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THE ROLE OF BURIED VIABLE SEEDS IN SALINE DESERT PLANT COMMUNITY

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Abstract

The relationship between seed to vegetation and its temporal dynamics in two saline desert communities were studied for a period of 12 months. Perennial halophytic shrubs dominated vegetation and the buried seed bank. Existing vegetation and seed bank flora showed a marked similarity. The seed densities of *Cressa cretica, Salsola baryosma* and *Haloxylon recurvum* varied with growing season, showing the transient nature of seed bank. The seeds of *Suaeda fruticosa* were found persisting in the soil in large densities. The significance of seed bank for perennial species in saline desert communities is discussed.

Introduction

The crucial and controversial question, whether soil seed banks play an important role in population dynamics of halophytic shrub species in saline deserts has been difficult to resolve because recruitment from seed bank appeared to be a rare phenomenon. However, for annuals which constitute 40% or more of the flora, seeds can be most prevalent form of the species, and during long drought, the only form for several years (Kemp 1989) and after rains seeds become primary form of recruitment. A few studies have been conducted on the seed bank dynamics of desert communities (Nelson and Chew 1977, Reichman 1984, Henderson *et al.* 1988, Coffin and Lauenroth 1989, Hegazy 1990) and on inland saline habitats (Philipupillai and Ungar 1984, Ungar and Riehl 1980, Khan and Ungar 1986, Khan 1990). The precise requirements for inducing germination of seeds that have been stored in saline desert conditions and their seasonal dynamics in affecting halophytic shrub populations are currently not known. The significance of seed reserve of this study is to evaluate the temporal dynamics in the seed bank and its relationship to the shrub dominated salt desert communities.

Materials and Methods

The study was carried out at the University of Karachi campus, situated at about 8 kilmeter, north east of Karachi city (Latitude 24° 48'N, Longitude 65° 55'E). Mean summer temperature is 36 °C and mean winter temperature is 15 °C. Rains are mostly received during monsoon season extending from June to August. The two halophyte communities in the campus were studied where vegetation is dominated by perennial halophytic shrubs. *Cressa cretica* dominates the community I and *Suaeda fruticosa* the community II. Both communities are subjected to moderate grazing and disturbance. Both communities were sampled using point centered quarter method (Cottam and Curtis 1956) before and 20 days after rainfall by placing grid at 20 random points.

Fruits of *Suaeda fruticosa, haloxylon recurvum, Salsola baryosma* and *Cressa cretica* were collected from plants growing in salt flats of Karachi University Campus. Seeds were separated from infructescences and stored in paper bags at 4°C. Initially seeds were surface sterilized with 0.5% sodium hypochlorite solution for 1 min. after which they were washed thoroughly with distilled water. Some seeds were scarified by placing them in conc. H_2SO_4 for 1 min. after which they were thoroughly washed with distilled water. Germination was carried out in test tubes of 12mm in diameter and 150mm in length. In each of these test tubes a Whattman # 1 filter paper strip (2 × 13 cm) was folded in such a manner that two depressions were formed. This strip was placed in the test tube after putting 25 seeds in the depression. Two ml of test solution was gently poured into the tubes, which were then temporarily sealed using rubber bands and polythylene sheets. Four replicates were used for each treatment. Seeds were considered to be germinated upon emergence of radicle. Seeds were germinated in 0, 1, 3, 5% NaCl solutions under 10-25°C alternating temperature regime.

Ten soil cores, measuring 2.5 × 15 cm were collected from each community. These soil cores were stored in plastic bags and screened using 2 mm sieve. Soil texture was determined by hydrometer method (Boyoucous 1951). pH of the soil was determined by using a mixture of soil and distilled water in a ratio of 1:5 with the help of pH meter (Radiometer Ion 85). Soil salinity (1:5 dilution) was estimated by using conductivity meter (Radiometer CD-83). The mixture was shaken for 60 minutes by mechanical shaker.

