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IMPACT OF MICROHABITAT ON SURVIVAL OF *SERIPHIDIUM QUETTENSE* SEEDLINGS

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Abstract

Two years study was conducted to examine the influence of microhabitats i.e., plant canopies and interspaces on the seedling emergence and survival of *Seriphidium quettense* in relation to soil temperature and soil moisture in natural habitat. The growth rate of first year seedlings are also examined. Relative abundance of microhabitats was determined by using square quadrates. Soil temperature and soil moisture of two microhabitats were recorded at 0-5, 5-10 and 10-15 cm depth. Results showed that soil moisture in spring was found critical for seed germination while in summer it had greater impact on the survival of first year seedlings. Precipitations in March and April promoted seed germination while monsoon rains influenced seedling survival. Soil moisture and soil temperature in different microhabitats were significantly different in different months, reflected significant influence upon seedling emergence and their survival. Seedling emergence and survival was higher under plant canopies than in open interspaces. Highest mortality rate of first year seedlings were observed in June and August under high soil temperature and low soil moisture contents. High soil moisture in July due to occurrence of precipitation decreased the mortality rate of first year seedlings. After winter, no mortality occurred. Survived seedlings of the first year had high root to shoot ratio. Results further depicted that conspecific plant canopies are favorable microsites for seedling survival. Furthermore, high root to shoot ratio may enable them to survive in arid habitat.

Introduction

Seriphidium quettense (Podlech) synonym *Artemisia quettensis* is a dominant shrublet in Hazarganji, Balochistan, Pakistan (Ghaphoor, 2002). It belongs to the plant family Asteraceae. This shrub provides forage to small ruminants when other range species produce limited dry matter particularly under drought conditions. Likewise, this shrub provides many benefits to humans and animals including feed for livestock and wildlife, erosion control and industrial products (McKell, 1989). However, rangelands of Balochistan have been degrading very rapidly by overgrazing and removal of vegetation for fuel purposes.

Native species have evolved under the prevailing stresses of the region and have the ability to exploit limited available resources. In arid and semi arid rangelands, re-establishment of important native species is vital to maintain function, structure, diversity and stability of the landscape. Seedling growth rate in their natural environment reflects potential of their sustainability in their native habitat. Germination of seeds, their establishment and survival are important parameters of colonization and population dynamics of plants (Erikson & Ehrlen, 1992). Seed germination and growth of desert plants are dependent greatly upon seedbed characteristics particularly soil moisture (Owens & Norton, 1992) and temperature (Ren *et al.,* 2005). In arid environment, any microsite that prevents desiccation might be a suitable site for seeding survival (Harper, 1977). Information about these parameters can help range managers to re-habilitate native plant species.

Objectives of the research were to investigate: 1) the influence of two dominant microhabitats (conspecific adult canopies and open interspaces) upon seedling emergence and survival in relation to soil moisture and soil temperature and 2) growth rate of first year seedling of the test plant.

Materials and Methods

Study site: The experiments were conducted in Chiltan National Park, Hazarganji, Balochistan, Pakistan. Experiments were conducted in an extended area of the park that was protected from livestock grazing since 1998. Dominant vegetations of the site are *Seriphidium quettense, Cymbopogon jawarencusa, Crysopogon aucheri, Berberis lycium* and annual grasses. Climate of the area is of Mediterranean type. Area receives rainfall mostly in winter months, however rainfall occurs occasionally in summer season as well. Mean annual rainfall of over 19 years is 200mm. Soil of the area is sandy-to-sandy loam (Marwat *et al*., 1992).

