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Seed Germination Response of Two Desert Species from Saudi Arabia to Temperature

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Abstract. *Artemisia abyssinica* Sch. Bip. is a perennial plant which is a very effective sand-binder. In Saudi Arabia, the species is associated with sand formations, especially the mobile red sand dunes of Nefud, Dahna and the provincen easter. On the other hand, *Cassia senna* L. is a xerophytic legume, a common weed of cultivated fields and waste land in Tihamah, and its geographical distribution in Saudi Arabia is limited to foothills and sandy plains of Hejaz. Comparisons were made between the germination responses to temperature of freshly harvested seeds. The seeds of these two species from two contrasting habitats of Saudi Arabia were germinated at six alternating temperature regimes (18/8°C, 20/10°C, 25/15°C, 30/20°C, 35/25°C and 40/30°C). Germination rates and percentages correlated with their habitat distribution. *Artemisia abyssinica* is associated with sand formations, whereas *Cassia senna* shows wide ecological amplitude in its germination temperature responses. Possibly *C. senns* has developed an ecotype in response to wadis and silty flat bottoms. This ecotype may widen its ecological amplitude and may extend its distribution into warmer and humid regions where runoff water collects.

Introduction

Artemisia abyssinica is a wild species collected from the desert of the Riyadh area of Saudi Arabia. It is a green shrub with numerous dense leafy erect upper branches. The leaves are alternate, with tufted deeply pinnatisect linear lobes up to 4 cm long. According to Migahid [1] its geographical distribution in Saudi Arabia includes the Nefud region (which comprises the great northern Nefud, Dehna and Al-Qassim area), eastern and western Najd, and the eastern region between Dahna and the Arabian Gulf (Fig. 1). In contrast *Cassia senna* (syn. *C. acutifolia* Del.), is a glabrous perennial undershrub with lanceolate acute leaflets, legume straight, thin papery, 2-3 times as long as broad [1]. Al-Helal *et al.* [2] found that it is adapted to the dry climate of Saudi Arabia, and temperature and salinity are major factors that influence its seed germination. One of the most important factors that affects germination is the temperature response, which may be closely correlated with the geographical distribution of the species as reported by earlier authors [3, pp. 93-119] [9].

