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Effects of Colored Water Pillows on Cucumber (Cucumis sativus) Yield and Water Productivity under Greenhouse Conditions

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Renkli su yastığı, damlama sulama, hıyar, verim, sera

Abstract

In this study, the effects of black and white colored water pillows on the yield and Water productivity of the 'Marathon' cucumber variety were investigated and compared with the drip irrigation method. This study examined yield per decare and per plant, number of fruits per plant and per square meter, and seasonal water consumption values. In terms of the evaluated parameters, water pillows provided statistically higher values compared to drip irrigation, except for the seasonal water consumption, where they provided lower values. Yields per hectare for white and black water pillows were found to be 124.67 and 126.53 tons, respectively, while the drip irrigation yield was 78.24 tons. Seasonal plant water consumptions were 419 mm for water pillows and 622 mm for drip irrigation. These results indicated that the water pillow irrigation method was more effective in terms of yield and Water productivity than drip irrigation in greenhouse cucumber cultivation.

Renkli Su Yastıklarının Sera Koşullarında Hıyar (Cucumis sativus) verimi ile Su Verimliliği Üzerine Etkileri

Özet

Bu çalışmada, siyah ve beyaz renkli su yastıklarıyla gerçekleştirilen sulamanın Maraton çeşidi hıyarın verimi ve sulama suyu kullanımı üzerindeki etkileri incelenmiş; elde edilen bulgular damla sulama yöntemi ile karşılaştırılmıştır. Çalışmada, dekara ve bitki başına verim, bitki başına ve metrekaredeki meyve adedi ile dönemlik su tüketimi değerleri incelenmiştir. Değerlendirilen parametreler açısından su yastıkları konuları, damlama sulama konusuna göre istatistiksel olarak daha yüksek, ancak dönemlik su tüketimi açısından ise daha düşük değer vermiştir. Hektara verim değerleri, beyaz ve siyah su yastıklarında sırası ile 124.67 ve 126.53 damlama sulamada ise 78.24 ton olarak bulunmuştur. Mevsimlik bitki su tüketimleri su yastıkları ve damlama sulama yöntemlerinde sırasıyla 419 mm ve 622 mm'dir. Bu sonuçlar, serada hıyar yetiştiriciliğinde su yastıkları ile sulama yönteminin verim ve su kullanım etkinliği açısından damlama sulamaya göre daha etkili olduğunu göstermiştir.

1. INTRODUCTION

Vegetables play a significant role in our diet for a healthy life. Cucumbers are rich in iron and calcium minerals, as well as vitamins A, B, C, and K, making them an excellent source of B vitamins. Thanks to the B vitamins they contain, cucumbers help maintain emotional and mental health. Cucumbers are composed of 95% water, which facilitates the easy elimination of toxins from the body. They help alleviate bad breath, hydrate the body, and provide a substantial portion of the daily vitamin requirement. They are beneficial for high blood pressure. In addition to their diuretic properties, cucumbers also help resolve constipation issues. They regulate blood

pressure and are rich in fiber. By contributing to the digestive system, they prevent indigestion. Furthermore, cucumbers serve as a good tonic for the liver, kidneys, and gallbladder.

Tomato is the most produced vegetable in the world, with an approximate production of 190 million tons, while cucumber holds a significant position in global vegetable production with around 95 million tons (FAO, 2023). In Turkey, tomato ranks first in vegetable production for the year 2024, with 13.300.000 tons. Cucumber is the most widely grown vegetable after tomato, watermelon, onion, and pepper, with a production value of 1.741.613 tons (TUIK, 2024).

The increase in crop production is influenced by three main components: climate, soil, and the plant itself. Additionally, other measures to increase production, such as irrigation, plant nutrition, pest and disease control, and cultural practices, are also significant. However, the role of irrigation in increasing crop production is quite distinct compared to the others. Irrigation alone does not simply ensure an increase in yield; it also enhances the effectiveness of other yield-enhancing factors. For instance, high-quality seeds are a yield-enhancing measure. However, if adequate irrigation is not provided, the expected increase in yield will not occur. Today, pressurized irrigation methods are known as modern techniques. Among these, drip irrigation is a method that not only offers high irrigation efficiency but also leads to greater yield increase. In this method, to maximize water efficiency, control weeds, and further increase yield, mulching is also applied.

The water pillows, which are the subject of this article, are a new irrigation method developed in our country (Gerçek, 2006). The method is a combination of drip irrigation and mulching. In trials conducted using this method, it was initially compared with surface irrigation methods, and the advantages of the water pillow irrigation method were revealed (Gerçek et al., 2009a; Gerçek et al., 2009b; Gerçek & Okant, 2010). In later stages, it was compared with drip irrigation, and its superiority was determined in different vegetables, including tomato (Gerçek et al., 2017), pepper (Demirkaya & Gerçek, 2013), eggplant (Gerçek & Demirkaya, 2020), and bell pepper (Gerçek & Demirkaya, 2021). The effects of plastic mulches of different colors on plants vary. Researchers working on this subject have revealed the effects of colors on yield. Csizinszky et al. (1995) reported that colored plastic mulches have different effects depending on the season, location, and years. Black mulches cause an increase in yield during the spring season, while white and aluminum-colored mulches contribute to greater soil warming in summer and autumn, thus increasing yield (Tarara, 2000). In a study by Diaz-Perez and Batal (2002), in which they investigated the yield values of tomatoes under black, grey, silver, red, white, and non-mulched conditions, they reported different yield values for different seasons.

