Variability in grain cadmium concentration among durum wheat cultivars: impact of aboveground biomass partitioning

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Variability in Grain Cadmium Concentration among Durum Wheat Cultivars: Impact of Aboveground Biomass Partitioning

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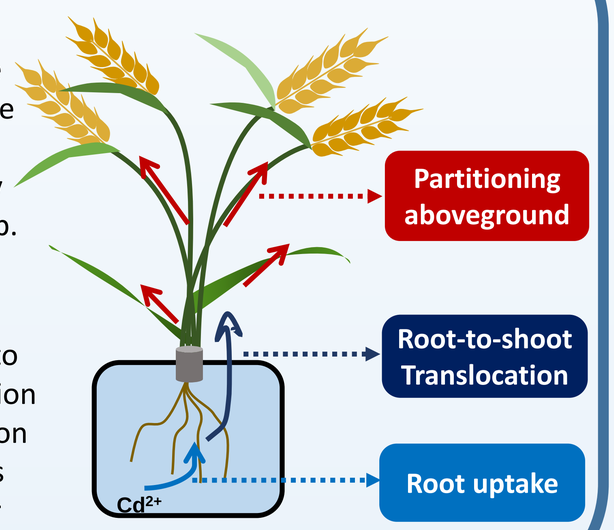
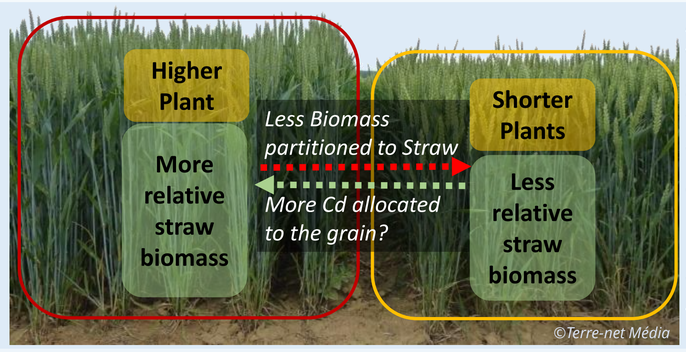
Background

Cd pollution in agricultural soil is a common challenge around the world. Cereals is a major component of the human diet. The dietary intake of Cd contaminated cereals is toxic to humans. This problem is particularly important in durum wheat (*Triticum turgidum* L. subsp. *durum*) since this species accumulates more Cd than other commonly grown cereals.

Using low-Cd accumulating cultivars is one approach to minimize the Cd load in durum wheat grains. This option first needs to evaluate to what extent the concentration of Cd in the grain varies among durum wheat cultivars and to understand the main processes responsible for this variation.



Hypothesis & Objectives



Assuming that aboveground vegetative organs (straw) are sinks for Cd in competition with grains during grain filling, we expect that cultivars allocating more relative biomass to the straw (could be cultivars with longer stems) would accumulate less Cd in their grains.

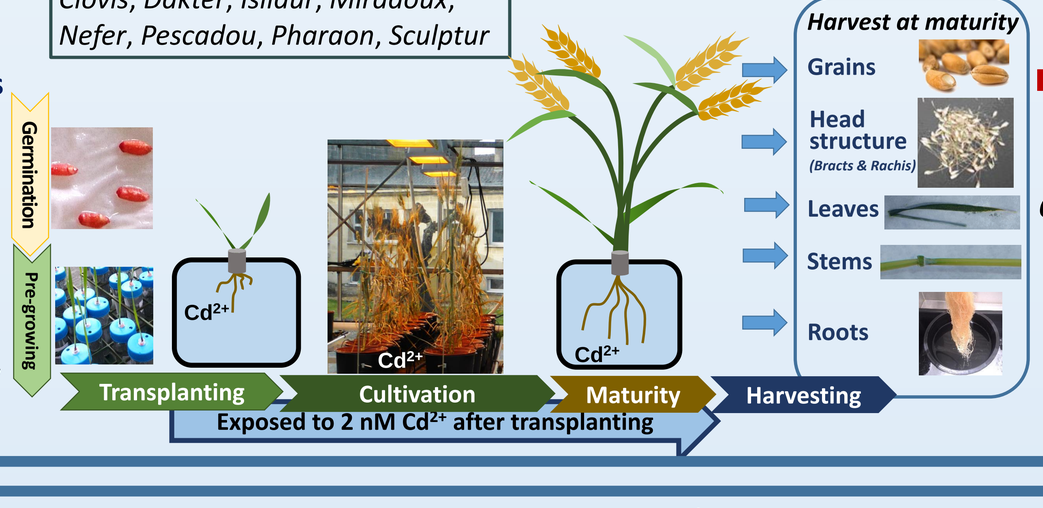
- To assess the variation of grain Cd concentration among French durum wheat cultivars.
- To test whether the different pattern of aboveground biomass partitioning affects the grain Cd concentration between cultivars.

