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Performance of some *Prunus* rootstocks to transmit micronutrients to leaves

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Abstract

This study was conducted to investigate the intake of micro plant nutrients of promising genotypes in the selection study of some wild plums that can be rootstock for apricots in Malatya and Elazığ region. The study was carried out in 2020 on the land of Malatya Apricot Research Institute and in the Soil, Plant and Water Analysis Laboratory of the Kahramanmaraş Eastern Mediterranean Transitional Zone Agricultural Research Institute. Soil samples were conducted from 0-30 cm and 30-60 cm depths in order to determine the micronutrients in the soil from the area where the trial was established. According to the analysis results, it was determined that the micronutrient elements examined in the top soil (0-30 cm), except boron, were at sufficient levels. As a result of the analysis of leaf samples taken from 69 rootstocks selected in June, scoring was made by applying weighted 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, in the leaf contents, iron 33.65-101.00 mg kg^{-1}, manganese 19.01-106.27 mg kg^{-1}, copper 4.15-13.03 mg kg^{-1}, zinc 9.25-35.55 mg kg^{-1} and boron 19.54-35.55 mg kg^{-1} varied between. It has been determined that obtained these values are highly similar to the reference values, and when compared with other literature data, manganese is high, iron is relatively low, and other micronutrients elements are sufficient.

Keywords: Plant nutrition, Scion, Selected rootstocks, Soil and leaf analysis, Weighted grading

Introduction

Fruit trees, consist of two different plants as rootstock and scion produced by grafting. Although these two different plant parts have different genetic structures, they are in mutual symbiotic relationship (Shahkoomahally et al., 2020). With the variety that forms the scion part, the breeding of the plant in the rootstock part contains different criteria (Hernández et al., 2010). In fruit trees, which have a long generation period, since the breeding of the variety takes a long time also, it is the most practical method to reproduce these varieties by grafting. With the grafting becoming necessary, the importance of using rootstock has increased one more time (Taaren et al., 2016). The foremost criterion for a rootstock is the intake of plant nutrients from the soil at desired rates (Yahmed et al., 2020). Nawaz et al. (2016) also reported that the intake of plant nutrients at desired rates is closely related to the yield and quality of the variety grafted on the rootstock. However, considering the demands from producers and consumers, and the rapid changes in biotic and abiotic climate and soil conditions, the importance of rootstock breeding studies is better understood (Tombesi et al., 2011; Gündeşli, 2018). Rootstocks affect resistance to soil biotic factors such as growth force (Beckman et al., 1992; Layne, 1994), yield, quality, nematode as well as also the uptake and use of plant nutrients (Boyhan et al., 1995) with the phenological properties of the fruit varieties grafted on them. The factor that plays an important role in the emergence of all these features is the healthy transmission of plant nutrients from the rootstock to the scions.

Plum rootstocks provide dwarfing in the growth strength in apricot varieties grafted on them. Such situations in which vegetative growth is suppressed causes an increase in leaf nutrient content and the nutrient competition between vegetative growth and fruits in favor of fruit (Faust, 1989). Failure of the developed rootstocks to adapt well to different soil conditions causes difficulties in the transmission of plant nutrients, as well as problems in the graft compatibility rate and post-grafting development.

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Fe, Mn, Cu, Zn and B are known as micronutrients in plant nutrition. Although these elements are uptaken very little by plants, they have very important roles in plant metabolism. They are essential elements as catalysts in chlorophyll formation, oxidation and reduction mechanisms in plants. It has been reported that micronutrients are an important source in the mobility of nutrients in the vegetative tissues of plants, but there is not enough information about these mobility mechanisms (Pearson and Rengel, 1994).

This research study was conducted on the land of Malatya Apricot Research Institute and in Soil, Plant and Water Analysis Laboratory belonging to Kahramanmaraş Eastern Mediterranean Transitional Zone Agricultural Research Institute in 2020, in order to determine the transmission of micronutrients from soil to leaves in different plum species obtained by selection breeding in Malatya and Elazığ provinces.

