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Germination of *Hammada elegans* from Saudi Arabia

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ABSTRACT. *Hammada elegans* is a desert perennial, widely distributed in Saudi Arabia and an effective sand-binder. Germination was tested over a range of fluctuating temperatures and in various concentrations of seawater under two fluctuating temperature regimes. The wide range of temperatures at which seeds of *H. elegans* can germinate, their high salt tolerance, the synchronization of fruit-setting with optimal conditions for seed germination and subsequent seedling establishment and the massive production of light winged fruits providing effective means of dispersal, all contribute to the success and wide distribution of *H. elegans* in Saudi Arabia.

Hammada elegans (Bunge) Botsch. (= *Haloxylon schweinfurthii* Asch., and *Haloxylon salicornicum* auct., non Bounge), a member of the chenopodiaceae is a succulent undershrub. The species is present in almost all of Migahid's (1978) phytogeographical regions of Saudi Arabia. The work described in this paper reports an attempt to establish whether the germination temperature responses of *H. elegans* contribute to its wide geographical distribution in Saudi Arabia.

H. elegans is an effective sand-binder and is widespread in a variety of desert habitats: wadi-terraces, sandy plains, gravel deserts, etc. It dominates a community that is present at the landward edge of the salt marsh vegetation at Al-Shiggah 43° 5′N, 26° 25′E, in Al-Qassim district (Fig. 1). Here the salinity is lower than that in the rest of the marsh (Table 1).

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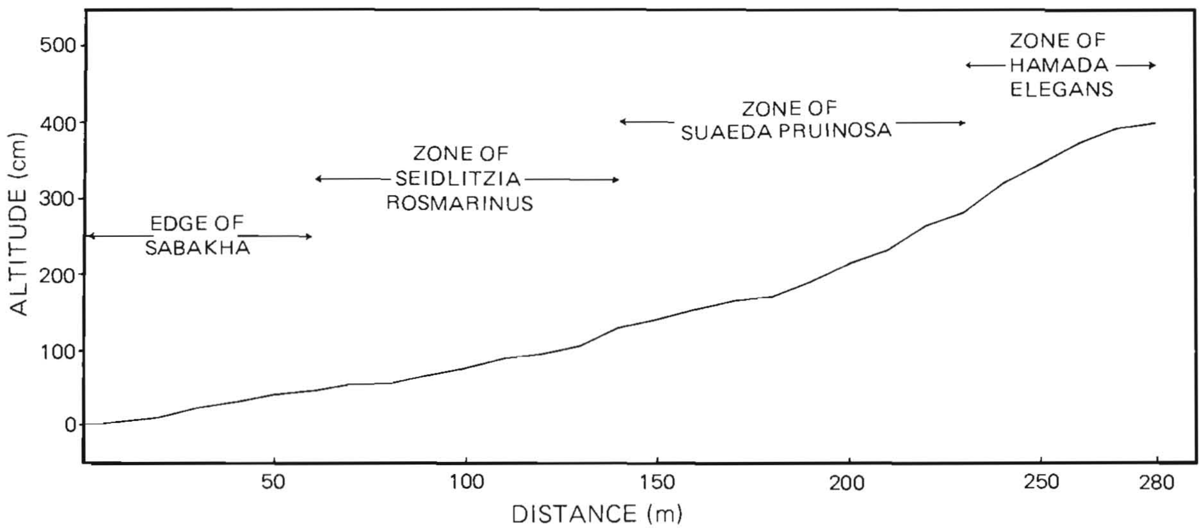

Fig. 1. A transect across the salt marsh at Al-Shiggah in Al-Qassim district showing the different zones of vegetation in relation to ground level.

Table 1. Total water-soluble salts in soil samples collected within the habitats of *Hammada elegans*, *Suaeda pruinosa* and *Seidlitzia rosmarinus* at Al-Shiggah.

Zone	Depth (cm)	Total water-soluble salts (ppm)
Hammada elegans	0-5	512
	5-25	339
	25-50	345
Suaeda pruinosa	0-5	54400
	5-25	14080
	25-50	10880
Seidlitzia rosmarinus	0-5	78080
	5-25	18560
	25-50	12800

The inhibition of germination by high salinity is a major factor in the zonation of plants in saline habitats (Toole *et al.* 1956, Kassas and Zahran 1967, Mahmoud *et al.* 1983a). The seeds of *H. elegans* were germinated in various concentrations of seawater at two fluctuating temperature regimes.

