Sensor kinases TOR and GCN2 orchestrate translation and autophagy in response to carbon, nitrogen and sulfur supply for cysteine synthesis in higher plants

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Carbon, nitrogen and sulfur are three major macronutrients for plant development and growth. In the past decades, the specific responses under nutrient deficiency were well studied; however, sensing and regulation to coordinate different nutrients and metabolism still remain unclear. In plants, cysteine (Cys) represents the first meeting point between the primary metabolism of sulfur, carbon and nitrogen. Here, we addressed the consequences of cysteine limitation by specific down-regulation of sulfide or *O*-acetylserine (OAS) supply, which offers the S source or C/N backbone for cysteine biosynthesis, in genetically engineered *Arabidopsis thaliana* plants with decreased corresponding enzyme SiR (*sir1-1*) or Serat (*serat tko*) activity. Our results revealed a distinct metabolic phenotype and a specific transcriptional response between both transgenic lines. Furthermore, we demonstrate that the retarded growth of both *sir1-1* and *serat tko* is caused by decreased translation rates. Interestingly, translation in *serat tko* is arrested by induction of GCN2-dependent phosphorylation of eIF2a. Instead of GCN2, decreased TOR activity plays a dominant role in decreasing translation rate in *sir1-1*, which further results in the decreased level of rRNA and induction of autophagy. Our results reveal for the first time that specific sensing of precursor availability for Cys biosynthesis allows plants to precisely coordinate S metabolism and C/N metabolism to orchestrate translation and plant growth.