Effects of salinity and gibberellic acid on mineral concentration of date palm seedlings

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ABSTRACT
An experiment was carried out at the United Arab Emirates University, in Al-Ain, to study the effect of saline irrigation water on the mineral concentration of two date palm (*Phoenix dactylifera* L) cultivar seedlings. Salt alone, a combination of NaCl and gibberellic acid (GA_3), or GA_3 alone were tested with different levels. Then the shoot and root mineral concentrations were measured for each nutrient. The results concluded that irrigation of date palm seedlings with GA_3 in combination with 24 mg/l salt alleviated adverse effect of salts by reducing the accumulation of Na and Cl in shoots and roots of date palm seedlings over using 24 mg/l salt alone.

KEYWORDS
Phoenix dactylifera, irrigation, saline water, GA, chemical composition, seedlings, stems, roots.

Effets de la salinité et de l'acide gibbérellique sur la composition minérale de plantules de palmier dattier.

RÉSUMÉ
Une expérimentation a été entreprise à l'université d'Al-Ain (UAE) pour étudier l'effet d'une irrigation à l'eau salée sur la composition minérale de plantules de deux cultivars de palmier dattier (*Phoenix dactylifera* L). Le sel seul (NaCl), puis NaCl combiné avec de l'acide gibbérellique (GA_3) et enfin GA_3 seul ont été successivement ajoutés à l'eau d'irrigation, chacun de ces éléments étant testé à différentes concentrations. La teneur en éléments minéraux a ensuite été mesurée dans les tiges et les racines des jeunes plants. Les résultats ont montré que l'irrigation des plantules avec une solution salée (24 mg/l NaCl) additionnée de GA_3 tempérait l'effet du sel, en réduisant l'accumulation de Na et de Cl dans les tiges et les racines des jeunes palmiers dattiers, par rapport à l'utilisation d'eau salée à 24 mg/l NaCl seule.

MOTS CLÉS
Phoenix dactylifera, irrigation, eau saline, gibbérelline, composition chimique, plantule, tige, racine.

Efectos de la salinidad y del ácido giberélico sobre la composición mineral de plántulas de palma datilera.

RESUMEN
Una experimentación fue emprendida en la Universidad de Al-Ain (UAE) para estudiar el efecto de una irrigación con agua salada sobre la composición mineral de plántulas de dos cultivares de palma datilera (*Phoenix dactylifera* L). La sal sola (NaCl), y luego NaCl combinado con ácido giberélico (GA_3) y por fín GA_3 solo, fueron sucesivamente añadidos al agua de irrigación, cada uno de estos elementos siendo sometido a prueba con diferentes concentraciones. La proporción de elementos minerales se medió después en los tallos y en la raízes de los jóvenes plantones. Los resultados mostraron que la irrigación de las plántulas con una solución salada (24 mg/l NaCl) adicionada con GA_3 temperaba el efecto de la sal, reduciendo la acumulación de Na y de Cl en los tallos y en las raízes de las jóvenes palmas datileras, respecto a la utilización de agua salada con 24 mg/l NaCl sola.

PALABRAS CLAVES
Phoenix dactylifera, riego, agua salina, ácido giberélico, composición quimica, plántulas, tallo, raízes.

introduction

In many areas of the world, including the United Arab Emirates, saline irrigation water is a serious problem for agriculture.