This study investigated the effects of white and black water pillows on the yield and irrigation water usage of 'Marathon' variety cucumber grown in a greenhouse during the summer season, and compared these effects with the drip irrigation method.

2. MATERIALS AND METHODS

2.1. Plant Material Used In The Experiment

In the experiment, the 'Marathon' variety cucumber, a table and vine-type variety, was used. The 'Marathon' variety has an almond-shaped fruit with a light green color, a fruit length of 11-15 cm, and a fruit weight of 90-130 g.

2.2. Experimental Area

The research was conducted in an 8.0x20.0 m Venlo-type, anti-frost polycarbonate greenhouse, oriented along the East-West axis, located at the Research and Application Centre of Kayseri University, Safiye Çıkrıkçıoğlu Vocational School, between April 9, 2020, and July 24, 2020. In the greenhouse where the research was conducted, soil samples were collected from the 0–30 cm and 30–60 cm depths to determine some of the various physical and chemical properties of the soil. The results of the analysis are presented in Table 1. As shown in the table, the greenhouse soil has a sandy-loam texture, with a pH ranging from 7.46 to 7.55. Prior to the experiment, 3.5 tons of farmyard manure per decare were applied to the greenhouse. No chemical fertilizers were used, as there was no deficiency of plant nutrients based on the soil analysis.

Table 1. Some physical and chemical properties of greenhouse soil

Soil depth, cm	Texture	pH	EC, dS m^{-1}	Lime, %	Organic matter, %	Available, kg da^{-1}	
						K_2O	P_2O_5
0-30	Sandy loam	7.43	0.552	8.21	6.40	252.0	72.35
30-60	Sandy loam	7.51	0.339	3.78	3.15	298.0	85.02

2.3. Methods Used In The Experiment

The seedlings were planted when they had 4 true leaves, in plots measuring 90x60x50 cm, with 28 plants per plot (10.5 square meters), oriented along the north-south axis. The experimental design is presented in Figure 1. Upon planting, all plots were initially irrigated with 10 mm of water per day for 5 days, and then regular irrigation treatments began. The plastic pipes used in the water pillow irrigation method had a half circumference of 60 cm, with 1 mm diameter holes placed at 50 cm intervals along the bottom centre of the pipe. The plastic pipes were placed alternately between rows, with every other row being empty. Mulch of the same color as the water pillows was applied to the empty rows, thereby covering the entire soil surface area of the water pillow plots. Two different colored water pillows were used in the experiment, namely: white water pillow (WWP) and black water pillow (BWP), as shown in Figure 2.

