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Araştırma Makalesi

# Performance of Transmit of Some Macronutrients from Soil to Leaves in Selected *Prunus* Rootstocks

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## Abstract

This study was carried out to investigate the uptake of plant nutrients from the soil and their transmission performance to the leaves of rootstocks considered promising in the wild plum species rootstock breeding project carried out in Malatya and Elazığ provinces of Turkey. The study was completed in 2020 on the land of the Malatya Apricot Research Institute and the laboratories of the Kahramanmaraş East Mediterranean Transitional Zone Agricultural Research of Institute. According to the analysis results of the soil samples taken from 0-30 cm and 30-60 cm depths of the experimental area, it was determined that the concentrations of other nutrients except available phosphorus were in very good condition. As a result of the analysis of leaf samples taken from 69 rootstocks selected in June, scoring was made by applying measured grading to the amounts obtained. This method has been applied for the first time in the world with this study. At the end of the study, it was determined that phosphorus varied between 0.16-0.55%, potassium 0.80-2.40%, calcium 0.41-3.48% and magnesium 0.15-0.49% in leaf contents. When the values obtained from our study and the data obtained from similar studies were compared, it was seen that there was a great deal of similarity.

**Key words**: Macronutrients, plant nutrition, *Prunus,* rootstock, soil

# Seçilmiş *Prunus* Anaçlarında Topraktan Yapraklara Bazı Makrobesin Maddelerinin İletim Performansları

## Öz

Bu çalışma, Türkiye'nin Malatya ve Elazığ illerinde yürütülen yabani erik türleri anaç ıslah projesinde ümitvar kabul edilen anaçların topraktan bitki besin maddelerinin alımını ve yapraklara iletim performanslarını araştırmak amacıyla yürütülmüştür. Çalışma, 2020 yılında Malatya Kayısı Araştırma Enstitüsü Müdürlüğü arazisi ve Kahramanmaraş Doğu Akdeniz Geçit Kuşağı Tarımsal Araştırma Enstitüsü Müdürlüğü laboratuvarlarında tamamlanmıştır. Deneme alanının 0-30 cm ve 30-60 cm derinliklerinden alınan toprak örneklerinin analiz sonuçlarına göre, alınabilir fosfor dışında diğer besin elementlerinin konsantrasyonlarının çok iyi durumda olduğu belirlenmiştir. Haziran ayı döneminde seçilen 69 adet anaçtan alınan yaprak örneklerinin analizleri sonucunda elde edilen miktarlara tartılı derecelendirme uygulanarak puanlamalar yapılmıştır. Bu yöntem dünyada ilk kez bu çalışma ile uygulanmıştır. Çalışma sonunda yaprak içeriklerinde fosforun % 0.16-0.55, potasyumun % 0.80-2.40, kalsiyumun % 0.41-3.48 ve magnezyumun ise % 0.15-0.49 arasında değiştiği saptanmıştır. Çalışmamızdan elde edilen değerler ile benzer çalışmalardan elde edilen veriler karşılaştırıldığında büyük oranda benzerlik gösterdiği görülmüştür.

**Anahtar kelimeler:** Makro bitki besin maddeleri, bitki besleme, *Prunus*, anaç, toprak

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## Introduction

Trees used in modern fruit growing generally consist of two separate plants, rootstock and scion. The breeding of the plant in the scion section with the breeding of the plant in the rootstock section involve different criteria (Hernández et al., 2010). Selection of varieties that need to be propagated by grafting on a suitable rootstock in modern fruit growing is very important due to the long production time from seed (Taaren et al., 2016). Uptake nutrients from the soil in proportions appropriate to the request of the scion or variety is the primary criterion for a suitable rootstock (Yahmed et al. 2020). This situation is closely related to the yield and quality of the variety grafted on the rootstock. However, considering the demands from the producers and consumers, the rapid changes in the abiotic and biotic climate and soil conditions, the importance of the rootstock breeding studies is better understood. In this sense, as in other fruit rootstock breeding (*Prunus*) rootstock breeding studies are also mobile and active. Especially for the last twenty decades, rootstock breeding studies, which are resistant to extreme climate-soil and abiotic and biotic stress conditions, have a positive effect on fruit yield and quality, have good graft compatibility, and are compatible with different planting densities are also carried out in our country. These breeding studies are carried out as selection breeding studies in our country, which is the homeland of many different *prunus* species.