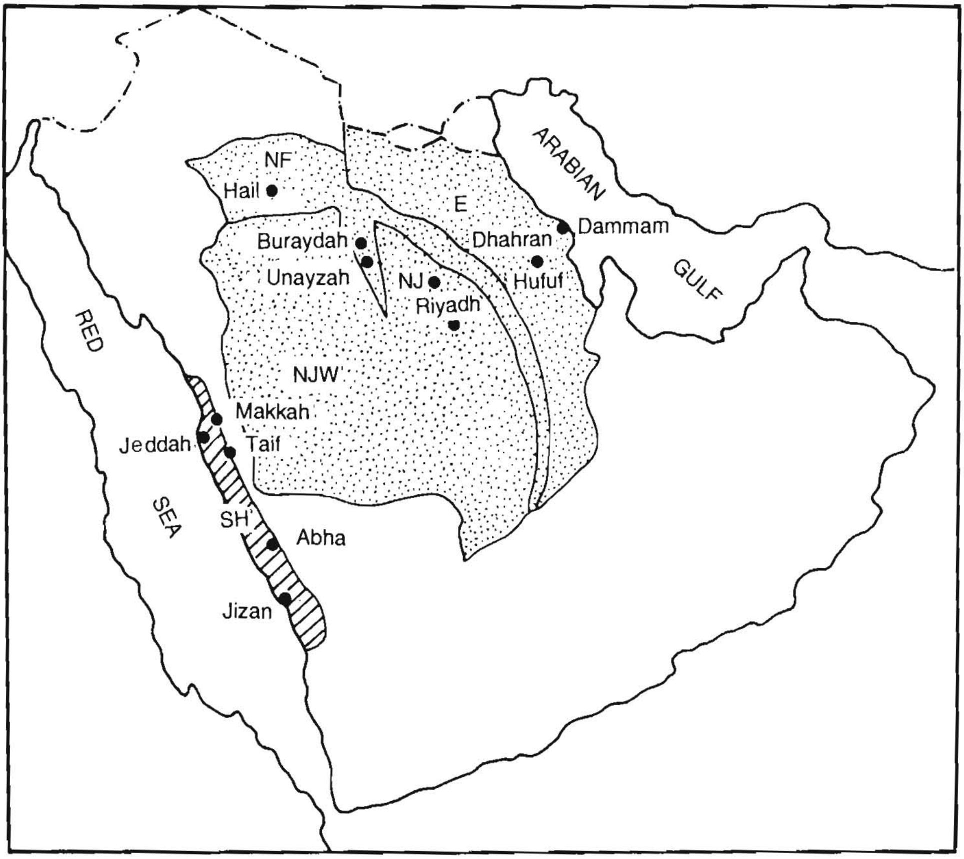

Fig. 1. Geographical distribution (stipple) of *Artemisia abyssinica* Sch. Bip. in Saudi Arabia. E = Eastern region, between Dahna and Arabian Gulf; NF = Nefud regions, including the great northern Nefud area, Dahna and Al-Qassim area; Nje = Eastern Najd; NJw = Western Najd.

Grographical distribution (hatched) of *Cassia senna* L. SH = South Hejaz, representing the southern part of the western Hejaz extending south of Jeddah to the Yemen borders.

Germination represents a critical event in the plant life cycle and its timing largely predetermines the chances of survival of a seedling to maturity. Amongst mechanisms responsible for coordinating germination with physical features of the environment two of the most important are the temperature response characteristics and the proportion of seeds with dormancy restrictions on growth of one kind or another, especially in desert plants [7].

The work described here shows the effect of temperature and considers the effect of different habitat on the germination rates and percentage of two desert species from Saudi Arabia.

Materials and Methods

The seeds of *Artemisia abyssinica* were collected from plants of large natural stands in the Riyadh central region and were used immediately. The seeds were cleaned by gently rubbing between the fingers and removing the husk by exposure to a gentle wind current. This cleaning allowed selection of fully developed seeds. The seeds were sorted to reject those which were insect damaged or broken; there was no discrimination between large and small seeds. The seeds were germinated on moist filter paper in germination flasks. Three replicates (20 seeds each) were used. The seeds were germinated over the following range of alternating temperature regimes by day and night (18/8°C, 20/10°C, 25/15°C, 30/20°C, 35/25°C and 40/30°C). A seed was considered to have germinated when the radicle emerged. The germinated seeds were discarded