Materials and Methods

Four different species of Plum genotypes (Prunus cerasifera, Prunus divaricata, Prunus domestica and Prunus spinosa) determined by selection breeding from Malatya and Elazığ regions were used as material in this study. Myrobolan 29C (Prunus cerasifera) was used as a control plant. From these rooted genotypes, a garden was established on the land of Malatya Apricot Research Institute in October 2019, with a distance of 1.5 m x 1 m above and between rows. Three samplings of each genotype were planted. Leaf samples were taken from single-year seedlings. Full-grown leaf samples were taken from each of these seedlings that had completed one year of age.

Soil samples

A total of 40 soil samples were collected from depths of 0-30 cm and 30-60 cm by zigzagging walking (Z-shaped) among the rootstocks used in the study in order to represent the study area. 20 soil samples taken from a depth of 0-30 cm were thoroughly mixed in a clean bucket and made into a single sample of 2 kg. The same procedure was done by taking it from 30-60 cm depth also. 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 pieces of branches 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 according to the modified Bouyoucus hydrometer method (Klute, 1986). The soil reaction (pH) was measured by pH meter with glass electrodes in soil (sature the soil reaction (pH) was measured by pH meter with glass electrodes in soil (saturated sludge) saturated with water prepared as reported by Richards (1954). Total salt contents (%), 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). SOM (%) was determined by the Walkley-Black method modified by Richards (1954). The amounts of available iron, manganese, copper and zinc (mg kg^{-1}), as Lindsay and Norvell (1978) reported, were determined with the Agilent 5100 brand ICP-OES device measuring of the filtered solutions obtained from soils extracted with DTPA solution (Klute, 1986). Boron contents that can be taken by the plants were determined in the ICP-OES device according to the method reported by Klute (1986).

Leaf samples

Collecting leaf samples:

In June, leaves were selected, which completed the development from the middle part of their sprouts of the seedlings were selected. 150 leaves were collected from each iteration. 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 cleaned and discarded. Then, the dust on it was cleaned by pre-washing. Next, it was passed through the 0.1 N HCl solution and washed with pure water. The washed leaves were laid loosely and left to dry in the drying cabinet at 65 °C until their weight did not change (about 48 hours). The dried samples; it was stored in the refrigerator until it was analyzed in plastic bags in a labeled way (Lilleland and McCollam, 1961; Steyn, 1961; Sannoveld and Dijk, 1982; Kacar, 2008).

Determination of nutrients uptaken by plants:

The dried leaf samples were ground in a tungsten coated hand mill. 0.30 g was taken from the milled 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 wet digestion, samples were filtered and Fe, Mn, Cu, Zn and B 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 the 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, each plant nutrient was given a score according to its minimum and maximum values. The scoring was based on the coefficient obtained from the minimum and maximum difference. After collecting their scores took from each plant nutrient of the rootstock candidates, the total points that micronutrients

received were obtained. After applying the re-modified weighed grading to these scores, the general status of the rootstocks in the transmission of nutrients was determined.

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

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

Iron			Copper			Manganese			Zinc			Boron		
Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
33,65	101	6,74	4,15	13,03	0,89	19,01	106,27	8,73	9,25	35,55	2,63	19,54	75,55	5,60
Scores			Scores			Scores			Scores			Scores		
1	33.65	40,39	1	4.15	5,04	1	19.01	27,74	1	9.25	11,88	1	2.63	25,14
2	40,4	47,14	2	5,05	5,94	2	27,75	36,48	2	11,89	14,52	2	25,15	30,75
3	47,15	53,89	3	5,95	6,84	3	36,49	45,22	3	14,53	17,16	3	30,76	36,36
4	53,90	60,64	4	6,85	7,74	4	45,23	53,96	4	17,17	19,80	4	36,37	41,97
5	60,65	67,39	5	7,75	8,64	5	53,97	62,70	5	19,81	22,44	5	41,98	47,58
6	67,40	74,14	6	8,65	9,54	6	62,71	71,44	6	22,45	25,08	6	47,59	53,19
7	74,15	80,89	7	9,55	10,44	7	71,45	80,18	7	25,09	27,72	7	53,2	58,80
8	80,90	87,64	8	10,45	11,34	8	80,19	88,92	8	27,73	30,36	8	58,81	64,41
9	87,65	94,39	9	11,35	12,24	9	88,93	97,66	9	30,37	33	9	64,42	70,02
10	94,40	<	10	12,25	<	10	97,67	<	10	33,01	<	10	70,03	<

