View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by Journals Of University Of Gezira

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

Ahmed B. A. Khalifa[1], Ibtihal H. M. Hamed[1], Shaker B. Ahmed[2], Mohamed A. Ali[3], Imad-eldin Ahmed Ali[3], Lee Heng[4] and Salah B. Bakheit[3]

[1]Kassala and Gash Research Station, Kassala, Sudan.
[2]Department of Agricultural Engineering, Faculty of Agriculture, Omdurman Islamic University, Sudan.
[3]Agricultural Research Corporation, Wad Medani, Sudan.
[4]Soil and Water Management and Crop Nutrition Section, IAEA, Vienna, Austria.

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.

Formatted: Font: Bold, Complex Script Font: Bold

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). Khalel (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:

$$ET_c = ET_o \times K_c \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

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

The crop water requirement (CWR) for every irrigation frequency was calculated using the following equation:

$$CWR = ET_c \times (3, 5, 7, 9 \text{ and } 12 \text{ days}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where
ET_c = crop evapotranspiration (mm/day).
To overcome losses in discharge, the gross depth (dg) was calculated using the following equation:

$$dg = \frac{ET_c \text{ mm}}{EU} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where
EU= emission uniformity (90%).

Volume of water for bubbler irrigation was applied in liter/tree using the following equation:

$$V = A \times Aw\% \times dg \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

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:

$$\text{Time of irrigation} = \frac{\text{Volume of water to be applied (liter)}}{\text{Bubbler discharge rate (l/h)}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

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:

$$WP = \text{Yield/TAW} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

where
TAW is total applied water (m^3/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.

Formatted: Justified

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 25t/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.

Irrigation frequency (days)	Number of fruits/tree		Yield (t/ha)	
	2013	2014	2013	2014
3	185a	198 b	20a	22 b
5	182a	221 a	20a	25 a
7	162ab	196 b	17b	22 b
9	144b	170 c	15c	22 b
12	144b	162 c	15c	21 b
SE±	8.06	5.8	0.44	0.64
CV%	8.5	5.3	4.4	5.0
Significance level	**	***	***	***

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 seasons (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.

Irrigation frequency (days)	Fruit weight (g)		Total soluble solids (%)	
	2013	2014	2013	2014
3	511b	544 ab	8.9	9.1
5	542a	567 a	8.9	9.0
7	515b	434 b	8.9	9.1
9	502bc	528 b	8.9	9.0
12	493c	532 b	8.5	9.0
SE±	5.8	7.3	0.13	0.81
CV%	1.9	2.4	2.5	1.5
Significance level	**	*	NS	NS

*, ** 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).

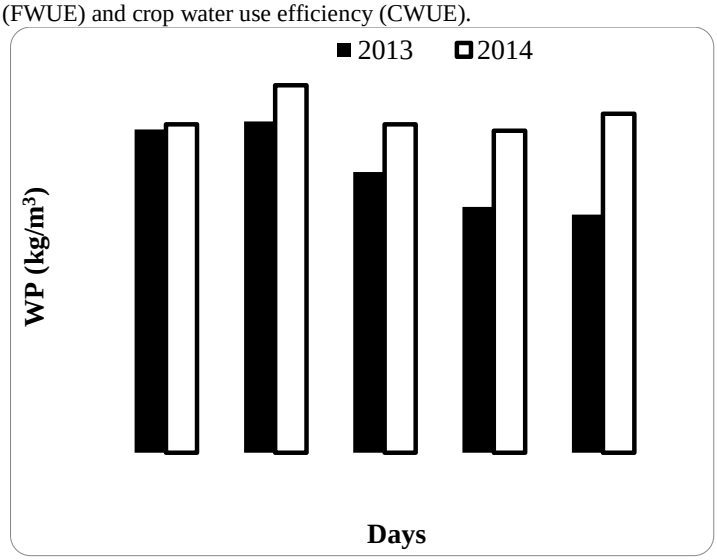

Figure 1. Effect of bubbler irrigation frequency on water productivity (WP) (kg/m^3) of foster grapefruit under Khartoum State conditions.

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.

ACKNOWLEDGEMENTS

The authors are in full praise and thanks to "Allah" who gave them the power, health and patience to conduct this study. The authors would like to thank the IAEA Regional Project RAF/5/071 "Enhancing Crop Nutrition and Soil and Water Management and Technology Transfer in Irrigation Systems for Increased Food Production and Income Generation" for supporting this work. Special thanks, appreciation and gratitude to Mr. Kedir Almalik for supporting and funding this work. We would like to extend our gratitude to all who contributed to the success of this work.

