Genetic and physiological determinants controlling cadmium accumulation in lettuce (Lactuca sativa)

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Genetic and Physiological determinants controlling cadmium accumulation in lettuce (*Lactuca sativa*)

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Cadmium is an extremely toxic pollutant causing a great number of diseases. It is a widespread metal whose concentration rises in cultivated soils. Food or feed crops are thus exposed to it, which ultimately causes potential sanitary problems as a consequence of the entry of cadmium in the food chain. Among the vegetable species used for food, lettuce shows one of the highest capacities to accumulate cadmium. Our objectives are to characterize mechanisms controlling cadmium accumulation in this species and identify the corresponding genetic determinants. The long-term goal is the breeding for cadmium under-accumulation in lettuce.

A phenotypical analysis of cadmium accumulation was carried out on 18 lettuce genotypes representing the genetic diversity of the species. A great variability of response was revealed, both with respect to cadmium accumulation and to cadmium translocation from roots to shoot. The lettuce genotypes displayed independent variations for both traits, and also between these traits and cadmium tolerance. In contrast, a very strong positive correlation linked cadmium and zinc accumulation.

Increasing calcium and iron concentration in the culture medium had a protective effect against cadmium accumulation, however this characteristic did not discriminate the lettuce genotypes presenting extreme cadmium accumulation phenotypes. Interestingly, experiments measuring ^{109}Cd influx in roots, ^{109}Cd efflux from roots and ^{109}Cd translocation from roots to shoots revealed that the genotype displaying the least cadmium accumulation could be discriminated from the genotype displaying the highest one by its markedly increased ability to efflux cadmium from the roots to the culture medium.

Progeny analysis from crosses between the genotypes displaying extreme performances for cadmium accumulation, cadmium translocation from roots to shoots and cadmium tolerance revealed that none of these traits was supported by a single genetic determinism. QTL mapping is under development. Surprisingly, the genetic analysis demonstrated that the ability to limit cadmium accumulation (and thus probably to increase cadmium efflux from the roots) was recessive.

In conclusion, phenotypic analysis of cadmium accumulation in a large set of lettuce genotypes revealed that a major determinant limiting cadmium accumulation in this species is the ability to efflux cadmium from the root to the culture medium.