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PROLINE AND WATER STATUS OF SOME DESERT SHRUBS BEFORE AND AFTER RAIN

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Abstract

Four desert shrubs (*Abutilon indicum*, *Aerva javanica*, *Calotropis procera* and *Senna holosericea*) commonly found in Karachi and its vicinity were studied for the plant water status and proline content during rainy and dry periods. Succulence in all plants increased after rainfall and this increase was substantial in *Calotropis procera*. *Senna holosericea* maintained more negative water potential while it was less negative in *Calotropis procera*. Proline content substantially decreased in all species after rainfall and in the case of *Senna holosericea* it decreased from about 330 to less than 140 m mol. L^{-1} plant water. Our data clearly indicate that increase in proline is related to increase in drought stress.

Introduction

Most plants are exposed to water stress due to extreme soil water deficits in arid and semi-arid environments (Morgan, 1984). Large areas of the earth's surface where temperature would permit plant growth are arid or semi-arid deserts. The survival of land plants in such areas relies on the availability of water and their adaptation under stress (Kramer, 1984). Adaptation to water stress in plants involves the reduction of cell dehydration by avoidance (leaf shedding, leaf rolling and low stomatal conductance) or tolerance through osmotic adjustment (Turner, 1979). Osmotic adjustment refers to the lowering of osmotic potential due to the net accumulation of solutes in response to water deficit or salinity (Munns, 1988). It is an important mechanism in drought tolerance as it enables the continuation of cell expansion (Wyn Jones & Gorham, 1983), stomatal and photosynthetic adjustments (Ludlow, 1980) and better plant growth by lowering water potential in response to decreasing soil water (Wyn Jones & Gorham, 1983).

Plants under stress undergo osmotic adjustment by accumulating one or more low molecular weight organic solutes known as compatible osmolytes (Naidu *et al.*, 1992). They are potent osmoprotectants that play a role in counteracting the effect of osmotic stress (Yoshiba *et al.*, 1997). Proline is one of the most common compatible osmolytes in water stressed plants that does not interfere with normal biochemical reactions and make their survival possible under stress (Stewart, 1981). It is accumulated in various plants that are subjected to water stress or salinity (Stewart & Lee, 1974; Storey *et al.*, 1977; Aziz & Khan, 2000, 2001).

The present study was designed to understand the changes in plant water status and proline contents in four desert shrubs of Karachi before and after rainfall.

Materials and Methods

The study was conducted on the arid shrub community in 1995 at the University of Karachi during the dry (January) and wet (August) periods. The climate of this area is sub tropical desert type where average annual rainfall is less than 250 mm and most of the precipitation is received during the monsoon (July / August) period, while remaining part of the year is usually dry. We conducted our studies on perennial desert shrubs like *Abutilon indicum*, *Aerva javanica*, *Calotropis procera* and *Senna holosericea*.

Leaf water potential was measured in the field by using a dew point microvoltmeter (Wescor HR 33 T). Leaf discs (young and old) from shoots of plants (five replicates) were punched and inserted in a sample chamber and water potential was measured after equilibration. To determine variation in plant succulence and soil moisture content, samples were randomly collected and brought to the laboratory in pre-weighed plastic bags. Fresh weight was immediately taken and then samples were oven dried at 80 °C for 24 hours after which dry weights were calculated. For proline measurements five replicates of 0.5 g each of leaves was boiled in 10 ml of water for 2 hours at 100 °C using a dry heat bath. This hot water extract was cooled and filtered using Whatman no. 42 filter paper and then used directly to measure proline (Bates *et al.*, 1973). The results were analyzed with two way ANOVA to determine if significant differences were present among means.

Results and Discussion

Plants follow an osmoconformor strategy by lowering their tissue water and osmotic potential due to the net accumulation of solutes (osmotic adjustment) in response to water deficit (Munns, 1988) or salinity (Khan *et al.*, 1999, 2000). An increase in solute including the osmolytes occurs with the reduction in water potential (Turner & Jones, 1980). Accumulation of proline as an osmolyte in our studies occurred to varying extents in all species. Proline levels in both young and old leaves substantially increased during the dry period (Fig. 3). There was a significant ($P<0.05$) variation in proline content among all plant species (Table 1) and between seasons ($P<0.001$) with maximum accumulation in *S. holosericea* and minimum in *A. indicum* (Fig. 3). Two-way interactions of species x seasons on proline was also significant ($P<0.01$) (Table 1). In general higher proline content was observed in young leaves than the old ones (Fig. 3). *Senna holosericea* accumulated higher proline content during the dry period, followed by *C. procera* and *A. javanica* and it was minimum in *A. indicum*. However, as the rain approached, levels of proline dropped dramatically in all species. The accumulation of proline in plants subjected to water stress or salinity has been observed widely (Stewart & Lee, 1974; Storey *et al.*, 1977; Cavalieri, 1983; Aziz & Khan, 2000, 2001). Higher levels of proline during the dry period in *S. holosericea* was a feature of decreased water potential as indicated in other drought stress studies (Singh *et al.*, 1973; Storey *et al.*, 1977; Naidu *et al.*, 1992; Turner & Jones, 1993). *Calotropis procera* also had a higher proline content during the dry period though it is the most succulent species. On the contrary, *A. indicum* and *A. javanica* (being less succulent) showed a more negative water potential than *C. procera* but still had lower proline content. These results indicate that the survival of *C. procera* in arid regions depends upon increased succulence and osmotic adjustment both, whereas, the survival of other species depends upon the availability of moisture during rainy season and they follow osmoconformor strategy during the dry period through osmotic adjustment.