Experiment 1

Procedure

Fully developed and undamaged seeds were liberated from freshly collected fruits; there was no discrimination between large and small seeds. The seeds were germinated in distilled water in germination flasks kept in dark incubators maintained over a range of (12 hourly) alternating temperature regimes: 20/7, 23/8, 27/12, 32/16, 36/21 and 42/23°C. These were selected in accordance with meteorological data at Unayza station in Al-Qassim district. Four replicates (25 seeds each) were used. A seed was considered to have germinated when the radicle emerged. Germinated seeds were discarded immediately and counts were made daily until no seed had germinated for seven successive days. In counting, the lid of the germinator was removed allowing the change of air and briefly exposing the seeds to light.

Results

The seeds of *H. elegans* attained equally high germination percentages (90% or more except for the 42/23°C temperature regime, 86%) at equally high rates over the whole range of temperatures tested (Table 2).

Table 2. Final germination percentages of seeds of *Hammada elegans* at different fluctuating temperatures and also the length of incubation (days) for 50% of the maximum germination percentage to be reached. Ninety-five per cent confidence limits are included.

20/7°C		23/8°C		27/12°C	
% germination	**Time for 50% germination**	**% germination**	**Time for 50% germination**	**% germination**	**Time for 50% germination**
98 ± 3.182	0.510 ± 0.079	97 ± 2.755	0.512 ± 0.081	94 ± 3.182	0.455 ± 0.175

32/16°C		36/21°C		42/23°C	
% germination	**Time for 50% germination**	**% germination**	**Time for 50% germination**	**% germination**	**Time for 50% germination**
94 ± 3.182	0.455 ± 0.175	90 ± 3.182	0.525 ± 0.139	86 ± 5.511	0.600 ± 0.113

Experiment 2

Procedure

Seeds of *H. elegans* were germinated over the following range of salt concentrations obtained by diluting Red Sea water: 2305.5 ppm (= 5 per cent seawater) 4611 ppm (10 per cent), 9222.5 ppm (20 per cent), 18445 ppm (40 per cent), 36890 ppm (80 per cent) and 46112 ppm (100 per cent). Germination took place in germination flasks kept in dark incubators maintained at 20/7 and 32/16°C. The procedure adopted was similar to that in Experiment 1.

Results

At both temperature regimes, the seeds attained closely similar high germination percentages (> 90 per cent) at equally high rates over the salinity range 5-40 per cent seawater. At 80 and 100 per cent seawater concentrations, and at both temperature regimes, seed germination attained quite high percentages (68-94%), the lowest germination percentage being shown at the highest salinity and the 32/16°C temperature regime. At these high salinities, germination was significantly faster at the higher temperature regime (Table 3, Fig. 2).

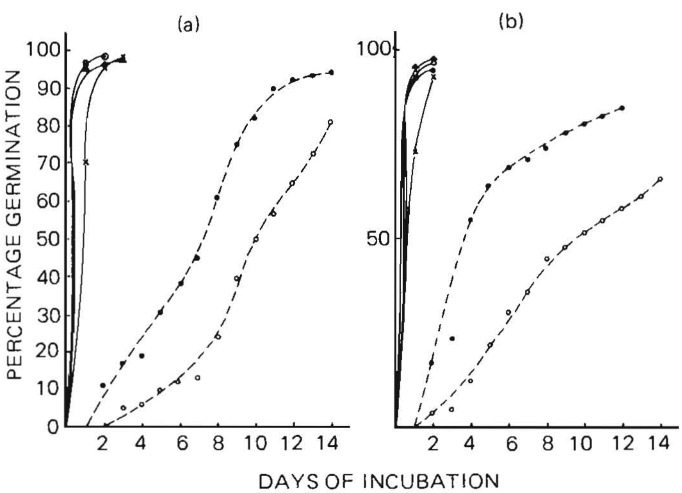

Fig. 2. Progress of germination of the seeds of *Hammada elegans* at different salinities: ●—●, 2305.5 ppm; O—O 4611 ppm; ▲—▲ 9222.5 ppm; x—x, 18445 ppm; ●---● 36890 ppm; O---O 46112 ppm, all at two fluctuating temperature regimes: (a) 20/7 and (b) 32/16°C.

