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CADMIUM UPTAKE AND REPARTITION OVER THE VEGETATIVE STAGE IN *HELIANTHUS ANNUUS* GROWN AT Cd 2 AND 20 nM

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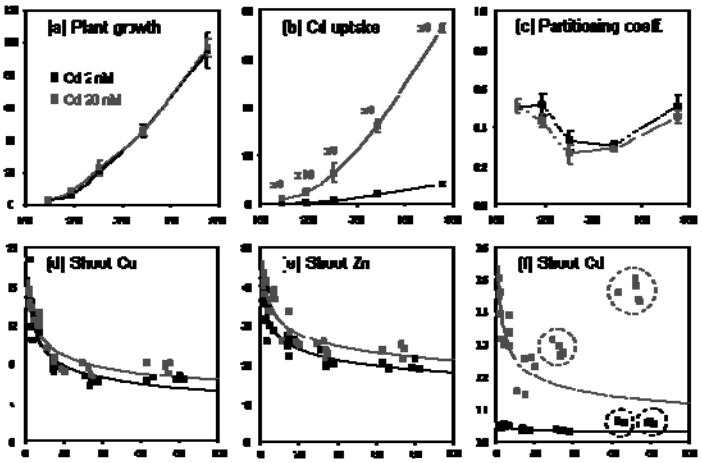
ABSTRACT

Although processes governing the fate of Cd in plant tissues are well described at high level of Cd exposure (vacuolar sequestration, xylem loading, xylem-to-phloem transfer), the literature is lacking of a formalization of this knowledge in a simulation model. There are some indications showing that the concentration of metals in a plant organ can depend on the growth of this organ due to a dilution effect (Chen et al., 2008; Ekvall and Greger, 2003). These observations can be summarized by the following model: $C = a*Biom^{-b}$ where *C* is the concentration of trace elements in the plant compartment (leaves, stems, seeds), *Biom* is the biomass of the plant compartment, *a* and *b* are parameters. The parameter *b* describes the dilution intensity when the parameter *a* synthesizes the effect of the bioavailability and that of the plant species. The main objective of this work is to test this model on *Helianthus annuus*, for variations in biomass resulting from the phenology. We worked at a level of Cd exposure that commonly occur in agricultural soils (nM range) and for which metals repartition between plant organs has rarely been described.

One cultivar of sunflower (ES BIBA) commonly cultivated in France was grown in greenhouse in a ¼ Hoagland nutrient solution with 2 or 20 nM $Cd(NO_3)_2$. Plant sampling was performed at five phenological stages (6, 9, 14, 19 and 31 expanded leaves). Plants were divided into roots, stems, leaves (excluding the petiole) and flower bud (when present). All plant tissues were freeze-dried, weighed and milled. Their total N content was measured by the combustion method of Dumas and their content in Cd, Cu and Zn by ICP-MS after a micro-wave digestion in a mix HNO_3-H_2O_2. Xylem sap was collected on every plant by the "root pressure" method and analysed for its concentration in metals (ICP-MS), organic acids and amino acids (LC-DAD).

The figure shows the evolution of [a] plant dry weight (g), [b] plant uptake of Cd (µg) and [c] partitioning coefficient of Cd to shoots (unitless) over thermal time (° days) and the relationships between [d] Cu content, [e] Zn content, [f] Cd content (µg g-1) and biomass (g) in plant shoots, at Cd 2 and 20 nM.



Plant growth was not affected by the level of Cd exposure. The 10-fold rise in the concentration of Cd in nutrient solution induced an almost 10-fold increase in the plant uptake of Cd. The partitioning coefficient of Cd to shoots varied over time, contrary to that of Zn, and was fairly similar at Cd 2 and 20 nM. All these results suggest that at low level of Cd exposure, which characterize agricultural soils, the uptake and the root-to-shoot translocation of Cd in sunflower are not much regulated. Investigations are in progress to check whether the molecular processes involved in Cd homeostasis (e.g. PCs synthesis) are induced at this low concentration.

A decrease in Cu and Zn content was observed with plant growth in stems, leaves (so shoots) and roots. This result confirms that the dilution of Cu and Zn in plant biomass has a physiological origin. The "dilution model" presented above described nicely the experimental data for Cu and Zn. A comparison of the *b* value with the one obtained for N is necessary to know whether the dilution of Cu and Zn can be explained in the same way as the one of N. For Cd, the re-concentration of the metal in aerial tissues observed at the two last stages of vegetative growth still needs to be figured out. Interestingly, a similar trend was observed in the concentrations of Cd and of some amino acids and organic acids measured in xylem sap.

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