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

Name of the element	Chemical icon	Content in dry matter (mg kg^{-1})	Available shape for plant
Iron	Fe	100 (50-250)	Fe^{+2}, Fe^{+3}
Manganese	Mn	50 (20-200)	Mn^{2+}
Copper	Cu	6	Cu^{+}, Cu^{+2}
Zinc	Zn	20	Zn^{2+}
Boron	B	20 (6-60)	BO_3^{-3}, $B_4O_7^{-2}$

Results and Discussion

Soil properties according to analysis results

According to soil analysis results; the soils of the research area were determined as loamy, slightly alkaline and non-saline. The study area soils were found extremely calcareous also at both depths (0-30 cm and 30-60 cm). The fact that the soils are very calcareous can be due to the parent material. Topsoil (0-30 cm) contains well, subsoil (30-60 cm) contains moderate organic matter. In a depth of 0-30 cm, available iron, manganese, copper and zinc were determined to be sufficient for plants. But, at a depth of 30-60 cm, zinc may have been binded to clay minerals, organic matter or lime, converting into an unavailable form for plants. It has been found that the boron that can be taken by the plants is not to be sufficient for the plant also at both depths (Table 3). Yılmaz et al. (2020), in a their study conducted in Malatya soils, reported that 25.42% of Malatya soils had very little and little boron deficiency and the reasons for this were due to the fact that the soils were the slightly alkaline and calcareous. It is thought that the fact that the soils of the study area are loam texture, that is, in a permeable structure, may also cause the boron to be washed.

Evaluations in Table 3; texture was made according to Bouyoucos (1951), and pH was evaluated according to USDA (1998), and total saline was evaluated according to USDA (2018), and lime was evaluated according to FAO (2006), and organic matter was according to Ülgen and Yurtseven (1995), and available iron, manganese, copper and zinc were according to Lindsay and Norvell (1978), and also available boron was according to Wolf (1971).

Results related to the transmission of nutrients from the soil to the leaves

Leaf iron contents in all rootstocks were distribution between 33.65 mg kg^{-1} and 101.00 mg kg^{-1} (Table 4 and 5). The highest leaf iron contents were found in 23 KV 03 (*P. spinosa*), 23 KK 12 (*P. cerasifera*) and 23 MR 03 (*P. divaricata*) rootstocks, and determined as 101.00 mg kg^{-1}, 95.66 mg kg^{-1} and 95.63 mg kg^{-1}, respectively (Table 4). The lowest iron contents were found in 23 KK 13 (*P. divaricata*, 33.65 mg kg^{-1}, Table 5), 23 AK 12 (*P. domestica*, 40.23 mg kg^{-1}, Table 4) and 23 KK 11 (*P. domestica*, 41.04 mg kg^{-1}, Table 4) rootstocks. It was determined that the average leaf iron content of all rootstocks was 58.48 mg kg^{-1} (Table 5). When leaf iron contents of the rootstocks are examined in

