Journal of Tropical Forest Science 9(4): 458-464 (1997)

SEEDLING PERFORMANCE OF TWO DESERT PLANT SPECIES *(PROSOPIS JULIFLORA* AND *BLEPHARIS SINDICA)* GROWN UNDER UNIFORM EDAPHIC CONDITIONS

M. Z. Iqbal & M. Shafiq

Department of Botany, University of Karachi, Karachi-75270, Pakistan

Received October 1994

IQBAL, M.Z. & SHAFIQ, M. 1997. Seedling *growth* of two desert plant species *(Prosopis juliflora* and *Blepharis sindica)* grown under uniform edaphic conditions. *Prosopis juliflora* and *Blepharis sindica,* collected from different sites at the Karachi University Campus, showed significant variations in plant growth when grown under uniform environmental conditions. *Blepharis sindica* developed from site A showed better growth parameters (leaf number, plant height, root/shoot ratio) compared to site B, while plants developed from site C showed intermediate growth. Seedlings of *P. juliflora* collected from site B showed a significantly lower leaf number ($p<0.001$) but better plant biomass (more root dry weight and shoot dry weight) than those from sites A and C. Low plant height *of B. sindica* from site B led to its low shoot dry weight. Seedling survival of B. *sindica* and *P. juliflora* from site B was seriously affected by their low leaf numbers, and in the case of the former species, by its low plant height However, the plant height of *P. juliflora* did not differ significantly among seedlings from the three sites. *Blepharis sindica* also showed significant differences ($p<0.01$) in plant circumference. The results indicate that *P. juliflora* from site B and *B. sindica* from site A gave the best growth response in their new habitat. These results are not only important in understanding the influence of edaphic factors on plant growth, but would also provide useful information about the adaptive nature of the species in different stands.

Key words: Adaptation - desert species - edaphic factor - seedling growth - soil analysis

IQBAL, M.Z. & SHAFIQ, M. 1997. Pertumbuhan anak benih dua spesies tanaman gurun *(Prosopis juliflora* dan *Blepharis sindica)* yang ditanam di bawah keadaan edafik yang seragam. *Prosopis juliflora* dan *Blepharis sindica* yang diambil dari tapak yang berbeza di Kampus Universiti Karachi menunjukkan perubahan ketara dalam pertumbuhan tanarnan apabila ditanam di bawah keadaan persekitaran yang seragam. *Blepharis sindica* yang dibesarkan dari tapak A menunjukkan parameter pertumbuhan yang lebih baik (bilangan daun, ketinggian tanaman, nisbah akar/ pucuk) berbanding dengan tapak B, sementara tanaman yang dibesarkan dari tapak C menunjukkan pertumbuhan perantaraan. *Anak* benih *P. juliflora* yang diambil dari tapak B begitu ketara menunjukkan bilangan daun yang kurang ($p < 0.001$) tetapi biojisim tanaman yang lebih baik (lebih berat kering akar dan berat kering pucuk) daripada tanaman dari tapak A dan C. Ketinggian tanaman yang rendah *B. sindica* dari tapak B menyebabkan berat kering pucuknya rendah. Kemandirian anak benih *B. sindica* dan *P. juliflora* dari tapak B sangat terpengaruh dengan bilangan daun yang kurang, sementara spesies yang sebelumnya terpengaruh dengan ketinggian tanaman yang rendah. Bagaimanapun, ketinggian tanaman *P. juliflora* tidak berbeza dengan ketara berbanding anak benih dari tiga tapak tersebut. *Blepharis* *sindica* juga menunjukkan perbezaan yang ketara (p<0.01) dalam ukur lilit tanaman. Hasil menunjukkan bahawa *P. juliflora* dari tapak B dan *B. sindica* dari tapak A memberikan tindak balas pertumbuhan di habitat barunya. Keputusan ini tidak hanya penting dalam memahami faktor edafik ke atas pertumbuhan tanaman, tetapi juga menyediakan maklumat berguna mengenai keadaan menyesuai spesies di dirian yang berbeza.

Introduction

Prosopis juliflora Sw., a native of West Indies and Mexico and now distributed world-wide, is a common weed in waste lands in Sindh, Punjab and the northern areas up to Kashmir. Seeds of P. *juliflora* are found in droppings of animals, and acid scarification is necessary for their germination. A remarkable shrub that grows in the hot and dry desert, *P. juliflora* provides fuelwood, timber and forage for sheep and goats, stabilises sand dunes and is used as shade plant and wind breaks (Khoshoo & Subrahmanyan 1985). It grows on almost any type of soil, even with the roots in tidal brackish water. It tolerates temperatures up to 48 °C and does well with as little as 150 mm and as much as 750 mm annual rainfall (Hocking 1993). *Blepharis sindica* Stocks *ex* T. Anders is distributed in Sindh (Thatta, Hyderabad), lower Baluchistan (Lasbela) and up to the Punjab deserts in Pakistan. It is a short perennial shrub, with seeds that are difficult to germinate. Its requirements vary with temperature and moisture availability.