Data collection: Two dominant microhabitats interspaces and plant canopies of S*eriphidium quettense* were evaluated for seedling recruitment and survival from the soil seed bank. At the study site, two 160 m long transect lines, parallel to each other with the distance of 15 m apart were established. Sixteen points, 10 m apart were marked on each transect line and 5 x 5 m plots (total 32 plots) were established. Twenty-six plots were used for checking seedling emergence and survival in different microhabitats, three for soil moisture content, and three for soil temperature. Plots were randomly assigned for recording of seedlings emergence and survival. One meter square quadrate (sub-divided into 20 x 20 cm cells) was used to determine the relative abundance of microhabitats of 26 plots of seedling survival.

Seedling emergence was recorded in April 4, 2003. Within experimental plots, seedlings were located using one-meter square quadrates (sub-divided into a grid with 20 x 20 cm cells). Each emerged seedling was marked with thin wires of different colors. Seedling survival was recorded at 30 days interval. Seedling development was assessed by measuring root and shoot length of the seedlings at 30 days interval. Seedlings were dug from the area out side of 26 plots. Soil water content was measured by gravimetric method. Soil samples were collected from 0-5, 5-10 and 10-15 cm depths from each microhabitat of the soil moisture plots. Soil samples were collected at 30 days interval. Soil temperature was also measured from the three soil temperature plots at 30 days interval by using thermocouples attached to a hand held digital thermometer (HANNA, HI 9055 K). Soil temperature reading was taken from each microhabitat at a depth of 0-5, 5-10 and 10-15 cm. Soil temperature was recorded in morning, mid day and at evening times. Rainfall data were also obtained from the Arid Zone Research Center's automatic weather station.

Three and four factorial Randomize Complete Block Designs (RCBD) were used for soil moisture and soil temperature data, respectively. MSTAT-C computer software package for statistical analyses was used for calculation of analyses of variance (ANOVA). Descriptive analysis was used for seedling survival due to very low number of emerged and survived seedlings.

Results

Rainfall distribution and seedling recruitment: The monthly rainfall distribution was noted to be much lower than those of long-term average rainfall (except during the month of January, 2004). The year 2003 growing season had comparatively better rainfall distribution in spring and summer seasons (Fig. 1). A total of 79, 10 and 15 mm of rainfall was recorded in February, March and April, respectively, which is the optimal time for seedling recruitment of many plant species in high land of Balochistan. Monsoon rains in July i.e., 24 mm had no impact on recruitment of *Seriphidium quettense* seedlings. However, these rains played a key role in their survival (Table 4). In year 2004 season, only 68 and 16 mm rainfall was received in the months of January and February respectively while no rainfall occurred in the months of March and April. Similarly no seedling recruitment was observed in the same year.

Soil moisture and soil temperature: Moisture contents of soil were significantly different ($p<0.01$) among months during the year, 2003 and 2004 (Fig. 2). It was higher in April and July 2003, and in March and May 2004. Soil moisture between microhabitats was found non-significant ($p>0.05$) during both years. However, moisture contents were high in spaces under plant canopies than those in open interspaces Soil moisture contents among various depths were also found significant ($p<0.05$) in year 2003 and 2004. There was a direct relationship between soil moisture and depths (Tables 1 and 2).

For soil temperature, main factors viz., months, microhabitats and depths were found significant ($p<0.05$). Interspaces had comparatively high soil temperature than S*eriphidium quettense* plant canopies. There was inverse relationship between soil temperature and soil depth (Table 3).

Seedling growth and survival: Densities of emerged seedlings of S*eriphidium quettense* were higher under plant canopies than in open interspaces. Similarly, the densities of survived seedlings were also higher under plant canopies than in interspaces. At the end of the first growing season (August 2003), only 0.39 and 0.036 seedlings/m^2 were surviving under plant canopies and in interspaces, respectively. All of the seedlings survived during the winter months and no cold mortality was recorded in the spring of second year. At the end of second growing season, density of survived seedlings was further reduced to 0.034 and 0.011 under adult conspecific plants and in open interspaces, respectively (Table 4). It was also found that survived seedlings had very slow growth rate. At the end of August 2003, survived seedlings attained a mean height of 2.94 cm with 38.8 cm root length and 21 secondary roots $plant^{-1}$. Seedlings attained maximum growth rate in April and May (Fig. 3).

