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SPATIOTEMPORAL SEED BANK FLORA OF *PERISTROPHE PANICULATA* COMMUNITY IN A SEMI ARID DESERT OF KARACHI, PAKISTAN

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Abstract

Seed bank studies of *Peristrophe paniculata* was carried out for two consecutive years at two different sites. Although, both the sites were dominated by *P. paniculata,* however differ in vegetation pattern. Site ‘A’ possessed populations of annuals fully exposed to sunlight. While, site ‘B’ possessed annuals along with perennials located in somewhat shady area. Input to the seed bank was mainly determined by the seed dispersal. Persistent seed bank was observed in annual plant species with increasing numbers in the third collection (i.e. after seed dispersal). On the other hand, perennial plants mostly exhibited transient nature of seed bank, with no or low numbers in some collections. Significant difference in seed numbers was observed on temporal and spatial scale. Seed densities were higher in the samples collected before rainfall and after dispersal of seeds at both the sites in both the years. High degree of similarity was observed between above and below ground vegetation; however this similarity was more pronounced at site ‘B’ which was located in shady area, thus providing better soil moisture conditions for seed germination. Moreover, above and below ground vegetation was diverse and flourished in 2013, due to high germination rates, followed by heavy summer rains, providing ample amount of moisture along with high temperature. This study can be used to predict the above ground vegetation and vise versa.

Key words: *Peristrophe paniculata*, Arid, Seed bank, Persistent, Similarity.

Introduction

Soil seed banks are a key to understand the flow of plant populations, species and ecosystems (Cabin *et al.,* 1998). Moreover, they play a crucial role in determining the vegetation of any area (Hirsch *et al*., 2012). Seed banks are formed by seeds, either born and produced on site or carried to the site by dispersal agents and accumulated in the soil (Brhane *et al*., 2006). According to Alvarez-Aquino *et al*. (2005), seed banks are aggregation of ungerminated viable seeds buried in the soil. Plant populations of arid and semi-arid areas have seed banks that are huge and species rich (Caballero *et al.,* 2005). Desert seed banks are generally composed of light weighted wind dispersed seeds that usually lack dispersal structures and are distinguished by temporal and spatial alterations in seed density (Guo *et al.,* 1999).

The high level of temporal and spatial variability in seed banks from arid and semiarid regions is basically determined by patch scale heterogeneity in vegetation cover and inter-annual climatic heterogeneity (Quevedo-Robledo *et al.,* 2010). Patches play the crucial role in seed bank patterning which shapes population and community dynamics (Caballero *et al*., 2008). Degree of disturbance (Fenner, 1985), dispersal of seeds (Nathan & Muller-Landau, 2003), season (Garwood, 1989), geographical location (Williams-Linera, 1990), physical and chemical properties of soil (De Falco *et al.,* 2009) are also important in shaping the spatial patterns of soil seed bank.

Seed banks are one of the fundamental constituents in desert ecosystems and other stressful habitats where congenial conditions for seed germination and seedling establishment are quite impulsive both in space and time (Koontz & Simpson, 2010). The size of the seed bank varies widely and these variations in seed bank dynamics are affected by the composition, distribution and dominance of above-ground species. Therefore, it is foremost important to understand the relationship between the standing vegetation and the soil seed bank. Such informations are essential for developing strategies for the maintenance, management and protection of habitat in arid regions. The present study was designed to elucidate the seed bank dynamics of *Peristrophe paniculata* (Forssk.) Brummitt, the most common herb, after monsoon showers. It is extensively distributed in the subtropical desert of Karachi and is also important economically and pharmaceutically. The present study also reveals the relationship between above and below ground vegetation on temporal and spatial scale.

Materials and Methods

Study site: The study was carried out for two years i.e., in 2012 and 2013. Two sites were chosen for the study purpose, designated as site ‘A’ and site ‘B’. Both the sites were located in the Karachi University Campus, Sindh (Lat. 24˚ 48’ N, Long. 65˚ 55’ E). *Peristrophe paniculata* (Forssk.) Brummitt, was the dominant species on both the sites in both the years. It is the most common summer annual in Karachi. Large stands of *P. paniculata* emerge after monsoon showers and are widely distributed in maritime subtropical desert of Karachi. *P. paniculata* is also economically and pharmaceutically important.

