



# Effects of water pillow irrigation method on some quality properties of hot red pepper

## *Su yastığı sulama yönteminin kırmızı acı biberin bazı kalite özelliklerine etkisi*

Sinan GERÇEK<sup>1\*</sup> , Nuray ÇÖMLEKÇİOĞLU<sup>2</sup> 

<sup>1</sup>Erciyes University, Seyrani Agricultural Faculty, Biosystem Engineering Dept. 38126 Kayseri, Turkey

<sup>2</sup>Eskişehir Osmangazi University, Agricultural Faculty, Horticulture Dept. 26160 Eskisehir, Turkey

### To cite this article:

Gerçek, S. & Çömləkçiođlu, N. (2020). Effects of water pillow irrigation method on some quality properties of hot red pepper. Harran Tarım ve Gıda Bilimleri Dergisi, 24(3): 317-324.

DOI:10.29050/harranziraat.672759

### Address for Correspondence:

Sinan GERÇEK

e-mail:

sgercek@erciyes.edu.tr

### Received Date:

15.01.2020

### Accepted Date:

07.07.2020

© Copyright 2018 by Harran University Faculty of Agriculture. Available on-line at [www.dergipark.gov.tr/harranziraat](http://www.dergipark.gov.tr/harranziraat)



This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

### ABSTRACT

This study was carried out to determine the effects of water pillow irrigation method on quality attributes (water soluble dry matter content, moisture, protein, ash and L-ascorbic acid) of hot red pepper. Fruit yield and quality obtained under water pillow (WP) irrigation were compared with those under furrow irrigation (FI). Experiments were carried out under semi-arid climate conditions of Turkey. The irrigation intervals were 5-day for FI and 7, 9 and 11-days for WP. The amounts of applied irrigation water were found to be 1718.1, 1160.2, 906.1 and 761.4 mm for FI, WP<sub>7</sub>, WP<sub>9</sub> and WP<sub>11</sub>, respectively. Fruit water soluble dry matter contents varied between 9.5%-11.2%, moisture contents between 86.3-91.5%, pH between 4.40-4.80, protein contents between 1.32-1.38%, ash contents between 0.98-1.09%, and L-ascorbic acid contents between 105-118 mg 100 g<sup>-1</sup>. Although the amount of irrigation water used in WP<sub>11</sub> treatment was 125% less than the amount used in FI treatment, no significant differences were observed in quality traits of both irrigation methods as well as capsaicin contents and extractable color of the samples.

**Key Words:** Pepper, Water saving, Capsaicin, Water soluble solid

### Öz

Bu çalışma, yeni bir sulama yöntemi olan su yastığı sulamasının, acı kırmızı biberin kalite özellikleri (suda çözünür kuru madde içeriđi, nem, protein, kül ve L-askorbik asit) üzerindeki etkilerini belirlemek amacıyla yapılmıştır. Su yastığı (WP) yönteminden elde edilen meyve verimi ve kalite verileri karık sulama (FI) yöntemi ile karşılaştırılmıştır. Araştırma Türkiye'nin yarı kurak iklim koşullarında gerçekleştirilmiştir. Sulama aralıkları FI için 5, WP konuları için ise 7, 9 ve 11 gün olarak seçilmiştir. Uygulanan sulama suyu miktarları FI, WP<sub>7</sub>, WP<sub>9</sub> ve WP<sub>11</sub> için sırasıyla 1718.1, 1160.2, 906.1 ve 761.4 mm olarak bulunmuştur. Meyvenin suda çözünür kuru madde içerikleri %9.5-11.2, nem içeriđi %86.3-91.5, pH 4.40-4.80, protein içeriđi %1.32-1.38, kül içeriđi %0.98-1.09 ve L-askorbik asit içeriđi 105-118 mg 100 g<sup>-1</sup> arasında değişmektedir. WP<sub>11</sub> konusundaki sulama suyu miktarı, FI konusundaki miktardan %125 daha az olmasına rağmen, hem sulama yöntemlerinin kalite özelliklerinde, hem de kapsaisin içeriđinde ve örneklerden elde edilebilen renklerinde önemli farklılıklar gözlenmemiştir.

