BAHÇE 54 (Özel Sayı 1): 47–54 (2025)
https://doi.org/10.53471/bahce.1548989

Determination of Drought Resistance of Some Miniature Rose Varieties

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Gönderilme Tarihi: 12 Eylül 2024 *Kabul Tarihi: 27 Kasım 2024*

ABSTRACT

It is important to identify plants with high drought resistance to minimize irrigation water in landscape areas. The experiment was carried out for six months at Çanakkale Onsekiz Mart University COSMOTLAB. The study aimed to determine the effects of four different irrigation levels [(S100), (S75), (S50), (S25)] on plant water consumption (ET), morphological and phenological parameters of four different miniature rose varieties (Mandarin, Orange Juwel, Zwergen Fee 09 and Zwerkönig 78) frequently used in landscape areas. As a result of the study, according to irrigation levels, the highest flower number values were observed in S100 and the lowest values were observed in 75% water restriction (S25). Water stress caused a decrease in the number of buds and a decrease in flower yield. In addition, it was observed that the flowering performance of the varieties was good even at 25% water restriction (S75) in the miniature rose varieties Mandarin, Orange Juwel and Zwerkönig 78 (except Z09). As a result, it can be said that Mandarin's ET values (255.7-642.3 mm) are lower than other varieties, the highest plant height value under S50 is reached and when other parameters are evaluated together, it is more resistant to drought than other varieties.

Keywords: Plant water consumption, drought, miniature rose, ornamental plant

Bazı Minyatür Gül Çeşitlerinin Kuraklığa Dayanımlarının Belirlenmesi

ÖZ

Peyzaj alanlarında sulama suyunun en aza indirilmesi için kuraklığa dayanıklılığı yüksek bitkilerin belirlenmesi önemlidir. Deneme, Çanakkale Onsekiz Mart Üniversitesi BİSİTLAB'da altı ay süreyle yürütülmüştür. Çalışmada, 4 farklı sulama seviyesinin [%100 (S100), %75 (S75), %50 (S50), %25 (S25)] peyzaj alanlarında sıkça kullanılan 4 minyatür gül çeşidinin (Mandarin, Orange Juwel, Zwergen Fee 09 ve Zwerkönig 78) bitki su tüketimine (ET), morfolojik ve fenolojik parametrelerine (bitki boyu, çiçek sayısı, çiçek çapı, petal sayısı) etkilerinin belirlenmesi amaçlanmıştır. Çalışma sonucunda, sulama seviyelerine göre çeşitlerin hepsinde çiçek sayısı değerleri en yüksek S100, en düşük değerler ise %75 su kısıtı uygulanan konuda (S25) görülmüştür. Su stresi, tomurcuk sayısının azalmaya ve buna bağlı olarak çiçek veriminde azalmaya sebep olmuştur. Ayrıca, Mandarin, Orange Juwel ve Zwerkönig 78 minyatür gül çeşitlerinde (Z09 dışında) tomurcuk sayısının %25 su kısıtında (S75) bile çeşitlerin çiçeklenme performanslarının iyi olduğu görülmüştür. Sonuç olarak, Mandarin'in ET değerlerinin (255,7-642,3 mm) diğer çeşitlere oranla daha düşük, S50 konusunda en yüksek bitki boyu değerine ulaşmış olması ve diğer parametreler birlikte değerlendirildiğinde diğer çeşitlere göre kuraklığa daha dayanıklı olduğu söylenebilir.

Anahtar Kelimeler: Bitki su tüketimi, kuraklık, minyatür gül, süs bitkisi

INTRODUCTION

Importance of Ornamental Plants

Plants constitute a large part of the earth's surface and are indispensable in terms of both functional use and economic income [1]. In our brave new world and developing world, the importance of ornamental plants is growing day by day with the increasing demand for landscape areas due to the intensity of social problems. In our country, which is rich in biodiversity, there are 11,707 identified plant species and 3649 of these species are endemic [2, 1].

