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Energy status and its control on embryogenesis of legumes: ATP distribution within *Vicia faba* embryos is developmentally regulated and correlated with photosynthetic capacity

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Abstract:

To analyse the energy status of *Vicia faba* embryos in relation to differentiation processes, we measured ATP concentrations directly in cryosections using a quantitative bioluminescence-based imaging technique. This method provides a quantitative picture of the ATP distribution close to the *in vivo situation.* ATP concentrations were always highest within the axis. In pre-storage cotyledons, the level was low, but it increased strongly in the course of further development, starting from the abaxial region of cotyledons and moving towards the interior. Greening pattern, chlorophyll distribution and photosynthetic O_2 production within embryos temporally and spatially corresponded to the ATP distribution, implicating that the overall increase of the energy state is associated to the greening process. ATP patterns were associated to the photosynthetic capacity of the embryo. The general distribution pattern as well as the steady state levels of ATP were developmentally regulated and did not change upon dark/light conditions. The major storage protein legumin started to accumulate in abaxial regions with high ATP, whereas starch localized in regions with relatively lower ATP levels. This suggests a role of the energy state in the partitioning of assimilates into the different storage-product classes. Highest biosynthetic rates occurred when cotyledons became fully green and contained high ATP levels, implicating that a photoheterotrophic state was required to ensure high fluxes. Based on these data, we propose a model for the role of embryonic photosynthesis to improve the energy status of the embryo.

Key-words: ATP imaging, energy status, photosynthesis, metabolic gradient, cell differentiation, seed development