Positional Cues for Lipid Storage in Cereal Seeds

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Oil storage in seeds is developmentally controlled, and undergoes multiple modulations within particular tissues. Understanding of the regulatory networks requires quantitative visualization data on storage lipid. Recently we explored a rapid and non-invasive NMR based detection, visualization and quantification of lipid and were able to characterize lipid storage in living seeds. The *in vivo* lipid mapping can be combined with other topographical methods for metabolite imaging, microsensors, as well as analysis transcript and metabolite profiling, flux analysis and laser microdissection techniques. Using these powerful tools, here we address the hypothesis that *in vivo* oxygen concentrations inside developing seeds locally affect assimilate partitioning to storage lipid. Two monocot species, maize (non-green seed) and barley (seed with photosynthetically active pericarp) were used as model in this study. Both types of seed possess a highly compartmentalized oil storage in embryo/aleurone, reaching local oil levels comparable to those of rapeseed as evidenced by NMR-based lipid mapping. Enhanced O_2 availability increased ^{14}C-label uptake into the embryo, labelling of acetyl-coenzyme A, and finally label incorporation into lipids. Expression analysis demonstrates that this response was connected with the up-regulation of genes involved in lipid biosynthesis, energy metabolism and regulatory genes (ABA signalling, transcription factors). *In situ* hybridization in embryo shows a transcriptional upregulation of cell wall bound-invertase colocalized to lipid storing regions. This points on the role of this enzyme for maintaining source-to-sink unloading of sucrose, and ultimately determination of sink strength and assimilate partitioning towards embryo. We conclude that the *in vivo* oxygen delivery to the different regions of seed is a regulatory factor for gene expression, local metabolic activity and assimilate partitioning. We further conclude that the study of lipid storage *in vivo* opens novel perspectives for experimental seed biology and is expected to facilitate genetic engineering and breeding of improved crops.