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RELATIONSHIP OF SEED BANK TO PLANT DISTRIBUTION IN SALINE ARID COMMUNITIES

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Abstract

Species of seed bank and those occurring in vegetation were compared for six desert halophytic shrub communities. Perennial shrubs like *Suaeda fruticosa, Haloxylon recurvum, Cressa cretica* and *Salsola baryosma* dominated the six communities studied. Communities also showed very low species diversity. The seed bank was represented by a large number of species as compared to the species present in the vegetation, indicating a poor relationship between seed bank and vegetation. *S. fruticosa* maintains a persistent seed bank thereby dominating the seed bank flora of almost all communities irrespective of the dominant species. All other perennial halophytic species studied showed a transient nature of the seed bank. Monthly seed bank data was collected for 2 halophytic species for 12 months. Presence of *H. recurvum, S. fruticosa* and *C. cretica* was higher in the seed bank after seed dispersal and except for *S. fruticosa* seeds, the number of all other species declined substantially in the soil.

Introduction

Seed dormancy and production of soil seed reserve are significant mechanisms in the saline environments because they permit a temporal distribution of germination (Ungar, 1987a). All of the seeds in a population are not exposed to conditions which will cause local extinction. However, significance of soil seed reserve in determining the establishment of plant populations in saline habitats are not well documented. Although the nature of the seed banks in coastal and inland saline habitats has been reported (Ungar & Riehl, 1980; Jefferies *et al.,* 1981, 1983; Keddy & Reznicek, 1982, 1986; Smith & Kadlec, 1983; Hopkins & Parker, 1984, Khan & Ungar, 1986; Wertis & Ungar, 1986) but the role of seed bank and its dynamics in affecting halophytic shrub populations in arid saline areas is not clearly understood.

Role of seed bank and their relationship to the shrub vegetation in a desert community is also poorly understood (Henderson *et al.,* 1988; Coffin & Lauenroth, 1989; Khan, 1990; Hegazy, 1990). Presence of transient and persistent seed bank in desert communities indicate some role of seed bank in regulating vegetation dynamics in a saline desert region (Khan, 1990). The purpose of this study was to investigate the relationship between vegetation and the seed bank along with its temporal dynamics.

Materials and Methods

Site Description: The study area is located on the Karachi University Campus, 30 kilometer north of the Arabian sea and about 8 kilometer north of Karachi city (Latitude 24°48' N and Longitude 66°55' E). Karachi represent a sandy desert belt of Pakistan along the Arabian coast. The climate of Karachi is sub tropical maritime desert (Chaudhry, 1961). Rainfall is seasonal, averaging 22 cm per year between June and September and rare for the remainder of the year. Occasionally there are dry years too. The mean maximum temperature is 35°C in July and mean minimum temperature is

Table 1. Vegetation and seed bank characteristics of community 1

	Vegetation			Seed Bank
Name of Species	RD	RF	RC	Seed density
Suaeda fruticosa	22	27	53	981
Cressa cretica	75	67	39	01
Salsola baryosma	03	06	26	04
Zygophyllum simplex	-	-	-	02
Aristida mutablis	-	-	-	06
Cyperus rotundus	-	-	-	05
Cleome viscosa	-	-	-	02

Haloxylon recurvum, Atriplex griffithii, Digera muricata, and *Convolvulus glomeratus* are represented in the seed bank with equal to or less than 1 seed/m^2.

Table 2. Vegetation and seed bank characteristics of community 2

	Vegetation			Seed Bank
Name of Species	RD	RF	RC	Seed density
Suaeda fruticosa	53	53	47	336
Cressa cretica	03	03	04	02
Salsola baryosma	17	17	27	02
Haloxylon recurvum	10	10	08	05
Prosopis juliflora	17	17	24	-
Suaeda nudiflora	-	-	-	03
Zygophyllum simplex	-	-	-	19
Blepharis sindica	-	-	-	06
Commicarpus boisseri	-	-	-	09
Aristida mutablis	-	-	-	15
Cyperus rotundus	-	-	-	12

Atriplex griffithii, Amaranthus viridis, Leucus urticifolia, and *Salvia santolinifolia* are represented in the seed bank with equal to or less than 1 seed /m^2.

