



Opinion

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Low Chilling Requirement Apple Cultivars as a Potential Genomic Resource for Improving Heat Stress Tolerance During Global Warming



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The heat challenge in Apple

Climate change-induced global warming is projected to continue [1] and negatively affect various annual as well as perennial crops [2,3] Many deciduous trees require a specific cold period, for dormancy bud break, flowering and fruiting, together termed chilling requirement. Species with High Chilling Requirements (HCR), such as apple (*Malus x domestica* - MD), which is an important global crop, are expected to experience higher levels of damage and suffer more than other species with low or no chilling requirements. During rises in temperature, MD are likely to suffer from damaged reproductive processes, particularly dormancy release of floral buds, pollen/stigma interactions, fertilization and fruit development [4,5]. In the past, an “escape strategy” was successfully practiced in warm regions where most of the apple production was relocated from the hot valleys, up-hill to cooler environments. This strategy, which is still an option for coping with heat, seems to be less relevant for the future due to the above-mentioned predictions that even cooler regions will warm up. Thus, alternative solutions need to be developed.

Genetic Solutions

Here we present that adopting a genetic approach will be more promising and beneficial for the long run. This approach will exploit the natural variation of heat tolerance capacities that exists among different genotypes of MD that inhabit various environments which experience different grades of heat. Throughout the years, extensive breeding efforts yielded apple cultivars with Low Chilling blooming Requirements (LCR), which

can successfully bloom in regions with relatively hot winters [6]. Since several of these commercial LCR cultivars, (such as “Anna,” “Ein-Shemer,” and “Dorsset-Golden”) includes one parent of Middle Eastern origin [6], we hypothesize that their genome is adapted to hot and dry climates. Therefore, these genomes can potentially serve as genetic resource for identifying specific LCR genes which are associated with the response to HS. These genes are predicted to provide novel genetic tools which will lead to improvement of HS tolerance in apple during climate change conditions. In order to be able to utilize these genetic tools, a comparative characterization of the HS response in HCR and LCR cultivars is required. Below (Figure 1) is a schematic example of how we may achieve a collection of tools comprising Phenomics, Transcriptomics, Proteomics, Metabolomics and computational science for improving HS tolerance in apple. The knowledge gained by mining the suggested database can be translated through classic breeding or CRISPR based genome editing [7] into development of new heat tolerant MD cultivars, which will increase farmers’ ability to successfully cope with the foreseen heat challenge.

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Conflict of Interest

The authors declare no competing interests.

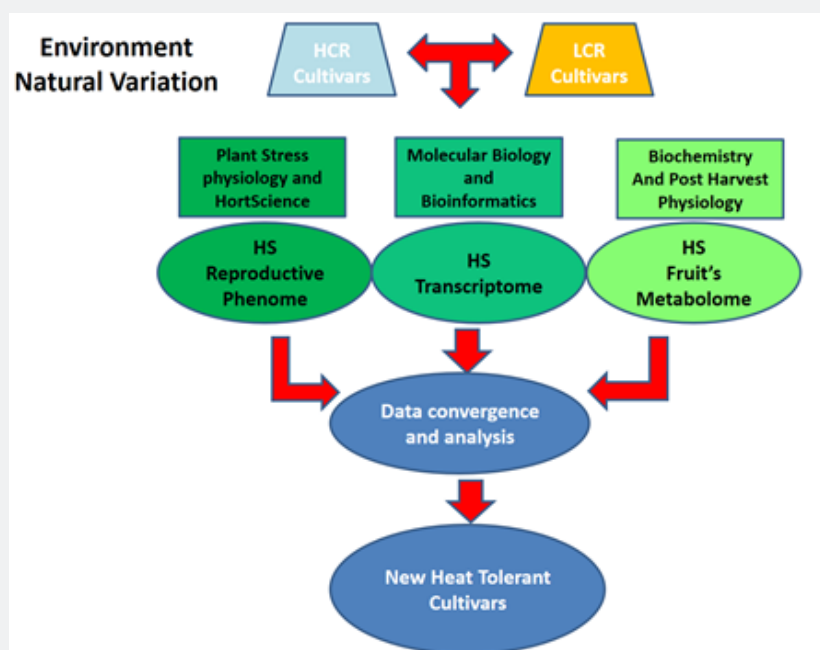


Figure 1: Flowchart for development of a genetic resource for improving heat stress tolerance in apple. The new genetic resource should be based on comparison of the response to heat stress in HCR and LCR cultivars. These cultivars are to be examined through an “OMICS” approach, comprising Phenomics, Transcriptomics, Proteomics, Metabolomics and computational science. Integration of the multiple results will enable the identification of LCR genes which are associated with HS. These candidate genes would then be used through classic breeding or CRISPR based genomic editing to improve the tolerance to HS in MD.

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