This study was carried out in Malatya Apricot Research Institute's land and Kahramanmaraş East Mediterranean Transitional Zone Agricultural Research Institute Laboratories in 2020, in order to investigate the nutrient uptake from the soil and their transmission performance on the leaves, of the rootstocks, which are thought to be promising in the wild plum species rootstock breeding project carried out in Malatya and Elazığ provinces of Turkey.

## Materials and Methods

The material of the study consists of wild plum genotypes belonging to four different species (*Prunus cerasifera, Prunus divaricata, Prunus domestica* and *Prunus spinosa*) obtained by selection breeding from Malatya and Elazıg regions. Myrobolan 29C (*Prunus cerasifera*) was used as a control rootstock. As of October 2019, a garden has been established at a distance of 1.5 m x 1 m from these rooted genotypes on the lands of the Apricot Research Institute. The garden area is 670 m2 (50 m x 13.4 m). Three saplings of each genotype were planted. Leaf samples were taken from one-year-old seedlings. One-year-old leaf samples were taken from each of these growing saplings.

### Sampling

#### *Soil samples*

In order to represent the land soil, a total of 40 soil samples were taken from 0-30 cm and 30-60 cm depths by zigzag drawing (Z-shaped) among the rootstocks used in the study. 20 soil samples taken from the same depth were mixed thoroughly in a clean bucket and made into a single sample of 2 kg. A total of 2 samples were obtained. Soil samples brought to the soil preparation room were laid in drying containers, and the large stones and twigs inside were cleaned and left to dry. The dried soil samples were beaten with wooden mallets and passed through a 2 mm sieve and made ready for analysis. Soil texture in soil samples made ready for analysis was determined by the modified Bouyoucus hydrometer method (Klute, 1986). Soil reaction (pH) was measured with a glass electrode pH meter in the soil saturated with water (saturated sludge) prepared as reported by Richards (1954). Total salt content (%), electrical conductivity values (EC) of soils were calculated by measuring with electrical conductivity device from saturated sludge (Richards, 1954). Lime ($CaCO_3$) (%) was determined volumetrically in Scheibler calcimeter (Klute, 1986). Organic matter (%) was determined by the modified Walkley-Black method by Richards (1954). Available phosphorus (mg $kg^{-1}$) was determined by spectrophotometer device according to the method of Olsen et al. (1954). The contents of available potassium, available calcium and magnesium (mg $kg^{-1}$) useful for the plant were determined by measuring with the Agilent 5100 brand ICP-OES device according to the ammonium acetate (pH= 7.0) method (Richards, 1954).

#### *Leaf Samples*

In June, the leaves were selected, which completed the development from the middle part of the shoots of all the saplings were selected. A total of 150 leaves were collected. The samples taken were numbered and placed on the paper bags. The collected leaf samples were brought to the laboratory without waiting. Here, plants were laid out on papers with their own numbers written. Unhealthy and worn leaves were removed. The dust on it was cleaned by pre-washing. It was then

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passed through a 0.1 N HCl solution and washed with distilled water. The washed leaves were laid loosely and left to dry in the drying cabinet at 65 °C until their weight did not change (approximately 48 hours). The dried samples were ground and stored in labeled plastic bags in the refrigerator until analysis (Lilleland & McCollam, 1961; Steyn, 1961; Sannoveld & Dijk, 1982; Kacar, 2008).

***Determination of nutrients***

The dried leaf samples were ground in a tungsten coated hand mill. 0.30 g was taken from the ground plant parts and analyzed according to wet digestion method in a pressurized microwave oven with 0.5 ml nitric acid ($HNO_3$, d = 1.42) and 2 ml hydrogen peroxide ($H_2O_2$, 30%) as reported by Miller (1998). After the digestion process, the samples were filtered and available P, K, Ca and Mg amounts were determined in Agilent 5100 brand ICP-OES device. The accuracy of the results was also checked with the certified values of the relevant minerals in reference plant materials obtained from the National Institute of Standards and Technology (NIST, Gaithersburg, MD, USA).