**Anahtar Kelimeler:** Biber, Su tasarrufu, Kapsaisin, Suda çözünür katı madde

### Introduction

Pepper is one of the leading vegetables widely grown in Turkey. According to 2018 data, its annual production for Turkey and world is about 2 554 974 and 36 771 482 tons, respectively (FAO,

2020). It contains vitamins and fiber but it also has pungency providing flavor in various formulations. Depending on the species, varieties and climate, its characteristics such as color, pungency, aroma and shape show a great variation. Hot flavor of pepper is derived from

capsaicin and dihydrocapsaicin, which are generally present only in genus *Capsicum*. Capsaicin is present in all types of peppers. Capsaicin is a derivative of vanillic acid and has many positive alterative effects on human health such as reducing tissue damage, inducing certain cancer cells to undergo apoptosis. It has also a putative role in cancer chemoprevention (Erdost, 2004), and therapeutic effects on some diseases such as on fatty liver disease, vascular endothelium in the context of hyperglycemia, favorable effects on atherosclerosis, metabolic syndrome, diabetes, obesity, non-alcoholic fatty liver, cardiac hypertrophy, hypertension and stroke risk (Mc Carty et al., 2015). An increase in the level of capsaicin improve the pungency level of pepper (Rollyson et al., 2014), which plays an important role in consumer preference. During further stages of maturation, a change is observed in color of red pepper as a result of oxidation in tissues, caused by increased oxygen uptake and surplus. It was reported that ascorbic acid in tissues preserved the color of both fresh and ground peppers due to its antioxidant activity (Biac et al., 1994). Similarly, addition of ascorbic acid into pepper provides a positive effect on its color (Carvajal et al., 1997). Irrigation method and amount of water may have significant impacts on

yield and quality attributes of the pepper (Gencoglan et al., 2006). The pungency of pepper also changes depending on irrigation stress conditions (Estrada et al., 1999; Lau et al., 2011). Generally, a decrease in irrigation water increases the pungent in pepper. Also an interaction between pungency and space of row and total amount of irrigation water was also reported (Wierenga and Hendrickx, 1985). The environmental factors have forced cultivators and researchers to develop new irrigation systems and to study their effects on yield and quality attributes. Large amount of the land in southeastern region of Turkey is planned to be irrigated when Southeastern Anatolia Project (1.8 million hectares) is completed. Pepper is widely grown and consumed in this area and presently irrigated by wild flooding and unscientific furrow methods. As is known these methods cause many problems such as high water losses, low irrigation efficiencies, drainage and salinization. These irrigation methods can also cause the spread of serious diseases, resulting in economic losses as well as yield and quality. Therefore, a good irrigation method must have affirmative results such as saving water, increasing irrigation efficiency, producing more crops and improving the quality at same time.



Figure 1. A view of the experimental plot showing the plastic pipes of WP irrigation method

Şekil 1. Su yastığı sulama yöntemindeki plastik borularının denemedeki bir görünüşü

The water pillow (WP) is a combination of trickle irrigation and mulching (Gerçek, 2006) (Fig. 1). Although WP uses less water than all other irrigation methods, it does not create stress conditions in the crops, so the quality and quantity of the crops are expected to be at maximum levels. Despite the limited number of studies conducted with the WP, the superiority of the method over different plants has been proven (Demirkaya and Gerçek, 2013; Altunlu et al., 2017; Gerçek et al., 2017). Previous researches revealed various advantages of water pillows such as higher water use efficiency, yield quality and quantity, no erosion and weeds, less labor needs, land and water resource preservation. Gerçek et al. (2011) stated that tomatoes irrigated with water pillow method were more appropriate than those irrigated with drip irrigation for tomato paste and ketchup production in terms of both the quality and the cost of the final product. It seems that there has been no research so far on the effects of WP and other irrigation methods on bitterness of hot pepper. This research is intended to fill this gap by comparing the effects of WP irrigation method (7, 9 and 11 days) using different irrigation intervals on some quality properties of pepper fruits, with the FI method.

## Materials and Methods

Field experiments were conducted during 2004-2005 over the research fields of Agricultural Faculty under semi-arid climate conditions of Şanlıurfa province (37° 07' N-38° 48' E) with an altitude of 468 m. Experimental soils were deep and well drained with a clay loam texture, 60% clay, 8% sand and 32% silt in 0-90 cm soil profile. Soil permanent wilting point, field capacity, pH and dry bulk density were 22.3%, 32%, 7.3 and 1.38 g cm<sup>-3</sup>, respectively. Irrigation water pH and EC values were 7 and 0.31 dS m<sup>-1</sup> respectively. Pepper seeds (*Capsicum annuum* L.) were sown in trays on 23<sup>rd</sup> of February in both trial years. The seedlings were grown in a greenhouse until transplantation to the field. Seven-week old seedlings were planted at spacing of 50x70 cm on