Seed bank data were collected over a period of 12 months. To analyse the seed bank 40 soil cores were collected from each community at 20 random spots. The cores were picked up with the help of a crore sampler measuring 2.5 × 15cm. These soil cores were brought to the laboratory in polythene bags. These cores were air dried, and large pebbles and twigs were removed. Twenty soil cores were subjected to germination treatment. These cores were watered regularly and placed under natural photoperiod to record the emergence of seedlings. The soil in each core was inverted after ten days. The seedling emergence was monitored upto fifty days. The emerged seedlings were identified, recorded and removed. The remaining twenty samples were analysed under binocular and the seeds of each species were sorted out manually. The seeds were identified with the help of seed herbarium.

Results and Discussion

Vegetation at both communities is dominated by perennial halophytic species (Tables 1 and 2). Species diversity of both community is low. Community I is dominated by *Cressa cretica* followed by *Suaeda fruticosa* (Table 1). However, during monsoon rains salinity level goes down and allows annuals like *Sporobolus arabicus* and *Cynodon dactylon* invade the area. Few *Prosopis* *juliflora* seedlings were also present. Community II is dominated by *Suaeda fruticosa* and *Haloxylon recurvum*. A few other shrubs like *Fagonia indica, Salsola baryosma, Capparis decidua* and *Blepharis sindica* were also found. After the rainfall other species like *Aristida mutablis, Sporobolus arabicus, Zygophyllum simplex* invaded the communities. A few elevated areas show the presence of *Abutilon indicum* and *Heliotropium ophioglossum*. The soil texture of both communities is sandy loam with pH about 8 and the conductivity was about 30 ms cm^{-2}. Soil data of both communities show no difference.

Table 1. Species composition of community I before and after rain.

Species	Time of sampling							
	Before rain				After rain			
	D3	C3	F3	IV	D3	C3	F3	IV
Cressa cretica	85	23	76	68	68	67	57	64
Suaeda fruticosa	15	78	24	32	20	20	27	27
Sporobolus arabicus	—	—	—	—	04	05	03	05
Cynodon dactylon	—	—	—	—	06	07	10	9.53
Prosopis juliflora	—	—	—	—	03	0.16	03	2.05

Table 2. Species composition of community II before and after rain.

Species	Time of sampling							
	Before rain				After rain			
	D3	C3	F3	IV	D3	C3	F3	IV
Blepharis sindica	25	0.4	16	13.6	10	0.41	6.15	5.52
Capparis decidua	02	13	04	6.3	02	12.41	03	5.80
Fagonia indica	02	0.25	04	2.1	01	0.28	2.38	1.22
Haloxylon recurvum	28	44	36	36	19	34.48	28.06	27.18
Salsola baryosma	02	0.08	04	02	01	2.03	1.94	1.66
Suaeda fruticosa	43	42	36	40.3	40	46	32.14	39.38
Abutilon indicum	—	—	—	—	01	0.01	1.38	0.80
Aristida mutabilis	—	—	—	—	03	0.07	2.15	1.72
Heliotropium ophioglossum	—	—	—	—	02	1.17	3.38	1.52
Sporobolus arabicus	—	—	—	—	04	0.14	3.23	2.46
Zygophyllum simplex	—	—	—	—	16	2.57	15.5	10.69

Study of the seed bank was conducted using 2 methods. The data presented in Table 3 represent the first method in which soil was simply watered and the emerging seedlings were counted. This technique appeared to be not successful since most of the seeds show some kind of dormancy. Result presented in Table 4 indicate that seeds could not germinate due either to the presence of hard seed coat or high salinity. Seed dormancy could be alleviated by acid scarification (H_2SO_4) and reduction in soil salinity. Data obtained by counting the number of seeds present in the soil

Table 3. Germination of scarified and unscarified seeds of some halophytes under various salinity treatments

Species	Treatment	NaCl (%)			
		0	1	3	5
Cressa cretica	Nonscarified	25 ± 2	18 ± 2	08 ± 1	04 ± 0.6
	Scarified	89 ± 7	78 ± 5	39 ± 1	16 ± 4
Suaeda fruticosa	Nonscarified	35 ± 3	25 ± 4	03 ± 1	0
	Scarified	91 ± 6	85 ± 4	26 ± 4	05 ±1
Haloxylon recurvum	Nonscarified	21 ± 2	10 ± 2	0	0
	Scarified	75 ± 4	45 ± 3	10 ± 4	0
Salsola baryosma	Nonscarified	80 ± 6	46 ± 3	5 ± 2	0
	Scarified	84 ± 5	55 ± 5	29 ± 3	10 ± 3

Table 4. Average number of individuals whose seeds germinated and seedlings grew in the substrate sample collected from two communities.