The distribution of a species is dependent not only on the extent to which the physical environment can satisfy its resource requirements but also on its ability to tolerate periods and levels of environmental stress (Tivy 1993). Grime (1979) describes environmental stress as a deficiency of light, moisture and mineral nutrients and suboptimal temperatures which limit photosynthetic production. The individualistic behaviour of species within plant communities has long been recognised (Gleason 1926, Whittaker 1956).

Less than one percent of the world's plants have been sufficiently studied for their potential value, and only in the last decade has there been an increasing awareness of the value of many unexploited plants in the arid and semi-arid tropics, and the need to manage these resources for the benefit of the local peoples and as an aid to combating desertification (Wickens *et al.* 1985).

The characteristics and distribution of natural communities, the nature of the environment, and the interrelationships of organisms and environment, are subject to natural laws, which the ecologists seek to recognise and verify. Such knowledge would enable strong recommendations for land use to be made to enhance its contribution to society. However, the ecology of natural vegetation is still inadequately known and the ecology of cultivated plants has not been significantly studied (Oosting 1956).

This investigation was initiated to examine, using garden loam soil, the adaptability of the species *Prosopis juliflora and Blepharis sindica,* collected from three different sites at the Karachi University campus. Such studies would be helpful in understanding the ecology and adaptability of these species.

Materials and methods

Three different sites at the campus of the University of Karachi having stands of the two species, *P. juliflora* and *B. sindica,* were selected as sites A, B and C. The phytosociology of these stands has been previously studied by Iqbal and Shafiq (unpublished). All these sites were situated at about 12 km northeast of Karachi city (24°48'N, 65°55'E). The mean summer temperature is 36 °C and mean winter temperature 15 °C. Rains are mostly received during the monsoon season extending from June to August. All the three sites in the campus are characterised by perennial shrubs with different vegetation composition, and different soil conditions. The communities are open with exposed rocks or with loose textured soil and exhibit different responses in plant growth. The campus area is classified as semi-arid due to low rainfall.

Seedlings of P. *juliflora* and *B. sindica* having uniform height and growth form were collected from the three sites and transplanted into plastic pots (25 cm diameter and 22 cm in depth) containing garden loam soil (3 parts fine sand and 1 part humus by volume) at the experimental station of the Department of Botany. There were five replicates of each species. The seedlings were irrigated daily. After six weeks, their quantitative growth variables such as number of leaves, plant circumference and height were noted. All the plants were harvested and separated into roots, shoots and leaves and dried at 80 °C in an electrical oven for 24 h and their dry weights were determined. The data were statistically analysed using ANOVA (analysis of variance).

Three soil samples were obtained from each site at 0-30 and 30-60 cm depths and later thoroughly mixed for each site. Physical analysis of the soil was carried out by the pipette method of the USDA (1951). Calcium carbonate was determined by the acid neutralisation method of Qadir *et al.* (1966). Alkaline earth carbonate and chloride were determined by titration methods. Electrical conductivity was measured by a conductivity meter, while sodium and potassium concentrations were measured by Flame Photometer 410 Corning.

Results;

Mean data for both species *(P. juliflora* and *B. sindica)* for plant height, leaf number, plant circumference, root dry weight, shoot dry weight, root/shoot ratio and total plant dry weight are given in Table 1, and soil characteristics in Table 2. A significant ($p<0.001$) difference in the number of leaves was observed for both species. The numbers of leaves for *P. juliflora* seedlings were 98, 87 and 58 at sites C, A and B respectively. This species had lower plant circumference at $p<0.001$ significance level for sites A and C, and intermediate values of other growth parameters, such as root dry weight (0.22 g), root/shoot ratio (1.4) and total plant dry weight (0.53 g) for seedlings from site C. The differences in leaf number and plant circumference were significant ($p<0.001$) for *P. juliflora.* The lowest plant circumference of both species, *P. juliflora* (38.1 cm) and *B. sindica*

(41.14cm),were observed in site C seedlings. Plant height of *P. juliflora* seedlings was the lowest (18.54 cm) from site A while that of *B. sindica* seedlings from the same site was the highest (14.40 cm). Among the sites, there was no significant difference in plant height of *P. juliflora,* but *B. sindica* did show a significant ($p<0.05$) reduction in plant height from 14.40 cm (site A) to 4.74 cm (site B). *Blepharis sindica* seedlings collected from site B exhibited poor growth, having low leaf number (82), plant height (4.74 cm), root dry weight (0.60 g), total biomass (0.83g) and root/shoot ratio (0.73). Leaf number was also the lowest (58) but plant height was intermediate (19.3 cm) in *P. juliflora* seedlings from site B.

