Biology Seminar

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Transgenic Plants Over-Expressing H^+-PPases: A New Strategy to Improve Plant Biomass, Mineral Nutrition and Abiotic Stress Tolerance

Cells expend as much as 50% of their total intracellular energy reserves to maintain gradients of ions across their membranes. The electrochemical potential of these ion gradients represents stored energy. Plants and fungi are similar in that they use proton (H^+) gradients as the "currency" (proton electrochemical gradient =PEG) with which to mediate transport of ions. The simplicity of the vacuolar H^+-PPase structure makes it an excellent candidate for manipulating the proton gradients in plants. A potential role for plant H^+-PPases in growth and development was hinted by a study of pear fruit development, showing that both protein levels and activity of a type I H^+-PPase were enhanced in young fruit at the cell division stage. In line with these early observations, Li*, et al.* reported that the overexpression of the type I H^+-PPase AVP1 in Arabidopsis resulted in increased cell division at the onset of organ formation, hyperplasia, and increased auxin transport. Furthermore, *avp1-1* null mutants displayed severely disrupted root and shoot development and reduced auxin transport. Changes in the expression of AVP1 affected the abundance and activity of the plasma membrane (PM) H^+-ATPase that correlate with apoplastic pH alterations and auxin transport efficiencies. Therefore, it has been hypothesized that in addition to its established role in the maintenance of vacuolar pH, the type I H^+-PPase of *Arabidopsis thaliana* facilitates the trafficking of the P-type H^+-ATPase to the PM.

It has been shown that the up-regulation of either *Arabidopsis thaliana* or *Thellungiella halophila* type I H^+-PPases, results in improved growth and photosynthetic capacity under normal or limiting nutrient conditions or under water deprivation or salinity stress conditions in Arabidopsis, tomato, rice, cotton, corn and alfalfa engineered plants. Manipulation of the type I H^+-PPase contributes to the regulation of the pH in the apoplast and rhizosphere. Rhizosphere acidification is a central mechanism for plant mineral nutrition. Accordingly, AVP1 transgenic Arabidopsis, tomato and rice plants outperform controls when grown under phosphate limitations and accumulate higher contents of potassium under all conditions tested. Furthermore, up-regulation of AVP1 in both *Arabidopsis thaliana* and *Lactuca sativa* results in enhanced performance (i.e., larger roots and shoots) when grown under limiting nitrate (2 mM) conditions (Paez, J., *et al* manuscript in preparation). Nitrate uptake experiments showed that *AthAVP1*OX plants have from 28 to 78% higher uptake than controls. Is there a common denominator that can explain all of the above phenotypes? Our current hypothesis suggests that the type I H^+-PPase is involved in the regulation of phloem sucrose transport and that sucrose could be the actual common denominator. Our research is currently focusing in both, learning more about the function and regulation of these H^+-PPases in plants and translating these observations into a variety of agriculturally important crops.

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