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Role of specific plant root derived chemicals in pesticide attenuation and resistance

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Xenobiotic metabolism in plants often includes a primary step, most commonly an oxidation or hydrolysis that serves to provide a functional group that is suitable for subsequent conjugation. In grasses, benzoxazinones appear to play an important role in this metabolism. In the plants they exist as benzoxazinone acetal glucosides. Herbivory and other stresses allow β-glucosidases to release the aglucone from the glucosidic precursors which have accumulated in plant cell vacuoles.

Aglucones can also be passively set free into soils by rotting plant material or actively released via root exudation. Therefore, it would appear that benzoxazinones also have the potential to influence the degradation of pesticides in the rhizosphere itself.

We investigated the influence of corn root exudates on the degradation of atrazine and its chlorinated metabolites desethylatrazine (DEA) and desisopropylatrazine (DIA) in vivo in a hydroponic system. Up to 30% of the disappearance of atrazine and DEA, and up to 10% of DIA removal from the solution medium in our study could be explained by the formation of hydroxy metabolites in the solution itself, indicating the importance of this pathway for the fate of these triazine compounds in the rhizosphere. HMBOA (3,4-dihydro-2-hydroxy-7-methoxy-2H-1,4-benzoxazin-3-one), the lactam precursor of the benzoxazinone DIMBOA (2,4-dihydroxy-7-methoxy-1,4-benzoxazin-3-one), and a tentatively identified derivative of MBOA (2,3-dihydro-6-methoxybenzoxazol-2-one) were detected in the corn root exudates. These findings further indicate that certain plants such as corn have the potential to promote the hydrolysis of triazine residues in soils, and thus reducing their toxicity and mobility, by exudation of benzoxazinones.

In laboratory experiments, we specifically studied the effect of 2,4-dihydroxy-7-methoxy-1,4-benzoxazin-3-one (DIMBOA), the major benzoxazinone of corn, on the degradation of different chemical classes of pesticides. It could be shown that the substrate range of the major cyclic hydroxamic acid in corn, the 2,4-dihydroxy-7-methoxy-1,4-benzoxazin-3-one (DIMBOA), is broader as reported in literature so far. Besides atrazine and diazinon, DIMBOA also catalyzes the degradation of desethylatrazine (DEA) and desisopropylatrazine (DIA), the predominant toxic breakdown products of atrazine in soils. Additionally, DIMBOA also catalyzes the degradation of 2,4-D, which is widely used as weed control and which was a major component (about 50%) of the product Agent Orange.