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Germinable soil seed bank of desert plant communities in wadi Al-Ammaria, Riyadh, Saudi Arabia

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ABSTRACT

Soil-seed content of the desert vegetation in Wadi Al-Ammaria Riyadh, Saudi Arabia was evaluated. The soil seed bank was assessed using soil sample, from eight community types which form distinct vegetation units of the study area. The germinable seeds contained in the uppermost 2 cm of the soil showed a great diversity among the different communities. It ranged between 37 seedlings m^{-2} in the soil inhabited by *Alhagi maurorum* to 2478 seedlings m^{-2} in the soil inhabited by a *Rhazya stricta* community type. The seed output exhibited a wide variation among the investigated species. It ranged between 168 seeds per individual plant of *lagonychium farcatum* to 20775 seeds in *Haloxylon salicornicum*.

Keywords: Desert ecology, plant communities, Saudi Arabia, seed ecology, soil seed bank.

INTRODUCTION

There has been increasing interest in the role of the seed bank in determining the future vegetation of an area, especially following a disturbance. examination of habitat and plant community differences within a desert region indicates that seed bank dynamics are governed by local plant distribution, flowering and fruiting events (Leck *et al.* 1989). Dye (1969) found significant differences in mean seed densities and species composition between two plant community types not far from each other. In desert vegetation, which is composed of a diversity of plant species with different growth and life-forms including a significant proportion of annuals, it is expected that seed banks would be occasionally large and always patchy, reflecting the dynamics and dispersal patterns of various species (Kassas and Batanouny 1984; Walter and Box 1983).

The soil seed bank is part of the vegetation (Willems, 1983). New seeds are continuously added by the seed rain (Harper 1977), representing a record of the past and present state of the vegetation of the area. Due to its important role in

plant evolution, population dynamics and community processes, the ecology and dynamics of the seeds buried in the soil have received increasing attention during the recent years. Valuable information on the relationship between the soil seed bank and the composition of the standing vegetation in different natural habitats have recently been published by numerous investigators (i.e. Thompson 1978, Batanouny *et al.* 1991 and 2000, Bertiller 1998, Egly 1986, Kemp 1989 and Zayed 1980. However, little is known about the viable seeds in desert soils of Saudi Arabia (Al-Yemeni and Al-Farraj 1995). This study was undertaken to evaluate the buried viable seed content of soils in different microhabitats in Wadi Al-Ammaria in Saudi Arabia (Fig. 1).

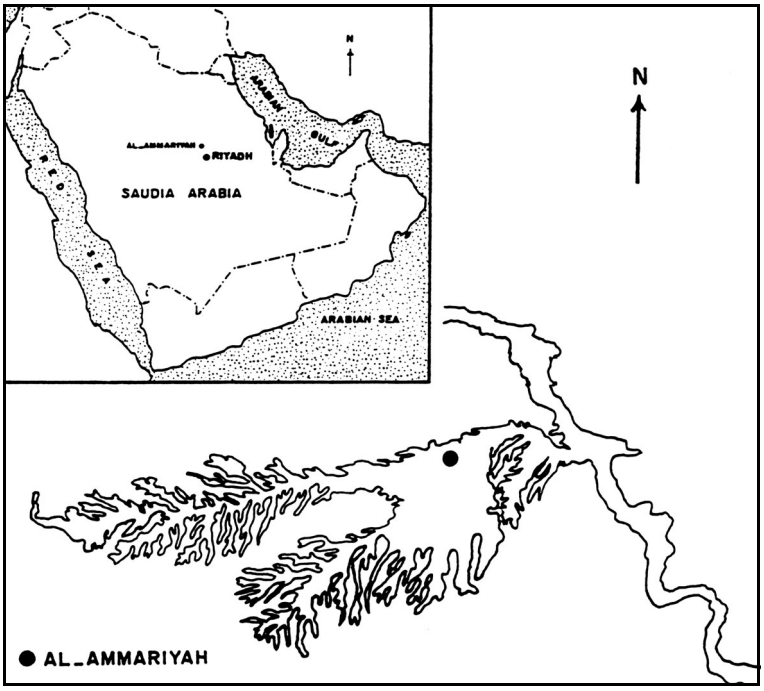

Fig. 1. A map of the study area

MATERIALS AND METHODS

The present investigation was undertaken during a period extending from the 5th of November 200 to the 5th of May, 2001, in Wadi Al-Ammaria. The vegetation characteristics were derived from the study of representative stands, which were chosen on a subjective basis.