15°C in January. The temperature remain suitable for plant growth throughout the year. Strong coastal winds and dew formation are the characteristic features of Karachi.

Field studies were conducted at six saline plant communities having predominantly shrubby halophytic composition. Moderate grazing by cattle occurred throughout the sites.

Vegetation Sampling: The plant communities were sampled using Point-centered Quarter method (Cottam & Curtis, 1956). The species composition of each site was evaluated by placing the grid randomly on 20 different points.

Seed Bank Sampling: Forty soil seed bank samples were collected using 2.5 x 15 cm metal soil core from a depth of 15 cm in the plastic bags. Twenty soil samples spread in the plastic trays were regularly provided with water for seed germination. Seedlings were identified, counted and then removed. At every 15 days interval for upto 6 weeks the soil present in the tray upturned to expose more seeds to light. The remaining 20 soil samples from each community were examined under the binocular microscope and the seeds separated manually. Seeds of various species were sorted into various groups and identified with help of the seed collection from existing flora and specimens present in the Karachi University Herbarium.

Seed bank data were collected over a period of 12 months. To analyse the seed bank, 40 soil cores collected from each community at 20 random spots in polythene bags with the help of a core sampler measuring 2.5 x 15cm. The soil after air drying and removal of large pebbles and twigs was subjected to germination treatment. The soil regularly watered was 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 50 days. The emerged seedlings were identified and then removed. The remaining 20 samples were analysed under binocular microscope and the seeds of each species were manually sorted out and identified after comparision with the seed herbarium.

Soil Sampling and Analysis: Twenty soil samples collected at 0-15 cm depth using the metal soil core of 9 cm in diam, were brought to the laboratory, air dried and after removal of larger pebbles and plant parts stored in a plastic bags for physicochemical analysis. Soil texture was determined by Bouyoucous hydrometer method (Bouyoucous 1951). pH was measured using a pH meter (Radiometer CD-83) where 10 g soil was suspended in 10 ml of distilled water with further dilution series of 1:2, 1:3, 1:4, and 1:5. Carbonate was determined by acid neutralization method. Salinity measurements were made using conductivity meter (Radiometer, CD-83), where 10 g of air-dried soil was suspended in 50 ml of water, agitated for 2 h with mechanical shaker and then filtered with buchner funnel using vacuum extraction. Ammonium acetate extraction procedure were used to estimate Na and K concentrations in the soil using flame photometer.

Results

Vegetation: Perennial shrubs like *Suaeda fruticosa, Cressa cretica* or *Atriplex griffithii* dominated in all the six communities studied (Table 1-6). Number of species present in the vegetation was substantially lower and diversity increased with decrease in salinity. Community dominated by *A. griffithii* have high species diversity whereas other communities showed low species diversity.

Table 3. Vegetation and seed bank characteristics of community 3

	Vegetation			Seed Bank
Name of Species	RD	RF	RF	Seed density
Suaeda fruticosa	69	11	39	233
Salsola baryosma	05	22	19	02
Haloxylon recurvum	18	56	25	01
Leucus urticifolia	-	-	-	14
Zygophyllum simplex	-	-	-	10
Blepharis sindica	-	-	-	04
Commicarpus boisseri	-	-	-	05
Aristida mutablis	-	-	-	25
Eragrostis ciliaris	-	-	-	10
Tragus biflorus	-	-	-	06
Cleome viscosa	-	-	-	02

Amaranthus viridis, Digera muricata, Tephrosia strigosa, Eragrostis pilosa, and *Heliotropium ophioglossum* are presented in the seed bank with less than one or 1 seed/m^{2}.

Seed Bank: Number of species represented in the seed bank was much higher than the existing vegetation (Table 1-6), thus indicating a poor relationship between existing vegetation with those represented in the seed bank. *S. fruticosa* appears to have persistent seed bank since it maintained a large seed bank as compared to other a species. Other species present in the seed bank showed transient nature of the seed bank. Community 1 was dominated by *C. cretica* (IVI = 181) with *S. fruticosa* (IVI = 102) as second dominant. However, representation of *C. cretica* in seed bank was very low (1 seed m^{-2})

Table 4. Vegetation and seed bank characteristics of community 4

	Vegetation			Seed Bank
Name of Species	RD	RF	RC	Seed density
Suaeda fruticosa	20	27	20	270
Cressa cretica	68	57	67	09
Cynodon dactylon	06	10	07	-
Sporobolus arabicus	04	03	05	-
Prosopis juliflora	02	03	03	-
Blumea obliqua	-	-	-	01
Cleome viscosa	-	-	-	2

Table 5. Vegetation and seed bank characteristics of community 5.