Irrigation with saline water has been found to reduce plant growth and productivity of date palm trees (FURR and ARMSTRONG, 1962; ALJUBURI, 1993; HASSAN and EL-SAMNOUDI, 1993). Salinity also reduced shoot and root dry weight of sour orange, Volkamer lemon and Balady lime seedlings (ZEKRI and PARSONS, 1990; ALJUBURI, 1995), leaf and root fresh weight, leaf number and growth rate of date palm, Volkamer lemon and Balady lime seedlings. It increased growth rate in macrophella and rough lemon seedlings (HEWITT, 1963; FURR et al, 1966; SALEM and EL-KHORIEBY, 1989; ALJUBURI, 1992; AHMED et al, 1993; ALJUBURI and AL-MASRY, 1996) and the percentage of dry matter of date palm seedlings (ALJUBURI, 1992; ALJUBURI and AL-MASRY, 1995). In general, salinity leads to high accumulation of Cl, Na, and K in date palm leaves (HASSAN and AL-SAMNOUDI, 1993). Similarly, the addition of NaCl to irrigation water increased N, P, K, Na and Cl, but reduced Ca and Mg concentrations in the shoots of most rootstocks (ZEKRI, 1993). Most researchers found that the application of saline water to citrus plants decreased N, K, Ca, Mg, P, Fe, Mn, Zn, and Cu concentrations in leaves and roots (NAWAR and IBRAHIM, 1984; ATALLA, 1987; BANULS et al, 1990). However, ZID and GRIGNON (1987) concluded that salinity had no effect on K and N concentrations but led to large Na and Cl accumulation in *Citrus aurantium* leaves. The high accumulation of Cl and Na in date palm leaves may provide beneficial physiological activity through osmotic adjustment (HASSAN and ABOU-EL-AZAYEM, 1990; HASSAN, 1991; HASSAN and EL-SAMNOUDI, 1993). AHMED et al (1993) found that accumulation of ions in date palm roots and leaves gradually increased with increasing salt concentration in the irrigation water up to 12 000 ppm and that further increase had no significant effect. The percentage of shoot dry weight of date palm seedlings increased with application of saline water alone or in combination with GA_3 (ALJUBURI, 1995).

The objective of this study was to investigate the potential improvement in growth or performance of date palm seedlings under saline conditions due to the addition of GA_3.

materials and methods

The experiment was conducted in the shade house of the Experimental Station of Agricultural Sciences College at Al-Oha region, in the United Arab Emirates.

Two-year-old date palm (*Phoenix dactylifera* L) seedlings of Khalas and Lulu cultivars of uniform size were transplanted into plastic pots (40 × 25 cm) containing yellow sand. The seedlings were irrigated with water 3 times a week in addition to 1.5 l seedling/week with half-strength Hoagland's nutrient solution (HOAGLAND and ARNON, 1950).

The seedlings were arranged in a complete randomized block design equally split among three levels of irrigation water salinity: 0, 12 and 24 mg/l NaCl plus $CaCl_2$ in a mixture of 1:1 by weight. Salinity treatments were imposed by irrigating each seedling once a week with 1.5 l of different concentrations of salt in addition to 1.5 l of various concentrations of GA_3 solution (0.05 mg/l and 0.15 mg/l) added monthly. The experiment consisted of nine treatments replicated five times with two seedlings as the experimental unit.

Six months after treatment, the seedlings were removed from their pots. Roots were washed free of soil with tap water and rinsed with distilled water and separated from the shoots. The roots and shoots were separately oven dried for 4 d at 60 °C, ground, weighed and stored for mineral analysis.

Nitrogen was determined by the micro-Kjeldahl method (CHAPMAN and PRATT, 1961). Chloride was measured using a Buchler-cotlove chloridometer after extracting the samples with a nitric acetic acid solution. Measurement of Na, Ca, Mg, K, Zn, Mn, and Fe was conducted after wet digestion with a mixture (4:1) of nitric/perchloric acid. Phos-

phorus concentration was determined by autoanalyser (Model CSA 100).

The data were subjected to analysis of variance and Duncan's multiple range test was used for mean comparison at $P < 0.05$.

results and discussion

Irrigation of Khalas seedlings with saline water did not affect shoot N concentration (table I). With the exception of the high salt level combined with the high GA_3 concentration, addition of GA_3, with or without salts, to irrigation water increased shoot N concentration of Khalas seedlings. However, with the exception of the 12 mg/l salt treatment, irrigation of Lulu seedlings with water containing salts, GA_3 or both reduced significantly leaf N concentration. The data also show that shoot N concentrations of Khalas seedlings were higher than those of Lulu seedlings with the exception of the 12 mg/l salt and control treatments (table I); date palm seedlings response depends on cultivars more than on hormone concentrations. The results of salinity effect on shoot N level of Lulu seedlings are in agreement with those of NAWAR and IBRAHIM (1984) and BANULS et al (1990), which showed that salinity reduced leaf N concentrations of pear and citrus seedlings, and the results of Khalas are in agreement with ZEKRI (1993), which showed that salinity increased N concentration in citrus leaves.