general, it is seen that leaf iron contents of 55 of seventy rootstocks are compatible with the reference values. Mestre et al. (2015), in a their conducted on peaches, it is understood that the results they received around 59.8-86.3 mg kg^{-1} on average were similar to our study. The leaf iron contents of rootstocks were found to be high according to the results of Jimenez et al. (2008). The other fifteen rootstocks used in the study showed no leaf degradation that would cause a high degree of chlorosis. Iron content of rootstocks is closely related with chlorosis. This also directly affects the content of leaf chlorophyll. In rootstocks, iron deficiency in microelements and, accordingly, chlorosis is an important criterion. Rootstocks are requested to transfer sufficient amount of iron to the scion grafted onto itself, it at high pH. This situation, which is increased the quality of the leaf and the amount of chlorophyll, also increases the efficiency of photosynthesis. In general, it has been reported that iron uptake mechanism of the root system in rootstocks is in two different ways (Tagliavani & Rombola, 2001). Gündeşli et al. (2020) reported in a study they conducted that these mechanisms may differ in terms of the operating speed in rootstocks, therefore the selection of appropriate rootstocks is important. We can say that this situation is foreseen as an important criterion in rootstock selection. Plants uptake iron with their roots from the soil. If they do not get enough, the deficiency is eliminated by foliar fertilization. In this sense, rootstock becomes more important (Mayer et al., 2015). Because rootstock means the root of the plant to be grafted on. It is understood that most of the rootstocks used in the study are promising.

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	Slightly alkaline	7.76	Slightly alkaline
Total saline (%)	0.042	Non-saline	0.041	Non-saline
Lime (%)	37.72	Extremely calcareous	38.38	Extremely calcareous
Organic matter (%)	3.25	Good	2.67	Good
Available iron (mg kg^{-1})	6.49	Good	8.02	Medium
Available manganese (mg kg^{-1})	6.65	Sufficient	6.26	Sufficient
Available copper (mg kg^{-1})	4.14	Sufficient	1.80	Sufficient
Available zinc (mg kg^{-1})	0.95	Sufficient	0.40	Low
Available boron (mg kg^{-1})	0.87	Low	0.87	Low

Leaf manganese contents of rootstocks varied between 19.01 mg kg^{-1} and 106.27 mg kg^{-1} (Table 4). In the distribution where the average manganese content was 50.24 mg kg^{-1} (Table 5), the manganese contents of 32 rootstocks were determined above the average value. When compared with the reference values, it is understood that the leaf manganese content is at the desired level. Looking at the results obtained from similar studies, Karlıdağ et al. (2019) determined the average leaf manganese contents as 32.09 mg kg^{-1} in apricot, and Milosevic and Milosevic (2011) found the average leaf manganese content between 20.71 mg kg^{-1} and 68.82 mg kg^{-1} in their study. These results appear to be similar to our results. Jimenesa et al. (2018) found the manganese contents of leaves between 36.74-74.32 mg kg^{-1} in a study they conducted on peaches. Similar values have been also reported by Mestre et al. (2017). Although these results are somewhat high, it is seen that they are generally compatible with the results obtained from our study.

It is understood from the tables that leaf copper contents in selected rootstocks range between 4.15 mg kg^{-1} and 13.03 mg kg^{-1} (Table 4 and 5). In the distribution where the average copper content is around 8.64 mg kg^{-1} (Table 5), it is seen that 32 rootstocks are above the average value, and when compared with the reference values, almost leaves of all rootstocks have high copper content. When compared with the sufficiency levels, it was also determined that there was no copper deficiency in the leaves of all rootstocks (Table 2). This situation can be explained by the fact that there is no problem in transmitting the copper nutrient, which is taken from the soil enough, to the leaves and is accumulated in the leaves. In other words, in all the rootstocks, there appears to be no problem in uptaking copper from the soil and transmitting it to the leaves.

