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ECOLOGICAL STUDIES ON RAWDHAT SYSTEM IN SAUDI ARABIA - II. SOIL SEED BANK OF RAWDHAT KHORIM

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Abstract

The germinable seeds in the seed bank in the uppermost two centimeter layer of the soil of Rawdhat Khorim in the Riyadh region of Central Saudi Arabia was studied using 1250 cm^2 soil samples collected in winter season from three line transects. The seed bank composition was determined using germination experiment. Most of the seedlings emerged in the first three weeks. The final number of seedlings ranged from 18 to 1190/m^2. The floristic composition of the emerged seedlings consisted of 56 plant species. There was a compositional difference in the emerged seedlings between sites having different soil texture. Biomass of the emerged seedlings ranged from 2.14 to 51.8 g/m^2 depending on the seedling density and soil texture.

Introduction

Seed bank ecology is important for understanding the plant community development and its population dynamics. Seed bank is an aggregation of ungerminated seeds capable of replacing mature annual and perennial plants (Baker, 1989). Seeds often occur as a thin discontinuous layer near the soil surfaces. Young (1988) reported that distribution of seeds in this layer is usually influenced by the habitat microtopography and the location of the litter deposition etc. Information regarding seed bank are large and expanding rapidly (Egley, 1989; Benoit *et al.*, 1989; Hodgson & Grime, 1990) and have been documented for many different plant communities (Thompson & Grime, 1979; Probert, 1981; Leck *et al.*, 1984; Fenner, 1985). Evaluation of soil seed-bank is important for the development of terrestrial plant communities, successional patterns and regulation of their population dynamics (Baker, 1989; Fenner, 1985; Khan, 1990). It is also part of the vegetation (Ungar & Riehl, 1980). The seed-bank, therefore, provide a substantial flexibility for potential community changes and maintaining genetic diversity in popultion and community (Leak *et al.*, 1984; Ortega *et al.*, 1997).

Existence of soil seed banks in the desert habitat and their role in plant population dynamics are poorly understood (Kemp, 1989; Khan, 1990; Al-Yemeni & Al-Farraj, 1995). The only previous study in Central Saudi Arabia on buried seed banks was conducted by Al-Yemeni & Al-Farraj (1995). They found that the viable seeds in the desert seed-bank vary from 44 to 2660 seedling/m^2, depending upon the microhabitat types. Zayed (1980) reported the highest number of seedlings 6400 /m^2 in desert soils whereas Batanouny *et al.*, (1991) reported higher seed density in the arable land of Egypt which ranged from 256 to 3516 seeds/m^2.

The objectives of this study were to determine (1) the relative abundance of seeds in the soil seed bank of Rawdhat Khorim and (2) to ascertain how this may relate to the species composition of the above ground vegetation.

Study site

The study site "Rawdhat Khorim" is located between (25° 30N and 47° 30E) and about 120 Km North East of Riyadh (Fig. 1). Full description of the site was given in an earlier study by Al-Farraj *et al.*, (1997), who identified 114 plants species.