13<sup>th</sup> of May of both years. The first flowering occurred within 85 days (May 18). The first harvest was achieved within 135 days (July 8) (Çömlekçioğlu et al., 2008). All plots were fertilized with the same amount of fertilizer (220 N; 60 P<sub>2</sub>O and 300 K<sub>2</sub>O<sub>5</sub> kg ha<sup>-1</sup>). In the experiments, two different irrigation methods were applied: water pillow (WP) and furrow irrigation (FI) method. While irrigation intervals of the WP were 7-day (WP<sub>7</sub>), 9-day (WP<sub>9</sub>) and 11-day (WP<sub>11</sub>), FI interval was 5-day, according to the local agronomic practices (Gerçek et al., 2009). Each plot was 2.1 m wide and 25.5 m long, two row in the middle were used for yield evaluations. A hot pepper which has long blocky shape fruits and dark red color at full mature stage, was used in the experiment (Çömlekçioğlu, 2007).

Peppers were harvested when the fruits reached to full (red) maturity. Ten pepper fruits were selected randomly from two rows between pillows and furrows. The pepper samples were analyzed for extractable color (Anon., 1985) by measuring the absorbance of acetone extracts of capsicums and their oleoresins at 460 nm; pungency values were determined as sensorial (Anon., 1991) trials by a panel of 10 trained assessors. Water-soluble solids (WSS) were determined with refractometric method. The pH and titratable acidity (Altan, 1992), moisture, ash and protein contents were also determined (Anon., 1983). L-ascorbic acid (L-AA) was determined with spectrophotometric method using 2,6-dichlorophenolindophenol (Hışıl, 1993). The amount of total capsaicinoids, nordihydrocapsaicin, capsaicin and dihydrocapsaicin were determined as outlined by Hartman (1970) using HPLC (Shimadzu, CTO-10AS column oven, DGU-14A degasser, LC-10AD, SPD-M10A photo diode array (PDA) detector and SCL-10A control system). Conditions of chromatography were as follows: C-18 (250 x 440 mm, ID) Nucleosil Macherey Nagel Column was used with isocratic; acetonitrile-water (40-60) as mobile phase and flow rate of 1 mL/min. Detector was 280 nm photo diode array (PDA). Injection volume and pressure were 20 µL and

129-132 kgf cm<sup>-2</sup>, respectively. For capsacin The irrigation methods seem to have no significant effect on pH values (4.4 to 4.8) of pepper samples. Protein contents of pepper samples changed between 1.32% and 1.38% and the ash contents ranged from 0.98% to 1.09%. However, the ash content in 2004 was higher than that of 2005, protein and ash contents of pepper samples showed no significant alterations as a result of irrigation treatments. The effects of irrigation methods on L-ascorbic acid content of samples were not found to be significant. Analysis, N-Vanillylnonanamide was used as external standard. Trials were carried out in completely randomized blocks design (CRBD) with three replications. Experimental results were subjected to analysis of variance with SAS software (Anon., 1990). Means were grouped with LSD (Least Significant Difference) test (Steele and Torrie, 1980).

## Results

In this study, the effects of the WP irrigation with different intervals on the yield and some quality properties of pepper were investigated and compared with traditional FI method. As a

two-year average, FI, WP<sub>7</sub>, WP<sub>9</sub> and WP<sub>11</sub> were irrigated 22, 16, 13 and 11 times, respectively (Table 1). The amounts of applied irrigation water are 1718.1, 1160.2, 906.1, 761.4 mm for FI, WP<sub>7</sub>, WP<sub>9</sub> and WP<sub>11</sub>, respectively. For the FI, WP<sub>7</sub>, WP<sub>9</sub> and WP<sub>11</sub> treatments, the average yield values are 32.6, 35.9, 33.9 and 31.3 tons per hectare respectively. There are significant differences in the amount of irrigation water according to the treatments. The irrigation water differences between FI and WP<sub>7</sub>, WP<sub>9</sub> and WP<sub>11</sub> were determined as 557.9, 812 and 956.7-mm, respectively. Although there were significant differences in the amount of total irrigation for FI and WP, no significant difference was found between yield values (Table 1). Some physical properties of pepper fruits are given in Table 2. Significant differences were not observed (P>0.05) in fruit yield and fruit size of samples irrigated with FI and WP methods (Table 1 and 2). The average yields were generally higher in WP treatments than FI which indicating that the minimum water supply in WP<sub>11</sub> could be satisfactory for pepper growth. The highest water-soluble solids values were observed in FI treatment (Table 3).