It is seen in Tables that the leaf zinc content of all selected rootstocks varied between 9.25 mg kg^{-1} and 35.55 mg kg^{-1} (Table 4). Zinc contents of the rootstocks an average were found as 18.80 mg kg^{-1} (Table 4), and 25 of rootstocks were determined above the average sufficiency amounts. In the rest of the rootstocks, it was determined that the obtained leaf zinc contents were at sufficient levels and there was no any deficiency. In fact, it is seen that there is

a widespread lack of microelements in the territory of Turkey where agriculture is carried out. Zinc and iron deficiency are the leading them (Eyüpoğlu et al., 1993; Aliyazıcıoğlu et al., 2013). Research has reported that the most accurate and practical way of uptaking zinc in plants and transferring it to products would be the selection of genotypes with good zinc intake (Çakmak et al., 1998; Ullah et al., 2017). It is welcomed that the zinc values of the rootstocks used in our study are realized at the expected levels.

In the rootstocks used in our study, leaf boron contents showed a distribution between 19.54 mg kg^{-1} and 75.55 mg kg^{-1} (Table 4). The average boron value was found to be 23.49 mg kg^{-1} (Table 5). Considering this average value, it is understood that the leaf boron contents of the rootstocks used in the study are at optimum values and there will be no boron deficiency or toxicity. Especially due to its active role in many physiological events such as fertilization and fruit formation, and due to the losses of yield and quality in its deficiency, this nutrient element is also requested to be found between 6-60 mg kg^{-1} in plant leaves (Jones et al., 1991). In a previous study, it was reported that the average leaf boron content varied according to varieties and showed distribution between 60-80 mg kg^{-1} (Çakmak, 2002). The values (23.62-92.54 mg kg^{-1}) related to the leaf boron contents obtained from the study conducted by Milosevic and Milosevic (2011) on apricots can be given this as an example. Kacar and Fox (1967) reported that boron concentrations in 20 soils, they collected from different parts of Turkey ranged from 0.70-4.55 mg kg^{-1} and that 25% of soils had boron deficiency. Although there is an available boron deficiency in both depths in soils of the working garden, no deficiency was detected in the leaves of the rootstocks. It is thought that the reason for this is that the plants completed their deficiency by uptaking the available boron from irrigation water. Or it may have uptaken it from the deeper soil where their roots reached.

As a result of the weighted grading applied to the data obtained from this research, it is seen that high differences occur in the microelement transmission in all rootstocks and each genotype transmits different microelement at a level that can be considered good. It is understood that the scores in the total scoring range between 9.00 and 37.00 and the average score is 23.49 (Table 4 and 5). Considering the general distribution, it is seen that 40 of the rootstocks have an average value and above, and 10 of them get scores close to the average. It is understood that the remaining 20 rootstocks are around 10 points (Tables 4 and 5). Forcada et al. (2020) reported that the difference in nutrient transmission between rootstocks is accepted as normal and this is due to genetic variation, therefore it is important to select the appropriate rootstock. While the rootstocks that got the highest scores according to the micronutrients they absorbed, they were 23 KK 18 (*P. cerasifera*), 23 MR 04 (*P. domestica*) and 23 AR 18 (*P. cerasifera*), the scores of these rootstocks were also determined as 37.00, 34.00 and 33.00 (Table 4), respectively. The rootstocks with the lowest scores were also determined as 44 YY 06 (P. domestica) (14.00), 44 AK 13 (P. domestica) (13.00) and 44 YY 18 (P. domestica) (9.00) (Table 5).

Conclusion

In the majority of Turkey's soil, the soil reaction (pH) is known to be slightly alkaline. This situation causes major problems in the uptake of many microelements, especially iron, and malfunctions in plant growth and consequently yield losses. In modern fruit growing, this deficiency is tried to be overcome by appropriate fertilization programs. However, not using the appropriate rootstock greatly reduces the effectiveness of these programs. Therefore, in the studies of rootstock breeding, it is very important that the efficiency of the rootstock to uptake plant nutrients from the soil is high. In this research which we have done, the study data on the selected rootstocks uptaking the plant nutrients from the soil and transmitting them to the leaves were found promising. In the study, 70 rootstocks were used (Table 4). These rootstocks were compared with the control rootstock and it was examined to what extent they took nutrients from the soil. At the end of the study, it was determined that most of the rootstock candidates (46 of them) had higher leaf nutrient content than the control rootstock. These performances of rootstock candidates mean that they are promising considering the values of the control rootstock. As a result of the study, no selection was made, and these results will be taken into account in the future selection.

