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Research Article

# Investigations of Some Morphological, Pomological, and Physiological Parameters with Mineral Content of Different *Rosa* L. Taxa Grown under Greenhouse Condition

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**Abstract:** Horticulture is a discipline mainly concerned with the cultivation of plant material for food supply, medicinal use, or functional and aesthetic purposes by humans, they are a genetically diverse group and play an important role in the economy of modern society, as well as at the center of the healthy diet of the urban population. In this respect, *Rosa* L. are important plants for traditional pharmacological practices and landscape studies. In this context, within the scope of the research, some morphological, pomological, physiological, and mineral contents of important taxa such as *Rosa alba* L.'Semiplena', *R. banksiae* R.Br. cv '*Alba*', *R. canina* L.'Yildiz', *R. centifolia* L., *R. chinensis* Jacq. 'Old Blush', *R. foetida* Herrm., *R. heckeliana* Tratt. subsp. *vanheurckiana* (Boiss. Ö. Nilsson), *R. hemispharica* J.Herrm., *R.* x *odorata* (hort ex. Andrews) Sweet 'Louis XVI', *R. pisiformis* (Christ) Sosn., *R.* x *damascena* Mill., and *R.* x *damascena* Herrm. 'Semperflorens'(Loisel. & Michel) Rowley for landscape design and horticulture were determined. Within the scope of the research, the morphological, physiological, and pomological characteristics and nutrient contents of taxa adapted to semi-arid conditions and different *Rosa* taxa spreading in Anatolia were determined. Principal component analysis and cluster analysis were also used to determine the similarities and differences of these parameters measured in different *Rosa* L. taxa.

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## 1. Introduction

*Rosa* species are in the *Rosales* order. There are approximately 8000 species of economic and ecological importance, nine families of this order are divided into three main subgroups. Members of the *Rosaceae* family, which is one of these three subgroups, are generally distributed in the area from the temperate regions of the Northern Hemisphere to the subtropical region and contain nearly 100 genera and more than 2000 species throughout the world. There are 58 endemic *Rosa* species in Anatolia and there is an endemism rate of 24% in Turkiye (Nilsson, 1972; Campbell, 2002; Evans, 2002; Heywood et al., 2007; Hurkul and Koroglu, 2019; Altun et al., 2021).

Horticulture is a discipline primarily concerned with the cultivation of plant material by humans for food supply, medicinal use, or functional and aesthetic purposes. They are a genetically diverse group and play an important role in the economy of modern society. They are also central to the healthy diet of the urban population. From this point of view, roses and rosehip plants are extremely important garden plants because they contain these features. Although there is a wide variety of rose taxa in the world today, studies are continuing to determine some characteristics of roses due to the abundance of roses grown and the increasing number of newly bred varieties.

The first systematic description of roses was made by Aristotle's student Theophrastos, and he also included roses in his work known as Historia Plantarum. Theophrastos mentions three types of roses in his work and it is assumed that these are *Rosa canina*, *R. sempervirens,* and *R. centifolia* (Ozcan, 2012). Some roses that were used in ancient times and still exist today; *R.* x *damascena*, *R. moschata*, *R. hemisphaerrica,* and *R.centifolia* species (Baktir, 2015). In addition, natural roses that are sectorally important are *R. canina*, *R. dumalis*, *R. foetida,* and *R. hemisphaerica* (Sahin, 2011; Korkmaz and Ozcelik, 2015). In this context, within the scope of the research, some morphological, pomological, physiological, and mineral contents of important taxa such as *Rosa alba* L.'Semiplena' *R. banksiae, R.* Br. Cv '*Alba*', *R. canina* L.'Yildiz', *R. centifolia* L., *R. chinensis* Jacq. 'Old Blush', *R. foetida* Herrm., *R. heckeliana* Tratt. subsp. *vanheurckiana* (Boiss. Ö. Nilsson) *R. hemispharica* J.Herrm., R.x *odorata* (hort ex.Andrews) Sweet 'Louis XVI', *R. pisiformis* (Christ) Sosn., *R.* x *damascena* Mill. and *R.* x *damascena* Herrm. 'Semperflorens' (Loisel. & Michel) Rowley, for landscape design and horticulture were determined. Within the scope of the research, the morphological, physiological, and pomological characteristics and nutrient contents of taxa adapted to semi-arid conditions and different *Rosa* taxa spreading in Anatolia were determined. These parameters were classified by different statistical evaluations.

## 2. Material and Methods

### 2.1. Material

Some of the natural rose species distributed in the Iran-Turanian Phytogeographic Region are the widely used Bengal rose (*R. chinensis* cv. 'Old Blush'), Halfeti rose (*R.* x *odorata* cv. 'Louis XIV'), Rosehip (*R. canina*), white rose (*R. alba* 'Semi Plena'), Van yellow rose (*R. heckeliana* subsp. *vanheurckiana*), Damask rose (*R.* x *damascena*), hedge rose (*R. hemisphaerica*), Banks rose (R. *banksiae* cv. '*Alba*'), *Rosa* de Mai (*R.* x *centifolia*), yellow rose (*R. foetida*), Hosap rose [*R. pisiformis* (Christ) D.] and evergreen rose (*R.* x *damascena* 'Semperflorens') rose species and subspecies of some morphological, pomological, physiological, and mineral contents were determined. Taxa names are written in full at this stage, and in other parts of the manuscript, they are given in a short form without authorization.

#### *2.1.1. Climatic characteristics of the greenhouse*

Natural rose species are generally spread at high altitudes. Within the scope of the research, changes in stomatal parameters were determined in relatively warm conditions. In the Southeastern Anatolia Region, very high temperatures are observed in June and July. In this context, leaf samples were collected in these periods in 2020 and 2021. In this process, cooling units were not operated in the greenhouses where the plants were grown. Temperature values were also measured with Onset Computer H21-002 HOBO® Micro station and the averages were transferred to the data compiler. At the time the leaf samples were taken, the average temperature of the greenhouse was 39.8°C and the RH (%) value was determined as 59.8.

#### *2.1.2. Physical and chemical properties of the growing medium*

The findings obtained in the analyzes made; the pH of the growing medium in which the study was carried out was 7.14, clayey/loamy structure, and low in organic matter. Lime content was determined as 6.14% and salt content as 0.04%. In Japan, Yamane (1990) reported that the pH of the topsoil in natural stands of *R. rugosa* varied between 5.1 and 7.6. According to unpublished data from the University of Copenhagen Biology Institute; in the regions where *R. rugosa* grows naturally in Denmark, pH values were determined as 4.66-7.74, lime rate 6.26%, and organic matter content 1.20%

(Bruun, 2005). The results of the soil analysis carried out within the scope of the thesis and the aforementioned literature were found to be close to each other.

The chemical properties of the soil used in the greenhouse where the research was carried out, were analyzed. According to the results, the P value was high, the K value was critical, and the Fe, Cu, Zn, Mn, and B values were sufficient. It was determined that the growing environment was generally at sufficient levels in terms of the content of plant nutrients required for rose cultivation, fertilization was not done and the research was carried out in this way.