***Evaluation of results***

After the leaf samples were analyzed in triplicate, the measured grading method modified by Uğur and Kargı (2018) was applied to the obtained results (Table 1). This method was used for the first time in the world with this study. With this method, a score was given to each plant nutrient according to their minimum and maximum values. Scoring was made according to the coefficient found by adding the minimum value to the value obtained by dividing the difference between the maximum value and the minimum value of the nutrients that the cultivars take from the soil by 10. After collecting the points that the rootstock candidates received from each plant nutrient, the total points received by the macronutrients were obtained. After applying the modified weighted grading to these scores again, the general condition of the rootstocks in nutrient transmission was determined.

Table 1. Basis value ranges for the scores used in the weighted grading

| Phosphorus | | | Potassium | | | Calcium | | | Magnesium | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Min.** | **Max.** | **Mean** | **Min.** | **Max.** | **Mean** | **Min.** | **Max.** | **Mean** | **Min.** | **Max.** | **Mean** |
| 0.16 | 0.55 | 0.039 | 0.8 | 2.4 | 0.16 | 0.41 | 3.48 | 0.31 | 0.15 | 0.49 | 0.030 |
| | **Points** | | | **Points** | | | **Points** | | | **Points** | |
| 1 | 0.00 | 0.199 | 1 | 0.00 | 0.96 | 1 | 0.00 | 0.72 | 1 | 0.00 | 0.18 |
| 2 | 0.20 | 0.239 | 2 | 0.97 | 1.13 | 2 | 0.73 | 1.04 | 2 | 0.19 | 0.22 |
| 3 | 0.24 | 0.279 | 3 | 1.14 | 1.30 | 3 | 1.05 | 1.21 | 3 | 0.23 | 0.26 |
| 4 | 0.28 | 0.319 | 4 | 1.31 | 1.47 | 4 | 1.22 | 1.38 | 4 | 0.27 | 0.30 |
| 5 | 0.32 | 0.359 | 5 | 1.48 | 1.64 | 5 | 1.39 | 1.55 | 5 | 0.31 | 0.34 |
| 6 | 0.36 | 0.399 | 6 | 1.65 | 1.81 | 6 | 1.56 | 1.72 | 6 | 0.35 | 0.38 |
| 7 | 0.40 | 0.439 | 7 | 1.82 | 1.98 | 7 | 1.73 | 1.89 | 7 | 0.39 | 0.42 |
| 8 | 0.44 | 0.479 | 8 | 1.99 | 2.15 | 8 | 1.90 | 2.06 | 8 | 0.43 | 0.46 |
| 9 | 0.48 | 0.519 | 9 | 2.16 | 2.32 | 9 | 2.07 | 2.23 | 9 | 0.47 | 0.50 |
| 10 | 0.52 | | 10 | 2.33 | | 10 | 2.24 | | 10 | 0.51 | |

The adequacy levels of the macronutrient contents determined by leaf analysis were evaluated according to Table 2.

## Results and Discussion

***Research area soil properties***

According to soil analysis results; the soils of the research area were determined as loamy, slightly alkaline and non-saline. The soils of the study area were found extremely calcareous at both depths of 0-30 cm and 30-60 cm. Topsoil (0-30 cm) contains well, subsoil (30-60 cm) contains moderate organic matter. Available phosphorus is medium in the topsoil and low in the subsoil. Available potassium, calcium and magnesium were found at sufficient and high levels at both depths (Table 3).

https://doi.org/10.30910/turkjans.919682

Table 2. Macro plant nutrients required for the growth of most plants and some characteristics related to them (Trash, 1996; Jones & Jacobsen, 2001; Epstein & Bloom, 2005)

| Name of the Element | Chemical Icon | Content in Dry Matter (%) | Available Shape for Plant |
|---|---|---|---|
| Phosphorus | P | 0.2 (0.1-0.5) | $H_2PO_4^-$, $HPO_4^{-2}$ |
| Potassium | K | 1.0 | $K^+$ |
| Calcium | Ca | 0.5 (0.2-1.0) | $Ca^{+2}$ |
| Magnesium | Mg | 0.2 (0.1-0.4) | $Mg^{+2}$ |

***Macronutrients contents in the leaves***

When the plant analysis results are examined, it is understood that all rootstock seedlings, except for *P. divaricata* rootstock with code number 23 KK 13 in the 70th row, get enough of the macro plant nutrients from the soil. This situation is clearly seen in the scoring table (Table 4). It is thought that the *P. divaricata* rootstock with code number 23 KK 13 could not get enough phosphorus and potassium from the soil or that these two plant nutrients were transmitted to the other organs of the rootstock more than the leaves.