	Vegetation			Seed Bank
Name of Species	RD	RF	RC	Seed density
Suaeda fruticosa	58	43	60	310
Haloxylon recurvum	29	38	37	02
Sporobolus arabicus	05	01	05	1
Heliotropium ophioglossum	03	03		01
Prosopis juliflora	01	02	01	-
Salsola baryosama	01	02	<01	-
Zygophyllum simplex	01	02	<<01	-
Fagonia indica	01	02	<<01	-
Abutilon indicum	01	02	<<01	-

Table 6. Vegetation and seed bank characteristics of community 6.

	Vegetation			Seed Bank
Name of Species	RD	RF	RC	Seed density
Atriplex griffithii	65	65	24	8.7
Lactuca sativa	10	10	04	<1
Indigofera oblongifolia	06	06	06	-
Chloris barbata	05	05	01	<1
Chorchorus depressus	05	05	02	-
Rhynchosia minima	03	03	01	-
Heliotropium ophioglossum	01	01		02
Suaeda fruticosa	03	03	08	-
Prosopis juliflora	01	01	54	-
Eupohorbia geniculata	01	01	<01	-
Trianthema pentandra	-	-	-	4.1
Cenchrus cilliaris	-	-	-	3.3
Tribulus terrestris	-	-	-	1.8
Aristida mutablis	-	-	-	1.8

Aerva javanica, Achyranthus aspera, Sida ovata, Sporobolus arabicus, Boerhaavia procumbens, and *Salsola baryosma* are present in the seed bank with less than 1 seed/m^2.

Table 7. Physical and Chemical Properties of Soils Collected from Six Communities

Soil Parameters	Plant Communities					
	I	II	III	IV	V	VI
Texture	Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay loam
pH	8.6	8.5	8.3	8.4	8.6	8.5
Conductivity (ms/cm)	26	34	23	28	29	15
Na^+ (%)	0.4	0.4	0.3	0.3	0.4	0.2
K^+ (%)	0.06	0.001	0.007	0.006	0.007	0.009

as compared to *S. fruticosa* (981 seeds m^{-2}). In community 6 which was dominated by *A. griffithii* only 8 seeds m^{-2}) were found present in the seed bank. This indicate that most of the species present in the saline desert communities have transient seed bank.

Data regarding physical and chemical properties of the soil (Table 7) showed that texture of soil was generally sandy clay loam with alkaline pH (8.3-8.6). Electrical conductivity was high except in community 6. Sodium concentration was relatively high with very low K concentration.