Table 1. Growth of *Prosopis juliflora* and *Blepharis sindica* seedlings collected from different sites

Parameter		Site		
		A	B	C
Leaf number	PJ	87 ± 6	58 ±4	98 ± 8***
	BS	164 ± 11	82 ±2	148 ± 13'"
Plant circumference (cm)	PJ	42.67 ± 3.69	59.90 ± 3.09	38.10 ± 2.78"'
	BS	44.70 ± 3.90	51.31+2.91	41.14± 4.45"
Plant height (cm)	PJ	18.54 ± 0.28	19.3 ±0.55	20.06 + 1.60
	BS	14.40 ± 0.58	4.7410.28	13.20 + 0.28'
Total plant dry weight (g)	PJ	0.19 ± 0.02	0.82 + 0.30	0.53 + 0.15
	BS	1.43± 0.09	0.83 ±0.05	1.24± 0.07
Shoot dry weight (g)	PJ	0.12 ± 0.01	0.42 ±0.11	0.31 + 0.11
	BS	0.73 ± 0.12	0.23 + 0.04	0.60 + 0.08
Root dry weight (g)	PJ	0.07 + 0.03	0.40 + 0.12	0.22 + 0.07
	BS	0.70 ± 0.07	0.60 + 0.06	0.64 + 0.06
Root/shoot ratio	PJ	1.71 ± 0.33	1.05+0.17	1.40± 0.14
	BS	1.04± 0.25	0.73 ±0.42	0.93 ± 0.15

PJ = *P. juliflora,* BS = *B. sindica,* ± = standard error,
*** = $p< 0.001$,**= $p<0.01$, *=$p<0.05$.

Site C had the highest maximum water holding capacity of soil (22.97%) and the lowest EC (480.75 us cm), alkaline earth carbonate content (2.46meq I^{-1}) and $CaCO_3$ content (15.25%) (Table 2). The soil of site A had the lowest contents of silt (5.5%),and clay particles (1.36%) as well as the lowest maximum water holding capacity (16.66%). Other soil characteristics of this site such as Na^+ (792 ppm) and EC (550us cm) were at intermediate levels. The soil properties of site B were also intermediate.

Discussion

A plant's competitive capacity tends to be greatest in optimum habitat conditions. High salt contents may cause suppression of plant growth. The presence of a high contentof sodium salts at site B might be the cause of the reduction in leaf number and root/shoot ratio in *B. sindica* and *P. juliflora.*

Table 2. Soil properties of the three different sites

Property	Site A	Site B	Site C
Silt %	5.50	10.97	12.16
Clay %	1.36	5.72	3.66
Sand %	92.30	75.15	77.90
Soil type	Sand	Loamy sand	Loamy sand
MWHC % of soil	16.66	21.44	22.97
pH	7.46	7.45	8.05
CaCO, %	16.75	22.50	15.25
Alkaline earth carbonate (meq 1'")	5.42	2.48	2.46
Cl (meq I^{-1})	8.75	5.65	7.08
Exhangeable Na* (ppm)	792	883	750
Exchangeable K* (ppm)	515	241	433
Electrical conductivity (is cm)	550	563	481

MWHC = maximum water holding capacity of soil.

In another study portioning growth and photosynthesis between leaves and stem in *Spartium juncerum,* Erik (1992) concluded that nitrogen limitation caused a general reduction in above-ground growth: NO_3~ limitation resulted in a large reduction in leaf area while excess NH_4^+ caused a decrease in growth of leaves and stem. *Blepharis sindica* seedlings from site A showed the best plant growth in terms of leaf number, plant height and biomass production. Shaukat *et al.* (1983) ranked *B. sindica* at the 9th position out of 13 species in their adaptability phytosociological investigation of the same site A of the campus. This proved the better adaptability of *B. sindica* in that community where the edaphic factors, e.g. pH, $CaCO_3$, alkaline earth carbonate, MWHC and salts concentrations, might be conducive to its better growth of (Table 2). It has been suggested that the preference of many plants for a soil of a particular mineral nutrient status or pH is the result not so much of casual relationship as of the relative competitive ability of the plants adapted to these conditions. Salisbury (1992) noted that white sorres *(Rumex acetosa)* showed a preference for acid soils, but in the absence of competition it can grow better in limed than in unlimed soils.