Ornamental Plants in Landscape Areas

Ornamental plants can be defined as plants that are used and grown in landscape areas with different methods for functional, visual and economic purposes. In this regard, the production and content

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of the ornamental plant industry are incredibly diverse [3]. In the world, the production of ornamental plants has been gaining value day by day since the beginning of the 20th century. In connection with the impact of globalization on income in different parts of the world, it is observed that the use of ornamental plants per capita has increased in many countries. The ornamental plants sector, which is directly related to landscape areas and projects, can be divided into 3 main groups cut flowers, interior and exterior. In our country, a wide variety of plant materials have begun to be used in landscape projects by public institutions, organizations and private sector companies. Plants used in urban areas are often used for purposes such as screening, privacy, orientation and security [4, 5, 6, 7, 1].

Importance of Water for Plants

Water is the basic source of life and is a need for all living things on earth. Water is essential for the maintenance of basic life activities and is also frequently used in social areas such as domestic use, industry, transportation, agriculture and tourism [8]. As the world develops and more complex life networks and conditions emerge in the social context, the need for water increases day by day due to the increase in all practices that destroy usable water resources, especially human activities, rapid population growth, and industrial development. For this reason, new research is constantly being conducted due to the decreasing water resources in the world. It is predicted that there will be an estimated 50% increase in water demand in the world in 2030, and the water demand, which is around 4,500 km^3, will increase to 6,900 km^3 due to factors such as global warming, drought and increasing population [9]. It is anticipated that the water allocated to landscape areas will decrease as food crops will be a priority due to the increasing water demand and the decreasing water resources.

Water stress caused by drought is one of the most crucial stress factors affecting landscape areas. Since visual quality is at the forefront in landscape areas, it is inevitable to meet the irrigation water needs of plants [10]. The amount of water required by plants varies according to species and varieties, and tolerance ranges also vary widely [11, 8]. Irrigation is one of the most crucial factors affecting the yield and quality of all plants. For this reason, it is unusual for a stressed plant to be healthy [12]. In addition, the water requirement of the plants to be used in landscape areas should be determined correctly. In areas where water should be used limitedly, a plant-specific restriction value should be determined to save water and not lose its texture and form characteristics [13]. The decrease in the amount of water in the soil is one of the biggest reasons why plants experience stress. When the water the plant takes in from the environment is less than the water it loses through transpiration, water stress begins in the plant [14].

This study aims to determine the effects of plant water consumption, morphological and phenological characteristics of Mandarin, Orange Juwel, Zwergen Fee 09 and Zwerkönig 78 miniature rose varieties, which have an important place in the landscape, under different irrigation levels and to determine their drought resistance.

MATERIAL AND METHODS

Material

•*Trial Area and Setup:* The experiment was conducted in the Crop Stress Monitoring and Thermography Laboratory (COSMOTLAB) at Çanakkale Onsekiz Mart University, Faculty of Agriculture in 2020-2021 (Figure 1).

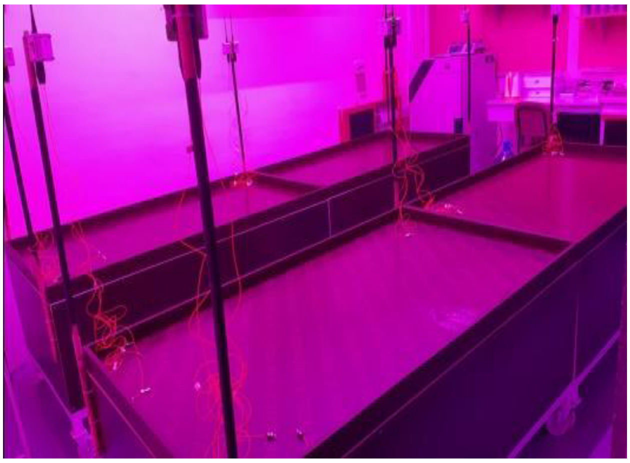

Figure 1. Trial area

The experiment was carried out under controlled laboratory conditions at 23±1°C and 40±5% relative humidity (Figure 2). CO_2 sensors were integrated into the existing measurement system and indoor and outdoor carbon dioxide values were measured. The ventilation unit worked depending on both CO_2 and relative humidity. When the difference between the CO_2 value in the laboratory and the value outside is 10%, the ventilation system is automatically activated to equalize the CO_2 amount. The plants are illuminated with a special lighting system with a special spectrum created with a combination of 450 nm-660 nm-730 nm and a 16/8 h photoperiod (Figure 2). The experiment was carried out with 4 different varieties, 4 different irrigation levels and 5 replicate (Figure 3).

