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Germination, Growth and Drought Resistance of Native and Alien Plant Species of the Genus *Prosopis* in the Sultanate of Oman

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Abstract: *Prosopis juliflora* is an alien plant species introduced into Oman nearly three decades ago. This species competes intensively with indigenous *Prosopis cineraria* plant species. In this study, the germination rates of untreated seeds of *P. cineraria* were significantly low compared with *P. juliflora*. When both seeds were placed together, only 6% of *P. cineraria* were germinated, whilst 73% of *P. juliflora* were germinated. This may suggest that the latter species possesses allelochemicals that prevent the germination and growth of other plant species. The relative growth rates (RGR) per week of *P. juliflora* seedlings were significantly higher compared with *P. cineraria* seedlings under both stress and un-stress conditions. This invasive alien species poses a real threat to biodiversity of many plant communities in Oman. Sites that have a relatively diverse species must be protected from this invasive alien species.

Key words: Alien, *Prosopis cineraria*, *Prosopis juliflora* germination, drought resistance

INTRODUCTION

The genus *Prosopis* of the family leguminosae is recognised worldwide as a genus of economic importance with excellent examples of multi-purpose trees found in many parts of arid and semi-arid environments (Sacheti and Al-Rawahy, 1998). Out of several *Prosopis* species, *Prosopis cineraria* (L.) Druce is the only indigenous species in Oman (Sacheti and Al-Rawahy, 1998). This species is morphologically distinct from alien *Prosopis juliflora* (Schwartz) D.C. species, which has been introduced (from the arid Southwest United States and Northwest Mexico) into Oman as a fast growing ornamental tree in landscape planting throughout the country (Brown, 1991). As in other alien plant species, *P. juliflora* has escaped from cultivation sites and is quickly spreading into natural habitats. In many parts of the world, invasive alien species are considered to be the second most significant threat to biodiversity following direct human destruction (Rubec and Ledd, 1996). In Oman the spread of *P. juliflora* invasive alien species has now reached unprecedented proportions (Ghazanfar, 1999) threatening many indigenous plant species, including *P. cineraria*. To conserve threatened indigenous plant species from an invasive alien species, it is necessary to know basic information on biology of both indigenous and alien species. Very little information is available on how *P. juliflora* plants compete with indigenous species, e.g. *P. cineraria* plants, in their natural habitats. Seeds of both *P. cineraria* and *P. juliflora* often dispersed through seed deposition by browsing animals and may be through birds. The seedlings of both *P. cineraria* and *P. juliflora* are well adapted to survive under extreme environmental conditions and have been reported to survive under drought (Ghazanfar, 1998) and salinity (Brown, 1991) conditions. *P. juliflora* has been recognised as a serious pest because it spreads rapidly into valuable agricultural lands due to its easy propagation and ability to withstand adverse environmental conditions and heavy grazing (Leaky and Last, 1980). It has been described by National Academy of Science (NAS, 1979) as being a major weed spreading rapidly due to its vigorous habit and overall domineering competitiveness with other vegetation. This species was one of the most successful tree species used for rehabilitating marginal sites in India (Garg, 1999). The present study aimed to investigate seed germinability of *P. cineraria* and *P. juliflora* plant species under field conditions and study the growth rates of seedlings under water deficit condition. We are hopping that this study will open the door for more investigations on the effects of alien species on the natural biodiversity of Oman.

MATERIALS AND METHODS

Seed collection and storage: Seeds of both *Prosopis cineraria* (L.) Druce and *Prosopis juliflora* (Schwartz) D.C. were collected from the Bowsher area of the Sultanate of Oman (23.5N, 58.6E) when they became available in the summer months of 2000. In order to

minimize seeds damage through insect infestation, pods were collected whilst still on the trees. Seeds were then immediately extracted from the pods, kept for a week at -4°C to kill any insects and stored at room temperature.

Seed germination: Seeds of both *P. cineraria* and *P. juliflora* were germinated on surface soil samples collected from the Bowsher area at ten random locations. Soil samples were sun-dried, thoroughly mixed and passed through a 2 mm sieve to remove seeds and debris. The mixed soil was placed in 7 cm plastic pots, filled to 5 cm depth. Seeds were placed at a depth of approximately 0.5 cm at the middle of the pot. Fifty pots were used for *P. cineraria* seeds, 50 pots for *P. juliflora* seeds and other 50 pots for seeds of both species, one of each placed approximately 1 cm apart. Pots were irrigated once every 3 days at a maximum field capacity, which was 35.2±2.4% (mean ± S.E., n = 20). Pots were kept nearly 5 weeks in a nursery at ambient conditions (22 – 34.5°C and 52 – 88 %RH). The number of seeds germinated was counted and the experiment was repeated three times during October/November 2001, February/March 2002 and October/November 2002. The whole experiment was done for untreated seeds, seeds treated with dry heat (70°C for 6 h) and seeds that were manually scarified with course sand paper.