Irrigation of Khalas seedlings with saline water did not affect shoot P concentration. A low concentration of saline water (12 mg/l) in combination with low GA_3 (0.05 mg/l) concentration increased shoot P concentration of Khalas seedlings over the control. Compared with the control, irrigating Lulu seedlings with saline water or with 12 mg/l salts in combination with GA_3 reduced shoot P concentration. The results of shoot P concentration of Khalas and Lulu seedlings are in agreement with those of ZEKRI (1993), NAWAR and IBRAHIM (1984) and BANULS et al (1990) who showed that salinity increased or decreased leaf P concentrations in citrus and pear respectively.

Table I
Effect of salinity and GA_3 on shoot mineral concentration of date palm seedlings, Khalas and Lulu cultivars. Values are mean of analysis of ten seedlings: five replications each with two seedlings.

Treatment	Dry weight (%)						ppm									
	N		P		K		Na		Cl		Mn		Zn		Fe	
	Khalas	Lulu	Khalas	Lulu	Khalas	Lulu	Khalas	Lulu	Khalas	Lulu	Khalas	Lulu.	Khalas	Lulu	Khalas	Lulu
Control	1.20cde	1.34abc	1.80bcd	1.83bc	0.88d	1.06b	0.13L	0.13L	0.74j	0.77j	16.5gh	19.0f	64.4a	60.1bc	207.8ef	191.8ef
12 mg/l salt	1.13def	1.22bcd	1.80bcd	1.45f	0.53h	0.64f	0.90g	0.68j	1.74fg	1.62gh	28.3a	17.4g	53.5def	49.2fgh	274.8cde	235.9de
24 mg/l salt	1.25bcd	0.95gh	1.84bc	1.47ef	0.55gh	0.57g	2.02a	1.71b	3.65a	3.19b	18.8ghi	19.0f	48.8ghi	39.0j	323.6cd	254.6de
0.05 mg/l GA_3	1.45a	0.93gh	1.84bc	1.84bc	0.81e	1.09a	0.15k	0.13L	0.83ij	1.01i	16.5ghi	16.1hij	62.5ab	57.3cd	217.5ef	179.3ef
0.15 mg/l GA_3	1.48a	0.95gh	1.80bcd	1.62cdef	0.89cd	0.91c	0.13L	0.16k	0.71j	0.83ij	16.7gh	15.3j	64.7a	60.2bc	204.6ef	111.8f
12 mg/l salt + 0.05 mg/l GA_3	1.48a	0.99fgh	2.16a	1.57ef	0.55gh	0.63f	0.98f	0.74i	1.78fg	1.78fg	20.7e	15.4ij	49.5fgh	45.0i	179.3ef	166.4ef
12 mg/l salt + 0.15 mg/l GA_3	1.38ab	1.05efg	2.02ab	1.58def	0.57g	0.62f	0.83h	0.89g	1.54h	1.90f	26.2b	22.7cd	53.8de	51.6efg	456.4a	357.7bc
24 mg/l salt + 0.05 mg/l GA_3	1.38ab	0.86h	1.98ab	1.64cdef	0.55gh	0.57g	1.61d	1.62d	2.75d	2.93c	22.6cd	22.2d	54.8de	46.1hi	351.7bc	238.7de
24 mg/l salt + 0.15 mg/l GA_3	1.19cde	0.90gh	1.79bcd	1.69cde	0.56g	0.61f	1.66c	1.22e	2.94c	2.41e	23.7c	23.0cd	55.2de	51.6efg	424.4ab	462.6a

For each element and both cultivars, mean separation within columns and rows followed by the same letter do not differ significantly (p = 0.05), using Duncan's multiple range test.