Compliance with Ethical Standards

Conflict of interest

The authors declared that for this research article, they have no actual, potential or perceived conflict of interest.

Author contribution

The contribution of the authors to the present study is equal.

All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

Ethical approval

Ethics committee approval is not required.

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Data availability

Not applicable.

Consent for publication

Not applicable.

Table 4. Transmission status and scoring list of micronutrients uptaken by all selected rootstocks.

Line number	Code	*Species*	Fe (mg kg^{-1})	Fe scores	Mn (mg kg^{-1})	Mn scores	Cu (mg kg^{-1})	Cu scores	Zn (mg kg^{-1})	Zn scores	B (mg kg^{-1})	B scores	Micro total
1	23 KK 18	*P.cerasifera*	90.50	9	54.24	5	11.36	9	35.55	10	37.58	4	37.00
2	23 MR 04	*P.domestica*	88.32	9	35.24	2	10.20	8	23.41	6	66.91	9	34.00
3	23 AR 18	*P.cerasifera*	64.11	5	64.10	6	10.50	8	26.37	7	55.90	7	33.00
4	23 KK 05	*P.cerasifera*	65.56	5	63.51	6	9.75	6	22.56	5	72.47	10	32.00
5	23 KK 12	*P.cerasifera*	95.66	10	40.28	3	9.25	7	17.74	4	63.52	8	32.00
6	23 KV 03	*P.spinosa*	101.00	10	61.83	5	8.02	5	17.58	4	60.14	8	32.00
7	44 AK 06	*P.cerasifera*	62.38	5	101.46	10	12.34	10	21.12	5	29.24	2	32.00
8	23 MR 03	*P.divaricata*	95.63	10	53.81	4	8.80	7	12.12	2	64.24	8	31.00
9	44 AK 02	*P.divaricata*	58.55	4	60.12	5	10.80	9	17.04	3	72.42	10	31.00
10	44 YY 11	*P.cerasifera*	75.90	7	106.27	10	9.42	7	19.23	4	30.55	2	30.00
11	44 YY 16	*P.cerasifera*	57.41	4	66.86	6	13.03	10	27.59	7	36.24	3	30.00
12	23 KK 15	*P.cerasifera*	49.99	3	81.54	8	8.56	5	20.59	5	62.19	8	29.00
13	23 KK 16	*P.spinosa*	68.20	6	51.94	3	9.13	7	24.60	6	49.12	7	29.00
14	23 KK 04	*P.cerasifera*	52.74	3	43.48	3	10.66	8	18.34	4	75.55	10	28.00
15	23 KV 02	*P.domestica*	55.68	4	40.38	4	11.48	9	19.25	4	56.01	7	28.00
16	44 AK 03	*P.divaricata*	55.43	4	36.83	3	9.02	7	18.25	4	70.29	10	28.00
17	23 KK 09	*P.cerasifera*	50.78	3	71.08	6	11.13	8	17.04	3	55.68	7	27.00
18	23 KL 01	*P.cerasifera*	61.63	5	38.95	3	10.36	7	17.76	4	61.52	8	27.00
19	23 KV 01	*P.cerasifera*	60.15	4	44.57	3	9.16	7	23.60	6	55.67	7	27.00
20	23 AK 12	*P.domestica*	40.23	1	64.22	6	7.93	5	27.40	7	53.95	7	26.00

Table 4. Transmission status and scoring list of micronutrients uptaken by all selected rootstocks (continuation)