Community	Species	Time (month)											
		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
I	*Cressa cretica*				1.02	0.25	0.25	0.25					
	Suaeda fruticosa				1.02	0.25	0.25						
II	*Blepharis sindica*				0.25	0.51							
	Suaeda fruticosa				0.25	0.25	0.25						

sample show the close relationship between vegetation and the seeds buried in soil (Tables 5 and 6). In community I similarity between vegetation and seed bank is higher showing presence of only *Atriplex grifithii* and *Blumea* sp. not found growing in the vegetation. These seeds may have reached there from adjoining less saline communities (Table 5). Similar close relationship between vegetation and seed bank was observed in community 2.

Dynamics of seeds were monitored throughout the year. The data show some interesting pattern. Seed bank size of this desert community is very small. Few seeds of other species are reported present in the seed bank. Community 1 seed bank was dominated by the same species as that of those dominated the vegetation. However, on contrary to vegetation, *Suaeda fruticosa* seeds maintained a dominant seed bank rather than *Cressa cretica*. Number of seeds peaked during February through March and declined thereafter. Community 2 shows the similar pattern where both above and below ground flora is dominated by *Suaeda fruticosa* and *Haloxylon recurvum*. Results presented in Figs. 1 and 2 show that seeds of *Suaeda fruticosa* maintain a persistent seed bank whereas other species like *Cressa cretica* in community I and *Haloxylon recurvum* and *Salsola baryosma* show a transient nature of seed bank.