Site ‘A’ was totally exposed to sunlight and mostly contained populations of annual plant species. In 2012, four annual plant species i.e. *Peristrophe paniculata, Tephrosia strigosa*, *Gynandropsis gynandra, Digera muricata* and one perennial plant such as *Trichodesma amplexicaule* were present at site ‘A’. During 2013, *Peristrophe paniculata, Tephrosia strigosa, Gynandropsis gynandra, Digera muricata* were the annual species, whereas, *Trichodesma amplexicaule* and *Abutilon indicum* were the perennial species.

The site 'B' was located in the somewhat shaded area, providing better soil moisture conditions, having annuals as well as perennials species. *Peristrophe paniculata*, *Gynandropsis gynandra*, *Ruellia patula*, *Digera muricata* and *Indigofera cordifolia* were the common annuals, whereas, *Prosopis juliflora* and *Senna holosericea* were the perennial plant species present at site 'B' in 2012. During 2013, *Peristrophe paniculata, Gynandropsis gynandra, Digera muricata, Indigofera Indigofera cordifolia, Ruella patula* were the annuals, whereas, *Senna holosericea, Eragrostis ciliaris* and *Rhyncosia minima* were also present on the ground.

Determination of soil seed bank: Seed bank studies were carried out at both the sites in both the years. Twenty soil samples were collected at random points by using an aluminum corer of 1.5 cm diameter to a depth of 15 cm from each site. These were collected at three phenological states i.e., before rainfall (before germination of seeds from buried seed pool), after rainfall (after germination of seeds from buried seed pool) and after dispersal of seeds from the standing vegetation. Seeds were sorted out manually with the help of binocular microscope, identified and counted (Aziz & Shaukat, 2012). Seeds were identified with the help of seed album, prepared from seeds collected from the study site.

Results

Soil seed bank during 2012: In 2012, five species viz., *Peristrophe paniculata, Tephrosia strigosa, Gynandropsis gynandra, Digera muricata,* and *Trichodesma amplexicaule* were present on the site 'A'; whereas, seeds of three species such as *Peristrophe paniculata, Digera muricata* and *Abutilon indiucm* were sorted out from the seed bank samples (Table 1). Two species viz., *P. paniculata* and *D. muricata* were found to be common on the ground and in the buried seed reserves

Seven species such as *Peristrophe paniculata*, *Gynandropsis gynandra, Ruellia patula*, *Prosopis juliflora, Senna holosericea, Digera muricata* and *Indigofera cordifolia* were present at site 'B' in 2012**.** Seeds of *Peristrophe paniculata*, *Gynandropsis gynandra, Ruellia patula, Senna holosericea* and *Achranthes aspera* were sorted out from the soil seed bank samples (Table 2). *P. paniculata*, *G. gynandra, R. patula* and *S. holosericea* were found to be the common species in the above and below ground vegetation. In this way, 7 species were present on the ground and 5 in the seed bank samples. Whereas, 4 species were found to be the common in the above and below ground vegetation.

P. paniculata was the dominant species on the ground as well in the seed bank samples. Seed bank data collected at three phenological states i.e. before rainfall (before germination of seeds), after rainfall (after germination of seeds) and after dispersal of seeds showed significant difference in the seed numbers of *P. paniculata* ($p<0.001$). Great resemblance between above and below ground vegetation was observed at site 'A' and 'B' in 2012. *P. pniculata* exhibited significant differences with time ($F = 48.32$, $p<0.001$) and site ($F = 55.38$, $p<0.001$).

Soil seed bank during 2013: During 2013, some of the species such as *Peristrophe paniculata, Gynandropsis gynandra, Tephrosia strigosa, Digera muricata, Trichodesma amplexicaule* and *Abutilon indicum* were recorded at site 'A'. Of them, seeds of four species (i.e. *Peristrophe paniculata, Gynandropsis gynandra, Tephrosia strigosa* and *Digera muricata*) were sorted out from the buried seed reserves (Table 3). These species formed the common vegetation types of the area.