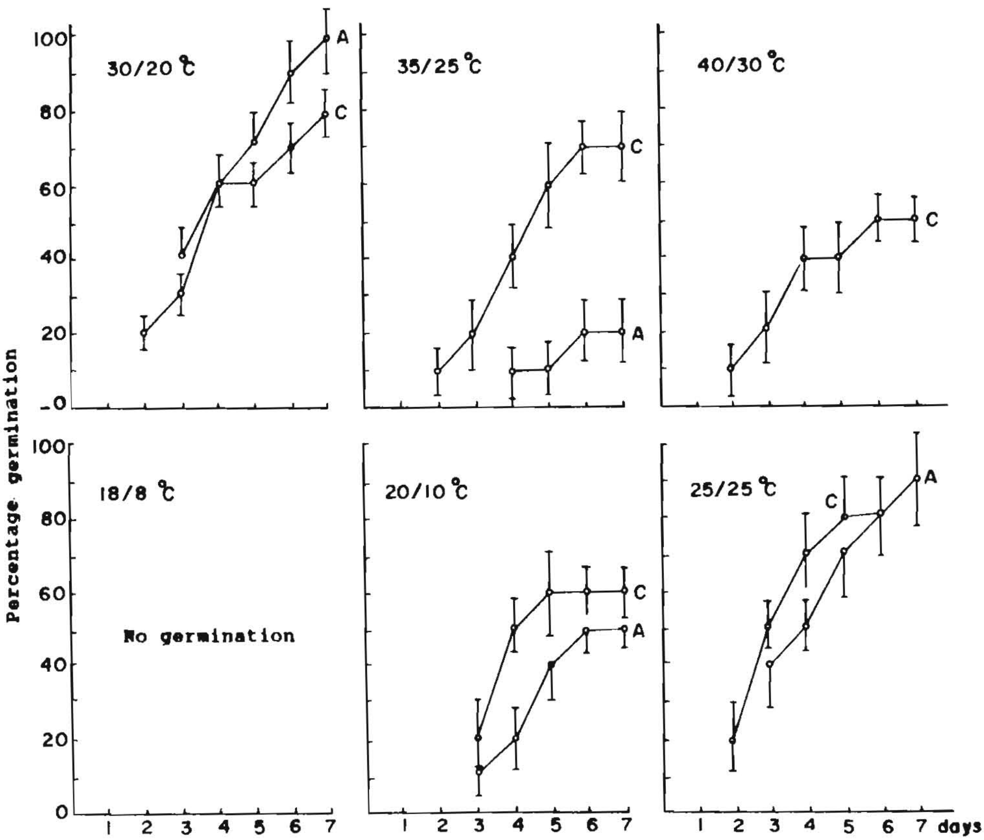

Fig. 2. Germination percentage of seeds of two species from different habitats of Saudi Arabia at six alternating temperature regimes.

A = *Artemisia abyssinica* Sch. Bip., C = *Cassia senna* L.

Vertical bars represent ± S.E.

immediately and counts were made daily until no more seeds germinated for seven successive days. The seed count involved the removal of flask lids which allowed a change of air and probably prevented the accumulation of carbon dioxide from germinating seeds.

Fully developed undamaged seeds of *Cassia senna* were liberated from freshly collected pods from Jizan southern region. There was no discrimination between large and small seeds. The seeds of *C. senna* have impermeable seed coats. In order to increase the permeability of the testa, batches of 50 seeds were soaked separately in concentrated sulphuric acid for 15 min. The seeds were stirred vigorously every 5 min with a glass rod to prevent deposition of carbon on their surfaces which might have interfered with the action of the acid. After the appropriate time in the acid, the seeds were washed thoroughly with tap water and were then soaked in distilled water for 10 min. The seeds were placed in germination flasks over the same range of alternating temperature regimes as used for the seeds of *Artemisia abyssinica* and the same procedures were followed.

Results

The percentage germination of seeds at different alternating temperatures is shown in Fig. 2. At low temperatures (18/8°C) there was not germination of either species. The germination percentages increased with rise of temperature attaining their maximum at 30/20°C being lower at 35/25°C and even lower at 40/30°C. *A. abyssinica* did not germinate at the low temperature of 18/8°C but at 20/10°C the germination was up to 50% by the 6th day of imbibition. This value increased at 25/15°C and was 100% at 30/20°C by the 7th day of imbibition. Percentage germination was low at 35/25°C and seeds did not germinate at 40/30°C.

This work sugests that germination of non-dormant seeds of *A. abyssinica* is regulated by the responses to the season of optimal environmental conditions for subsequent growth and establishment of seedlings. The mechanisms which synchronize the event of germination with the season favorable for growth and establishment of plant species are of great importance amongst the many processes which constitute the adaptations of plants ot their arid environment [3-13]. In many plant species the geographical distribution depends on their closely adapted responses to temperature, day length and rainfall.

The germination temperature responses of seeds of *A. abyssinica* indicate that the most favorable temperature regime is 30/20°C. This is close to the range of temperaure during the months of February, March and April (Table 1) when the comparatively cooler moist season prevails within the habitat range of the species and moisture is more likely to be available. Germination is inhibited at the moderate temperatures which characterize the cool winter season. These results are in agreement with those of Mahmoud *et al.* [7]. However, because of the unstable nature of the mobile sandy

Table 1. Meteorological data of Central and Southern regions of Saudi Arabia

		Central region					Southern region				
		Temperature °C		Relative humidity %		Rainfall	Temperature °C		Relative humidity %		Rainfall
Year	Months	Max	Min	Max	Min	mm	Max	Min	Max	Min	mm
1991	Feb.	25.8	9.2	30	6	1.4	33.9	22.1	89	26	4
"	Mar.	25.4	12.8	50	8	52.3	37.6	23.6	88	36	0.0
"	Apr.	33.4	17.5	24	7	0.0	31.4	25.5	96	19	8

habitat of the species, the seeds are frequently subjected to burial and exposure, which may affect germination.

C. senna showed 60% germination at 20/10°C by the 5th day of imbibition and showed the highest percentage germination (80%) at 25/15°C and at 30/20°C. Percentage germination decreased at 35/25°C but was 50% even at 40/30°C by the 6th day of imbibition (Fig. 2).

