



Comparison of bubbler, sprinkler and basin irrigation for date palms (*Phoenix dactylifera*, cv. Zahdi) growth in Kish Island, Iran

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Abstract

This project was conducted to investigate the response of date palm (*Phoenix dactylifera*, cv. Zahdi) growth to three different irrigation methods: basin, bubbler and sprinkler irrigation systems under Kish Island climatic conditions during five successive years (2000-2004). This date planting comprised of 86 relatively uniform 10 year-old date-palms, which were cleaned, trimmed and standard fertilized regularly, but they have not been pollinated artificially during experiment. The results of this project demonstrated that the mean values of leaf number, leaf size, tree height and leaf mineral content of date palm were significantly ($P = 0.05$) influenced by irrigation systems. As expressed in greater annual leaf number and tree height the general trend of growth increased as water availability to tree increased. The maximum vegetative growth (the mean height, leaf number and leaf size) was produced from palm trees irrigated with the bubbler irrigation system during five years, followed by the basin method. Bubbler irrigation was superior to basin and sprinkler irrigation, due to less evaporation and higher water availability to plants. Mineral contents of the leaves were also influenced by irrigation system. An increase in N content of leaves, with some between-year variations in relative values, was found and a fairly uniform N content in leaves of the bubbler-irrigated dates. P_2O_4 content did not significantly change in the treatments during the three years of analyses. Similarly, K content varied annually (non-significantly) between treatments. Date palm trees could be grown and also take up minerals when only a small part of the area between trees was irrigated. The advantage of using bubbler irrigation under marginal conditions of saline water, soil stress and atmospheric dryness, the conditions under which the experiment was carried out, is discussed.

Key words: Drought tolerance, evapotranspiration, Kish Island, flood irrigation, water use efficiency.

Introduction

Date palm (*Phoenix dactylifera* L.) has been cultivated in the most southern parts of Iran for centuries. According to FAO, Iran with about more than 11×10^6 t yr⁻¹ (18% of total world date production) ranks 1st to 2nd in world date production ¹. Date palm is mainly cultivated for its nutritious fruit in Iran, however, it is substituting for the many ornamental trees in the parks and landscape. For example, Kish Island's use of the date palm is mostly ornamental, although edible fruit can be produced here. In natural areas, dates are irrigated by a constant supply of water from the oases that are near, by seasonal flooding or by high water tables. While date palm is an extremely drought tolerant plant (e.g., established trees have been known to survive several years of heat with no irrigation or rain), it is not recommended cultural practice, and when there is no rainfall or irrigation, growth rate and fruit production are greatly diminished ^{2,3}. Majority of irrigated date area in Iran is under flood irrigation which is resulting in huge losses through deep percolation and seepage. Deep watering on a regular basis is vital to good growth of all species of palms. To some extent, growth rate can be regulated by watering practices. The estimated consumption of water by date palms is variable (about 25×10^3 – 29×10^3 m³ ha⁻¹ yr⁻¹) ⁴. In commercial growing areas dates of the southern province of Khuzestan, Iran, are irrigated every 10 to 14 days in warm weather (summer) and every

30 to 40 days the rest of the year. In other words, based on the soil moisture and evapotranspiration rates recommended amounts per month were applied during the growing season once or twice per week and once or twice per month, in the cool season ⁴.

Water deficiency diminishes growth quality and production of date palms which are used in the Kish Island's landscapes ⁵. In view of the water crises in the arid area, Kish Island has been tenaciously following the strategy of preserving its water resources on the one hand and containing the greenery over most of the area on the other. The programs include reducing water consumption through improving irrigation methods. Modern irrigation systems such as sprinklers and drip bubbler system are used in developed countries. The bubbler irrigation technique seemed to be promising for use in the arid and semi-arid areas, since water usage is more efficient, and the small output (albeit over a long period) might prevent a sudden rise in the water table, as compared with other irrigation methods, such as basin or sprinkler irrigation ⁶. Thus, it is anticipated that a considerable amount of water will be saved as result from converting the traditional irrigation systems into the modern methods. Even date palms would grow and yield well, however, only a part of the entire space between trees is wetted. The aim of the present study was to investigate the response of date palm growth to basin,

bubbler and sprinkler irrigation systems under Kish Island climatic conditions.