At site 'B' *P. paniculata* also formed the major part of seed bank as well as the ground vegetation. Eight species like *Peristrophe paniculata, Gynandropsis gynandra, Digera muricata, Indigofera cordifolia, Ruella patula, Senna holosericea, Eragrostis ciliaris and Rhyncosia minima* were present on the ground. While seeds of six species such as *Peristrophe paniculata, Gynandropsis gynandra, Digera muricata, Ruella patula, Senna holosericea* and *Achyranthes aspera* were found in the seed bank samples (Table 4). Out of six, five species like *P. paniculata, G. gynandra, D. muricata, R. patula and S. holosericea* were found to be the common species on above and below ground vegetation.

P. paniculata was again the dominant species in the seed bank and on the ground. At different phenological states *P. paniculata* showed significant differences ($p<0.001$) in seed densities. More seeds were found in the first and third collection i.e. in the samples collected before rainfall (before germination) and after dispersal from above ground vegetation. Standing vegetation was found to be well represented in the seed bank samples. *P. paniculata* showed significant differences with time ($F = 63.10$, $p<0.001$) and site ($F = 78.36$, $p<0.001$). Whereas, interaction of time x site ($F = 135.66$, $p<0.001$) also exhibited significant differences.

Table 1. Seeds extracted from the soil samples collected at three phenological states at site 'A' in 2012. (Mean ± Standard Error).

Plant species	Before rainfall	After rainfall	After dispersal
Peristrophe paniculata (Forssk)	3.05 ± 0.39	1.33 ± 0.78	2.78 ± 0.49
Tephrosia strigosa (Dalz.)	2.42 ± 0.25	1.05 ± 0.99	2.75 ± 0.44
Gynandropsis gynandra (L.) Briq.	2.15 ± 0.06		1.33 ± 0.54
Digera muricata (L.) Mart.	1.33 ± 0.08		1.57 ± 0.19
Trichodesma amplexicaule Roth.	1.42 ± 0.17	0.73 ± 0.13	1.35 ± 0.11

Table 2. Seeds extracted from the soil samples collected at three phenological states at site 'B' in 2012. (Mean ± Standard Error).

Plant species	Before rainfall	After rainfall	After dispersal
Peristrophe paniculata (Forssk.)	4.22 ± 0.79	1.08 ± 0.33	3.78 ± 1.03
Gynandropsis gynandra (L.) Briq.	2.75 ± 0.42	1.17 ± 0.45	2.57 ± 0.89
Ruellia patula Jacq.	1.15 ± 0.84	1.00 ± 0.79	1.00 ± 0.73
Prosopis juliflora DC.	0.17 ± 0.07		
Senna holosericea (Fresen.) Gretter	1.33 ± 0.57		
Digera muricata (L.) Mart.	3.25 ± 1.02	1.22 ± 0.72	3.07 ± 0.77
Indigofera cordifolia Heyne ex Roth.	1.57 ± 0.38	1.00 ± 0.08	2.15 ± 0.99

Table 3. Seeds extracted from the soil samples collected at three phenological states at site 'A' in 2013. (Mean ± Standard Error).

Plant species	Before rainfall	After rainfall	After dispersal
Peristrophe paniculata (Forssk.)	5.22 ± 1.01	1.17 ± 0.19	4.25 ± 0.78
Gynandropsis gynandra (L.) Briq.	5.10 ± 0.98	0.75 ± 0.33	3.21 ± 0.69
Tephrosia strigosa (Dalz.)	3.72 ± 0.76		3.00 ± 1.22
Digera muricata (L.) Mart.	4.11 ± 0.99	1.05 ± 0.31	3.06 ± 0.86
Trichodesma amplexicaule Roth.	1.07 ± 0.76		
Abutilon indicum (L.) Sweet	1.00 ± 0.39		

Table 4. Seeds extracted from the soil samples collected at three phenological states at site 'B' in 2013. (Mean ± Standard Error).