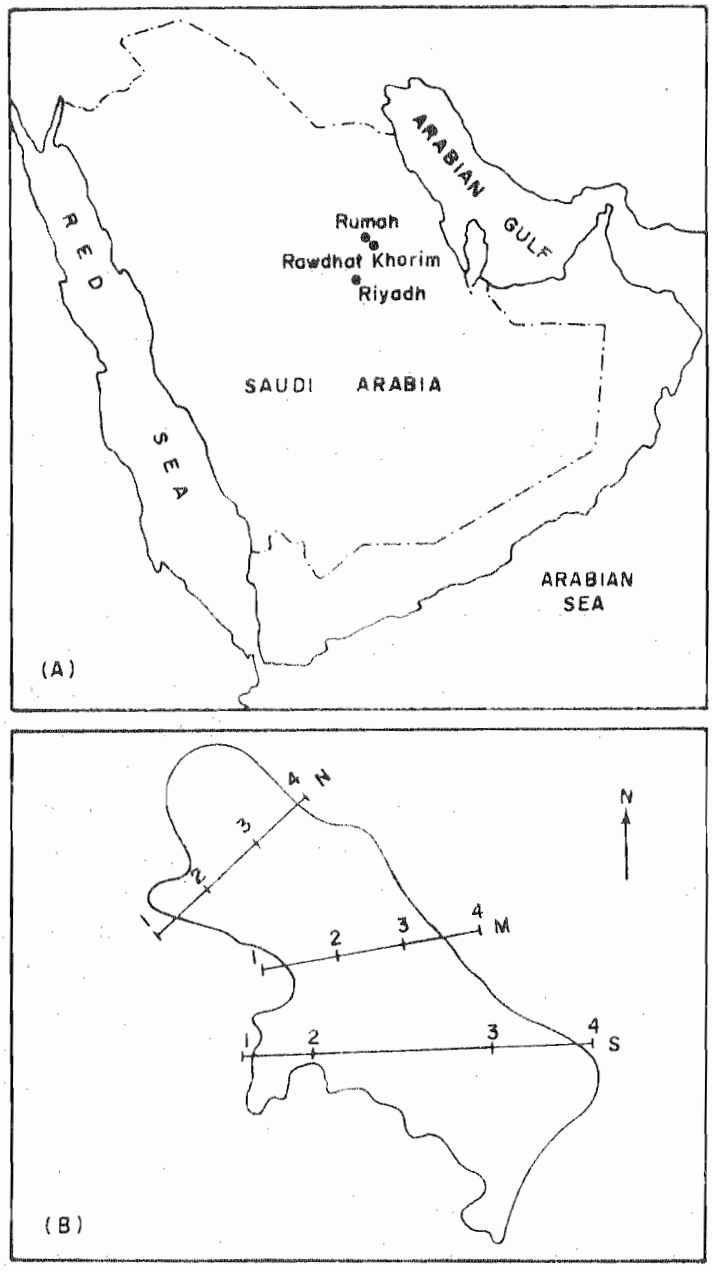

Fig. 1. Map of Saudi Arabia (A) and Rawdhat Khorim (B) where N, M, and S represent, northern, middle and southern transects, respectively.

Material and Methods

Three trips were made during the winter (January, 1977) for the collection of the soil samples. Three line transects were laid down across the Rawdhat Khorim viz., North (N), Middle (M) and South (S), (Fig. 1B). Each one of these transect was divided into

four collection points, with four replicates making up 48 soil samples. Each soil sample unit was taken from the uppermost two cm of the soil surface over an area of 25 cm X 25 cm and represents a volume of 1250 cm^3. All soil samples were transported in cloth bags to the green house of Botany Department at College of Science, King Saud University. Soil samples were dried at room temperature and sieved to remove any debris present and later put into trays each measuring approximately 50 X 50 cm. Seed germination experiment was conducted in the green house for all the soil samples where the day and night temperature was kept at 36/21 $\pm 2^{\circ}C$ respectively. Each soil sample unit was replicated four times and placed in completely randomized block design. Irrigation was made twice a week with tap water. The emerged seedlings in each tray were counted daily until no further seedlings appeared for five successive weeks. At the end of the experiment, all seedlings were harvested and oven dried at $85^{\circ}C$ for 48 hours, then the dry weights of the seedlings were recorded. Identification of plant species was made according to Migahid (1990) and Mandaville (1990).

Results and Discussion

The occurrences of soil seed banks in desert and semi-desert environment are usually concentrated in the upper two centimeters (Baker, 1989), while Kemp (1989) reported that seeds of many desert annual species germinate and emerge from a depth of more than one centimeter.

Our results indicate that the emergence of seedlings begins in the first week in all sites of the three transects. The number of emerged seedlings was found to increase on a weekly basis from 0.3 in N4 to a maximum on the fifth week in M3-1190 seedlings/m^2. (Fig. 2, 3 and 4). The number of emerged seedlings showed a wide variation in the soil samples. The highest number of seedlings was recorded from soil collected in the middle part of the Rawdhat (M2-1190, N2-1126 and S2-1036 seedlings/m^2), while the lowest values were recorded in soil collected from transects N4-18.1, S4-200 and M1-243 seedlings/m^2, respectively (Table 1).