Table 1. Irrigation water applied and fruit yields under different irrigation methods

Çizelge 1. Farklı sulama yöntemlerinde uygulanan sulama suyu ve meyve verimi

Irrigation method Sulama yöntemi	Irrigation interval (days) Sulama aralığı (gün)	Mean number of irrigations Sulama sayısı	Mean applied water (mm) Uygulanan sulama (mm)	Mean yield (t ha <sup>-1</sup> ) (2004) Ortalama Verim (t ha <sup>-1</sup> )	Mean yield (t ha <sup>-1</sup> ) (2005) Ortalama verim, (t ha <sup>-1</sup> )	Mean yield of two years (t ha <sup>-1</sup> ) iki yıl verim ortalaması (t ha <sup>-1</sup> )
FI	5	22	1718.1	32.8 <sup>a</sup>	32.5 <sup>a</sup>	32.6 <sup>a</sup>
WP <sub>7</sub>	7	16	1160.2	36.1 <sup>a</sup>	35.8 <sup>a</sup>	35.9 <sup>a</sup>
WP <sub>9</sub>	9	13	906.1	34.1 <sup>a</sup>	33.7 <sup>a</sup>	33.9 <sup>a</sup>
WP <sub>11</sub>	11	11	761.4	31.4 <sup>a</sup>	31.1 <sup>a</sup>	31.3 <sup>a</sup>

Table 2. Physical properties of pepper fruits as affected by different irrigation treatments (2004-2005)

Çizelge 2. Biber meyvelerinin farklı sulama işlemlerinden etkilenen fiziksel özellikleri (2004-2005)

Irrigation method Sulama yöntemi	Mean fruit width (mm) Ortalama meyve genişliği (mm)	Mean fruit length (mm) Ortalama meyve uzunluğu (mm)
FI	43.95	80.70
WP <sub>7</sub>	43.00	78.80
WP <sub>9</sub>	41.90	80.80
WP <sub>11</sub>	42.00	77.75

Samples within each column depicted with a common superscript do not differ significantly (P>0.05)

Moisture contents of pepper samples ranged from 86.28% to 91.54%. The difference between mean moisture contents was not significant ( $P>0.05$ ). The lowest L-AA content ( $105 \text{ mg } 100 \text{ g}^{-1}$ ) was determined in WP<sub>9</sub> treatment whereas the highest ( $118 \text{ mg } 100 \text{ g}^{-1}$ ) value was obtained from WP<sub>7</sub> treatment. Color is one of the most important properties of pepper. WP irrigation method caused in general a decrease in color values (Table 3). Although the highest color value (199.80) was determined in FI treatment plots, the lowest value (192.6) was found in WP<sub>9</sub> treatment plots and the difference in color values of samples was found to be insignificant. The effects of irrigation treatments on pungency (5000 SHU) of peppers were also not to be

significant ( $P>0.05$ ). The capsaicinoids contents of samples are presented in Table 4 and capsaicinoid compounds in total capsaicinoids are given in Table 5. The most prevailing compound that causes pungency in all samples irrigated with different frequencies was capsaicin and it was followed by dihydrocapsaicin and nordihydrocapsaicin (Table 4 and 5). The differences in capsaicin and dihydrocapsaicin values were not found to be significant since there was no water deficiency in the current treatments. Although the amount of water applied in FI treatments and WP<sub>7</sub>, WP<sub>9</sub> and WP<sub>11</sub> treatments were different, the differences in capsaicin and dihydrocapsaicin values were not significant.

