VARIABILITY IN GRAIN CADMIUM CONCENTRATION AMONG DURUM WHEAT CULTIVARS: IMPACT OF ABOVEGROUND BIOMASS PARTITIONING

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Keywords: Low-dose cadmium; cereal; genotypic variation; shoot sequestration; stem height

Introduction

One way to minimize the Cd load in durum wheat grains is to use low-Cd accumulating cultivars, i.e. cultivars with a low ability to accumulate Cd in the grain. This option first requires evaluating to what extent the concentration of Cd in the grain varies among durum wheat cultivars and identifying the main processes responsible for the differences. This work aims at understanding the ecophysiological processes that drive the accumulation of Cd in durum wheat grains. The partitioning of Cd among aboveground organs is poorly described in the literature, even though durum wheat lines differ considerably in stem height and grain size, i.e. in their aboveground partitioning of biomass. Assuming that the leaves and stem are sinks for Cd in competition with grains during grain filling, one would expect that a shift in the aboveground partitioning of biomass would affect the concentration of Cd in the grain. The objective of this work was to test this hypothesis in eight French durum wheat lines that differ in their aboveground structure.

Methods

Eight French widely cultivated durum wheat cultivars were grown hydroponically in the presence of Cd, with five replicates per cultivar. The cultivars differed in their stem height and in their grain size but also in precocity and in their grain protein content. None possess the allele responsible for the low-Cd trait at *Cdu1* (Zimmerl et al., 2014). At maturity, the partitioning of biomass and Cd among organs was analyzed. The concentration of Cd^{2+} in the nutrient solution was fixed at 2 nM to reproduce the level of exposure to Cd found in low to moderately contaminated agricultural soils (Sauvé et al., 2000). 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. This model was adjusted to the experimental data obtained for the 8 French cultivars.

$$Grain\ Cd = GAF \times \frac{QCd_{tot} \times (1 - RSF)}{Grain\ DW} \quad \text{with} \quad GAF = \alpha \times \left(\frac{Leaves\ DW}{Grain\ DW}\right)^{-\beta}$$

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

Results

Grain Cd concentration ranged from 0.03 to 0.08 µg g^{-1} and was thus in the same range as that measured in field trials. A 2.4-fold variation in grain Cd was observed within French lines, which was not explained either by a difference in uptake or by a difference in the root sequestration of Cd (Table 1). The model shown in eq. 1 provides a good prediction of the intraspecific variation in grain Cd (Fig. 1). One important finding is that is the leaf biomass was the main factor explaining the variation in grain Cd (data not shown) which strongly suggests that the accumulation of Cd in the grain depends on the aboveground partitioning.

Table 1. Grain Cd concentration (µg g^{-1} DW), Cd uptake (µg), root sequestration factor (*RSF*) and grain allocation factor (*GAF*), measured at maturity in 8 French durum wheat cultivars.

	CLO	DAK	ISI	MIR	NEF	PES	PHA	SCU
Grain Cd	0.076 b	0.086 b	0.061 ab	0.036 a	0.060 ab	0.057 ab	0.062 ab	0.075 b
QCd_{tot}	5.53 b	4.79 ab	4.39 ab	4.92 ab	4.07 ab	3.51 ab	4.59 ab	3.18 a
RSF	0.35 a	0.49 a	0.47 a	0.43 a	0.48 a	0.37 a	0.48 a	0.40 a
GAF	0.24 b	0.16 a	0.25 b	0.14 a	0.24 b	0.21 ab	0.25 b	0.25 b

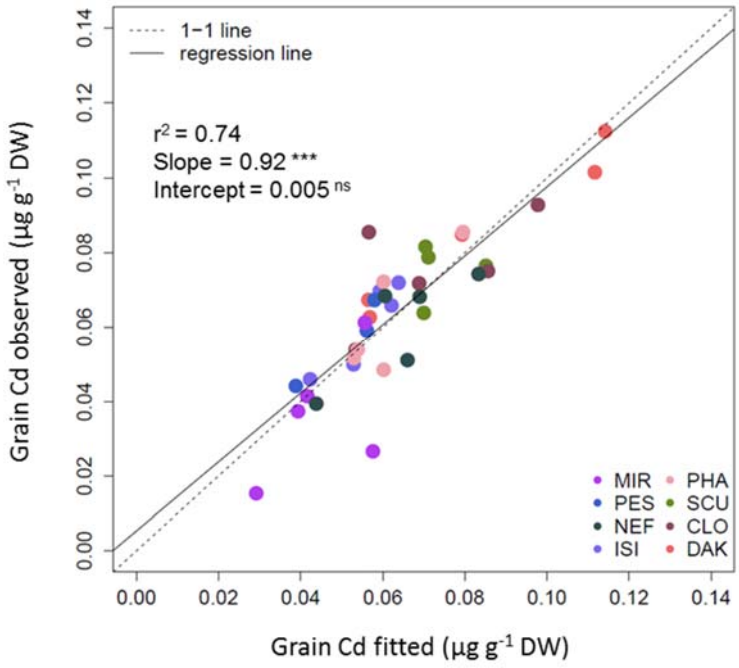

Figure 1. Relationships between the values of grain Cd concentration predicted by the model and those measured experimentally in the 8 French durum wheat lines considered in the study.

Conclusion

The partitioning of aboveground biomass may influence the concentration of Cd in grain, in addition to the sequestration of Cd in roots. Breeding programs tend to reduce the stem height of cereals to improve their resistance to logging. This work suggests that this selection may promote the accumulation of Cd in durum wheat grains.

References

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