Shoot K concentration of Khalas and Lulu seedlings decreased when irrigated with saline water alone or in combination with GA_3. However, application of low GA_3 concentration to Lulu seedlings increased shoot K concentration over the control. These findings are also in agreement with those of NAWAR and IBRAHIM (1984), ATALLA (1987) and BANULS et al (1990) who showed that the salinity decreased K concentration in pear and citrus leaves and roots.

Shoot Na concentrations of Khalas and Lulu seedlings increased with increasing salinity in irrigation water. Gibberellic acid application at low concentrations to Khalas and at high concentration to Lulu seedlings increased shoot Na concentration relative to non-treated seedlings. The combination of low saline water and low GA_3 concentration increased shoot Na concentration of both Khalas and Lulu seedlings as compared with application of low salinity in irrigation water alone, whereas the combination of low salinity in irrigation water with high GA_3 concentration reduced shoot Na concentration of Khalas seedlings. The combination of high saline water with low GA_3 concentration reduced shoot Na concentrations of both Khalas and Lulu seedlings, compared with application of high concentration of saline water alone. For both cultivars, all the combinations of treatments were higher in shoot Na concentrations than the control.

Shoot Cl concentration was also increased with increasing salinity in irrigation water for Khalas and Lulu seedlings over the control. However, shoot Cl concentration of Khalas and Lulu seedlings was not affected by GA_3. Addition of GA_3 to high saline irrigation water reduced Cl accumulation in Khalas and Lulu seedlings. Application of high concentration of GA_3 in combination with low concentration of saline water decreased shoot Cl concentration of Khalas, but increased that of Lulu seedlings compared with the low salinity treatment. Compared with the no salt control treatment, all salinity treatments increased shoot Cl concentration of Khalas and Lulu seedlings. These results are in agreement with those of HASSAN and AL-SOMNOUDI (1993), ZID and GRIGNON (1987) and ZEKRI (1993) who demonstrated that salinity in irrigation water increased leaf Na and Cl concentrations in date palm and citrus seedlings. The results are also in agreement with those of HALE and ORCUTT (1987) who showed that the application of plant growth regulators on some plants alleviated the effects of salt stress.

Irrigation of Khalas seedlings with 12 mg/l salt alone or in combination with GA_3 increased shoot Mn concentration over the control. Application of GA_3 or 24 mg/l saline water alone had no effect on Khalas shoot Mn concentration. Gibberellic acid, low salinity in irrigation water and low salinity in combination with low concentration of GA_3 decreased shoot Mn concentration of Lulu seedlings as compared with the control. The combination of low salts with high GA_3 and high salt with GA_3 increased Lulu shoot Mn concentration over the control. The high salt treatment without addition of GA_3 had no effect on shoot Mn concentration of Lulu seedlings. The data indicated that Mn accumulation in date palm seedlings not only increased by applying GA_3 with saline water, but also depended on the cultivar. These results are in agreement with those of AHMED et al (1993) who showed that the accumulation of ions in leaves and roots of date palm seedlings gradually increased with increasing salt concentration in irrigation water up to 12 000 ppm and further increase had no effect.

Shoot Zn concentration of Khalas and Lulu seedlings was reduced with salt application in irrigation water alone or in combination with GA_3, while it was not affected by GA_3 alone. The results of this study also showed that shoot Zn concentration of Khalas seedlings was higher than that of Lulu seedlings. Similar results were obtained by NAWAR and IBRAHIM (1984), BANULS et al (1990) and ATALLA (1987) who showed that the salinity decreased mineral concentrations in the pear and citrus shoot.