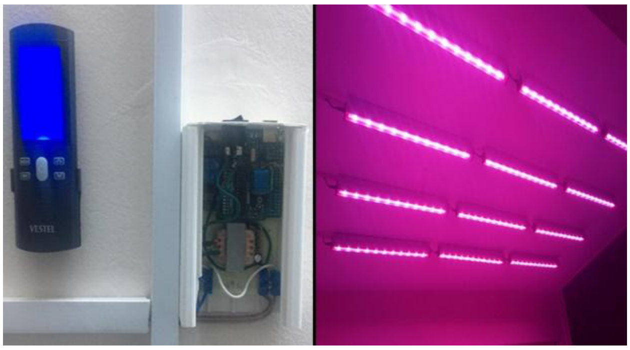

Figure 2. Temperature and lighting system

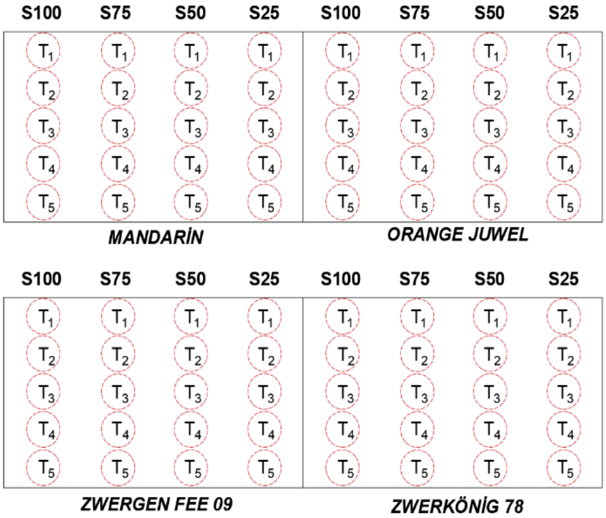

Figure 3. Experimental pattern

•*Characteristics of the Growing Medium:* A 1:1:1 loamy soil+peat+perlite mixture was used as the growing medium and one was planted in each pot (Figure 4). Each pot in which the plants are planted has a volume of 10 liters.

•*Plant Characteristics:* Four different miniature rose varieties were used: Rosa spp. cv. Mandarin, Orange Juwel, Zwergen Fee 09 and Zwerkönig 78 (Figure 5).

Figure 4. Preparation of growing medium

Figure 5. Varieties used as plant material

Method

•*Irrigation and Plant Water Consumption*

Before the trial, the pot capacity (field capacity) of each pot was determined [15]. Before this application, the weights of the plants and growing medium and the tare of all pots to be used in the experiment were taken into account and the weights of all pots were equalized.

The irrigation interval throughout the experiment was determined as 7 days. Irrigation was done by applying the moisture values determined by weighing the pots in the S100 treatment to the treatments as shown in Table 1. The irrigation water required for irrigation was taken from the city's mains water. The amount of irrigation water to be applied was measured with a measuring tape and slowly added to the pots by hand (Figure 6).

Table 1. Irrigation treatments covered in the experiment

Irrigation Treatment	Explanation
S100	Replenishing the moisture loss in the pots to the pot capacity at 7-day intervals
S75	Application of 75% of the water applied to the S100 treatment
S50	Application of 50% of the water applied to the S100 treatment
S25	Application of 25% of the water applied to the S100 treatment

Figure 6. Watering the pots

Plant water consumption of the plant for each treatment was calculated using the water balance method (Equation 1) [16]. To determine plant water consumption, the weights of all pots were taken every 14 days (Figure 7).

$$ET = I + P - D \pm R \pm \Delta s \quad (1)$$

In the equation; ET=Plant water consumption (mm), I=Irrigation water amount (mm), P=Rainfall (mm), D=Deep infiltration (mm), R=Surface runoff (mm), Δs=Moisture changes between two weighing (mm).