## 2.2. Methods

### *2.2.1. Determination of plant growth characteristics*

Plants of different *Rosa* taxa propagated by cuttings were transplanted into 5 L pots in 2019, plant length (cm), plant crown width (cm), and plant crown/height ratio measurements were made in 2021. Growth patterns of 2-year-old plants were determined according to height and crown width. The codes of these parameters were denoted as; PL:plant height, PW:plant grown, PR:the ratio of the crown to the height of the plant.

### *2.2.2. Morphological analysis*

Leaf area was calculated in cm² with the help of ImageJ program and determined according to Klamkowski and Treder (2008). Leaflets were classified as the bottom (1), middle (2), and tip (3), and leaf areas were determined by the same method. The leaves and leaflets of the plants belonging to each taxon were counted one by one, and the average leaf and leaflet measurements per plant were made in cm. In the same way, pedicel lengths were determined. The codes of these parameters were denoted as; LL: leaf length, LWH: leaf width, LA: leaf area, PW: pedicel width, LR: the ratio of the length to the width of the leaf, L1L: tip leaflet length, L1WH: tip leaflet width, L1A: tip leaflet area, L2A: middle leaflet area, L3A: bottom leaflet area.

### *2.2.3. Pomological analysis*

Pomological analyzes were carried out according to the mentioned literature (Ercisli, 1996; Gunes, 2010; Kazankaya et al., 2005; Najda and Buczwoska, 2013; Encu, 2015; Hatipoglu and Ak, 2021; Guler et al., 2021). After the harvest of rosehip/rose fruits that reached harvest maturity, the yields of the samples brought to the laboratory were determined, and the fruits of each taxon were counted and recorded. 10 replications and 30 fruits in each replication were taken from the related taxa and weighed individually with a scale sensitive to 0.01 g and the average values were recorded. 30 fruits were selected from the *Rosa* L. taxa included in the study, and the width and height values of each fruit were determined using a 0.05 mm precision caliper. A vertical line was drawn between the point where the fruit connects to the sepal and the mark of breaking off from the branch, and the horizontal part was recorded as width and the vertical part as height, making an angle of 90 degrees with this line.

From the *Rosa* L. taxa examined in the study, 30 fruits were selected randomly, and after removing the seeds from each fruit, the weight of the fruit was checked. The fruit flesh ratio of taxa was determined by the ratio of the fruit flesh weight to the total fruit weight. Fruit shapes in *Rosa* L. taxa were calculated according to the average aspect ratio of 30 randomly selected fruits in line with the index determined by Ercisli (1996).

The absorbic acid (Vitamin C) content of *Rosa* L. taxa examined within the scope of the research was determined by spectrophotometric method (Cemeroglu, 1992; Karasakal, 2007; Sanlidere Aloglu, 2018). The separated fruit fleshes of the fruits collected in November 2020 from different locations were ground using a blender and sieved. After the fruits were pureed, 5 g of fruit juice was taken into the flasks in 3 repetitions, the fruit sample was weighed, 45 ml of 0.4% oxalic acid was added and filtered with filter paper. 1 ml of the obtained filtrate was taken and 9 ml of dye solution (C12H6Cl2NNaO2-H2O) was added to it and readings were made at 520 nm wavelength. As a standard, a solution in which 9 ml of distilled water was added to 1 ml of filtrate was used (Ozdemir and Dundar, 1998; Aksoy, 2019).

The codes of pomological parameters were denoted as; FW: fruit weight, FL: fruit length, FWH: fruit width, FFR: fruit flesh ratio, FSI: fruit shape index, CV: C vitamin content.

#### *2.2.4. Physiological analysis*

The wet weights of the leaf samples taken from the pots in the experiment were determined, and the turgor weight was determined as a result of keeping them in petri dishes containing 100 ml of water for 24 hours. The samples were dried in an oven at 65-70ºC and their dry weights were determined by weighing them on a precision balance. Leaf relative water content was calculated according to Sanchez et al. (2004) (Dogan, 2018; Hatipoglu and Ak, 2021). This parameter is encoded as LRWC.

The amount of chlorophyll in the leaf was determined by the SPAD-502 Plus device with 10 separate measurements made from the bottom, middle, and tip parts of the compound leaflets in 2020 and 2021 (Khan et al., 2004). This parameter is encoded Ch.

In *Rosa* L. species, the leaves are in the form of leaflets; the differences in stomatal characteristics between the tip (A), middle (B), and lower (C) leaflets of the leaves were also investigated. Leaf samples were taken at noon for stomatal counts and measurements. The lower surfaces of the leaves were completely painted with transparent nail polish and left to dry. The tape was attached to the dried nail polished leaves and then removed and attached to the slides. Thus, stomata were examined under the microscope. The number of stomata per unit area (pcs/mm-2) value of the slide molds was photographed under the microscope; the number of stomata displayed in the 0.776 $mm^2$ field of view was determined by adapting to 1 mm2 area. (Kara and Ozeker, 1999; Bekisli, 2014; Dikmetas, 2019). For stomata/pore length and width (µm) values, the length and width of 10 stomata in the photographs of stomata/pore patterns were measured in MShot-1.3.10 computer program and measured in µm (Bekisli, 2014). For the stomata width/stomata length ratio, it was obtained by dividing the stomatal width by the stomatal length. The codes of stomata parameters were denoted as; STL: stomata length, SWH: stomata width, SD: stomata density, PRL: pore length, PWH: pore width.

#### *2.2.5. Mineral content analysis*

Leaf samples were taken from the middle parts of annual shoots together with their stems, representing the bottom, middle, and end leaflets of each plant. This process was performed with 10 replications for the samples taken. The samples brought to the laboratory were first thoroughly washed with running water and then washed with distilled water. The samples were left to dry for 7 days at room temperature and were mixed 3 times a day to prevent moisture. After these processes, it was dried in an oven and then ground. Nitrogen amount was calculated as % by the Khejdal method (Kacar, 1972; Ozdemir, 2005). Phosphorus in the leaves was determined by the colorimetric determination of the color in the spectrophotometer as a result of the dry burning process (Olsen, 1954). The determination of calcium and potassium in leaves was read in a flame photometer (Kacar, 1972). The determination of magnesium in leaves; after dilution of plant samples prepared by the dry burning method, it was determined by reading with an atomic absorption instrument (Kacar, 1972). 1 ml of sulfuric acid and then 19 ml of ethyl alcohol were added to the leaf samples weighing 1 g. The ash was first burned in the furnace at 250˚C for 2 hours, then at 650˚C for 4 hours, and left to cool. Then 5 ml of HCL (Hydrochloric Acid) has been added to the burnt leaves. Leaf samples were filtered using sterile filter paper, crucibles were filled with distilled water, and the process was repeated 2-3 times. Mn, Cu, Zn, and Fe contents were calculated in ppm units in atomic absorption spectrophotometer (Kacar, 1972; Ryan et al., 2001).