Discussion

Spring season is the optimal time for seed germination of *Artemisia* species (Bai & Romo 1996; Booth & Bai, 1999) if soil moisture is adequate enough to allow their germination. Bai & Romo (1995) reported that seedlings of *Artemisia frigida* emerge only when soil moisture is above 1.5 M pa. In the present study, lack of precipitations during the months of March and April for the year 2004 may be one of the reasons for no seedling recruitment of the species.

Table 1. Mean (± S.E.) Soil moisture contents (%) of different parameters (microhabitats and soil depths) during 2003 in different months.

Month	Microhabitat		Depth (cm)		
	Canopy	Interspace	0-5	5-10	10-15
April	1.988 ab	2.956 a	1.133 bc	2.875 a	3.407 a
May	0.571 c	0.422 c	0.185 c	0.485 bc	0.82 bc
June	0.521 c	0.447 c	0.583 bc	0.343 bc	0.525 bc
July	1.456 bc	0.744 c	0.733 bc	1.253 bc	1.313 b

Values within a column represented by different letters are significantly different at $p<0.05$

Table 2. Mean Soil moisture contents (%) of different parameters (microhabitats and soil depths) during 2004 in different months.

Month	Microhabitat		Depth (cm)		
	Canopy	Interspace	0-5	5-10	10-15
March	1.447 a	1.423 a	0.0789 cde	0.224 ef	0.245 ef
April	0.338 c	0.45 bc	0.32 ef	1.52 b	2.51 a
May	1.351 a	1.059 ab	0.13 f	0.31 ef	0.75 def
June	0.55 bc	0.415 c	0.85 cde	1.37 bcd	1.42 bc

Values within a column represented by different letters are significantly different at $p<0.05$

Table 3. Mean Soil temperature (°C) of different parameters (microhabitats and soil depths) during 2004 in different months.

Month	Microhabitat		Depth (cm)		
	Canopy	Interspace	0-5	5-10	10-15
March	26.21 e	30.85 d	28.06 e	29.01 e	28.52 e
April	35.00 c	37.98 bc	35.99 d	36.82 d	36.67 d
May	39.43 ab	42.1 a	43.8 a	40.68 abc	37.81 bcd
June	38.13 bc	40.29 ab	41.01 ab	39.25 bcd	37.35 cd

Values within a column represented by different letters are significantly different at $p<0.05$

Table 4. Mean (± S.E.) densities of emerged and survived seedlings of *Seriphidium quettense* in different microhabitats during 2003 and 2004 seasons.

	Canopies	Interspaces
Emerged seedlings /m^2 (2003)	(20) 1.31± 0.23	(2) 0.14 ± 0.03
Survived seedlings /m^2 (2003)		
May, 2003	(15) 0.99 ± 0.19	(2) 0.12 ± 0.02
June, 2003	(10) 0.68 ± 0.15	(1) 0.07 ± 0.016
July, 2003	(9) 0.57 ± 0.15	(1) 0.07 ± 0.01
August, 2003	(6) 0.39 ± 0.12	(0.54) 0.036 ± 0.001
Survived seedlings /m^2 after winter 2003 (April, 2004)	(6) 0.39 ± 0.12	(0.54) 0.036 ± 0.001
Survived seedlings /m^2 by the end of the second growing season (August, 2004)	(1) 0.034 ± 0.030	(0.23) 0.011 ± 0.0075

Numbers in parenthesis indicate total number of emerged and survived seedlings.

