Multilevel Analysis of Responses to Low Carbon in Arabidopsis

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The regulation of sugar production, storage and use is of central importance in plants. However, the sensing and transduction mechanisms involved are still controversial and there is a lack of specific information about which groups of genes are regulated by which carbohydrate in which condition. To tackle these questions we performed parallel determinations of metabolite, transcript and enzyme profiles in Arabidopsis plants running out of carbon. We used two models, the starch-less pgm mutant which experiences carbon starvation every night, and wild-type plants exposed to a prolonged night. This approach allowed us to address the following questions: How do plants sense their carbon status? We estimate that about 5% of the genes are responding early to carbon shortage, probably via several transduction pathways. By analysing co-responses between metabolites and transcripts, we found some evidence that one signalling pathway involves glucose-6-P. How are changes in transcription integrated? We compared changes in transcript levels with changes in enzyme activities from various pathways and found no relation between the amplitudes of the diurnal changes in transcripts and maximal enzyme activities. Moreover changes in enzyme activities were generally strongly delayed in plants under extended night conditions. How are short term responses managed? As an example we found that post-translational activation of ADP-glucose pyrophosphorylase was increased in plants that were previously experiencing a period of carbon starvation, a mechanism linked to the increased rate of starch accumulation under such conditions.