Table 3. Some physical and chemical properties of the research area soils

| Soil Properties | Value (0-30 cm) | *Evaluation | Value (30-60 cm) | *Evaluation |
|---|---|---|---|---|
| Sand (%) | 47.4 | | 47.4 | |
| Silt (%) | 34.0 | | 34.0 | |
| Clay (%) | 18.6 | | 18.6 | |
| Texture | | Loam | | Loam |
| pH | 7.72 | Slighly alkaline | 7.76 | Slighly alkaline |
| Total Saline (%) | 0.042 | Non-saline | 0.041 | Non-saline |
| Lime (%) | 37.72 | Extremely calcareous | 38.38 | Extremely calcareous |
| Organic Matter (%) | 3.25 | Well | 2.67 | Medium |
| Available Phosphorus (mg $kg^{-1}$) | 8.93 | Medium | 5.03 | Low |
| Available Potassium (mg $kg^{-1}$) | 550 | Very high | 210 | Well |
| Available Calcium (mg $kg^{-1}$) | 3340 | Well | 3340 | Well |
| Available Magnesium (mg $kg^{-1}$) | 290 | Very high | 260 | Very high |

*Evaluations; texture was evaluated according to Bouyoucos (1921), pH was evaluated according to USDA (1998), total saline was evaluated according to Anonymous (2018), lime was evaluated according to FAO (2006), organic matter was evaluated according to Ülgen and Yurtseven (1995), available phosphorus and potassium were evaluated according to Rehm et al. (1996), Calcium was evaluated according to Loue (1968), and magnesium was also evaluated according to FAO (1990).

It was determined that the leaf phosphorus content of the rootstocks varied between 0.16% and 0.55%, and the average phosphorus content in all rootstocks was 0.31% (Table 4). These results show that the rootstocks uptake up phosphorus within the limits of their sufficiency (Table 2). The highest phosphorus contents were obtained in 44 AK 06 (*P. cerasifera*) (0.55%), 44 YY 16 (*P. cerasifera*) (0.46%) and 23 KK 18 (*P. cerasifera*) (0.43%) rootstocks (Table 4). The lowest leaf phosphorus contents were found in 44 YY 18 (P. domestica) (0.21%) and 23 KK 13 (*P. divaricata*) (0.16%) rootstocks (Table 4). Milosevic et al. (2014) reported that *P. spinosa* and *P. cerasifera* in their study on interstocks, leaf phosphorus content varied between 0.20% and 0.33%. It is understood that our study results are similar to those of Milosevic et al. (2014). Forcada et al. (2020) found leaf phosphorus content between 0.30-0.37% in a similar study in different rootstocks. Reig et al. (2018) also reported that leaf phosphorus values changed between 0.14-0.19% in a study of some plum rootstocks. It is understood that the maximum concentrations of phosphorus obtained in these two studies are low and different from our findings. Phosphorus is not a factor limiting the growth of rootstocks and the varieties that will be grafted on them, and it is required in small amounts besides being a macronutrient (Mayer et al., 2015). Leaf phosphorus content of rootstocks

https://doi.org/10.30910/turkjans.919682

and vaccinate varieties are different. These plants need less phosphorus and the excess phosphorus is stored in cell vacuoles. This situation is important for the uninterrupted continuation of biochemical reactions and growth (Tomaz et al., 2020). Thus, optimum carbon metabolism and maximum biomass will be formed in parallel with photosynthetic activity in genotypes that able to transmit phosphorus effectively and in sufficient amounts to leaves and shoots (Ullah et al., 2017). It can be thought that this situation will also affect the yield and quality of the varieties grafted on the rootstock.