Materials and Methods

This experiment was conducted in a Randomized Complete Block Design (RCBD) experiment with four replications in one of the date palm (*Phoenix dactylifera*, cv. Zahdi) planting in Kish Island, Iran, during five successive years (2000 to 2004). This date planting comprised of 86 relatively uniform 10 year-old 'Zahdi' date palms, which were conventionally practiced (fertilized in accordance to soil analysis, cleaned and trimmed regularly), but they have not been artificially pollinated for fruit production during experiment. Kish Island's climate is predominately hot with an average temperature of 35°C and the average relative humidity being 80%. The months starting from May till July are very hot. The precipitation is scanty (about 120-140 mm yr⁻¹) and starts falling in late October and continues intermittently in until April and occasionally in May. While the rainfall is very low, the potential evapotranspiration (PET) exceeds 2,300 mm yr⁻¹. Kish Island's soils generally have poor structure with low water-holding capacity. They have quite high gypsum or calcium carbonate levels and are very low in organic matter. Low cation exchange capacities, high pH (>8) and alkaline soils reduce the availability of many essential plant microelements (Fe, Mn and Zn)⁷. Irrigation water (very saline, EC of 2.24 dS m⁻¹, which requires filtration) was mostly supplied from the sea (16 times/year) for 5 years.

Three different irrigation methods (basin, bubbler and sprinkler irrigation) were compared. Bubbler system of irrigation was installed in 2000. The system consists of a single one-half inch polyethylene tubing placed above ground along each side of each row with a total of 8 L h⁻¹ for each palm. Bubbler system was operated for 24 h d⁻¹ during the warm season (May – July), the watering was decreased for 18 h d⁻¹ after July.

Basin system was a traditional system, with a ring-basin with 80 to 120 cm diameter and 20 cm deep during experiment. Water application rates in basin system ranged from approximately 120 L d⁻¹ palm⁻¹ in the winter to about 360 L d⁻¹ palm⁻¹ in the summer. This makes it easier to moisten the root zone soil to the desired depth. Sprinkler irrigation does not allow water to hit the terminal bud or palm leaves. Sprinklers wetted the entire surface between trees. The growth quantity (leaf number, leaf size and tree height), leaf mineral content and bunch production of date palm were measured regularly every year.

Plant tissue samples were collected every year from each treatment. Tissue samples consisted of about 15 to 20 segments of leaf petioles per sample. To determine soil nutrient status, soil samples were collected at a depth 30-60 cm. Both soil and plant samples were oven dried at 60°C for 48 hours and ground to pass through a 40 mesh screen and were analyzed for macro and micronutrients prior to application of the first fertilizer treatment. All soil and plant samples were digested according to technique used by (SCD) Sealed Chamber Digest⁸ in June in all treatments during the five years.

Beginning in 2001, fertilizer plan was done for all treatments. For example, bubbler-irrigated trees were fertilized once a month with a pre-calculated amount of fertilizer proportional to the amount of water given. Fertilizers were applied to none palm in the winter. Fertilization consists of one application in May or June of approximately 10 kg of cow manure per palm. The manure was

placed around tree and then covered with soil.

Results and Discussion

The results of this project demonstrated that the quantity and quality of date palm growth was significantly influenced by irrigation system. Leaf number, inflorescences, tree height, leaf mineral (N, P, K) content and yield were increased with increasing irrigation water. The maximum mean of tree height (8.40 m) and leaf number (28.5 leaves) were produced from palm trees irrigated with the bubbler irrigation system in 2003-2004, followed by basin-irrigated palms (mean leaf number 23.3 and tree height 7.20 m). The minimum tree height (6.5 m) and leaf number (21.4) were produced from palm trees irrigated with the sprinkler irrigation system, but leaf size and color of the sprinkler-irrigated palms were better than in the other treatments (Table 1). From measurements of the spike leaf elongation, it can be concluded that more water was available to bubbler-irrigated trees than to sprinkler-irrigated ones. This was pronounced even when a smaller amount of water was given during the first two years. The greater vegetative growth of the spike leaf was reflected in increased leaf production.