The soil seed bank was estimated in the soil samples collected from the uppermost two cm of the soil. A sampling area of 50x50-cm was used. Ten replicates of soil samples were collected from different localities of each community type and stored in cotton bags. The soil samples were air-dried,

mixed thoroughly to make an almost homogenous mixture, and sieved on two mm sieve mesh to separate the large pebbles and plant debris. The seed bank was estimated by sowing method according to Robberts & Neilson (1982).

Plastic trays (40x40x10 cm) were used. The trays were filled partially with two cm thick of previously oven-dried sand to get rid of any contained viable seeds. The collected soil samples were then spreaded homogeneously to have a thickness of 2 cm in each tray (to simulate natural conditions). Five replicates were used for each community type. The trays were watered twice a week and emergence of the seedlings was monitored over a period of 40 days. At the end of the experiment (12 weeks), the standing seedlings were identified according to (Migahid, 1990). The experiment was carried out in the green house of the Botany and Microbiology Department, College of Science, King Saud University under temperatures ranging from (21 to 24°C) and (15 to 18°C) during the day and night respectively.

Seed productivity was estimated for the most common species growing in the Wadi. For each species, seed output of at least five mature plants was estimated at the time of their seed production. In each individual plant the number of seeds per fruit and the total number of fruits per individual were estimated to obtain the total seed output.

RESULTS

Seed germination:

Examination of data presented in Table (1) and illustrated in Fig (2V) show that emergence of seedlings from soil supporting an *Acacia gerrardii* community started four days after sowing with very limited values ranging from zero to three seedlings/tray with a total value equivalent to 11 seedlings m^{-2}. The number of emerged seedlings increased sharply with an increase in time till a maximum of 1450 seedlings m^{-2} was attained after about 4 weeks, after which the number of the emerged seedlings remained more or less unchanged. By the end of the experiment (12 weeks after sowing), a total of 9 perennial and 16 ephemeral species were identified (Table 2).

Data presented in Table (1) and illustrated in Fig. (2 I) show that emergence of seedlings from soil supporting an *Alhagi maurorum* community started about 8 days after sowing with a limited number of 3 seedlings m^{-2} twelve days after sowing, the number increased to 21 seedlings m^{-2} after which it increased to a maximum of only 37 seedlings m^{-2} after about 4 weeks. The emerged seedlings include only one perennial species *(Francoeuria crispa)* and 3 ephemeral represented by *Chenopodium album, Sonchus oleraceus* and *Spergularia diandra*.

Table (1) Number of seedlings (m^{-2}) emerged from soil collected from different habitats occupied by different communities growing in Wadi Al-Ammaria, Saudi Arabia.

Days after sowing	Acacia gerrardii	AlHagi maurorum	Haloxylon Salicornicum	Pennisetum divisum	Rhanterium epapposum	Rhazya stricta	Ricinus communis	Salsola imbricata
4	11	0	5	0	10	1	4	8
8	195	2	189	42	123	503	439	70
12	636	21	489	106	468	1279	990	330
16	811	27	746	136	616	1594	1164	407
20	1052	31	1375	221	873	2097	1330	642
24	1235	32	1438	236	1117	2218	1348	738
28	1305	36	1665	290	1242	2490	1554	1066
32	1436	37	1732	277	1250	2500	1633	1302
36	1450	37	1751	270	1250	2478	1642	1315
40	1450	37	1738	266	1250	2478	1642	1315