#### *2.2.6. Statistical analysis*

Statistical analysis of data for all variables was performed using Minitab 18. program. The difference between applications was determined by the LSD multiple analysis test. Principal component analysis (PCA) and clustering analysis (Dendogram) were performed using the R 4.1.1 package program.

## 3. Results

### 3.1. Plant growth characteristics of some *Rosa* L. taxa

In order to determine the differences in the growth characteristics of the plants, the findings related to the plant height (cm), plant crown width (cm), and plant crown/height ratio of 12 taxa are given in Table 1, and the numerical values were found to be statistically significant at the 5% level. In the study, the PLs of the taxa varied between 38.00 cm (*R.* x *damascena* ‘Semperflorens’) to 138.33 cm

(*R. chinensis* 'Old Blush'). PW values were determined between 46.32 cm (*R. foetida*) – 112.14 cm (R. *heckeliana* subsp. vanheurckiona). *R. hemisphearica* taxa had the most superior PR value (1.47), while *R. alba* 'Semiplena' had the least value (0.70) in terms of this feature (Table 1). In line with this information, a shape index was created for the growth characteristics of rose species. According to this shape index, if the crown/height ratio of plants grown (PR) under the same conditions and at the same age is between 0.70 and 0.95, the plant is erect; 0.96-1.24, the plant is broad/erect; bigger than 1.24, the plant is broad. According to PR; *R. alba* 'Semiplena', *R. canina* 'Yildiz', *R. centifolia*, *R. foetida*, *R. odorata* 'Louis XIV' and *R. pisiformis* taxa are 'erect'; *R. banksiae* '*Alba*', *R. chinensis* 'Old Blush', *R. chinensis* 'Viridflora' and *R.* x *damascena*taxa are 'broad/erect'; *R. heckellana* subsp. vanheurckiona, *R. hemispharica,* and *R.* x *damascena* 'Semperflorens' taxa are 'broad'. This classification is similar to the evaluations of Koca (2014).

Table 1. Growth characteristics of some *Rosa* L. taxa

| Taxa | Plant growth characteristics | | |
|---|---|---|---|
| | **PL** | **PW** | **PR** |
| ***R. alba* 'Semiplena'** | 91.33±3.50cd | 64.62±3.04f | 0.70±0.01g |
| ***R. banksiae* '*Alba*'** | 96.33±2.66bc | 95.32±3.42c | 0.98±0.01d |
| ***R. canina* 'Yildiz'** | 83.67±2.07e | 68.81±4.09e | 0.81±0.01f |
| ***R. centifolia*** | 100.04±3.53ab | 94.02±4.19c | 0.94±0.01de |
| ***R. chinensis* 'Old Blush'** | 103.33±3.32a | 107.33±4.20b | 1.05±0.01c |
| ***R. foetida*** | 57.66±3.78f | 46.32±3.21i | 0.80±0.01f |
| ***R. heckeliana* subsp. *vanheurckiona*** | 89.30±3.01de | 112.14±4.51a | 1.25±0.01b |
| ***R. hemispharica*** | 62.60±2.64f | 91.64±3.05d | 1.47±0.01a |
| ***R. odorata* 'Louis XIV'** | 61.33±4.33f | 52.34±2.51g | 0.77±0.01f |
| ***R. pisiformis*** | 84.31 ±2.51e | 68.63±3.51e | 0.81±0.01f |
| ***R.* x *damascena*** | 56.67±4.72f | 50.31±5.50h | 0.89±0.01e |
| ***R.* x *damascena* 'Semperflorens'** | 38.00±3.00g | 49.00±3.78h | 1.29±0.01b |
| **Average** | **77.05** | **75.04** | **0.98** |
| **LSD (%5)** | **6.626** | **1.731** | **0.060** |

*: The differences between the averages with different letters in the same column are statistically significant. (P <0.05). **: It is the average of 10 repetitions. PL:plant height, PW:plant grown, PR:the ratio of the crown to the height of the plant.

### 3.2. Morphological parameters of some *Rosa* L. taxa

Morphological parameters of some *Rosa* L. taxa are given in Table 2. *R. foetidataxa* had the lowest values in LWH, LL, LA, and PW parameters. The highest values were obtained by R. *alba* 'Semiplena' (7.50 cm) in LWH, *R. pisiformis* (7.15 cm) in LL, *R. centifolia* (43.31 cm2) in LA, *R. centifolia* (2.41 cm) in PW, and *R. heckeliana* (1.13 cm) in LR. In the leaflet measurement parameters, *R. centifolia* taxa had the highest values. Similarly, *R. foetida* taxa generally had the lowest values in leaflet measurement parameters (Table 2 and 3.).

Table 2. Morphological parameters of leaves

| Taxa | Leaf Characteristic | | | | |
|---|---|---|---|---|---|
| | LWH | LL | LA | PW | LR |
| ***R. alba* 'Semiplena'** | 7.50±0.90a | 6.82±1.19a | 33.85±1.17b | 1.53±0.51d | 1.10±0.06e |
| ***R. banksiae'Alba'*** | 5.72±0.09f | 6.16±0.61 cd | 12.83±0.53g | 1.46±0.10e | 0.93±0.08e |
| ***R. canina* 'Yildiz'** | 6.06±0.37d | 5.57±0.36f | 18.67±1.58d | 1.53±0.25d | 1.08±0.02b |
| ***R. centifolia*** | 7.30±0.20b | 6.47±0.28b | 43.31±0.71a | 2.41±0.10a | 1.12±0.05a |
| ***R. chinensis* 'Old Blush'** | 6.32±0.88c | 6.02±0.47de | 13.05±1.47g | 1.29±0.22f | 1.04±0.07c |
| ***R. foetida*** | 2.89±0.09h | 2.77±0.18h | 4.35±0.40h | 1.01±1.10g | 1.04±0.09c |
| ***R. heckeliana* subsp. vanheurckiona** | 6.27±0.57c | 5.54±0.51f | 17.42±1.07e | 1.28±0.29f | 1.13±0.01a |
| ***R. hemispharica*** | 6.29±1.19c | 6.22±1.16c | 20.72±1.05c | 1.76±0.07b | 1.01±0.01d |
| ***R. odorata* 'Louis XIV'** | 5.69±0.34f | 6.40±0.35b | 18.61±0.96d | 0.96±0.28g | 0.88±0.05f |
| ***R. pisiformis*** | 5.94±0.86e | 7.15±0.97a | 36.98±0.81de | 2.20±0.52e | 0.85±0.03g |
| ***R. x damascena*** | 5.48±0.35g | 5.06±0.28g | 14.26±1.41f | 1.46±0.46e | 1.08±0.05b |
| ***R. x damascena* 'Semperflorens'** | 6.10±0.43d | 5.87±0.25e | 18.53±0.57d | 1.68±0.24c | 1.03±0.04cd |
| **Average** | **5.96** | **5.82** | **19.47** | **1.48** | **1.01** |
| **LSD (%5)** | **0.119** | **0.152** | **0.713** | **0.062** | **0.098** |

