**Journal of Tekirdag Agricultural Faculty**
Tekirdağ Ziraat Fakültesi Dergisi

Mayıs/May 2023, 20(2)
**Başvuru/Received:** 26/03/22
**Kabul/Accepted:** 06/10/22
**DOI:** 10.33462/jotaf.1093951

http://dergipark.gov.tr/jotaf
http://jotaf.nku.edu.tr/

**ARAŞTIRMA MAKALESİ** **RESEARCH ARTICLE**

# Determination of the Effect of Different Irrigation Regimes on Some Quality Properties of Cucumber

Hıyarın Bazı Kalite Özellikleri Üzerine Farklı Sulama Rejimlerinin Etkisinin Belirlenmesi

**Harun KAMAN[1*], Ömer ÖZBEK[2], Ersin POLAT[3]**

## Abstract

This study aimed to examine the effects of varying levels of deficit irrigation applied through partial root drying (PRD) and conventional deficit irrigation on some parameters of cucumber plant such as fresh and dried biomass, plant stem diameter, number of leaf, fruit length, fruit diameter, fruit weight, water soluble dry matter (WSDM). Seven irrigation treatments (DI75, APRD75, FPRD75, DI50, APRD50, FPRD50) were examined together with the control treatment (FULL). The irrigation water of the treatments DI75, APRD75 and FPRD75 are 25% less than the FULL treatment. The irrigation water of the DI50, APRD50 and FPRD50 treatments is 50% less than the FULL treatment. DI75 and DI50 are traditional deficit irrigation applications in which both sides of the plant root zone are wetted. In APRD75 and APRD50 treatments, one half of the plant root zone is wetted and the other half is left dry and the wet/dry parts are switched in each irrigation application. In FPRD75 and FPRD50 treatments, one half of the plant root zone is wetted and the other half is left dry for a fixed period during the entire season. It has been revealed that 25% and 50% water deficit levels affect the amount of biomass as a result of the application of conventional deficit irrigation and partial root drying (PRD) techniques when compared to the FULL treatment. However, it has been found that the parameters such as plant stem diameter, fruit length, fruit diameter, fruit weight and WSDM are not affected. When the results obtained in the research are evaluated; it has been observed that water application techniques (DI, APRD, FPRD) have a significant effect on both plant development and yield when the same amount of water is given. As irrigation water constraint increases, the yield has been found to decrease. However, the decrease in the amount of irrigation water and the decrease in yield have not been the same. Research aiming to save irrigation water is increasingly important, especially in arid and semi-arid regions where water is scarce and expensive. In this regard, the fact that the decrease in yield remains smaller than the rate of decrease in irrigation water can be seen as an advantage of PRD treatments.

**Keywords:** Drip irrigation, Deficit irrigation, Partial root drying, Biomass, Fruit diameter, Fruit weight.

[1]***Sorumlu Yazar/Corresponding Author**: Harun Kaman, Akdeniz Üniversitesi, Ziraat Fakültesi, Tarımsal Yapılar ve Sulama Bölümü, 07058 Kampüs, Antalya, Türkiye. E-mail: hkaman@akdeniz.edu.tr OrcID: 0000-0001-9308-3690.
[2]Ömer Özbek, Batı Akdeniz Tarımsal Araştırma Enstitüsü Müdürlüğü, Toprak ve Su Kaynakları Bölümü, Antalya, Türkiye. E-mail: omer.ozbek@tarimorman.gov.tr OrcID: 0000-0001-6334-1222.
[3]Ersin Polat, Akdeniz Üniversitesi, Ziraat Fakültesi, Bahçe Bitkileri Bölümü, 07058 Antalya, Türkiye. E-mail: polat@akdeniz.edu.tr OrcID: 0000-0003-2414-5071.
**Atıf/Citation:** Kaman, H., Özbek, Ö., Polat, E. (2023). Determination of the effect of different irrigation regimes on some quality properties of cucumber. *Journal of Tekirdag Agricultural Faculty*, 20(2): 318-333.

## Öz

Bu araştırmada; farklı kısıntılı sulama suyu düzeylerinin geleneksel kısıntılı sulama ve yarı ıslatmalı sulama teknikleriyle uygulanması sonucu hıyar bitkisinde taze ve kuru biyokütle, bitki gövde çapı, yaprak sayısı, meyve boyu, meyve çapı, meyve ağırlığı, suda çözünebilir kuru madde gibi kalite parametrelerine etkilerinin belirlenmesi amaçlanmıştır. Kontrol konu (Tam sulama) ile birlikte yedi sulama (DI75, APRD75, FPRD75, DI50, APRD50, FPRD50) konusu ele alınmıştır. DI75, APRD75 ve FPRD75 konularının sulama suyu Tam sulama konusuna kıyasla 25% daha azdır. DI50, APRD50 ve FPRD50 konularının sulama suyu ise Tam sulama konusuna kıyasla 50% daha azdır. DI75 ve DI50 bitki kök bölgesinin her iki tarafının ıslatıldığı geleneksel kısıntılı sulama uygulamalarıdır. APRD75 ve APRD50 konularında bitki kök bölgesinin görece olarak bir yarısının ıslatılıp diğer yarsının kuru bırakıldığı ve ıslak/kuru kısımların her sulamada yer değiştirildiği uygulamadır. FPRD75 ve FPRD50 konularında tüm sezon boyunca sabit bir şekilde bitki kök bölgesinin görece olarak bir yarısının ıslatılıp diğer yarsının kuru bırakıldığı uygulamadır. Tam sulama konusuna kıyasla %25 ve 50% su kısıntısı seviyelerinin geleneksel kısıntılı sulama ve yarı ıslatmalı sulama teknikleriyle uygulanması sonucu biyokütle miktarını etkilediği ortaya çıkmıştır. Ancak, bitki gövde çapı, meyve boyu, meyve çapı, meyve ağırlığı ve suda çözünebilir kuru madde parametrelerini etkilemediği belirlenmiştir. Araştırmada elde edilen sonuçlar değerlendirildiğinde; su uygulama tekniklerinin (DI, APRD, FPRD) aynı miktarda su verildiği şartlarda hem bitki gelişimine hem de verime önemli etkisi olduğu görülmüştür. Sulama suyunun kısıntı düzeyi artıkça verimde azalma saptanmıştır. Ancak, sulama suyu miktarındaki azalış ile verimdeki düşme oranı aynı olmamıştır. Sulama suyundan tasarruf sağlamaya yönelik araştırmalar özellikle suyun kıt ve pahalı olduğu kurak ve yarı kurak bölgelerde önemini gittikçe artırmaktadır. Bu bağlamda, verimdeki düşüş sulama suyundaki azalma oranından daha küçük kalması PRD konularının bir avantajı olarak görülebilir.


**Anahtar Kelimeler:** Damla sulama, Kısıntılı sulama, Kısmi kök kuruluğu, Biyokütle, Meyve çapı, Meyve ağırlığı

## 1. Introduction

Cucumber is produced in 135 countries, mainly in China. Cucumber production in the world was 87805086 tons in 2019, followed by China with 70288130 tons, Turkey with 1916645 tons and Russia with 1626360 tons in the top three countries in production (FAO, 2021). Cucumber is produced in every region in Turkey, especially in the Mediterranean and Aegean regions, and the total production of cucumber in 2017 was 1827782 tons. 1687927 tons of this production is classified into two categories as table cucumber and gherkin, and about 61% of cucumber production is done in greenhouses (Yağcıoğlu, 2018). The amount of table cucumber production in Turkey in 2021 was 1696520 tons. 40346 tons of this production took place in a low tunnel, 249975 tons in a glass greenhouse, 754754 tons in a plastic greenhouse, 124976 tons in a high tunnel, and 441163 tons outdoor (Anonymous, 2022). Cucumber is one of the most important vegetables grown in greenhouses and is the second most vegetable species grown in greenhouses after tomato in Turkey. Cucumber is a plant that requires more technical knowledge and experience when produced in a greenhouse compared to other vegetables. Together with this, when the cultivation technique is applied properly and the necessary environmental conditions are ensured, higher yields and profits can be obtained in cucumber production compared to other greenhouse vegetables (Yücel Engindeniz, 2017). In recent years, the effect of many different applications on the yield and quality characteristics of cucumber in Turkey has been studied. Söylemez et al. (2020) examined the effect of different irrigation levels on yield and some quality characteristics in perlite and coco peat environments. Akın et al. (2020) examined the effect of mycorrhiza application and different irrigation levels on yield and yield components in cucumber. Tarakçıoğlu (2017) introduced new ways in plant cultivation in environments with soil pollution and emphasized the importance of deficit irrigation and fertilization-related studies. Dursun et al. (2017) conducted a study on cucumber fertilization and examined the effect of different doses of fertilizer applications on cucumber yield.

