SHORT NOTE

Variation in seasonal and diurnal leaf water potential of a Namib dune succulent

by

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Much research work has been performed on water movement in the soil, plant and atmosphere continuum using agricultural plants with high and moderate total rainfall amounts (greater than for example 500 mm). However, a desert environment presents a totally different and often more complex situation. For a plant to exist in a desert, it often has to cope with high soil and air temperatures and extreme aridity. *Trianthema hereroensis* and *Stipagrostis sabulicola* are endemic to the Namib Desert and are the only living plant species which continue to survive and grow in certain areas of the Namib dunes for prolonged periods without rain. *T. hereroensis* is restricted to the western half of the southern Namib dune system. The frequent but irregular occurrence of advective fog provides a source of water which *T. hereroensis* is able to utilise by imbibition through its leaves and then translocation to the root system (Seely, De Vos and Louw, 1977).

Plants hold water under tension. The pressure required to exude water from a leaf cut at the petiole may be defined as the water potential of the leaf. The gradient of water potential between the roots and the leaves is proportional to the driving force for water movement (Campbell, 1977). Water potential (volumetric) may be more accurately defined as the chemical energy needed to move a unit volume of water from the system under consideration to a reference position (Savage, 1978). The reference position is normally taken to be that of pure free water at the same temperature as the water in the system, and at atmospheric pressure. Water potential values are therefore always less than or equal to zero and have the units of pressure (Pa, kPa or MPa).

Scholander, Hammel, Bradstreet and Hemmingsen (1965) described a method for the measurement of water potential of vascular plants by measuring the sap pressure using a pressure chamber. The pressure chamber has been widely used in the measurement of xylem water potential of plants (Ritchie and Hinckley, 1975).

Water potentials of Sonoran desert shrubs have been measured (Halvorson and Patten, 1974). The lowest water potential recorded was −8 510 kPa for midsummer and the highest during the study period was −670 kPa (in March). The average summer diurnal variation of all the species studied was found to be similar to the winter average of −1 000 kPa, although a single species fluctuated below −4 000 kPa during a 24 h period in summer. Seasonal water potential differences of up to −6 000 kPa were found in the desert shrub *Atriplex nuttallii* (Branson, Miller and McQueen, 1976).

The study was undertaken at two sites, Flodden Moor and Rooibank, both near Gobabeb (23°36′ S, 15°01′ E). Three xylem water potential measurements were performed approximately every two hours for a 24 h period. This was repeated every month for both sites.

Commercial pressure chambers available to us were too bulky for field use and required excessive amounts of nitrogen gas. Due to the rugged terrain, transport and gas costs and time involved in replenishing supplies, we required a robust, relatively cheap and small unit that did not use too much gas and could be used in remote, sandy sites. We designed a stainless steel unit that has a small chamber (120 cm^3). Brass rings were used to decrease the volume of the chamber. The chamber was pressure tested to 9000 kPa.

The plant material required for sampling was first covered with a slightly moistened cotton cloth and then sticky plastic wrap. The petiole was cut with a stainless steel razor blade, inserted through a rubber stopper and the edges sealed with Prestik. A slow pressure increase rate of about 20 kPa s^{-1} was used. Care had to be exercised when choosing plant material representative of the whole plant. Also, it was important to ensure that the sampling method was consistent.

In order to ascertain how many replicate xylem water potential measurements would suffice for a plant of uniform condition, the following experiment was conducted: Two sets of ten leaf water potential measurements were performed in quick succession, during stable weather conditions around midday, using two plants of uniform condition. The mean, standard deviation and coefficient of variation for the first set was −2977 kPa, 183 kPa and 6% respectively and −2630 kPa, 120 kPa and 5% for the second. The mean of the first three measurements from each set was −2903 and −2543 kPa with respective standard deviations of 116 and 40 kPa. Thus, as few as three measurements were sufficient for the average value to be within the 95% confidence limits of the population mean.

Thermocouple psychrometers (Savage, Cass and De Jager, 1981) were placed in a desert soil in an attempt to measure soil water potential. Large measurement errors in water potential were experienced due to temperature gradients.

The diurnal variation in xylem water potential of *T. hereroensis* is presented (Fig. 1). The lowest water potential was −2510 kPa, occurring at 15h00 in July. Maximum xylem water potentials occurred before sunrise, depending on the presence of fog. At night, the plant is exposed to cool moist air and in the early morning it is most likely to experience the advective fogs.

Seasonal variation in xylem water potential is small with large monthly standard deviations (Table 1). Since fog has been recorded in every month of the year at Flodden Moor and Rooibank, *T. hereroensis* does not appear to experience a definite wet and dry period. This may explain the small seasonal variation in xylem water potential.

