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# Germination of the Halophyte: *Zygophyllum decumbens* from Saudi Arabia

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ABSTRACT. *Zygophyllum decumbens* is a low perennial shrublet. Freshly collected seeds of *Z. decumbens* were germinated over a range of fluctuating temperature regimes. They were also germinated in varying salinity levels at two fluctuating (12 hourly) temperature regimes: 21/10 and 36/21 °C.

Seeds germinated to comparable high percentages over the whole range of the temperature regimes tested but the rate of germination increased with rising temperature reaching an optimum within the range 21/10-36/21 °C.

The inhibition of germination of the seeds of this species by excessive salinities (40, 80 and 100% seawater) is due to high osmotic potential of the medium.

*Zygophyllum decumbens* Del. is a low perennial shrublet. According to Migahid (1978) its distribution in Saudi Arabia includes the northern rgion (N), north Hijaz (NH) and east Najd (NJe), Fig. 1. The species is associated with *wadi* terraces and depressions.

The establishment of any species within a geographical region depends on its closely adapted response to prevalent ecological conditions including temperature, day length and rainfall. Thompson (1970) showed that the distribution of different species of Caryophyllaceae in Europe was reflected in the temperature responses of their seeds during germination. The mechanisms which synchronize the event of germination with the season of environmental conditions favourable for subsequent growth and establishment of plants are of great importance amongst the many processes which constitute the adaptations of plants to desert environment (Koller 1969, Mahmoud 1977, Mahmoud *et al.* 1983a,b). 'Amongst the mechanisms responsible for coordination of germination with the physical parameters of the environment, two of the most important are the temperature response characteris-

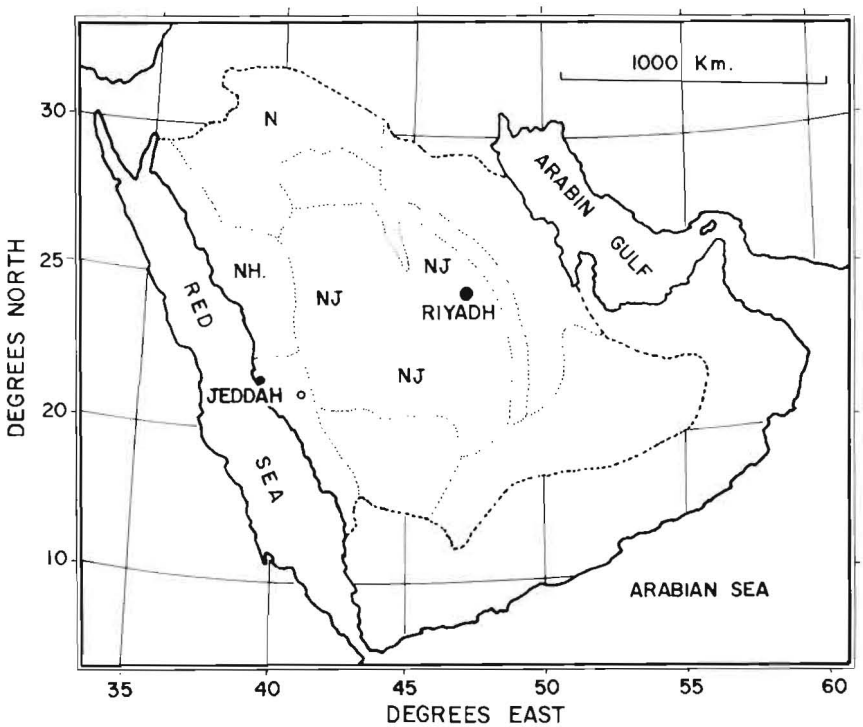


**Fig. 1.** Geographical distribution of *Zygophyllum decumbens* in Saudi Arabia
NH = North Hijaz representing the western part of Saudi Arabia that extends alongside the Red Sea coast north of Jeddah.
N = Northern region including Tabouk, Al-Jawf and Sakakah areas.
NJe = Eastern Najd.

tics and the proportion of the seeds with dormancy restrictions on growth of one kind or another', Thompson (1973). The work described below comprises an attempt to investigate the germination responses of the seeds of *Z. decumbens* to temperature and salinity.