N, P and K contents in leaves are presented in Table 2. A steady increase in N content of leaves, with some between-year variations in relative values was found, but N content of leaves was fairly uniform in all treatments. Phosphorus content did not vary appreciably during the five years. K content varied annually (non-significantly) between treatments, except in 2003. Although the mineral content of the leaves (Table 2) was significantly different in some years between different irrigation treatments, it cannot explain the differences in mineral uptake by date palms.

Leaf mineral contents of basin-irrigated trees as compared with sprinkler irrigated ones were significantly higher in 3 out of five years. No significant differences were found in leaf mineral contents during the other two years between treatments. Bubbler irrigation supplies palms with water and nutrients at frequent intervals, permits minimal evaporation in comparison with sprinkler irrigation and permits slow rates of water application that help maintain a stable water table. The value of bubbler irrigation over the other irrigation systems for date palms grown under optimal conditions of soil, water and climate, requires further study.

Conclusions

The main aim of this trial was to study the water consumption of the date palm trees. Following tentative conclusions can be drawn: i) marked response in vegetative growth accorded when more water availability is presented; ii) even under such circumstances, bubbler irrigation may prove advantageous at least in establishment of young trees, by economizing on water use and by reducing weed growth on unneeded ground surfaces.

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Table 1. Annual mean production of tree height (m) and leaf and cluster number from date palm (*Phoenix dactylifera*, cv. Zahdi) irrigated by three different (bubbler, basin, sprinkler) irrigation systems under Kish Island's climate conditions during five years^a.

Year	Bubbler			Basin			Sprinkler		
	Leaf number	Tree height	Cluster number	Leaf number	Tree height	Cluster number	Leaf number	Tree height	Cluster number
2000	18.4 c	4.80 c	0.0 d	19.3 c	4.50 a	0.0 d	17.5 c	4.1 c	0.0 d
2001	20.7 b	5.20 b	4.2 c	21.5 b	4.90 bc	5.0 c	20.5 b	4.8 c	5.4 c
2002	22.9 b	5.80bc	6.0 b	22.6 a	5.80 b	6.1 b	21.3 a	5.5 b	7.2 b
2003	25.0ab	6.10 b	7.5 b	21.9 b	6.20 a	7.1 b	21.0 a	6.0 a	6.5bc
2004	28.5 a	8.40 a	10.3 a	23.3 a	7.20 a	9.5 a	21.4 a	6.6 a	8.4 a

^a Mean separation within columns by Duncan's multiple range test at P=0.05.

Table 2. Mean mineral contents (%) in leaves of date palm irrigated by three different (bubbler, basin, sprinkler) irrigation systems under Kish Island's climate conditions.

Year	Bubbler			Basin			Sprinkler		
	N	P	K	N	P	K	N	P	K
2000	1.35 a	0.09 b	0.65 a	1.26 a	0.08 a	0.65 a	1.45 a	0.08 a	0.61 ab
2001	1.46 b	0.08 a	0.62 a	1.4 ab	0.08 a	0.64 a	1.43 a	0.09 a	0.54 a
2002	1.64 c	0.08 a	0.64 a	1.65 b	0.09 a	0.54 b	1.56 a	0.09 a	0.72 b
2003	1.73 d	0.09 a	0.67 a	1.71 c	0.09 a	0.68 a	1.65 b	0.09 a	0.63 ab
2004	1.73 d	0.08 a	0.66 a	1.79 c	0.08 a	0.67 a	1.74 b	0.08 a	0.69 b

^a Each value is average over five years (2000-2004). Mean separation within columns by Duncan's multiple range test at P=0.05.