Asian Journal of Plant Sciences

ISSN 1682-3974

science alert

ANSInet
an open access publisher
http://ansinet.com

Asian Journal of Plant Sciences 6 (6): 962-966, 2007
ISSN 1682-3974

Interaction of Salinity and Temperature on the Germination of Doum (*Hyphaene thebaica*) Seed in Saudi Arabia

Yusef Saleh Siraj Ali
Department of Plant Production, College of Agriculture, King Saud University, Riyadh, Saudi Arabia

Abstract: A greenhouse experiment evaluated the effect of water salinity (electrical conductivity of 0.03, 12.0, 24.0 and 36.0 dS m^{-1}) and temperature (15, 25, 30 and 35°C) on the germination of Doum (*Hyphaene thebaica*) seed over 2 weeks period. Treatment solutions were prepared using NaC1 and $CaC1_2$ in 2:1 molar ratio. Germination declined with increasing salinity at each counting date and salinity × temperature interactions were highly significant. Germination was severely limited at 15°C having only 18% germination in the control treatment (0.03 dS m^{-1}). The temperature for optimum germination ranged between 25-35°C for all salinity treatments. The final cumulative germination percentage was highest at 25°C in most of the water salinity treatments. However, percent germination showed decreases on either side (25 and 35°C) of the optimum temperature range. The germination rate reduced drastically at 15°C in all water salinity treatments, with intermediate effect at 25 and 35°C at the lower salinity level, while decreasing with increasing salinity at all temperature. Overall the trend for the effect of temperature on reduction in germination rate index in different water salinity treatments in descending order is 15 > 45 >35 > 25°C. The results suggested that Doum seed is moderate to high tolerant to salinity stress during germination with temperature ranging between 25-35°C.

Key words: Doum seed, germination, salinity levels, temperature, interaction

INTRODUCTION

Doum palm, a tree of the palm family, grows in the southern and western parts of Saudi Arabia. The doum palm grows upto a height of 6-9 m, usually with forked leaves of 65-75 cm length, deeply lobed and fan shaped. The palm is unique among woody ornamental plants and can only be propagated from seeds similar to other members of the palm family. The seeds germinate by developing the seedling axis at some distance from the actual seed. The first structure, that emerges from the seed, is called the cotyledonary petiole. It grows downward into the soil and swells at its base. From this swelling emerges the first seedling root (radicle) and seedling shoot (plumule) (Fig. 1).

Fig. 1: Germination of doum seed

Germination is one of the most critical periods for successful growth of a crop when subjected to soil and water salinity. Generally, the germination failure on saline soils is due to the high salt concentration in the seed planting zone resulting from the upward movement of soil solution and its subsequent evaporation at the soil surface. Therefore, the crop may be subjected to higher soil salinity levels during germination than in later growth stages (Bernstein, 1974; Bernstein and Hayward, 1958).

Numerous studies (Ayers, 1951; Ayers and Hayward, 1948; Francois *et al*., 1984; Sharma, 1976; Stone *et al*., 1979) have demonstrated that the rate and percentage of seed germination are adversely affected with an increase in soil salinity and the corresponding decrease in osmotic potential of the germination medium. The air-temperature also plays an important role in seed germination and the temperature × salinity interactions on the germination of a number of plant species were also observed (Sharma, 1976; Stone *et al*., 1979; Tadmor *et al*., 1969; Ungar, 1967).

Virtually all palm trees require high temperature for rapid and uniform germination of their seed. Around 48-70°C is the acceptable range, whereas, the temperature range between 38-45°C probably yields the best results for seed germination. The seed of Paurotis palm

(*Acoelorraphe wrightii*) was reported to germinate best at 43-50°C, with only 11% germination below 39°C (Carpenter, 1988a). The native Keys thatch palm (*Thrinax morrisii*) and Silver palm (*Cocothrinax argentata*) showed best germination between 42-46°C, with few seeds germinating below 32°C (Carpenter, 1987; Carpenter and Gilman, 1988). The seed of Pindo palm (*Butia capitata*) germinated best within 2-3 weeks at 50°C for the duration of the germination period (Carpenter, 1988b). Some research has suggested that fluctuating temperatures at 12 h intervals may increase total germination for certain species (Carpenter, 1989) but this is not practical for most growers.

Both the temperature and the salinity stress often limit crop establishment of irrigated soils in Saudi Arabia. Therefore, a better understanding of the effects of these environmental factors and their interactions on Doum seed germination is important for the development of optimum cultural practices for improved stand establishment of doum palm under saline conditions.

The objective of this study was to evaluate the germination response of doum seed to a wide range of water salinity levels and temperature ranges alongwith salinity x temperature interactions influence on the seed germination.