The control of germination by high salinities constitutes a major factor in the zonation and growth of plants in saline habitats (Toole *et al.* 1956, Ungar 1967, and kassas and Zahran 1967). The ability of the seeds of *Z. decumbens* to germinate under varying degree of salinity was examined.

## Experiment 1

*Procedure*

Seeds were liberated from freshly collected capsules obtained from plants growing in a depression near Dariya Dam 20 km north east of Riyadh, fully de-

veloped seeds were selected for the tests. The seeds were sorted, and those that were broken or insect-damaged were rejected; there was no discrimination between large and small seeds. The seeds were germinated over a range of alternating (12 hourly) temperature regimes: 18/8, 21/10, 28/14, 32/16, 36/21 and 40/26 °C. These temperature regimes simulate temperature cycles that prevail during both the rainy and the dry season, as indicated by meteorological data at Khurais station (150 km east of Riyadh) within the habitat range of the species. The seeds were germinated in distilled water in germination flasks in dark incubators maintained at the appropriate temperatures. 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 germinated to comparable high percentages (92-95%) over the whole range of the temperature regimes tested, but the rate of germination increased with rising temperature reaching an optimum within the range 21/10 °C-36/21 °C (Table 1, Fig. 2). Periods (days) of incubation required for 50% of seeds to germinate (Table 1) are indicatives of rates of germination.

**Table 1.** Germination percentages attained by the seeds of *Zygophyllum decumbens* germinated at different (12 hourly) fluctuating temperature regimes and also the periods of incubation (days) needed by the seeds to attain 50% germination. Ninety-five per cent confidence limits are included.

| Temperature °C | % Germination | Period for 50% Germination (days) |
|---|---|---|
| 18/8 | 92 ± 3.182 | 6.125 ± 0.273 |
| 21/10 | 92 ± 4.500 | 4.300 ± 0.857 |
| 28/14 | 94 ± 3.182 | 2.975 ± 0.678 |
| 32/16 | 93 ± 2.755 | 2.075 ± 0.207 |
| 36/21 | 95 ± 5.276 | 1.775 ± 0.261 |
| 40/26 | 92 ± 4.500 | 4.075 ± 0.164 |

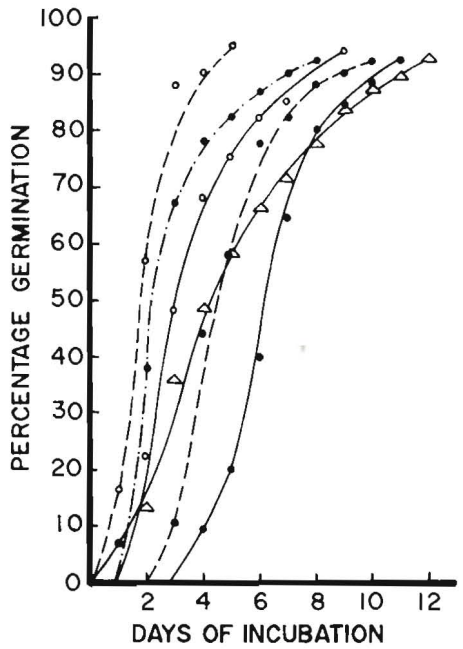


**Fig. 2.** Progress of the germination of the seeds of *Zygophyllum decumbens* at different fluctuating temperature regimes: 18/8°C ●—●; 21/10°C ●-----●. ; 28/14°C ○—○; 32/16°C ●-·-·-·-●; 36/21°C ○-----○; 40/26°C △——△.

## Experiment 2

*Procedure*

Seeds of *Z. decumbens* were germinated over the following range of salt concentrations obtained by diluting Red Sea water: 2305.5 ppm (= 5 per cent seawater), 4611 (10 per cent), 9222.5 (20 per cent), 18445 (40 per cent), 36890 (80 per cent) and 46112 (100 per cent). Germination took place in germination flasks in dark incubators maintained at alternating (12 hourly) temperature regimes: 21/10 and 36/21 °C. These temperature regimes represent upper and lower limits of the optimal temperature range for the germination of the species. The procedure then adopted was similar to that in Experiment 1.