*: The difference between the averages with different letters on the same column is statistically significant. (P <0.05). LL: leaf length, LWH: leaf width, LA: leaf area, PW: pedicel width, LR: the ratio of the length to the width of the leaf,

Table 3. Morphological parameters of leaflets

| Taxa | Leaflet Characteristic | | | | |
|---|---|---|---|---|---|
| | L1L | L1WH | L1A | L2A | L3A |
| ***R. alba* 'Semiplena'** | 4.02±0.32a | 2.25±0.24ab | 7.39±1.41b | 6.38±10.29bc | 2.26±0.76bc |
| ***R. banksiae'Alba'*** | 3.46±0.25abc | 1.18±0.10de | 2.80±0.32ef | 1.92±0.14ef | 1.16±0.38cd |
| ***R. canina* 'Yildiz'** | 3.22±0.24bc | 2.23±0.11ab | 5.39±0.48cd | 4.22±0.15c | 2.13±0.41bc |
| ***R. centifolia*** | 4.14±0.17a | 2.60±0.26a | 11.92±0.16a | 8.68±1.00a | 5.80±1.18a |
| ***R. chinensis* 'Old Blush'** | 4.03±0.39a | 1.65±0.10cd | 4.41±0.78de | 2.63±0.65de | 1.35±0.69cd |
| ***R. foetida*** | 1.27±.0.19d | 1.01±0.07e | 1.14±0.02f | 0.90±0.14f | 0.66±0.08d |
| ***R. heckeliana* subsp. vanheurckiona** | 3.23±0.40bc | 1.87±0.29bc | 3.94±1.01de | 3.69±0.68cd | 1.30±0.53cd |
| ***R. hemispharica*** | 3.46±0.58abc | 2.14±0.65ab | 5.23±2.46cd | 3.87±2.04cd | 1.72±0.58bcd |
| ***R. odorata* 'Louis XIV'** | 4.13±0.90a | 2.41±0.53a | 6.83±2.20bc | 4.00±0.31cd | 0.70±0.23d |
| ***R. pisiformis*** | 3.95±0.18a | 2.50±0.10a | 6.96±0.61bc | 6.04±0.37b | 2.73±1.18b |
| ***R. x damascena*** | 2.88±0.34c | 1.63±0.11cd | 3.46±0.51de | 3.00±0.17 cde | 1.14±0.77cd |
| ***R. x damascena* 'Semperflorens'** | 3.67±0.15ab | 2.18±0.22ab | 5.38±0.97cd | 3.90±0.83cd | 1.57±0.67 bcd |
| **Average** | **3.46** | **1.98** | **5.40** | **4.09** | **1.88** |
| **LSD (%5)** | **0.683** | **0.495** | **1.983** | **1.497** | **1.187** |

*: The difference between the averages with different letters on the same column is statistically significant. (P <0.05). L1L: tip leaflet length, L1WH: tip leaflet width, L1A: tip leaflet area, L2A: middle leaflet area, L3A: bottom leaflet area.

## 3.3. Pomological parameters of some *Rosa* L. taxa

Pomological parameters were determined as a result of fruit measurements and ascorbic acid analysis in *Rosa* L. taxa. In the study, FWs of taxa varied between 0.19 g (*R. banksiae* '*Alba*') to 4.44 g (*R. centifolia*), and FL values were between 8.82 – 23.18 mm (Table 4.). FWH values were determined between 6.65–21.24 mm in *R. banksiae* '*Alba*' and *R. centifolia*, respectively. *R. pisiformis* had the least FWH (0.06 mm), while *R. centifolia* had the most superior value (3.33 mm) in terms of this feature. FFRs varied by 58.64% (*R. pisiformis*) to 89.32% (*R. chinensis* 'Old Blush'), and FSI values were recorded between 0.95-1.70 (Table 3). It can be said that the fruit characteristics of rose hips vary according to the species, growing region, climate, and ecological conditions. In this context, the aforementioned data of the fruits collected from the regions to which they are adapted show significant differences. The findings are similar to the pomological data determined in the literature (Kovacs et al., 2005; Celik et al., 2005; Kızılci, 2005; Savir, 2008; Gunes, 2010; Ozcelik, 2013; Akkus, 2016; Ipek and Balta, 2020; Tomlijenovic et al., 2021; Guler et al.,2021).

However, vitamin C values vary widely in studies. As a result of the analyzes made to determine the amount of vitamin C; 12.04-43.77 mg/100 g (Turkben et al., 2010), 1074 mg/100 g, and 2962 mg/100 g (Ercisli et al. 2001), 282.70-1173.40 mg/100 g (Gunes and Sen, 2001), 73-987 mg/100 g (Kazankaya et al., 2001), 1074-2557 mg/100 g (Ercisli and Esitken, 2004), 301-1183 mg/100 g (Kazankaya et al.

2005), 65.75 to 136.14 mg/100 g (Celik et al., 2006), 575.48-1369.89 mg/100 g (Savir, 2008), 2200 mg/ 100 g (Kazaz et al., 2009), 517-1032 mg/100 mL (Celik et al., 2009), 108.57- 908.57 mg/100 g (Gunes and Dolek, 2010), 575.48-1369.89 mg/100 g (Ekincialp and Kazankaya, 2012), values such as 332.47-1603.53 mg/100 g (Ozen, 2013). In the study, the CVs of the taxa varied between 36.34 to 1101.36 mg/100 g. As a result of the vitamin C analysis; *R. pisiformis* (1101.36 mg/100 g), *R. alba* 'Semiplena' (1041.85 mg/100 g) had high values.

