalus, P.arabica* are grown naturally in Anatolia region. Recently, clonal rootstock breeding studies have been started especially in these species grown in natural environments in Turkey. Recently, clonal rootstock breeding studies have been started in these species (Bolat et al., 2017). The use of appropriate rootstocks in modern fruit growing is done for purposes such as increasing yield and quality, shortening the juvenile period, creating an appropriate flowering period, and providing resistance to difficult soil conditions (Darikova et al., 2011). This classical production method, which is possible with grafting, has been used for thousands of years. In apricot cultivation, grafting is used intensively with the spread of clonal rootstocks (Milosevic et al. 2014). Rootstock breeding studies have been carried out for apricots in the world and important results were revealed by examining the growth vigor (Jimenez et al., 2003), yield (Sosna and Licznar–Małańczuk, 2012), quality (Hernandez et al., 2010), and fruit biochemical properties (Gündoğdu, 2019). However, as in many fruit trees, the discussion about the appropriate rootstock usage still continues because of the complex structure of rootstock and scion relationship in apricots (Son and Küden, 2003). In recent years, changes and deteriorations in climate and soil conditions have increased the importance of rootstock use. The breeding of rootstocks that adapt well to these difficult conditions are well compatible with the varieties grafted on, are easily propagated vegetatively, control the growth force, increase the yield and quality of the grafted variety, and have good adhesion to the soil has become increasingly important (Uğur, 2017). Myrobolan rootstocks (*P.cerasifera*) are used as rootstocks in many countries where apricot cultivation is intense (Turkey, Poland, Romania, Russia, Serbia, Czech Republic, France, Hungary, Switzerland). However, these rootstocks may not be suitable for intensive cultivation due to their strong crown (Milosevic et al., 2014; Sitarek and Bartosiewicz, 2011; Güney, 2019). In addition, some apricot cultivars grafted on Myrobolan rootstocks show delayed graft mismatches (Sosna and Licznar–Małańczuk, 2012). For this reason, dwarf growing rootstocks according to the average data obtained from selected rootstock candidates from three to four different *Prunus* species were used in this study to create more compact trees. The study was carried out in the fields and laboratories of the Eastern Mediterranean Transition Zone Agricultural Research Institute in 2020 to investigate the uptake of nutrients from the soil in apricot cultivars grafted on these species.

MATERIAL and METHODS

The research was carried out in the greenhouse and laboratories of Kahramanmaraş Eastern Mediterranean Transition Zone Agricultural Research Institute in pot conditions in 2020 (Table 1). In the experiment, three Mikado, Mogador, and Flopria early apricot cultivars were grafted onto 6 rootstock candidates from each species belonging to four different species and leaf nutrient contents besides the development status of examined plants were determined. Myrobolan 29C (*P. cerasifera*) was used as the control rootstock.

Table 1. Some physical and chemical properties of the soils in field conditions used in the pots

Soil Properties	Value (0-30 cm)	*Evaluation	Value (30-60cm)	*Evaluation
Sand (%)	47.4		47.4	
Silt (%)	34.0		34.0	
Clay (%)	18.6		18.6	
Clay (%)				
Texture		Loam		Loam
pH	7.72	Slightly alkaline	7.76	Slightly alkaline
Total salt (%)	0.042	Saltless	0.041	Saltless
Organic matter (%)	3.25	Good	2.67	Medium
Available phosphorus (mg kg^{-1})	8.93	Medium	5.03	Low
Available potassium (mg kg^{-1})	550	Very high	210	Good
Available calcium (mg kg^{-1})	3340	Good	3340	Good
Available magnesium (mg kg^{-1})	290	Very high	260	Very high

* The evaluations were made according to; Texture, Bouyoucos (1921), pH USDA (1998), total salt Anonymous (2018), organic matter Ülgen and Yurtsever (1995), available phosphorus and potassium Rehm et al. (1996), available calcium Loue (1968), and available magnesium FAO (1990).