*Results*

The graphs in Fig. 3 shows the course of germination of the seeds of *Z. decumbens* germinated in the various salinities and temperature regimes. The data in Table 2 includes the final germination percentages and the periods (days) of incubation needed for attaining 50 per cent germination.

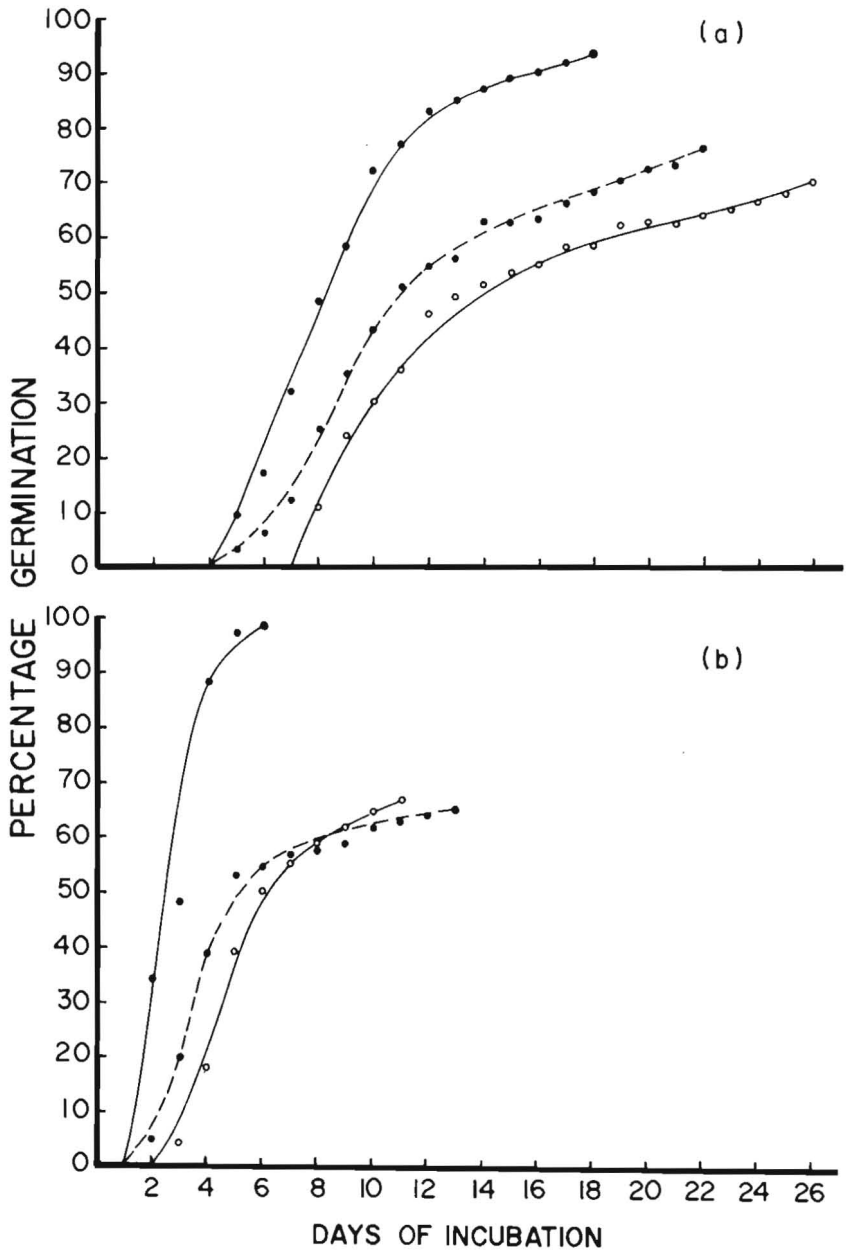


**Fig. 3.** Course of germination of the seeds of *Zygophyllum decumbens* in different salinities: 2305.5 ppm (5% seawater) ●——●; 4611 (10%) ●- - - -●; 9222.5 (20%) ○——○. All at two fluctuating temperature regimes: 21/10°C (a) and 36/21°C (b).

