Effects of bubbler irrigation frequency on yield and quality of foster grapefruit under Khartoum State conditions

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ABSTRACT

The experiment was carried out in private orchards at Tayba Alhasnab area of south Khartoum, Sudan, (latitude 15° 35´ N, longitude 32° 60´ E, altitude 380 masl) during 2013 and 2014 to study the effects of bubbler irrigation frequency on yield and quality of grapefruit under Khartoum State conditions. Five different frequencies of irrigation were applied at 3, 5, 7, 9 and 12 days. Treatments were replicated 4 times in a randomized complete block design (RCBD) and each plot encompassed 3 trees. The results revealed that higher yield and number of fruits per tree were obtained with 5 days irrigation frequency in both years. The 5 days irrigation frequency increased total yield of foster grapefruit by 39% and 8% in the first and second year, respectively, compared to the 12 day. The highest fruit weight was obtained with 5 days irrigation frequency in both years. Moreover, irrigation frequency every 5 days had the highest water productivity.

Keywords: Grapefruit, bubbler irrigation, irrigation frequency, water productivity.
INTRODUCTION

Irrigation plays a major role in Sudan’s agricultural production. Irrigation systems should be able to make possible the fullest utilization of the limited water available (Adam, 2006). The high efficiency of modern irrigation systems, such as trickle, drip, bubbler and sprinkler irrigations are now in practice, which save water and produce high yields (Dagdelen et al., 2009).

Bubbler irrigation is a combination of surface and drip irrigation that needs a small basin, because the discharge is too high, 50 to 225 l/h, to infiltrate. It is usually used for orchards and big trees (Ismail, 2002). Ibrahim et al. (2012) reported that bubbler irrigation gave the highest mean values of growth parameters on date palm, while the basin irrigation gave the lowest values. Bubbler irrigation system supplies water through a small diameter bubbler tube supplied from larger diameter polyethylene pipe. Bubbler flow is controlled by changing bubbler diameter or length or both (Al-Amoud, 2008).

In the Sudan, bubbler irrigation has been used at a large scale to produce high value fruit crops. However, it is released for citrus by Khalifa et al. (2014). They reported that bubbler irrigation system increased the total yield of foster grapefruit by 20%, and saved irrigation water by 70% with highest marginal rate of return and water productivity compared to surface irrigation.

Correct frequency of water application is one of the most important factors in drip irrigation management, because of its positive effects on soil water regime, root distribution around the emitter, amount of water uptake by roots and the amount of water percolation under the root zone (Wang et al., 2006). Due to these phenomena of irrigation frequency, water use efficiency (WUE) and crop yields may differ under different irrigation frequencies, although the same quantity of water is applied (Wang et al., 2006).

Several experiments have shown positive responses in some crops to high frequency drip irrigation by Segal et al. (2000) and Sharmasarkar et al. (2001). Khalil (2015) reported that drip irrigation method every 3 days was preferable to get the best water status for plants, in addition to the high tuber yield of potato. Bagali et al. (2012) found that onion bulb yield increased significantly with shorter intervals of drip irrigation.

Intensive research on fruits was carried out in the Sudan, mainly on management practices. However, research in the future should be directed to the proper water management because the poor irrigation and water stress significantly depress root elongation and reduce fruit number, size and weight (Saeed et al., 1990). The objective of this study was to evaluate the effect of bubbler irrigation frequency on yield and quality of foster grapefruit under Khartoum State conditions.

MATERIALS AND METHODS

The experiment was established in a private orchard at Tayba Alhasnab area, Khartoum, to evaluate the effect of irrigation frequency on yield and quality of foster grapefruit irrigated by bubbler irrigation. A bubbler irrigation system was used to irrigate the crop and installed in the laterals at distances of 7 m apart and one distributor per tree with a discharge of 100 l/h. Five irrigation frequencies were applied at 3, 5, 7, 9 and 12 days. Treatments were replicated 4 times in a randomized complete block design and each plot encompassed 3 trees. The irrigation water requirement was applied according to Khalifa et al. (2014).

The meteorological data were recorded during the study period to compute the daily reference evapotranspiration by REF-ET software version 2.0 Allen (2000). The crop water requirement was calculated according to Allen et al. (1998) using the following formula:
ETc = ET0 × Kc……………... (1)

where
ETc = crop evapotranspiration (mm/day), Kc is crop coefficient (was taken from FAO-56 documentation Table 12)) and ET0 is reference crop evapotranspiration (mm/day).