Measurements of drought resistance: Seedlings of both *P. cineraria* and *P. juliflora* were used for measurement of drought resistance. Seeds were germinated on a surface soil sample collected from the Bowsher area in a similar way as explained above, using 30 cm plastic pots filled to 27 cm depth. The objective of this experimental trial was to compare the growth rates of daily watered plants with that of the same species subjected to water stress. The experiment was started when seedlings were four weeks old in January 2002 and continued for the next six months. Two hundred pots were used for each species, half were irrigated daily to maximum field capacity (35.2±2.4 %) and other half were irrigated once every four days to maximum field capacity. Soil water contents -which were made every 12 hours for 12 days during March and May 2002 using a 10 mm diameter cork borer- of stressed and unstressed pots were (mean±S.E) 11.5±3.6 and 33.8±1.1%, respectively. Weeds were removed by hand and the soil surface scarified each week to prevent caking of the surface. Plants were harvested in June 2002. Harvested plants were carefully washed to remove excess soil and then separated into shoots and roots. Leaf areas were obtained by using Delta T. Devices meter. Fresh weights of shoots and roots were obtained and then dried in an oven set at 70°C for 72 hours. The relative growth rates (RGR) per week were then calculated. The whole experiment was repeated during January – June 2003. Air temperature, relative humidity and light intensity measurements were taken daily at noon times (Table 1).

Table 1: Monthly minimum and maximum environmental data consists of air temperature (°C), relative humidity (%RH) and light intensity (PAR) taken at the Bowsher area of the Sultanate of Oman at noon times from January 2002 to June 2002. Similar data was obtained from January to June 2003

	Air temp (°C)			RH (%)			PAR (μmol m^{-2} s^{-1})		
Month	Min	-	Max	Min	-	Max	Min	-	Max
January	18.6	-	24.1	40	-	58	0720	-	1170
February	22.3	-	27.5	54	-	77	1071	-	1440
March	25.2	-	32.6	51	-	83	1360	-	1830
April	29.6	-	37.4	49	-	69	1550	-	2100
May	32.3	-	39.8	59	-	89	1620	-	2370
June	36.1	-	47.5	53	-	85	1690	-	2410

Data analysis: Statistical analysis of data was performed using the 'SPSS' for Windows statistical data analysis. Data were analysed using ANOVA to determine the significance of differences between plant species and/or treatments. All data were presented as means ±S.E.

RESULTS

Seed germination: The results of seed germinations of both species are shown in Table 2. We noticed that the seeds of *P. juliflora* were capable of germinating immediately after sowing and there was no further germination after 11 days even in untreated seeds, whilst in case of *P. cineraria* 46% of all germinated seeds was recorded in weeks three and four. Without pre-treatment and in dry-heat treatment, the germination of *P. juliflora* seeds was significantly higher compared with the germination of *P. cineraria* seeds (ANOVA, F= 237.0, P<0.001). Seed germination of both species was effected significantly by pre-treatments (ANOVA, F= 11.5, P<0.01). There was a significant difference in a number of seeds germinated when both *P. cineraria* and *P. juliflora* seeds were placed adjacent to each other, being higher in *P. juliflora* (ANOVA, F = 348.4, P<0.001).

Drought resistance: The effect of drought stress on the growth parameters measured in *P. cineraria* and *P. juliflora* seedlings are shown in Table 3. The data indicated that the shoot RGR/week of *P. cineraria* seedlings exposed to drought condition was significantly different (ANOVA, F = 21.3, P<0.001) from the shoot RGR/week when seedlings were not subjected to drought stress. Part of these reduction in shoot RGR/week was from leaf senescence, thus the leaf area was highly reduced (ANOVA, F = 60.5, P <0.001) when subjected to water stressed condition compared with unstressed

Table 2: Percentage germination of seeds of two *Prosopis* plant species collected from the Bowsher area of the Sultanate of Oman

	% Seed Germination ± S.E. of mean					
	Single seed in a pot					Both seeds in a pot
Species	No pretreatment	Dry-heat	Manual scarification	F-ratio	Sig of F	Manual scarification
P. cineraria	31.5±2.7	39.0±2.0	94.5±1.4	379.2	<0.001	06.2±2.1
P. juliflora	89.0±1.7	95.5±1.6	98.5±1.4	11.5	<0.01	78.6±2.6
F-Ratio	237.0	320.8	2.1			348.4
Sig of F	<0.001	<0.001	>0.05			<0.001

Table 3: Relative growth rates (RGR) per week of shoot and roots of two *Prosopis* species irrigated daily (unstressed) and subjected to drought stress (stress). Leaf area and percentage of dead plants are also shown. Values are the means of at least 118 plants ± s.e. of means. Ratios were calculated as unstressed/stressed

