Mechanisms of plant-xenobiotic interactions: potential consequences for herbicide use and environmental risk assessment

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Extended summary

In relation with the importance of agriculture and agro-industry in the Brittany region, and with the presence of a Medical School of Public Health, several institutes in Rennes are carrying out research on environmental consequences of chemical pollutions. The Research Institute for Environmental and Occupational Health (University of Rennes 1/ INSERM) analyses molecular processes related to human pathologies in the context of environmental challenges, whether drug-, pesticide- or pollutant-related, and our Institute of Ecosystems-Biodiversity-Evolution Studies (University of Rennes 1/ CNRS) develops research projects on the effects of environmental pesticide contaminants on natural communities of non-target soil and freshwater organisms (microorganisms, phytoplankton, plants, earthworms, arthropods, molluscs, small mammals), from molecular mechanisms to landscape-level biodiversity dynamics. In this context, our interest and expertise on plant responses to abiotic stresses has led us to investigate from a mechanistic point of view the impact of herbicide contaminants on the model plant *Arabidopsis thaliana* and on perennial rye-grass (*Lolium perenne*), which is an important component of vegetated filter strips of field margins. Given their ubiquity and persistence in soils and in water bodies, herbicides are environmental xenobiotic pollutants of high concern. Whereas their action is usually assessed as the result of unilinear modes of action on a specific biochemical target with a typical dose-response dynamics, integrative analysis of physiological, metabolomic and

transcriptomic responses to low environmentally-relevant doses of herbicides and herbicide breakdown products, such as glyphosate, AMPA (glyphosate breakdown product), atrazine, desethylatrazine and hydroxyatrazine (atrazine breakdown products), reveals numerous cryptic effects, with major reorientations of carbon and nitrogen metabolism, modifications of stress-related metabolisms, and large-scale changes of gene expression consistent with the involvement of regulatory processes and signalling mechanisms. Analysis of herbicide-regulated genes and their promoters further reveals that signalling pathways related to plant hormones, low energy sensing, environmental stress sensing, and biotic interactions are involved in or interact with herbicide-related signalling. In accordance with earlier serendipitous studies, our current work with hormone signalling mutants indicates that these interactions can result in mechanisms of adjustment that can determine the level of sensitivity or tolerance to contamination with a given herbicide or with mixtures of herbicides, depending on the environmental and developmental status of the plant. Moreover, identification of mechanistic interactions between xenobiotic, abiotic and biotic stress signalling pathways gives novel insights on interferences between herbicide pollution and climate change stressors. Consideration of herbicide-related signalling processes should be useful for designing herbicide use strategies, for environmental risk assessment and for global change impact assessment.

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