Table 1. Results of two-way ANOVA of characteristics in leaves by plant species (P) and seasons (S).

Independent variable	P	S	P x S
Water potential	42.7*	68.1**	23.1*
Proline	32.7*	67.5***	61.3**
Leaf succulence	133.9***	84.1**	27.2*

Note: Numbers represent F-values. * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$.

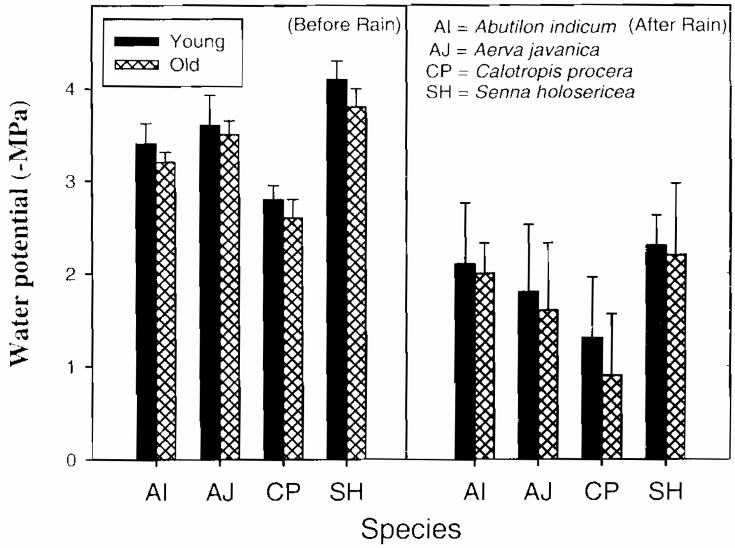

Fig. 1. Leaf water potential (-MPa) of four desert shrubs before and after monsoon rains.

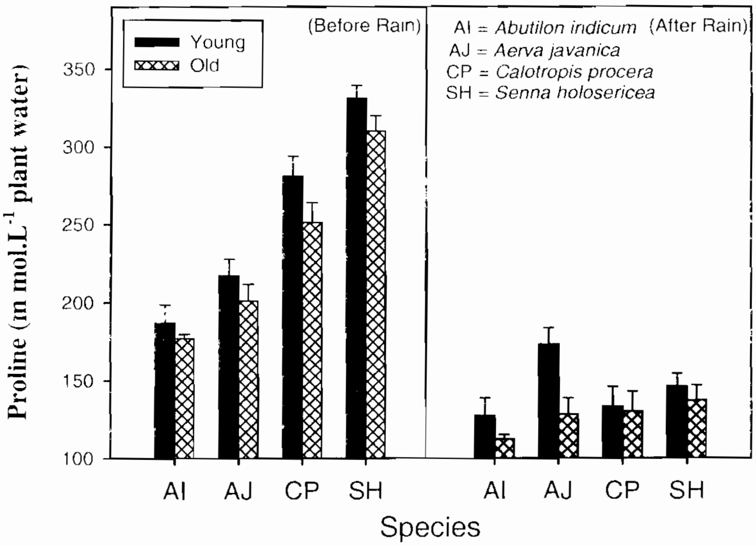

Fig. 2. Leaf proline (m mol.L^{-1} plant water) content of desert shrubs before and after monsoon rains.

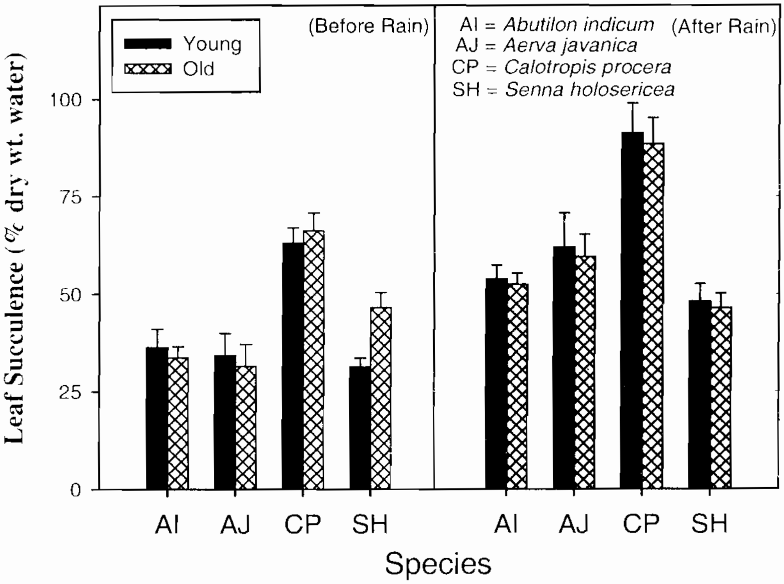

Fig. 3. Leaf succulence (% dry wt.) of desert shrubs before and after monsoon rains.

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