Introduction

*Melastoma malabathricum* L. is an aluminum (Al) accumulating woody plant that grows in tropical Southeast Asia in acid soils with high Al concentrations. This species accumulates more than 10,000 mg Al kg\(^{-1}\) in leaves of the monospecific Al and Al-mutate complexes (Watanabe et al., 1998). It was also demonstrated that the Al-form for translocation from the roots to the shoots is an Al-citrate complex (Watanabe and Osaki, 2001). However, the exact mechanisms of Al uptake in *M. malabathricum* roots remain to be elucidated (Fig. 1). In the present study, La uptake in *M. malabathricum* was compared with Al uptake (Experiment 1), and the role of the mucilage exuded by *M. malabathricum* roots in Al uptake was examined (Experiment 2).

Materials and methods

**Experiment 1: Responses of *M. malabathricum* roots to aluminum and lanthanum**

*M. malabathricum* seedlings were transferred to containers filled with a standard nutrient solution (pH 4.2) (Control), or with nutrient solution containing either 0.5 mM Al or 0.5 mM La at 0.5, 3, 24 and 72 h after commencing the treatment, seedlings were harvested. Al in the roots was fractionated into symplastic, apoplastic, and residual fractions. The method used for the symplastic fraction was that of Tice et al. (1992) was used for the analytical fractionation, whereas 5 mM EDTA with 5 mM CaCl\(_2\) was used as desorbing solution (pH 4.2). Concentrations of the minerals and organic acids in each fraction were determined.

**Experiment 2: Role of the root mucilage in aluminium uptake in *M. malabathricum***

In general, the mucilage is considered to be effective in excluding Al (Horst et al., 1982). Although *M. malabathricum* is an Al accumulating plant, it exerts large quantities of mucilage from its roots (Fig. 2). Moreover, the mucilage exudation is reduced in the absence of Al (Fig. 8).

**Exp. 2.1: Selectivity for the absorption of cations in the mucilage**

One mL of the mucilage treated with roots of *M. malabathricum* grown in nutrient solution was added to 4 mL of the cation mix solution (0.1 mM AlCl\(_3\), 0.1 mM BaCl\(_2\), 0.1 mM LaCl\(_3\), pH 4.2), shaken for 2 h and centrifuged at 12,000 g. The supernatant was filtered on a membrane filter. Al, Ba and La concentrations in the filtrate were determined to calculate the concentration of these cations adsorbed to the mucilage.

**Exp. 2.2: Effect of the removal of the mucilage on cation uptake**

*M. malabathricum* seedlings from which mucilage was removed were transferred to containers containing the standard nutrient solution with 0.5 mM AlCl\(_3\) at pH 4.2 (Muci). As a control, the seedlings with the mucilage were also treated (+Muci). At the end of the 10-day treatment period, the seedlings were sampled to determine their mineral concentrations in shoots.

**Exp. 2.3: Determination of the Al-form in the mucilage**

Al, citrate and other cations adsorbed to the mucilage were measured in the mucilage by Al-NMR. Al-NMR spectra were measured at a concentration of 200 mM Al and 100 \(\mu\)M Al citrate solution (Exp. 2.3). Al solution (0.1 M H\(_2\)SO\(_4\)) was used as an external reference for calibration of chemical shift (\(\delta\) ppm).

Results and Discussion

**Experiment 1: Responses of *M. malabathricum* roots to aluminum and lanthanum**

Although the Al concentration in the symplastic fraction increased with time of treatment (Fig. 4), that in the apoplastic fraction only increased until 3 h, and stayed at this level until the end of the experiment. The Al level was higher in the symplastic fraction after 72 h than in the apoplastic fraction, exceeding 4 µmol g\(^{-1}\) fw (Control), or with nutrient solution containing either 0.5 mM Al or 0.5 mM La. At 0.5, 3, 24 and 72 h after commencing the treatment, seedlings were harvested. Al in the roots was fractionated into symplastic, apoplastic, and residual fractions. The method used for the symplastic fraction was that of Tice et al. (1992) was used for the analytical fractionation, whereas 5 mM EDTA with 5 mM CaCl\(_2\) was used as desorbing solution (pH 4.2). Concentrations of the minerals and organic acids in each fraction were determined.

**Experiment 2: Role of the root mucilage in aluminum uptake in *M. malabathricum***

The mucilage exuded from *M. malabathricum* roots adsorbed more Al than Ba (Fig. 6). This can be explained by the general phenomenon that the amount of the cation absorbed by the cation exchanges increases with the number of charges on the cation. Interestingly, the mucilage adsorbed more Al than Ca (Fig. 6). As both Al and La are trivalent cations, it was suggested that Al uptake in *M. malabathricum* roots can be explained by the general phenomenon that the amount of the cation absorbed by the cation exchanges increases with the number of charges on the cation (Fig. 6).

**Conclusion**

The reason why *M. malabathricum* actively absorbs Al should be elucidated in future.

References