One of the most important factors affecting the yield and quality of crop production in Turkey and around the world is the use of appropriate amounts and good quality irrigation water. However, water resources are under significant threat due to irregularities in rainfall regimes and human-caused damage. This threat, therefore, affects the sustainability of agricultural production. Thus, it is becoming important to use the irrigation water in agriculture most efficiently. In recent years, some studies have been conducted on cucumber irrigation; Bozkurt and Sayılıkan Mansuroglu (2017) examined the effect of a subsurface drip irrigation system in which the laterals are placed at different depths on cucumber yield; Turhan et al. (2015) examined the effect of different salinity levels applied to cucumber plants on yield and fruit characteristics; Kırbay and Özer (2015) investigated the effect of different shading applications on cucumber yield and quality.

It is highlighted that Turkey is one of the countries at the risk of the possible effects of global warming, while the Mediterranean and Central Anatolia regions may be more affected by climate change. Reducing the negative effects of agricultural drought can be possible with measures and proper planning. Therefore, the measures to be taken before the drought and steps to be taken during the drought should be planned separately. Although it is not possible to increase the amount and improve the quality of water resources by interfering in the amount and time of rainfall, it is possible to reduce the negative effects caused by drought (Kapluhan, 2013). For example, increasing the efficiency of water use in agricultural irrigation may be the most important way. In order to increase the efficiency of water use in agricultural irrigation, different types of deficit irrigation applications could be considered. Many studies have also been conducted in Turkey on deficit irrigation (for example; Azder et al., 2020; Göçmen and Erdem, 2019; Ali et al., 2021). In general, the studies conducted by Azder et al. (2020) and Ali et al. (2021) were about the amount of irrigation water applied affects the reactions of plants.

In contrast to traditional deficit irrigation, another application of deficit irrigation is the partial root drying (PRD) technique. Water loss is less in the leaves of plants grown under the PRD technique and their stomata are relatively closed (Zhang et al., 1987; Davies and Zhang, 1991; Davies et al., 1994). This study aimed to determine the changes in biomass, yield and fruit quality in cucumber under deficit and optimal irrigation practices. This research aimed to identify the effects of varying deficit irrigation levels through the application of different irrigation levels by conventional deficit irrigation and partial root drying (PRD) techniques on the parameters of the cucumber plant, such as biomass, plant stem diameter, fruit length, fruit diameter, fruit weight and water soluble dry matter (WSDM).

## 2. Materials and Methods

### *2.1. Study and characteristics*

This research was carried out in two different greenhouses in the Research and Application Area of the Faculty of Agriculture of Akdeniz University in 2011 and 2012. The greenhouse was designed with a size of 16×60 m, which is widely used in Turkey and is established in a north-south direction. The height of the research area is 54 m above sea level (Anonymous, 1998). Summers are hot and dry, winters are warm and rainy in the research area where the Mediterranean climate prevails. January is the coldest month with an average annual temperature of 9.2°C, the average annual temperature is 18.0°C, and July is the hottest month with an average annual temperature of 28.2°C in Antalya. The average annual proportional humidity is 63%, the average total precipitation is 1063.5 mm, and the average total evaporation is 1886.3 mm (Anonymous, 2000). The soil type of the research area is the Gölbaşı series. Gölbaşı series, which is developed on massive travertines, is included in the Entisol ordo because they are young soils that do not show much profile development. All profiles of the soils of this series, which have an AC horizon and are very young, have a clay-tin texture. They are located in almost flat and almost-flat topographies (Sarı et al., 1993).

### *2.2. Plant material*

Deltastar F1 – hybrid cucumber species were used in the study. This type is a multi-cucumber type, the fruits of which are of high quality and homogeneous, have a long shelf life, are suitable for cultivation in the late autumn and early spring.

### *2.3. Irrigation implementation and research planning*

Irrigation applications were carried out by drip irrigation method. The seven treatments used in the study are: (1) FULL, traditional control treatment applied without any water deficit in the irrigation water that plant needs and it was calculated according to the Class-A evaporation pan; (2) DI75, traditional deficit irrigation in which 75% of the amount of water that was applied to the FULL treatment to both sides of the plant roots; (3) DI50, traditional deficit irrigation in which 50% of the amount of water that was applied to the FULL treatment to both sides of the plant roots; (4) APRD75, 75% of the amount of water applied to the FULL treatment was applied and irrigated sides of the root zone were alternated every irrigation; (5) APRD50, 50% of the amount of water applied to the FULL treatment was applied and irrigated sides of the root zone were alternated every irrigation; (6) FPRD75, 75% of the amount of water applied to the FULL treatment was applied to the same half of the plant root through the irrigation season, (7) FPRD50, 50% of the amount of water applied to the FULL treatment was applied to the same half of the plant root through the irrigation season.

The irrigation treatments examined in the study were placed in the greenhouse in a random way and 3 replicates. Seedlings were planted into the soil according to the random parcel experimental design. The planting process of the cucumber was carried out leaving 50 cm- of space between plants on the same line and 80 cm-space between lines. There were 16 plants in each line and a total of 5 lines in each irrigation treatment. Harvesting was carried out from 14 plants, generally from an iteration of each treatment, taking into account the edge effect. Watering was planned to be once a week at fixed intervals until flowering, and twice a week from the time of fruit set to the final harvest. A-Class evaporation container was placed in the greenhouse and the amount of irrigation water applied to the control (FULL) treatment was calculated with the help of the following Equation (1) using evaporation measurements taken from this (Kirda et al., 2004; Kaman et al., 2006).

$$I = K \times Ep \qquad \text{(Eq. 1)}$$

In equation: I refers to the irrigation water (mm); K refers to the coefficient of vegetation cover; Ep refers to the total evaporation (mm) from the Class-A evaporation container corresponding to the irrigation intervals.

100 mg $l^{-1}$, 30 mg $l^{-1}$ and 200 mg $l^{-1}$ of nitrogen, phosphorus and potassium fertilizers, respectively were applied in line with the data obtained from the research results and the manufacturer's practices in the region, which are considered necessary for the cucumber plant (Kirda and Baytorun, 1999).

### *2.4. Observations and measurements made on plants and fruits*

In order to determine potential changes in the plants and fruits under different irrigation practices in the research, the parameters of fresh and dried biomass, plant stem diameter, number of leaf, fruit length, fruit diameter, fruit weight, water soluble dry matter (WSDM) were observed and measured.

Biomass measurements were made by cutting plants in 3 replicates, one from each iteration of each treatment. This process continued from the beginning of the irrigation until the final harvest date. In the calculation of biomass, the cut plants were divided into stem, leaf and fruits and kept in the drying oven at 65°C until they reached a constant weight. Then, the amount of biomass on the soil was calculated by weighing and averaging the dried samples.

Stem diameter measurements were made before starting irrigation applications, six plants (six replicates) were marked from each treatment to represent each treatment during the whole season.

Fruit length, fruit diameter and fruit weight were measured/weighed at each harvest and monitored throughout the season.

Apart from the difference in the level of irrigation water and the way of applying irrigation, fertilization, pruning, spraying, etc. were made equally. Therefore, parameters such as fruit length, fruit diameter, fruit weight, water soluble dry matter (WSDM) in cucumber plants were affected only by the level of irrigation water applied and how it was applied.

The data obtained from the study were subjected to variance analysis according to the random parcel experiential design pattern, and the data with a statistical difference in the averages were evaluated at a 5% significance level using the Tukey multiple comparison test.

In addition, more detailed information regarding the material and method of the research could be seen in the publication by Kaman et al. (2022).

