

Salt-Tolerance of Tissue-Cultured Date Palm Cultivars under Controlled Environment

L. Al-Mulla, N. R. Bhat, and M. Khalil

Abstract—A study was conducted in greenhouse environment to determine the response of five tissue-cultured date palm cultivars, Al-Ahamad, Nabusaif, Barhee, Khalas, and Kasab to irrigation water salinity of 1.6, 5, 10, or 20 dS/ m. The salinity level of 1.6dS/m, was used as a control. The effects of high salinity on plant survival were manifested at 360 days after planting (DAP) onwards. Three cultivars, Khalas, Kasab and Barhee were able to tolerate 10 dS/m salinity level at 24 months after the start of study. Khalas tolerated the highest salinity level of 20 dS/ m and 'Nabusaif' was found to be the least tolerant cv. The average heights of palms and the number of fronds were decreased with increasing salinity levels as time progressed.

Keywords—Acclimatization, Irrigation water salinity, Kuwait, Land degradation.

I. INTRODUCTION

IRRIGATION induced salinization of arable land is a wide spread problem in Kuwait. High salt contents in the soil and irrigation water limits plant growth and lead to degradation of soil. Several studies have been conducted to determine the effects of high soil salinity on growth and productivity in date palm [1], [2], [3], [4]. However, under Kuwait's climatic conditions, plants are exposed to multiple stress conditions such as salt spray, extreme temperatures, low relative humidity, strong winds, and high evaporation rates at the same time. All these factors accelerate the buildup of salt in the soil. The study reported here was conducted to understand the response of five leading date palm varieties to saline irrigation water under greenhouse conditions.

II. MATERIALS AND METHODS

The study was conducted in the greenhouse at KISR using one year old five cultivars of tissue-cultured date palm, namely, Al-Ahamad, Nabusaif, Barhee, Khalas, and Kasab. Young palms were procured and acclimatized prior to their use in the study. Fifteen-gallon polyethylene containers filled with agricultural soil and planted with one acclimatized tissue-cultured date palm were used in this experiment. Plants were allowed to fully establish in these containers for two months before subjecting them to salinity treatments. Salinized nutrient solutions @ 1.6, 5, 10, or 20 dS/ m salinity were used for irrigation. Soil from the containers was analyzed for pH and other chemical properties prior to the experiment and at 180 and at 720 days after planting

(DAP). The experiment consisted of four salinity levels, five cvs. and three replications (5 plants / replication). With fifteen plants in each experimental treatment and 60 plants under each cultivar, a total of 300 plants were used in this study. Treatments were arranged in a completely randomized block design (CRBD), and recommended cultural and plant protection practices for aphids and mites were followed in growing these plants.

III. RESULTS

A. Chemical Properties of Soil

A representative soil sample was analyzed at the initiation of this study (Table I) for various chemical parameters. The soil samples where the experimental palms were planted were further analyzed after 180 and at 720 days of planting to understand the effect of various treatments on salt buildup and nutrient status of the soil (Table II and III). There were corresponding increases in soil salinity at the end of 720 DAP. Continuous irrigation with saline water only slightly increased the pH, but significantly increased the EC of the soil from 2.08 dS/m at time zero (Table I) to 72.4 dS/ m at 720 DAP. Similarly, the levels of Ca^{++} , Mg^{++} , K^+ , Na^+ and Cl^- in the soil increased from 105.9, 18.0, 5.3, 15.4 and 19.4 mg/ kg, respectively at time zero (Table I) to 2,310, 167, 97, 2,210 and 7,612 mg/ kg at salinity level of 20 dS/m (Table 3), respectively, at 720 DAP. The comparison of levels of Na^+ , K^+ , Ca^{++} , Mg^{++} , and Cl^- in the soil with plant responses to salinity of irrigation water suggested that increased concentrations of salts in the soil with the passage of time progressively decreased plant survival and vegetative growth in these varieties. The most salt-tolerant cultivar (cv. Khalas) was found to be capable of tolerating high levels of Na^+ (above 2,200 ppm) and Cl^- (7,600 ppm) in the soil.

TABLE I
THE CHEMICAL ANALYSIS OF A REPRESENTATIVE GROWTH MEDIUM SAMPLE ANALYZED DURING THE INITIATION OF THE STUDY

Sample	pH	ECe (dS/m)	Cations (mg/kg)				Anions (mg/kg)		
			Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺	Cl ⁻	CO ₃ ⁻²	HCO ₃ ⁻
Prior to Planting	7.9	2.67	105.89	17.99	5.31	15.41	19.39	<1	30.39
Prior to initiation of Salinity Treatments	8.0	2.08	42.6	11.16	73.49	1.15	51.76	<1	31.73

ECe: Electrical conductivity

TABLE II
CHEMICAL ANALYSIS OF THE GROWTH MEDIUM USED IN THE SALINITY STUDY AT 180 DAYS AFTER PLANTING

Salinity Level (dS/m)	pHs	ECe (dS/m)	Cations				Anions			Total	
			Ca	Mg	K	Na	Cl	CO ₃	HCO ₃	N	P
			(mg/kg)							%	(mg/kg)
1.6	7.78	1.9	43.4	8.74	2	51.8	63.4	<1	22.98	0.044	64.78
5	7.62	6.1	448	82.86	117.12	576.8	1173.6	<1	13.48	0.014	84.9
10	7.5	11.84	735.4	62.06	99.64	1221.2	2369.8	<1	15.26	0.022	91.08
20	7.44	19.16	1215.4	48.68	86.7	2003.4	4185.8	<1	15.56	0.02	111.08