The highest number of seedlings was found in the soil collected from the middle transect M4 which is a protected area well inside the "Rawdhat" away from the road traffic. This part is usually rich in plant cover compared to the surrounding area. The lowest number of seedlings was recorded in the soil collected from an unprotected northern part of "Rawdhat" which is near to the road traffic and usually poor in plant cover (Al-Farraj *et al.*, 1997). The result showed that most of the viable seeds in the soil seed bank of the study area are present in the uppermost two centimeter of the soil surface. However, this does not represent the whole soil seed banks of the study area as it contains other seeds such as non-viable, dormant and deeply buried seeds. Our results therefore, represent only part of the potential maximum of seeds in the soil seed bank and are in good agreement with the results reported by Harper (1977), while the rest may form part of the total soil seed banks which remains present in a dormant state and has been recognized as a deposit account. The seeds of the entire soil seed-bank is also not able to germinate at any particular time for many reasons (Hopkins *et al.*, 1984; Fenner, 1985; Bradbeer, 1988; Mayber & Poljakoff-Mayer, 1989; Al-Hodgson *et al.*, 1990; Yemeni & Al-Farraj, 1995; Ortega *et al.*, 1997).

The seedling number in our results is comparatively lower than that reported by Zayed (1980) & Al-Yemeni & Al-Farraj (1995). Zayed (1980) reported 400 seedlings in the desert soil seed banks of Egypt while Al-Yemeni & Farraj (1995) reported a higher value of 2260 seedlings from desert soil seed banks of Saudi Arabia. Higher emergence

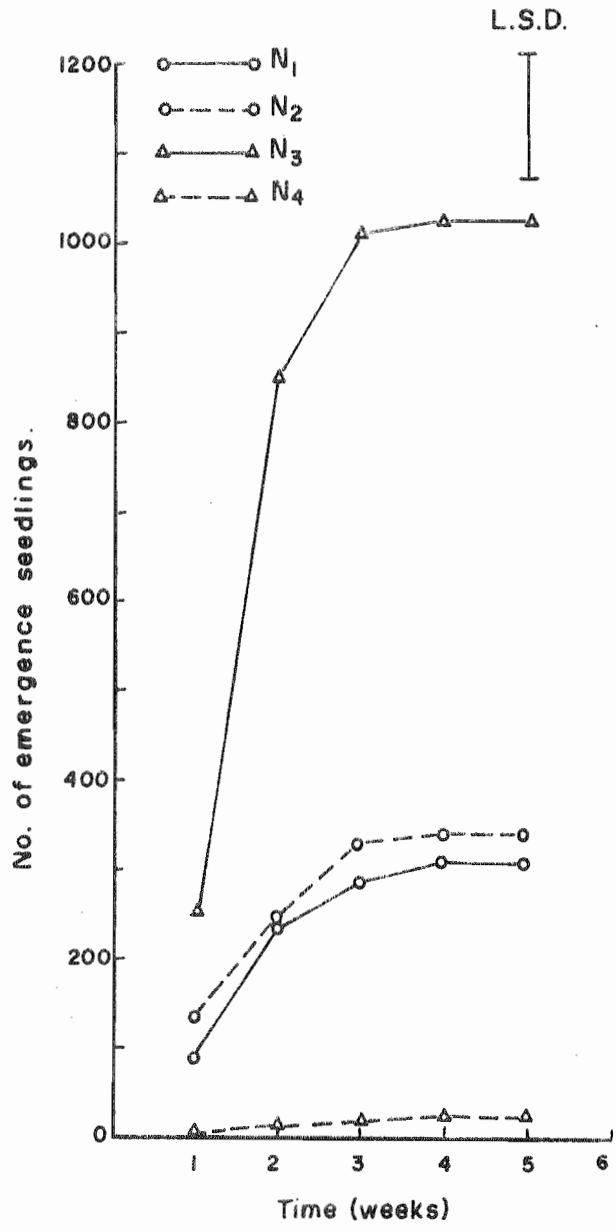

Fig. 2. Emergence of seedlings/m^2 from soils collected from Northern transects (N) of Rawdhat Khorim where N1-N4 represents the sites across the transects. Germination experiment was conducted in green house.

rates have been found in cultivated fields, which ranged from 10,000 to 100,000 plants/m^2 as reported by Williams & Egly (1978).

Spatial differences of emerged seedlings between sites differing in soil texture were attributed primarily to the dynamics of the seeds of annual plants, soil seed composition, soil fertility and micro-climate of the habitat (Henderson *et al.*, 1988; Al-Yemeni & Al-Farraj, 1995; Ortega, *et al.*, 1997). The interaction between the effects of soil texture on plant community composition contribute to spatial variation in soil seed bank (Coffin *et al.*, 1987 & Al-Farraj *et al.*, 1997), the low and variable patterns of precipitation found in semi-arid regions (Fenner, 1985) and spatial and temporal variability in processes important on the storage of germinable seeds (Coffin *et al.*, 1989).

