

## **Effect of Interaction Between Sodium Chloride and Temperature on Germination of Rice Grains from Saudi Arabia**

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**ABSTRACT.** The effect of constant temperatures (20, 25, 30, 35 and 40°C) on the rate of seed germination was studied. Seed germination percentage was high at 20, 25, 30 and 35°C and was significantly reduced at 40°C. The rate of germination appeared to be best at 30 and 35°C.

NaCl at 0.001 and 0.01 M had no effect on germination at the temperatures studied (25, 30 and 35°C). Seed germination tolerance to a higher salt concentration was temperature-dependent. 0.1 M had no effect at 25 and 30°C but inhibited germination significantly at 35°C. 0.2 M inhibited germination significantly at 30 and 35°C. 0.3 M inhibited germination significantly at all temperatures studied.

Temperature and salinity are among the major environmental factors that influence seed germination (Bishnoi and Pancholy 1980, Al-Helal *et al.* 1989, Grime *et al.* 1981, Woods and Macdonald 1971, and Larik and Al-Saheal 1986). In the warm environmental habitat, such as that in Saudi Arabia, the combination of salt stress and temperature stress presents an extreme environment to seed germination which must be overcome by a species in order for it to establish itself successfully in such an environment. It has been reported that seed germination is influenced by the interaction between temperature and salinity in some species (Okusanya 1977, and Rivers and Weber 1971).

Rice is an important crop species that is cultivated successfully in Al-Ahssa oasis in the eastern part of Saudi Arabia. Since there is a lack of information

concerning the physiology of seed germination, this research was initiated to study the influence of the interaction between salt and temperature on seed germination.

## Materials and Methods

### *Materials*

Brown rice (cv. Al-Ahssa) grains were obtained commercially from Al-Ahssa in 1990 and were stored in closed containers at 4°C.

### *Germination*

Large quantities of seeds were allowed to imbibe water overnight at room temperature (about 25°C), then 15 of them were distributed per Petri-dish over the surface of two layers of Whatman No. 1 filter paper moistened with 10 ml of either distilled water or the appropriate NaCl solution (0.001, 0.1, 0.2 and 0.3 M). Four replicates were placed in an incubator at the appropriate temperature (20, 25, 30, 35 and 40°C) in darkness. Radicle emergence was taken as a sign of germination. The number of germinated seeds was counted daily and calculated as a percentage of the total number of seeds. In the case of NaCl treatment, only the germination percentage of the final day (the 6<sup>th</sup> day) was presented. In all cases the germination percentage of the last day was subjected to analysis of variance and LSD test at the 95% confidence.

## Results

The results in Fig. 1 show the rate of germination at the different temperatures in darkness. Rice grains germinated during the first day of incubation at all the temperatures studied, but germination was very low at 40°C (less than 5%) and was relatively low at 20 and 25°C (25 and 27% respectively) and high at 30 and 35°C (75 and 78% respectively).

At all temperatures, the germination percentage increased gradually from the first day onwards and it appears from the figures that the rate of germination was slow at 20 °C in the first 3 days as compared to that at 25, 30 and 35 °C. Also the germination rate was very slow at 40 °C as compared to that of the other temperatures.

As shown in Fig. 1 the final germination percentage was reduced significantly at 40 °C.

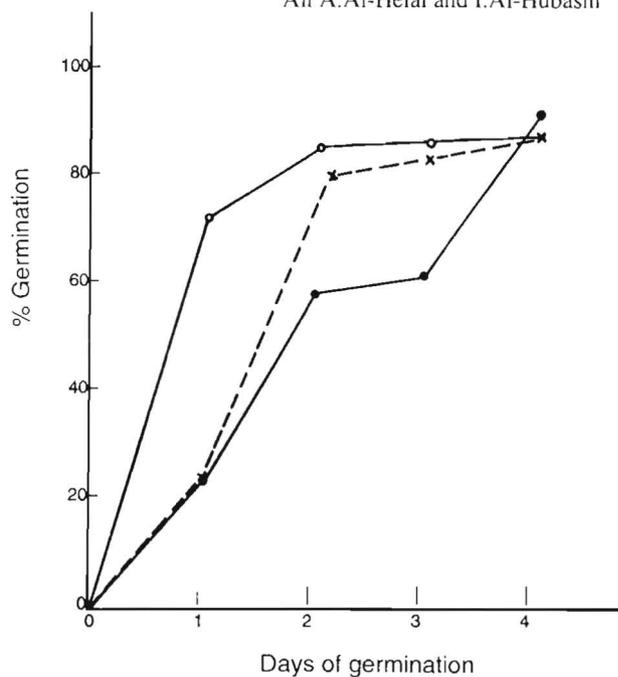


Fig. 1a. Percentage seed germination at 20 (●—●), 25 (x-----x) and 30°C (o—o).