In an agricultural situation, a water potential gradient exists between the soil, plant and atmosphere. Water moves along a decreasing gradient from the soil to the roots and then to the atmosphere. In spite of the large measurement errors in soil water potentials, there was no doubt that the water potential at a soil depth of

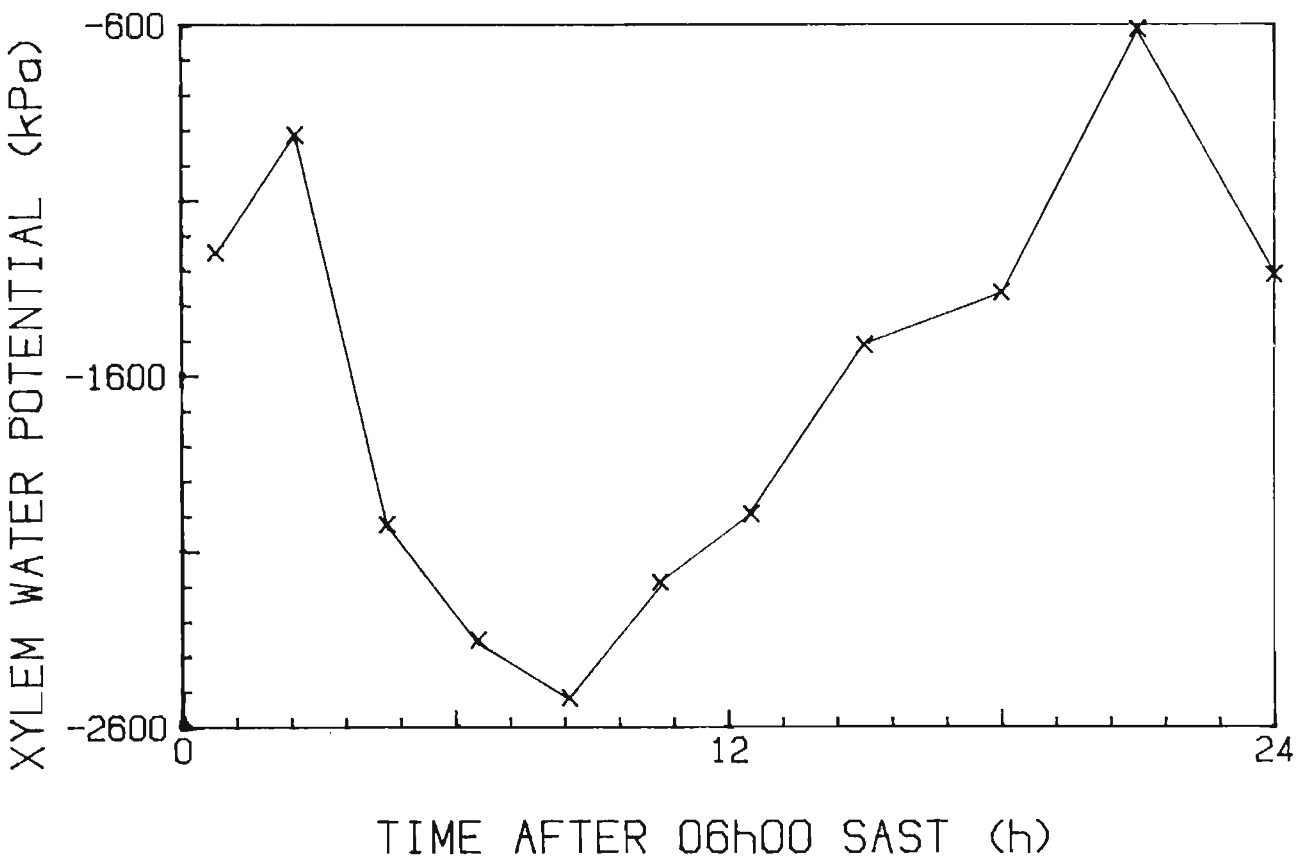

FIGURE 1: Diurnal variation in xylem water potential of *T. hereroensis*, July 1982.

about 500 mm was always lower (more negative) than xylem water potential of living material during non-fog days. Also, during these times, the atmospheric water potential was lower than that of living leaf material water potential. It is concluded then that during the day and in the absence of fog, living leaf material is a source of water and there is no unidirectional continuous flow of water but rather flow from the leaf region to the roots and from the leaf region into the atmosphere (should the stomata be partially or fully open). Leaf material can exist at high water potentials, independent of the root system and the status of water in other leaf parts of the plant. This was confirmed by our attempts at measuring root water potential; these were beyond the limit of the pressure gauge (less than −6000 kPa).

SUMMARY

T. hereroensis exhibits a diurnal variation in leaf water potential (−1910 kPa in summer). There is, however, little seasonal variation and this may be due to the fact that there is no definite wet or dry period as fog can occur in all months of the year. It would appear that for a given plant, leaf material can exist independently of the status of water in the roots and other plant leaf parts. It is proposed that under evaporative demand conditions, water moves from the leaf to the roots and from the leaf to the atmosphere. Namely, there is no unidirectional continuous flow of water, as is generally the case for agricultural plants.

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TABLE 1: Seasonal variation in water potential for 1982/1983

Month	Average midday water potential (kPa)	Standard deviation (kPa)
July	— 2 370	64
August	— 2 810	686
September	— 2 500	168
October	— 2 590	389
November	— 2 860	507
December	— 3 190	120
February	— 2 740	565