INTERACTIONS BETWEEN ALUMINIUM AND PHOSPHORUS ON ROOT SURFACES AND CELL WALL MATERIAL*

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INTRODUCTION

Phosphorus fixation is recognized as an important factor contributing to the low availability of phosphorus in acid soils. While the precise mechanisms of phosphorus fixation remain subjects for debate there is general agreement that the precipitation of aluminium and iron phosphates, and the adsorption of phosphate onto positively charged surfaces of aluminium and ferric hydroxides are the most important processes.

The accumulation of phosphorus in the roots of plants growing in acid soils, and the development of phosphorus deficiency symptoms in the shoots have long been associated with interactions between aluminium and phosphorus (Hartwell and Pember 6). In a recent paper I described experiments which showed that a large proportion of the phosphorus in aluminium-treated roots was exchangeable and made no contribution to the phosphorus incorporated into phosphorylated intermediates in metabolism. These results suggest that aluminium and phosphorus are associated outside the plasmalemma, and for convenience this may be described as being on the cell, or root surface. There appear to be certain analogies between this process and the adsorption of phosphate by aluminium (Al$^{3+}$) resins and charged surfaces of amorphous precipitates of aluminium hydroxide described by Hsu and Rennie 7, and Hsu 9. In the present paper

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data are presented which show that aluminium becomes firmly bound to whole roots and preparations of cell wall material, and that such preparations have the capacity to fix phosphorus.

METHODS

Plant material

Barley seed, *Hordeum vulgare* L. var Proctor, was obtained from Marsters Seeds Ltd., Kings Lynn, England.

Plant culture

Seedlings were grown for five days in water cultures to which no phosphorus or aluminium were added, before uniform plants were selected for experimental purposes. The details of this culture and related information are described in Clarkson 4.

Preparation of cell wall material

There is no standard procedure for obtaining cell wall material, nor, indeed, is there any agreement on what such a preparation should contain. The material used below is therefore an arbitrary mixture of the structural elements in barley roots which have been treated with sodium hydroxide to remove as much cytoplasmic protein as possible. Most of the cell wall protein is not removed by this treatment; lipids and some pectins also remain.

Washed, excised material was passed between closely set stainless-steel rollers to squash the cells and remove some of the cell contents. The material remaining attached to the rollers was resuspended in water and stirred vigorously. Small fragments and cell organelles were separated from this suspension by filtration through a nylon mesh (25-µ meshes). This suspension/filtration step was repeated three times. The residue was then treated successively with 50 per cent ethanol for 20 minutes, *N* sodium hydroxide at 20°C for 20 minutes and finally with 10⁻³ *N* hydrochloric acid until the washings fell to pH 4.0. The residue was then washed in three changes of distilled water and stored at 20°C in distilled water. In the first experiment described below cell wall material was separated from roots which had been pretreated with aluminium; in this case the sodium hydroxide treatment and the acid wash were omitted.

Chemical analyses

Before analysis plant material was dried at 90°C for 24 hours, weighed and then ashed at 500°C for 24 hours. The ash was dissolved in 5 ml of 10⁻¹ *N* HCl.

Aluminium was determined spectrophotometrically as an aluminium-8 hydroxyquinolinolate complex extracted in chloroform. The procedure differed in only minor details from that of Noll and Stephanelli 11.

Phosphorus was determined spectrophotometrically using the method of Fiske and Subbrow 5 as modified by Bartlett 2.