Line number	Code	*Species*	Fe (mg kg^{-1})	Fe scores	Mn (mg kg^{-1})	Mn scores	Cu (mg kg^{-1})	Cu scores	Zn (mg kg^{-1})	Zn scores	B (mg kg^{-1})	B scores	Micro total
21	23 KK 03	*P.cerasifera*	60.83	5	66.43	6	8.69	6	24.08	6	34.39	3	26.00
22	23 PA 05	*P.domestica*	48.51	3	39.65	3	7.93	5	21.39	5	74.86	10	26.00
23	44 YY 02	*P.cerasifera*	62.08	6	39.29	3	10.86	8	17.83	4	37.88	5	26.00
24	23 AR 09	*P.spinosa*	58.93	4	42.00	3	10.20	8	17.09	3	57.17	7	25.00
25	23 KK 02	*P.cerasifera*	52.55	3	30.20	2	10.22	7	28.41	8	43.32	5	25.00
26	23 KK 14	*P.cerasifera*	60.91	5	46.21	4	7.02	5	16.59	3	60.25	8	25.00
27	44 AK 17	*P.divaricata*	52.18	3	69.91	6	8.69	6	13.05	2	63.63	8	25.00
28	44 YY 24	*P.cerasifera*	74.78	7	68.45	6	7.95	5	17.70	4	34.69	3	25.00
29	23 AR 15	*P.spinosa*	50.83	3	86.45	8	6.53	3	19.55	4	51.45	6	24.00
30	44 AK 01	*P.cerasifera*	52.66	3	24.85	1	8.67	7	21.69	5	66.03	8	24.00
31	44 YY 05	*P.domestica*	78.97	7	33.52	2	10.41	7	25.76	7	22.24	1	24.00
32	44 YY 10	*P.domestica*	63.01	5	44.34	3	9.55	7	19.90	5	38.57	4	24.00

33	44 YY 17	*P.domestica*	58.49	4	28.27	2	10.02	7	27.24	7	39.66	4	24.00
34	44 YY 19	*P.cerasifera*	55.89	4	45.82	4	9.34	7	20.78	5	30.86	4	24.00
35	44 AK 05	*P.divaricata*	55.10	4	41.12	3	10.23	8	15.27	3	45.68	5	23.00
36	44 AK 10	*P.cerasifera*	58.62	4	50.71	4	8.44	5	20.40	5	43.16	5	23.00
37	44 AK 15	*P.divaricata*	59.72	4	37.65	3	7.97	5	14.79	3	62.37	8	23.00
38	44 YY 04	*P.cerasifera*	64.38	5	40.73	3	9.81	7	21.66	5	33.21	3	23.00
39	44 YY 08	*P.cerasifera*	53.19	3	82.41	8	7.48	4	22.08	5	32.62	3	23.00

Table 4. Transmission status and scoring list of micronutrients uptaken by all selected rootstocks (continuation)