Materials

- **Cultivar**: eight French durum wheat cultivars, no *Cdu1* allele;
- Plants were trained to develop **4 tillers** from the start of elongation.
- **Hydroponics**: modified Hoagland's nutrient solution at pH 6.0, refreshed automatically;
- **Cd^{2+} was supplied after transplanting at low dose:** non-toxic, fixed at **2 nM** (*to reproduce the level of exposure to Cd found in low to moderately contaminated agricultural soils* [1]);

8 French Cultivars (×5 repetitions)
differing in their aboveground biomass partitioning

Clovis, Dakter, Isildur, Miradoux, Nefer, Pescadou, Pharaon, Sculptur



GF-AAS → Cd concentration

$$Grain\ Cd = \alpha \times \frac{QCd_{tot} \times (1 - RSF) \times Leaves\ DW^{-\beta}}{(Grain\ DW)^{(1-\beta)}}$$

Hypothesis: Straw, which was represented by leaves, compete Cd with Grain

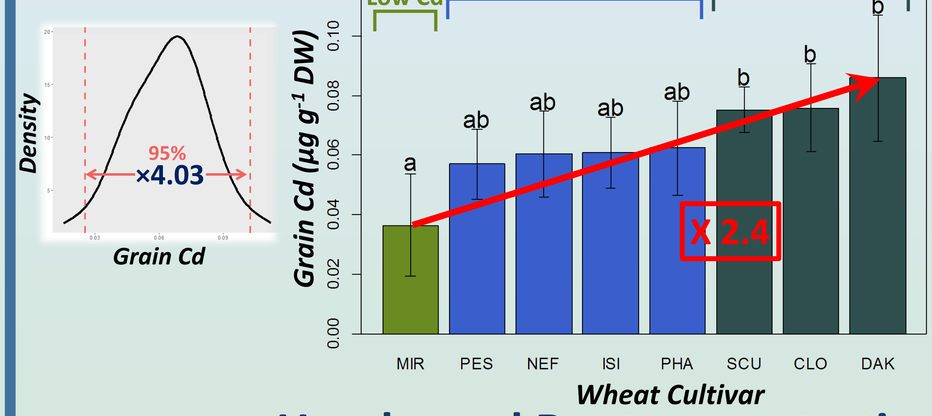
$$GAF = \alpha \times \left(\frac{Leaves\ DW}{Grain\ DW}\right)^{-\beta}$$

$$Grain\ Cd = \frac{QCd_{tot} \times (1 - RSF)}{Grain\ DW} \times GAF$$

The concentration of Cd in the grain (***Grain Cd***, µg g^{-1}) was modeled as a function of the grain biomass (***Grain DW***, g), the amount of Cd taken up by the roots (***QCdtot***, µg), a root sequestration factor (***RSF***) and a grain allocation factor (***GAF***) itself modeled as a function of the ratio between the biomass of leaves and that of grains.

Results

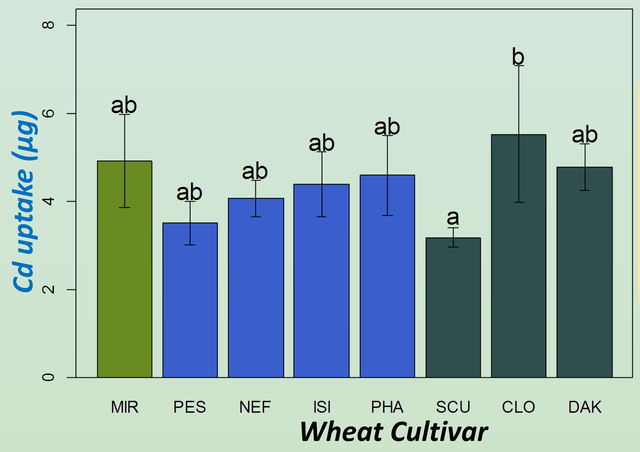
Grain Cd level



Grain Cd concentration ranged from 0.03 to 0.08 µg g^{-1} (2.4-fold) among cultivars and was thus in the same range as that measured in field trials.