**Table 2.** Germination percentages attained by the seeds of *Zygophyllum decumbens* germinated at two (12 hourly) fluctuating temperature regimes in different salinities; the periods (days) required by the seeds to reach 50% germination as well as 95% confidence limits are also included.

| Temperature °C | Distilled Water | | 2305.5 ppm (5% seawater) | |
|---|---|---|---|---|
| | % germination | Time for 50% germination | % germination | Time for 50% germination |
| 21/10 | 92 ± 4.500 | 4.300 ± 0.857 | 94 ± 5.276 | 8.000 ± 0.112 |
| 36/21 | 95 ± 5.276 | 1.775 ± 0.261 | 98 ± 3.182 | 2.450 ± 0.138 |
| | 4611 ppm (10%) | | 9222.5 ppm (20%) | |
| 21/10 | 76 ± 7.955 | 9.450 ± 1.069 | 70 ± 3.182 | 11.040 ± 2.770 |
| 36/21 | 65 ± 5.899 | 3.650 ± 0.651 | 67 ± 8.267 | 4.800 ± 0.834 |

At both temperature regimes, the seeds germinated in distilled water and in 5 per cent seawater concentration attained comparable high germination percentages (> 90 per cent), but germination decreased significantly as the salinity increased to 10 and 20 per cent seawater concentrations; no seed germinated at 40 per cent seawater concentration. At both temperature regimes, the speed of germination of the seeds decreased with increased salinity level, although germination of the seeds incubated at 36/21 °C was considerably faster (shorter periods for attaining 50% germination) than that of those at 21/10 °C (Table 2).

## Experiment 3

*Procedure*

The seeds of *Z. decumbens* at 21/10 and 36/21°C in 40, 80 and 100 per cent seawater concentrations, which did not germinate for 15 days (Experiment 2) were thoroughly washed with distilled water and germinated at the same temperature regimes in distilled water in germination flasks. The procedure then adopted was similar to that in Experiment 1.

*Results*

Figure 4 shows the course of germination; Table 3 includes the final germination percentages and periods of incubation (days) needed for attaining 50 per cent germination.

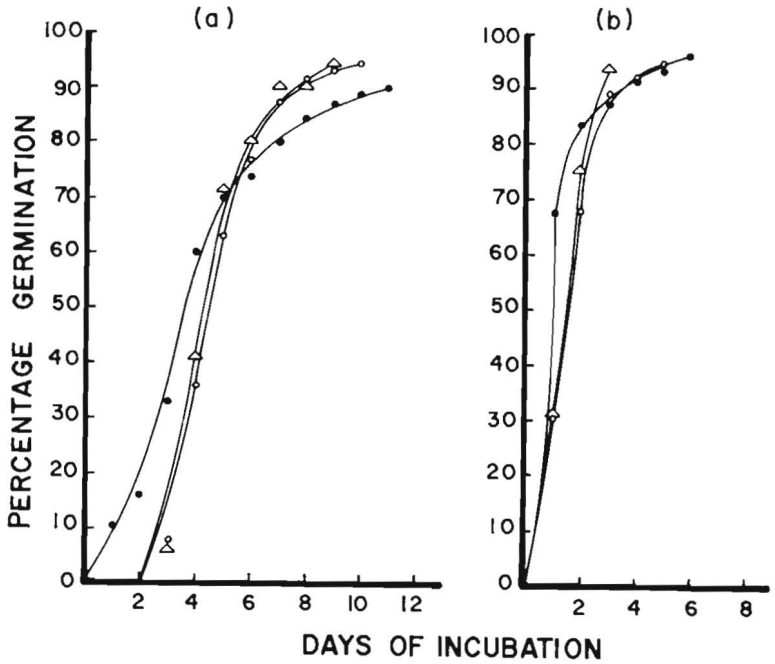


**Fig. 4.** Progress of germination of the seeds of *Zygophyllum decumbens* which were per-incubated, for 15 days, but did not germinate, at 21/10°C (a) and 36/21°C (b) in 40% seawater (18445 ppm) ●——●; 80% (36890) ○——○ and 100% (46112) △——△ and then germinated at the same temperatures in distilled water after they were thouroughly washed from salt with distilled water.