Deep infiltration in Equation 1 has been neglected since the moisture value will be completed to the maximum pot capacity. Water that could accumulate at the bottom of the pot was put back into the pot. Since the experiment was carried out in the pot environment under controlled conditions, rain and surface runoff were neglected.

Figure 7. Determining pot weights

•*Measurements Made in the Experiment*

In the experiment, plant height, number of flowers, flower diameter and number of petals were measured as morphological and phenological parameters.

•*Plant Height (cm):* The distance between the pot surface and the plant tip was measured using a ruler at the same time as physiological measurements (Figure 8) [17].

•*Number of Flowers (pieces):* The number of flowers that have started to open and have opened, excluding the buds on the plants in the experiment, was counted and expressed as numbers.

•*Flower Diameter (mm):* The marked flowers were measured in the specified x and y directions and their average values were calculated (Figure 9) [17].

•*Number of Petals (pieces):* The number of petals on the flowers on the plant was determined by counting them [17]. Measured from the full bloom period of the flowers.

Figure 8. Plant height measurement

Figure 9. Flower diameter measurement

Statistical Analysis

The data obtained from the study were analyzed in the R package program [18]. Among the examined characteristics, measurements taken on different dates were analyzed with the variance analysis model suitable for repeated measurement experiments. Harvest measurements and those measured at one time were subjected to variance analysis in factorial order. The significance of the differences between the levels of variance sources was evaluated with the Tukey HSD test. For measurements made at a time, irrigation treatments, genotypes and irrigation × genotype interactions were shown as bar graphs and multiple comparison test results were shown on these graphs. For measurements made on different dates, the difference between historical measurements and the average of the examined feature was taken into account to examine the changes in the examined features according to dates. For this purpose, graphs showing the historical change of each feature were created and the difference between each historical measurement from the general average was evaluated with the Kruskal-Wallis test. As a result of this test, the significance status is shown as a symbol on the graph.

RESULTS AND DISCUSSION

Total Irrigation Water Amount and Plant Water Consumption

As a result, the total irrigation water applied to the plants and plant water consumption values are given in Table 2.

In all varieties, the highest ET value is S100 and the lowest is S25 (Table 2). When we look at plant water consumption, it is seen that the M (Mandarin) variety consumes less water than other varieties in all aspects. For this reason, it becomes clear that the M plant, which consumes less water, should be preferred in areas where water is limited.

Table 2. Plant water consumption of rose varieties according to irrigation treatment (ET), mm

Irrigation Treatments	Mandarin (M)	Orange Juwel (OJ)	Zwergen Fee 09 (ZF09)	Zwerkönig 78 (Z78)
S100	642,3	796,3	736,2	675,9
S75	520,7	634,4	576,4	530,5
S50	393,0	468,5	437,6	399,6
S25	255,7	293,6	277,3	261,8

Morphological Measurements

•*Plant Height*

The results of the variance analysis of plant height values measured from miniature rose varieties in the experiment are given in Table 3. Therefore, it was determined that the main effects had a significant effect on the change in plant height, but the interaction was not significant.

Table 3. Analysis of variance for plant height

	Degrees of Freedom	Sum of Square	Mean Square	F Value	P
Replicate	2	48.94992	24.474962	3.194457	0.0552436
Variety	3	476.20305	158.734351	20.717912	0.0000002
Irrigation	3	211.14013	70.380043	9.185961	0.0001822
Variety: Irrigation	9	90.16141	10.017935	1.307535	0.2741753
Residuals	30	229.85089	7.661696	NA	NA

The comparison of plant height means by irrigation, variety and variety × irrigation interaction is shown in Figure 10. When irrigation treatments were considered, the highest plant height values in all varieties were seen in S100 and the lowest in S25 (Figure 10). While no difference was observed between S50 and S75 treatments, other treatments were statistically separated from them. When plant height values were compared according to varieties within irrigation treatments, it was seen that the OJ variety had visibly higher plant height values than the other varieties and the distinction between them was statistically significant. Additionally, it was determined that the differences between the other varieties were not significant. When the variety × irrigation interaction is reviewed, it is seen that the highest plant height value in all varieties except M variety (S50) is in S100 and the statistical difference between varieties and irrigation treatments is not significant (Figure 10). A study conducted on cyclamen plants observed a decrease in plant height in pink cyclamen due to a decrease in irrigation, but irrigation issues were not separated in red [19]. The study conducted on the primrose plant on two different primrose varieties stated that while the change in plant height was found to be statistically significant in white, it was not significant in purple [20]. As can be understood from this, plant development of different varieties of the same plant species may differ under water stress conditions.