## 3. Results and Discussion

The change between the yield values obtained in the study was found to be significantly different at Tukey's 5% level (Kaman et al., 2022). The 25% less irrigation water of the control treatment (FULL) was applied to the treatments of DI75, APRD75 and FPRD75, and similarly, the 50% less was applied to the treatments of DI50, APRD50 and FPRD50. The amount of irrigation water applied to the treatments covered in the study ranged between 152 mm and 217 mm in the first season and between 89 mm and 148 mm in the second season (Kaman et al., 2022). Yield values were found to have changed between 12267 kg da$^{-1}$ and 18810 kg da$^{-1}$ in the first season, and ranged between 10001 kg da$^{-1}$ and 19168 kg da$^{-1}$ in the second season. In the first season of the study, FPRD50 and DI50 treatments were the treatments with the lowest efficiency among irrigation applications, while in the second season, DI50 treatment was the treatment with the lowest efficiency.

### *3.1. Fresh and dried biomass*

Changes in total fresh and dried biomass of the irrigation treatments examined at the end of the first and the second seasons are given in *Figure 1* and *Figure 2*, respectively. Additionally, for first season, the detailed variation of the plant's fresh and dried biomass, including stem, leaf, fruit, blooming and unblooming flower, can be seen in *Figure 3*. In general, the biomass value tends to decrease numerically in the treatments with a 50% water deficit, while pruning operations applied during the season in all treatments also led to decreases in biomass values. During the plant development season, biomass values varied from treatment to treatment depending on plant development and leaf pruning. In general, the values of parameters of the fresh and dried biomass were decreased as expected at the time of pruned (*Figure 1*, *Figure2*, *Figure 3*).

Similarly, when the biomass values of the general average were examined, the APRD50 and FPRD50 treatments were found to be the treatments with the lowest biomass average compared to the control FULL treatment, which applied no water deficit. However, there was no statistically significant difference between other irrigation treatments and FULL treatment in terms of biomass values. Hossain et al. (2018) conducted research and found that varying irrigation levels affected the biomass of cucumber. It has been reported that as the irrigation water applied to the cucumber decreases, the fruit yield and the amount of biomass decreased significantly (Bozkurt and Sayılıkan Mansuroğlu, 2017; Ali et al., 2020; Parkash et al., 2021). Abd El-Mageed et al. (2018) explained that there is a strong relationship between the compound effect of deficit irrigation and growing season on biomass in cucumber. Similarly, it has been reported that there is a linear relationship between plant water consumption and biomass in studies that applied deficit irrigation in maize plants (Eck, 1986; Payero et al., 2009;

Djaman et al., 2013). It was found in another study in which the effects of water deficit applied in the varying stages of the growth of tomato plant that the water deficit applied until the flowering period suppressed the biomass significantly while the gradual water deficit applied after the flowering period had caused no significant loss in the biomass.

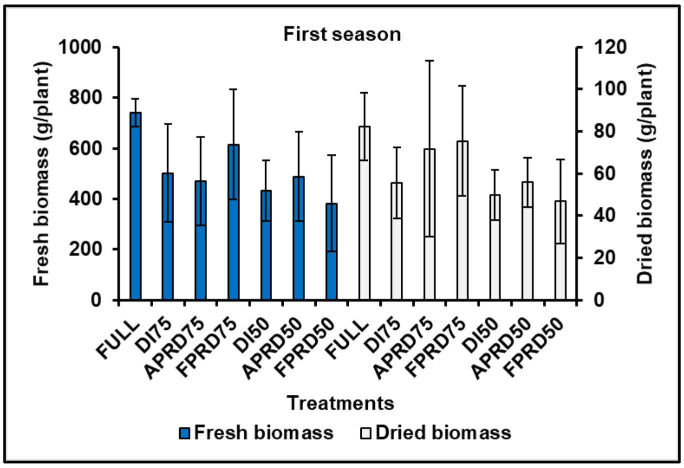


***Figure 1. Changes in total fresh and dried biomass at the end of the season of irrigation applications for the first season in the study.***

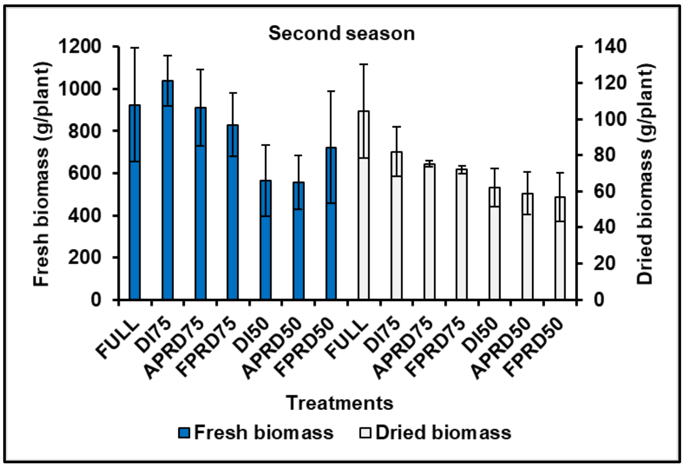


***Figure 2. Changes in total fresh and dried biomass at the end of the season of irrigation applications for the second season in the study.***

### *3.2. Stem diameter*

In detail, plant stem diameter change 5, 10 and 15 cm above the soil surface and on the soil surface in the first season of the study can be seen in *Figure 4*. In the second season of the study, the change in the stem diameter on the soil surface was given in *Figure 5*. In the first season, the stem diameter values measured in the soil surface ranged between 10.8 and 16.7 mm (*Figure 4*). In the second season, the stem diameter values measured in the soil surface ranged between 9.5 and 13.3 mm (*Figure 5*). The change between both years can be explained by the difference in temperature values. The effect of irrigation treatments on plant stem diameter was found to be statistically insignificant in both years of the study. Although the stem diameter values changed decimally between the treatments, this change was found to be statistically insignificant. In some of the studies where the effect of different irrigation treatments on stem diameter was examined, the effect of applications on stem diameter was found to be significant, while in some of them it was found to be insignificant. For example, Söylemez et al. (2020) found that irrigation levels decreased in cucumber plants grown in perlite and coco peat environments and watered at different irrigation levels (S1: 125%, S2: 100% and S3: 75%) and stem diameter values decreased significantly. Cemek et al. (2005) reported that significant changes in stem diameter values were observed depending on the irrigation water and plant water consumption. In another study conducted by Başak (2020) to examine the application methods of prohexadione-calcium (Pro-We) on the growth of cucumber seedlings, it was found that