Shoot Fe concentration of Khalas seedlings was higher than that of the control when irrigated with high salinity solution alone or in combination with GA_3 and with low salinity in combination with high GA_3 concentration. Irrigation of Lulu seedlings with high or low salt concentrations in combination with high GA_3 concentration increased shoot Fe

concentration over the control. Salinity, GA_3 in irrigation water alone, or salinity in combination with low GA_3 concentration had no effect on shoot Fe concentration of Lulu seedlings compared with the control (table I).

Irrigation of Khalas and Lulu seedlings with saline water had no effect on root N concentrations as compared with the control (table 2). Application of GA_3 alone or in combination with saline water generally increased root N concentration in Khalas seedlings over the control. Application of low concentration of GA_3 alone or high salinity in combination with high GA_3 concentration reduced root N concentration of Lulu seedlings as compared with the control. However, irrigation with GA_3 alone or in combination with saline water increased root N concentration more in Khalas than Lulu seedlings. The results of salinity effect on shoot N concentration of Khalas seedlings are in agreement with those of ZID and GRIGNON (1987) who showed that the salinity had no effect on citrus leaf N concentration and with those of BALKI and PADOLE (1982) who demonstrated that the GA_3 application on wheat plants under salinity conditions increased nutrient uptake.

Irrigating date palm seedlings of Khalas and Lulu cultivars with 24 mg/l saline water alone or in combination with GA_3 reduced root P concentration over the control, with exception of high salinity in combination with low GA_3 concentration on Khalas seedlings.

Irrigation of Khalas and Lulu seedlings with saline water alone or in combination with GA_3 reduced root K concentration as compared with the control with the exception of the low salt treatment alone or in combination with the high GA_3 concentration. Application of GA_3 on Khalas and Lulu seedlings had no effect on root K concentration as compared with the control (table II). These results are in agreement with those of ATALLA (1987) and BANULS et al (1990, who showed that salinity reduced root P and K concentrations of citrus seedlings.

Root Na concentration in Khalas and Lulu seedlings increased with increasing salinity in irrigation water. However, GA_3 application had no effect on root Na concentration

Table II
Effect of salinity and GA_3 on root mineral concentration of date palm seedlings, Khalas and Lulu cultivars. Values are mean of analysis of ten seedlings: five replications each with two seedlings.

Treatment	*Dry weight (%)*				*ppm*											
	N		*P*		*K*		*Na*		*Cl*		*Mn*		*Zn*		*Fe*	
	Khalas	*Lulu*	*Khalas*	*Lulu*	*Khalas*	*Lulu*	*Khalas*	*Lulu*	*Khalas*	*Lulu*	*Khalas*	*Lulu*	*Khalas*	*Lulu*	*Khalas*	*Lulu*
Control	0.74efgh	0.89cdef	1.36ab	1.23bcd	0.91a	0.79bc	0.29e	0.37e	0.85ij	0.85ij	32.6b	11.1j	19.1d	24.7abc	312.4ef	299.7ef
12 mg/l salt	0.71efgh	0.85cdefg	1.35ab	1.16bcde	0.54def	0.77bc	1.44c	0.89d	2.32d	1.64f	24.0c	15.2hi	19.7d	20.6cd	231.0f	256.8f
24 mg/l salt	0.90cde	0.71efgh	0.96ef	0.87f	0.35hi	0.63d	2.71a	1.50c	4.28a	2..28d	17.6fghi	23.2cd	19.2d	23.3bcd	323.6def	502.6bcd
0.05 mg/l GA_3	1.00bc	0.67gh	1.50a	1.05def	0.84abc	0.83abc	0.33e	0.27e	0.90l	0.69j	17.8efghi	22.1cde	21.6bcd	21.6bcd	4767.1bcde	283.8ef
0.15 mg/l GA_3	1.13b	0.77defgh	1.51a	1.17bcde	0.88ab	0.86abc	0.32e	0.28e	0.85ij	0.73ij	19.1defgh	19.7cdefg	22.6bcd	22.4bcd	562.8b	294.7ef
12 mg/l salt + 0.05 mg/l GA_3	1.10b	0.73efgh	1.33abc	1.01def	0.58de	0.59de	1.41c	0.97d	2.29d	1.58f	36.5a	21.3cdefg	22.2bcd	22.6bcd	796.1a	267.0f
12 mg/l salt + 0.15 mg/l GA_3	1.30a	0.90cde	1.18bcde	1.13bcde	0.51ef	0.76c	1.46c	0.89d	2.39d	1.32g	17.0ghi	19.9cdefg	21.0cd	20.5cd	512.9bcd	330.1cdef
24 mg/l salt + 0.05 mg/l GA_3	0.95bcd	0.70fgh	1.25bcd	0.96ef	0.45fg	0.38ghi	2.41b	1.44c	3.19c	2.08e	14.2ij	23.2cd	21.7bcd	28.1a	381.9bcdef	345.4cdef
24 mg/l salt + 0.15 mg/l GA_3	0.90cde	0.61h	1.10cdef	0.86f	0.29l	0.40gh	2.45b	0.89d	3.92b	1.08h	21.9cdef	23.0cd	20.8cd	25.5ab	539.4b	519.0bc

