How plants adjust photosynthesis in response to fluctuating light intensities

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LMU researchers have identified a set of proteins that enable plants to adjust their photosynthesis in response to fluctuating light intensities so as to make the best use of the light available.

Photosynthesis, the most important single biological process on Earth, is driven by sunlight. However, solar radiation is a fickle energy source, for the intensity of the light available in most environments is constantly changing - depending on factors such as the cloud cover and the distribution of shade. Now, LMU biologists led by Professor Peter Geigenberger, in collaboration with researchers at the Max Planck Institute for Molecular Plant Physiology in Potsdam and at the

University of Paris, have identified a number of proteins that are essential for the ability of photosynthesis to adapt to fluctuating light levels. Their findings appear in the journal *Molecular Plant*.

For optimal growth, plants need to maintain a high and stable rate of photosynthesis, and to do so they must be able to react quickly to sudden changes in light intensity: In the event of an abrupt increase in light flux, the excess energy is either dissipated as heat or the energy is diverted to metabolic processes in order to avoid the formation of reactive oxygen species, which would damage the photosystems and other cell components. When the light intensity falls, leaf cells must minimize heat loss as quickly as possible and adjust the distribution of energy transfer to metabolic operations. "We have now demonstrated that enzymes called thioredoxins are intimately involved in these acclimation processes," says Geigenberger.

Thioredoxins are small proteins, which are found in virtually all organisms and participate in many vital metabolic processes. Using genetically modified strains of the thale cress Arabidopsis thaliana, Geigenberger and his colleagues have shown that thioredoxins play a crucial role in ensuring that rates of photosynthesis are optimally maintained during short periods of high light intensity. The proteins essentially open a valve which allows the excess energy absorbed by the photosystems in the chloroplasts to be exported into the cytoplasm, thus avoiding the inhibition of photosynthesis itself. This mode of energy export is in turn sustained by a second thioredoxin-based system called NADPH-dependent thioredoxin reductase C (NTRC). The latter enzyme is also responsible for minimizing the loss of absorbed light energy as heat in phases when light intensities are low. "Consequently, in plants that lack NTRC photosynthetic efficiency is reduced, and their growth rates are lower," Geigenberger explains.

So his team now plans to study whether increased levels of thioredoxin activity can improve the overall efficiency of photosynthesis - and therefore growth rates - of plants exposed to fluctuating light environments. "Under natural conditions in the field, light intensities change very rapidly. If it were possible to boost the efficiency of photosynthesis by increasing thioredoxin activities in crop plants, this could offer a means of increasing yields," says Peter Geigenberger.

More information: Ina Thormählen et al. Thioredoxins play a crucial role in dynamic acclimation of photosynthesis in fluctuating light, *Molecular Plant* (2016). DOI: 10.1016/j.molp.2016.11.012

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