Table 3. The effects of different irrigation methods on some quality values of pepper

Çizelge 3. Farklı sulama yöntemlerinin biberin kalite değerleri üzerine etkileri

Year yıl	Irrigation methods Sulama yöntemi	Water soluble solid (%) Suda çözünen madde (%)	Moisture (%) Nem (%)	pH	Protein (%)	Ash (%) Kül (%)	L-AA ( $\text{mg } 100\text{g}^{-1}$ )	Extractable color (ASTA)* Çıkarılabilir Renk
2004	FI	11.20 <sup>a</sup>	86.28	4.70	1.32	1.07	107	198.60
	WP <sub>7</sub>	10.50 <sup>a</sup>	88.66	4.70	1.35	1.09	118	199.00
	WP <sub>9</sub>	9.50 <sup>b</sup>	90.54	4.80	1.32	1.07	114	195.00
	WP <sub>11</sub>	9.50 <sup>b</sup>	89.14	4.60	1.32	1.04	107	194.90
2005	FI	10.80 <sup>a</sup>	89.68	4.50	1.36	0.98	115	199.80
	WP <sub>7</sub>	9.50 <sup>a</sup>	86.60	4.70	1.33	1.01	106	196.80
	WP <sub>9</sub>	9.50 <sup>a</sup>	86.94	4.40	1.34	1.01	105	192.60
	WP <sub>11</sub>	10.50 <sup>a</sup>	91.54	4.80	1.38	1.04	115	196.50
Main effects								
2004		10.17	88.65	4.70	1.33	1.07 <sup>a</sup>	111.5	196.88
2005		10.08	88.69	4.60	1.35	1.01 <sup>b</sup>	110.3	196.43
	FI	11.00	87.98	4.6	1.34	1.03	111	199.20
	WP <sub>7</sub>	10.00	87.63	4.7	1.34	1.05	112	197.90
	WP <sub>9</sub>	9.50	88.74	4.6	1.33	1.04	110	193.80
	WP <sub>11</sub>	10.00	90.34	4.7	1.35	1.04	111	195.70
P values								
	Irrigation	0.014	0.820	0.654	0.982	0.795	0.985	0.305
	Year	0.731	0.987	0.217	0.477	0.005	0.790	0.832
	Irrigation x Year	0.133	0.620	0.076	0.862	0.306	0.291	0.850

\*ASTA: American Spice Trade Association (SHU: Scoville heat unit)

Table 4. Capsaicinoids content of pepper fruit as affected by irrigation method

Çizelge 4. Sulama yöntemlerinin biber meyvesinin kapsaisinoid içeriğine etkisi

Irrigation methods Sulama yöntemleri	Capsaicinoid (%)			
	Nor-dihydro capsaicin	Capsaicin	Dihydro capsaicin	Total capsaicinoid
FI	0.003 <sup>a</sup>	0.031 <sup>a</sup>	0.025 <sup>a</sup>	0.059 <sup>a</sup>
WP <sub>7</sub>	0.003 <sup>a</sup>	0.030 <sup>a</sup>	0.021 <sup>a</sup>	0.054 <sup>a</sup>
WP <sub>9</sub>	0.002 <sup>a</sup>	0.033 <sup>a</sup>	0.022 <sup>a</sup>	0.057 <sup>a</sup>
WP <sub>11</sub>	0.002 <sup>a</sup>	0.036 <sup>a</sup>	0.022 <sup>a</sup>	0.060 <sup>a</sup>

Table 5. Capsaicinoid compounds in total capsaicinoids content of pepper fruit as affected by irrigation method  
*Çizelge 5. Sulama yönteminden etkilenen biber meyvesinin toplam kapsaisin içeriği içindeki kapsaisin bileşikleri*

Irrigation methods Sulama yöntemleri	Capsaicinoid (%)			
	Nor-dihydro capsaicin (a)	Capsaicin (b)	Dihydro capsaicin (c)	b/c
FI	5.93 <sup>a</sup>	47.61 <sup>a</sup>	46.46 <sup>a</sup>	1.0
WP <sub>7</sub>	6.79 <sup>a</sup>	50.21 <sup>a</sup>	43.00 <sup>a</sup>	1.2 <sup>a</sup>
WP <sub>9</sub>	6.33 <sup>a</sup>	49.55 <sup>a</sup>	44.12 <sup>a</sup>	1.1 <sup>a</sup>
WP <sub>11</sub>	6.07 <sup>a</sup>	49.78 <sup>a</sup>	44.15 <sup>a</sup>	1.1 <sup>a</sup>
Pooled	0.09	0.98	1.93	0.1

Samples within each column depicted with a common superscript do not differ significantly ( $P>0.05$ )

