Regulation of grapevine sulfate transporters gene expression under abiotic stress

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Plants assimilate sulfur (S) mostly through the synthesis of cysteine (Cys) from sulfate (SO_4^{2-}) absorbed by the roots from the soil solution. Sulfate, an essential macronutrient, is an oxidized form of sulfur used in protein biosynthesis but also in the synthesis of a myriad of compounds among each the tripeptide glutathione (GSH) with a central role in abiotic stress tolerance/resistance to abiotic stress.

Specialized proteins, anion-type transporters, mediate the transfer of sulfate from the soil solution into the cytosol of root cells and throughout the plant. Two kinds of transporters mediate the uptake and the distribution of sulfate: high-affinity sulfate transporter (HAST) and low-affinity sulfate transporter (LAST). Plants have developed a complex and sophisticated network of sulfate transporters. In grapevine genome it was possible to identify gene sequences for 12 sulfate transporters genes which share with all plant sulfate transporters two conserved domains, sulfate transp (PF00916) domain and STAS domain (PF01740). Grapevine predicted sulfate transporters protein sequences were divided by phylogeny analysis into the same groups already described for *Arabidopsis thaliana* sulfate transporters. However, some differences could be identified between grapevine and Arabidopsis: only two protein sequences assigned to group one (G1, high affinity transporters) and a higher number of group three (G3) transporters. Furthermore, in some of the G3 sulfate transporters evident signs of gene duplication were observed and three of these transporters were identified in tandem on chromosome 11. Interestingly, in grapevine berries two of these genes showed a high expression level while the third was not expressed in none of tested mRNA from leaves, roots, berries and cell cultures, indicating that this isoform is probably only expressed under very specific condition.

VviATPS1 and VviSULTR3;1, both predicted to target the chloroplast were located in the same chromosome. *VviSULTR1;1* a HAST which responds to sulfate deficiency conditions by transcription activation was also identified in tandem with one G2 sulfate transporters (*VviSULTR2;2*) and, although they do not meet the gene duplication criteria, they apparently share regulation similarity since they are both predicted targets for miRNA395. Conversely to *VviSULTR1;1*, *VviSULTR2;2* transcript level was unresponsive to cell cultures sulfate deficiency and its expression was higher in grapevine leaves.

In Mediterranean climate conditions field grapevine plants are subjected to strong abiotic stress, namely water stress. A cross talk between water stress and sulfate metabolism has been established previously. In the follow up, the gene expression of

individual sulfate transporters was addressed in leaves and berries of distinct grapevine genotypes to tentatively depict different responses to abiotic stress.