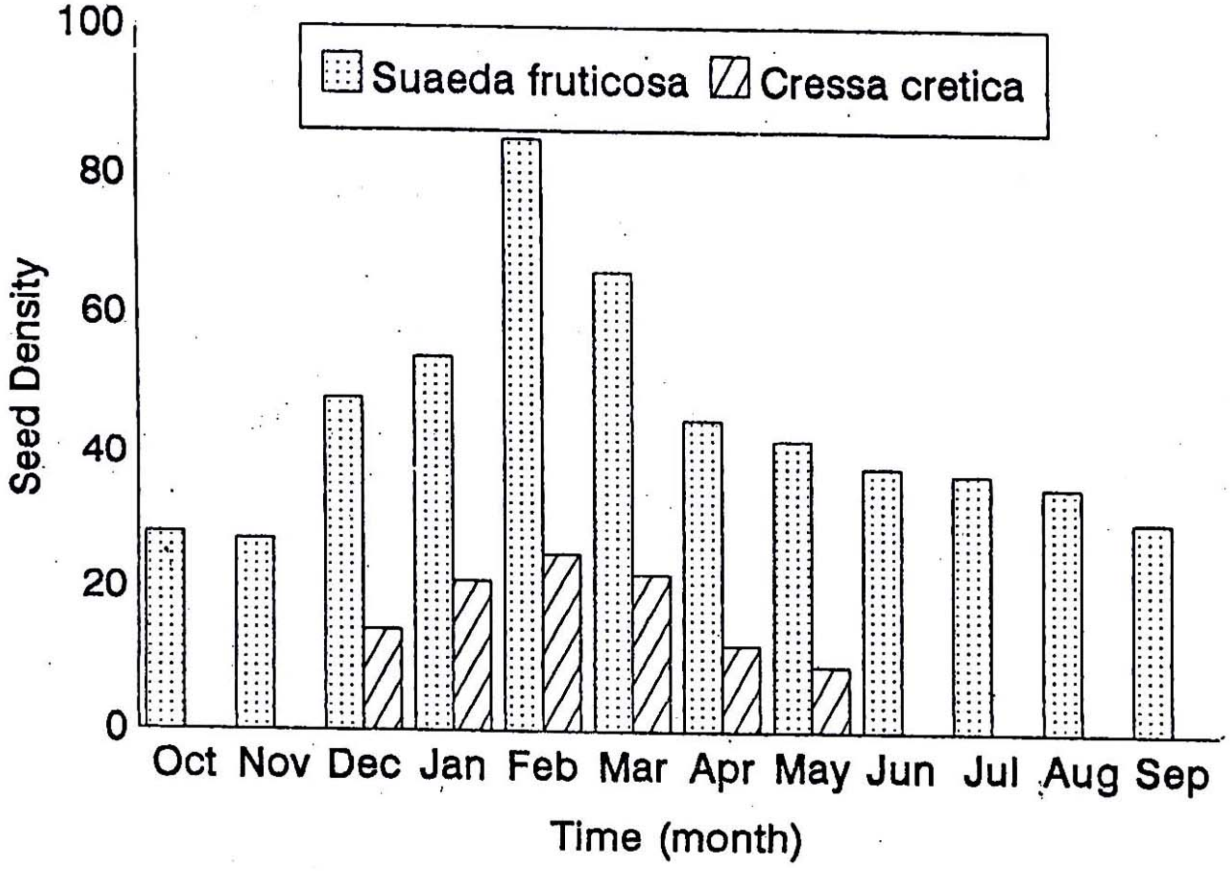

Fig. 1. Seasonal distribution of seed density ($\#/m^2$) in the seed bank from community I.