Table 2. Required plant Micronutrients for the development of most plants and some of their properties (Epstein and Bloom, 2005)

Element name	Chemical Symbol	Content in Dry Matter	Plant-Friendly Form
Iron	Fe	100 (50-250)	Fe^{+2}, Fe^{+3}
Copper	Cu	6	Cu^{+}, Cu^{+2}
Manganese	Mn	50 (20-200)	$Mn2^{+}$
Zinc	Zn	20 (6-60)	$Zn2^{+}$
Boron	B	20 (6-60)	BO_3^{-3}, $B_4O_7^{-2}$

Collecting Leaf Samples

The leaves which completed their development were collected from the middle part of the shoots of the seedlings per replication in June of years 2012-2016. The samples taken were numbered and placed on the paper bags and immediately were transferred to the laboratory. Unhealthy and worn leaves were removed and remained were sorted out on numbered papers. The leaves were treated with 0.1 N HCl solution followed by washing with distilled. The washed leaves were dried at 65°C approximately for 48 hours. Dried samples were ground, labeled in plastic bags, and kept in the refrigerator until analysis (Steyn, 1961; Lilleland and McCollam, 1961; Sannoveld and Dijk, 1982; Kaçar, 2008).

Determination of Nutrients

The contents of Fe, Cu, Zn, Mn, B were determined to the method, the pressurized microwave wet burning, described by Miller (1998). Two hundred fifty milligrams of dried leaf samples were burned by treating with 0.5 ml of Nitric acid (HNO3 d= 1.42) and 2 ml of Hydrogen peroxide (H2O2 30%). The obtained measurements of P, K, Ca, Mg, Fe, Cu, Zn, Mn were controlled with the certified values of the relevant minerals in the reference plant materials obtained from the National Institute of Standards and Technology (NIST, Gaithersburg, MD, USA). Total nitrogen was determined by the Kjeldahl method.

Evaluation of Results

The grafted plants which were used for leaf sampling were arranged in randomized blocks in a split-plot design. In the experiment, 18 rootstock pens combinations from three different species, 6 of each type, were used. The mean values obtained from these combinations based on species were arranged under the experimental design and were subjected to variance analysis. The experiment was arranged in triplicate, with 5 plants per plot. The variance analysis of all data was tested at 5% and 1% significance levels, and multiple comparisons were determined by LSD test. JMP 7 package program was used for statistical analysis.

RESULTS and DISCUSSION

The results showed that the contents of leaf micronutrients varied in different rootstocks and the values were found to be statistically significant within varieties besides the combinations (Table 3-4). However, different researchers have reported that plant leaf components may vary according to the rootstocks and cultivars (Jimenez et al., 2018; Yahmed et al., 2020). Therefore, researches have been carried out on the transmission of plant nutrients by rootstocks of different species (Shahkoomahall and Chaparro, 2020; Taaren et al., 2016). Studies on this subject report that the physiological characteristics of xylem vascular bundles of rootstocks (Tombesi et al., 2011) and root morphology and physiology are highly effective in ion uptake (Nawaz et al., 2011). Therefore, the selection of rootstocks and the establishment of healthy gardens by carrying out rootstock breeding studies of the species are important in terms of cultivation techniques.

Table 3. Fe, Mn and Cu contents of apricot cultivars grafted on different rootstocks

Rootstock	Cultivar	Fe (kg.mg^{-1})		Mn (kg.mg^{-1})		Cu (kg.mg^{-1})	
P.cerasifera	Mikado	48.62 ef	**48.84 D**	35.44 b	**37.21 A**	13.74 c	**14.89 C**
	Mogador	50.33 de		41.15 a		14.30 c	
	Flopria	47.56 f		35.05 b		16.63 ab	
P.domestica	Mikado	57.03 b	**52.61 B**	33.51 c	**33.77 B**	14.45 c	**15.69 B**
	Mogador	48.65 ef		32.48 cd		16.98 a	
	Flopria	52.17 c		35.32 b		15.64 b	
P.persica	Mikado	59.12 a	**57.75 A**	24.62 d	**24.69 D**	12.51 d	**12.06 D**
	Mogador	56.33 b		24.48 g		11.86 d	
	Flopria	57.81 ab		24.97 g		11.80 d	
Myrobolan 29C	Mikado	51.70 cd	**50.76 C**	32.10 de	**31.31 C**	17.58 a	**17.14 A**
	Mogador	50.55 cd		30.98 ef		16.94 a	
	Flopria	50.04 de		30.86 f		16.91 a	
LSD		**1.77****	**1.01****	**1.15****	**0.65****	**1.09****	**0.61****