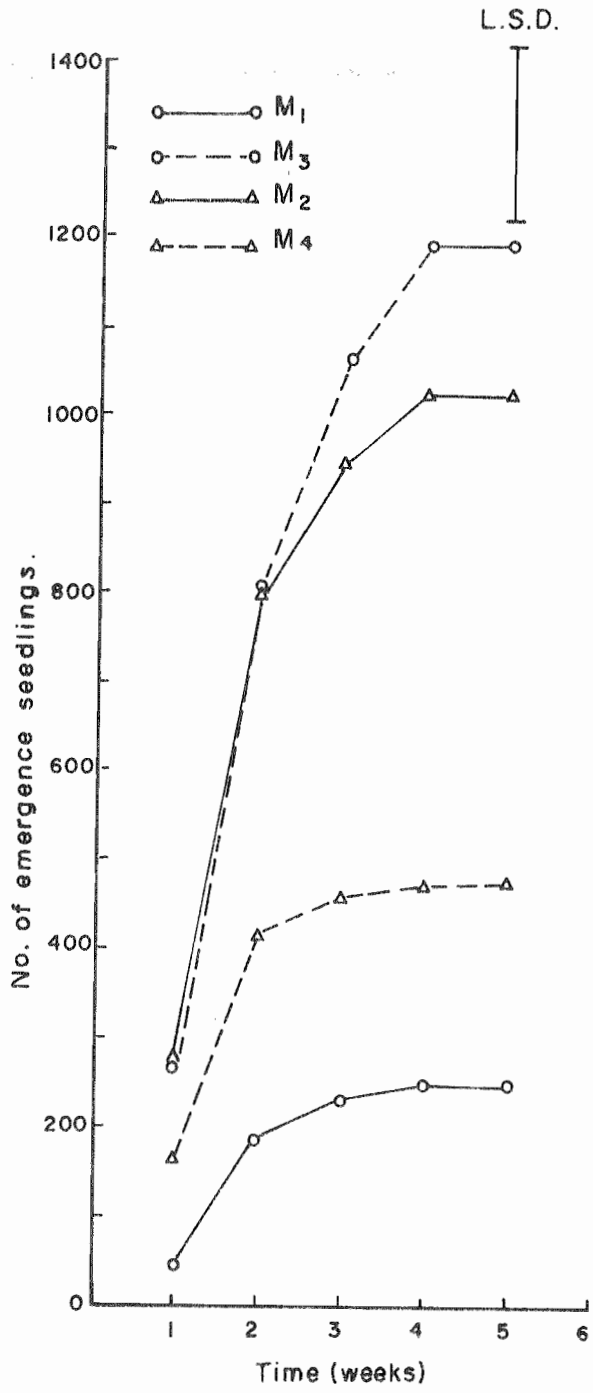

Fig. 3. Emergence of seedlings/m^2 from soils collected from Middle transects (M) of Rawdhat Khorim, where M1-M4 represents the sites across the transects. Germination experiment was conducted in green house.

The floristic composition of the emerged seedlings as well as the number of individuals per 0.25 cm^2 is shown in Table 1. The data reveals that the majority of the emerged plants from different transects were identified as winter annuals (49 species) and the rest as perennials plants. These results confirm that during winter and spring when the soil temperature is warm and humid there was a chance for the germination of seeds of these annuals that have a wide amplitude of temperature requirements. Dwarf shrubs, perennials and only one unidentified plant species, represent the rest of the emerged