Leaf potassium contents were found to be quite high compared to their phosphorus contents. Because plants uptake more potassium than phosphorus in its bodies. Potassium contents varied between 0.80-2.40%, and the average leaf potassium content was determined to be 1.71% (Table 4). Potassium contents varied between 0.80-2.40%, and the average leaf potassium content was determined to be 1.71% (Table 4). It is understood that the potassium amounts obtained between 0.80-2.40% have approximately twice the potassium content compared to the reference value of 1%. Shahkoomahally and Chaparro (2020) determined the potassium values in some plum and peach rootstocks between 2.58-3.54%. It is seen that these rates are slightly higher than our study results. Jimenes et al. (2018) determined leaf potassium contents between 0.15-0.21% in their study with rootstocks of different origin. These results are consistent with the results we found. Similar rates are found in other studies. Similar rates are found in other studies. According to Ragel et al. (2019), there is a close relationship between leaf potassium contents and use in plants and plant development and growth. They also reported that the presence of sufficient potassium in leaves and tissues, accumulating potassium in cell vacuoles, positively affected mineral nitrogen metabolism. Similarly, the presence of sufficient amounts of potassium in tissues is quite effective in activating the genes encoding the nitrate reductase enzyme (Li et al., 2017). The results we have obtained for potassium can be said that leaf potassium content is in appropriate amounts and therefore nitrogen metabolism is also positively affected.

In this study, in which the calcium contents altered between 0.41-3.48%, it is seen that the average leaf calcium content is 1.16% (Table 4). Mestre et al. (2017) found calcium content between 1.61-2.06% in their study on rootstocks belonging to different species. Milosevic et al. (2014), they reported that calcium concentrations varied between 1.67-1.88% in a similar study. When the results are compared, it is seen that the results obtained from both studies are among the results we found. From these results, it can be said that rootstocks in general transmit calcium very well.

It was determined that leaf magnesium values varied between 0.15-0.49% and the average magnesium content was 0.27% (Table 4). These values are similar to the study of Milosevic et al. (2014). However, they are found to be lower according to Shahkoomahally and Chaparro (2020), Jimenes et al. (2018) and Mestre et al. (2017). In our study, it is understood that leaf magnesium content remained within the adequacy limits (0.10-0.40%). When it looks at the transmission of macronutrients by rootstocks in general, it is seen that positive results appear.

It is very normal that the results of our study are compatible with some literature and incompatible with others. Because plant, soil, climate and other ecological conditions are very important factors in the intake and selectivity of plant nutrients. In other literature also on this subject, it has been reported that plant leaf components show significant changes compared to rootstocks (Jimenez et al., 2018; Yahmed et al., 2020). Even if of the same species, different rootstocks transmit the different proportions of plant nutrients are largely related to the diameter of the xylem transmission bundles of rootstocks (Tombesi et al., 2011), and the ion uptake of its physiology with Root morphology (Nawaz et al., 2011; Mestre et al., 2015). Likewise, Marschner (2012) reported that the structure, surface area and cation exchange capacity of the root system are important features in the uptake of nutrients from the soil. In this sense, the use of the correct rootstock and the efficiency of fertilization are very important in terms of yield in modern fruit growing (Savvas et al., 2009). On the basis of genotype, the highest scores in the transmission of all macronutrients were 44 AK 06 (*P. cerasifera*) (30 points), 23 AR 15 (*P. spinosa*) (25 points) and 23 KK 07 (*P. cerasifera*) and 23 KK 15 (*P. cerasifera*) (24 points) rootstocks are understood to have (Table 4). The lowest scores were taken by 44 YY 07 (*P. domestica*) and 44 YY 18 (*P. domestica*) (11 points), 44 AK 13 (*P. domestica*) (9 points) and 23 KK 13 (*P. divaricata*) (7 points) rootstocks (Table 4). In general, when foliar nutrient contents were examined on a species basis, it was observed that rootstock candidates belonging to *P. spinosa*

https://doi.org/10.30910/turkjans.919682

species transmitted macronutrients better. It was determined that these rootstocks were followed by *P. cerasifera* rootstocks, and *P. divaricata* and *P. domestica* rootstocks remained at a lower level in the transmission of macronutrients compared to the other group rootstocks. In addition, in the study 40 rootstocks scored above the control rootstocks in total score (Table 4).