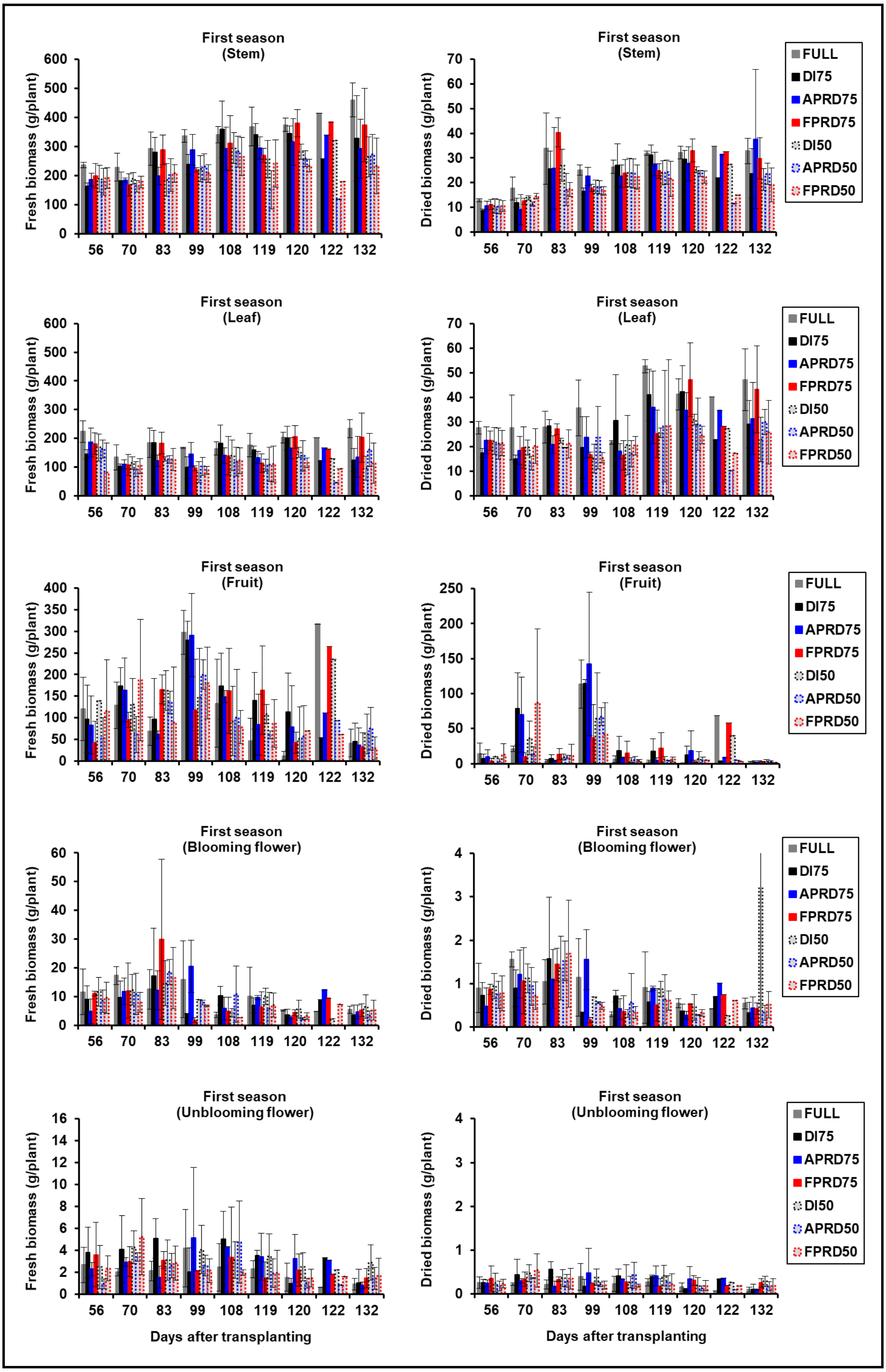


***Figure 3. Change of the plant's fresh and dried biomass, including stem, leaf, fruit, blooming and unblooming flower for first season.***

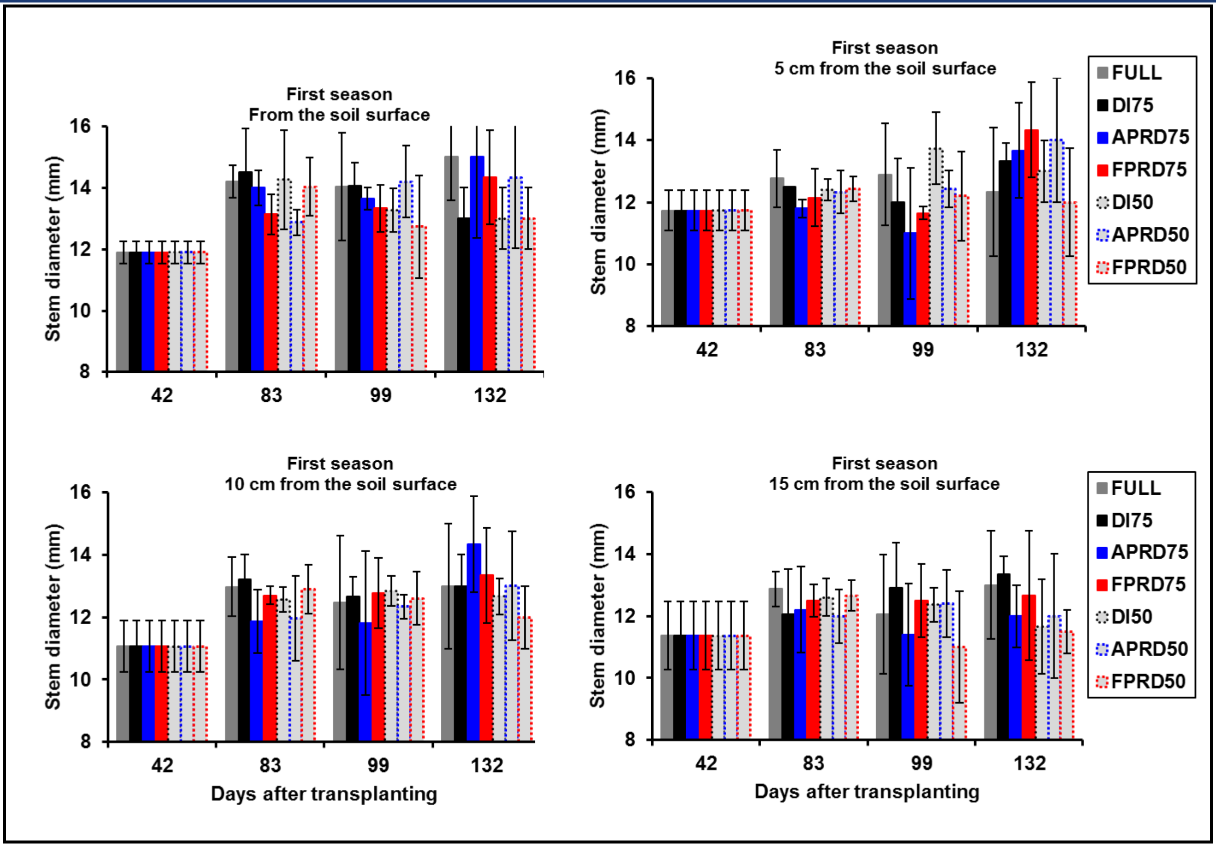


*Figure 4. Plant stem diameter change 5, 10 and 15 cm above the soil surface and on the soil surface in the first season of the study.*

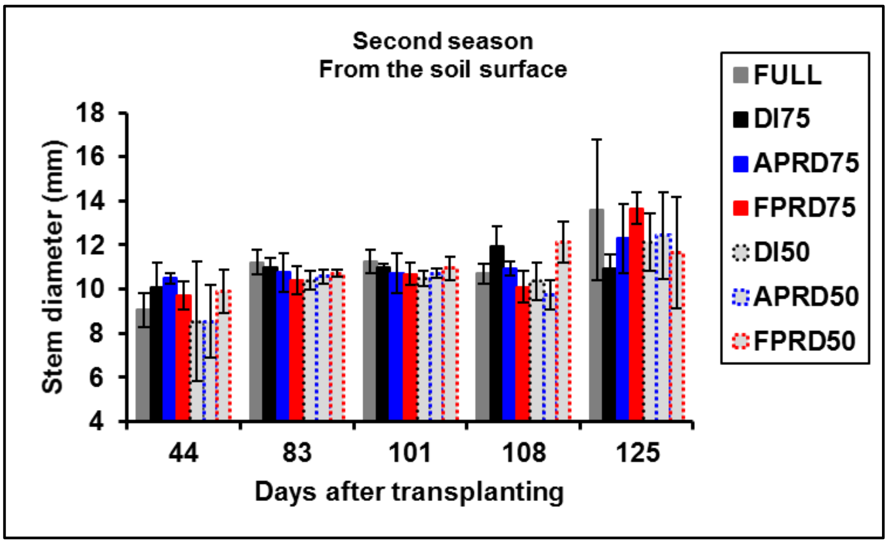


*Figure 5. Plant stem diameter change on the soil surface in the second season of the study.*

Pro-Ca applications slightly increased the stem diameter except for the 100 and 200 ppm doses applied at the seedling stage compared to the control plant; however, this increase was not found to be statistically significant. In another study conducted by Demirsoy and Aydın (2020) to determine the effects of the use of additional light sources to sunlight on the quality of cucumber (Beith Alpha F1) seedlings, it was reported that there was no statistically significant difference in the stem diameter between the applied treatments.

### *3.3. Number of leaf*

Changes in the number of plant leaf of the irrigation treatments examined in the study for the first and the second season is given in *Figure 6* and *Figure 7*, respectively. The change in the number of plant leaf was affected by the applied irrigation program. In general, the number of leaf increased at the beginning of the season until the end of the season, as expected.

In general, the values of some parameters such as fresh and dried biomass, number of leaves were decreased as expected at the time of pruned (*Figure 1, Figure2, Figure 3, Figure 6, Figure 7*).

