Seedling Growth and Aluminum Distribution in Root of Sago Palm under Low pH Condition

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ABSTRACT

To determine the aluminum (Al) tolerant ability of sago palm, seedlings were grown in culture solution at pH 3.6 including different level of $AlCl_3 \cdot 6H_2O$ corresponding in 0, 10, 20, 100 and 200 ppm Al. Total dry weight, plant length and total leaf area tended to be largest at treatment with 10 ppm Al followed by 0, 20, 100 and 200 ppm Al. The root system treated with 200 ppm Al was apparently different from the other plots, which the critical toxic level to inhibit sago palm growth was considered to be around 200 ppm Al. The Al^{3+} concentration tended to be lower in the leaflets at higher leaf position and the stele of adventitious roots, while it tended to be higher in the cortex of adventitious roots. Furthermore, the observation of Al localization in the roots stained with hematoxylin showed that Al was accumulated in the cell wall of exodermis. From fluorescent observation of roots stained with berberine-aniline blue, the development of suberin lamellae was found in the exodermis, which might suggest the suberin lamellae as the first barrier to restrict the radial movement of Al in sago palm roots under acid conditions.
KEYWORDS: adventitious root, aluminum localization, exodermis, sago palm, suberin lamellae

1. INTRODUCTION

Aluminum, as Al^{3+}, is generally believed to be inhibited in the root growth and nutrient uptake under acid condition. However, it has some reports that several plants species is also known to be enhanced by the application of Al (Osaki et al., 1997). Sago palm (*Metroxylon sagu* Rottb.) is one of the dominant species in tropical swampy, alluvial and peaty soil that are generally contain high exchangeable of Al. This palm species can be considered to be tolerant to Al, however, there are few studies on the Al-induced changes on growth responses of sago palm. Therefore, the aim of this study was to investigate the effect of Al concentration in culture solution on growth and aluminum distribution in root of sago palm under low pH condition.

2. MATERIALS AND METHODS

The seedlings at 10 months of age were transplanted in a Wagner pot that filled with vermiculite and Kimura B culture solution at pH 3.6 including different level of $AlCl_3 \cdot 6H_2O$ corresponding in 0, 10, 20, 100 and 200 ppm Al (here after Al-0, Al-10, Al-20, Al-100, Al-200) with 3 replications. The pH of the culture solution was adjusted with 1.0 N HCl as required. Culture solutions were changed every 2 days. At the end of the treatment, leaf area, fresh weight, dry mater weight, ion concentrations (leaflets, petioles and roots) and the observation of roots were investigated.

3. RESULTS AND DISCUSSION

Weekly increment of plant length, total leaf area and dry matter weight were largest in Al-10, followed by Al-0, Al-20, Al-100 and Al-200 plots (Table 1). The root system in Al-200 was apparently different from the other plots, which the branched roots were stunted, brownish and thick. The root dry weight was also smaller than the other plots. Consequently, the critical toxic level to inhibit sago palm growth was considered to be around 200 ppm Al in the media. The change in P, N, K^+, Ca^{2+} and Mg^{2+} concentrations with the Al treatments was moderate. The Al^{3+} concentration tended to be lower in the leaflets at higher leaf position and the stele of adventitious roots, while it tended to be higher in the cortex of adventitious roots (the values were in the range of 190 - 950 mg Kg^{-1} DM in all the plant parts even at Al-200). According to Chenery (1948), the thousands of plant species are classified (by the Al concentrations in the plant tissues) as l-accumulators (≥ 1,000 mg Kg^{-1} DM) or Al excluders (< 1,000 mg Kg^{-1} DM). Considering the result of Al^{3+} concentration in this study, sago palm is considered to have the Al exclusion ability under acid condition. Furthermore, the observation of Al localization in the roots stained with hematoxylin showed that Al was accumulated in the cell wall of exodermis and epidermis. This result indicated that the radial transport of Al was restricted by the exodermis. From fluorescent observation of roots stained with berberine-aniline blue, the development of suberin lamellae was found in the exodermis, which might suggest the suberin lamellae as the first barrier to restrict the radial movement of Al in sago palm roots under acid condition (Figure 1).

Table 1. Effect of Al concentrations on plant length, total leaflet area and dry matter weight.

Treatment (ppm)	Weekly increment of plant length (cm)	Total leaflet area ($cm^2 plant^{-1}$)	Dry matter weights (g plant^{-1}) Leaflet	Petiole	Root	Whole
Al - 0	2.0 ± 0.1 a	2418.8 ± 728.0 ab	17.3 ± 5.9 ab	20.1 ± 4.9 ab	9.0 ± 5.1 ab	46.4 ± 15.8 ab
Al - 10	2.0 ± 0.1 a	3008.6 ± 222.8 a	23.0 ± 1.3 a	27.1 ± 2.5 a	13.6 ± 0.8 a	63.7 ± 4.3 a
Al - 20	1.9 ± 0.2 ab	2092.0 ± 906.3 ab	15.7 ± 6.9 ab	16.3 ± 6.1 ab	6.7 ± 1.9 ab	38.7 ± 14.8 bc
Al - 100	1.9 ± 0.2 ab	2151.7 ± 150.5 ab	15.1 ± 0.5 ab	18.0 ± 2.9 ab	6.6 ± 0.9 b	39.7 ± 5.3 bc
Al - 200	1.7 ± 0.1 b	1153.4 ± 163.8 b	8.0 ± 1.7 b	11.2 ± 2.7 b	3.8 ± 1.7 b	22.9 ± 6.0 c

Mean ± SD (n=3). Different letters in the figure indicate significant differences (P<0.05, Turkey - Kramer test).

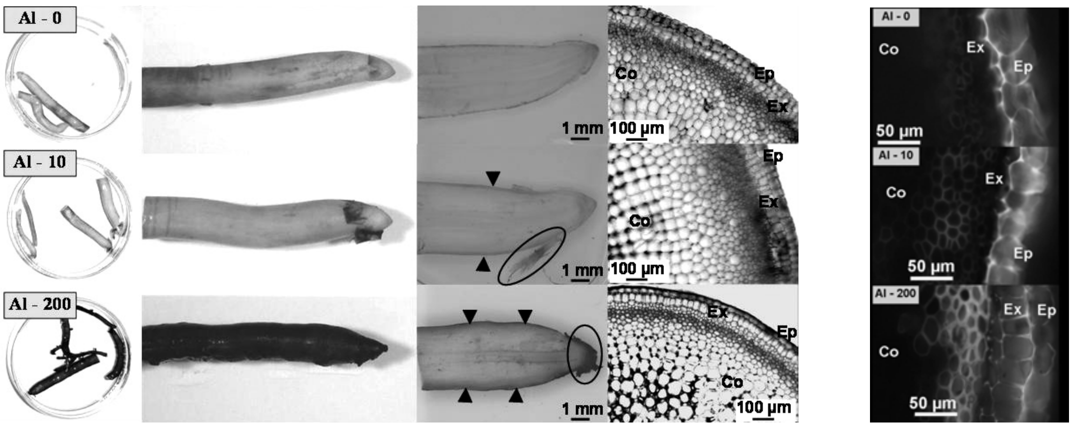

Figure 1. Localization of Al by hematoxylin staining of root cross and transversal sections (left) and fluorescent observation of roots stained with berberine-aniline blue (right). Roots were treated with difference concentrations of Al (0, 10 and 200 ppm Al). Co: cortex, Ep: epidermis, Ex: exodermis. Arrowheads and circles indicate the significantly stained regions.

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