For each element and both cultivars, mean separation within columns and rows followed by the same letter do not differ significantly (p = 0.05), using Duncan's multiple range test.

of Khalas and Lulu seedlings. Application of high salinity in irrigation water in combination with high and low GA_3 on Khalas or with high GA_3 concentration on Lulu seedlings reduced root Na concentration as compared with high salinity treatment. All treatment combinations had higher root Na concentrations than the control. The data also showed that Khalas seedlings accumulated more Na in their root than did Lulu seedlings.

Application of salts in irrigation water alone or in combination with GA_3 increased root Cl concentration of Khalas and Lulu seedlings. Gibberellic acid in combination with high salt concentration in irrigation water reduced root Cl concentration of Khalas and Lulu seedlings as compared with the high salinity level alone. Overall, irrigation with saline water alone or in combination with GA_3 increased root Cl concentration more in Khalas than in Lulu seedlings. The results are in agreement with HASSAN and AL-SAMNOUDI (1993) and ZEKRI (1993) who demonstrated that the salinity led to accumulation of Cl, Na and K in date palm and citrus seedlings respectively. The data also revealed that the Khalas seedlings accumulated more Na and Cl in their root than did Lulu seedlings. These results could conclude that the Khalas seedlings are more tolerant of salt than Lulu seedlings. Similar results were obtained by LAUCHLI and WIENEKE (1979) and HASSAN (1991) who showed that the plants exhibited a greater degree of salt tolerance than other crops that usually accumulate Na. These results may indicate that the high accumulation of Na and Cl plays an important role as osmotic adjustment in vacuoles and that it improve the water balance. Similar results obtained by MARSCHNER et al (1981) and HASSAN (1991) who reported that absorption of Na and Cl by plants serves a useful function by providing lower osmotic solutes.

With the exception of low salinity in combination with low GA_3, addition of salts or GA_3 alone or in combination to irrigation water reduced root Mn concentration of Khalas seedlings. However, root Mn concentration of Lulu seedlings increased with application of salts or GA_3 in irrigation water alone or in combination.

The addition of salinity or GA_3 to irrigation water had no effect on root Zn concentration of Khalas or Lulu seedlings. Irrigation of Khalas seedlings with saline water or with low concentration of GA_3 had no effect on root Fe concentration. Application of high concentration of GA_3 alone or in combination with saline water or low salinity with low GA_3 concentration increased root Fe concentration of Khalas seedlings. Irrigation with high concentration of saline water alone or in combination with high concentration of GA_3 increased root Fe concentration of Lulu seedlings. Root Fe concentration of Khalas seedlings was higher than that of Lulu seedlings when treated with high concentration of GA_3 or low concentration of salts in combination with low GA_3.

Differences in mineral concentrations between the two date palm cultivars could be attributed to their differential ability to absorb water and nutrients and to the physical differences between their roots systems (CASTLE and KREZDORN, 1975).

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