It was revealed that there were significant differences in leaf Fe contents of apricot cultivars grafted on selected rootstocks and control. Apricot cultivars grafted on *P.persica* rootstocks had the highest Fe content (57.75 kg.mg^{-1}), followed by *P.domestica* (52.61 kg.mg^{-1}), Control (50.76 kg.mg^{-1}) and *P.cerasifera* (48.84 kg.mg^{-1}) rootstock (Table 1). In rootstock-scion interactions, Fe contents of leaf were higher (59.12 kg.mg^{-1}) in Mikado apricot cultivars grafted on *P.persica* rootstock. The leaf content of iron from rootstocks obtained in this study was higher compared to the results obtained by Jimenez et al. (2008) from 18 rootstocks. Contrary, the results reported by Mestre et al. (2015) in peach were slightly higher than in this study with an average of around 59.8-86.3 mg.kg^{-1}. However, Orazem et al. obtained similar results in another study they conducted in 2011. The results showed that leaf deformations that cause high chlorosis were not observed in rootstocks from different species. The iron content of rootstocks is closely related to chlorosis which directly affects the leaf chlorophyll contents. Among microelements of leaves in rootstocks, iron deficiency and, accordingly, chlorosis is an important criterion. Rootstocks are required to transmit a sufficient amount of iron to the grafted scion at high pH. This increases the quality of the leaf and the amount of chlorophyll, as well as increases the efficiency of photosynthesis. In general, it has been reported that the iron element uptake mechanism of the root system in rootstocks is in two different ways (Tagliavani and Rombola 2001). Plants get most of the iron needed from the soil which makes the rootstock role more important (Mayer et al, 2015). The majority of rootstocks used in the study can be considered promising species. The iron is mainly found in the forms of $Fe(OH)^{+2}$, $Fe(OH)^{3,}$ and $Fe(OH)^{-4}$ in soil, which are ferric iron (Fe^{+3}) oxides. For adequate iron uptake from the soil solution, roots develop several mechanisms that increase iron solubility uptake. These mechanisms can be explained as the acidification of the soil while increasing the solubility of iron, the reduction of ferric iron to the more easily soluble Ferro (Fe^{+2}) form, and the release of stable, soluble complex compounds with iron (Marschener, 2012). Gundesli et al. (2020) reported that the speed of these mechanisms may differ in terms of selected rootstocks which makes it more important to select suitable rootstocks. It can be said that these mechanisms start with the acidification of the roots in the rhizosphere region. Roots release organic acids such as malic acid and citric acid, which increase the availability of iron and phosphate and release protons during the uptake of cations (especially ammonium) (Li et al., 2017). Iron deficiency stimulates the outflow of protons and reduces the ferric iron to its Ferro (Fe^{+2}) form by stimulating the release of ferric-chelate reductase enzyme (Taiz and Zeiger, 2008). Based on previous studies, the intensity of these mechanisms differs among rootstocks that can be predicted as an important criterion in rootstock selection. (Gündeşli, 2018). *P.cerasifera* and *P.domestica* rootstocks performed better with 37.21 kg.mg-1 and 33.77 kg.mg^{-1} values of leaf Mn content, respectively. Although the highest leaf Mn content was detected in the Mogador apricot cultivar grafted on *P.cerasifera* (41.15 kg.mg^{-1}), it was understood that the leaf Mn contents of other apricot cultivars grafted on the same rootstock were statistically significantly higher. Karlıdağ et al.(2019) and Milosevic and Milosevic (2011) reported the leaf Mn content as 32.09 mg.kg^{-1} and 20.71-68.82 mg.kg^{-1} in similar studies on apricots, respectively, which were higher than results obtained in this study. Likewise, in a study conducted by Jimenes et al.2018 on peaches, the leaf Mn content was found to be around 36.74-74.32 mg.kg-1 on average. Mestre et al. (2017) also reported similar values. The reason why these results were slightly higher than our study may be due to using trees in the field and mostly on trees aged 5 and above in these studies. Although the results of these previous studies are somewhat high, the results obtained from our study are generally compatible with the literature. The contents of Cu in leaves of apricot cultivars grafted on the control rootstock were the highest with 17.17 kg.mg^{-1} in total (Table 3).