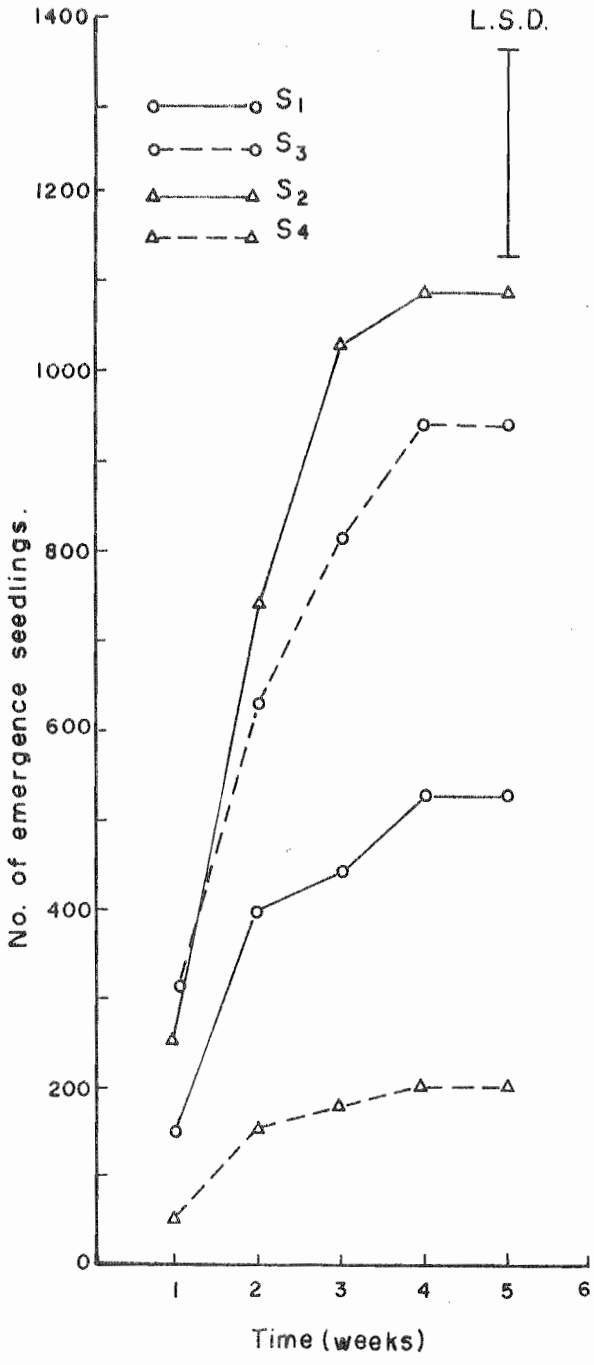

Fig. 4. Emergence of seedlings/m^2 from soils collected from South transects (S) of Rawdhat Khorium where S1-S4 represents the sites across the transects. Germination was conducted in green house.

species. Comparison of the floristic composition of the emerged seedlings found in our results with that of the above ground plant species reported by Al-Farraj *et al.*, (1997) indicate that there is a lack of correlation between the surface vegetation and the seed bank beneath. These results agree well with those reported by Batanouny *et al.*, (1991). The results also indicated a lack of perennial and shrub species, which may be attributed to the sparse distribution and a limited seed dispersal of these plant species in the communities.

Biomass of the emerged seedlings varies greatly along the transects which is presented in Table 2. The highest biomass values were recorded in transect N2 (51.7) followed by M2 (44.3), M3 (41.2) and S2 (35.0), while the lowest was recorded in S4 (2.1). This variability is independent of plant density of the emerged seedlings; the highest plant density was in M3 (1190) followed by S2 (1126.3) and N2 (1036.6), while the lowest was recorded in S4 (18.1). Such variability could be attributed to the microhabitat conditions such as soil texture, moisture and fertility, soil seed bank composition and disturbance regimes (Ortega *et al.*, 1997).

Table 1. Floristic composition of the seedlings (per m^2) from four sites in three transects (N=north, M=middle and S=south), crossing Rawdhat Khorim.

