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Effects of irrigation interval and quantity on the yield and quality of confectionary pumpkin grown under field conditions

Duran Yavuz[a,*], Musa Seymen[b], Nurcan Yavuz[a], Önder Türkmen[b]

[a] Department of Irrigation, Faculty of Agriculture, Selcuk University, Konya – Turkey
[b] Department of Horticulture, Faculty of Agriculture, Selcuk University, Konya – Turkey

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ABSTRACT

Confectionary pumpkin (*Cucurbita pepo* L.) is one of the important snacks preferred by consumers in Turkey due to its higher nutrient contents. However, there is no comprehensive study on water management in pumpkin cultivation in many countries including Turkey. Therefore, a 2-year study (2013–2014) was conducted to determine the effects of different irrigation intervals (S) and irrigation levels (I) on the seed yield and yield components of drip-irrigated confectionary pumpkin under the Middle Anatolian climatic conditions in Konya, Turkey. The experimental design was made in randomized blocks, in a 3 × 5 factorial scheme, with three replications. Treatments consisted of three irrigation intervals (S_7: 7 days, S_{14}: 14 days, and S_{21}: 21 days) and five irrigation levels (I_{100}: 100% irrigation or full irrigation, I_{75}: 75% of full irrigation, I_{50}: 50% of full irrigation, I_{25}: 25% of full irrigation, and I_0: no irrigation).

Seasonal plant water consumption or actual evapotranspiration (ET_a) of irrigation treatments varied from 194.2 to 660.2 mm in 2013 and from 208.6 to 629.6 mm in 2014. The irrigation interval (S) and the irrigation level (I) significantly affected the seed yield and quality of pumpkin in both the years. Typically, no significant differences were found among S_7I_{100}, S_7I_{75}, and $S_{14}I_{100}$ treatments in both the years although S_7I_{100} treatment produced the highest seed yield (1274 kg ha^{-1}). In 2013, except for 1000-seed weight, interaction between the irrigation interval and the irrigation level significantly affected the seed yield, the number of fruits per plant, seed yield per fruit, and mean fruit weight; however, in 2014, the effects of $S \times I$ interaction on the seed yield and yield components were not significant. Seed yields were significantly affected in a linear relationship by the amount of irrigation water and evapotranspiration in both the years. Seasonal yield response factors (k_y) were 0.92 and 1.27 in 2013 and 2014, respectively. In conclusion, I_{100} with a 7-day irrigation interval is recommended for pumpkin grown under field conditions to maximize the yield. However, if the irrigation water is scarce, it will be suitable to irrigate pumpkin with either 25% water deficit (7-day interval) or full irrigation (14-day interval) in semiarid conditions.

1. Introduction

In Turkey, the total available water volume is 112 billion cubic meters per year. Currently, the total used water is 50 billion cubic meters per year, and about 72% of this is used for irrigation. The average annual precipitation is 643 mm in Turkey as a whole, which changes from region to region and from year to year. The annual depth of precipitation is as high as 2500 mm in the Eastern Black Sea region and as low as 300 mm in some parts of Central Anatolia (Kaygusuz and Sari, 2003).

The Konya Plain, where water resources are limited, consists of 10% arable lands of Turkey. The climate of the Konya Plain is semi-arid with dry and hot summers, cold, and snowy winters. According to the long-term data, the total annual precipitation of the Konya Plain is 323 mm (Yavuz et al., 2012). Rainfall is extremely irregular and it is concentrated during winter, reducing thus the choice of annual summer crops to a very few. During the growing season, at some time-points, the temperatures and evaporation rates may go very high. In summer, temperatures may reach up to 40 °C and evaporation may reach up to 12 mm per day. Irrigation is essential during this period, and most of the water is drawn from the aquifers in the Konya Plain. This resulted in an excessive pumping of aquifer water, and the situation became so alarming that within a span of 33 years (1974–2007), the aquifer water level depleted by 14–15 m (WWF, 2008). In recent years, however, this depletion is estimated to be more due to excessive irrigation in the Konya Plain. Due to the lack of irrigation water, only one-third of the agricultural land in the Konya Plain can be irrigated. The increasing pumping costs and

* Corresponding author.
E-mail address: dyavuz@selcuk.edu.tr (D. Yavuz).

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Table 1
Variations of meteorological parameters of region during experimental years.

