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Germination response of *Cassia senna* L. seeds to sodium salts and temperature

A. A. AL-HELAL, M. M. AL-FARRAJ, R. A. EL-DESOKI AND I. AL-HABASHI

Department of Botany, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia

ABSTRACT

Cassia senna L. is adapted to the dry climate of Saudi Arabia, and temperature and salinity are major factors that influence its seed germination.

Seed germination percentage for the control was high at 15, 25, 35 and 40°C (98 to 100) and low at 45°C (only 8). Low concentration of either NaCl or Na_2SO_4 up to 0·01 M had no effect, except that Na_2SO_4 was effective in stimulating germination at 45°C. Seed germination tolerance to high salt concentration (0·1 and 0·2 M) was temperature-dependent, and more tolerance occurred at 25° and 35°C and less at 15° and 45°C.

Sulphuric acid was more effective in breaking seed coat dormancy than methanol, boiling water or incision of the testa.

INTRODUCTION

Salts, especially sodium salts affect seed germination (Gawad 1985; Al-Jibury *et al.* 1986) and plant growth (Black 1960; Brownell 1965; Brownell & Crossland 1972). Also, environmental conditions such as humidity and photoperiod influence the effect of sodium (Gale *et al.* 1970; Brownell & Crossland 1974; Al-Helal 1979).

Temperature and salinity are major factors regulating seed germination of desert plants (Koller *et al.* 1963; Al-Jibury *et al.* 1986; Al-Farraj *et al.* 1988). The present work gives data on the effect of temperature and sodium salt concentration on seed germination of a species adapted to the arid environment of Saudi Arabia.

MATERIALS AND METHODS

Cassia senna seeds were collected from Makkah Road in 1982 and were stored at 25°C.

Treatment for the breakage of seed dormancy:

To test the effect of different treatments on breaking seed dormancy, seeds were soaked either in ethanol (for 15, 30, 45 or 60 min), in boiling water (for 1, 2, 3, 4 or 5 min), or in sulphuric acid for 15 min, or the testa was incised. Seeds were germinated at 35°C in Petri-dishes (10 cm in diameter) moistened with 10 ml distilled water as

Table 1. Effect of various pretreatments on the subsequent germination of *Cassia senna*. After pretreatment, seeds were incubated for 6 days in darkness at 35°C. Figures are mean percentage germination from 4 replicates ± standard error

Pretreatment	% germination after 6 days
Water control	2 ± 1·6
Incision of testa	80 ± 8·6
H_2SO_4 (15 min)	100 ± 0·0
Methanol (60 min)	13 ± 4·7
Methanol (30 min)	5 ± 4·3
Methanol (15 min)	2 ± 1·6
Boiling water (1 min)	18 ± 5·7
Boiling water (2 min)	28 ± 4·2
Boiling water (3 min)	30 ± 8·8
Boiling water (4 min)	22 ± 5·0
Boiling water (5 min)	53 ± 10·6

described below. The results (Table 1) suggest that sulphuric acid was the most effective in breaking seed dormancy.

Consequently, seeds were soaked in sulphuric acid for 15 min and washed several times with distilled water. They were distributed, 15 per Petri-dish (10 cm in diameter) over the surface of two layers of Whatman No. 1 filter paper moistened with 10 ml of the experimental solution. Four replicates were placed in an incubator at the appropriate temperature under darkness. Radicle emergence was taken as a sign of germination and the number of germinated seeds was counted daily for 6 days and calculated as a percentage of the total number of seeds present in each sample.

RESULTS

Germination at 15°C

The results in Table 2 show seed germination percentage of *Cassia senna* seeds after 4 days of incubation in different concentrations of sodium salts at different temperatures.

Solutions of either NaCl or Na_2SO_4 at low concentration (up to 0·01 M) had no apparent effect on seed germination. Salt at 0·1 M, especially Na_2SO_4, reduced germination and 0·2 M of either salt inhibited germination completely.

Germination at 25°C

Percentage germination reached a high level in all treatments except 0·2 M Na_2SO_4 which was effective in reducing germination to 17% of the control.

Germination at 35°

Results were similar to those at 25°C except that germination was reduced at 0·2 M NaCl to 77% of the control and was almost completely suppressed at 0·2 M Na_2SO_4 (only 2% of the control).

Table 2. Percentage germination of *Cassia senna* seeds in different concentrations of NaCl or Na_2SO_4 at different temperatures. Seeds were incubated for 4 days in darkness. Each figure is the mean of 4 replicates ± standard error

	15°C		25°C		35°C		40°C		45°C	
Salt concn.	NaCl	Na_2SO_4	NaCl	Na_2SO_4	NaCl	Na_2SO_4	NaCl	Na_2SO_4	NaCl	Na_2SO_4
0	95 ± 3·2		100 ± 0		100 ± 0		97 ± 1·6		8 ± 3·2	
0·0001 M	89 ± 6·8	100 ± 0	100 ± 0	97 ± 4·2	98 ± 1·6	100 ± 0	93 ± 2·7	88 ± 5·7	18 ± 10·3	60 ± 10
0·001 M	91 ± 5·3	100 ± 0	98 ± 1·6	98 ± 1·6	97 ± 3·3	100 ± 0	92 ± 3·2	98 ± 1·6	7 ± 3·2	68 ± 12·8
0.01 M	93 ± 2·7	100 ± 0	100 ± 0	98 ± 1·6	100 ± 0	100 ± 0	95 ± 3·2	95 ± 5	2 ± 1·6	50 ± 13·7
0·1 M	63 ± 6·9	53 ± 8·2	100 ± 0	95 ± 3·2	100 ± 0	95 ± 1·6	93 ± 2·7	65 ± 7·8	3 ± 1·9	2 ± 1·6
0·2 M	0	0	93 ± 2·7	17 ± 10·3	77 ± 6·0	2 ± 1·8	0	0	0	0

Germination at 40°C

These data were similar to those obtained at 25°C except that germination was reduced in 0·1 M Na_2SO_4, while in 0·2 M concentration of either salt germination was totally inhibited.