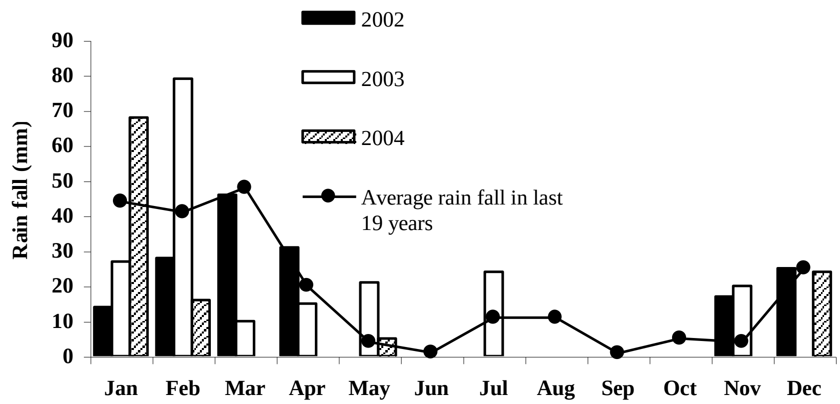

Fig. 1. Monthly rainfall distribution during the years 2002, 2003, 2004 and average rain fall for the last 19 years.

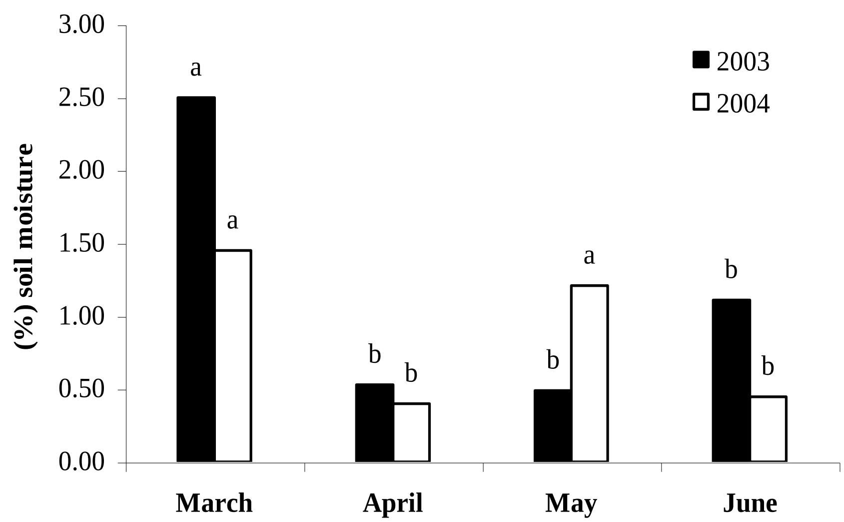

Fig. 2. Monthly (%) soil moisture in year 2003 and 2004. Values with the same subscript are not significantly different among months of the same year.

Density of new seedlings was quite low as compared to the average density of adult plants (4-5 plants/m^2). Low seedling recruitment in established stands of *Artemisia* has also been reported for *Artemisia rothrockii* (Bauer *et al.*, 2002) and for *Artemisia herba alba* (Friedman & Orshan, 1975). Friedman & Orshan (1975) found average density of *Artemisia herba alba* seedlings in Negev deserts of Israel quite low than the density of adult conspecifics and ranged from 1.1 to 0.6/m^2. Low seedling emergence may be attributed to low soil moisture and small size of the seeds. Because of the very small size, they may burry in the soil in substantial number (Harper, 1977), which can hinder their germination and emergence probably because of their high sensitivity towards light for germination (Silvertown & Doust, 1993).