As reported by Mahmoud [14] *C. senna* showed high temperature preference. Our results showed that *C. senna* did not germinate at 18/8°C, but attained 80% germination over the temperature ranges 25/15°C and 30/20°C and 50% at 40/30°C (Fig. 2). Further, as reported earlier by Mahmoud [14]and Obeid and Mahmoud [15] *C. senna* is associated with water runnels ranging from narrow channels to wadis and depressions. In the Jizan region, because of spate irrigation and a number of wadis, the species inhabits similar habitats in addition to drainage ditches and channels.

The results reported by Al-Helal *et al.* [2] and Mahmoud [14] showed that acid-treated seeds of *C. senna* germinated to a high percentage over a wide range of temperature (15-40°C). Our results indicate that the most favorable alternating temperature regime for germination is 30/20°C; these conditions prevalent in the Hejaz region together with the humid climate may lead to the remarkable abundance of this species here.

Discussion

In deserts, where rainfall is unpredictable, it is important that seeds do not germinate unless the soil contains enough water to enable the resulting seedlings to complete their life cycles. It therefore is significant for germination to be controlled by a regulated response to the environment. One mechanism that regulates germination and contributes to the survival of desert plants is the presence, in their seeds, of water-soluble, water-leachable germination inhibitors [14-22]. Moreover, these need minimal amounts of precipitation before they are leached out [5 & 23].

The present work suggests that the germination of non-dormant seeds of *A. abyssinica* is regulated by their response to the characteristics of the ambient daily temperature cycle of the habitat of the plant. These responses tend to synchronize the event of germination with the season of optimal environmental conditions for subsequent growth and establishment of seedlings.

The germination temperature response of seeds of *A. abyssinica* is at its best at 30/20°C, when moisture and temperature of the natural habitat of the species are likely to be favorable. The mechanism in *C. senns* is, however, different. Inhibition of germination is here attributed to the impermeability of its seed coat. This may be overcome experimentally by scarification with sulphuric acid. Delayed germination resulting from an impermeable seed coat is very common among desert plants [2, 4, 5, 10, 11, 13 & 14]. Since the seed coat becomes permeable to water as a result of prolonged wetting and probably by the increased activity of soil microorganisms during the rainy season, the thick seed coat of *C. senna* restricts germination to the time when abundant water is available. It also restricts the distribution of the species to habitats which normally receive abundant water. These results are in good agreement with those reported by Mahmoud [14]. Similiar results reported by Mahmoud [6] showed that the impermeability of the seeds of three species of *Acacia (A. nilotica, A. raddiana, A. tortilis)* is related to the water demand of the three species and the amount of water likely to be available within their habitats.

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استجابة الإنبات لدرجات الحرارة لنوعين من البذور الصحراوية من المملكة العربية السعودية

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(سُلِّم في ٣ جمادى الأولى ١٤١٥هـ؛ قُبل للنشر في ١٤ شعبان ١٤١٥هـ)

ملخص البحث. *Artemisia abyssinica* نبات حولي يتواجد على التكوينات الرملية وخاصة على الكثبان الحمراء المتحركة في صحراء النفوذ والدهناء وفي المنطقة الشرقية بينما نبات *Cassia senna* من البقوليات الجفافية ومن الأعشاب العامة المتواجدة في الحقول الزراعية والأراضي المهملة.

تمت مقارنة بين استجابة الإنبات لدرجات حرارة مختلفة لهذين النوعين من البذور (١٨/٨، ٢٠/١٠، ٢٥/١٥، ٣٠/٢٠، ٣٥/٢٥ و ٤٠/٣٠°م). كانت نسب الإنبات ذات علاقة شديدة بالتوزيع الموقعي للبذور حيث أثّر اختلاف الموقع على استجابة هذين النوعين للبذور.

وجد أن نبات *A. abyssinica* مترابط بالتكوينات الرملية وخاصة الحمراء المتحركة فيما وجد أن نبات *C. senna* أوضح نطاقًا واسعًا فيما يتعلق باستجابة الإنبات لدرجات الحرارة المختلفة.

فمن الممكن أن نبات *C. senna* طوّر تنوعًا بيئيًا في الاستجابة لمنحدرات الأودية وقيعان الطمي المسطّحة. هذا التنوع البيئي وسّع المدى البيئي للأنواع فيما يتعلق بدرجات الحرارة وأمكن توسيع توزيع الأنواع النباتية في المناطق الدافئة والرطبة مثل هذه المناطق والمتميزة بتجميع مياه الفيضانات.