Four days after sowing, the number of emerged seedlings from soil supporting an *Haloxylon salicornicum* community is very limited and did not exceed 5 seeds m^{-2} (Table 1 and Fig 2 VII). About 3 weeks after sowing, the emerged seedlings increased progressively with values ranging between 122 to 320 seedlings per tray with a total equivalent to 1375 seedlings m^{-2}. However, the number of emerged seedling increased gradually and attained its maximum value of 1738 seedling m^{-2} after about 7 weeks from sowing. By the end of the experiment (12 weeks), a total of two perennial and 18 ephemeral species were identified (Table 2). The parennial species were *Francoeuria crispa* and *Paronychia arabica,* and the ephemerals were Aizon canariense, Anastatica hierochuntica, Astragalus tribuloides, Emex spinosus, Eremobium aegyptiacum. Filago desertorum, Ifloga spicata, Koelpinia linearis, Malva parviflora, Matthiola longipetala, Notocerus bicorne, Picris radicata, Plantago amplexcaulis, Poa annua, Sclerocephalus arabicus, Spergularia diandra and *Trigonella hamosa*.

Seedling began to emerge from soil supporting a *Pennisetum divisum* community 8 days after sowing with a value amounting to 42 seedlings m^{-2} Table 1, Fig 2 II). The number of the emerged seedlings increased gradually and attained the highest value of 266 seedling m^{-2} after 4 weeks from sowing. After 3 weeks, the rate of seedling mortality slightly exceeded the rate of seedling emergence. The identified seedlings (Table 2) include only one perennial *Paronychia arabica)* together with six ephemerals namely; *Chenopodium murale, Eragrostis, barrelieri, Herniaria hirsuta, Plantago ovata, Polypogon mospliensis and Trigonella hamosa*.