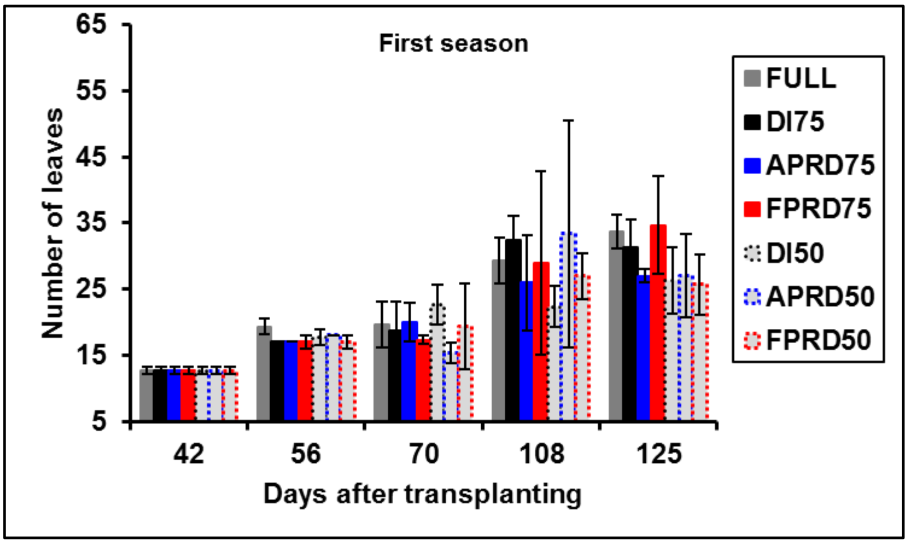


***Figure 6. Number of leaf changes of the irrigation treatments examined for the first season in the study.***

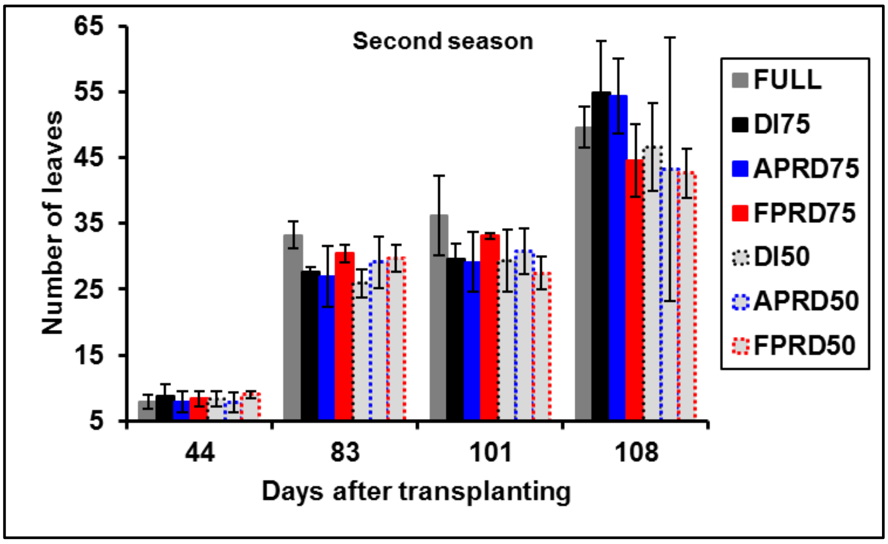


***Figure 7. Number of leaf changes of the irrigation treatments examined for the second season in the study.***

### *3.4. Fruit length*

The change in the fruit length for the first and second seasons of the study can be seen in *Figure 8 and Figure 9*, respectively. In the first season of the study, the fruit length was ranged between 15.9 - 21.8 cm, and in the second season, it was ranged between 16.3 - 18.9 cm. In the analysis of variance conducted for fruit length values, there was no statistically significant difference between irrigation treatments except for day 105 following the planting. The results of the LSD test for day 105 are given in *Table 1*. There was no statistically significant difference between the treatments of FULL, FPRD75, APRD50, DI75 and FPRD50 in the fruit length. However, the averages of these treatments were found to be higher than the DI50 treatment. In the FULL and FPRD75 treatments, the fruit length was found to be higher than in APRD75 and DI50 treatments (*Table 1*). In the second season of the study, there was no statistical difference between irrigation treatments in terms of fruit length. In a study conducted by Akın et al. (2020) to examine the effect of mycorrhiza application on yield and yield-related components of cucumber plant under various irrigation levels, it was reported that the fruit diameter, fruit length and fruit weight values ranged between 29-36 mm, 134-161 mm and 103-135 g, respectively. In addition, it has been reported that the effect of mycorrhiza and irrigation practices on fruit diameter, fruit length and fruit weight is important (Akın et al., 2020).

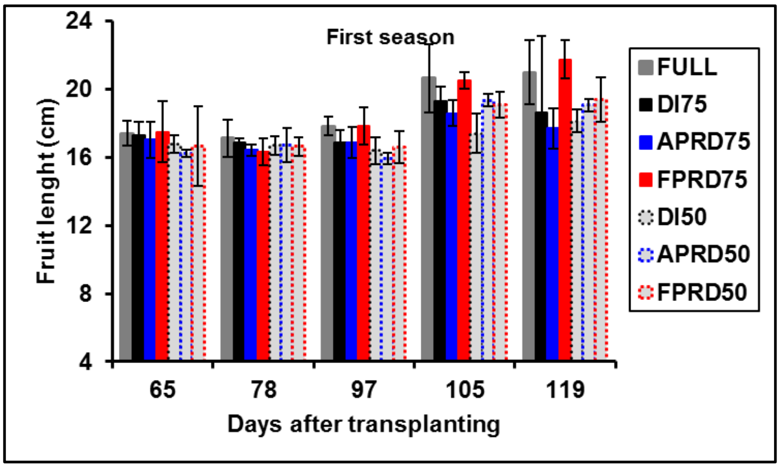


*Figure 8. The change in the fruit length in the first season of the study.*

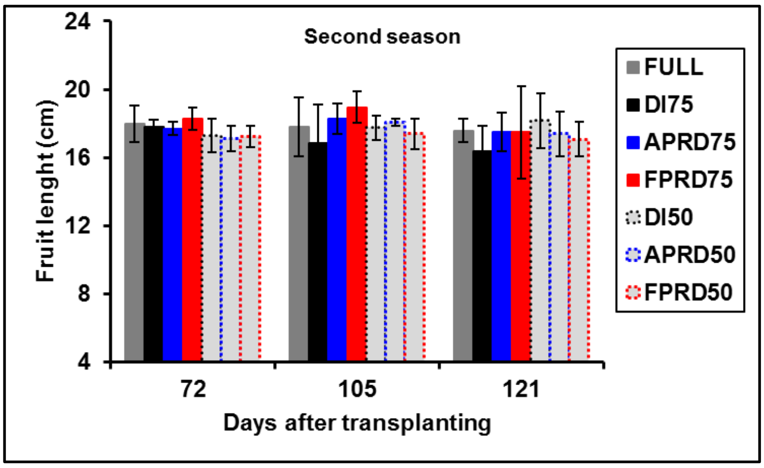


*Figure 9. The change in the fruit length in the second season of the study.*

***Table 1. The LSD test result of the fruit length for the 105th day after transplanting in the first season of the study (α=0.05).***

| Treatment | Fruit length |
|---|---|
| FULL | 20.66A |
| DI75 | 19.28AB |
| APRD75 | 18.58B |
| FPRD75 | 20.51A |
| DI50 | 16.72C |
| APRD50 | 19.36AB |
| FPRD50 | 19.10AB |
| Least Significant Difference 1.6721 | 1.67 |

### *3.5. Fruit diameter*

The change in the fruit diameter for the first and second seasons of the study is given in *Figure 10* and *Figure 11*, respectively. The fruit diameter was found to have ranged between 3.3–3.9 cm in the first season and 3.0–4.1 cm in the second season. In the analysis of variance conducted for fruit diameter values, no statistical differences were found between the treatments.