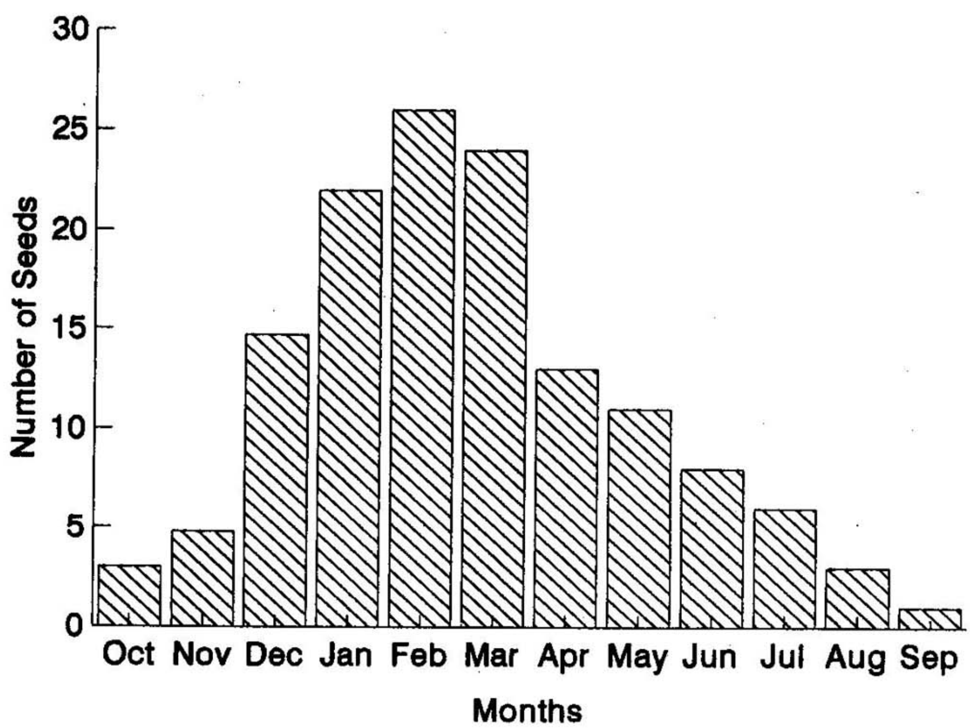

Fig.1. Seasonal distribution of *Cressa cretica* seeds (#/m^2) in the seed bank from community I.

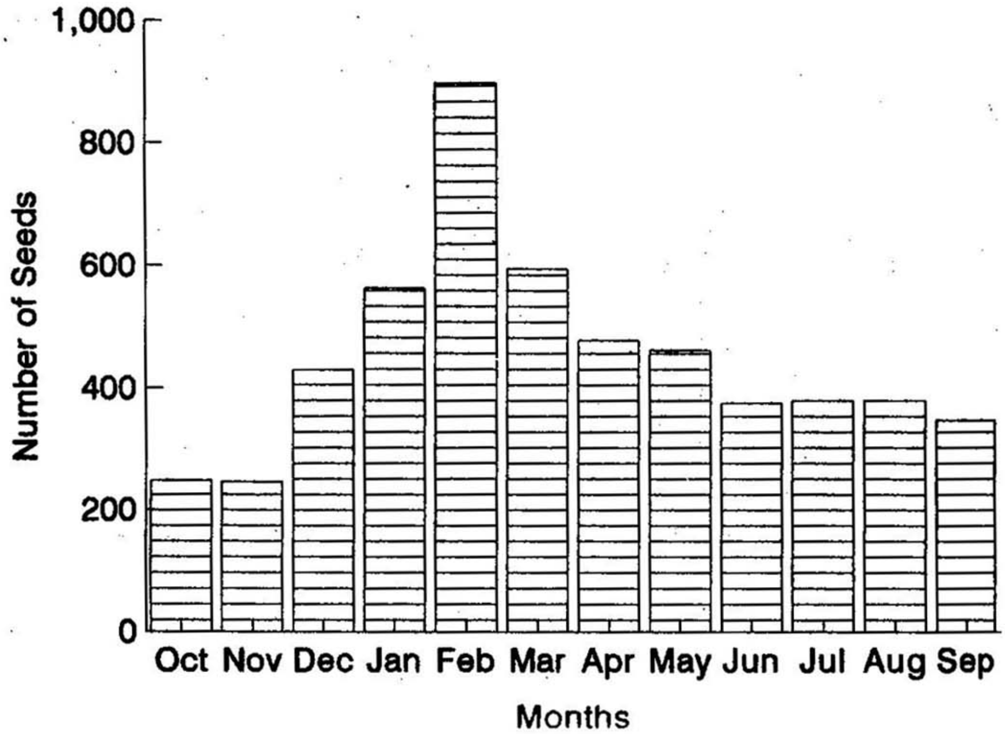

Fig.2. Seasonal distribution of *Suaeda fruticosa* seeds (#/m^2) in the seed bank from community I.

Seed bank data of community 1 and 2 collected at monthly interval (Fig. 1 and 2) shows the seasonal distribution of *S. fruticosa* and *C. cretica*. Number of seeds of both species attained a peak during February which declined thereafter. *C. cretica* is left with few seeds after few months, however, *S. fruticosa* continued to maintain a large seed bank throughout the season. Similar results were obtained for community 2 in which seasonal distribution of *H. recurvum* and *S. fruticosa* were studied (Fig. 3 and 4). *H. recurvum* showed a transient seed bank while *S. fruticosa* showed a persistent seed bank.

