ABSCISIC ACID (ABA) AND THE REGULATION OF SEEDLING GROWTH UNDER STRESS

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Abstract. Xylem sap abscisic acid (ABA) and leaf ABA of *Hopea odorata* Roxb. and *Mimusops elengi* L. were measured under conditions of soil compaction and drought to investigate the role of ABA in the regulation of stomatal conductance. A rapid and substantial increase in xylem sap ABA concentration but not leaf ABA concentration was correlated with soil drying in both species. However, xylem ABA concentration was lower in *M. elengi* seedlings than in *H. odorata* seedlings. The increase in xylem sap ABA concentration observed at high soil bulk density was correlated with reduced stomatal conductance. These results suggest that xylem ABA may act as a stress signal in the control of stomatal conductance. Reduced xylem ABA levels may explain the lower urban stress tolerance *M. elengi* seedlings relative to *H. odorata*.

Key Words. *Hopea odorata*; *Mimusops elengi*; soil compaction; drought; stomata conductance; xylem sap abscisic acid; urban environment.

Stomatal conductance is a primary determinant of the net carbon balance and growth of plant species, and, because of its influence on transpirational water loss, stomatal conductance determines the water balance of a plant. Stomata impose a critical control mechanism over water loss and gas exchange between the atmosphere and leaf cells (Liang et al. 1996). Effective stomata control is important for plant growth and survival, especially when water supply is limited. Accumulated evidence has shown that inhibition of leaf growth and stomatal conductance are perhaps the first responses when root systems are exposed to stress conditions, such as drought, flooding, and soil compaction (Passioura 1988; Davies and Zhang 1991; Tardieu and Davies 1993; Hartung et al. 1994). Under these conditions, roots may respond by synthesizing and exporting chemical signals through the transpiration stream to shoots where physiological processes are regulated (Davies and Zhang 1991; Gowing et al. 1993).

Tardieu and Davies (1992) found that the abscisic acid (ABA) content of root tips increased when maize (*Zea mays* L.) was grown in compacted soil, while the application of 1µM ABA to unstressed seedlings promoted the growth of short, thick roots similar to those produced in response to mechanical impedance (Hartung et al. 1994). Stypa (1987) also observed increases in ABA content in both the stunted roots and shoots of maize plants grown in compacted soil under laboratory conditions. In contrast, Lachno et al. (1982) and More et al. (1988) failed to detect any increase in ABA concentration in mechanically impeded roots of maize.

Although the effects of soil compaction have been extensively studied, few experiments have examined the involvement of root-to-shoot signaling in mediating plant responses. Increased xylem sap ABA concentrations and associated reductions in stomatal conductance have been recorded in the shoots of maize plants growing in compacted soil under field conditions (Tardieu et al. 1991). Hartung et al. (1994) also reported increases in xylem sap ABA concentrations in plants subjected to mechanical impedance. It is therefore possible that a root-sourced signal such as ABA may be involved in plant responses to soil compaction.

This experiment was designed to examine the relationship among stomatal conductance, xylem sap ABA concentration, and leaf water potential in two species grown in compacted and unwatered soil.

MATERIALS AND METHODS

The experiment was a 2 × 2 × 2 factorial design with two species (*Hopea odorata* and *Mimusops elengi*), two soil compaction treatments (compacted and noncompacted), and two soil moisture treatments (well watered and at soil water potential ≥ -1.5 MPa). Seedlings were planted in a Tropeptic haplorthox soil series in a series of soil columns consisting of 70 cm (28 in.) long sections of polyvinyl chloride [with internal diameter of 10 cm (4 in.)]. Each column contained two layers of soil. The lower layer was noncompacted, with an approximate bulk density of 1.0 g/cm^3, while the top layer was packed to a dry bulk density of 1.0 g/cm^3 or 1.5 g/cm^3 (Table 1). In total, eight different treatment combinations were used with 24-single plant replicates per treatment. Twelve days later, when the seedlings were well established (manifested by the appearance of new leaves), moisture stress was imposed by leaving half of the plants within each species unwatered, while the remaining half were watered daily. To determine soil water content, a 0 to 15 cm (0 to 6 in.) deep soil core was sampled with a punch 10 mm (0.4 in.) in diameter. Six samples were collected from each treatment. The soil core was weighed