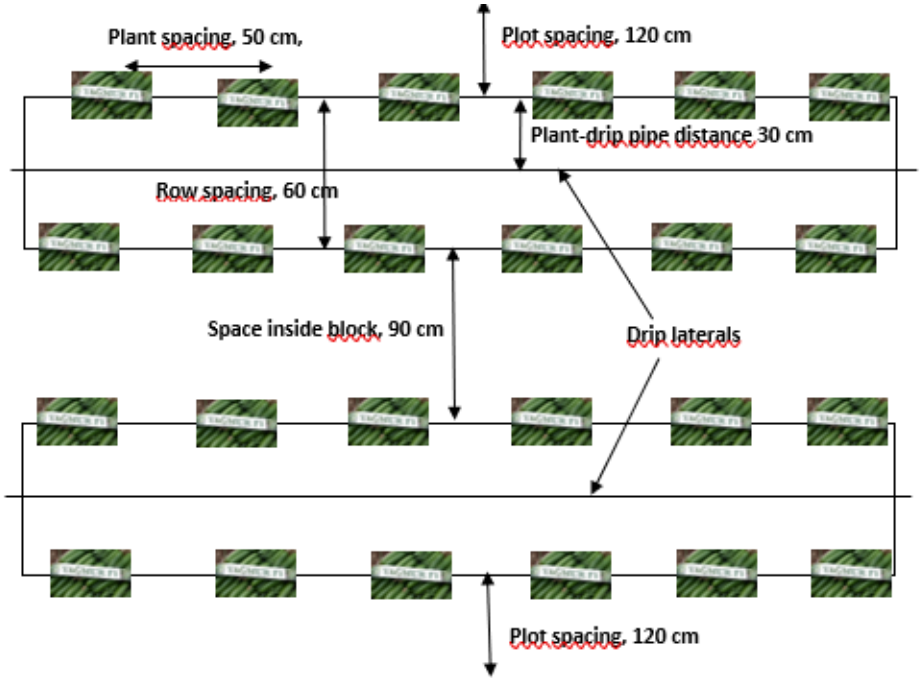

Figure 1: Experimental design

Figure 2. A view of the white and black water pillows in the experiment

In the drip irrigation (DI) plots, no mulch was used; only drip irrigation pipes were placed alternately between rows, similar to the water pillow plots, with every other row being empty. Irrigations were carried out based on changes in soil water content, with water pillows being irrigated approximately every 7-8 days on average, while drip irrigation was applied every 3 days. In total, 12 irrigations were performed for the water pillow method and 27 for the drip irrigation method. The amounts of irrigation water were measured using water meters. Throughout the season, 419 mm of water was consumed in the water pillow plots, while 622 mm of water was consumed in the drip irrigation plots. A total of 29 harvests were carried out during the experiment. The cucumbers harvested from each plant were counted to determine the number of fruits per plant and per square meter. The fruits were weighed to determine the yield per plant and per hectare. The plant heights were measured, and nodes were counted. Water productivity (WP) is the ratio of the yield per hectare to the amount of water consumed by the plant in each application. This value shows the yield (t) obtained per 1 mm of irrigation water consumed per hectare. It can be said that a higher WP value indicates a more efficient use of water and an increase in yield for the irrigation method.

3. RESULTS AND DISCUSSION

The values obtained from the research are presented in Tables 2 and 3. As shown in Table 2, yield per hectare, yield per plant, number of fruits per plant, and number of fruits per square meter were found to be statistically different. The highest yield was obtained from the black water pillow (BWP) treatment, followed by the white water pillow (WWP) and drip irrigation treatments. Although no statistically significant difference was found between the water pillow treatments, a difference was observed between the water pillow and drip irrigation treatments. The yield per hectare values were found to be 124.67 tons for WWP, 126.53 tons for BWP s, and 78.24 tons for drip irrigation. In terms of yield per hectare, there is a difference of 48.3 tons between drip irrigation and the black water pillow treatment. Similarly, BWP resulted in 1.86 kg higher yield per plant, 17.92 more fruits per plant, and 57.7 more fruits per square meter compared to drip irrigation. The percentage differences for these values are 38%, 32%, and 40%, respectively. A similar situation is valid for Water productivity. While 0.125 tons of yield was obtained per 1 mm of water consumed per hectare in drip irrigation, 0.302 tons of yield was obtained in the black water pillow treatment. This shows that water in the water pillow treatments is used 58% more efficiently.

Seasonal plant water consumption was 419 mm for the water pillow and 622 mm for the drip irrigation method. These results indicate that the water pillow irrigation method is more effective than drip irrigation in terms of yield and Water productivity in greenhouse cucumber production. Yaghi et al. (2013) compared drip irrigation and mulching (black and transparent) treatments in their study and found that the highest yield was obtained from the drip+mulching treatments. The results of our study are in agreement with those of Yaghi et al. (2013).

Table 2: Yield and irrigation water productivity of the 'Marathon' cucumber variety under different irrigation treatments

Treatments	Yield, t ha^{-1}	Yield per plant, kg plant^{-1}	Number of fruits per plant, fruit plant^{-1}	Number of fruits per unit area, fruit m^{-2}	WP, tha mm^{-1}
DI	78.247 b*	3.01 b	36.83b	87.03b	0.125
WWP	124.678 a	4.79 a	56.50 a	146.90 a	0.297
BWP	126.540 a	4.87 a	54.75 a	144.73a	0.302

*Different letters indicate differences at $p<0.05$

Table 3: Effects of different irrigation treatments on node count and plant height of the 'Marathon' cucumber variety

Treatments	Nodium numbers	Internodium distances
DI	13.56 b	89.44 b
WWP	16.87 a	100.85 a
BWP	17.37 a	106.56 a

*Different letters indicate differences at $p<0.05$

The values for node count and plant height for the treatments are provided in Table 3. The effects of the treatments on node count and plant height both parameters were found to be statistically significant. The highest node count was found in the black water pillow treatment, followed by the white water pillow and drip irrigation treatments. Similar results were obtained for plant height. From the above results, it can be concluded that water pillow treatments are an effective measure to increase yield. Additionally, black water pillows can be easily used in cucumber cultivation due to their ability to suppress weeds and maintain soil temperature. Cucumber cultivation is generally more common in warmer regions. The absence of mulching in drip irrigation systems can exacerbate evaporation and lead to increased soil salinity in these regions. However, the use of water pillows limits surface evaporation, leading to water savings and helping reduce soil salinization. This issue should be considered in newly irrigated agricultural areas. Indeed, some researchers, such as Yaycılı and Alikamanoğlu (2012), have reported that 50% of the world's agricultural land will face salinity problems by 2050.

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