MATERIALS AND METHODS

Several seed lots of doum seed, collected from different sites in Saudi Arabia, were mechanically scarified, screened for seed quality using standard germination test (AOSA, 1996) and visual ratings of seed vigor. Salinity tolerance of seed lots with standard germination in excess of 60% was evaluated in preliminary tests under isothermal conditions (25°C). The variations in salinity tolerance in these preliminary seed germination tests were strongly associated with the seed quality. Therefore, the interactions of salinity and temperature on doum seed germination were determined using only high quality seed (99% standard germination with very good seed vigor) in order to minimize the differences in response due to seed quality. The seedlot used was screened by gravity table.

Evaluation for salinity tolerance during germination was accomplished by placing 3 seeds in each pot (12 cm in diameter). The pots were filled with growth media (2:1 perlite and peatmoss, respectively) and treated with the fungicide Dithane M-45 (Mancozeb) at the rate of 0.1 g kg^{-1} of media. Five milliliter of distilled water or various solutions of NaCl and $CaCl_2$ (2: 1 molar ratio of NaCl to $CaCl_2$) were added to the pots. Germination response was determined with the solution concentrations of 0.03, 12.0, 24.0 and 36.0 dS m^{-1}. Measured values of electrical conductivity and the osmotic potential of these solutions are shown in Table 1. The electrical conductivity and the osmotic potential were measured with a conductivity bridge (Model PM-70CB, the Barnstead Co., Boston, MA) and a vapor pressure osmometer (Model 51130C, Wescor, Inc., Logan, UT), respectively. The pots were arranged in an incubator by following a Randomized Complete Block Design with one block per shelf over five shelves. The germination response to salinity at four temperatures (15, 25, 35 and 45°C) was evaluated by replicating the temperature twice in the same incubator during the experimental period. Temperatures were maintained within ±1°C of the target levels. The germination counts were made at 3, 6, 9 and 12 days after incubation. One blank treatment (Petri dish, three circles of filter paper and 5 mL of distilled water) per shelf was placed with the treatment dishes. Distilled water (representing the mean loss of water from the blanks) was added to each Petri dish on day 3, 6 and 9 to maintain salt concentrations near the target levels throughout the germination period. A germination rate index was determined by the following formula:

Table 1: Description of salt solutions used to determine the germination response of doum palm seed

Electrical conductivity (dS m^{-1})	Osmotic potential (MPa)
0.03	-0.020
12.0	-0.429
24.0	-0.893
36.0	-1.619

$$\text{Germination rate index} = \frac{G_3}{3} + \frac{G_6}{6} + \frac{G_9}{9} + \frac{G_{12}}{12}$$

Where, G_3, G_6, G_9 and G_{12} are germination percentages × 100 at 2, 6, 9 and 12 day after initiation of germination. Analyses of variance and orthogonal contrasts were used to analyze the data (SAS, 2000). Data from each counting date (3, 6, 9 and 12 day of incubation) were analyzed independently.

RESULTS AND DISCUSSION

The germination response of Doum palm seed to different water salinities and temperatures is illustrated in Fig. 2. The analysis of variances for these data are given in Table 2. The temperature and salinity interactions were highly significant at each counting date. Germination was severely limited at 15°C with the salinity control germinating at only 22% after one day. The low germination at 15°C suggests that minimum germination took place at this temperature for high-quality doum seed. The optimum temperature for germination for the control treatment ranged between 25-35°C. Similar conclusions