The crop water requirement (CWR) for every irrigation frequency was calculated using the following equation:
CWR = ETc × (3, 5, 7, 9 and 12 days) …………… (2)

where
ETc = crop evapotranspiration (mm/day).

To overcome losses in discharge, the gross depth (dg) was calculated using the following equation:
dg = ETc mm EU ……………………………………….. (3)

where
EU= emission uniformity (90%).

Volume of water for bubbler irrigation was applied in liter/tree using the following equation:
V = A × Aw% × dg……………………………………….. (4)

where
V = Volume of water in liter per tree, A = Plant area (row spacing (m) × plant spacing (m)), Aw% = Wetted area (0.3) and dg = gross depth (mm).

Time of irrigation was calculated using the following equation:
Time of irrigation = Volume of water to be applied (liter) ………… (5)

Bubbler discharge rate (l/h)

Cultural practices for citrus were carried out as recommended.

Yield per tree was recorded in tons/ha. Ten fruits were collected randomly for determination of quality such as fruit weight (g) and total soluble solids (TSS %).

Water productivity (WP) was estimated using the following equation:
WP = Yield/TAW ……………………………………………. (6)

where
TAW is total applied water (m3/ha).

Crop Stat statistical program was used for data analysis and the least significant difference was used for mean separation at the probability level of 0.05.

RESULTS AND DISCUSSION

Number of fruits per tree and total yield
Irrigation frequency had significant effects on number of fruits per tree and total yield in both seasons (Table 1). The highest number of fruits per tree and the highest yield were obtained on trees irrigated every 5 days in both seasons. The highest yield ranged from 20 to 25 t/ha for the 5 days irrigation frequency in the two years (Table 1). The 5 days irrigation frequency increased total yield of foster grapefruit by 39% and 8% in the first and second year, respectively, as compared to the 12 day. Similar results were reported by El-Abd et al. (2012), who found that the highest yield of navel orange was recorded under a high irrigation frequency. Khalel (2015) noticed that irrigation every 3 days gave the highest total and marketable yield of potato. However, Kassem (2008) reported a tendency that potato yields decreased as irrigation frequency decreased in both seasons. Also Bagali et al. (2012) found that irrigation scheduled at one day
interval recorded significantly higher onion yield (46.9 t ha⁻¹) over three days interval (42.8 t ha⁻¹), and it was at par with two days interval (46.5 t ha⁻¹).

Table 1. Effect of bubbler irrigation frequency on number of fruits per tree and total yield (t/ha) of foster grapefruit under Khartoum State conditions.

<table>
<thead>
<tr>
<th>Irrigation frequency (days)</th>
<th>Number of fruits/tree</th>
<th>Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2013</td>
<td>2014</td>
</tr>
<tr>
<td>3</td>
<td>185a</td>
<td>198 b</td>
</tr>
<tr>
<td>5</td>
<td>182a</td>
<td>221 a</td>
</tr>
<tr>
<td>7</td>
<td>162ab</td>
<td>196 b</td>
</tr>
<tr>
<td>9</td>
<td>144b</td>
<td>170 c</td>
</tr>
<tr>
<td>12</td>
<td>144b</td>
<td>162 c</td>
</tr>
<tr>
<td>SE*</td>
<td>8.06</td>
<td>5.8</td>
</tr>
<tr>
<td>CV%</td>
<td>8.5</td>
<td>5.3</td>
</tr>
<tr>
<td>Significance level</td>
<td>**</td>
<td>***</td>
</tr>
</tbody>
</table>

** and ***: indicated significance at P≤ 0.01 and 0.001, respectively.

Fruit weight and total soluble solids
Irrigation frequency had significant effects on fruit weight in both seasons, but was not significant on total soluble solids (Table 2). The highest fruit weight was obtained with 5 days irrigation frequency in both years (Table 2). These results are in agreement with those on orange trees (Hussien et al., 2013). El-Abd et al. (2012) found that the highest values of fruit set (%) and fruit weight (g) on navel orange were recorded under a high irrigation frequency. Bagali et al. (2012) found that scheduling of drip irrigation of onion at shorter intervals i.e., at one or two days significantly increased plant height, number of leaves, leaf area and neck girth as compared to three days interval. The highest growth parameters and shoot dry weight were recorded for daily irrigation interval.