At both temperature regimes, the seeds pre-incubated at excessive salinities (40, 80 and 100 per cent seawater) and then transferred to distilled water germinated to comparable high percentages (> 90 per cent); seeds at 36/21°C germinated notably faster than those at 21/10°C (Table 3).

## Discussion

Seeds of *Z. decumbens* germinated to high percentages at the alternating temperature regimes, 18/8, 21/10 and 28/14°C (Fig. 2, Table 1). These temperatures simulate those of the rainy season within the natural habitat range of the species in Riyadh district (Fig. 5), that is, the season, when prevalent moisture conditions favour germination and subsequent seedlings establishment. Germination may start by December, and because of high temperature preference of the germinating seeds (Fig. 2, Table 1), germination peaks may be expected in March and April. However, the high germination percentages and the fast rates of germination attained at 36/21, and 40/26°C which simulate the temperature regimes prevalent

**Table 3.** Germination percentages of the seeds of *Zygophyllum decumbens* which were preincubated for 15 days at 21/10°C and 36/21°C in different salinities and then germinated at the same temperatures in distilled water; the periods (days) required by the seeds to reach 50% germination, as well as 95% confidence limits are included.

| Temperature C° | Distilled Water | | 40% sea water concentration then in distilled water | |
|---|---|---|---|---|
| | % germination | Time for 50% germination | % germination | Time for 50% germination |
| 21/10 | 92 ± 4.500 | 4.300 ± 0.857 | 90 ± 3.182 | 3.450 ± 0.137 |
| 36/21 | 95 ± 5.276 | 1.775 ± 0.261 | 96 ± 4.500 | 0.850 ± 0.137 |

| Temperature C° | 80% sea water concentration then in distilled water | | 100% sea water concentration then in distilled water | |
|---|---|---|---|---|
| | % germination | Time for 50% germination | % germination | Time for 50% germination |
| 21/10 | 94 ± 9.546 | 4.400 ± 0.389 | 94 ± 3.182 | 4.270 ± 0.345 |
| 36/21 | 94 ± 3.182 | 1.500 ± 0.357 | 94 ± 5.511 | 1.400 ± 0.113 |

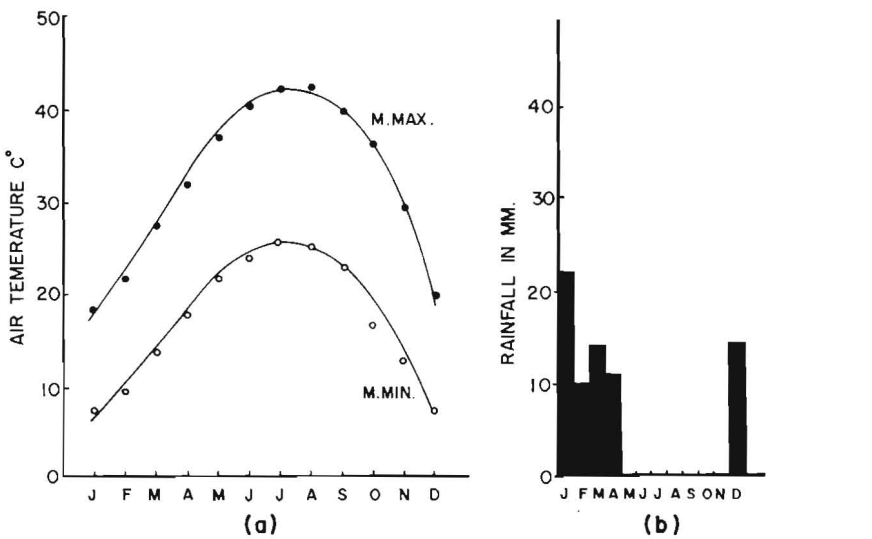


**Fig. 5.** Meteorological data obtained at Khurais station (150 km East of Riyadh) (a) mean daily temperature maxima (●) and minima (○); (b) monthly rainfall (Data are averages of 9 year records).

during the dry summer months of May and July respectively in Najd (Fig. 5) indicate that moisture controls germination that is, if moisture is adequate seeds germinate over a wide range of temperature (Fig. 2, Table 1). The hygroscopic pear-shaped deeply 5-parted capsules will only dehisce and liberate the seeds, when they are adequately moistened. This indicates that ecological factors other than the critical germination temperature requirements may control the distribution of the species in Saudi Arabia.