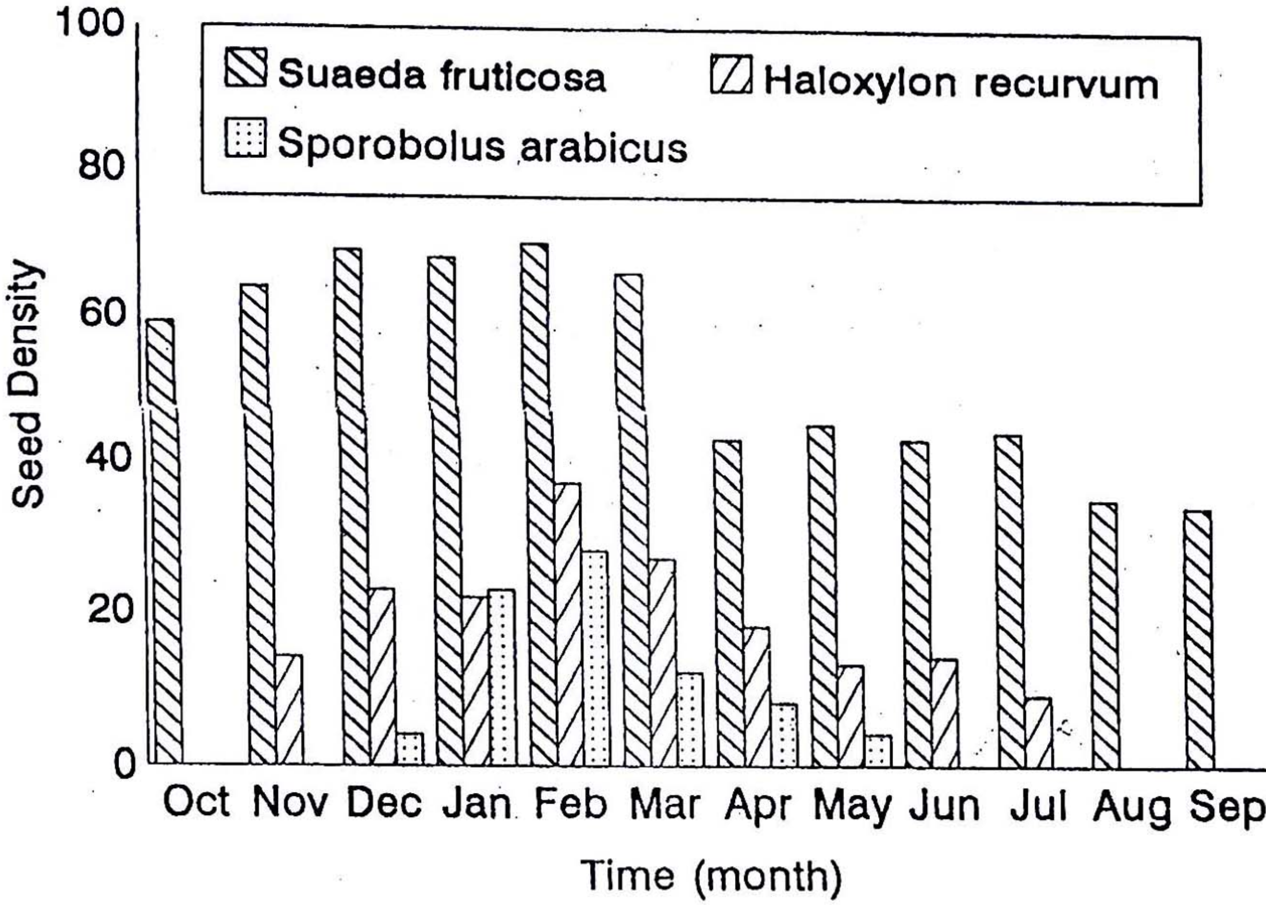

Fig. 2. Seasonal distribution of seed density ($\#/m^2$) in the seed bank from community II.

The spatial and temporal dynamics of desert seed banks can be understood, in principle, by considering the process that governs additions to the seed bank, redistribution, and depletion of seed from seed bank (Harper 1977). While it is relatively easy to identify the major processes that regulate seed banks, it is much more difficult to quantify them. Additionally, the role that different processes play in regulating seed banks can vary with the spatial and temporal scale considered (Kemp 1989). Saline desert community have low species diversity, usually dominated by a few halophytic shrubs. Salt tolerant annuals invade the community after monsoon rains. High soil salinity may be responsible for the low diversity of the vegetation. Rains play a prominent role in regulating vegetation of saline communities (McMahon and Ungar 1978). Due to temporary lowering in salinity levels by drainage and high moisture content in the soil, seeds of different species present in soil have the chance to recruit into the population. However, rains in a desert ecosystem are rare and usually lower the salinity for a short period and rapid drying results in gradual increase in salinity.