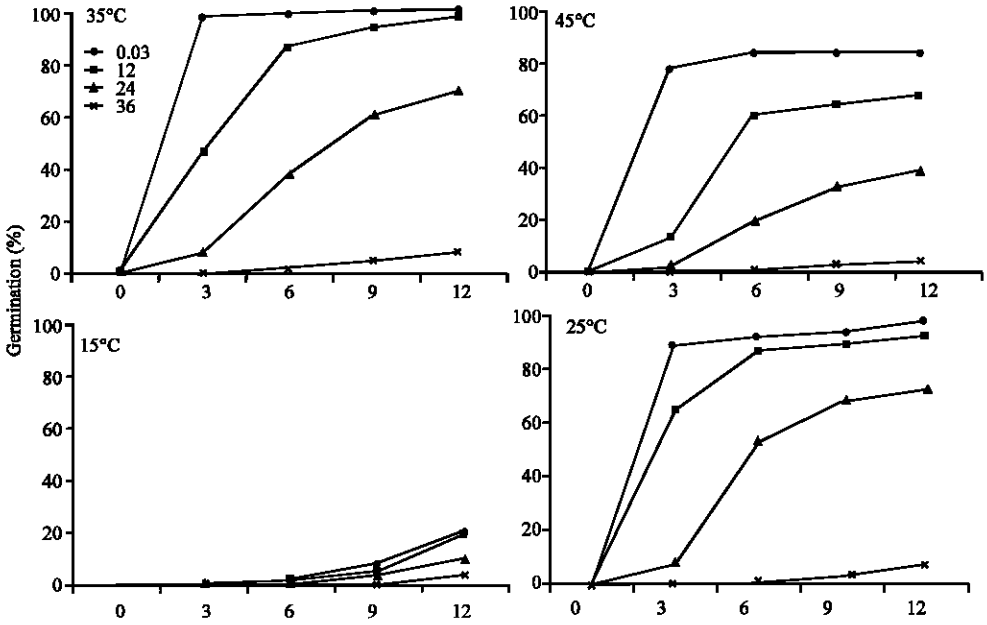

Fig. 2: Cumulative germination of doum seed at 4 different temperatures under different water salinity treatments

were reported by Davis and Pritchards (1998) and Moussa *et al.* (1998) who observed similar germination temperatures when a number of doum seed lots were grown and tested at several locations.

The final cumulative germination percentage was maximum at 25°C in all the water salinity treatments. There was no significant difference in final germination percentage at 25 or 35°C in the low salinity levels ranging between 6.3-17.3 dS m^{-1} (Fig. 3). However, at 22.5 dS m^{-1} water salinity treatment, a significantly higher germination percentage was observed at 25°C than 35°C. In several plant species, higher temperatures increased the detrimental effects of salinity during germination and, in a few cases, altered the optimum germination temperature at specific salinity levels (Sharma, 1976; Stone *et al.*, 1979; Tadmor *et al.*, 1969; Ungar, 1967). However, in most of the cases reviewed, the optimum germination temperature remained identical throughout the different levels of salinities tested. The germination percentage at 45°C was significantly lower than that obtained at 35°C in different salinity levels indicating that 45°C temperature is higher than the optimum germination temperature for doum seed but at least is 5-10°C below the maximum.

Germination rate (expressed as germination rate index) was influenced by salinity and temperature similar to the pattern found for final germination (Fig. 4). Temperature × salinity interactions were highly significant (Table 2). Germination rates at 25 and 35°C were almost identical throughout the range of different water salinities. At the lower salinity levels (0.30-12.0 dS m^{-1}), the germination

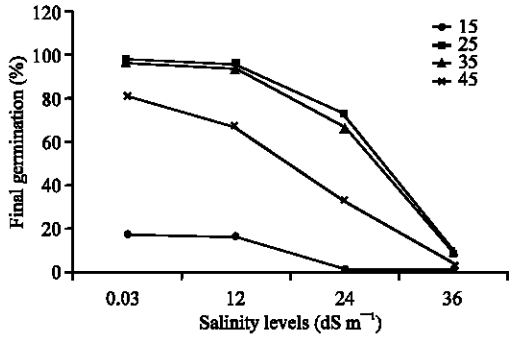

Fig. 3: Final cumulative germination percentages of doum at 12 days after initiation of germination as a function of salinity and temperature

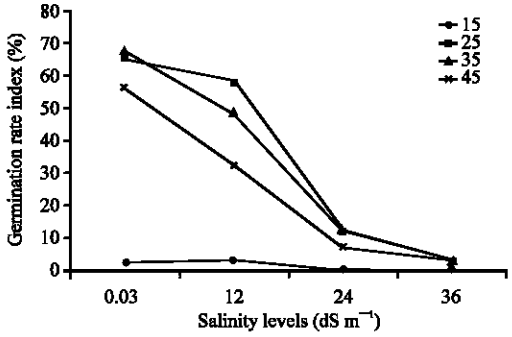

Fig. 4: Germination ratio index of doum as a function of salinity and temperature

Table 2: Analysis of variance and trend comparisons for the cumulative germination and germination rate index of doum seed at four temperatures and four salinity levels

	Mean square				
	Cumulative germination-days after initiation				
Source	3	6	9	12	Germination rate index
Temperature (T)	**	**	**	**	**
Linear	**	**	**	**	**
Quadratic	**	**	**	**	**
Cubic	*	-	-	-	-
Salinity (S)	**	**	**	**	**
Linear	**	**	**	**	**
Quadratic	**	**	**	**	**
Cubic	**	**	**	**	**
T × S	**	**	**	**	**
CV	16.1	11.75	9.80	10.60	9.28

*, **: Significant at the p = 0.05 and 0.01 levels, respectively

rate index at 45°C was significantly lower than that at 25 or 35°C but significantly higher than that at 15°C. The time lag in germination at 15°C, as indicated by the lower germination rate, is primarily a response to temperature with a lesser salinity effect than that observed for the 45°C treatment. Other studies (Tadmor *et al*., 1969; Ungar, 1967) showed similar salinity × temperature interactions on either side of the optimum temperature in salinity sensitive species. In some salt tolerant species, however, high temperatures appear to stimulate seed germination over a wide range of salinity (Ungar, 1967). At the higher salinity levels (>12.0 dS m^{-1}), germination rates at 25 and 35°C were similar. Overall the trend for the effect of temperature on reduction in germination rate index in different water salinities in descending order is 15 > 45 >35 > 25°C (Fig. 4).