Table 4. Zn and B contents of apricot cultivars grafted on different rootstocks

Rootstock	Cultivar	Zn (kg.mg^{-1})		B (kg.mg^{-1})	
	Mikado	20.88		72.38	
P.cerasifera	Mogador	22.00	**21.10 A**	75.38	**74.92 C**
	Flopria	20.43		77.01	
	Mikado	19.53		77.89	
P.domestica	Mogador	19.86	**20.00 B**	75.02	**75.49 C**
	Flopria	20.61		73.57	
	Mikado	16.07		88.03	
P.persica	Mogador	15.51	**15.79 D**	85.78	**86.76 A**
	Flopria	15.79		86.46	
	Mikado	18.04		85.51	
Myrobolan 29C	Mogador	17.40	**17.60 C**	82.51	**83.52 B**
	Flopria	17.34		82.55	
LSD		**N.S.**	**0.86****	**N.S.**	**2.96****

Similar to Mn results, the high values of Zn contents in the leaves were obtained from *P.cerasifera* rootstocks (21.10 kg.mg^{-1}), however, there was no difference in terms of cultivar, nor in the interactions (Table 4). Half of the agricultural lands (28 million hectares) in Turkey have a widespread deficiency of microelements which zinc and iron deficiency are the leading ones (Eyüpoğlu et al., 1993; Aliyazıcıoğlu et al., 2013). Studies have reported that the most accurate and practical way of zinc uptake in plants and its transfer to crops will be the selection of genotypes with good zinc uptake (Çakmak et al., 1998; Ullah et al., 2017). The values of zinc in the leaves of rootstocks used in our study were found to be at the expected levels. Similar results were observed in the content of B in leaves. Although there was no significant difference in the interactions in terms of B contents, it is understood that rootstocks originating from *P.persica* had higher B uptake (86.76 kg.mg^{-1}). However, comparing the results obtained in this study with the reference values in Kacar (2008) showed that the values are within these reference values.

CONCLUSION and SUGGESTIONS

As a result of the examination of the leaf micronutrient contents obtained from 18 selected and 1 control rootstock used in the study, it was concluded that the amount of nutrient intake varies according to the species. In general, no differences were observed in total micronutrient uptake among the rootstock species in terms of kg.mg-1. It is suggested that the interaction of rootstock species with varieties should be taken into account in the study, where there is no difference in terms of total micronutrient contents of leaves based on varieties. It would be appropriate to continue selection studies with the same intensity in terms of apricot rootstock breeding in all *Prunus* species, which have a very rich diversity in the natural plant population of Turkey. It would be appropriate to consider the necessity of fruit growing in Turkey's high alkaline soil conditions in rootstock breeding programs. High alkaline soil conditions cause major problems in the uptake of many microelements, especially iron, disruptions in plant development, and ultimately yield losses. Therefore, it is very important to select rootstock with a high nutrient uptake efficiency from the soil in rootstock breeding studies. In this study, despite the high pH, the results showed that the rootstocks generally take the microelements within the reference values. Compared to previous studies, somewhat low values obtained from this study draw attention. However, it is thought that these results obtained from the early tree development stage may give positive levels in the coming years. Moreover, in many rootstock breeding studies, it has been reported that micronutrient deficiencies such as Fe, Zn, etc. can be experienced. The results revealed that all three rootstock species were not at the desired level in terms of iron, some rootstocks had very good leaf iron contents, but most of them remained at the minimum levels of the reference values. The absence of chlorosis symptoms on the leaves in the observations led to the conclusion that the iron content of the leaves did not cause problems in the development of the plant. Consequently, results regarding the transmission of plant nutrients from the soil by the selected rootstocks were found to be positive and makes it more prominent to continuing research on these rootstocks.

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