Table 4. Pomological parameters of some *Rosa* L. taxa

| Taxa | Pomological Parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | FW | FL | FWH | FSI | FFW | FFR | CV |
| ***R. alba* 'Semiplena'** | 3.48±0.54b | 23.18±1.68a | 18.72±1.54b | R(1.27e) | 2.62±0.75b | 77.82±1.60bcd | 1041.85±2.05a |
| ***R. banksiae* '*Alba*'** | 0.19±0.05j | 8.82±0.62f | 6.65±0.70g | R(1.32c) | 0.12±0.03i | 61.81±1.78f | 506.56±1.50d |
| ***R. canina* 'Yildiz'** | 1.65±0.34d | 22.17±1.59ab | 15.09±1.59c | O(1.58b) | 1.14±0.41cde | 72.05±1.76e | 99.85±2.13f |
| ***R. centifolia*** | 4.44±0.75a | 20.31±1.25b | 21.24±1.80a | Fr(0.95i) | 3.33±0.68a | 72.40±1.10e | 401.06±1.75e |
| ***R. chinensis* 'Old Blush'** | 1.60±0.18de | 17.49±1.25c | 13.45±0.80e | R(1.30d) | 1.43±0.16cd | 89.32±0.58a | 30.79±1.58g |
| ***R. foetida*** | 0.61±0.14hi | 13.73±1.20e | 12.38±1.41ef | Fr(1.11g) | 0.49±0.13ghi | 81.09±1.95b | 40.17±0.94g |
| ***R. heckeliana*** | 0.35±0.08ij | 13.89±1.18de | 8.18±1.21g | C(1.70a) | 0.25±0.08hi | 80.21±1.92bc | 592.61±2.39bc |
| ***R. hemispharica*** | 0.74±0.19gh | 13.94±1.00de | 13.42±1.32e | Fr(1.04h) | 0.62±0.18fgh | 82.11±2.01b | 75.77±1.17fg |
| ***R. odorata* 'Louis XVI'** | 1.00±0.09fg | 12.80±1.40e | 11.65±0.62f | Fr(1.10g) | 0.85±0.10efg | 87.99±1.87a | 36.34±1.39g |
| ***R. pisiformis*** | 0.11±0.03j | 7.35±0.71f | 7.14±0.66g | Fr(1.03h) | 0.06±0.01i | 58.64±1.79f | 1101.36±1.45a |
| ***R.* x *damascena*** | 1.31±0.39ef | 16.16±2.11c | 13.66±1.47cd | Fr(1.18f) | 1.01±0.29def | 75.37±2.23cde | 632.87±0.23b |
| ***R.* x *damascena* 'Semperflorens'** | 1.99±0.55c | 15.70±1.50cd | 15.20±1.69c | Fr(1.03h) | 1.55±0.50c | 74.55±1.76de | 577.34±1.55c |
| **Average** | **1.46** | **15.47** | **13.07** | **1.21** | **1.12** | **76.11** | **420.55** |
| **LSD (%5)** | **0.331** | **1.878** | **1.580** | **0.017** | **0.450** | **5.402** | **50.962** |

*Fr: Flat Round, R: Round, O: Oval, C: Conical**: The difference between the averages with different letters on the same column is statistically significant. (P <0.05). ***: It is the average of 30 repetitions. FW: fruit weight, FL: fruit length, FWH: fruit width, FFR: fruit flesh ratio, FSI: fruit shape index, CV: C vitamin content.

### 3.4. Physiological parameters of some *Rosa* L. taxa

Physiological parameters of some *Rosa* L. taxa are given in Table 5. The values determined on the change of the LRWC according to the taxa were found to be statistically significant (p<0.05). As a result of the research; the highest LRWC were *R. chinensis* 'Viridflora', *R. canina* 'Yildiz, *R. foetida* and R. *chinensis* 'Old Blush; the lowest LRWC were determined in R. *heckeliana* and R. pisiformis taxa. Bucsa and Zamfirce (2017) found the highest LRWC values in R. nitidula, R. rubiginosa and R. *canina* taxa in their study, and they stated that there were statistically significant differences in LRWC rates between different taxa. In the study, it was concluded that these values varied during the vegetative and flowering periods in *Rosa* L. taxa. In studies conducted on different plant species, it has been stated that stress applications reduce the proportional water content of the leaves (Cekic, 2004; Irfan et al., 2014; Semida et al., 2015; Dogan, 2018). In woody landscape and ornamental plants; It is stated that determining physiological data such as leaf proportional water content will provide sustainable plant use in many application areas such as determining the tolerance of the plant against stress conditions such as water, temperature and drought, and determining ozone damage.

Ch values in leaves of different taxa were found to be statistically significant. According to the results of the research, the lowest chlorophyll content was obtained from *R. banksiae* '*Alba*' (28.13), and the highest chlorophyll content was obtained from plants belonging to R. *chinensis* 'Old Blush' (44.39) and *R. odorata* 'Louis XIV' (42.99) taxa. On the other hand, it was determined that the chlorophyll content of the taxa commonly used in semi-arid conditions had higher leaf chlorophyll content than the taxa brought from different ecologies. In studies conducted on different plants, it has been stated that the amount of chlorophyll in the leaves of plants that are under stress conditions and have adaptation problems to the ecology it is in, decreases, and it has been reported that this low value causes problems in photosynthesis and carbon fixation (Cekic, 2004; Hassan et al., 2005; Krantev et al., 2008; Liu et al., 2015; Semida et al., 2015; Piršelová et al., 2016).

The stomatal parameters of the leaflets at the tip (A), middle (B), and lower (C) ends of the leaves taken from 2 different directions of the rose taxa used as plant material in the study were determined. When the mean stomatal length values of the taxa were examined, the highest value was *R. odorata* 'Louis XIV' (36.99 µm); the lowest values were found in the R.*canina* 'Yildiz' taxa (23.81 µm). In all taxa, the stomatal length parameter was found to be statistically significant in all four groups.

Descriptive statistics and comparison results for stomatal width in six taxa are given in Table 2. As seen in Table 2; The highest stomatal width value was determined as 25.65µm in R.*odorata* 'Louis XIV'. The lowest stomatal width value was determined in *R.* x *damascena* (17.55 µm) and R. *canina* 'Yildiz' (17.82 µm). While the variation in A-B-C leaflet values was five in stoma width values, four variations were detected in the two-year general average values. As a result of its adaptation to semi-arid conditions, *R. odorata* 'Louis XIV' received a geographical indication in 2021 in order to contribute to rural tourism and the rural population to turn to different business areas (TURKPATENT, 2022). It is important to compare the parameters of these two taxa with rose species grown in Anatolia.

Zarinkamar (2007), Orcen el. (2013) and Alp et al. (2016) stated in their study that the number of stomata per unit area (mm²) tends to increase as stoma sizes decrease. Kalariya et al.(2017) explain this by reducing the stomatal density and osmotic stress caused by drought, disrupting normal stomatal motility, and forming more adjacent stomatal clusters in the leaf epidermis. The research gives similar results to that study. These results confirm that the size of the stomata decreases as the water content in the leaf decreases (Xu and Zhou, 2008). However, the surface area parameter in the leaf did not change which provides a linear proportion with these two parameters. Due to anthropogenic effects, nature is adversely affected in many ways during the rapid change process on earth and deterioration in the ecological balance occurs. In this context, studies on the health of plants affected by these effects and their sustainable use in landscape planning studies have gained importance. Determination of data such as chlorophyll content, stomatal parameters, and leaf proportional water content in woody landscape and ornamental plants can be used in many application areas such as the determination of plant water stress, cold/drought tolerance, and ozone damage. For this reason, it is thought that sustainability in plant uses will be ensured as a result of studies aimed at revealing this situation and determining the different characteristics of plants. The research focused on the identification of stress resistant species in roses, an important species for landscape planning studies. It is thought that the research will contribute to the cultivation and promotion of high temperature resistant species and also to urban plant planning by determining the relationship between the relevant parameters.

