DOES NITROGEN SUPPLY IMPACT THE CADMIUM FLUXES TO DEVELOPING DURUM WHEAT GRAINS?

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Introduction

Durum wheat (*Triticum turgidum* L. subsp. *durum*) is the fourth most important cereal crop in France. It can accumulate Cd in grain to levels exceeding international trade standards which are threatening for human health. Cd imported into developing grains may originate from either Cd directly taken up by roots or Cd indirectly remobilized from vegetative organs. Previous studies have shown that, with a maintained supply of Nitrogen (N) during the grain filling period, the remobilization of Cd from vegetative organs to grains is supposed quite limited (Harris & Taylor, 2013). In the field, however, the availability of N in soil is often low during grain filling. Under this condition, the remobilization of N takes place and accounts for most of the N present in the grain at maturity (Bahrani et al., 2013). Thus, there is a need to know whether the supply of N during grain filling has an impact on the Cd remobilization and the level of Cd in the grains. In the present study, we used the Cd isotopic tracing to answer this question and to determine the quantitative importance of the two origins of the grain Cd.

Methods

The French durum wheat cultivar *Sculptur* was used in this study. Fifteen plants were grown hydroponically and exposed to 100 nM Cd ($p(Cd^{2+}) = 10.78$). Five plants were harvested at anthesis. The rest 10 plants were kept growing in the nutrient solution where the source of Cd was changed for a source enriched in the isotope ^{111}Cd. We kept providing N for 5 of them, but cut the N supply for the other 5 plants. At maturity, they were all harvested. All the organs, which are roots, stems, leaves, spikelets+rachis (S+R) and mature grains, were oven-dried, milled, digested when necessary and analyzed for their total concentration in N and Cd. The Cd accumulated before or after anthesis was distinguished based on the isotopic ratio $^{114}Cd/^{111}Cd$ which was assessed by HR-ICP-MS and quantified base on the theory and equation introduced by Rodríguez-Cea et al. (2006). The apparent flow of N was calculated based on the difference of N amount for each organ between anthesis and maturity.

Results

The concentration of Cd in mature durum wheat grains ranged from 1.02 to 1.57 µg g^{-1} DW, which were 5 to 8 times higher than the threshold value (0.2 µg Cd g^{-1}). When the supply of N was maintained after anthesis, the remobilization played an important role for both Cd and N. Indeed, on average 48% of the Cd and 57% of the N imported in developing grains were remobilized from vegetative organs. Stems were the main source for grain Cd whereas leaves were the main source for grain N. The Cd taken up post anthesis was not only allocated to the grain but to every aboveground organs. When the supply of N was cut at anthesis, no decrease in the concentration of Cd was observed in the grain. Moreover, no difference in the

origins of grain Cd was detected between the two N supplies. The proportion of grain Cd issued from remobilization was on average higher under the low N supply (58%) than that under the high N supply (52%) but the difference was not significant ($P > 0.05$). Surprisingly, the concentration of N in the grain was the same under both N supplies. The efficiency of N remobilization thus increased when we cut the supply of N but this did not enhance the efficiency of Cd remobilization. Furthermore, no decline in the post-anthesis uptake of Cd occurred when the N supply was cut.

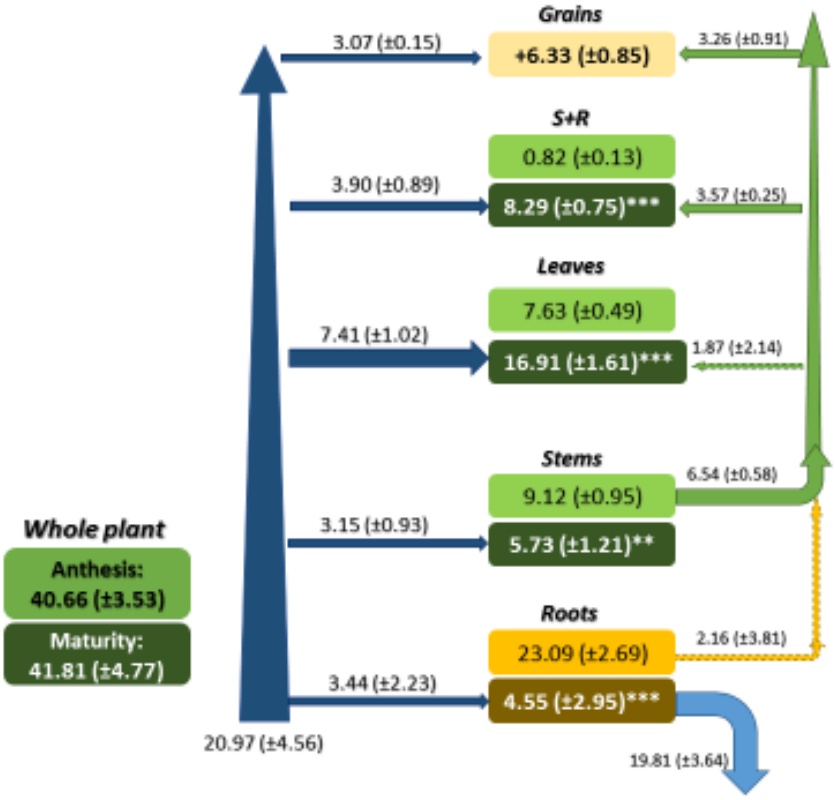

Figure 1. Cadmium contents in hydroponically grown durum wheat with sufficient N supply

Conclusion

By using the Cd isotopic tracing, we successfully separated the Cd remobilization from uptake and quantified them. Unlike other studies, our study showed that about half of the grain Cd originate from the Cd remobilization of pre-anthesis stores. The N remobilization was promoted by the low N supply after anthesis, but it has no impact on the Cd fluxes into developing grains.

References

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