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Effect of NaCl salinity and incubation temperature on the germination of two cultivars of pearl millet

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ABSTRACT

Pearl millet (*Pennisetum spicatum*) is one of the most important food crops cultivated in many areas in Saudi Arabia at various temperatures and high salinity stress. The objective of this study was to study the effect of different levels of salinity (0, 50, 100, 200, 300 mM NaCl), and different incubation temperatures (20, 30, 40ºC) on seed germination of two pearl millet cultivars. The results indicate that seed germination percentages of the two cultivars were significantly reduced on the application of the highest concentration of NaCl at all tested temperatures, while 50 and 100 mM NaCl did not affect significantly the percentage of seed germination when the seeds were incubated at 20, 30 and 40ºC. At 40ºC, the 300 mM NaCl caused 70% and 42% reduction in seed germination in the case of Jaizan and Khulais cultivars, respectively. The study reveals that seeds of Jaizan pearl millet showed less resistance to salinity than seeds of Khulais cultivars. The sensitivity of both cultivars to salinity increased with increasing in temperature.

Key words: Pearl millet, *Pennisetum spicatum*, salinity stress, temperature stress, seed germination**.**

INTRODUCTION

Pearl millet (*Pennisetum spicatum*) is one of the most important food crops in the arid and semi-arid tropics. In Saudi Arabia, pearl millet is grown in many areas with different temperatures such as Jaizan, Mecca, Asir and Al-Baha. Salinity arising from irrigation causes a major problem for crop growth in these areas. It has been established that salinity and temperature have different effects on seed germination (Gul & Weber, 1999; Khan & Unger, 1999; Yu *et al.*, 1999; Khan *et al*, 2000; Gulzar & Khan, 2001; Khan & Gulzar, 2003). El-Fawal & El-Nathlawy (1989) reported that seed germination and seedling growth decrease more obviously in saline habitats associated with high temperature.

In arid regions, such as that in Saudi Arabia, saline soils are primarily encouraged with drought and extreme temperatures (Quispe & Jacobsen, 1999). The interaction of salt and temperature stress provides an extreme environment to seed germination which could be overcome by emerging tolerant species capable to establish themselves in such an extreme environment.

This investigation was meant to study the combined effect of different NaCl concentrations and incubation temperatures on the germination of two cultivars of *Pennesitum spicatum* from Saudi Arabia.

MATERIALS AND METHODS

Seeds of two cultivars of pearl millet, *Pennesitum spicatum* L. cv. Khulais and Jaizan, were obtained commercially from Khulais and Jaizan in 2006 and were stored at 4°C. Before germination, the seeds were surface sterilized by soaking for two minutes in 0.1% mercuric chloride, then washed five times with distilled water. The germination was allowed in 9-cm Petri dishes each containing one disk of Whatman filter paper No.1 and 5 ml of NaCl solution. Germination experiments were conducted in incubators set at 20, 30 and 40°C. Seeds were germinated in distilled water (0) and in 50, 100, 200 and 300 mM NaCl solutions under the selected temperatures in dark. Four replicates each contained 10 seeds were used for each treatment. Seeds were considered germinated with the emergence of the radicles. Percentage germination was recorded every day until no further seeds germinating. In all cases, the germination percentage of the last day was statistically analyzed using analysis of variance (Systat, Inc., Evanston, Illinois, USA).