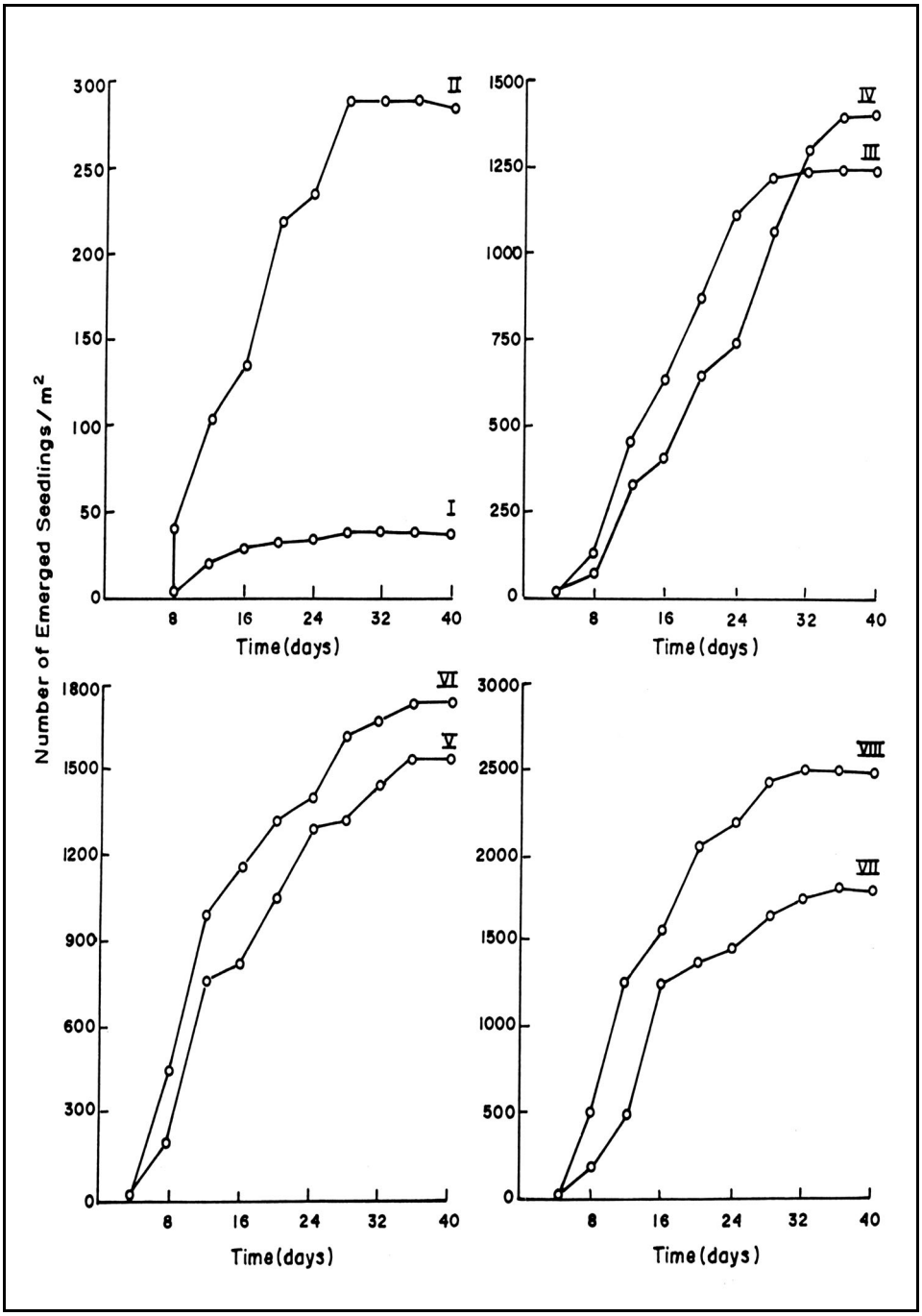

Fig. 2. Emergence of seedlings m^{-2} from soil samples collected from different communities and irrigated twice a week over a period of 6 weeks. **I.** *A. maurorum*, **II.** *P. divisum*, **III.** *R. epapposum*, **IV.** *S. imbricata*. **V.** *A. gerrardii*, **VI.** *R. communis*, **VII.** *H. salicornicum* and **VIII.** *R. stricta community* type.

Table (2) Floristic composition of emerged seedlings, 12 weeks after sowing. Samples collected from different communities growing in Wadi Al-Ammaria, Saudi Arabia.

	Communities							
Species	**Acacia gerrardii**	**Alhagi maurorum**	**Haloxylon Salicornicum**	**Pennisetum divisum**	**Rhanterium epapposum**	**Rhazya stricta**	**Ricinus communis**	**Salsola imbricata**
PERENNIALS	-	-	-	-	-	-	-	-
Acacia gerrardii Benth.	+	-	-	-	-	-	-	-
Atriplex leucoclada Boiss.	+	-	-	-	-	-	-	-
Convolvulus lanatus L.	+	-	-	-	-	-	-	-
Francoeuria crispa (Forrsk. Cass.)	+	+	+	-	-	+	+	-
Paronychia arabica (L.) Del.	+	-	+	+	+	+	+	-
Peganum harmala L.	+	-	-	-	-	-	-	-
Rhanterium epapposum Oliv.	+	-	-	-	+	-	-	-
Rhazya stricta Decne.	+	-	-	-	-	-	-	-
Riccnus communis L.	-	-	-	-	-	-	+	-
Zilla spinosa (L.) Prante.	+	-	-	-	-	-	-	-
EPHEMERALS	-	-	-	-	-	-	-	-
Aizoon conairense L.	-	-	+	-	-	-	-	-
Anastatica hiero chuntica L.	-	-	+	-	+	-	-	-
Anisosciadium lanatum Boiss.	+	-	-	-	+	-	-	+
Atractylis arabica Rech.	-	-	-	-	+	-	-	-
Astragalus tribuloides Del.	+	-	+	-	-	-	+	-
Bassia eriophora (Schrad. Kuntze)	-	-	-	-	-	-	-	+
Chenopodium album L.	-	+	-	-	-	-	-	+
Chenopodium murale L.	+	-	-	+	+	-	+	+
Coronopus didymus (L.) Sm.	-	-	-	-	-	-	-	+
Emex spinosus (L.) Campol.	-	-	+	-	+	-	-	-
Eragrostis barrelieri Dav.	+	-	-	+	+	-	-	-
Eremobium aegyptiacum (Spreng.)	-	-	+	-	-	-	-	-
Asch. in Boiss	-	-	-	-	-	-	-	-

Table 2 cont.