•*Number of Flowers*

The results of the variance analysis of the flower number values measured from miniature rose varieties within the scope of the experiment are given in Table 4. Accordingly, it was seen that only the main effects had a significant effect on the change in this parameter.

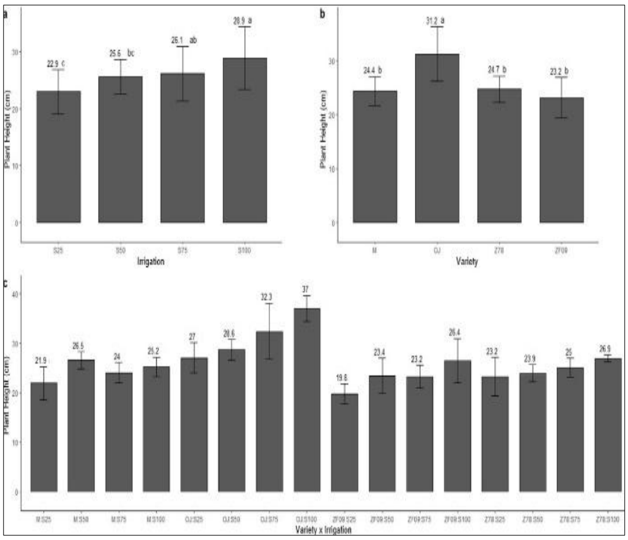

Figure 10. Comparison of plant height values with irrigation, variety and variety × irrigation interaction means

Table 4. Variance analysis for flower number

	Degrees of freedom	Sum of Square	Mean Square	F Value	P
Replicate	2	3.701446	1.850723	0.8505327	0.4372310
Variety	3	179.979432	59.993144	27.5709177	0.0000000
Irrigation	3	49.316340	16.438780	7.5547341	0.0006593
Variety: Irrigation	9	24.179501	2.686611	1.2346800	0.3117787
Residuals	30	65.278724	2.175957	NA	NA

The comparison of the means of irrigation, variety and variety × irrigation interaction of the number of flowers is shown in Figure 11. When irrigation treatments were examined, the highest flower number values in all varieties were seen in S100, the lowest in S25, and statistically, S25 and S100 treatments differed more significantly (Figure 11). When the flower number values were compared according to the varieties within the irrigation treatments, it was seen that the ZF09 variety was visibly higher than the other varieties and the difference between the other varieties was not statistically significant (Figure 11). When variety × irrigation treatment interactions are taken into account, it is seen that the highest flower number in other varieties except ZF09 variety (S75) is in S100 treatment and the statistical difference between varieties × irrigation treatments is not significant (Figure 11). A study conducted on cyclamen plants stated that the number of flowers in the pink cyclamen species was not affected by different irrigation levels in their experiments [19]. The study conducted on two different colored primrose varieties that the purple flower had more flowers than the white one in all irrigation levels [20]. Differences between studies are thought to be due to the plant.

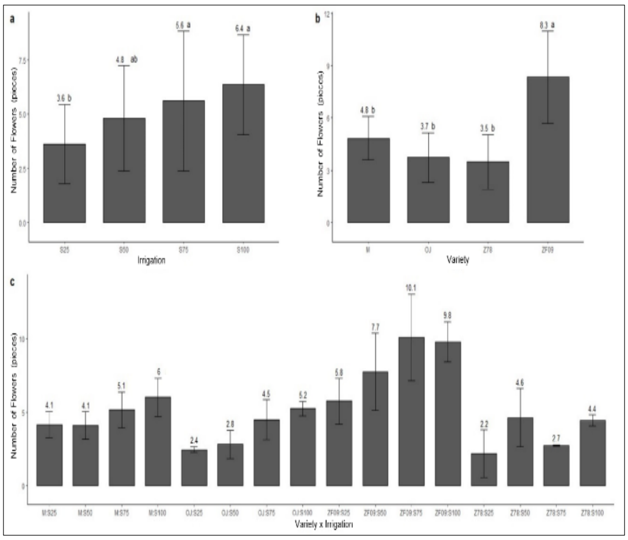

Figure 11. Comparison of the mean values of flower number by irrigation, variety and variety × irrigation interaction