Table 3. The final germination percentages attained by seeds of *Hammada elegans* at two fluctuating temperature regimes in different salinities; the length of time (days) to reach 50% of the maximum germination percentage as well as 95% confidence limits are also included.

Temperature °C	2305.5 ppm (5% sea-water)		4611 ppm (10%)		9222.5 ppm (20%)	
	% germination	Time for 50% germination	% germination	Time for 50% germination	% germination	Time for 50% germination
20/7	98 ± 3.182	0.505 ± 0.014	98 ± 3.182	0.503 ± 0.013	97 ± 2.756	0.505 ± 0.014
32/16	95 ± 2.755	0.480 ± 0.076	97 ± 2.756	0.505 ± 0.014	97 ± 2.756	0.505 ± 0.014

Temperature °C	18445 ppm (40%)		36890 ppm (80%)		46112 ppm (100%)	
	% germination	Time for 50% germination	% germination	Time for 50% germination	% germination	Time for 50% germination
20/7	98 ± 3.182	0.700 ± 0.225	94 ± 9.545	6.950 ± 0.210	81 ± 8.267	9 ± 0.909
32/16	93 ± 2.756	0.700 ± 0.355	85 ± 2.756	3.675 ± 0.132	68 ± 6.364	6.6 ± 1.889

Discussion

In deserts, where rainfall is low and unpredictable, it is important that seeds should not germinate unless the soil contains enough water to enable the resulting seedlings to complete their life cycles. Germination controlled by regulated responses to the environment would clearly enhance biological success. Mechanisms that regulate germination and contribute to the survival of desert plants may involve the presence, in their seeds, of water-soluble, water-leachable germination inhibitors. These need minimal levels of precipitation before they are leached out (El-Naggar 1965). Other mechanisms invoke seed-coat impermeability (Mahmoud 1977, Mahmoud and El-Sheikh 1978, Mahmoud 1984, and Mahmoud *et al.* 1984) and germination temperature responses which synchronize germination with the season of optimal environmental conditions (Mahmoud *et al.* 1983b, c).

The freshly harvested seeds of *H. elegans* do not appear to have a genetically fixed mechanism of innate dormancy or any of these other mechanisms by which their germination is regulated. With adequate moisture, seeds germinated rapidly to near completion (> 90%) over the whole range of alternating temperature regimes investigated (Table 2). These simulate the temperature cycles that prevail during both the rainy and the dry season within the regions where the species occurs (Fig. 3). If the species germinates too readily in response to an early shower or to an occasional rain event at the beginning of the dry season the seedlings may risk total mortality. Therefore, in the absence of a germination-regulatory mechanism in the seeds of *H. elegans* which allows germination to take place only when ecological conditions are such that successful germination and establishment

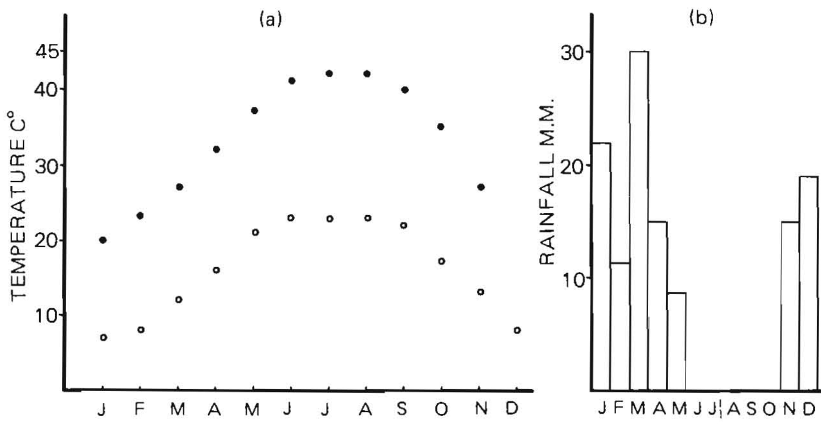

Fig. 3. Meteorological data obtained at Unayza within the habitat range of *Hammada elegans*. (a) mean daily temperature maximum (●) and minimum (○) and (b) mean monthly rainfall. Data are averages for the period 1970-1979.