Based on the study findings, the salinity tolerance of doum seed during germination could be classified as slight to moderately tolerant (Maas and Hoffman, 1977) over the temperature range between 15 and 45°C. This salt tolerance classification was determined on the basis of the salinity levels resulting in a 50% reduction in final germination at day 12. The salinity levels, at which a 50% reduction in the final germination occurred, varied somewhat among the different temperatures. Germination was highly tolerant at 25°C, moderately tolerant at 35°C and slightly less at 45°C and significantly less tolerant at 15°C, but overall falling within the moderately tolerant range. Although most crop species tolerate salinity in a similar manner during all growth stages (Bernstein, 1974; Bernstein and Hayward, 1958), but there are notable exceptions in some crop species (Ayers and Hayward, 1948; Francois *et al*., 1984). Overall the trend for the effect of temperature on reduction in germination rate index in different water salinities in descending order is 15 > 45 >35 > 25°C.

The range of genetic diversity among traits studied in doum is considered to be very limited, but there is no certainty that the inherent germination response of the doum plants from different environmental conditions to salinity and temperature would be similar to Saudi doum.

ACKNOWLEDGMENT

The authors sincerely thank the King Abdul Aziz City for Science and Technology (KACST) for providing funds for this study under Grant No. A.T. 14-57

REFERENCES

AOSA (Association of official Seed Analysis), 1996. Rules for testing seeds. Proc. Assoc. Off. Seed Anal., 60: 1-116.

Ayers, A.D. and H.E. Hayward, 1948. A method for measuring the effects of soil salinity on seed germination with observations on several crop plants. Soil Sci. Soc. Am. Proc., 13: 224-226.

Ayers, A.D., 1951. Seed germination as affected by soil moisture and salinity. Agron. J., 44: 82-84.

Bernstein, L. and H.E. Hayward, 1958. Physiology of salt tolerance Annu. Rev. Plant Physiol., 9: 25-46.

Bernstein, L., 1974. Crop Growth and Salinity. In: Drainage for Agriculture, Van, S.J. (Ed.). Agron. Monogr. 17. ASA, Madison, Wis., pp: 39-54.

Carpenter, W.J., 1987. Temperature and inhibition effects on seed germination of *Sabal palmetto* and *Serenoa repen*. Hortic. Sci., 22: 660-662.

Carpenter, W.J. and E.F. Gilman, 1988. Effect of temperature and desiccation on the germination of *Thrinax morrisii*. Proc. Fla. State Hortic. Soc., 101: 288-290.

Carpenter, W.J., 1988a. Temperature affects seed germination of four Florida palm species. Hortic. Sci., 23: 336-337.

Carpenter, W.J., 1988b. Seed after-ripening and temperature influence *Butia capitata* germination. Hortic. Sci., 23: 702-703.

Carpenter, W.J., 1989. Influence of temperature on germination of *Sabal causiarum* seed. Principes, 33: 191-194.

Davies, R.I. and H.W. Prichard, 1998. Seed storage and germination of the palms *Hyphaene thebaica*, *H. petersiana* and *Medemia argun*. Seed Sci. Technol., 26: 823-828.

Francois, L., E.T. Dononvan and E.V. Mass, 1984. Salinity effects on seed yield, growth and germination of grain sorghum. Agron. J., 76: 741-744.

Maas, E.V. and G.J. Hoffman, 1977. Crop salt tolerance current assessment. J. Irrig. Drain. Div., Am. Soc. Civ. Eng., 103: 115-134.

Moussa, H., H.A. Margolis, P.A. Dube and J. Odongo, 1998. Factor affecting the germination of doum palm (*Hyphaene thebaica* Mart.) seeds from the semi-arid zone of Niger, West Africa. For. Ecol. Manage., 104: 27-41.

SAS, 2000. SAS User's Guide: Statistics. Version 15. SAS Institute, Cary, NC.

Sharma, M.L., 1976. Interaction of water potential and temperature effects on germination of three semi-arid plant species. Agron. J., 68: 390-394.

Stone, J.E., D.B. Marx and A.K. Dobrenz, 1979. Interaction of sodium chloride and temperature on germination of two alfalfa cultivars. Agron. J., 71: 425-427.

Tadmor, N.H., Y. Cohen and Y. Harpaz, 1969. Interactive effects of temperature and osmotic potential on the germination of range plants. Crop Sci., 9: 771-774.

Ungar, I.A., 1967. Influence of salinity and temperature on seed germination. Ohio J. Sci., 67: 120-123.