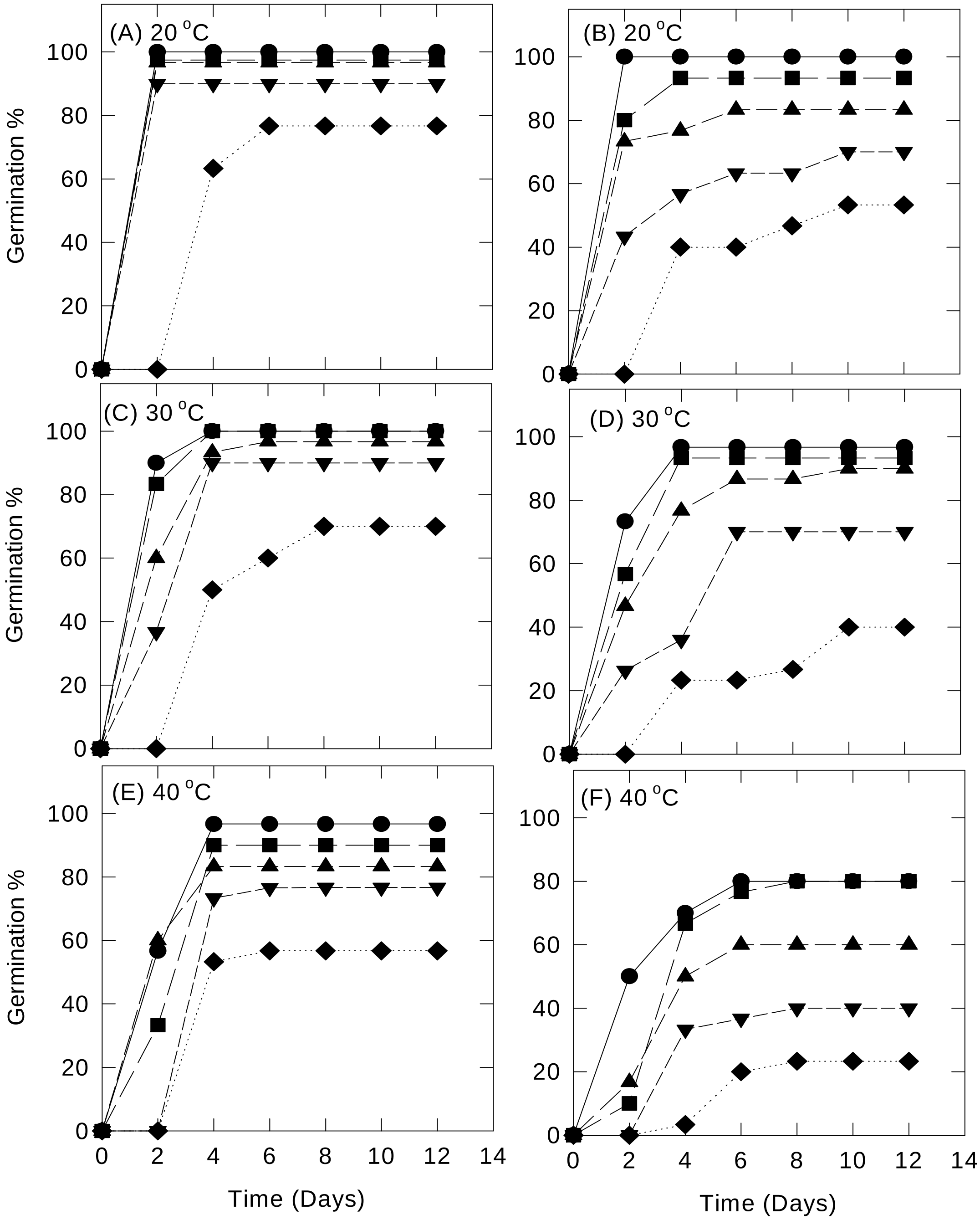

Fig. - 1:Progress of germination (%) of Peral millet (*Pennesitum spicatum* L. cv. Khulais) A & C & E, and Peral millet (*Pennesitum spicatum* L. cv. Jaizan) B & D & F at different temperatures
● Distilled water ■ 50 mM NaCl ▲ 100 mM NaCl ▼ 200 mM NaCl ◆ 300 mM NaCl

RESULTS

Fig. -1 shows the germination percentages of the two pearl millet cultivars at different temperatures in dark. At all temperatures, the germination percentage increased gradually from the second day onwards. The germination percentages were generally lower in the pearl millet of Jaizan incubated at all temperatures compared to the pearl millet of Khulais. Also, the germination of Jaizan pearl millet incubated at 40°C was lower at the highest NaCl concentrations (300 mM), as compared to that of the other temperatures. The percentage of reduction was more than 70% compared to that of control (Table. 1). On the other hand, the highest NaCl concentration significantly reduced seed germination of Khulais pearl millet grown at 40°C to about 42% compared to control (Table. 2).

Table - 1: The final germination percentages (± SE) of Jaizan pearl millet seeds germinated at 20, 30, 40 °C and different NaCl concentrations.