Table 4. Transmission status and scoring list of macronutrients up taken by all selected rootstocks

| Line Number | Code | *Species* | P (%) | P score | K (%) | K score | Ca (%) | Ca score | Mg (%) | Mg score | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 44 AK 06 | *P.cerasifera* | 0,55 | 10 | 1,59 | 5 | 2,40 | 10 | 0,34 | 5 | 30 |
| 2 | 23 AR 15 | *P.spinosa* | 0,24 | 3 | 1,06 | 2 | 3,48 | 10 | 0,49 | 10 | 25 |
| 3 | 23 KK 07 | *P.cerasifera* | 0,33 | 5 | 1,90 | 7 | 1,26 | 4 | 0,43 | 8 | 24 |
| 4 | 23 KK 15 | *P.cerasifera* | 0,28 | 4 | 1,51 | 5 | 1,97 | 8 | 0,42 | 7 | 24 |
| 5 | 23 MR 03 | *P.divaricata* | 0,35 | 5 | 1,92 | 7 | 1,43 | 5 | 0,34 | 5 | 22 |
| 6 | 44 YY 16 | *P.cerasifera* | 0,46 | 8 | 1,90 | 7 | 1,07 | 3 | 0,28 | 4 | 22 |
| 7 | 44 YY 24 | *P.cerasifera* | 0,31 | 4 | 1,99 | 8 | 1,43 | 5 | 0,31 | 5 | 22 |
| 8 | 23 AR 04 | *P.spinosa* | 0,29 | 4 | 1,60 | 6 | 1,72 | 6 | 0,31 | 5 | 21 |
| 9 | 23 AR 18 | *P.cerasifera* | 0,37 | 6 | 1,55 | 5 | 1,53 | 5 | 0,33 | 5 | 21 |
| 10 | 23 KK 05 | *P.cerasifera* | 0,32 | 5 | 1,92 | 7 | 1,45 | 5 | 0,29 | 4 | 21 |
| 11 | 44 AK 02 | *P.divaricata* | 0,34 | 5 | 1,58 | 5 | 1,40 | 5 | 0,35 | 6 | 21 |
| 12 | 44 AK 04 | *P.cerasifera* | 0,28 | 4 | 1,62 | 5 | 1,76 | 7 | 0,34 | 5 | 21 |
| 13 | 23 AK 12 | *P.domestica* | 0,28 | 4 | 1,55 | 5 | 1,64 | 6 | 0,33 | 5 | 20 |
| 14 | 23 KK 16 | *P.spinosa* | 0,35 | 5 | 2,40 | 10 | 0,94 | 2 | 0,25 | 3 | 20 |
| 15 | 23 KK 17 | *P.cerasifera* | 0,31 | 4 | 1,66 | 6 | 1,63 | 6 | 0,27 | 4 | 20 |
| 16 | 23 KK 18 | *P.cerasifera* | 0,43 | 7 | 1,97 | 7 | 0,84 | 2 | 0,28 | 4 | 20 |
| 17 | 44 AK 09 | *P.cerasifera* | 0,35 | 5 | 1,62 | 5 | 1,57 | 6 | 0,27 | 4 | 20 |