## Discussion

Although the amount of total water and irrigation intervals are dissimilar in the water pillow and furrow irrigation treatments, it was found no statistically significant difference in yield and other investigated values. This might be due to the mulch effect of the plastic pipes used in the WP method. According to the climate data of the study area, high temperature, wind and low relative humidity increased irrigation water consumption (Gerçek et al., 2009). This situation was clearly observed in FI irrigation method. However, in the same climatic conditions, the plastic pipes used in the WP method decreased strongly the evaporation from the soil with covering the soil surface as mulch during the irrigation period. This allows the irrigation water to remain in the plant root zone for a long time and be used by the plant. The WP<sub>7</sub>, WP<sub>9</sub> and WP<sub>11</sub> treatments saved water by 48%, 89.6% and 125% respectively according to the FI treatment. It is a well-known fact that the use of mulch reduces the evaporation from the soil surface. Water saving in all WP treatments is quite remarkable. An increase in plant water consumption is expected because of global warming and climate change. Some applications that prevent evaporation from soil root zone will become more important. WP can easily play this role with its mulch effect. Many researchers have come up with this conclusion (Yang et al., 2011; Singh and Kamal, 2012; Ahmed et al., 2014). The average gross composition and quality criteria of pepper affected by different irrigation treatments of this study are the same (89.6%) reported by Hayoğlu (1999) for Şanlıurfa pepper.

The changes in L-AA content values are insignificant and consistent with previous reports (Daood et al., 1996; Koc et al., 2004). Similar color value of 184.5 was reported by Koç et al. (2004). Color values of the treatments were quite close to each other. Such a situation may be resulted from sufficient water supply in treatments. Previous researchers indicated that there were not any significant differences in yield and quality values of the plants fully irrigated with different methods (Dorji et al., 2005; González-Dugo et al., 2007), but there were significant differences in yield and quality parameters of plants under deficit irrigation (Abayomi et al., 2012; Khan et al., 2008; Ahmed et al., 2014). Sezen et al., (2017) indicated insignificant differences in color parameters of fully irrigated plants, but significant differences in color parameters of deficit-irrigated plants. The differences in color parameters of the plants were not found to be significant because water deficits were not applied to present irrigation treatments. Therefore, present findings comply with those earlier ones. Both Capsaicin and dihydrocapsaicin are substantial in hot pepper (Prasad et al., 2008), and come from hot pepper's pungency (Estrada et al., 1999). Water deficits increase capsaicin and dihydrocapsaicin contents of the pepper (Estrada et al., 1999).

Our results mentioned above showed good agreement with the values reported by Somos (1984). Gerçek et al. (2011) irrigated tomato with the WP and drip irrigation methods and compared both methods in terms of some physicochemical criteria for their convenience for tomato paste and ketchup production. For this purpose, pH, titratable acidity (%), brix (%), dry matter (%), serum separation (%), viscosity and

color ( $L$ ,  $a$ ,  $b$ ) values of tomatoes were analyzed. The pH, titratable acidity, brix, serum separation (%), dry matter and viscosity values of tomatoes irrigated with the water pillow-drip irrigation methods were found to be 4.29–4.22, 0.41–0.39%, 5.3–4.8%, 64.4–69.7%, 6.48–5.72% and 52.4–38.6 cP while color values of  $L$ ,  $a$  and  $b$  were measured as 26.34–25.92, 18.92–17.55 and 16.52–16.48, respectively. All values excluding  $b$  color value obtained by the analyses were significantly different ( $p>0.05$ ).

It was concluded that tomatoes irrigated with WP method were more appropriate for both ketchup and tomato paste production. Despite the differences in the amount of used total water and irrigation intervals of WP and FI treatments (Table 1), their differences in water soluble solids, moisture, pH, protein, ash and L-ascorbic acid contents were insignificant ( $p>0.05$ ). The insignificant effects of different irrigation methods on pungency and yield indicated that pepper plants did not suffer from water stress in any of the treatments. The yields obtained from both methods were not significantly different ( $p>0.05$ ), but WP methods resulted apparently in higher amount of yield. This is particularly important because WP provides less water application and uses water economically. The FI method results in excessive irrigation and, in addition to other hazards, causes unnecessarily high costs.

It can be concluded that, with respect to salinization, weed control, high water use efficiency, no external energy and labor requirement, WP irrigation method seems more suitable for hot pepper culture especially in semi-arid regions.

**Conflict of Interest:** The authors declare that they have no conflict of interest.

### Acknowledgement

The authors are grateful to Dr. Juan Carlos Diaz-Perez, Professor at University of Georgia College of Agricultural and Environmental Sciences, Department of Horticulture, Tifton, GA,

USA for his valuable comments and helps in the preparation of this paper.