Species	Communities							
	Acacia gerrardii	Alhagi maurorum	Haloxylon Salicornicum	Pennisetum divisum	Rhanterium epapposum	Rhazya stricta	Ricinus communis	Salsola imbricata
Filago desertorum (Pomel)	-	-	+	-	-	+	-	-
Wag.	-	-	-	-	-	-	-	-
Flaveria trinerva (Spreng.) Mohr.	+	-	-	-	-	+	-	-
Herniaria hirsuta L.	-	-	-	+-	-	-	-	-
Infloga spicata (Forssk.) Sch. Bip.	-	-	+	-	-	-	-	-
Koelpinia linearis Pall.	-	-	+	-	-	-	-	-
Lactuca serrula L.	-	-	-	-	-	-	-	+
Launaea capitata (Spreng.) Dandy	-	-	-	-	+	-	-	-
Lepidium sativum L.	-	-	-	-	-	-	-	+
Malva parviflora L.	+	-	+	-	-	-	-	+
Mathiola longipetala (Vent.) DC.	-	-	+	-	-	-	-	-
Medicago lciniata (L.) Mill.	-	-	+	-	+	+	-	+
Noto cerus bicorne (Ait.)	+	-	+	-	-	-	-	-
Picris radicata (Forssk.) Dess.	+	-	+	-	+	+	-	-
Plantago amplexcaulis Cav.	+	-	+	-	-	+	-	-
Plantago ovata Forssk.	-	-	-	+	+	-	+	+
Poa annua L.	+	-	+	-	+	+	+	+
Polypogon monsfiensis L.	+	-	-	+	+	-	-	-
Scerocepalus arabicus Boiss.	+	-	+	-	+	-	+	-
Sisymbrium orientale L.	-	-	-	-	-	-	-	+
Sonchus olescaceus L.	-	+	-	-	-	-	-	-
Spergularia diandra (Guss.)	+	+	+	-	+	+	+	+
Trigonella hamosa L.	+	-	+	+	+	+	-	-
Urospermum picroides (L.) F.W. Schmidt.	+	-	-	-	+	+	-	-
Total number of Species	25	4	20	6	19	11	9	12

present (-) = not recorded

Eight days after sowing, 123 seedlings appeared in soil from the *Rhanterium epapposum* community, and 12 days after sowing the number of the seedlings increased to 468 seedlings m^{-2} (Table 1, Fig. 2 III). One month after sowing, the number of seedlings reach a maximum of 1250 seedlings m^{-2}. The emerged seedlings included two perennial and 16 ephemeral species (Table 2). The perennials were *Paronychia arabica* and *Rhanterium epapposum,* While the ephemeral species were *Anastatica hierochuntica, Anisosciadium lanatum, Atractylis arabica, Chenopodium murale, Emex spinosus, Eragrostis barrelieri, Launaea capitata, Medicago laciniata, Picris radicata, Plantago ovata, Poa annua, Polypogon monspliensis, Sclerocephalus arabicus, Spergularia diandra, Trigonella hamosa and Urospermum picroides*.

Examination of the data presented in (Table 1) and illustrated in (Fig 2 VIII) show that the number of seedlings appearing in soil from the *Rhazya stricta* Community sharply increased from one seedling after 4 days to 503 seedlings m^{-2} after 12 days from sowing. After about 3 weeks, there were 2097 seedling m^{-2}, and 32 days after sowing the number of the emerged seedlings peaked at 2478 seedlings m^{-2}. By the end of the experiment, a total of 2 perennials. *(Filago desertorum, Flaveria trinerva, Medicago laciniata, Picris radicata, Plantago amplexicaulis, Poa annua, Spergularia diandra, Trigonella hamosa* and *Urospermum picroides)* were recognized.

The number of seedlings emerging from the soil of the terraces inhabited by *Ricinus commnis* increased sharply from four to 990 and 1330 seedling m^{-2} as the time increased from 4 to 12 and 20 days after sowing respectively (Table 1 and Fig 2 VI). The period extending from 24 to 36 days after sowing showed a high increase in the emerged seedlings reaching a maximum of 1642 seedlings m^{-2} after about 7 weeks. By the end of the experimental period, 3 perennials *(Francoeuria crispa, paranychia arabica* and *Ricinus communis)* and 6 ephemerals *(Astragalus tribuloides, Chenopodium murale, Plantago avata, Poa annua, Sclerocophalus arabicus* and *Spergularia diandra)* were identified (Table 2).