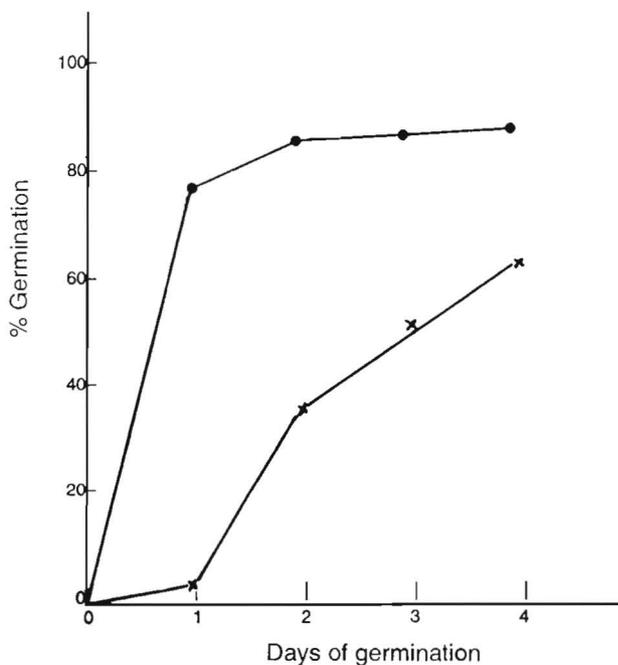


Fig. 1b. Percentage seed germination at 35 (●—●) and 40°C (x-----x)

Note: Only the final germination percentage at 40°C was significantly different at 95% from all the other values.

*Effect of NaCl on Germination*

The results in Table 1 illustrate the seed germination percentage of rice grains after 6 days kept at different concentrations of NaCl at different temperatures.

NaCl at low concentrations (0.001 and 0.01 M) had no apparent significant effect on seed germination at all the temperatures studied, however, salt at higher concentrations reduced the germination percentage and the reduction was temperature-dependent.

At 25°C NaCl inhibited germination significantly at 0.3 M only. At 30°C NaCl inhibited germination significantly at 0.2 and 0.3 M, while at 35°C NaCl inhibited germination significantly at 0.1, 0.2 and 0.3 M, and the inhibition increased with increasing salt concentration.

**Table 1.** Germination percentage after 6 days in different concentrations of NaCl at different temperatures

NaCl(M) / Temperature	25°C	30°C	35°C
0.001	96.7 ± 5.3a	93.3 ± 5.1a	93.3 ± 3.8a
0.01	96.6 ± 3.9a	90.0 ± 4.7a	93.3 ± 2.9a
0.1	88.7 ± 9.3ab	93.3 ± 7.3a	75.0 ± 9.1bc
0.2	92.3 ± 7.2a	61.7 ± 10.3c	56.7 ± 10.5c
0.3	25 ± 15d	5 ± 4.8e	3.3 ± 5.5e

**Note:** Numbers without common letters are significant at 95%.

### Discussion

It is clear from the results that the final germination percentage and the germination rate of rice grains were temperature-dependent. Also, it appeared from the results that germination occurred at a wide range of high temperature (20 to 40°C) although the final germination was significantly reduced to about 60% at 40°C. The tolerance of seed germination for rice to a wide range of temperature is important for a crop to be successfully cultivated in a warm habitat.

The dependence of seed germination rate on temperature has already been reported for several species (Mahmoud *et al.* 1984, Al-Farraj *et al.* 1988, and Mahmoud 1985).

It is clear from the results that NaCl up to 0.2 M had no effect on seed germination of rice at 20°C and this might indicate that the grains of this cultivar can tolerate a relatively high NaCl level. Patolia and Iyengar (1979) studied the effect of sea water salinity on seed germination of 36 cultivars of rice and they concluded that the different cultivars differ in their salt tolerance and a few cultivars tolerated up to 20% salinity though with a reduction in the germination percentage.

The inhibitory effect of high salt concentrations on seed germination of rice is similar to that which has been reported for several species (Al-Helal *et al.* 1989, Larik and Al-Saheal 1986, Okusanya 1977, and Larik and Hafiz 1983). The inhibitory effect of salt on seed germination might be due to ionic toxicity (Rudolfs 1925, Uhvits 1946 and Redmann 1979) or by prevention of uptake of water because of high osmotic potential of the medium (Leiner *et al.* 1959, Barbour 1968, Ungar and Hogan 1970, and Michael *et al.* 1972).

The results of this investigation showed that the tolerance of rice seed germination to NaCl salinity was temperature-dependent and the results suggest that tolerance decreased with increasing temperature of germination. The reduction of tolerance at higher temperatures is not known at the present time but it might be due in some part to the faster accumulation of ions up to a toxic level. However, the dependence of seed germination on the interaction between salt stress and temperature has been reported for several species (Okusanya 1977, Rivers and Weber 1971, and al-Helal *et al.* 1989).

