Overexpression of *Brassica rapa* MDHAR alleviated stress responses by enhancing a host antioxidant system in *A. thaliana*

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Ascorbate (vitamin C) plays an important role in detoxification of reactive oxygen species (ROS) in most living organisms. Monodehydroascorbate reductase (MDHAR; EC1.6.5.4) is crucial to regenerate the oxidized form of ascorbate (monodehydroascorbate) so it can be recycled to maintain ROS scavenging ability. The MDHAR gene from *Brassica rapa* was cloned and introduced into *Arabidopsis thaliana* to test the hypothesis that enhanced ROS scavenging activity of *BrMDHAR* alleviates cold stress. *BrMDHAR* was expressed under the control of either the CaMV 35s promoter or stress inducible SWPA2 promoter. Ectopic expression of *BrMDHAR* led to the up-regulation of various antioxidant enzymes involved in ROS defense mechanisms. Subsequently, the cellular levels of antioxidant molecules ascorbate and glutathione increased while ROS levels decreased significantly. The transgenic plants had an enhanced tolerance to freezing stress exhibiting lower hydrogen peroxide content, lower lipid peroxidation activity, and higher chlorophyll content. These results suggest that ectopic expression of *BrMDHAR* confers tolerance to freezing stress not only by simply recycling ascorbate but also by inducing the co-regulation of the ascorbate–glutathione cycle which in turn enhanced the antioxidant capacity of the host plant.