In such xeric condition where *B. sindica* was best adapted at site A, *P. julijlora* showed intermediate response for leaf number, plant circumference and plant height at the same site. Shaukat *et al.* (1983) found that the decaying shoots and roots of *Inula grantioides* were inhibitory to germination and seedling growth of *Cenchrus pennisetiformis.* They suggest that this plant suppresses the growth and abundance of other species in xeric communities. The low root dry weight of *P. juliflora from* site A could be due to the suppression by *I. grantioides.*

Plants vary in their tolerance of highly acid, alkaline or saline soils, all of which affect nutrient availability and balance. The extent to which soil chemical conditions such as lime richness, acidity, etc., affect some species or depress growth so that some species are less able to compete than others is still a debatable ecological question (Salisbury 1992). The reduction in plant height of P. *juliflora* collected from site A could be correlated with the findings of Davies *et al.* (1992) who reported that, for potted seedlings of *Leucadendron xantkocanus* when grown under different nutrient and water regimes, increasing water had significant positive effect on productivity and that drought reduced root/shoot ratio and leaf specific weight.

The reduction in number of leaves for both species developed from site B might be due to the high sodium concentration, calcium carbonate content and electrical conductivity of the soil. Besides other factors which are responsible for plant growth, physical properties of soil, such as soil strength, bulk density, texture and structure influence greatly the root penetration, growth and yield of various crops *(Gerad et al.* 1982). Plant nutrient availability, their fixation and downward movement with water depend on these physical properties of the soil (Sial 1991). The lowest root/shoot values of both species could be correlated with these factors.

Seedlings of both species from site C gave the smallest plant circumference. This could be due to the high pH (8.05) of the soil. Site B seedlings gave the best performance in plant circumference which could be linked to the physical properties of the soil in this site, especially its texture (Table 2). Seedlings of *P. juliflora* taken from site A, which had the lowest water holding capacity (16.66%), showed the lowest plant height (18.54 cm).

Because of the paucity of information relating to the adaptation of the two desert plants tested in natural plant communities under field conditions, an attempt has been made in this study to examine their response when grown under different edaphic conditions.

References

DAVIES, G.W., FI.YON, A.P. & MIDGLEY, G.F. 1992. Growth and gas exchange responses of *Leucadendron xanthoconus* (Proteaceae) seedlings to different nutrient and water regimes. *South African Journal of Botany* 58(1): 56 - 62.

ERIK, T.N. 1992. Portioning growth and photosynthesis between leaves and stems during nitrogen limitations in *Spartium juncerum*. *American Journal of Botany* 79(11): 1217- 1223.

GERAD, C.J., SEXTON, P. & SHAW, G. 1982. Physical factors influencing soil strength and root growth. *Agronomy Journal* 74(12) : 875 - 879.

GLEASON.HA. 1926. The individualistic concept of the plant association. *Bulletin of the Torrey Botanical Club* 53 : 7 - 26.

GRIME, J.P. 1979. *Plant Strategies and Vegetation Processes.* Chichester, John Willey & Sons, New York.

HOCKINO, D. 1993. *Trees for Dry Lands.* Oxford ABD IBH Publishing Co. Pvt. Ltd. New Delhi 11001: 279 - 283.

KHOSHOO, T.N. & SUBRAMANYAM, G.V. 1985. Ecodevelopment of arid lands in India with non-agricultural economic plants - a holistic approach. Pp. 243 - 265 in Wickens, F.E., Goodin, J.R. & Field, D.V. (Eds.) *Plants for Arid Lands.* Unwin Hyman Ltd., London, UK.

OoSTING, J.H. 1956. *The Study of Plant Communities.* W.H. Freeman and Company, San Francisco. 440 pp.

QADIR, S.A., QURESHI, S. Z. & AHMAD, M.A. 1966. A phytosociological survey of the Karachi University campus. *Vegetatio* 13 : 339 - 362.

SALISBURY, EJ. 1992. The biological equipment of species in relation to competition. *Journal of Ecology* 17: 197-222.

SHAUKAT, S.S., KHAN, D. & ALI, S.T. 1983. Suppression of herbs by *Inula grantioides* Boiss. in the Sind Desert, Pakistan. *Pakistan Journal of Botany* 15(1) : 43 - 67.

SIAL, N.B. 1991. Growth and yield performance of wheat under different soil textures. *Pakistan Journal of Agricultural Engineering and Veterinary Science* 7(1-2) : 56 - 60.

TIVY.J. 1993. *Biogeography. A Study of Plants in the Ecosphere.* 3rd edition. Longmans Group, U.K. 452 pp.

USDA. (1951). *Soil Survey Manual* U.S. Department of Agriculture Handbook No. 18, U.S. Government Printing Office, Washington D.C.

WHITTAKER, R.H. 1956. Vegetation of the Great Smoky mountains. *Ecological Monograph* 26 : 1 - 80.

WICKENS, G.E., GOODIN J.R. & FIELD, D.V. 1985. *Plants for Arid Lands.* Unwin Hyman Ltd. UK. 452 pp.