Formatted: Space After: 0 pt

Formatted: Space After: 0 pt

Formatted: Space After: 0 pt

Formatted: Right, Right-to-left, Space After: 10 pt, Adjust space between Latin and Asian text, Adjust space between Asian text and numbers

Adam, I. A. 2006. Designing and Developing an Automated Sprinkler Irrigation System. Ph.D. Thesis, Faculty of Agriculture, University of Khartoum, Sudan.

Al-Amoud, A. I. 2008. Performance of bubbler irrigation system as compared to trickle for large size date palm tree farm. The Canadian Society for Engineering in Agricultural, Food, Environmental, and Biological Systems. Annual Conference, North Vancouver, British Columbia, July 13 - 16, 2008.

Allen, R. G. 2000. REF-ET. Reference evapotranspiration calculation software. University of Idaho. Moscow. Idaho.

Allen, R.G., L.S. Pereira., D. Raaes and M. Smith. 1998. Crop evapotranspiration. Guidelines for computing crop water requirement, FAO, Irrigation and Drainage, Paper 56. United Nations, Rome, Italy.

Bagali, A. N., H. B. Patil, M. B. Guled and V. Patil. 2012. Effect of scheduling of drip irrigation on growth, yield and water use efficiency of onion (*Allium cepa* L.). Karnataka Journal of Agricultural Science 25 (1):116-119.

Dagdelen, N., H. Başal, E. Yılmaz, T. Gurbuz and S. Akçay. 2009. Different drip irrigation regimes affect cotton yield, water use efficiency and fiber quality in western Turkey. Agricultural Water Management 96 (1): 111-120.

El-Abd, A. A. 1., E. A. Moursi and M. A. Gabr. 2012. Effect of irrigation water regime on navel orange yield, fruit quality and some water relations in the north middle Nile delta region. Journal of Plant Production 3 (6): 1049- 1061.

Hussien, S. M., E. A. Ismail, M. N. H. Ismail and T. A. Eid. 2013. Effect of applying surface and bubbler irrigation systems on fruitful Washington navel orange trees production. Egyptian Journal of Agricultural Research 91 (4): 1565-1580.

Ibrahim, Y. Mohamed., A. B. Saeed and A. W. Mohammed Elamin. 2012. Effect of irrigation water management on growth of date palm off shoots (*Phoenix dactylifera* L.) under the River Nile State conditions. Uinversity of Khartoum Journal of Agricultural Scinces 20(3): 275-285.

Ismail, S. A. 2002. Design and Management of Field Irrigation Systems. 1st Ed. Glalhazi and participates. Education Institution Alexandria, Egypt.

Kassem, M. A. 2008. Effect of drip irrigation frequency on soil moisture distribution and water use efficiency for spring potato planted under drip irrigation in a sandy soil. Misr Journal of Agricultural Engineering 25(4): 1256-1278.

Khalel, A. S. 2015. Effect of drip irrigation intervals and some antitranspirants on the water status, growth and yield of potato (*Solanum tuberosum* L.). Journal of Agricultural Science and Technology 5:15-23.

Khalifa, A. B. A., M. A. Ali and A. Y. Yagoub. 2014. Optimizing water productivity, yield and quality of grapefruit irrigated by bubbler and surface irrigation under Khartoum State conditions. The 56th Meeting of the National Crop Husbandry Committee, Agricultural Research Corporation. Wad Medani. Sudan.

Saeed, A. B., H. A. Etewy and O. S. A. Hassan. 1990. Watering requirement and scheduling of date palm. Journal of Agricultral Mechanization in Asia, Africa and Latin America 2(4): 49-52.

Segal, E., A. Ben-Gal and U. Shani. 2000. Water availability and yield response to high-frequency micro-irrigation in sunflowers. In: Proceedings of the Sixth International Micro-irrigation Congress on 'Micro-irrigation Technology for Developing Agriculture, 22-27 October, South Africa.

Sharmasarkar, F.C., S. Sharmasarkar, S.D. Miller, G.F. Vance and R. Zhang. 2001. Assessment of drip irrigation and flood irrigation on water and fertilizer use efficiencies for sugar beets. Agricultural Water Management 46: 241-251.