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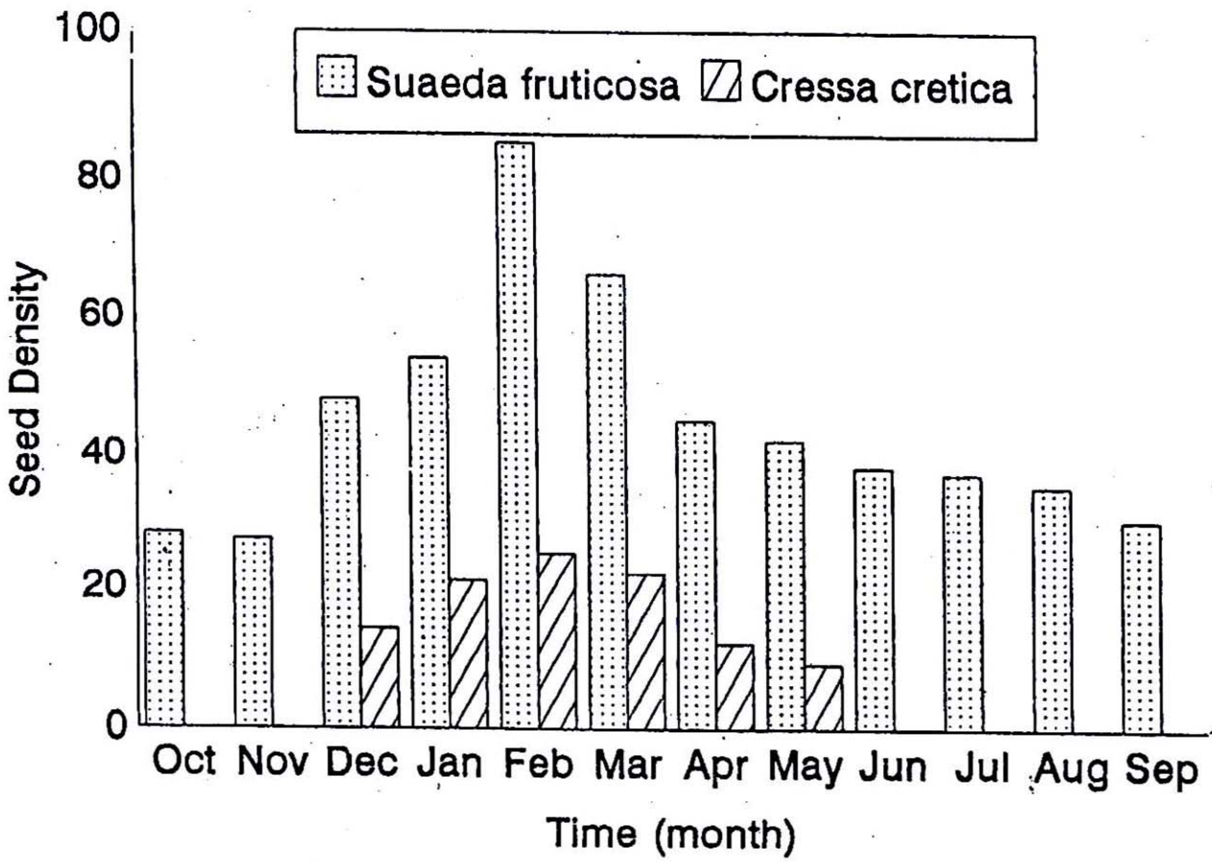

Fig. 1. Seasonal distribution of seed density (#/m^2) in the seed bank from community I.

Table 5. Seed density (m^2) and diversity in the seed bank from community I

Species	Time (month)											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Atriplex grifithii				1.27	0.76							
Blumea sp.	0.51	4.08	3.31									
Cressa cretica			13.91	20.91	25.25	23.21	12.24	9.69	7.91			
Cynodon dactylon			0.51									
Suaeda fruticosa	26.26	24.48	43.35	51.25	83.89	55.59	46.16	42.33	38.50	38.50	34.93	26.75

Table 6. Seed density (m^2) and diversity in the seed bank from community II

Species	Time (month)											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AGU	SEP
Aerva javanica					1.79							
Aristida mutabilis			1.79	3.57								
Haloxylon recurvum		13.89	20.14	19.51	35.19	27.03	15.31	9.39	10.30	7.65		
Blepharis simlica							1.53	0.25				
Salsola baryosma			4.08	20.65	25.78	9.94	5.35	3.28				
Sporobolus arabicus			0.51									
Suaeda fruticosa	58.9	62.73	68.59	68.19	69.01	61.96	40.54	42.84	40.37	39.52	35.13	31.24
Zygophylla simplex	0.45	10.96	02.80	03.31	01.53							

