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Thesis abstract

Phosphorus remobilisation during grain filling in rice

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Phosphorus (P) is applied to crops to ensure high yields but adds to costs and contributes to water eutrophication. Most P in cereals is in harvested grain removed from fields. Improving plant P recycling and/or reducing the P in grains may overcome this; however, the physiology and molecular mechanisms of P remobilisation from vegetative tissues to developing grains must be better understood.

The pattern of P accumulation in developing rice (*Oryza sativa* L. *ssp. indica* cv. IR64) grains and P remobilisation from flag leaves were investigated during grain filling. Transcriptome (RNA-seq) analysis was undertaken at two time points, six days after anthesis (DAA) when flag leaf P content was maximal, and 15 DAA when flag leaf P content had declined due to P remobilisation to developing grains. Three P-starvation response (PSR) genes (*OsPAP3*, *OsPAP9b* and *OsPAP10a*) and three genes not previously implicated in the P-starvation response (*OsPAP26*, *SPX-MFS1* and *SPX-MFS2*) had expression profiles consistent with a role in P remobilisation. Metabolic pathway analysis suggested phospholipids may be degraded and replaced by other lipids, liberating P for export to developing grains.

The effect of P withdrawal from nutrient solution during grain filling on biomass accumulation, yield, flag leaf photosynthesis and remobilisation of P from leaf P fractions was investigated. Phosphorus withdrawal at anthesis or 8 DAA impaired photosynthesis by 16 DAA, presumably due to competition for P between vegetative tissues and developing grains. Withdrawal of P at anthesis led to premature mobilisation of inorganic P (Pi) from flag leaves at 8 DAA, most likely vacuolar Pi that met the P demands of developing grain while ensuring sufficient P was available for metabolic activities. The lipid P fraction appeared to be the first P fraction mobilised at 8 DAA when P was withdrawn at anthesis, presumably because reserves of vacuole Pi were insufficient. Early remobilisation of lipid-P suggested phospholipids were replaced by other lipids to conserve P, although further lipidomics studies are required to confirm this.

RNA-seq analysis of flag leaves under P-limited conditions during grain filling identified genes which may play a role in P remobilisation during grain filling. The response to P withdrawal was clearly distinct between early (8 DAA) and the later (16 DAA) stages of grain filling. Upregulated expression of genes involved in photosynthesis occurred at 8 DAA while at 16 DAA withdrawal of P induced genes involved in the degradation of polysaccharides to monosaccharides.

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