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PHYTOTCHEMICAL PHYTOTOXINS AND HORMESIS – A COMMENTARY

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The three papers (Hadacek *et al.*, 2010; Liu *et al.*, 2010; Sinkkonen *et al.*, 2010) following this short commentary are the result of an attempt by Regina Belz (Univ. Hohenheim) and me to generate a special issue dealing with dose-response aspects of allelochemicals. I use the term allelochemical to denote a plant secondary compound used by a producing plant to harm competitors, giving it an advantage in a Darwinian situation. Unfortunately, we were not able to produce a full issue, but the three papers that were contributed are novel and quite interesting.

I would like to preface my thoughts on these papers with some brief comments about allelochemicals. As with all toxins, carefully conducted dose response studies with allelochemicals generally results in the finding of hormetic responses. For example, in studies conducted by Belz (2008) and Belz and Cedergreen (2010) pronounced hormesis was found at low doses of parthenin, a potent phytotoxic terpenoid, on mustard and lettuce seedlings. Unfortunately, only a very small fraction of the published dose-response experiments with allelochemicals have been conducted with the range and precision to clearly show hormesis, even though the early workers in allelopathy were clearly aware that some or all allelochemicals had the potential to be hormetic (Rice, 1984). Finally, many of the papers that claim particular phytochemical phytotoxins are allelochemicals do not clearly prove that they have such a role in nature (Duke, 2010).

The paper by Liu *et al.* (2010) models hormesis in allelopathic situations from the literature. To generate at better model, they add ecological limiting factor models to a model previously generated by one of these authors (An *et al.*, 1993). The new model improves modeling of allelopathic hormesis, providing a basis for further research on plant allelopathic hormesis.

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Sinkkonen *et al.* (2010) is not about allelopathy, but the concept generated from this paper might apply to hormesis caused by any phytotoxin, including allelochemicals. This paper is an extension of earlier research by these authors (e.g., Sinkkonen *et al.*, 2008). These authors demonstrate that growth of a subpopulation of a plant species may be inhibited by a phytotoxin at a dose that might stimulate growth of other members of the population. In their studies, the fastest growing members of the plant population were the most sensitive to adverse effects of the chemical. Two out of three plant species tested had subpopulations that were inhibited by a variety of phytotoxins at low doses. They conclude by stating that selective toxicity at low doses should be considered in parallel with hormesis.

A controversial theory that impinges on allelopathy as well as most other areas of plant chemical ecology is proposed in the third paper (Hadacek *et al.*, 2010). The authors hypothesize that secondary products of plants have evolved to help the plant cope with reactive oxygen species (ROS) and that the redox chemistry between these compounds and ROS, as well as with molecular oxygen, contribute to the hormetic effects caused by these secondary compounds. They point out that the availability of transition metals that can serve as electron donors to the Fenton reaction can modulate the redox reactions. They further reason that since the responses to different doses of ROS demonstrate hormesis, these natural modulators of ROS can be hormetic. This function of secondary plant compounds in reacting with ROS and molecular oxygen is proposed to be the sole "reason for being" for these compounds. In light of the huge amount of literature showing co-evolution of secondary products of plants and their biotic environment, I find the estimate of the importance of the ROS modulation in the hypothesis by these authors to be grossly overstated. However, the authors provide a good argument for this to be at least one of the functions of some of these compounds under some circumstances. It is a highly thought provoking paper whether you agree with the "raison d'être" hypothesis or not.

None of the three papers in this section turned out to be the typical "grind and test" allelopathy paper. Each of them provides fresh insight into how allelochemicals might influence hormesis.

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