When temperature and moisture are favourable, the seeds of *Z. decumbens* are capable of germination in salinities well beyond those encountered by the adult plants in their natural habitat (Tables 2 and 4). Successful germination of this species, as similar to that of other desert plants e.g. *Francoeuria crispa* (Mahmoud *et al.* 1983b) and *Rhazya stricta* (Mahmoud *et al.* 1984) may thus occur, when favourable moisture and temperature conditions prevail, even without earlier leaching of soil.

The littoral salt marsh vegetation at Rabigh (on the Red Sea coast, 150 km north of Jeddah) is characterized by its zonal arrangement. The *Halopeplis perfoliata* zone is followed landward successively by the *Aeluropus massauensis* and *Zygophyllum coccineum* zones. *Z. decumbens* is an important component of *Z. coccineum* community type which occupies the highest ground where the saline water table lies below 3 metres (Mahmoud *et al.* 1982). Because of this, and the leaching caused by additional drainage water which is introduced by *wadis* draining the neighbouring Hijaz mountains, the soil salinity is considerably lower than that in the rest of the marsh (Mahmoud *et al.* 1982) but is comparable to that encountered by *Z. decumbens* in its natural habitat in Riyadh district. However, the notable absence of *Z. decumbens* from the comparatively low-lying highly saline zones of *H. perfoliata* and *A. massauensis*, where the saline water table is shalow, is probably due to the low salt tolerance of the seeds of the species as compared

**Table 4.** Total water soluble salts in soil samples collected during the dry season (August 1982) within the habitat of *Zygophyllum decumbens*.

| Habitat | Profile No. | Depth cm | Total water soluble salts ppm |
|---|---|---|---|
| Upper slope of a deep depression | 1 | 0-5 | 169.6 |
| | | 5-25 | 211.2 |
| Bed of same depression | 2 | 0-5 | 800.0 |
| | | 5-25 | 640.0 |
| Shallow depression | 3 | 0-5 | 163.2 |
| | | 5-25 | 288.0 |

with that of *H. perfoliata* (Mahmoud *et al.* 1983c) and *A. massauensis* (Mahmoud 1984). Successful germination of the seeds of *Z. decumbens* in the zones of *H. perfoliata* and *A. massauensis* is not possible without marked dilution of the salts during the rainy season. However, because of the unreliable and low rainfall at Rabigh (Mahmoud *et al.* 1982), the appropriate combinations of environmental conditions for successful germination of the seeds of *Z. decumbens* are unlikely to occur.

A saline habitat can inhibit germination in two ways: (a) by poisoning the embryo due to toxic effects of certain ions (Uhvits 1946) or, by preventing uptake of water due to high osmotic potential of the medium (Ayers and Hayward 1948, Ayers 1952, Ungar 1962, Boorman 1968, Macke and Ungar 1971, Mahmoud *et al.* 1983b). Evidence from Experiment 3 indicates that the inhibition of the germination of the seeds of *Z. decumbens* is due to high osmotic potential of the medium.

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# إنبات بذور نبات الرطريط الملحى *(Zygophyllum decumbens)*

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نبات الرطريط نبات معمر، وقد تمت دراسة تأثير أنظمة مختلفة من درجات الحرارة المتبادلة على إنبات بذوره وكذلك تأثير تركيزات مختلفة من ماء البحر على الإنبات تحت نظامين حرارين: (٢١/١٠، ٣٦/٢١°م).

نبتت بذور الرطريط بنسب عالية وبسرعة فى جميع درجات الحرارة التى تم اختبارها، ولكن سرعة الإنبات تزيد بارتفاع درجة الحرارة وتصل ذروتها فى المدى بين ٢١/١٠-٣٦/٢١°م.

اتضح أن قدرة تحمل البذور للملوحة تفوق كثيرا تركيز الأملاح فى بيئة النبات الطبيعية.