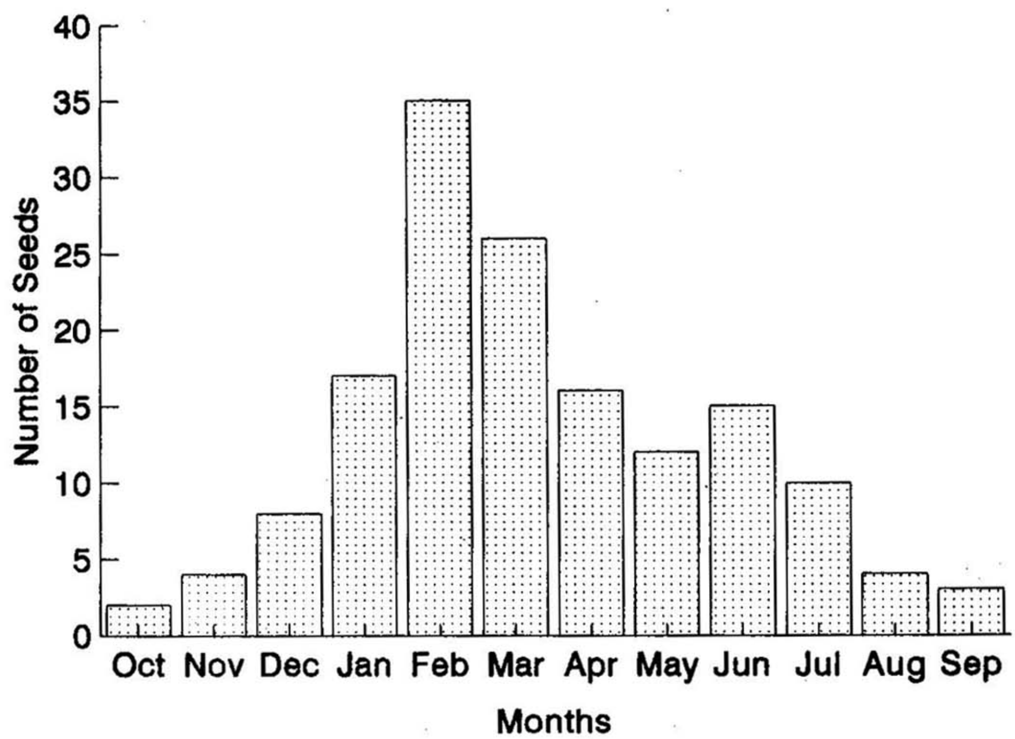

Fig. 3. Seasonal distribution of *Haloxylon recurvum* seeds (#/m^2) in the seed bank from community II.