Species →	*P. cineraria*			*P. juliflora*		
Parameter ↓	Unstressed	Stressed	Ratio	Unstressed	Stressed	Ratio
Shoot RGR/week	0.62±0.05	0.31±0.03	2.0	0.80±0.06	0.73±0.04	1.1
Root RGR/week	0.63±0.04	0.68±0.06	0.9	0.87±0.05	0.88±0.06	1.0
Leaf area (cm^2)	129.7±7.6	32.3±3.6	4.0	190.2±7.4	106.2±8.2	1.8
Root length (cm)	25.6±1.5	37.2±2.5	0.7	27.3±1.9	28.1±2.0	1.0
Dead plants	3%	41%	0.1	2%	4%	0.5

condition. Drought stress, however, did not significantly affect the shoot RGR/week of *P. juliflora* (ANOVA, F=3.9, P>0.05). There was no significant difference (ANOVA, F<1.7, P<0.05) in root RGR/ week of both *P. cineraria* and *P. juliflora* seedlings. However, there was a significant difference (ANOVA, F = 13.2, P<0.01) in the length of main root between stressed and unstressed seedlings of *P. cineraria*, being longer in stressed seedlings. The number of dead seedlings differ among two species with drought stress condition being higher in *P. cineraria* (41%) than *P. juliflora* (5%).

DISCUSSION

Two *Prosopis* plant species used in this study were *P. cineraria* and *P. juliflora*. Both species have great ecological importance and are recognised multipurpose useful leguminous species. *P. cineraria* is the only native *Prosopis* species in Oman (Sacheti and Al-Rawahy, 1998); whereas *P. juliflora* is an invasive alien species, which was introduced into Oman nearly three decades ago. The success of this alien plant species in Oman has been attributed to intentional introduction of the species in order to be used as a landscaping tree. It is now spreading at alarming rates and there are now millions of self-seeded trees present all over the country. Seeds are germinating fast after moderate or good rainfall. In this study the proportion of germinated seeds was higher in *P. juliflora* than in *P. cineraria*. Furthermore, the germination of *P. cineraria* seeds was very much prevented by the presence of *P. juliflora* seeds. Warrage and Al-Humaid (1998) reported that *P. juliflora* plants possess allelochemicals that inhibit the germination and spread of other plant species. Similar observations were also reported by Noor *et al.* (1995). Allelophatic effects of *P. cineraria* on germination of other plant species have also been reported (Dhawan *et al.*, 1996); but according to the results presented here the effects of allelochemichals produced by *P. juliflora* may be stronger and more effective.

Both native *P. cineraria* and invasive alien *P. juliflora* species are well known for their adaptation to grow under drought stress conditions (Brown, 1991). However, the result obtained here indicated that seedlings of *P. juliflora* are performing better under drought stress condition compared with seedlings of *P. cinerarias*. Significantly reduction in shoot RGR/ week in *P. cineraria* seedlings was observed under drought stress condition. A Similar observation was also reported by Harris (1992) with *P. cineraria* seedlings. The leaf area reduction in *P. cineraria* was mainly due to leaf senescence rather than leaf size. If the rate of leaf senescence becomes faster than the rate that new leaves produced, the photosynthetic leaves will decrease (Munns and Termaat, 1986) and this in turn will reduce net assimilation rates and relative growth rates. In many cases, however, shoots are affected more than roots (Navari-Izzo and Rascio, 1999). This also was the case for both *P. cineraria* and *P. juliflora* seedlings in this study, where significant differences between root RGR/week of stressed and non-stressed pots were not observed. These results were qualitatively similar to several other experiments with legumes under drought stress (Navari-Izzo and Rascio, 1999) and salt stress (Winicov, 1991; Jain *et al.*, 1991; Al-Rawahy, 2000). Cheesman (1993) has discussed the importance of root/ shoot ratio in stressed plants. Higher root/ shoot ratio in stressed plants reduces the demand for certain elements within the shoot and increases the ability of root to supply required water and elements. However, the cost for these changes is the reduced ability to supply products of photosynthesis to the roots and growing apices, therefore in long-term exposure to

drought stress the growth is likely to be strongly reduced. In comparison between RGR/week of roots, we observed significant differences between two species in both stressed and unstressed treatments, being higher in *P. juliflora* seedlings. The results presented in this study indicated that *P. juliflora* invasive alien species is performing better under drought stresses compared with *P. cineraria* native species. In many parts of Oman, *P. cineraria* is not only facing interspecific competition with *P. juliflora* but young pods are lopped for fodder (Ghazanfar, 1999). Many animals, especially goats, tend to consume seeds once they have fallen to the ground. In our field observations, browsing domestic animals are more reluctant to consume the pods of *P. juliflora* compared to native tree species. As a result the number of *P. juliflora* seeds in seed banks is greater than seeds of native tree species. This may explain why regeneration rates of *P. juliflora* are higher in many parts of Oman compared with other wild plant species.

In conclusion, alien *P. juliflora* species has high seed germination rates, grows faster and better adapted to drought conditions compared with native *P. cineraria* species. Trees of *P. cineraria* are being lost from several regions of Oman because of the spread of invasive alien species. The potential risk that an introduced *P. juliflora* tree species may impose on *P. cineraria* and other plant communities in Oman needs to be evaluated.

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