Table 5. Physiological parameters of some *Rosa* L. taxa

| Taxa | Physiological Parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | LRWC | Ch | STL | SWH | SD | PRL | PRWH |
| ***R. alba* 'Semiplena'** | 41.19±1.65d | 34.87±3.23e | 30.57±2.33bc | 15.34±2.31g | 156.20±6.93i | 19.57±3.01g | 7.76±0.98i |
| ***R. banksiae* '*Alba*'** | 39.50±1.93e | 28.13±1.40i | 27.73±3.13c | 19.73±2.53bc | 169.40±7.54h | 20.63±2.41e | 10.99±1.21c |
| ***R. canina* 'Yildiz'** | 74.33±5.25a | 38.85±1.64d | 23.81±4.66g | 15.51±3.03fg | 202.76±8.11d | 19.02±3.93h | 8.53±1.02h |
| ***R. centifolia*** | 30.44±0.71h | 32.94±2.00g | 31.14±6.06b | 18.16±2.63d | 148.04±6.43j | 24.03±1.97c | 10.70±1.31cd |
| ***R. chinensis* 'Old Blush'** | 73.41±5.69b | 44.39±1.82a | 26.90±5.08e | 21.26±4.03a | 199.47±6.21e | 21.93±2.22d | 14.90±1.10a |
| ***R. foetida*** | 73.99±5.80ab | 35.69±1.75e | 27.51±5.01c | 16.15±3.93ef | 212.30±8.24b | 20.20±3.05f | 10.34±1.24de |
| ***R. heckeliana*** | 24.06±0.93j | 33.30±1.75fg | 27.76±3.03c | 18.77±3.33d | 213.40±7.06a | 17.42±1.98j | 10.73±1.46cd |
| ***R. hemispharica*** | 55.00±5.00c | 29.79±3.49h | 29.90±3.31c | 19.60±2.33c | 188.10±4.88f | 22.24±1.46d | 10.13±1.46ef |
| ***R. odorata* 'Louis XVI'** | 38.23±2.93f | 42.99±3.53ab | 36.99±6.60a | 21.51±2.33a | 133.20±3.44k | 30.12±2.15a | 13.46±1.05b |
| ***R. pisiformis*** | 25.49±0.84i | 34.69±2.55ef | 26.59±5.01ef | 15.45±2.33fg | 173.80±7.83g | 17.90±1.85i | 9.42±1.96g |
| ***R.* x *damascena*** | 31.30±5.78g | 42.34±1.65a | 25.62±5.09f | 16.68±2.33b | 203.50±3.95c | 18.17±2.53i | 9.67±1.46fg |
| ***R.* x *damascena* 'Semperflorens'** | 41.60±5.13g | 40.99±3.23c | 31.81±4.08b | 17.79±2.33e | 124.30±5.20l | 26.14±2.16b | 10.17±1.64ef |
| **Average** | **45.70** | **36.59** | **28.33** | **18.22** | **177.04** | **21.45** | **10.57** |
| **LSD (%5)** | **0.844** | **1.414** | **0.970** | **0.763** | **0.490** | **0.417** | **0.514** |

*: The difference between the averages with different letters on the same column is statistically significant. (P <0.05). **: It is the average of 20 repetitions. LRWC: leaf relative water content Ch: chlorophyll content STL: stomata lenght, SWH: stomata width, SD: stomata density, PRL: pore lenght, PWH: pore width.

### 3.5. Mineral contents of some *Rosa* L. taxa

The macro and micro nutrient elements examined in the samples taken from *Rosa* L. taxa are given in Table 6. It was determined that nitrogen (N), phosphorus (P), potassium (K) and calcium (Ca), magnesium (Mg) contents of macronutrients analyzed in the samples taken from *Rosa* L. taxa differed statistically from each other. Accordingly, the highest nitrogen content (1.63%) was R. x *damascena*; the lowest nitrogen content (1.00%) was determined in the leaves of the *R. pisiformis* taxa. The average phosphorus (P) content of the leaf samples of the *Rosa* L. taxa in the study was the highest in the R.

*heckeliana* (0.36%) taxa. According to Kacar and Katkat (1998), potassium, one of the mobile elements, passes from old leaves to young leaves in plants. For this reason, it is stated that the potassium content of young leaves is higher than that of old leaves. According to the analysis results of the leaf samples taken from *Rosa* L. taxa, the mean potassium (K) content was the lowest in *R. pisiformis* (0.68%), and the highest value was found in the leaves of the *R. banksiae* '*Alba*' (1.1.82%) taxa (Table 6.).

It was determined that the contents of iron (Fe), copper (Cu), zinc (Zn), and boron (B) examined in the samples taken from *Rosa* L. taxa differed statistically from each other (Table 7.). When the average micronutrient content of the leaf samples taken from the middle parts of the annual shoots of *Rosa* L. taxa were compared, it was determined that the accumulation of all the nutrients examined in the leaves differed according to the species and subspecies, except for the Mg element. Looking at the results of the analysis, *R.* x *damascena* (Damask rose), which has the highest nitrogen content, draws attention to its low copper and boron content. It has been concluded that the taxon *R. odorata* 'Louis XIV' has generally lower contents than other taxa in terms of both macro and micro nutrients.

Table 6. Macro mineral contents in leaves of *Rosa* L. taxa

| Taxa | N (%) | P (%) | K (%) | Mg (%) |
|---|---|---|---|---|
| ***R. alba*** **'Semiplena'** | 1.13±0.00g | 0.17±0.00e | 1.54±0.01e | 0.27±0.01f |
| ***R. banksiae*** **'*Alba*'** | 1.16±0.01f | 0.14±0.00f | 1.82±0.02a | 0.27±0.01f |
| ***R. canina*** **'Yildiz'** | 1.09±0.00h | 0.32±0.00b | 1.75±0.01b | 0.34±0.00d |
| ***R. centifolia*** | 1.19±0.01f | 0.13±0.00g | 1.58±0.02d | 0.27±0.00f |
| ***R. chinensis*** **'Old Blush'** | 1.34±0.00d | 0.23±0.00d | 1.67±0.01c | 0.27±0.01f |
| ***R. foetida*** | 1.52±0.02b | 0.10±0.00h | 1.49±0.01f | 0.36±0.01c |
| ***R. heckeliana*** **subsp.** ***vanheurckiana*** | 1.36±0.05d | 0.36±0.00a | 1.03±0.01h | 0.42±0.01b |
| ***R. hemispharica*** | 1.24±0.01e | 0.17±0.00e | 1.59±0.02d | 0.33±0.00d |
| ***R. odorata*** **'Louis XVI'** | 1.47±0.01c | 0.09±0.00i | 1.68±0.02c | 0.28±0.01f |
| ***R. pisiformis*** | 1.00±0.00i | 0.10±0.00h | 0.68±0.01i | 0.43±0.01a |
| ***R.*** **x** ***damascena*** | 1.63±0.05a | 0.25±0.00c | 1.50±0.02f | 0.29±0.01e |
| ***R.*** **x** ***damascena*** **'Semperflorens'** | 1.03±0.01i | 0.10±0.00 h | 1.35±0.01 g | 0.34±0.01d |
| **Average** | **1.26** | **0.18** | **1.48** | **0.32** |
| **LSD (%5)** | **0.030** | **0.009** | **0.030** | **0.013** |

*: The difference between the averages with different letters on the same column is statistically significant. (P <0.05).