Seedlings emergence from soil supporting the Salsola imbricata community started 4 days after sowing with a limited value amounting to 8 seedlings m^{-2}, after which seedling emergence showed a remarkable rise to value from 70 to 330 seedlings m^{-2} after 8 and 12 days respectively (Table 1, Fig 2IV). During the time period extending from 12 to 36 days, the number of emerged seedling shows a gradual increase until a maximum of 1313 seedlings m^{-2} was reached. No perennial species have been recorded within the emerged seedlings at the end of the experiment (Table 2). On the other hand, 12 ephemeral species were identified, including *Anisosciadium lanatum, Bassia eriophora, Chenopodium album, Coronopus didymus, Lactuca serrula, Lepidium sativum, Malva parviflora,*

Medicago laciniata, Plantago ovata, Poa annua, Sisymbrium orientale and spergularia diandra (Table 2).

In general, data on the germinable seeds buried in the upper 2 cm of soil Table 1 clearly showed that:

First in the majority of the collected soil samples, the emergence of the seedlings started 4 days after sowing except for those collected from habitats supporting *Alhagi maurorum 4 and Pennisetum divisum* in which emergence of the seedlings started 2 or 4 days later.

Second, the number of the seedlings increased progressively, attaining a maximum peak about 5 weeks after sowing.

Third, the lowest numbers of emerged seedlings, amounting to 37 and 290 m^{-2}, were recorded in the soil inhabited by *Alhagi maurorum* and *Pennisetum divisum* communities, respectively. On the other hand, the highest values of 1642, 1751 and 2475 seedlings m^{-2} were recorded in soil samples collected from vegetation dominated by *Ricinus communis, Haloxylon salicornicum* and *Rhazya stricta,* respectively.

Fourth, at the end of the experiment which extended for about 12 weeks, a total of ten perennials and 35 ephemeral species were identified. The species density (Table 2) showed a wide diversity among the studied community tyupes: *Acacia gerradii* (9 perennials and 16 ephemerals), *Alhagi maurorum* (one perennial and 3 ephemerals), *Haloxylon salicornicum* (two perennials and 18 ephemerals), *Pennisetum divisum* (one perennial and 6 ephemeral), *Rhanterium epapposum* (2 perenniala and 16 ephemeral), *Rhazya stricta* (2 perennials and 9 ephemerals), *Ricinus communis* (3 perennials and six ephemerals) and *Salsola imbricta* (12 ephemerals).

Seed Productivity of Some Common Plant Species:

Examination of data presented in Table 3 reveals that the number of seeds produced per fruit, number of fruits, and, consequently the total seed output per individual plant, showed a wide variation among the different species studied. One-seeded fruits are represented by fruits of *Cenchrus ciliaris, Pennisetum divisum, Francoeuria crispa and Rhanterium epapposum*. On the other hand, many-seeded fruits are represented by the fruits of Zilla spinosa (2 seeds), *Ricinus communis* (3 seeds), *Acacia ehrenbergiana4 and Haloxylon salicornicum* (average of 5 seeds), *lagonychium farcatum* (average of 6 seeds), *Farsetia aegyptia* (average of 7 seeds) and *Rhazya stricta* (average of 12 seeds per fruit).

The total seed output per plant exhibited a wide variation among the studied species. This value ranged between a relatively low number of 168 seeds per

individual plant of Lagonychium forcatum to a high seed output amounting to 7164, 9360 and 20775 per one individual plant of *Francoeuria crispa, Rhazya stricta and Haloxylon salicornicum*, respectively.

Table 3. Seed productivity of some common perennial species growing in Wadi Ammaria.