Year	Month	Average temperature (°C)	Relative humidity (%)	Precipitation (mm)	Average wind speed (m s^{-1})
2013	May	18.4	46.7	47.0	2.4
	June	21.6	37.8	8.8	2.9
	July	23.3	34.1	0.8	3.3
	August	23.5	32.4	–	3.0
	September	18.6	41.6	3.0	2.3
Average/total		21.1	38.5	59.6	2.8
2014	May	15.4	53.1	31.6	2.3
	June	19.5	46.8	55.6	2.6
	July	24.7	35.0	9.6	3.2
	August	24.9	32.2	2.8	3.1
	September	18.3	57.9	58.2	2.3
Average/total		20.1	45.0	157.8	2.7
1960–2013	May	15.7	55.9	43.8	2.2
	June	20.1	48.4	22.9	2.5
	July	23.4	42.1	6.8	2.8
	August	22.8	42.9	5.5	2.6
	September	18.4	48.0	11.0	2.1
Average/total		20.1	47.5	90.0	2.4

the risk of overdrawing the aquifers with consequent salt–water intrusion have made it necessary to develop strong recommendations on water usage for growers and land use planning authorities. Therefore, the scientifically applied agricultural research programs related to water saving and conservation are essential in the Konya Plain, where agricultural activities account for more than 75% of the total water consumption. Water conservation can also be achieved by improving the efficiency of water utilization by crops, including the cultivation of plants that are less demanding for seasonal irrigation water. In this context, pumpkin is one of the most important plants. It demands lower water consumption compared with other crops, such as sugar beet, corn, and carrot, in Middle Anatolian.

Pumpkin serves as a reliable source of produce and provides a household food security to the growers. Its leaves, flowers, and fruits are used as vegetables, and roasted seeds as snacks (Mwaura et al., 2014). Pumpkin seeds contain the antioxidant beta-carotene, which helps improve immune function and reduce the risk of cancer and heart disease. In addition, pumpkin seeds also contain many vitamins and nutrients, including calcium, iron, magnesium, potassium, zinc, selenium, nicotinic acid, folic acid, and vitamins A, C, and E (Ghanbari et al., 2007; Ondigi et al., 2008).

Water deficit is an important factor that affects the crop production under arid and semiarid conditions (Hussain et al., 2004). It affects almost all plant growth processes. However, the response to drought stress depends on the intensity, the rate and duration of exposure, and the stage of crop growth (Wajid et al., 2004). The crop yield is mostly affected by the field water management, particularly in irrigation-based agriculture in arid and semiarid regions (Al-Omran et al., 2005). It is necessary to maximize the yield by making most efficient use of available water to sustain with rapid industrialization and urban development. Therefore, we need to supply the right amount of water required by a crop. Furthermore, it is essential to develop a suitable irrigation schedule to get the optimum yield for a particular ecological region, as plant water consumption depends mostly on plant growth, soil, and climatic conditions (Ertek et al., 2004).

Al-Omran et al. (2005) studied squash using surface drip irrigation (DI) and subsurface drip irrigation (SDI) methods in sandy soils with three clay deposits and found that the fruit yield shows a linear relationship with the increased irrigation level for each season under the same treatment. They found that fruit yields significantly increased with clay deposits compared with control. The differences between DI and SDI on fruit yields were also significant. The seasonal water use of squash (*Cucurbita pepo* L.) was 304 and 344 mm over 93 days in spring and 238 and 272 mm over 101 days in fall under trickle and furrow irrigation methods, respectively (Amer, 2011). Moreover, the fruit yield and quality of squash were significantly affected by season, and irrigation method, and quantity. The highest seed yield of 1268 kg ha^{-1} was reported for pumpkin with full irrigation in the Thrace region of Turkey (Cakir, 2000). In New Zealand, Fandika et al. (2011) compared the yield and water use efficiencies of squash and pumpkin by irrigating them eight times during the course of investigation. The water use of pumpkin and squash was 413 and 408 mm, respectively, whereas the total fruit yields of pumpkin and squash were 72.8 and 54.3 t ha^{-1}, respectively.

The prudent use of water resources (Hoekstra and Chapagain, 2007) and the correct pumpkin cultivars will help growers to meet the yield and quality demands, which will maximize financial returns (Searle et al., 2003) during adverse climate variability (Perry, 2007). The scientific information on the agronomic performance of pumpkin under different water environments in Turkey is scarce. Therefore, the objective of this research was to determine the most suitable combination of different irrigation intervals and irrigation levels on the yield and yield components of pumpkin.

2. Materials and methods

2.1. Experimental site

The study was conducted at the experimental field of Faculty of Agriculture of Selcuk University located in Konya, Turkey, during the months of May–September for 2 years (2013 and 2014). The experimental field is located at 38°02′N latitude, 32°30′E longitude, and 1105-m altitude. According to the long-term meteorological data, the climate in this region is semiarid with the total annual precipitation of 312 mm. The climatological data during the experimental season are listed in Table 1. The total rainfall from May to September in 2013 was 59.6 mm, which corresponds to 27% of the annual rainfall, and in 2014, it was 157.8 mm, which corresponds to 43% of the annual rainfall.

The soils in the area have a clay texture and are alluvial. Volumetric soil water contents at field capacity and wilting point are 0.29 cm^3 cm^{-3} and 0.16 cm^3 cm^{-3}, respectively. Mean bulk density varies from 1.38 to 1.42 g cm^{-3} in the soil profile. The available water holding capacity within the top 90 cm of soil depth is 126.3 mm. Some soil properties of the experimental site are listed in Table 2.