Table 2. Effect of bubbler irrigation frequency on fruits weight (g) and total soluble solids (%) of foster grapefruit under Khartoum State conditions.

<table>
<thead>
<tr>
<th>Irrigation frequency (days)</th>
<th>Fruit weight (g)</th>
<th>Total soluble solids (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2013</td>
<td>2014</td>
</tr>
<tr>
<td>3</td>
<td>511b</td>
<td>544 ab</td>
</tr>
<tr>
<td>5</td>
<td>542a</td>
<td>567 a</td>
</tr>
<tr>
<td>7</td>
<td>515b</td>
<td>434 b</td>
</tr>
<tr>
<td>9</td>
<td>502bc</td>
<td>528 b</td>
</tr>
<tr>
<td>12</td>
<td>493c</td>
<td>532 b</td>
</tr>
<tr>
<td>SE*</td>
<td>5.8</td>
<td>7.3</td>
</tr>
<tr>
<td>CV%</td>
<td>1.9</td>
<td>2.4</td>
</tr>
<tr>
<td>Significance level</td>
<td>**</td>
<td>*</td>
</tr>
</tbody>
</table>

*, ** and NS: indicated significance at P≤ 0.05, 0.01 and not significant, respectively.

Water productivity (WP)
Water productivity was maximum with bubbler irrigation system because of less evaporation and/or runoff. Generally, our results indicated that the highest water productivity was found with 5 days irrigation frequency in both years (Fig. 1). These results are in agreement with those
reported by Kassem (2008) who found that high frequency irrigation enhanced field water use efficiency (FWUE) and crop water use efficiency (CWUE).

CONCLUSION

The highest yield, yield components and quality of foster grapefruit – and water productivity were obtained for the high irrigation frequency (5 days) compared to low irrigation frequency (12 days).

RECOMMENDATION

Based on the above findings to obtain high foster grapefruit production with high quality, 5 days bubbler irrigation frequency is recommend to be adopted by the grapefruit growers under Khartoum State conditions.

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التكرار الري الفعلي على الانتاجية وجودة فروت فوستر تحت ظروف ولاية الخرطوم، السودان.

عثمان م. أحمد، محمد أ. حامد، أحمد ش. بابكر، علي م. أحمد، علي ع. أحمد، هينق، وصلاح ب. بخيت

السودان، جدارية الحسناب، السودان، الخرطوم، بستان في مدينة جنوب الخرطوم، السودان، خلال الفترة من 2013 و2014.

التكرار الري (الري فترات مختلفة من معاملات بركية) 3 و 5 و 7 و 9 و 12 يومًا، مع مراقبة اتحملت الانتاجية الفعلية، وحولت نسبة الفروت، في يومين، و30 يومًا، في بستان في مدينة جنوب الخرطوم، السودان.

التكرار الري كل 5 أيام أدى إلى زيادة الانتاجية بنسبة 39% و8% في عامي 2013 و2014. ونسبة أعلى إنتاجية في يومين.

للمزيد، يمكن مشاهدة نتائج الدراسة في جدارية الحسناب، السودان، الخرطوم.
اثر تكرار الري الفقاعي علي انتاجية وجودة القريب فروت فوستر تحت ظروف ولاية الخرطوم, السودان

أجريت التجربة في بستان خاص في منطقة طيبة الحسناب جنوب الخرطوم، السودان خلال الفترة من 2013 وحتى 2014. تم تطبيق خمسة معاملات مختلفة من فترات الري (3, 5, 7, 9 و12 يوم) وتم تكرارها في اربعة مرات. واعترضت قرارات الري على نظام المربعات العشوائية الكاملة وشملت كل قطعة 3 أشجار. وأظهرت النتائج أن الانتاجية العالية وعدد الثمار لكل شجرة تم الحصول عليها مع تكرار الري كل 5 أيام في كل عام. وبلغت نسبة زيادة الانتاجية بنسبة 39% و8% في السنة الأولى والثانية،别离. اضافةً إلى ذلك، تم تكرار الري كل 5 أيا، حيث أعطى نطاق نسبة زيادة حصول عليه مع تكرار الري كل 5 أيام أعلى زوجة للثمرة حصل عليه مع تكرار الري كل 5 أيام في العامين. اضافياً إلى ذلك، تم تكرار الري كل 5 أيام في كل من أول وثاني العام.