Molecular regulation of phosphate starvation responses in plants

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Phosphorus is one of the most limiting plant nutrients in the soil. Lack of available phosphate in the rhizosphere has severely reduced crop yields in vast stretches of acid soils in the tropics. Deficiency of phosphorus has resulted in numerous adaptations by plants to obtain and utilize the nutrient efficiently. The complex adaptation processes involve changes in the expression of hundreds of genes as indicated by microarray analysis. The genes that are altered during phosphate deficiency code for many functional and structural components. Many genes presumed to be associated with signal transduction pathways are altered during phosphate deficiency. Microarry data was further confirmed by Northern blot and RT-PCR analysis. Genes representing transcription factors such as WRKY, zinc finger binding factors, MYB exhibit phosphate starvation-mediated enhancement in expression. The coding sequences of these transcription factors were cloned into appropriate vectors to produce transgenic *Arabidopsis* either over-expressing or suppressing the expression of genes. Over-expression and RNAi knockout of some of the transcription factors showed distinct changes in plant growth in response to altered phosphate concentration in the medium.

It is not surprising to know that phosphate deficiency induced signaling is quite complex and multiple effectors are involved in the process. Characteristic changes in root morphology during phosphate starvation points to the involvement of plant hormones such as auxin and cytokinins. Addition of these hormones to growth media not only altered root morphology but also suppressed the expression of some of the phosphate starvation induced genes. In addition, sugar also plays an important regulatory role in phosphate starvation mediated responses. Input of sugar is not only required for initiation of changes in gene expression but also for many of the root architectural modifications associated with phosphate deficiency. Among the sugars (sucrose, glucose and fructose etc.) tested, sucrose had the most noticeable effect on gene expression. These data strongly point to the involvement of sugar in phosphate starvation mediated responses in plants. At present it is not clear how carbon and phosphate are interacting at the level of signal transduction.

Several genetic screens based on reporter gene expression and ionomics are being used to isolate mutants showing altered gene expression and phosphate content. T-DNA tagged and fast neutron bombardment generated mutants of *Arabidopsis thaliana* are being screened for mineral nutrient composition using ICP-MS. Plants expression the reporter gene luciferase under the regulation of promoter of high affinity phosphate transporter was generated by *Agrobacterium* mediated transformation. These plants were used for generating T-DNA tagged population. T-DNA tagged population is being screened for altered response of plants to phosphate deficiency or sufficiency. Mutants having altered phosphorus content and/or altered reporter gene expression are subjected to a battery of genetic and molecular tests. Characterization of these mutants should lead to molecular determinants regulating phosphate uptake and utilization by plants.