	N				M				S			
Species	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Annuals												
Anthemis deserti (Boiss.) Eig.	1	4				8	1	3	1	10	1	
Astragalus corrugatus Bertol.	4	3					5	11	17	16	33	7
Astragalus schimperi Boiss.								1				
Astragalus tribuloides Del.								2	15			3
Bassia muricata (L.) Aschers.				1				25	2			5
Chenopodium murale L.	14	12	2		15					22	3	3
Cutandia memphitica (Spr.) Benth.				9				494				42
Echium arabicum R. Mill									1			
Emex spinous (L.) Campd.		8	9		5			19	28	24	3	
Eragrostis barrelieri Dav.	22		1		8		17	16	73	1		
Eremobium lineare Hochr.								2				
Erodium laciniatum (Cav.) Willd.										3		1
Erucaria hispanica (L.) Druce							1					
Filago desertorum Pomel	16	38			2	8	20	12	26	48	45	22
Geranium sp.			4					4			6	
Grass	12		5	39	18		3	11	6			11
Herniaria hirsuta L.					2			4	51			
Ifloga spicata (Forssk.) Sch.-Bip.							1					12
Koelpinia linearis Pall.			8						5		4	
Launaea capitata (Spr.) Dandy	3	9	1			16		25	4	8		
Lepidium aucheri Boiss.	20	445	35			15		1				7
Lolium rigidum Gaud.	5	476			1	3			1	2	7	
Malva parviflora L.	13	44	8		7	33		9	4	39	29	19
Matricaria aurea (Loef.) Sch.	6	103	12		4	15	4	5	5	504	25	11
Medicago laciniata (L.) Mill.	17	15				34	117	4			58	10
Notoceras bicorne (Ait.) Amo							2					
Paronychia arabica (L.) DC.	32	4	5	2	174			560	277	11	44	39
Phalaris minor Retz.	1	1012	18	7	73	1751				40		
Picris babylonica Hand.-Maz.		1						7	18			
Plantago amplexicaulis Cav.							27		12	34	25	4
Plantago boissieri Haussk.								215				1
Plantago ovata Forssk.							29	7		22	25	17
Poa annua L.	238				9			155	669	6	246	67
Polypogon monsepeliensis Desf.		5				2						
Pulicaria incisa (Lam.) DC.		78										
Reichardia tingitana var. *arabica* (Hochst. & Steud.) Asch. & Schw.					16		3	13	3	36	10	8
Schimpera arabica Hochst.								2				1
Silene villosa Forssk.										2	1	
Sisymbrium irio L.	2		3								1	

Table 1 Cont.

Sonchus oleraceus L.		1										
Spergula fallax (Lowe) Krause.	630	42	6		487	7		43	44	10	137	346
Spergularia diandra (Gus.) Held.	11	51	13					1	137	51	8	88
Stipa capensis Thunb.						5	3327		19	2123	350	
Teucrium oliverianum Ging.												1
Tragus racemosus (L.) All.								1				
Trigonella anguina Del.	89	1139	747	14	39	723	864	148	476	704	1957	91
Trigonella hamosa L.	12	919	399		68	1244	352	47	3	23	1	20
Triplurospermum auriculatum (Boiss.) Rech.f.			5			9	2	8	1	2		9
Zilla spinosa Prantl.											1	
Perennials												
Acacia gerrardii Benth.												5
Calendula arvensis L.		1				25	13	6	21	32	23	7
Cenchrus ciliaris L.		3	2									
Citrullus colocynthis (L.) Sch.	2											
Cucumis prophetarum L.									1		2	
Heliotropium digynum Aschers.				1								
Pulicaria crispa (Forssk.) Benth.	11		102		34	307	69	2	6	130	22	4
Total	**1161**	**4413**	**1386**	**73**	**962**	**4205**	**4857**	**1863**	**1926**	**3881**	**3067**	**861**

Table 2. Biomass (g/m^2) and density ($plant/m^2$) of plants emerged from soils collected from different sites along three transects in Rawdath Khorim.

Site	Biomass g/m^2	Density $plant/m^2$
N1	17.658 ± 3.702 (cd)	522.9± 80.5 (b)
N2	51.759 ± 5.538 (a)	1036.6 ± 86.2 (d)
N3	30.091 ± 4.811 (bc)	939.3 ± 103.5 (a)
N4	09.56 ± 1.570 (d)	199.8 ± 11.6 (c)
LSD	18.9	237.8
M1	10.594 ± 1.600 (b)	243.1 ± 52.0 (c)
M2	44.323 ± 1.104 (d)	1025.5 ± 33.01 (d)
M3	41.282 ± 4.851 (d)	1190.6 ± 122.8 (d)
M4	12.379 ± 4.57 (b)	472.8 ± 19.4 (b)
LSD	16.0	194.2
S1	7.162 ± 0.812 (b)	304.4 ± 25.8 (b)
S2	35.020 ± 1.920 (d)	1126.3 ± 20.9 (d)
S3	07.600 ± 1.829 (b)	340.6 ± 49.2 (b)
S4	02.141 ± 0.751 (b)	18.1 ± 0.3 (c)
LSD	23.7	142.8

Bastrenta (1991) reported that reproductive efforts in some plant population decreased with an increase in disturbance regimes such as trampling and grazing. Biomass production has also been reported to effect the persistent seed banks due to its effect on plant size and reproductive allocations (Aziz & Khan, 1994).

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