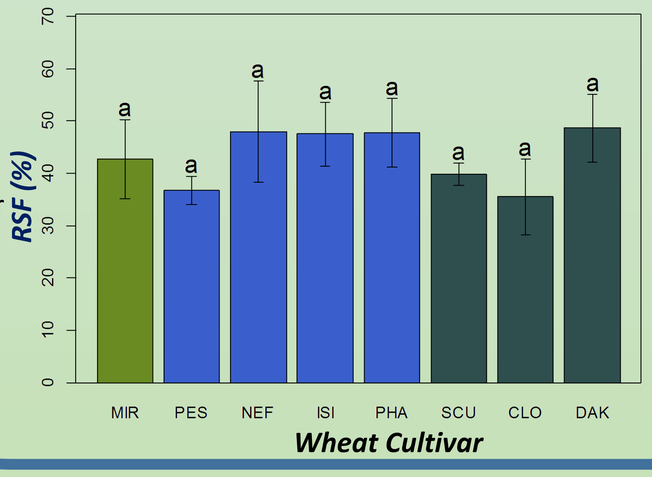
Uptake and Root sequestration of Cd

The French cultivar that took up more Cd maybe not the one with higher concentration of Cd in the grain.



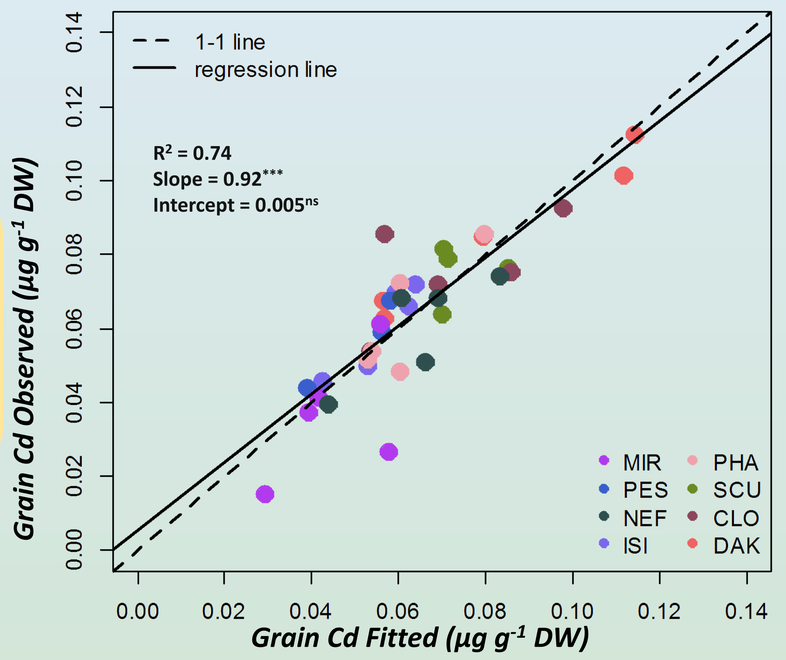
The 2.4-fold variation in grain Cd within French lines was NOT explained either by a difference in uptake or by a difference in the root sequestration of Cd.

There was no significant difference in root sequestration factor (RSF) values among French cultivars.



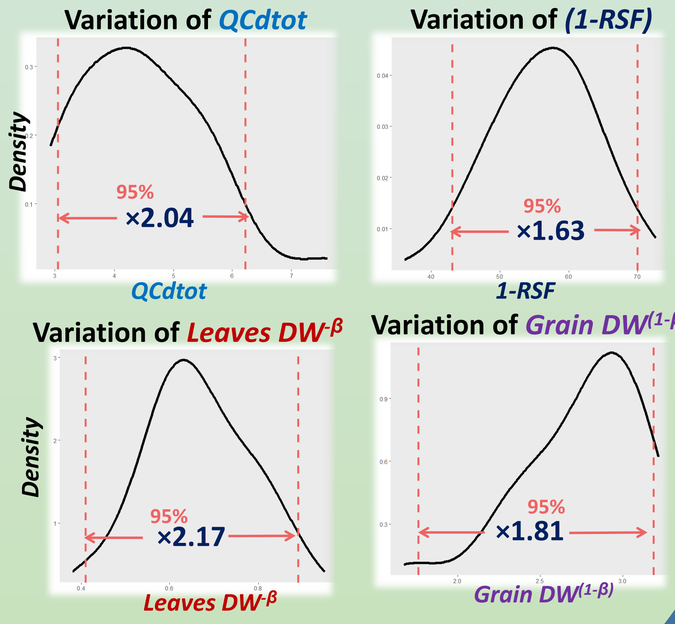
Modelling to Explain the Variability in Grain Cd

The model shown in the equation above provides a good prediction of the intraspecific variation in grain Cd.



The Leaf Biomass was the main factor explaining the variation in grain Cd

Variation of the explanatory variables of the model



Conclusions

- The grain Cd concentration varied 2.4-fold among French durum wheat cultivars.
- The partitioning of aboveground biomass may influence the concentration of Cd in grain.
- Breeding programs tending to reduce the stem height may promote the accumulation of Cd in durum wheat grains.

[1] Sauvé, S. et al *Environmental Science & Technology* (2000) *34*(2), pp. 291-296.