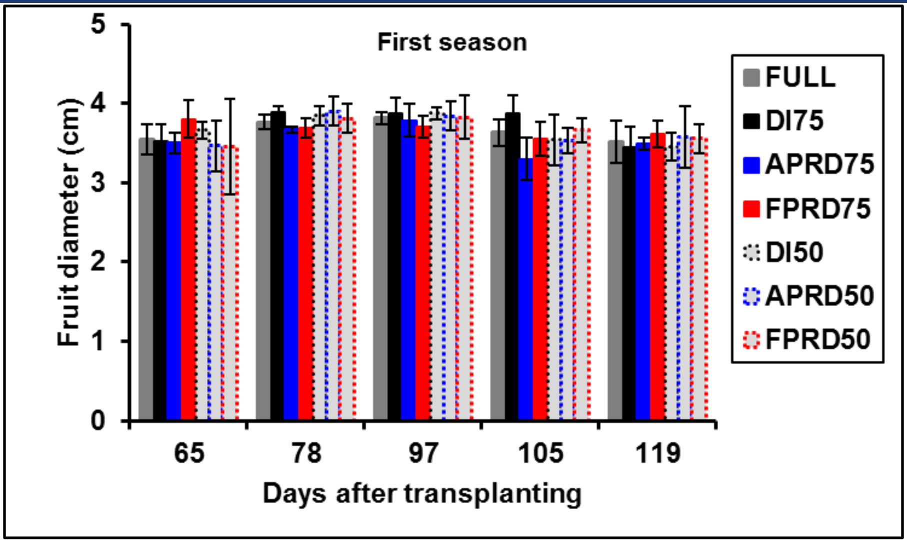


***Figure 10. The change in the fruit diameter for the first season of the study.***

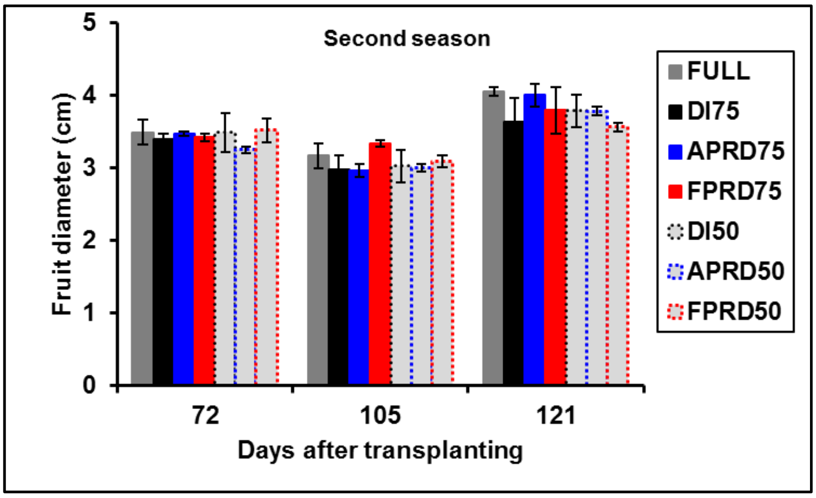


***Figure 11. The change in the fruit diameter for the second season of the study.***

### *3.6. Fruit weight*

The change in the fruit weight for the first and second seasons of the study can be seen in *Figure 12* and *Figure 13*, respectively. The fruit weight ranged between 133.2 – 206.3 g in the first season and 108.8 – 194.9 g in the second season. There was no statistically significant difference in the analysis of variance for the first season. In the second season, the fruit weight values on day 105 following the planting were found to be statistically significant (p=0.0078). The results of the LSD test are given in *Table 2*. When the fruit weight LSD results were examined, there was no statistical difference between FPRD75 and FULL treatments. However, the treatment of FPRD75 had a higher fruit weight value than the treatments of APRD75, FPRD50, APRD50, DI50 and DI75 (*Table 2*).

In the study, the effect of irrigation treatments on fruit length, fruit diameter and fruit weight in general (except for the fruit length on day 105 following the planting in the first season, fruit weigh on the day 105 in the second season after planting) were found to be not significant. Bozkurt and Sayılıkan Mansuroğlu (2017) reported that there is no statistically significant difference between the applied treatments in terms of fruit weight in cucumber irrigated at different levels with a subsurface drip irrigation system. Ali et al. (2020) reported that as the water deficit rate increases in the cucumber plant, the fruit length and weight decrease. These research results are generally similar to those of this study**.**

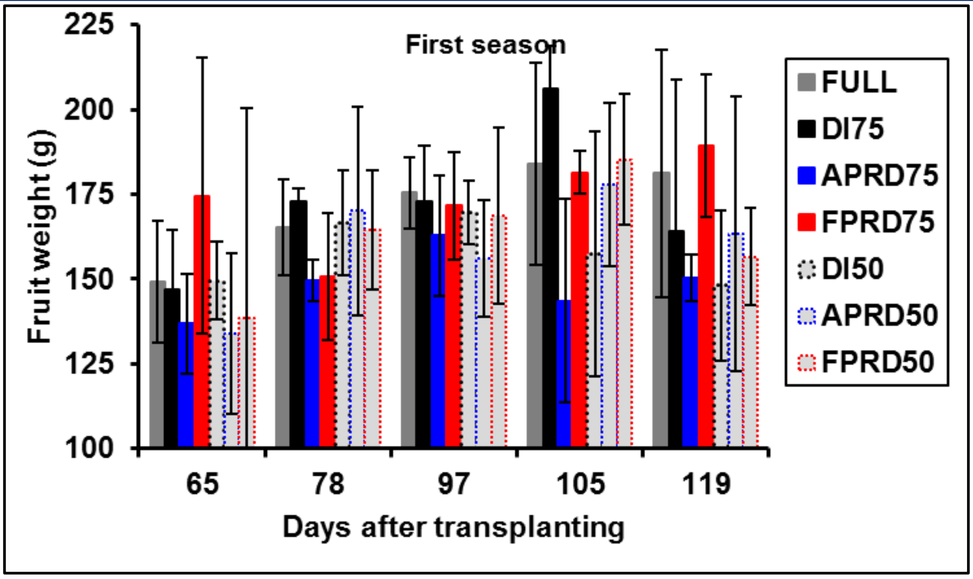


*Figure 12. The change in the fruit weight for the first season of the study.*

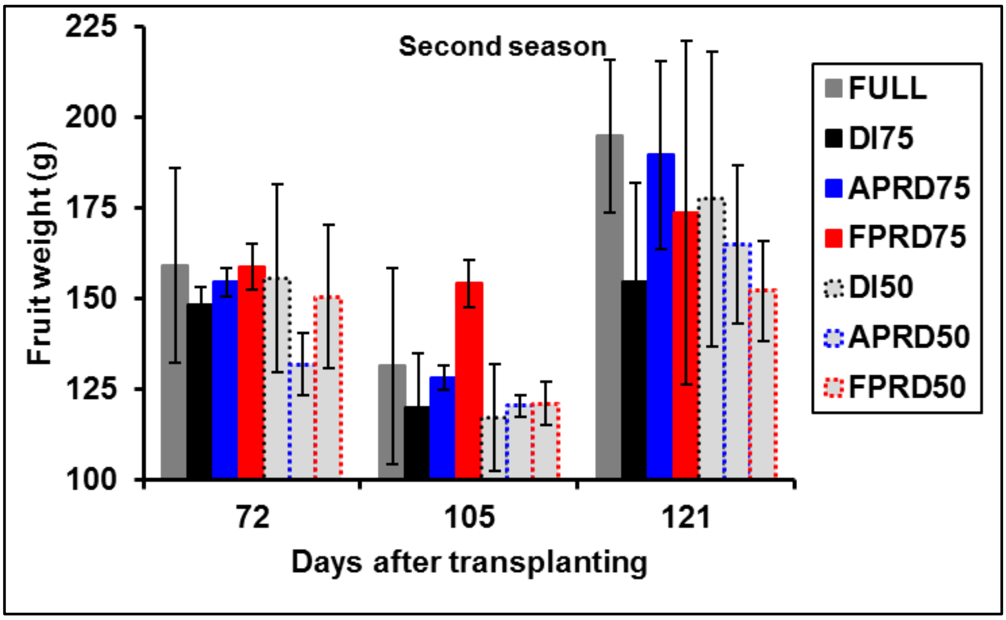


*Figure 13. The change in the fruit weight for the second season of the study.*

*Table 2. The LSD test result of the fruit weight for the 72, 105 and 121st day after transplanting in the second season of the study (α=0.05).*

| Treatment | Day after transplanting | | |
|---|---|---|---|
| | 72 | 105 | 121 |
| FULL | 159.3 | 131.5AB | 194.9 |
| DI75 | 148.4 | 108.8B | 154.8 |
| APRD75 | 154.6 | 128.2B | 189.7 |
| FPRD75 | 158.8 | 154.2A | 173.7 |
| DI50 | 155.6 | 117.4B | 177.6 |
| APRD50 | 131.9 | 120.5B | 164.9 |
| FPRD50 | 150.6 | 121.1B | 152.2 |
| Least Significant Difference | N.S. | 25.95 | N.S. |

### *3.7. Water soluble dry matter (WSDM)*

The rates of water soluble dry matter (WSDM) for the first and second seasons of the study is given in *Figure 14* and *Figure 15*, respectively. The rates of water soluble dry matter (WSDM) ranged between 2.7 and 3.9% in the first season. Except for day 97 in the first season after planting, there was no statistically significant difference between irrigation treatments in the second season WSDM measurements. The WSDM values in the first season on the day 97 after planting were found to be higher in the treatments where 50% irrigation deficit was applied and FPRD75 treatments than the other treatments. Dasgan et al. (2013) reported that WSDM values ranged between 3.62 – 4.12% in cucumber plants grown under the partial root drying (PRD) technique. Ali et al. (2020) reported that as the water deficit increases in cucumber plants grown through different irrigation levels and different doses of biofuel, the rate of WSDM increases in the fruit. These research results are generally similar to those of this research.