Species	Average seeds per fruit	Average fruits per plant	Total no. of seeds
Acacia ehrenbergiana	5	405	2025
Cenchrus ciliaris	1	1950	1950
Farsetia aegyptia	7	480	3360
Francoeuria crispa	1	7164	7164
Haloxylon salicornicum	5	4155	20775
Lagonychium farcatum	6	28	168
Pennisetum divisum	1	2320	2320
Rhanterium epapposum	1	5720	5720
Rhazya stricta	12	780	9360
Ricinus communis	3	430	1290
Zilla spinosa	2	1589	3187

DISCUSSION

The present study showed wide variations in the number of germinable seeds within soil samples collected from different community types. The low number of seedlings that emerged from the soil supporting *Alhagi maurorum* (37 m^{-2}) and *Pennisetum divisum* (266 m^{-2}) is attributed mainly to active retrogressive changes due to grazing, erosion and human activities that prevail in these habitats. Grazing is a common phenomenon in this Wadi, removing the flowering and fruiting twigs or possibly eradicating some plant species. Thus the seed output is greatly reduced. However, the number of the emerged seedlings increased to 1738 and 2475 seedlings m^{-2} in the localities inhabited by *Haloxylon salicornicum* and *Rhazya stricta* community types respectively. These high densities of germinable seeds are due to the fact that *Rhazya stricta* and *Haloxylon salicornicum* receive considerable amounts of seeds carried with water and wind-born sediments. Since these two species are mount-forming plants, such mounds provide favourable habitats for plant growth and accumulation of seeds as well. Batanouny *et al*. (2000) showed that seed content of the mounds inhabited by *H. salicornicum* growing along the Cairo-Suez desert amounted to 3432 seedlings/m^{-2}, a value which is about six-fold that of the level spaces between the mounds.

The number of species that emerged from the soil samples collected from the different community types exhibited clear variation and ranged from four species in soil inhabited by *Alhagi maurorum* to 25 species in the *Acacia gerrardii* community type (Table 2). The high species density in the later case may be due to a number of factors such as the improved temperature conditions, water regimes and nutrient enrichment of the soil under the canopy of *Acacia* trees. Hoffman (1996) is in agreement with this conclusion. On the other hand the low species density (4) in the community dominated by *Alhagi* may be due to erosion and compaction of the soil surface.

Desert plants produce a large amount of seeds as a means of struggling for existence (Abdel Rahman and Batanouny, 1959). Seed output showed a great diversity among different species, even those growing in the same environment. Seed production (seed output) has an increasing effect on the amount of seeds stored in the soil. This was clearly demonstrated in the soil supporting *Haloxylon salicornicum* and *Rhazya stricta*. In addition to the high seed output in the two dominant species, the soil characters, especially soil depth, may contribute to the large soil seed bank of such community types.

In conclusion, the vegetation of the area includes species with different growth and life forms, consequently there is diversity of the phenological aspects in different seasons. Thus, vegetation and seed bank studies are required to be carried out seasonally for two successive years in order to have a full account of the standing vegetation and of its stored seeds in the soil of the different habitats. Distraction of the surface soil layer by human activities accelerates the erosion effect on the soil, which is reflected on the vegetation and seed bank. Thus, these activities must be limited or prevented as much as possible. Grazing is a common phenomenon in the study area. The grazing animals cause pruning of the flowering twigs or it may eradicate some species; as a result, the seed output of plants is greatly reduced, especially in the arid environment of the study area. Thus, grazing is prohibited or at least is controlled in the Wadi in order to reduce its effects on the vegetation of this area.

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محتوى التربة من البذور القابلة للإنبات للمجتمعات النباتية الصحراوية في وادي العمارية – الرياض – المملكة العربية السعودية

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خلاصة

تم في هذا البحث دراسة محتوى التربة من البذور القابلة للإنبات لثمانية عشائر نباتية تكون الكساء النباتي في وادي العمارية بالرياض في المملكة العربية السعودية. أثبتت الدراسة أن الطبقة السطحية من التربة بعمق سنتيمتران يوجد بها تباين شديد في عدد البذور القابلة للإنبات حيث تراوح هذا العدد بين 37 بادرة/ م^2 في البيئة التي تنمو عليها عشيرة العاقول ويزداد هذا العدد ليصل إلى 2478 بادرة/ م^2 من التربة التي ينمو عليها عشيرة الحرمل. وعند دراسة إنتاجية بعض النباتات المهمة من البذور لوحظ اختلاف كبير بين إنتاجية الأنواع النباتية من حيث عدد البذور حيث تراوح أعدادها ما بين 168 بذره في نبات العاقول إلى 20775 بذرة في نبات الرمث.