Crops coping with water scarcity

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Despite significant improvements in crop yield potential and yield quality over the last decades, the forecasted global climatic changes are raising great concern about yield safety. In particular, drought represents a major threat to agriculture and food production. Even in the most productive agricultural regions short periods of water deficiency are responsible for considerable reductions in seed and biomass yields every year. Over 70% of the globally available fresh water is used in agriculture to sustain crop production, with only 30% of this returned to the environment. To cope with the detrimental effects of climate changes on crop yield and to fulfil the growing demand for food production it is imperative to develop new crops with higher performance under water scarcity, able to consume less water and to maintain high efficiency.

Plants have evolved two different strategies to resist drought: dehydration avoidance and dehydration tolerance. Dehydration avoidance refers to the plant capacity to maintain high plant water status under the effect of drought. Plant avoid being stressed through mechanisms which enhance the capture of soil moisture (e.g. reaching deep soil moisture with a long root), or reduce water loss by transpiration (e.g. decreasing the aperture of the stomatal pores distributed on the leaf surface). Dehydration tolerance is the ability of the plant to conserve plant function in a dehydrated state. This strategy is relatively rare in nature and either breeding programs or plant biotechnology approaches have given a preference to dehydration avoidance over dehydration tolerance as the major strategy for plants to cope with drought stress. Multiple complex pathways are involved in controlling this process, and engineering only a single trait in some cases is not a winning strategy. Because transcription factors (TFs) are proteins that naturally act as master regulators of cellular processes, they are excellent candidates for modifying complex traits such as dehydration avoidance in crop plants, and TF-based technologies are likely to be a prominent part of the next generation of successful biotechnology crops. Some examples of modified transcription factors that improve plant response to drought and salinity stress, a direct consequence of water scarcity, in the model plant Arabidopsis thaliana, will be presented. In one case a transcription factor involved in the control of the opening and closing of stomatal pores, epidermal structures that regulate CO_2 uptake for photosynthesis and the loss of water by transpiration, has been identified and engineered to obtain plants that maintain high water status and high productivity also in water stress conditions. In a second example a transcription factor controlling the composition and thickness of cuticle has been studied. Finally an example of a transcription factor that, when over-expressed, enhances plant salt stress tolerance.

The next step is to transfer to crop the technology set up in model plant. The first results of this transfer are very promising.