| 18 | 44 YY 11 | *P.cerasifera* | 0,38 | 6 | 1,56 | 5 | 1,39 | 5 | 0,29 | 4 | 20 |
| 19 | 44 YY 13 | *P.domestica* | 0,29 | 4 | 1,98 | 7 | 1,52 | 5 | 0,30 | 4 | 20 |
| 20 | 23 KV 04 | *P.spinosa* | 0,24 | 3 | 1,80 | 6 | 1,53 | 5 | 0,32 | 5 | 19 |
| 21 | 23 MR 04 | *P.domestica* | 0,33 | 5 | 2,17 | 9 | 0,95 | 2 | 0,24 | 3 | 19 |
| 22 | 44 YY 08 | *P.cerasifera* | 0,36 | 6 | 1,88 | 7 | 0,98 | 2 | 0,30 | 4 | 19 |
| 23 | 23 KK 09 | *P.cerasifera* | 0,30 | 4 | 1,76 | 6 | 1,42 | 5 | 0,28 | 3 | 18 |
| 24 | 23 KK 12 | *P.cerasifera* | 0,29 | 4 | 1,40 | 5 | 1,39 | 5 | 0,29 | 4 | 18 |
| 25 | 23 KK 14 | *P.cerasifera* | 0,28 | 4 | 1,57 | 5 | 1,36 | 4 | 0,34 | 5 | 18 |
| 26 | 23 PA 05 | *P.domestica* | 0,28 | 4 | 1,86 | 7 | 1,09 | 3 | 0,29 | 4 | 18 |
| 27 | 44 AK 17 | *P.divaricata* | 0,27 | 3 | 1,65 | 6 | 1,40 | 5 | 0,29 | 4 | 18 |
| 28 | 44 AK 10 | *P.cerasifera* | 0,29 | 3 | 1,75 | 6 | 1,44 | 5 | 0,27 | 4 | 18 |
| 29 | 44 YY 02 | *P.cerasifera* | 0,37 | 6 | 1,92 | 7 | 0,78 | 2 | 0,24 | 3 | 18 |
| 30 | 44 YY 20 | *P.divaricata* | 0,25 | 3 | 1,78 | 6 | 1,23 | 4 | 0,32 | 5 | 18 |
| 31 | 44 YY 22 | *P.divaricata* | 0,33 | 5 | 1,78 | 6 | 1,13 | 3 | 0,29 | 4 | 18 |
| 32 | 23 AR 09 | *P.spinosa* | 0,33 | 5 | 1,66 | 6 | 1,14 | 3 | 0,25 | 3 | 17 |
| 33 | 23 KK 02 | *P.cerasifera* | 0,37 | 6 | 2,09 | 8 | 0,67 | 1 | 0,19 | 2 | 17 |
| 34 | 23 KK 03 | *P.cerasifera* | 0,32 | 5 | 1,93 | 7 | 1,00 | 2 | 0,23 | 3 | 17 |
| 35 | 23 KK 06 | *P.cerasifera* | 0,33 | 5 | 1,71 | 6 | 1,01 | 2 | 0,27 | 4 | 17 |
| 36 | 23 KV 01 | *P.cerasifera* | 0,35 | 5 | 1,98 | 7 | 1,03 | 2 | 0,28 | 3 | 17 |
| 37 | 44 YY 01 | *P.domestica* | 0,33 | 5 | 1,70 | 6 | 1,13 | 3 | 0,24 | 3 | 17 |
| 38 | 44 YY 06 | *P.domestica* | 0,27 | 3 | 1,73 | 7 | 1,36 | 4 | 0,25 | 3 | 17 |