are likely to occur, the survival of the species is at stake. However, reductions in this potential waste of resources are achieved by mechanisms which are not related directly to the germination characteristics, that are relevant to the favourable season for successful establishment. The fruit setting is timed with the best time of the year: December to January (beginning of the rainy season); the non-dormant seeds germinate when favourable conditions for growth and establishment of seedlings are more likely to prevail, thus increasing the chances of seedling survival. Furthermore, *H. elegans* produces ample supplies of light winged fruits which provide an efficient means of distribution. This gives an increased probability of propagules finding fresh habitats that are suitable environment. As reported by Freas and Kemp (1983), the models developed by MacArthur (1972) and Venable and Lawlor (1980) for desert annuals predict that efficient seed dispersal would negate the necessity for innate dormancy which offsets the possibility of population extinction due to complete germination followed by complete mortality under severely unfavourable desert conditions.

When moisture and temperature are favourable, the seeds of *H. elegans* can germinate in salinities higher than those encountered by, or tolerated by, adult plants in their natural habitat. The data in Table 4 show the total water soluble salts in soil samples collected during the dry season from the Jeddah-Makkah region and Al-Shiggah salt marsh in Al-Qassim region, where the species is abundant. Because of the salt tolerance of the seeds of *H. elegans* (the seeds attained high percentages over the whole range of salinities tested (Fig. 2 and Table 3), successful germination may occur with the advent of winter rains even without earlier leaching of the soil.

The absence of *H. elegans* from the zones of *Suaeda pruinosa* and *Seidlitzia rosmarinus* at Al-Shiggah salt marsh (Fig. 1) might be explained by the failure of its seeds to germinate on account of very high salinities in the surface of the soil (Tables 1 and 4). However, the tolerance of germination to salinity shown by *Hammada elegans* with reference to the salinity in the habitats of *H. elegans* (Table 4) compared with those in the zones of *Suaeda pruinosa* and *Seidlitzia rosmarinus* (Table 1) suggests that the failure of its seedlings to become established in extremely saline conditions is more likely than failure of germination.

The wide amplitude of temperatures and salinities at which seeds of *H. elegans* can germinate, the synchronization of fruit-setting with the optimal conditions for seed germination and subsequent seedling establishment, the massive production of fruits with efficient means of distribution, the aphyllous shoots which have low rates of transpiration, all contribute to the success and wide distribution of *H. elegans* in Saudi Arabia.

Table 4. Total water-soluble salts in soil samples collected within the habitats of *Hammada elegans*.

Habitat	Profile	Depth	Total water soluble salts (ppm)
Terrace of a desert wadi along Makkah-Jeddah road	1	0-5	712
		5-25	450
		25-50	320
Same as (1)	2	0-5	704
		5-25	448
		25-50	256
A depression along Makkah-Jeddah road	3	0-5	960
		5-25	448
		25-50	640
Same as (3)	4	0-5	1728
		5-25	320
		25-50	250
Wadi Fatima along Makka-Jeddah road where the halophyte *Suaeda monoica* is abundant	5	0-5	4160
		5-25	1600
Same as (5)	6	0-5	11200
		5-25	1728
Same as (5)	7	0-5	1088
		5-25	860
On sand deposits at landward end of Al-Shiggah salt Marsh	8	0-5	512
		5-25	339
		25-50	345

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إنبات بذور نبات الرمث

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نبات الرمث *Hammada elegans* من النباتات المعمرة واسعة الانتشار في المملكة العربية السعودية والتي تحجز الرمال.

تمت دراسة تأثير أنظمة مختلفة من درجات الحرارة المتبادلة على إنبات البذوروكذلك تأثير تركيزات مختلفة من ماء البحر على الإنبات تحت نظامين حراريين.

المدى الحرارى الواسع الذى تنبت فيه البذور وتحملها للملوحة العالية وإنتاج البذور في بداية الموسم المطير حتى يتم الإنبات في الظروف البيئية المثلى التي تمكن البوادر المنبثقة من البذور من أن تنمو وتتوطن، إنتاج كميات وفيرة من الثمار المجنحة التي تساعد على انتشارها، إنتاج المجموع الخضرى اللاورقي مما يقلل من عملية النتح، كلها عوامل تساعد على نجاح الرمث وانتشاره الواسع في المملكة العربية السعودية.

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