Table 7. Micro nutrient contents in leaves of *Rosa* L. taxa

| Taxa | Fe (ppm) | Cu (ppm) | Zn (ppm) | Mn (ppm) | B (ppm) |
|---|---|---|---|---|---|
| ***R. alba*** **'Semiplena'** | 120.51±1.44d | 12.01±0.97d | 27.32±1.30h | 73.37±1.18d | 114.72±1.34d |
| ***R. banksiae*** **'*Alba*'** | 92.91±1.35i | 13.00±0.22c | 25.50±0.21i | 32.30±0.40j | 91.84±1.84h |
| ***R. canina*** **'Yildiz'** | 119.28±1.44d | 13.54±0.32b | 37.62±0.66b | 43.18±0.49i | 101.50±1.60f |
| ***R. centifolia*** | 112.60±1.79e | 13.02±0.18c | 45.89±0.81a | 60.98±0.92f | 104.15±1.06e |
| ***R. chinensis*** **'Old Blush'** | 125.77±1.70c | 11.55±0.08e | 28.49±0.28f | 49.24±0.73g | 164.99±1.88b |
| ***R. foetida*** | 138.01±1.79b | 10.58±0.41fg | 27.47±0.17gh | 76.89±1.08c | 90.41±1.88h |
| ***R. heckeliana*** **subsp.** ***vanheurckiana*** | 157.14±1.80a | 11.58±0.18e | 31.27±0.38d | 64.94±1.06e | 69.89±1.42j |
| ***R. hemispharica*** | 106.39±1.37f | 12.01±0.32d | 28.31±0.51fg | 78.13±1.38c | 139.07±1.71c |
| ***R. odorata*** **'Louis XVI'** | 78.68±1.01j | 10.27±0.20g | 25.10±0.24i | 74.49±1.09d | 94.36±1.10g |
| ***R. pisiformis*** | 119.95±1.80d | 10.76±0.19f | 33.72±0.24c | 92.77±0.95b | 85.34±1.30i |
| ***R.*** **x** ***damascena*** | 96.15±1.33h | 14.24±0.31a | 30.66±0.23de | 45.08±0.99h | 56.30±1.39k |
| ***R.*** **x** ***damascena*** **'Semperflorens'** | 102.97±1.71g | 10.40±0.31fg | 29.86±0.38e | 111.33±0.98a | 168.22±0.38a |
| **Average** | **114.01** | **11.91** | **30.93** | **66.88** | **106.74** |
| **LSD (%5)** | **2.735** | **0.423** | **0.930** | **1.687** | **2.479** |

*: The difference between the averages with different letters on the same column is statistically significant. (P <0.05).

### 3.6. Cluster and principal component analyses

Cluster analysis, which is one of the multivariate statistical analysis methods, is a method used to divide individuals into groups according to their similarities. As a result of cluster analysis, plants within the same group are more similar in terms of characteristics than plants between other groups (Polumackanycz et al., 2020; Guler et al., 2021). The purpose of using cluster analysis in our research is to distinguish plants that are similar in terms of morphological, physiological, pomological, and biochemical characteristics from those that are different. The advantage of applying a dendogram for the interpretation of the results is that it divides the data into groups, taking into account all the data variability, without the need for any generalization.

In our study, a dendogram tree was formed as a result of 37 different parameters examined in 12 different rose taxa, and as a result, 4 different groups were formed in the dendogram graph (Figure 1). In group 1, *R. foetida* took place alone. In the taxa under the 2nd group in the dendogram tree, *R. canina* ‘Yildiz’ and R. *damascena* are more similar to each other, and *R. banksiae* '*Alba*' and *R. chinensis*

'Old Bush' are also similar to each other, and also in the 2nd group of *R. heckeliana*. *R. alba* 'Semiplena' and R. *centifolia* were under group 3 in the dendogram and were found to be similar in line with the parameters examined. *R.* pisiformis, *R. odorata* 'Louis XVI' clustered in group 4 in the dendogram graph. In *R. hemispharica* and *R. damascena* 'Semperflorens' were found to be more similar compared to the others.

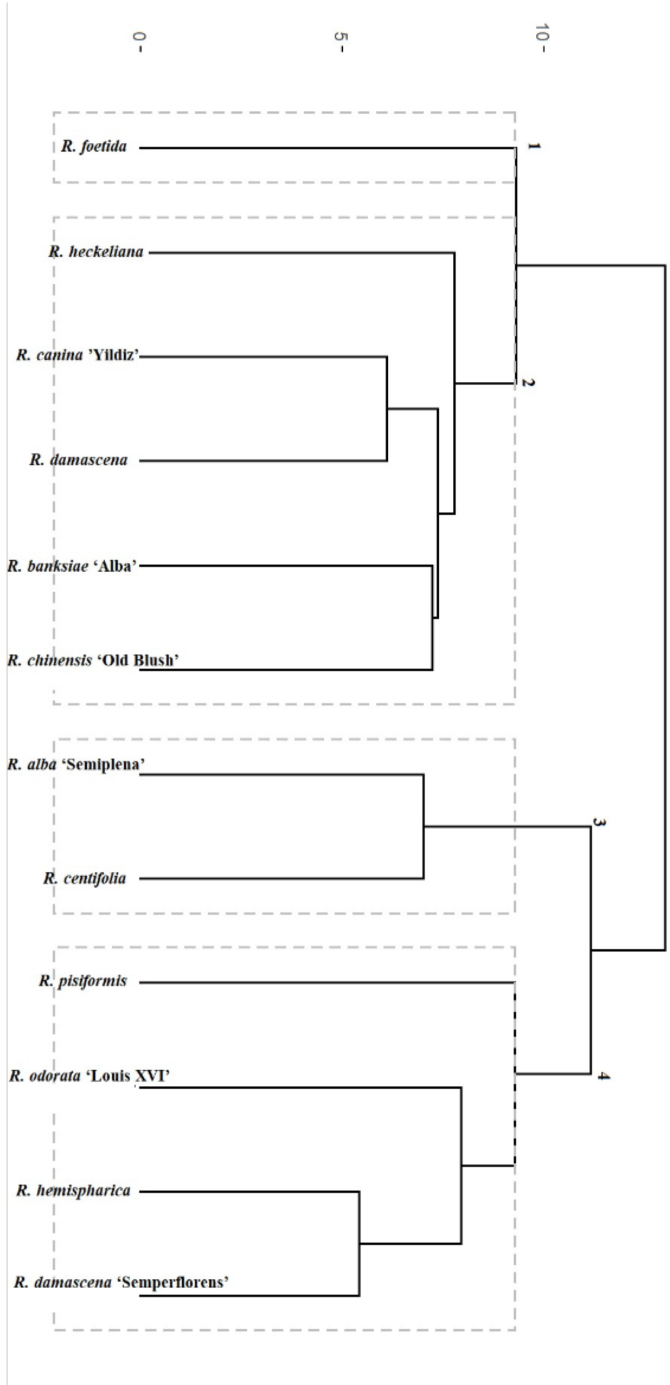


Figure 1. Comparative dendogram plot of some *Rosa* L. taxa.