•Flower Diameter

The results of the variance analysis of the flower diameter values measured from miniature rose varieties within the scope of the experiment are given in Table 5. Accordingly, it was seen that only the effects of the main effects on the change in flower diameter were significant.

The comparison of the flower diameter means of irrigation, variety and variety × irrigation interaction is shown in Figure 12.

When irrigation treatments were examined, the highest flower diameter values were seen in S100, the lowest in S25 in all varieties, and statistically, other treatments except S75 differed from each other. When flower diameter values were compared according to varieties, it was determined that the highest flower diameter was in the Z78 variety (Figure 12). In addition, it was determined that the differences between the varieties were significant and that 61, OJ and ZF09 varieties were similar to each other but different from other varieties. When the variety × irrigation treatment interactions are taken into account, the highest plant height value is in the S100 treatment in all varieties except the ZF09 variety (S100-S75). In addition, when the variety and irrigation interaction is examined, it is seen that the difference between the treatments is not statistically significant (Figure 12).

Table 5. Variance analysis for flower diameter

	Degrees of Freedom	Sum of Square	Mean Square	F Value	P
Replicate	2	0.0431727	0.0215864	0.1409628	0.8690935
Variety	3	24.1526394	8.0508798	52.5736832	0.0000000
Irrigation	3	8.9530360	2.9843453	19.4883081	0.0000003
Variety: Irrigation	9	1.9503511	0.2167057	1.4151268	0.2257951
Residuals	30	4.5940550	0.1531352	NA	NA

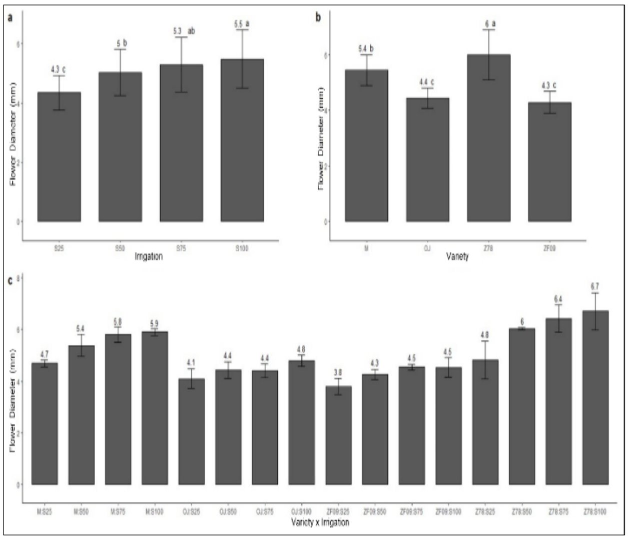

Figure 12. Comparison of flower diameter values with irrigation, variety and variety × irrigation interaction means

•Number of Petals

The results of the variance analysis of the number of petals values measured from miniature rose varieties within the scope of the experiment are given in Table 6. Accordingly, it was seen that the change in the number of petals depended only on the varieties.

The comparison of the mean of the number of petals by irrigation, variety and variety × irrigation interaction is shown in Figure 13. When irrigation treatments were examined, the highest number of petal values were observed in S75 and the lowest in S50 in all varieties. Statistically, the distinction between irrigation treatments is insignificant. When the number of petal values is compared according to the varieties within the irrigation treatments, it is seen that the highest number of petals is in the OJ variety and the lowest is in the Z78 variety (Figure 13). In addition, it was determined that the differences among the varieties were significant and all varieties were statistically different from each other. When the variety × irrigation interaction is examined, the highest number of petals value is in S100 in M and Z78 varieties, S75 in OJ and S25 in ZF09. Additionally, the statistical difference between varieties and irrigation treatments is not significant (Figure 13).