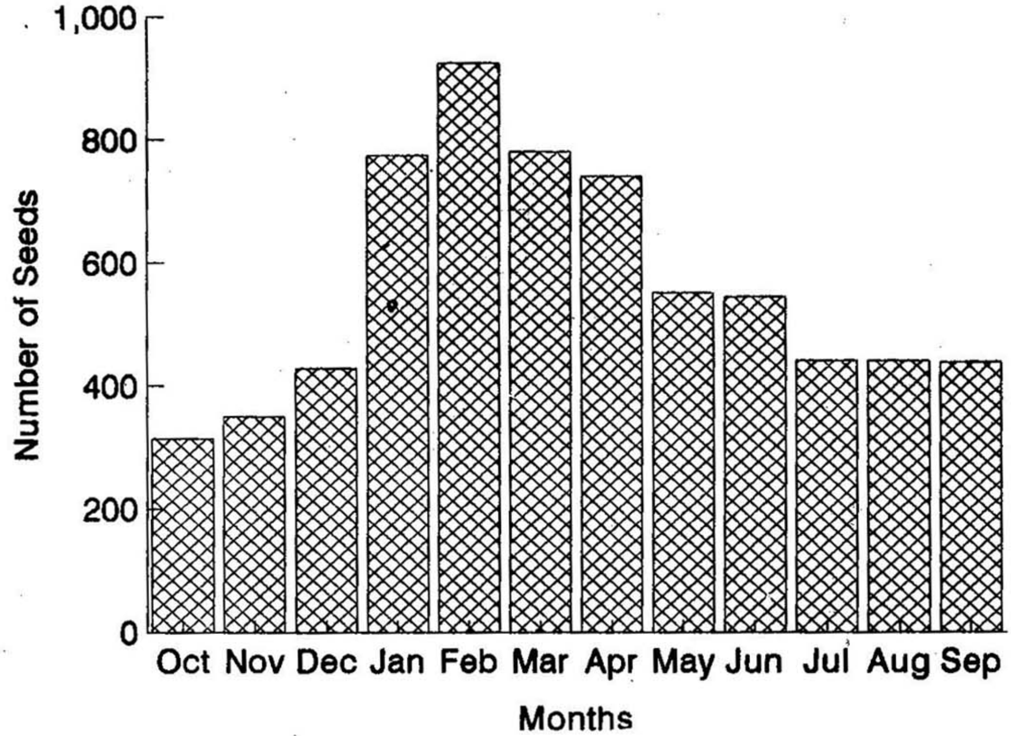

Fig.4. Seasonal distribution of *Suaeda fruticosa* seeds (#/m^2) in the seed bank from community II.

Discussion

Saline desert communities are characterizeed by the dominance of a few halophytic shrubs. High soil salinity could be the cause of low species diversity in these communities. Rains may play a prominent role in regulating the vegetation of saline community (McMahon & Ungar, 1978). Annual monsoon rains lowers the salinity levels by drainage and high moisture content in the soil. Seeds of annuals as well as perennials have a chance to recruit into the community. However, rapid drying in a desert condition results in a corresponding rapid increase in soil salinity. These plants have to develop strategy to reproduce in a very short period.

Six communities studied have very low species diversity. Communities are dominated by *S. fruticosa* or *C. cretica* with exception of *A. griffithii* which dominated in one community. *P. julifora*, a large shrub, was noticed invading these communities. Seed bank showed a quite different picture. Seeds of *S. fruticosa* are always present in large number despite their importance in the vegetation. This represents a persistent nature of the seed bank while other halophytic species maintain a very small seed bank inspite of their dominance in the vegetation. This represents a transient seed bank. Temporal distribution of *S. fruticosa, H. recurvum*, and *C. cretica* were monitored for 12 months showed that increase in the number of seeds in the seed bank corresspond to the seed dispersal from parent plants. Seeds of *S. fruticosa* maintains high diversity throughout the year but the density of *H. recurvum* and *C. cretica* rapidly decreases to few seeds per square meter. Relationship between vegetation and seed bank was rather poor. Seed bank is represented by large number of annuals which are not present in the vegetation.

Transient nature of seed bank for dominant species like *C. cretica* and *A. griffithii* could be attributed to seed predation. Louda (1989) indicated that seed predation may create the difference between transient and persistent seed pools. Hopkins & Parker (1989) reported seed predation as a factor in maintaining seed bank in a perennial salt marsh community.

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 & Riehl, 1980; Jefferies *et al.*, 1981, 1983; Keddy & Reznick, 1982, 1986; Smith & Kadelac, 1983; Hopkins & Parker, 1984; Ungar, 1984, 1988; 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 *S. fruticosa* showed a persistent seed bank while seeds of other halophytes e.g., *H. recurvum, S. baryosma*, and *C. cretica* showed 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 (1993) studied the seasonal dynamics of seed reserve in a coastal marsh community dominated by *C. cretica* which showed a transient nature of the seed bank. No seeds were found during the month of September - February and the number of seeds in the seed bank increased for few months and then began to drop substantially and no seed was found during August. Hopkins & 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 *Spartina foliosa*, did not produce a persistent seed bank. The seed bank at both the communities is dominated by the perennial halophyte *S. fruticosa* because this species display persistent nature of seed bank. The seeds of *S. fruticosa* showed little variation throughout the growing season at both the communities. More or less consistent distribution of *S. 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 (1987a) 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 differences between years and within years have also been documented in the seed bank of a semi-arid grassland by Coffin & Lauenroth (1989). Perennial plants needs only limited success, as once they become established, they are able to perpetuate vegetatively (Ungar, 1987b).

Halophytic species reported here show a 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 evaporation 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 desert ecosystems effects of seed predation also need experimental verification and any study upon the seed bank dynamic over an extended period can explain about the vegetation dynamics of these saline desert ecosystems.

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