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Effects of Lanthanum Chloride on Activity of Redox System in Plasma Membrane of Rice Seedling Roots*

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Abstract: The plasma membrane was isolated and purified by using the method of aqueous two-phase partitioning from rice *(Oryza sativa)* seedling roots. The effect of $LaCl_3$ on the activity of redox system of plasma membrane has been studied. The reduction rate of $Fe(CN)_6^{3-}$ and the oxidation rate of NADH in plasma membrane are stimulated below the concentration of 40 μmol L^{-1}, but depressed in pace with the increasing of $LaCl_3$ over the concentration of 40 μmol L^{-1}. The possible effect of $LaCl_3$ on the uptake of Fe element by rice seedling was also discussed.

Key words: rare earths; rice; redox; iron uptake
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Rare earths have a beneficial effects on promoting the crop growth and increasing its yield. Some researchers have demonstrated that the rare earths can not enter the protoplast and only stay outside the plasma membrane[1]. There is an oxidation-reduction (redox) system on the plasma membrane of plant cell which can catalyze a series of redox reactions, promote the uptake of mineral elements, control the growth of plant and transport the solutes etc.[2]. In this study, the plasma membrane was isolated and purified with the method of aqueous two-phase partitioning from rice seedling roots, the effects of $LaCl_3$ on the activity of redox system of plasma membrane and the uptake of iron element by rice seedling were observed.

1 Materials and methods

After sterilising, imbibing and germinating, the seeds of rice *(Oryza sativa* cv. Jiahezaozan) were transplanted onto nylon mask and treated with 0, 20, 40, 60, 80, 100 μmol L^{-1} of $LaCl_3$ solution. One week later, the $LaCl_3$ solution was replaced with nutrient culture solution. After seven days, seedling roots were used to extract the plasma membrane and the aboveground parts were prepared for the measurement of Fe content. Plasma membrane was isolated and purified with the method of aqueous two-phase partitioning following the procedure of Zheng et al.[3]. Membrane protein content was measured with Coomassie Brilliant Blue G-250 by Bradford[4]. The reduction rate of $Fe(CN)_6^{3-}$ was assayed with Jiao's procedures[5] having some modifications. The assay procedures of oxidation rate of NADH is similar to that of the assay of $Fe(CN)_6^{3-}$ reduction rate. For assaying the value of extinction, it is need to calculate the quantity of NADH being oxidized according to the extinction coefficient of 1 mmol L^{-1} being 6.23.

Aboveground parts of plant samples were stove-dried to a constant weighing at 80 °C. The dry samples were ground into fine powder in a mortar and sieved with a cloth of 150 μm nylon, then digested with HNO_3-$HClO_4$. The contents of Fe was measured with an atomic absorption spectrophotometer of PE AA800. All

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the experiments were replicated by three times.

2 Results and discussion

Standard redox system exists widely in plant plasma membrane, its electron donor is NAD(P)H and electron acceptor is $Fe(CN)_6^{3-}$. The ions of Fe^{3+} are reduced to Fe^{2+} during electron transferred along the redox system, and then uptaken by plant[2]. Owing to the impermeability to cell membrane of $Fe(CN)_6^{3-}$ and thus it can not enter the cell, the activity of redox system of plasma membrane could be observed through investigating the changes of reduction rate of $Fe(CN)_6^{3-}$ and oxidation rate of NADH when adding the external $Fe(CN)_6^{3-}$ as an electron acceptor[2]. When $LaCl_3$ concentration varied from 0 to 40 μmol·L^{-1}, the reduction rate of $Fe(CN)_6^{3-}$ increased gradually (Fig. 1), and the highest activity reached at 40 μmol·L^{-1} of $LaCl_3$, being higher by 142 % than that of control treatment. When the concentration of $LaCl_3$ was higher than 40 μmol·L^{-1}, the reduction rate of $Fe(CN)_6^{3-}$ decreased in pace with the increasing concentration of $LaCl_3$, and become the lowest at the concentration of $LaCl_3$ being 100 μmol·L^{-1}, which is only 75 % than that of control treatment.

The variation tendency of the oxidation rate of NADH is basically the same to that of the reduction rate of $Fe(CN)_6^{3-}$ (Fig. 1). The oxidation rate of NADH approached the maximum, higher by 156 % than that of the control treatment when concentration of $LaCl_3$ was 40 μmol·L^{-1}. In contrast, the lowest oxidation rate of NADH reached at 100 μmol·L^{-1} of $LaCl_3$, only 70 % than that of control treatment.

The effect of $LaCl_3$ on Fe uptaken by rice seedlings is shown in Fig. 2. Fe content in aboveground parts of rice seedlings increase gradually along with the increasing of $LaCl_3$ concentration from 0 to 40 μmol·L^{-1}, the maximal content reaches at 40 μmol·L^{-1} of $LaCl_3$. Over the latter concentration, Fe content in plant sample reduced in pace with the increasing of $LaCl_3$ concentration. There is a positive correlationship between the Fe content in plant and the reduction rate of $Fe(CN)_6^{3-}$ and the oxidation rate of NADH.

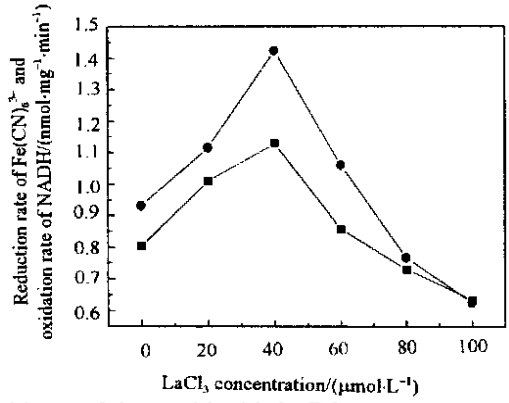

Fig. 1 Effects of $LaCl_3$ on reduction rate of $Fe(CN)_6^{3-}$ and oxidation rate of NADH in plasma membrane of rice seedling roots

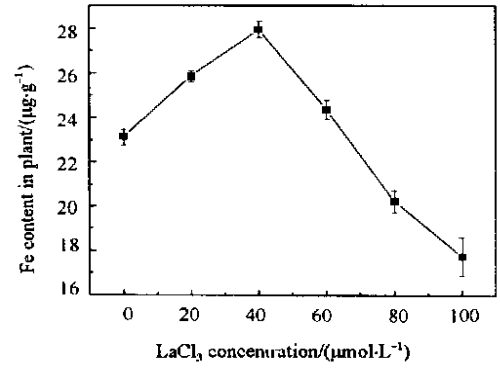

Fig. 2 Effect of $LaCl_3$ on uptake of Fe by rice seedling

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