Line number	Code	*Species*	Fe (mg kg^{-1})	Fe scores	Mn (mg kg^{-1})	Mn scores	Cu (mg kg^{-1})	Cu scores	Zn (mg kg^{-1})	Zn scores	B (mg kg^{-1})	B scores	Micro total
40	44 YY 15	*P.domestica*	90.83	9	48.92	4	6.65	3	20.85	5	29.63	2	23.00
41	23 KK 11	*P.domestica*	41.04	2	34.72	2	8.18	6	29.03	8	37.52	4	22.00
42	23 KK 17	*P.cerasifera*	49.31	3	72.52	7	7.78	5	14.64	3	38.04	4	22.00
43	23 KV 04	*P.spinosa*	50.59	3	59.11	5	6.61	3	10.78	3	64.14	8	22.00
44	44 AK 16	*P.divaricata*	59.14	4	48.37	4	7.54	5	13.70	2	54.58	7	22.00
45	44 YY 22	*P.divaricata*	68.69	6	59.37	5	6.96	3	16.28	3	37.74	5	22.00
46	44 YY 23	*P.divaricata*	54.09	4	42.27	3	9.16	7	14.30	3	42.59	5	22.00
47	Kontrol	*P.cerasifera*	58.48	4	50.24	4	8.64	5	18.80	4	46.08	5	22.00
48	23 AR 13	*P.spinosa*	49.41	3	35.62	2	7.44	4	17.02	3	67.03	9	21.00
49	23 KK 06	*P.cerasifera*	53.96	4	61.01	5	10.15	7	19.46	4	19.54	1	21.00
50	44 AK 09	*P.cerasifera*	57.92	4	51.65	4	8.61	5	14.44	3	42.09	5	21.00
51	44 YY 12	*P.cerasifera*	60.65	5	42.86	3	9.24	7	20.36	5	24.63	1	21.00
52	23 AR 05	*P.spinosa*	43.65	2	28.66	2	7.87	5	12.62	3	62.92	8	20.00
53	23 MR 05	*P.divaricata*	44.48	2	44.33	4	7.48	4	14.91	3	58.27	7	20.00
54	44 AK 04	*P.cerasifera*	52.69	3	66.67	6	7.38	4	14.47	2	42.90	5	20.00
55	44 DR 04	*P.cerasifera*	44.97	2	57.15	5	6.12	3	13.49	2	54.58	7	19.00
56	44 YY 01	*P.domestica*	52.01	3	44.79	3	8.90	7	19.39	4	27.54	2	19.00
57	23 KK 07	*P.cerasifera*	54.74	4	19.01	1	8.33	6	22.46	5	26.48	2	18.00
58	44 AK 14	*P.divaricata*	48.61	3	33.59	2	8.73	7	18.16	4	28.56	2	18.00
59	23 AR 04	*P.spinosa*	48.31	3	57.76	5	5.81	2	9.25	1	52.32	6	17.00

Table 5. Transmission status, and minimum, and maximum, and standard deviation values, and scoring list of micronutrients taken by all selected rootstocks.

Line number	Code	*Species*	Fe (mg kg^{-1})	Fe scores	Mn (mg kg^{-1})	Mn scores	Cu (mg kg^{-1})	Cu scores	Zn (mg kg^{-1})	Zn scores	B (mg kg^{-1})	B scores	Micro Total
60	23 AR 10	*P.cerasifera*	58.65	4	38.35	3	5.78	2	11.75	1	58.64	7	17.00
61	23 KK 08	*P.cerasifera*	44.30	2	45.01	3	7.52	4	16.36	3	42.24	5	17.00
62	44 YY 03	*P.domestica*	47.52	3	26.44	1	8.24	5	23.35	6	24.36	2	17.00
63	44 YY 13	*P.domestica*	53.50	3	56.47	5	7.58	4	16.60	3	27.96	2	17.00
64	44 YY 20	*P.divaricata*	54.11	4	54.95	5	7.46	4	10.24	1	36.34	3	17.00
65	44 YY 07	*P.domestica*	54.27	4	35.75	2	7.10	4	18.91	4	29.81	2	16.00
66	44 YY 09	*P.cerasifera*	49.12	3	52.51	4	8.38	5	14.40	2	26.18	2	16.00
67	23 KK 13	*P.divaricata*	33.65	1	53.22	4	4.15	1	12.02	2	47.67	6	14.00
68	44 YY 06	*P.domestica*	55.57	4	33.73	2	7.27	4	14.65	3	22.29	1	14.00
69	44 AK 13	*P.domestica*	42.95	3	24.51	1	6.87	3	19.48	4	28.08	2	13.00
70	44 YY 18	*P.domestica*	45.19	2	38.30	3	5.69	2	11.72	1	23.91	1	9.00
Minimum			33.65		19.01		4.15		9.25		19.54		9.00
Maximum			101.00		106.27		13.03		35.55		75.55		37.00
Average			58.48		50.24		8.64		18.80		46.08		
Standard deviation			13.4806		17.12727		1.646738		5.014842		15.44921		

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