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## References

- Al-Farraj, M.M., Al-Helal, A.A., El-Desoki, R.A. and Al-Hubshi, I. (1988) Eco-physiological studies on *Citrullus colocynthis* (L.) Schard and *Cucumis prophetarum* (Jusl. ap.) L. in Saudi Arabia. I. Seed germination. *Arab Gulf J. Scient. Res. Agric. Biol. Sci.* **6**(3B): 377-387.
- Al-Helal, A.A., Al-Farraj, M.M., El-Desoki, R.A. and Al-Habashi, I. (1989) Germination response of *Cassia senna* L. seeds to sodium salts and temperature. *J. Univ. Kuwait (Sci.)*, **16**: 281-287.
- Barbour, M.G. (1968) Germination requirements of the desert shrub *Larrea divaricata*. *Ecology*, **49**: 915-923.
- Bishnoi, U.R. and Pancholy, D.K. (1980) Comparative salt-tolerance in triticale, wheat and rye during germination. *Pl. and Soil*, **55**: 491-493.
- Grime, J.P., Mason, G., Curtis, A.G., Rodman, J., Band, S.R., Mowfrth, M.A.G., Neal, A.M. and Shaw, S. (1981) A comparative study of germination characteristics in a local flora. *J. Ecol.*, **69**: 1017-1059.
- Larik, A.S. and Al-Saheal, Y.A. (1986) Effect of salt stress on germination and seedling growth of wheat, triticale and barley. *J. Coll. Sci.*, King Saud Univ. **17**(1): 37-44.
- Larik, A.S. and Hafiz, H.M.I. (1983) Genotypic response to salinity. *Gen. Agr.*, **37**: 355-360.
- Leiner, H.R., Mayer, A.M. and Evenari, M. (1959) The nature of the germination inhibitors present in dispersal units of *Zygophyllum dumosum* and *Trigonella arabica*. *Physiol. Plant.* **12**: 245-250.
- Mahmoud, A. (1985) Germination of *Cassia italica* from Saudi Arabia, *Arab Gulf J. Scient. Res.* **3**(2): 437-447.
- Mahmoud, A., El-Sheikh, A.M. and Abdulbest, S. (1984) Influence of salinity and temperature on seed germination of *Artemisia abyssinica* sch. Bip., *Peganum harmala* L. and *Calotropis procera* (Ait) f. J. *College Sci.*, King Saud Univ. **15**(2): 379-388.
- Michael, D., Williams, D. and Ungar, I.A. (1972) The effect of environmental parameters on the germination and development of *Suaeda depressa* (Pursch) wats. *Amer. J. Bot.*, **59**(9): 912-918.
- Okusanya, O.T. (1977) The effect of sea water and temperature on the germination behaviour of *Crithmum maritimum*. *Physiol. Plant.* **41**: 265-267.
- Patolia, J.S. and Iyengar, E.R.R. (1979) Salinity effects of early and medium duration cultures of rice during germination. *Oryza*, **16**(1): 66-67.
- Redman, R.E. (1979) Osmotic and specific ion effects on the germination of alfalfa. *Canad. J. Bot.* **52**: 803-808.
- Rivers, W.G. and Weber, D.J. (1971) The influence of salinity and temperature on seed germination in *Salicornia bigelovii*. *Physiol. Plant.* **24**: 73-75.
- Rudolfs, W. (1925) Influence of water and salt solution upon absorption and germination of seeds. *Soil Sci.* **20**: 15-37.
- Uhvits, R. (1946) Effect of osmotic pressure on water absorption and germination of alfalfa seeds. *Amer. J. Bot.* **33**: 273-283.

- Ungar, I.A. and Hogan, W.** (1970) Seed germination in *Ira annua* L. *Ecology* **51**: 150-154.
- Woods, L.E. and Macdonald, H.A.** (1971) The effects of temperature and osmotic moisture stress on the germination of *Lotus corniculatus*. *J. Exp. Bot.* **22**(72): 575-585.

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## تأثير كلوريد الصوديوم ودرجة الحرارة على انبات حبوب الأرز من المملكة العربية السعودية

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لقد تم دراسة تأثير درجات الحرارة الثابتة (٢٠، ٢٥، ٣٠، ٣٥، ٤٠م) على معدل انبات بذور الأرز المحلي . كانت النسبة المئوية للانبات مرتفعة عند درجات الحرارة ٢٠، ٢٥، ٣٠ و ٣٥م وقد انخفضت النسبة المئوية للانبات بشكل معنوي عند درجة الحرارة ٤٠م . ويتضح من النتائج أن معدل الانبات كان أفضل عند درجة حرارة ٣٠ و ٣٥م .

كلوريد الصوديوم عند تركيز ٠,٠٠١ و ٠,٠١ و ٠,٠١ جزئ لم يكن له تأثير على الانبات عند درجات الحرارة المدروسة (٢٥، ٣٠ و ٣٥م) . يتضح من النتائج أن المقاومة لتركيز أعلى من الملوحة يعتمد على درجة حرارة الانبات . تركيز ٠,٠١ جزئ لم يؤثر على الانبات عند درجتي حرارة ٢٥ و ٣٠م ولكنه يثبط الانبات عند درجة حرارة ٣٥م . وتركيز ٠,٠٢ جزئ يثبط الانبات عند درجتي حرارة ٣٠ و ٣٥م وتركيز ٠,٠٣ جزئ يثبط الانبات عند جميع درجات الحرارة المدروسة .