



in all hypocotyl cells, with a concomitant reduction in GSNOR activity, thus mediating nitrosative stress (Chaki et al., 2011a,b). Similar behavior was observed in sunflower under biotic stress, specifically in relation to the fungus *Plasmopara halstedii*. However, it is interesting to note that GSNO was observed to be localized and distributed in the sunflower hypocotyls of the resistant cultivar, while GSNO showed a general and homogeneous distribution in all hypocotyl cell types. This appears to contribute to its resistance to fungus, with GSNO after infection being exclusively redistributed to the epidermal cells which are usually this pathogen's penetration sites in sunflowers (Chaki et al., 2009). GSNO mobilization has also been described in wounded *Arabidopsis* leaves where GSNO content increased and showed a uniform

distribution pattern, whereas, in systemic leaves, GSNO was first detected in vascular tissues and later extended to the parenchyma cells (Espunya et al., 2012). These findings in relation to different plant species and under different stresses bolster the notion that GSNO appears to be a mobile signal in response to diverse types of stress. Although, the experimental evidence suggests the GSNO movement between plant cells and organs, future specific experiments will be needed to confirm it.

S-NITROSOGLUTATHIONE AND PLANT DEVELOPMENT

The effect of NO on seed germination, root architecture, development, and fruit ripening has been routinely studied using NO donors such as sodium nitroprusside. However, more recently, GSNO has

begun to be used as it is considered to be a more physiological NO donor (Liu et al., 2007; Zandonadi et al., 2010; Semchuk et al., 2011). However, to our knowledge, there is no information on the content of endogenous GSNO during these plant processes. As mentioned earlier, the use of LC-ES/MS to detect and quantify GSNO has provided some initial data on GSNO content in plant organs. Thus, analysis of GSNO in the main organs of pepper plants have indicated that GSNO was most abundant in roots, followed by leaves and stems, which directly correlated with the content of NO in each organ and inversely correlated with GSNOR activity (Airaki et al., 2011). Very recently, it has been also reported the subcellular localization of GSNO in pea leaves by electron microscopy immunocytochemistry and immunogold particles were clearly visible in cytosol, chloroplasts, mitochondria, and peroxisomes (Barroso et al., 2013).

On the other hand, the involvement of NO in plant reproductive biology has been reported (Bright et al., 2009; Zafra et al., 2010). Thus, NO can act as a negative regulator of pollen tube growth in plants such as *Lilium longiflorum*, *Arabidopsis thaliana*, and *Paulownia tomentosa* (Prado et al., 2004, 2008; He et al., 2007) and as a positive stimulus of pollen tube growth in *Pinus bangeana* in a dose-dependent manner (Wang et al., 2009). Recently, analysis of GSNO by LC-ES/MS in olive pollen subjected to *in vitro* germination has shown the presence of GSNO (unpublished data) whose content closely correlated with the NO content previously reported (Zafra et al., 2010) and inversely correlated with GSNOR gene expression.

CONCLUSIONS

The study of GSNO, which is part of the metabolism of NO in higher plants, has begun to increase our knowledge of the physiological significance of this universal molecule that is involved in almost all the process where GSNO has been studied. Consequently, the analysis of GSNO content and metabolism during plant development and under environmental stress conditions presents a new challenge in relation to the signaling properties of GSNO.

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