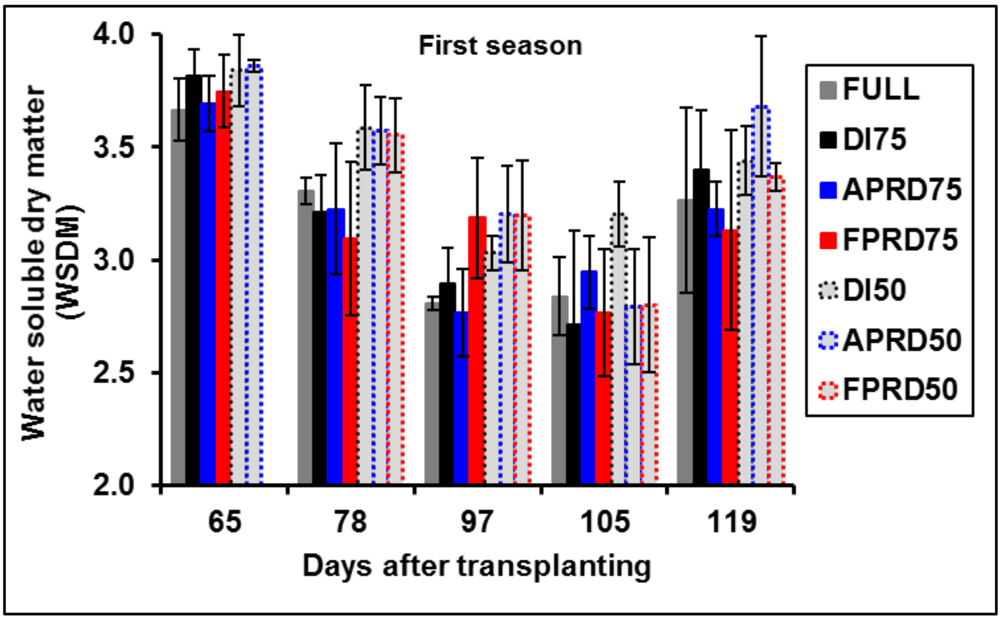


*Figure 14. The rates of water soluble dry matter (WSDM) for the first season of the study.*

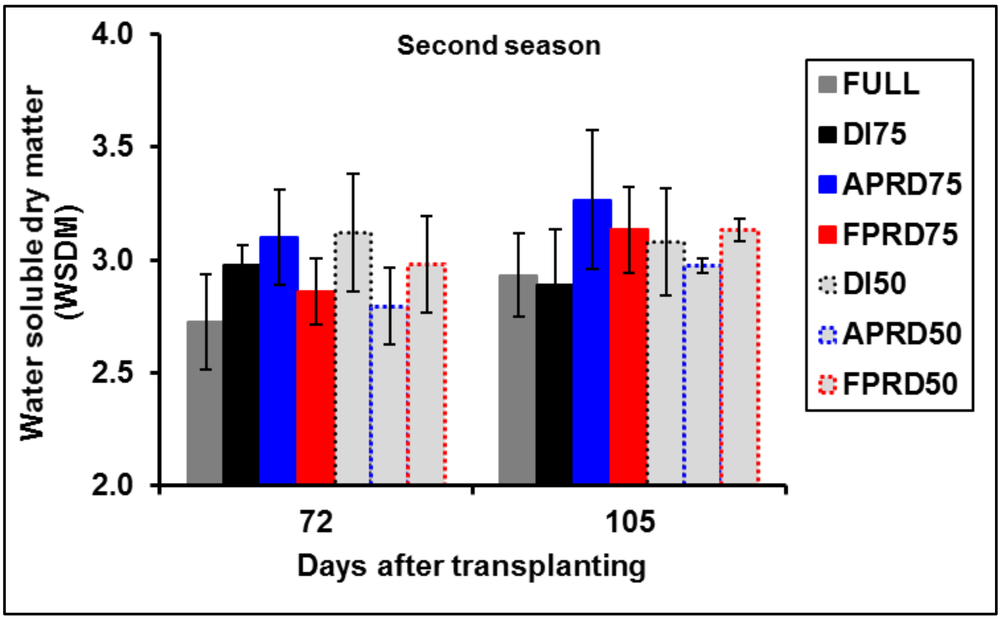


*Figure 15. The rates of water soluble dry matter (WSDM) for the second season of the study.*

## 4. Conclusions

Apart from the irrigation water level and the application methods used in the study, all agricultural operations such as fertilization, pruning, spraying, etc. were the same in the whole study. For this reason, in the study aimed to examine the effects of varying levels of deficit irrigation applied through partial root drying (PRD) and conventional deficit irrigation on some parameters of cucumber plant such as fresh and dried biomass, plant stem diameter, number of leaf, fruit length, fruit diameter, fruit weight, water soluble dry matter (WSDM).

It was revealed that 25% and 50% water deficit levels applied through conventional deficit irrigation and partial root drying (PRD) techniques affected the amount of biomass when compared to the FULL treatment. In general, the values of some parameters such as fresh and dried biomass, number of leaves were decreased as expected at the time of pruned.

It was found that it did not affect the parameters such as plant stem diameter, fruit length, fruit diameter, fruit weight and WSDM. When the results obtained in the study were evaluated, it was seen that water application techniques (DI, APRD, FPRD) had a significant effect on both plant development and yield when the same amount of water was given.

As the level of irrigation deficit increases, a decrease in yield was observed. However, the decrease in the amount of irrigation water and the decrease in yield had not been the same.

Research aiming to save irrigation water is increasingly important, especially in arid and semi-arid regions where water is scarce and expensive. In this regard, the fact that the decrease in yield remains smaller than the rate of decrease in irrigation water can be seen as an advantage of PRD treatments.

**Acknowledgment**

The authors would like to thank the Research Fund of Akdeniz University for support given to this study. Regarding the study, the water-yield relationship data of the research was published by Kaman et al. (2022).

## References

Abd El-Mageed, T. A., Semida, W. M., Taha, R. S. and Rady, M. M. (2018). Effect of summer-fall deficit irrigation on morpho-physiological, anatomical responses, fruit yield and water use efficiency of cucumber under salt affected soil. *Scientia Horticulturae,* 237: 148-155.

Akın, S., Şimşek, M., Sarıoğlu, A. ve Keskiner, A. D. (2020). Mikoriza uygulaması ve farklı sulama seviyelerinin geç dönemde yetiştirilen hıyarın verim ve verim bileşenleri üzerine etkisi. *Harran Tarım ve Gıda Bilimleri Dergisi,* 24 (2): 241-249.

Ali, A. B., Elshaikh, N. A., Hussien, G., Abdallah, F. E. and Hassan, S. (2020). Biochar addition for enhanced cucumber fruit quality under deficit irrigation. *Bioscience Journal* 36 (6): 1930-1937.

Ali, M., Gençoğlan, C., Gençoğlan, S. and Uçak, A. B. (2021). Yield and water use of eggplants (*Solanum melongena* L.) under different irrigation regimes and fertilizers. *Journal of Tekirdag Agricultural Faculty,* 18(3): 533-544.

Anonim (1998). 1997 Yılı Çalışma Raporu. T.C. Tarım ve Köyişleri Bakanlığı, Tarım İl Müdürlüğü, Antalya, 71ss.

