The water relations of Inga multinervis for efficient water use in forest systems

Yasiel Arteaga Crespo a,1, Yudel García Quintana a, Reinier Abreu Naranjo a, Yamila Lazo Pérez a, Dunia Chávez Esponda a, María de Decker a

a Universidad Estatal Amazónica. Campus Central. Paso Lateral Km. 2 1/2 Vía a Napo, Troncal Amazónica E45, Puyo.

Graphical Abstract

Abstract

Inga multinervis, a little-known species, is being used in agroforestry systems for nitrogen fixation and soil improvement. The aim of this research was to characterize the water relations of the species I. multinervis from pressure-volume measurements. The results indicated that the species has the capacity for osmotic and elastic adjustment, given to the low solute potentials and elasticity of the cell walls, thus its use is recommended in degraded forest systems with low water levels in the soil.

*Corresponding author.
E-mail address: yarteaga@uea.edu.ec
Introduction

Inga multinervis is a species of legume in the Fabaceae family, which grows only in Ecuador. Its natural habitats are subtropical or tropical moist lowland forests and subtropical or tropical moist montane forests (Neill and Pitman, 2004). This little-known species is being used in agroforestry systems for nitrogen fixation and soil improvement. Consequently, from the physiological point of view it’s important to increase the knowledge of this species for future forest management, which will allow its use in mitigating environmental impacts.

Pressure–volume (P–V) curves are frequently used to analyze water relation properties of woody plants in response to transpiration-induced tissue water loss. Generally, P–V-derived parameters reflect the environmental conditions of growth.

Reforestation of degraded land requires the use of selected species which should provide sustainable long-term ecological services. Eco-physiological properties of trees are commonly considered when their capacity for growth and stress tolerance are evaluated (Kozlowski and Pallardy, 1997; Larcher, 2003).

The aim of this research was to characterize the water relations of the species I. multinervis for efficient use of water in forest systems.

Materials and Methods

Study site and plant materials

The study was carried out at Universidad Estatal Amazónica, located in the Province of Pastaza, Ecuador. Sampling was carried out in the proximity to the university. Plant material included the tree species. multinervis.

P–V curve analysis

Measurements for P–V analyses were performed using a pressure chamber (Model 1000, PMS Instruments, Corvallis, OR) following the method described in previous studies (Tyree and Hammel 1972; Kubiske and Abrams 1990).

Statistical analysis

Statistical analyses were performed using analysis of variance.

Results and discussion

P–V parameters

Figure 1 shows typical Höfler diagrams obtained from P–V curves for I. multinervis. These diagrams represent dynamic changes of water potential (ψw), osmotic potential (π), pressure potential (ψp) and bulk elastic modulus (r) in relation to relative symplastic water content (SWC).

![Figure 1. Plots of relative water content (RWC) against water potential (Ψw).](image-url)

Table 1 shows the water relation parameters derived from P–V curves for I. multinervis.

| Water Parameter | Value |
|-----------------|-------|
| ψw              | 0.50  |
| π                | 0.45  |
| ψp              | 0.40  |
| r                | 0.35  |
| 100–RWC (%)     | 0.30  |
| 20              | 0.25  |
| 30              | 0.20  |
| 40              | 0.15  |
| 50              | 0.10  |
| 60              | 0.05  |

Table 1. Water parameters from I. multinervis
Osmotic potential (MPa) -2.41
Osmotic potential at water saturation with full turgor (MPa) -3.62
Bulk elastic modulus (MPa) 7.81
Relative water content at turgor loss point (%) 73.31

I. multinervis showed higher osmotic potential and osmotic potential at water saturation with full turgor than other species, such as Robinia pseudoacacia, Quercusiaotungensis, Syringaobliqua, Acer stenolobum, Armeniacasibirica, Pyrusbetulaefolia, Caraganamicrorhulla, Rosa hugonis according to reported by Yan et al.,(2013). These authors reported for these species bulk elastic modulus and relative water content at turgor loss point above those shown by I. multinervis. Bulk elastic modulus is one of the key leaf physiological traits of plantdrought tolerance estimated from the relationship between the leaf-water potential and leaf-water volume, also known as the pressure-volume curve. It is mechanistically related to other P-V parameters that include osmotic potential at turgor loss point, osmotic potential at full turgor, and relative water content at turgor loss point. These parameters have also been correlated with various aspects of drought tolerance (Lenz et al., 2006; Bartlett et al., 2012; Touchette et al., 2014). For instance, a more negative osmotic potential at turgor loss point extends the range of leaf-water potential at which the leaf remains turgid and maintains stomatal and hydraulic conductance, photosynthetic gas exchange, and plant growth, which is especially important when drought occurs during the growing season (Lenz et al., 2006; Bartlett et al., 2012).

These results indicate that the species presents high water absorption capacity of the soil, so it is recommended to use it for low water consumption and consequently less impact on the soil and the environment.

Conclusions
The determination of the water parameters from the P-V curves allows the characterization of the water relations of forest species. I. multinervis presented low values in the osmotic potential at water saturation with full turgor and in the water potential at turgor loss point, as well as low bulk elastic modulus, indicating that it is a suitable species for forest systems in low water content soils. The species is recommended to mitigate the environmental impacts associated with drought degraded soils.

Bibliography
Bartlett, M. K., Scoffoni, C., & Sack, L. (2012). The determinants of leaf turgor loss point and prediction of drought tolerance of species and biomes: a global meta-analysis. Ecology Letters, 15(5), 393-405.

Kozlowski, T. T., & Pallardy, S. G. (1997). Physiology of Woody Plants, 411 pp. Academic, San Diego, Calif.

Kubiske, M. E., & Abrams, M. D. (1990). Pressure-volume relationships in non-rehydrated tissue at various water deficits. Plant, Cell & Environment, 13(9), 995-1000.

Larcher, W. (2003). Physiological plant ecology: ecophysiology and stress physiology of functional groups. Springer Science & Business Media.

Lenz, T. I., Wright, I. J., & Westoby, M. (2006). Interrelations among pressure-volume curve traits across species and water availability gradients. Physiologia Plantarum, 127(3), 423-433.
Neill, D. & Pitman, N. 2004. Inga multinervis. The IUCN Red List of Threatened Species 2004: e.T45245A10988303.

Touchette, B. W., Marcus, S. E., & Adams, E. C. (2014). Bulk elastic moduli and solute potentials in leaves of freshwater, coastal and marine hydrophytes. Are marine plants more rigid? AoB Plants, 6.

Tyree, M. T., & Hammel, H. T. (1972). The measurement of the turgor pressure and the water relations of plants by the pressure-bomb technique. Journal of Experimental Botany, 23(1), 267-282.

Yan, M. J., Yamamoto, M., Yamanaka, N., Yamamoto, F., Liu, G. B., & Du, S. (2013). A comparison of pressure-volume curves with and without rehydration pretreatment in eight woody species of the semiarid Loess Plateau. Acta physiologiaeplantarum, 35(4), 1051-1060.