### References

- Abayomi, Y. A., Aduloju, M. O., Egbewunmi, M. A., and Suleiman, B. O. (2012). Effects of soil moisture contents and rates of NPK fertilizer application on growth and fruit yields of pepper (*Capsicum* spp.) genotypes. *Int. J. of AgriScience*, 2, 651-663.
- Ahmed, A. F., Yu, H., Yang, X., Jiang, W. (2014). Deficit irrigation affects growth, yield, vitamin c content, and irrigation water use efficiency of hot pepper grown in soilless culture. *Hortiscience*, 49(6), 722-728.
- Altan, A. (1992). *Laboratory Technique*. Cukurova University Faculty of Agriculture, Adana, Turkey, pp: 86-95.
- Altunlu, H., Ayranci, Y., Gerçek, S. (2017). Comparison of water pillow and drip irrigation systems for tomato (*Lycopersicon esculentum* Mill.) production under greenhouse conditions in the Mediterranean region of Turkey. *Bulgarian Journal of Agricultural Science*, 23, 76-82.
- Anonymous. (1983). *Methods of Analyses*. Ministry of Forestry and Agriculture, Ankara, Turkey, pp: 196-205.
- Anonymous. (1985). *American Spice Trade Association. Extractable color in Capsicums and their oleoresins. ASTA analytical methods*. USA, pp: 111-114.
- Anonymous. (1990). *SAS Users Guide: version 6.0* Ed, SAS, Cary, NC, pp: 201-213.
- Anonymous. (1991). *Determination of Scoville Index in spice-hot red pepper*. Turkish Standard Ins., Ankara, Turkey, pp: 350-354.
- Biac, P. H, Daood, G., Huszka, T. T. (1994). Biochemical and varietal perspective on the color loss in spice red pepper paprika. *Journal of the Ministry of Agri.*, 3, 32-37.
- Carvajal, M., Martinez, M. R., Martinez-Sanchez, F., Alcaras, C.F. (1997). Effect of ascorbic acid addition to peppers on paprika quality. *J. of Science Food Agriculture*, 75, 442-446.
- Çömlekçiöğlü, N. (2007) The effects of selfing on the pollen fitness and seed set in pepper. *J. of Agriculture Fac. of Harran Univ.*, 11, 1-6.
- Çömlekçiöğlü, N., Gerçek, S., Dikilitaş, M. (2008). Responses of pepper (*Capsicum Annuum* L.) to different irrigation frequencies and water amount: growth, yield and fruit characteristics. *Journal of Agriculture Faculty of Harran University*, 12 (4), 51-56.
- Daood, H. G., Vinkler, M., Marku, F., Hebshi, E. A., Biacs, P.A. (1996). Antioxidant vitamin content of spice red pepper (paprika) as affected by technological and varietal factors. *Food Chemistry*, 55, 365-372.
- Demirkaya, M., Gerçek, S. (2013). Farklı renkli su yastıklarının sera koşullarında biberin (*Capsicum annuum* L.) verimi ve su kullanma etkinliği üzerine etkileri. *Journal of Agricultural Sciences*, 19, 281-288.
- Dorji, K., Behboudian, M. H., Zegbe, J., Dominguez, A. (2005). Water relations, growth, yield, and fruit quality of hot pepper under deficit irrigation and partial root zone drying. *Scientia Horticulturae*, 104,