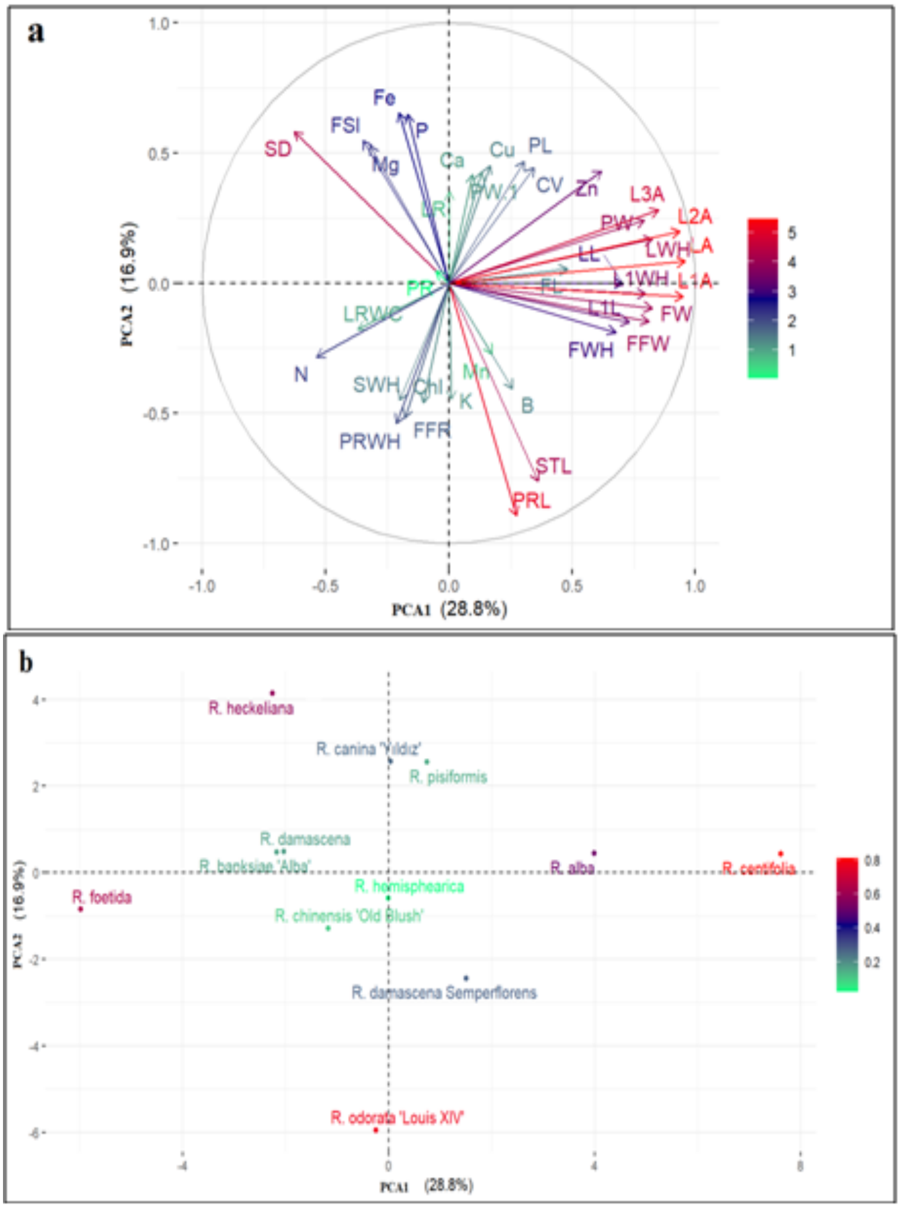


Figure 2. Comparative dendogram plot of some *Rosa* L. taxa.

PCA analysis is a statistical technique that is used to define the data in a smaller area by finding the general features in the multidimensional data, reducing the number of dimensions, and compressing the data. This method combines highly correlated variables to create a smaller set of artificial variables, called 'principal components', that generate the most variation in the data. The data obtained by PCA analyzes are reduced to smaller sizes and the differences and similarities between the applications are visually defined (Bozhuyuk et al., 2021; Guler et al., 2021). In our study, which we conducted to examine the morphological, physiological, pomological, and biochemical properties of different rose taxa, similarities and differences between 12 different rose taxa were determined. As seen in Figure 2 (a,b), the 12 rose taxa used in the study, which have similar characteristics, are located in the same place. The main logic of these groupings is shown in Figure 2 (a). The arrows in the graph show the values of the different parameters examined, that is, these values increase as you move toward the arrow direction.

## 4. Discussion

Within the scope of the research, 12 different *Rosa* L. taxa were studied. As a result of the research, in terms of plant growth parameters, *R. chinensis* 'Old Blush' and *R. centifolia*; in terms of morphological features, *R. alba* 'Semiplena', *R. centifolia* and *R. pisiformis*; in terms of pomological properties, *R. centifolia*, *R. alba* 'Semiplena' and *R. odorata* 'Louis XIV' were found to have high values. It was concluded that *R. pisiformis* and *R. alba* 'Semiplena' species contain high levels of vitamin C. In addition, *R. rugosa*, *R.* x *damascena*, *R.* x *damascena* 'Semperflorens', *R. banksiae* '*Alba*', *R. heckeliana* subsp. *vanheurckiana* and *R. montana* subsp. *woronovii* 'Gercekcioglu' were determined to be promising species in terms of vitamin C content. The vitamin C contents of the fruits of *R. chinensis* and *R. odorata* species, which are used extensively in urban landscape studies, were found to be low. In addition, it is thought that the *R. alba* species, which has higher values compared to other species in parameters such as weight, width and height in fruit and starts to bear fruit early, can be considered as an alternative agricultural product apart from its landscape feature. *R. canina* 'Yildiz', *R. chinensis* 'Old Blush', *R. odorata* 'Louis XIV', *R. heckeliana* stand out in photosynthetic parameters. It was determined that the contents of macro and micro nutrients examined in the samples taken from *Rosa* L. taxa differed statistically from each other. Principal component analysis and cluster analysis were also used to determine the similarities and differences of these parameters measured in different *Rosa* L. taxa.

## Conclusion

Roses that adapt to the ecological conditions they are in can be used with their aesthetic appearance and functional effects (erosion prevention, landscape restoration works, etc.). It can be used in slope areas, especially on intercity roads. If a visuality is provided with the fruits of the rose taxa studied and the value of the fruits is understood, the local people adopt these plants and a sustainable use can be achieved. The data obtained in the determination of physiological characteristics are the values reached under greenhouse conditions. In this respect, it is important to carry out pomological analyzes in the same ecology and to evaluate the plants in question as genetic materials.

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