The significance of soil seed reserve in determining the establishment of plant populations in saline desert habitat is not well documented. However, a limited number of investigations is currently available concerning the nature of seed bank in coastal and inland saline habitats (Ungar and Riehl 1980, Jefferies *et al.* 1981, 1983, Keddy and Reznicek 1982, 1986, Smith and Kadelac 1983, Hopkins and Parker 1984, Ungar 1984, McMillan 1988, Khan 1990). Seed dormancy and the production of a soil seed reserve are significant mechanisms in marshy habitats, because they permit a temporal distribution of germination, and all of the seedlings in a population are not exposed to conditions which will cause local extinction. Khan (1990) correlated the seed bank flora with that of existing vegetation in a shrubby saline desert community. He found a poor relationship between seed bank and existing vegetation. Seeds of *Suaeda fruticosa* show a persistent seed bank while seeds of other halophytes, e.g. *Haloxylon recurvum*, *Salsola baryosma*, and *Cressa cretica* show a transient nature of seed bank. The data reported here consider the temporal dynamics of the seed bank. These data show that the correspondence between seed bank and existing vegetation in a saline desert community will depend upon the period during which the data were taken. If the data are taken a few months after monsoon the relationship between seed bank and vegetation will be high. However, after this time, due to transient nature of the seed bank the relationship will become poor. McIntyre *et al.* (1989) found that *Diplachne fusca* can develop a persistent seed bank with 48,000 seed m^{-2}. Aziz and Khan (1991) studied the seasonal dynamics of seed reserve in a coastal marsh community dominated by *Cressa cretica*. They showed a transient nature of the seed bank. No seeds were found during the months of September-February and the number of seeds in the seed bank increased for few months but they begin to drop substantially and no seed was found during August. Hopkins and Parker (1984) found a good relationship between the dominance of the perennial halophyte *Salicornia virginica* and its importance in the seed bank of a San Francisco salt marsh. However, the other dominant perennials in zonal communities such as *Suaeda fruticosa*, did not produce a persistent seed bank. The seed bank at both communities is dominated by the perennial halophyte *Suaeda fruticosa* because this species displays persistent nature of seed bank.

The similarity between seed bank and vegetation was high. In hypersaline environments the existing vegetation is strongly represented in the seed bank (Ungar and Riehl 1980, Philipupillai and Ungar 1984). Hopkins and Parker (1984) have also documented 88% correspondence between vegetation and seed bank of a salt marsh. Henderson *et al.* (1988) found in a desert grassland community a noted 89% correlation between seed bank and vegetation, and proposed that extreme and unpredictable variation in desert grassland community selected the species having a persistent seed bank. Other studies like Thompson (1986), Parker and Leck (1985) and Henderson *et al.* (1988) show the similar results.

The seed bank of *Cressa cretica*, *Haloxylon recurvum* and *Salsola baryosma* showed seasonal and temporal variation, along the growing season. From February the seed densities decreased and until June the seed banks of the above species were exhausted. The transient nature of the seed bank of *Cressa cretica* has also been reported by Khan (1990). Coffin and Lauenroth (1989) have emphasized the need for intensive sampling of the seed bank of species occurring infrequently in the vegetation. The distribution pattern of seeds in the soil is also important in the presence of seeds in the soil cores (Thompson 1986).

The seeds of *Suaeda fruticosa* showed little variation throughout the growing season at both the communities. More or less consistent distribution of *Suaeda fruticosa* in the seed bank shows that this species forms persistent seed bank. The inability of the seeds to germinate immediately after dispersal may be the cause of persistent seed bank. Ungar (1987) has pointed out that precise requirements for inducing germination of halophyte seeds stored in the soil for long periods are unknown. Louda (1989) has proposed that preferred seed predation may also affect the persistent and transient nature of seeds in the seed bank. Predation hypothesis remains to be worked out in connection with the seed banks of salt desert communities. Temporal difference between years and within years have also been documented in the seed bank of a semi-arid grassland by Coffin and Lauenroth (1989). Perennial needs only limited success, as once they establish, they are able to perpetuate vegetatively (Ungar 1987). Halophytic species reported here show a very rare recruitment from the seeds. Usually they produce new individuals through vegetative growth. Upper soil layer is usually dry and even after rains water dries quickly due to higher rate of evaporaiton rendering it more saline. This increase in salinity few days after rains make any recruitment through seeds very difficult. Seeds appear to be the insurance of any loss of vegetation due to years of prolonged drought and the source of genetic variability. Seeds do not seem to have an immediate role in the population dynamics of desert shrubs. However, they certainly maximize the fitness of halophytic species on a long term evolutionary scale. In salt ecosystems effects of seed predation also need experimental verification and any study upon the seed bank dynamics over an extended period can sharpen our knowledge about the vegetation dynamics of these saline desert ecosystems.

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