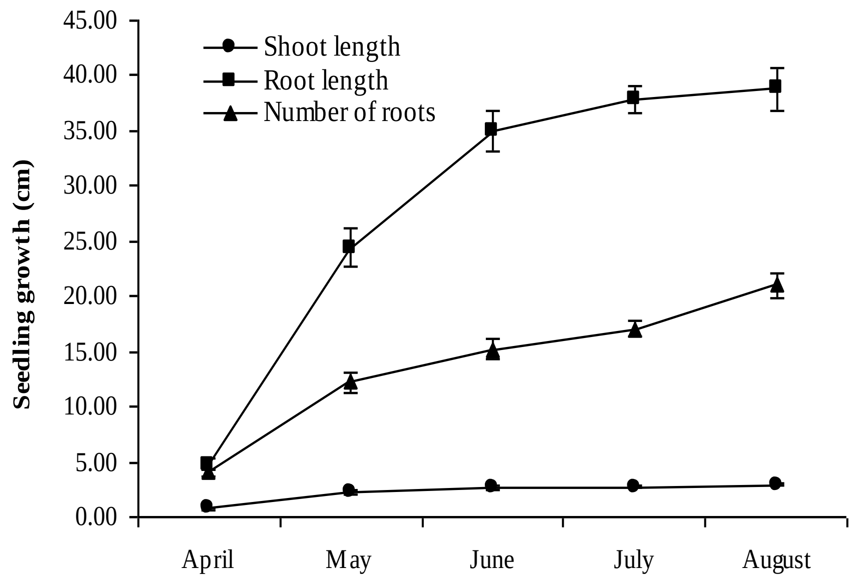

Fig. 3. Growth rate of shoot, main root and number of lateral roots of *Seriphidium quettense* seedlings during 2003.

Survival rate decreased with decreasing soil moisture. High mortality rates in the months of June and August when high soil temperature and paucity of precipitations severely depleted water from the soil and low mortality rate in the month of July when area received precipitations, which increased though non-significantly soil moisture, implies that survival of seedlings are dependent greatly upon soil moisture. The moisture contents of soil, indicates that summer precipitations are critical for survival of first year seedlings. In this connection, our results are also in agreement with the findings described by Owens & Norton (1992).

High density of survived seedlings of *Seriphidium quettense* was found under plant canopies. Most of the established seedlings were also observed in the vicinity of adult conspecific plants (personal observation). Survival rate of *Gutierrezia microcephala*, an arid land shrub was also found higher in the vicinity of adult plants than in bare interspaces (Paker, 1982). It reflects that plant canopies are more favorable microhabitats for seedling survival as compared to open interspaces. More open microsites have slightly higher diurnal temperature fluctuations than microsites under plant canopies (Thompson *et al.*, 1977; Pierson & Wight, 1991). Factors that alter environment of individual seedlings may also alter their probability of survival and successful establishment (Owens & Norton, 1992). Moreover, in desert plant communities, evapotranspiration in warm conditions can severely affect seedling survival and adult plants may facilitate them by providing shade and nutrients (Fowler, 1988; Guo, 1998). As observed in present findings that in warm conditions, soil moisture and soil temperature was comparatively better under plant canopies than compared with open interspaces. The accumulation of soil under plant canopies and high organic matter may also be the reason for comparatively high survival rate of the seedlings under or near adult plants in arid habitats.

Seedlings attained high growth rate in early growing season and with high root to shoot ratio. It can be attributed to high osmotic potential in early growing season (Shereen *et al*., 2005) due to high soil moisture contents. *Seriphidium quettense* seedlings invested most of the resources for belowground root growth rather than aboveground shoot growth. Achievements of maximum growth rate early in growing season when conditions are more favorable for plant growth and high root to shoot ratio seems to be adaptive feature of these species to survive in arid environment (Booth *et al*., 1990).

After winter no seedlings died, which indicates their good capability of winter tolerance. High survival rate of *Seriphidium quettense* may be due to low autumn precipitation that probably strengthen the seedlings and enable them to survive in winter season (Cawker, 1980). Our results suggest that winter temperature is not as critical as soil moisture for the survival of *Seriphidium quettense* seedlings.

Results suggest that conspecific plant canopies are favorable microsites for seedling survival. Soil moisture in spring is critical for seed germination while summer precipitations have greater impact on the survival of first year seedlings. Furthermore, high root to shoot ratio may enable them to survive in arid habitat.

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