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Research Paper

Effect of Phosphate Nutrition on Growth, Physiology and Phosphate Transporter Expression of Cucumber Seedlings

Zakira Naureen [1], Arjun Sham [2], Hibatullah Al Ashram [2], Syed A. Gilani [1], Salma Al Gheilani [1], Fazal Mabood [1], Javid Hussain [1], Ahmed Al Harrasi [3] and Synan F. AbuQamar [2,*]

[1] Department of Biological Sciences and Chemistry, University of Nizwa, Nizwa, Oman
[2] Department of Biology, United Arab Emirates University, P.O. Box 15551, Al-Ain, UAE;
[3] UoN Chair of Oman's Medicinal Plants and Marine Natural Products, University of Nizwa, Oman
* Correspondence: sabuqamar@uaeu.ac.ae; Tel.: +971-3-713-6733

Abstract: Although abundantly present in soils, inorganic phosphate (Pi) acquisition by plants is highly dependent on the transmembrane phosphate transporter (PT) gene family. Cucumber (*Cucumis sativus*) requires a large amount of phosphorus (P). The purpose of this study was to isolate the *CsPT2-1* from cucumber roots, and to determine the influence of Pi nutrition on cucumber growth, metabolism and transcript levels of *CsPT2-1* in tissues. Full length *CsPT2-1* was cloned and phylogenetically identified. In two greenhouse experiments, P-deficient seedlings provided with low or high P concentrations were sampled at 10 and 21 days post treatment, respectively. Addition of P dramatically reduced growth of roots but not shoots. Supplying plants with high P resulted in increased total protein in leaves. Acid phosphatase activity increased significantly in leaves at any rate higher than 4 mM P. Increasing P concentration had a notable decrease in glucose concentrations in leaves of plants supplied with >0.5 mM P. In roots, glucose and starch concentrations increased with increasing P supply. Steady-state transcript levels of *CsPT2-1* were high in P-deprived roots, but declined when plants were provided >10 mM P. To our knowledge, this is the first report focusing on a PT and its expression levels in cucumber.

Keywords: cucumber; phosphate; phosphate transporter; protein; starch; sugar.

1. Introduction

Despite phosphorous (P) plays a pivotal role in plant growth and development; it is one of the least accessible nutrients to plants. Many soils are inherently poor in available P content worldwide, although the total P amount may still be high (Nussaume *et al.*, 2011). Regardless of its abundance, P is not evenly distributed in soils due to its immobility that is attributed to its low diffusion coefficient (Schachtman *et al.*, 1998). Besides, most of the P is either assimilated by soil microbes or is chelated by cations, such as aluminium, iron (Fe), calcium or magnesium (Mn) (Von Vexhull and Mutert, 1998) which renders it to become the least available plant macronutrient (Raghothama, 1999). To complement this deficiency, around 30 million tons of P fertilizers are applied to crop plants (Koppelaar and Weikard, 2013); however, they pose numerous threats to the environment. For example, cultural eutrophication of lakes and ponds leads to algal blooms resulting in loss of valuable aquatic life. This has a direct effect on the environment through the increase in the cost and purification of water, the production of surface scums and odors; and therefore an increase in the population of insect pests (Gonzales *et al.*, 2005). In general, plants acquire only a small fraction of exogenous P supply; whereas the remainder is immobilized and lost in the soil (Raghothama, 1999). In addition, the increase in the world population has put a tremendous pressure on the agricultural industry to produce more food which, in turn, requires an increased production of fertilizers at the expense of fossil fuels (Fita *et al.*, 2012) adding extra cost on P fertilizers.

Phosphorous is involved in multitude of functions in plants such as photosynthesis, respiration, nucleic acid synthesis, energy generation and as an integral part of phosphoproteins and phospholipids (Raghothama, 1999; Vance *et al.*, 2003; Cordell *et al.*, 2011). Plants acquire P from the soil solution in the form of inorganic orthophosphates (Pi) predominantly in the form of $H_2PO_4^-$ (Raghothama, 1999) which is present in very low