Wang, F. X., Y. Kang, and S. P. Liu. 2006. Effects of drip irrigation frequency on soil wetting pattern and potato growth in North China Plain. Agricultural Water Management 79: 248-264.

Formatted: Normal, Justify Low, Indent: Before: 0", Hanging: 0.2", Line spacing: Multiple 1.15 li

اثر تكرار الري الفقاعي علي انتاجية وجودة القريب فروت فوستر تحت ظروف ولاية الخرطوم, السودان

وصلاح بابكر[4] ولي هينق[3] وعماد احمد علي[3] ومحمد احمد علي[2] وشاكر بابكر احمد[1] وابتهال حامد محمد[1] احمد بابكر احمد خليفة[3] بخيت

[1] محطة بحوث كسلا والقاش, كسلا، السودان.
[2] قسم الهندسة الزراعية, كلية الزراعة, جامعة ام درمان الاسلامية، ام درمان، السودان.
[3] هيئة البحوث الزراعية، وادمدني, السودان.
[4] قسم التربة وادارة المياه وتغذية النبات, الوكاله الدولية للطاقة الذرية, فيينا, النمسا.

الخلاصة

وحتي 2013 جنوب الخرطوم، السودان خلال الفترة من أجريت التجربة في بستان خاص في منطقة طيبة الحسناب لدراسة اثر تكرار الري الفقاعي علي انتاجية وجودة القريب فروت فوستر تحت ظروف ولاية الخرطوم. تم تطبيق 2014 يوم) وتكرارها في اربعة مرات علي نظام المربعات 12 و 9 و 7 و 5 و 3 خمسة معاملات مختلفة من فترات الري (أشجار. وأظهرت النتائج أن الإنتاجية العالية وعدد الثمار لكل شجرة تم الحصول عليها 3 العشوائية الكاملة وشملت كل قطعة % في 8% و 39 ايام ادي الي زيادة انتاجية القريب فروت بنسبة 5 أيام في كلا العامين. تكرار الري كل 5 مع تكرار الري كل ايام 5 يوم. اعلي وزن للثمرة حصل عليه مع تكرار الري كل 12 السنة الاولي والثانية علي التوالي مقارنة بتكرار الري كل ايام الي أعلى إنتاجية لوحدة المياه. 5 في العامين. اضافة الي ذلك ادي تردد الري كل

Formatted: Centered

Formatted: Centered

Formatted: Centered, Right-to-left

اثر تكرار الري الفقاعي علي انتاجية وجودة القريب فروت فوستر تحت ظروف ولاية الخرطوم, السودان

[3] وعماد احمد علي[3] ومحمد احمد علي[2] وشاكر بابكر احمد[1] وابتهال حامد محمد[1]احمد بابكر احمد خليفة [3] وصلاح بابكر بخيت ولي [4]هينق

محطة بحوث كسلا والقاش, كسلا، السودان.[1]

قسم الهندسة الزراعية, كلية الزراعة, جامعة ام درمان الاسلامية، ام درمان، السودان.[2]

هيئة البحوث الزراعية، واد مدني, السودان.[3]

قسم التربة وادارة المياه وتغذية النبات, الوكالة الدولية للطاقة الذرية, فيينا, النمسا.[4]

الخلاصة

جنوب الخرطوم، السودان خلال الفترة من أجريت التجربة في بستان خاص في منطقة طيبة الحسناب لدراسة اثر تكرار الري الفقاعي علي انتاجية وجودة القريب فروت فوستر تحت 2014 وحتي 2013 يوم) 12 و 9 و 7 و 5 و 3ظروف ولاية الخرطوم. تم تطبيق خمسة معاملات مختلفة من فترات الري (أشجار. وأظهرت 3وتكرارها في اربعة مرات علي نظام المربعات العشوائية الكاملة وشملت كل قطعة أيام في كلا 5النتائج أن الانتاجية العالية وعدد الثمار لكل شجرة تم الحصول عليها مع تكرار الري كل % في السنة الاولي 8% و39 ايام ادي الي زيادة انتاجية القريب فروت بنسبة 5العامين. تكرار الري كل 5 يوم. اعلي وزن للثمرة حصل عليه مع تكرار الري كل 12والثانية علي التوالي مقارنة بتكرار الري كل ايام الي أعلى إنتاجية لوحدة المياه.5ايام في العامين. اضافة الي ذلك ادي تردد الري كل