NaCl (mM)	Temperature (°C) 20	30	40
Control	100 ± 0.0 a	96.7 ± 3.3 a	80.0 ± 0.0 ab
50	93.3 ± 3.3 a	93.3 ± 3.3 a	80.0 ± 0.0 ab
100	83.3 ± 12 ab	90.0 ± 5.8 a	60.0 ± 11.5 b
200	70.0 ± 5.8 b	70.0 ± 5.7 b	40.0 ± 5.8 c
300	40.0 ± 5.8 c	53.3 ± 6.6 bc	23.3 ± 8.8 d

Means followed by the same letter do not differ significantly at 5% level of probability according to Scheffe's Test. Values shown are the mean of 4 replicate plots (± SE).

Table - 2: The final germination percentages (± SE) of Khulais pearl millet seeds germinated at 20, 30, 40 °C and different NaCl concentrations.

NaCl (mM)	Temperature (°C) 20	30	40
Control	100 ± 0.0 a	100 ± 0.0 a	96.7 ± 3.3 a
50	96.7 ± 3.3 a	100 ± 0.0 a	90.0 ± 10.0 a
100	96.7 ± 3.3 a	96.7 ± 3.3 a	83.3 ± 8.8 ab
200	96.7 ± 3.3 a	90.0 ± 5.8 a	76.7 ± 3.3 b
300	76.7 ± 6.7 b	70.0 ± 5.8 b	56.7 ± 8.8 c

Means followed by the same letter do not differ significantly at 5% level of probability according to Scheffe's Test. Values shown are the mean of 4 replicate plots (± SE).

NaCl at lower concentrations (50 and 100 mM) had no significant effect on the final germination percentages attained by the seeds of the two cultivars at all temperatures (Tables 1 & 2). However, 200 mM NaCl significantly reduced seed germination of Khulais cultivar at 40 °C and seed germination of Jaizan cultivar at all temperatures.

DISCUSSION

It is clear from the results that the final germination percentage and the germination rate of pearl millet were temperature-dependent. It appeared that germination occurred at a wide range of temperatures (20-40°C), although the final germinations at 40°C were reduced in Khulais pearl millet to about 42% and in Jaizan pearl millet to about 70% in the highest NaCl concentration (300 mM) compared to control.

The tolerance of seed germination of pear millet to a wide range of temperature is important for successful cultivation of a crop in a warm habitat. Salt tolerance during germination and early seedling stages is critical for the establishment of plants in such saline soil (Perez *et al.* 1998). Under these conditions, changes in the incubation temperature particularly, at high salt concentration may result in the malfunctioning of enzymatic system. This situation would lead to limitations in many physiological and biochemical vital processes for seed germination. The dependence of seed germination rate on temperature has already been reported for several species (Al-Helal *et al*., 1989; Khan & Ungar, 1998; Gulzar & Khan, 2001). The seeds incubated under high temperature with high NaCl concentration seemed to be subjected to a combined environmental stress, which is indicated by the low germination percentages that reached 30 and 58% at 300 mM in the case of Jaizan cultivar and Khulais cultivar incubated at 40°C, respectively.

It is clear from the results that NaCl up to 200 mM had no clear effect on seed germination of the two pearl millet cultivars at 20 and 30°C and this might indicate that the seeds of these cultivars can tolerate relatively high NaCl levels. However, the inhibition of seed germination of the two cultivars by excessive salinities is probably due to the high osmotic potential of the medium (Imamul-Huq, 1983).

In the present work, it appears that the incubation temperature and the salinity degree determine the salinity tolerance during germination of *Pennisetum spicatum*. Although the higher salinity decreases germination, the detrimental effect of salinity is generally less effective at temperatures of 20 and 30°C. The detrimental effect of salinity was found to be severe at higher temperatures in some species including *Sagittaria latifolia* (Delesalle & Blum, 1994), *Atriplex semibaccata* (De Villiers *et al*., 1994), *Polygonum aviculare* (Khan & Ungar, 1998), *Atriplex cordobensis* (Aiazzi *et al*., 2002) and *Sarcobatus vermiculatus* (Khan *et al*. 2002).

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