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Continuation of **Table 4.**

| Line Number | Code | *Species* | P (%) | P score | K (%) | K score | Ca (%) | Ca score | Mg (%) | Mg score | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 39 | 44 YY 12 | *P.cerasifera* | 0,36 | 6 | 1,56 | 5 | 0,84 | 2 | 0,30 | 4 | 17 |
| 40 | 44 YY 23 | *P.divaricata* | 0,25 | 3 | 2,10 | 8 | 1,07 | 2 | 0,29 | 4 | 17 |
| 41 | Control | *P.cerasifera* | 0,33 | 4 | 1,77 | 6 | 1,36 | 3 | 0,30 | 4 | 17 |
| 42 | 23 AR 05 | *P.spinosa* | 0,28 | 4 | 1,91 | 7 | 0,85 | 2 | 0,25 | 3 | 16 |
| 43 | 23 AR 10 | *P.cerasifera* | 0,25 | 3 | 1,55 | 5 | 1,39 | 5 | 0,26 | 3 | 16 |
| 44 | 23 KL 01 | *P.cerasifera* | 0,31 | 4 | 1,82 | 7 | 0,98 | 2 | 0,26 | 3 | 16 |
| 45 | 23 KV 02 | *P.domestica* | 0,31 | 4 | 1,29 | 3 | 1,26 | 4 | 0,34 | 5 | 16 |
| 46 | 23 KV 03 | *P.spinosa* | 0,26 | 3 | 1,80 | 6 | 1,19 | 3 | 0,30 | 4 | 16 |
| 47 | 23 MR 05 | *P.divaricata* | 0,31 | 4 | 1,73 | 6 | 1,08 | 3 | 0,25 | 3 | 16 |
| 48 | 44 AK 15 | *P.divaricata* | 0,24 | 3 | 1,78 | 6 | 1,20 | 3 | 0,27 | 4 | 16 |
| 49 | 44 YY 04 | *P.cerasifera* | 0,35 | 5 | 1,58 | 5 | 0,75 | 2 | 0,27 | 4 | 16 |
| 50 | 44 YY 09 | *P.cerasifera* | 0,28 | 4 | 1,55 | 5 | 1,21 | 3 | 0,29 | 4 | 16 |
| 51 | 44 YY 15 | *P.domestica* | 0,31 | 4 | 1,68 | 6 | 0,84 | 2 | 0,27 | 4 | 16 |
| 52 | 23 AR 13 | *P.spinosa* | 0,31 | 4 | 1,85 | 7 | 0,82 | 2 | 0,19 | 2 | 15 |
| 53 | 23 KK 04 | *P.cerasifera* | 0,34 | 5 | 1,98 | 7 | 0,68 | 1 | 0,19 | 2 | 15 |
| 54 | 44 AK 01 | *P.cerasifera* | 0,32 | 5 | 1,81 | 6 | 0,84 | 2 | 0,21 | 2 | 15 |
| 55 | 44 AK 03 | *P.divaricata* | 0,33 | 5 | 1,58 | 5 | 0,80 | 2 | 0,23 | 3 | 15 |
| 56 | 44 YY 03 | *P.domestica* | 0,30 | 4 | 1,82 | 7 | 0,81 | 2 | 0,21 | 2 | 15 |
| 57 | 44 YY 10 | *P.domestica* | 0,33 | 5 | 1,79 | 6 | 0,87 | 2 | 0,19 | 2 | 15 |
| 58 | 44 YY 19 | *P.cerasifera* | 0,31 | 4 | 1,79 | 6 | 0,75 | 2 | 0,26 | 3 | 15 |
| 59 | 44 DR 04 | *P.cerasifera* | 0,27 | 3 | 1,32 | 4 | 1,34 | 4 | 0,24 | 3 | 14 |
| 60 | 23 KK 08 | *P.cerasifera* | 0,26 | 3 | 1,72 | 6 | 0,95 | 2 | 0,29 | 3 | 14 |
| 61 | 44 AK 05 | *P.divaricata* | 0,33 | 5 | 1,53 | 5 | 0,91 | 2 | 0,21 | 2 | 14 |
| 62 | 44 YY 05 | *P.domestica* | 0,34 | 5 | 1,66 | 6 | 0,71 | 1 | 0,20 | 2 | 14 |
| 63 | 44 YY 17 | *P.domestica* | 0,37 | 6 | 1,69 | 6 | 0,41 | 1 | 0,16 | 1 | 14 |
| 64 | 23 KK 11 | *P.domestica* | 0,34 | 5 | 1,67 | 6 | 0,49 | 1 | 0,17 | 1 | 13 |
| 65 | 44 AK 14 | *P.divaricata* | 0,30 | 4 | 1,76 | 6 | 0,59 | 1 | 0,19 | 2 | 13 |
| 66 | 44 AK 16 | *P.divaricata* | 0,27 | 3 | 1,71 | 6 | 1,02 | 2 | 0,20 | 2 | 13 |
| 67 | 44 YY 07 | *P.domestica* | 0,27 | 3 | 1,64 | 5 | 0,65 | 1 | 0,21 | 2 | 11 |
| 68 | 44 YY 18 | *P.domestica* | 0,21 | 2 | 1,33 | 4 | 0,98 | 2 | 0,23 | 3 | 11 |
| 69 | 44 AK 13 | *P.domestica* | 0,26 | 3 | 1,45 | 4 | 0,45 | 1 | 0,15 | 1 | 9 |
| 70 | 23 KK 13 | *P.divaricata* | 0,16 | 1 | 0,80 | 1 | 0,84 | 2 | 0,24 | 3 | 7 |
| | Minimum | | 0,16 | 1 | 0,80 | 1 | 0,41 | 1 | 0,15 | 1 | 7 |
| | Maximum | | 0,55 | 10 | 2,40 | 10 | 3,48 | 10 | 0,49 | 10 | 30 |
| | Average | | 0,31 | | 1,71 | | 1,16 | | 0,27 | | |

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## Conclusion and Recommendations

With this study, it was revealed that the macro elements generally coincide with the limit values, compared to data of some studies phosphorus and potassium were in high ratios, and calcium, and magnesium remained lower. In addition, in this study, it was determined that the contents of leaf phosphorus, potassium, calcium and magnesium elements varied significantly according to each rootstock and most of them were among the adequacy limit values. At the end of the study, it was concluded that there is no problem in the transmission of macro nutrients such as phosphorus, potassium, calcium and magnesium to the leaves in selected rootstocks. It gives promising results in general and it would be beneficial to consider this situation in future studies.

**Conflict of Interest Statement:** The authors of the article declare that there is no conflict of interest between them.

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