- 137-149.
- Erdost, H. (2004). Capsaicin. *Uludag Univ. Journal of Faculty of Veterinary Med.*, 23, 1-2-3, 149-155.
- Estrada, A. B., Pomar, F., Diaz J., Merino, F., Bernal, A. (1999). Pungency level in fruits of Padron pepper with different water supply. *Scientia Horticulturae*, 81, 385-396.
- FAO, 2020. <http://www.fao.org/faostat/en/#data/QC>.
- Gencoglan, C., Akinci, I. E., Uçan, K., Akinci, S., Gencoglan, S. (2006). Response of red hot pepper plant (*Capsicum annum L.*) to the deficit irrigation. *Akdeniz University Journal of Faculty of Agriculture*, 19, 131-138.
- Gerçek, S. (2006). Water pillow: a new irrigation method. *Pakistan Journal Applied Sciences*, 62, 315-317.
- Gerçek, S., Çömlekçioğlu, N., Dikilitaş, M. (2009). Effectiveness of water pillow irrigation method on yield and water use efficiency on hot pepper (*Capsicum annum L.*). *Scientia Horticulturae*, 120, 325-329.
- Gerçek, S., Cankut, H., Can, A. (2011). Determination of some physicochemical properties of tomatoes irrigated with water pillow method and comparison with drip irrigation method. *International Food, Agriculture and Gastronomy Congress*, 193-194 pp., February, 15-19, 2012, Belek, Antalya.
- Gerçek, S., Demirkaya, M., Işık, D. (2017). Water pillow irrigation versus drip irrigation with regard to growth and yield of tomato grown under greenhouse conditions in a semi-arid region. *Agricultural Water Management*, 180, 172-177.
- González-Dugo, V., Orgaz, F., Fereres, E. (2007). Responses of pepper to deficit irrigation for paprika production. *Scientia Horticulturae*, 114, 77-82.
- Hartman, T. K. (1970). A rapid gas-liquid chromatographic determination for capsaicin in capsicum spices. *Journal of Food Sciences*, 35, 543-547.
- Hayoglu, I. (1999). Changes in some properties of hot red pepper grown in Şanlıurfa region occurred during production of ground pepper. *Harran University Journal of Faculty of Agriculture*, 3, 85-90.
- Hışıl, Y. (1993). *Instrumental Food Analyses*. Ege University, Faculty of Engineering, Izmir, Turkey, pp: 356-361.
- Khan, M. A. I., Farooque, A. M., Haque, M. A., Rahim, M. A. and Hoques, M. A. (2008). Effects of water stress at various growth stages on the physio-morphological characters and yield in chili. *Bangladesh J. of Agricultural Research*, 33, 353-362.
- Koc, A. B., Toy, M., Hayoglu, I., Vardin, H. (2004). Performance of a solar dryer used for red pepper drying. *Journal of Agriculture Faculty Harran University*, 8, 57-65.
- Lau, N. R., Lara, M. F., Garcia, Y. M., Moreno, E. Z., Antonio, A. G., Machado, I. E., Estévez, M. M. (2011). Water deficit affects the accumulation of capsaicinoids in fruits of capsicum chinense jacq. *HortiScience*, 46 (3), 487-492.
- McCarty, M. F., DiNicolantonio, J. J., O'Keefe, J. H. (2015). Capsaicin may have important potential for promoting vascular and metabolic health. *Open Heart*. 2(1): e000262. Published online 2015 June 17. doi:10.1136/openhrt-2015-00026.2
- Prasad, B. C., Kumar, V., Gururaj, H. B., Parimalan, R., Giridhar, P., Gokare, R. (2008). Characterization of capsaicin synthase and identification of its gene (csy1) for pungency factor capsaicin in pepper (*Capsicum sp.*) (Proceedings of the National Academy of Sciences of the United States of America (September 5, 2006) 103,36 (13315-13320) 0.1073/pnas.0605805103).
- Rollyson, W. D., Stover, C. A., Brown, K. C., Perry, H. E., Stevenson, C. D., McNeese, C. A., Ball, J. G., Valentovic, M. A., Dasgupta, P. (2014). Bioavailability of capsaicin and its implications for drug delivery. *Journal of the Controlled Release Society*, 196, 96-105.
- Sezen, S. M., Akyildiz, A., Agcam, E., Yazar, A., Dasgan, H.Y., Tekin, S. (2017). Critical quality parameters changing of red pepper in response to different irrigation methods and levels. *Int. Conference on Technology, Engineering and Science*, 1, 59-68.
- Singh, A. K., and Kamal, S. (2012). Effect of black plastic mulch on soil temperature and tomato yield in mid hills of Garhwal Himalayas. *Journal of Horticulture and Forestry*, 4, 78-80.
- Somos, A. (1984). The paprika. Budapest, Hungary, pp: 89-93.
- Steele, R., Torrie J. H. (1980). *Principles and procedures of statistics*. Mc Graw-Hill, New York, pp: 256-270.
- Yang, H., Liu, H., Li, Y., Huang, G., Wang, F. (2011). Precision drip irrigation on hot pepper in arid northwest china area. In: Li D., Liu Y., Chen Y. (eds) *Computer and Computing Technologies in Agriculture IV*. CCTA 2010. IFIP Advances in Information and Communication Technology, 345, 152-158.
- Wierenga, P. J. J. and Hendrickx, M. H. (1985). Yield and quality of trickle-irrigated chili peppers. *Agricultural Water Management*, 9, 339-356.