ECe: Electrical conductivity of saturated paste extract

TABLE III
CHEMICAL ANALYSIS OF THE GROWTH MEDIUM USED IN THE SALINITY STUDY AT 720 DAYS AFTER PLANTING

Salinity Level (dS/m)	pHs	ECe (dS/m)	Cations (mg/kg)				Anions (mg/kg)			
			Ca	Mg	K	Na	Cl	CO ₃	HCO ₃	
1.6	8.02	3.54	99.6	19	3.76	70.8	111.2	<1	25.58	
5	7.72	19.22	499	48.8	64.6	570.8	1199.8	<1	23.06	
10	7.4	58.86	1710.8	134.8	84	2119.6	5374.6	<1	16.58	
20	7.7	72.4	2310	167	97	2210	7612	<1	20.2	

ECe: Electrical conductivity of saturated paste extract

B. Survival and Vegetative Growth

The observations on growth performance of palms showed that until 180 DAP, all plants survived in all salinity treatments (Table IV). Effects of high salinity were first manifested at 360 DAP. The cv. Khalas showed the greatest tolerance to high salinity, as indicated by the highest number of plants that survived in the 20 dS/m treatment. Cultivar Nabusaif was found to be the most susceptible to high salinity. At the time of termination of the experiment (720 DAP), 40% of the total number of cv. Khalas survived in the highest salinity. However, all plants of cv. Barhee and 93% of total number of plants in cvs.

Al-Ahamad, Kasab, and Khalas and 73% of total number of plants in cv. Nabusaif survived in the 10 dS/ m treatment at 720 DAP. Therefore, it is concluded that cvs. Khalas, Kasab and Barhee had greater degree of tolerance to saline irrigation water than other cultivars, with Khalas being the most tolerant.

TABLE IV
SURVIVAL PERCENTAGE OF DATE PALM CULTIVARS IN DIFFERENT SALINITY TREATMENTS

Cultivar	Salinity Levels	Survival Percentage				
		0	180	360	540	720
		DAP	DAP	DAP	DAP	DAP
Al-Ahamad	1.6	100	100	100	100	100
	5.0	100	100	100	100	100
	10.0	100	100	100	93	93
	20.0	100	100	86	13	0
Khalas	1.6	100	100	100	100	100
	5.0	100	100	100	100	100
	10.0	100	100	100	93	93
	20.0	100	100	100	46	40
Nabusaif	1.6	100	100	100	100	100
	5.0	100	100	100	100	100
	10.0	100	100	93	80	73
	20.0	100	100	33	6	0
Kasab	1.6	100	100	100	100	100
	5.0	100	100	100	100	100
	10.0	100	100	100	93	93
	20.0	100	100	93	26	0
Barhee	1.6	100	100	100	100	100
	5.0	100	100	100	100	100
	10.0	100	100	100	100	100
	20.0	100	100	80	33	0

DAP: Days after planting

The vegetative growth parameters of the palms under different salinity treatments were compared. The average plant height was the greatest at the lowest salinity level and decreased with increasing salinity levels as well as with time. The salt-tolerant cv. Khalas also showed slow growth rate at 720 DAP. The average number of fronds per plant was the highest at lowest salinity level i.e., 1.6 dS/ m and decreased with increasing salinity of irrigation water. Cultivar Khalas recorded the highest number of plants at the termination of the study (720 DAP).

C. Leaf Tissue Analysis

The leaf tissue samples were analyzed during the study period at 180 DAP for micro and macronutrient. The samples were further analyzed for the same parameters at the termination of the study. Comparison of these two data sets showed that sodium and chloride content in all leaf samples during the termination of study was higher than that at 180 DAP, and plants were able to tolerate that level. The highest Na⁺ content of 3891 mg/ kg was observed at the end of study in 20 ds/m treatment, whereas it was as high as 9410 mg/kg in Nabusaif at 180 DAP. The phosphorus content in the plant was reduced due to high salt content beginning from 180 DAP until the end of experiment. The nitrogen content in leaf did not show much variation at 180 and 720 DAP. The palms were observed to have high content of nutrients like calcium, magnesium and potassium.

IV. DISCUSSION

The date palm tolerates high levels of salinity in the soil [5] and is more salt tolerant than most other fruit crops [6]. The results of the present study clearly demonstrated cultivar differences in their response to irrigation water salinity. Under controlled environment conditions, three out of the five cultivars tested (cvs. Khalas, Kasab and Barhee) were able to tolerate 10 dS/m salinity level until 24 months after the start of saline water irrigation treatment, but cv. Khalas was tolerant to the highest salinity level (20 dS/ m). Thus, among the five cultivars studied, Khalas was the most salt tolerant and Nabusaif was the most susceptible. The average height of palms and the number of fronds decreased with increasing salinity levels.

Several mechanisms have been suggested by a number of scientists that impart salt tolerance in tree crops [7]. Earlier studies of KISR with ornamental trees have shown that the presence of high salt concentration in the soil solution adversely affected root activity and reduced water uptake by roots even under non limiting soil moisture regimes [8]. [9] Studied the effect of salts ranging between 520 to 24,000 ppm on growth and salt uptake of 'Deglet Noor' and 'Medjool' varieties of date palm and showed that the average growth rate of leaves was depressed as the salinity level increased. They further suggested that the decline in the growth was more related to salinity of irrigation water than to salt content of the plants. [10] Studied the growth of four cultivars of date palms, 'Lulu,' 'Khalas,' 'Boman,' and 'Barhee,' using four salinity concentrations (0, 0.6, 1.2, and 1.8%) and found that the cultivar 'Lulu' was more affected by salinity than the other cultivars.

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