Plant species	Before rainfall	After rainfall	After dispersal
Peristrophe paniculata	7.17 ± 1.30	2.15 ± 0.56	6.72 ± 0.87
Gynandropsis gynandra	3.22 ± 0.47		4.22 ± 0.99
Digera muricata	3.77 ± 0.55	1.00 ± 0.00	4.05 ± 1.03
Indigofera cordifolia	2.15 ± 0.36		2.25 ± 0.67
Ruella patula	1.38 ± 0.66	0.73 ± 0.59	2.00 ± 0.72
Senna holosericea	1.00 ± 0.00		1.00 ± 0.05
Eragrostis ciliaris	2.11 ± 0.77	0.97 ± 0.38	1.05 ± 0.63
Rhyncosia minima	1.15 ± 0.01	1.17 ± 0.30	1.00 ± 0.04

Discussion

P. paniculata individuals dominated the standing vegetation as well as seed bank samples. Seeds of *P. paniculata* were found in all phenological states in both the years at both the sites, thus revealing the persistence nature of seed bank. According to Poschlod & Jaeckel (1993), persistent seed banks are those having numerous seeds in the soil surface with some in the lower layer lasting throughout the year. The significant variability in seed bank was observed on temporal and spatial scale. According to De Villiers *et al*. (2002), temporal changes of seed bank composition and diversity in arid and semi-arid areas fluctuate not only between years, but also between seasons. The seed bank population of site 'A' was mostly dominated by annual species; whereas, site 'B' also possessed seeds of perennial species mainly due to the presence of perennials in the existing vegetation. According to Dalling & Denslow (1998), seed bank dynamics of any area is greatly influenced by the standing vegetation of that area. Perennials species were found to posses the transient seed banks, their seeds were completely disappeared in some collections. Transient seed banks in perennials was also reported for *Cirsium vulgare* (De Jong & Klinkhamer, 1988) and *Cressa cretica* (Aziz & Khan, 1996). On the other hand, annual plant species on both the sites exhibited persistent nature of seed bank. Annual species were found to be more continuous in the seed bank. It might be due to their higher seed turnover. Since annuals rely upon continuous recovery from the existing vegetation, that's why they are usually more persistent in the seed bank than in the vegetation (Milberg & Hansson 1993). Seeds of those species were also found from the seed bank samples which were not present on the site and were only recovered in the soil samples. These are the species which produce mostly light weighted wind dispersed seeds, which may came from adjacent area to our study site, having populations of these plants. Moreover, above and below ground vegetation of site ‘B’ in both the years was more flourished and diverse than site ‘A’. It might be the shady location of site ‘B’, thus having high moisture level suitable for seed germination. Thus diverse above ground community disperse diverse seeds into the soil, thus producing diverse below ground vegetation.

Results indicated that existing vegetation of both the sites was well-represented in the seed samples in both 2012 and 2013. Similar results were also reported by Jerling (1984), he found direct correlation between the ground cover of *Triglochin maritime* L., and the density of its seeds in the soil seed bank. In the present study also, high degree of similarity was observed between above and below ground vegetation. However, this resemblance was more pronounced in the year 2013. It might be due to greater emergence of plants from the buried seed reserves due to greater amount of precipitation rate in the year 2013. Lower emergence of plants in 2012 might be due to lower amounts of monsoon showers, not fulfilling the ample requirement of moisture for seed germination. Similar results were also reported by Gutierrez *et al*. (2000), where soil seed densities and number of species recorded were particularly higher in the year after above-normal precipitation year contrasted with the first dry spell year. According to Pake & Venable (1996), annuals have particular requirements with respect to the water regime needed to sprout. This process avoids sprouting because of a monsoon beat which gives deficient dampness to finish the vegetation's cycle. Contrasts between the floral diversity and its soil seed bank are usually because of the germination biology contrasting among species.

It can be concluded, that above ground vegetation of both the sites in both the years reflected well in the below ground samples although species diversity between the above and below ground floras fluctuated over time and space. Environment plays an important role in determining the spatiotemporal seed bank diversity and composition. Moisture along with high temperature is the main factor affecting the germination of viable seed reserves from the buried seeds pool.

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