Germination at 45°C

Germination was poor in the control and in all NaCl solutions, especially at 0·1 and 0·2 M where germination was completely inhibited. Low concentration of Na_2SO_4 (up to 0·01 M) stimulated germination, while 0·1 and 0·2 M were inhibitory.

DISCUSSION

The inability of untreated seeds of *C. senna* to germinate at 30°C is due to the impermeability of the seed coat to water since the untreated seeds did not show signs of imbibing water. The results show that seed coat dormancy could be overcome experimentally by scarification with sulphuric acid, boiling water or by incising the testa. Impermeability of seed coat to water is very common among plants (Koller *et al.* 1963; Ismail 1983; Mahmoud 1985a) and several treatments have been recommended for breaking such dormancy (Mayer & Poljakoff-Mayber 1982).

The results show that acid-treated seeds of *C. senna* germinated to a high percentage over a wide range of temperature (15–40°C) which indicates the high thermal adaptation of this species to warm environment. Similar results have been reported for several desert plants (Ismail 1983; Mahmoud *et al.* 1984; Abulfatih & Bazzaz 1985; Al-Farraj *et al.* 1988).

The germination of *C. senna* seeds appears to tolerate a combination of high temperature and salt concentration (up to 0·2 M NaCl at 35°C), which is of great value to a species which lives in the warm environment of Saudi Arabia where saline habitats are common (Mahmoud 1985a). Combination of salt stress and temperature stress present an extreme environment to seed germination which must be overcome by a species to successfully establish itself in such environment.

The germination percentage of *C. senna* seeds appears to be affected by the interaction between temperature and salinity levels. These results are in a good agreement with those reported for various species (Malcolm 1964; Ungar & Hogan 1970; Okusanya 1977). The results suggest that the greatest tolerance to salt concentration occurs at 25°C and 35°C and they appear to be the optimal temperature for germination. Okusanya (1977) similarly showed that the greatest tolerance to sea water by *Crithmum maritimum* seeds occurred at the optimal temperature for germination.

The increase of salt tolerance at 25° and 35°C compared to that at 15°C might be due to the fact that temperature induces changes in membrane structure (Raison *et al.* 1980) making it more permeable to ions resulting in increased accumulation of inorganic ions from the external medium which would bring osmotic adjustment.

The inhibitory effect of salt on seed germination might be due to ionic toxicity (Rudolfs 1925; Uhvits 1946; Redmann 1974) or by preventing uptake of water because of low osmotic potential of the medium (Lerner *et al.* 1959; Barbour 1968; Ungar & Hogan 1970; Michael *et al.* 1972). The inhibitory effect of high concentration of sodium salt at 15°C appears to be osmotic since this inhibitory effect was not observed at higher temperature (25°C) where ion uptake should increase and more toxicity is expected. However, the inhibitory effect of 0·2 M Na_2SO_4 at 35°C and of

0·2 M of either salt at 40°C might be due to accumulation of ions to toxic levels. Mahmoud (1985b) suggested that the inhibitory effect of diluted sea water on germination of *C. senna* at alternate temperatures of 25–15°C was an osmotic effect and the inhibition at 40–25°C might be due in part to ionic toxicity.

The stimulatory effect of Na_2SO_4 on germination of *C. senna* at 45°C was specific to SO_4^{2-}, since NaCl could not induce germination at this temperature. The mechanism of this stimulation is not known at present and requires further investigation but SO_4^{2-} might induce some physiological and/or biochemical processes.

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تأثير أملاح الصوديوم ودرجة الحرارة على إنبات بذور العشرق

علي عبد المحسن الهلال ، محمد ماجد الفراج ، رمضان عبدالرحمن الدسوقي ، ابراهيم علي الحبيش
قسم النبات بكلية العلوم ، جامعة الملك سعود ،
ص . ب . ٢٤٥٥ ، الرياض ١١٤٥١ ، المملكة العربية السعودية

خلاصة

لقد تم دراسة تأثير تراكيز مختلفة من كلوريد الصوديوم وكبريتات الصوديوم على إنبات بذور العشرق تحت درجات حرارة مختلفة (١٥ ، ٢٥ ، ٣٥ ، ٤٠ و ٤٥°م) . كانت النسبة المئوية للبذور المنبتة في ماء عادي مرتفعة (٩٨-١٠٠٪) عند درجات الحرارة ١٥ ، ٢٥ ، ٣٥ و ٤٠°م وكانت منخفضة (٨٪) عند درجة حرارة ٤٥°م . إن أي من الملحين عند تركيز منخفض (٠١, مولار) لم يكن له تأثير واضح على الإنبات ، غير أن كبريتات الصوديوم كانت فعالة في استحثاث الأنبات عند درجة حرارة ٤٥°م .

ان تحمل البذور للتراكيز العالية من الأملاح (٠,١ و ٠,٢ مولار) يعتمد على درجة الحرارة ، فقد كان التحمل عاليا عند درجتي حرارة ٢٥ ، ٣٥°م ومنخفضا عند درجات حرارة ١٥ ، ٤٠ و ٤٥°م .

إن المعاملة بحمض الكبريتيك كانت أكثر فعالية في كسر كمون القصرة من المعاملة بالميثانول ، أو الغمر في ماء يغلي ، أو شق القصرة .