Anonim (2000). Antalya İli Uzun Yıllık Iklim Verileri. Antalya Meteoroloji Bölge Müdürlüğü, Antalya.

Anonim (2022). https://biruni.tuik.gov.tr/medas/?kn=92&locale=tr, (Erişim Tarihi: 22.02.2022).

Azder, G., Göçmen, E. and İstanbulluoğlu, A. (2020). Effects of different irrigation levels on yield and yield components of capia pepper (*Capsicum annum* CV. Kapija) in Tekirdağ conditions. *Journal of Tekirdağ Agricultural Faculty,* 17(3): 422-431.

Başak, H. (2020). Prohexadione-calcium uygulama yöntemlerinin hıyar (*Cucumis sativus* L.) fide gelişimi ve yaprak pigmentasyonu üzerine etkileri. *Erciyes Üniversitesi Fen Bilimleri Enstitüsü Fen Bilimleri Dergisi,* 36(2): 274-279.

Bozkurt, S. ve Sayılıkan Mansuroğlu, G. S. (2017). Sera hıyar yetiştiriciliğinde farklı damla sulama lateral derinlikleri ve sulama düzeylerinin bitki gelişimi ve verime etkileri. *Mustafa Kemal Üniversitesi Ziraat Fakültesi Dergisi,* 22(2): 61-66.

Cemek, B., Apan, M., Demir, Y. ve Kara. T. (2005). Sera koşullarında farklı sulama suyu miktarlarının hıyar bitkisinin büyüme, gelişme ve verimi üzerine etkisi. *Anadolu Tarım Bilimleri Dergisi,* 20 (3): 27-33.

Dasgan, H. Y., Kuşvuran, Ş. and Kirda, C. (2013). Using of partial root drying (PRD) in soilless grown cucumber by 41% deficit irrigation-II. *Turkish Soil Water Journal,* 2(2): 1249-1256.

Davies, W.J., Zhang, J. (1991). Root signals and the regulation of growth and development of plants in drying soil. *Annual Review Plant Physiology and Plant Molecular Biology,* 42: 55-76.

Davies, J. W., Tardieu, F. and Trejo, C. L. (1994). How do chemical signals work in plants that grow in drying soil? *Plant Physiology,* 104: 309-314.

Demirsoy, M. ve Aydın, M. (2020) İlkbahar dönemi hıyar (*Cucumis sativus* L.) fidesi yetiştiriciliğinde farklı ışık kaynaklarının fide kalitesine etkileri. *Uluslararası Anadolu Ziraat Mühendisliği Bilimleri Dergisi,* 2(2): 16-22.

Djaman, K., Irmak, S., Rathje, W. R., Martin, D. L. and Eisenhauer, D. E. (2013). Maize evapotranspiration, yield production functions, biomass, grain yield, harvest index, and yield response factors under full and limited irrigation. *Transactions of the ASABE,* 56(2): 373-393.

Dursun, A., Ekinci, M., Yıldırım, E., Karagöz, F. ve Kul, R. (2017). Serada hıyar (*Cucumis sativus* L.) yetiştiriciliğinde potasyum sülfat ve magnezyum sülfat'ın verim üzerine etkileri. *Akademik Ziraat Dergisi,* 6: 211-218.

Eck, H. V. (1986). Effects of water deficits on yield, yield components, and water use efficiency of irrigated corn. *Agronomy Journal,* 78 (6): 1035-1040.

FAO (2021). http://www.fao.org/faostat/en/#data/QC, (Erişim Tarihi: 22.02.2021).

Göçmen, E. and Erdem, T. (2019). Effects of different lateral layout and irrigation regimes on water use and vegetative growth parameters of young walnut trees. *Journal of Tekirdağ Agricultural Faculty,* 16(2): 181-191.

Hossain, S. A. A. M., Wang, L. and Liu, H. (2018). Improved greenhouse cucumber production under deficit water and fertilization in Northern China. *International Journal of Agricultural and Biological Engineering,* 11(4): 58-64.

Kaman, H., Kirda, C., Cetin, M. and Topcu, S. (2006). Salt accumulation in the root zones of tomato and cotton irrigated with partial root-drying technique. *Irrigation and Drainage,* 55: 533-544.

Kaman, H., Özbek, Ö. ve Polat, E. (2022). Serada yetiştirilen hıyarın yarı ıslatmalı sulama ve geleneksel kısıntılı sulamaya tepkisi. *Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi,* 25(2): 337-347.

Kapluhan, E. (2013). Türkiye'de kuraklık ve kuraklığın tarıma etkisi. *Marmara Coğrafya Dergisi,* (27): 487-510.

Kırbay, E. ve Özer, H. (2015). Farklı gölgeleme uygulamalarının örtüaltında organik olarak yetiştirilen hıyarın (*Cucumis sativus* L.) verim ve kalite üzerine etkisi. *Uluslararası Tarım ve Yaban Hayatı Bilimleri Dergisi,* 1(1): 7-14.

Kirda, C. and Baytorun, N. (1999). Fertigation under saline conditions: Irrigation management minimizing soil salinity risk. Ryan, J. (ed.), 2000. Plant Nutrient Management under Pressurized Irrigation Systems in the Mediterranean Region. Proceedings of the IMPHOS International Fertigation Workshop Organized by the World Phosphate Institute (IMPHOS), 25-27 April, pp. 288-296, Amman, Jordan. ICARDA, Aleppo, Syria.

Kirda, C., Cetin, M., Dasgan, Y., Topcu, S., Kaman, H., Ekici, B., Derici, M. R. and Ozguven, A. I. (2004). Yield response of greenhouse grown tomato to partial root drying and conventional deficit irrigation. *Agricultural Water Management,* 69: 191-201.

Parkash, V., Singh, S., Deb, S. K., Ritchie, G. L. and Wallace, R. W. (2021). Effect of deficit irrigation on physiology, plant growth, and fruit yield of cucumber cultivars. *Plant Stress,* 1: 100004.

Payero, J. O., Tarkalson, D. D., Irmak, S., Davison, D. and Petersen, J. L. (2009). Effect of timing of a deficit-irrigation allocation on corn evapotranspiration, yield, water use efficiency, and dry mass. *Agricultural Water Management,* 96(10): 1387-1397.

Sarı, M., Aksoy, T., Köseoğlu, T., Kaplan, M., Kılıç, Ş. ve Pilanalı, N. (1993). Akdeniz Üniversitesi Yerleşim Alanının Detaylı Toprak Etüdü ve Ideal Arazi Kullanım Planlaması. Akdeniz Üniversitesi Yayınları, Antalya, 145 ss.

Söylemez, S., Esin, Ş. ve Pakyürek, A. Y. (2020). Kısıtlı sulama koşullarında yetiştirilen hıyarın verim ve bazı kalite özelliklerine waterpad polimer uygulamasının etkisi. *Türk Tarım ve Doğa Bilimleri Dergisi*, 7(4): 1031-1042.

Tarakçıoğlu, C. (2017). Damla sulamayla farklı zamanlarda uygulanan azot dozlarının hıyarın verim ile bazı bitki besin maddesi içerikleri üzerine etkisi. *Akademik Ziraat Dergisi*, 6: 219-226.

Turhan, A., Kuşçu, H. ve Demir, A. O. (2015). Sulama suyu tuzluluğunun hıyarın verim, meyve özellikleri ve su kullanım etkinliği üzerine etkisi. *Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi,* 32(3): 29-38.

Yağcıoğlu, M. (2018). *Hıyarda (Cucumis sativus L.) tohum iriliği ile düşük sıcaklıkta çimlenme yeteneğinin karşılıklı melezleme ve genomik bağlantı analizleriyle QTL haritalanması*. (Doktora tezi) Ankara Üniversitesi Fen Bilimleri Enstitüsü Bahçe Bitkileri Ana Bilim Dalı, Ankara.

Yücel Engindeniz, D. (2017). Serada hıyar yetiştiriciliğinin ekonomik yönleri ve yatırım özellikleri (Economic aspects and investment characteristics of greenhouse cucumber growing in Turkey). *Tarım Ekonomisi Dergisi*, 23(1): 123-132.

Zhang, J., Schurr, U. and Davies, W. J. (1987). Control of stomatal behaviour by abscisic acid which apparently originates in roots. *Journal of Experimental Botany,* 38 (7): 1174-1181.