Table 6. Variance analysis for the number of petals

	Degrees of Freedom	Sum of Square	Mean Square	F Value	P
Replicate	2	58.43310	29.21655	1.6404627	0.2108084
Variety	3	3248.81138	1082.93713	60.8051998	0.0000000
Irrigation	3	67.80416	22.60139	1.2690320	0.3027419
Variety: Irrigation	9	138.69049	15.41005	0.8652501	0.5653307
Residuals	30	534.29828	17.80994	NA	NA

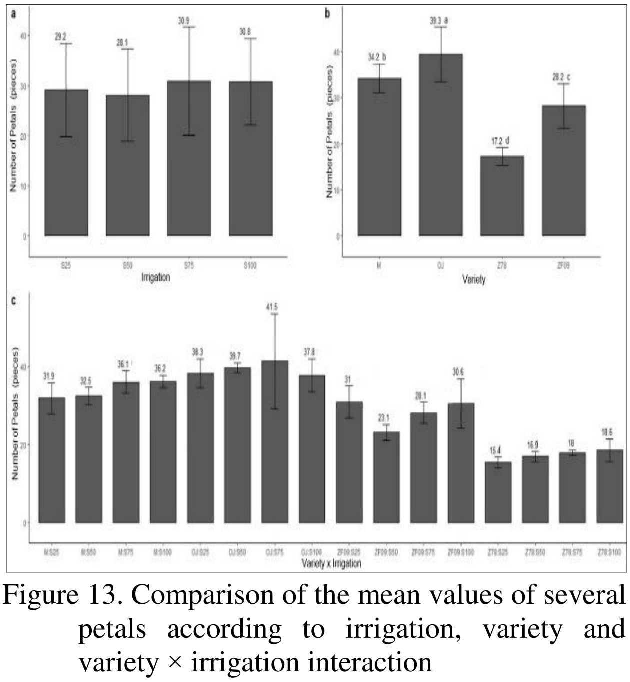

Figure 13. Comparison of the mean values of several petals according to irrigation, variety and variety × irrigation interaction

CONCLUSIONS

In recent years, the more frequent use of miniature roses, which are among the shrubby ornamental plants, in landscape applications has brought with it many questions about the method, frequency and amount of irrigation that should be used in plantations with these plants. Eventually, this experiment conducted on miniature roses, it was revealed which varieties came to the fore with their vegetative growth performance under water stress, and the effects of water stress, which became increasingly obvious in the changes in the morphological characteristics of the plants, were also clearly revealed in the physiological responses of the plants to water stress.

In this study, where the responses of different miniature rose varieties to water stress were evaluated in terms of morphological and phenological characteristics, it was determined that the Mandarin miniature rose variety came to the fore with less water consumption compared to the others, considering the total irrigation water applied and plant water consumption. In this sense, the use of miniature roses among plant materials in landscaping applications to be carried out in areas where water is more limited will be of particular importance in terms of a longer-lasting and visually high-quality plantation.

In the study, it was detected that irrigation applied to plants caused significant changes in the morphological characteristics of miniature roses. There are differences in the responses of miniature rose varieties according to the irrigation treatments applied in the study in terms of plant height. Plant height generally decreased with the decrease in irrigation level. Also, due to Mandarin reaching the highest plant height value at 50% water restriction among the varieties indicates that the plant's development performance is high despite water stress.

The most important features that provide visual quality in landscape plants are the presence of flowers and the size of the flowers. When the study was evaluated from this aspect, the highest number of flower values in all varieties according to irrigation treatments were seen in control (S100) treatment, and the lowest flower number values were seen in the S25 treatment, where water stress was applied the most. Similarly, although flower diameters tended to decrease due to the decrease in irrigation, the fact that flower diameter values were high in S75 irrigation, although varying according to varieties, showed that visual quality was preserved at 25% water restriction.

In future studies, it is advised that more exhaustive studies be conducted to define the changes in the physiological and morphological characteristics of different ornamental plants commonly used in landscape areas under water stress conditions.

ACKNOWLEDGEMENTS

This study was funded by the Scientific and Technological Research Council of Turkey under Research Project No: [120O276].

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