Can Zn Transport and Partitioning in the Rice Plant Be Modelled?

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INTRODUCTION

Considerable efforts are made to study mechanisms of micronutrient uptake, accumulation and partitioning in plants to increase micronutrient concentrations in cereal grains to enhance human nutritional value (Pearson et al. 1998, Grusak et al. 1999, Welch and Graham 2002). Some of the major crop-physiological issues remain unsolved, and critical relations are poorly quantified. Designing models that describe the dynamics of the element in the soil, the development of the uptake capacity of the root system, the dynamics of the demand of the crop and the mobility of the element in the plant could help in integrating current understanding. As a first step, we conceptualize a model for partitioning of Zn in plants after uptake by the roots.

METHODS

Model Concept

Zinc mass fraction in individual plant organs (OrgZnMF) is a function of the Zn mass fraction of the total plant (PlZnMF) (Fig. 1). Plant-Zn content and plant dry matter are the integrated values of Zn uptake and net photosynthesis, respectively, over a given period. The ratio of plant Zn content and dry matter defines PlZnMF. Based on dry matter partitioning over organs and the relations between OrgZnMF and PlZnMF, individual plant organ Zn mass fractions can be calculated. At any point in time, the difference between current OrgZnMF and the calculated OrgZnMF is the sink strength of the organ relative to that of other organs. Based on maximum translocation rates, final OrgZnMFs are calculated at the end of each time step. Allocation and re-translocation of Zn are handled in the same way.

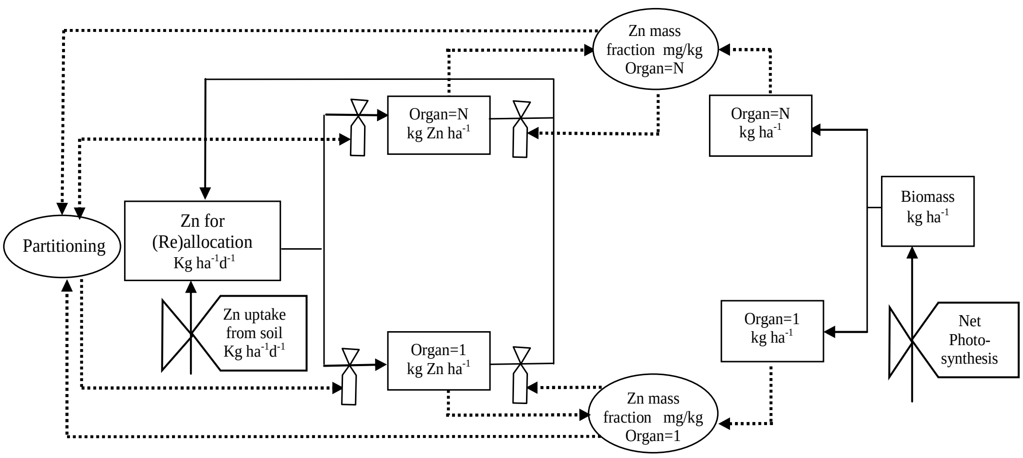

Fig. 1. Relational diagram of the proposed Zn allocation model.

Parameterisation of the Model

Two solution culture experiments were conducted, each with a wide range in Zn-supply levels and with two rice cultivars. The first experiment, with a very wide range in Zn supply, was used to obtain estimates of maximum Zn storage levels and the second, with a smaller range in Zn levels, to study the relations between the Zn mass fractions of the different organs at different stages. Regression analyses were used to obtain parameter estimates for the model.

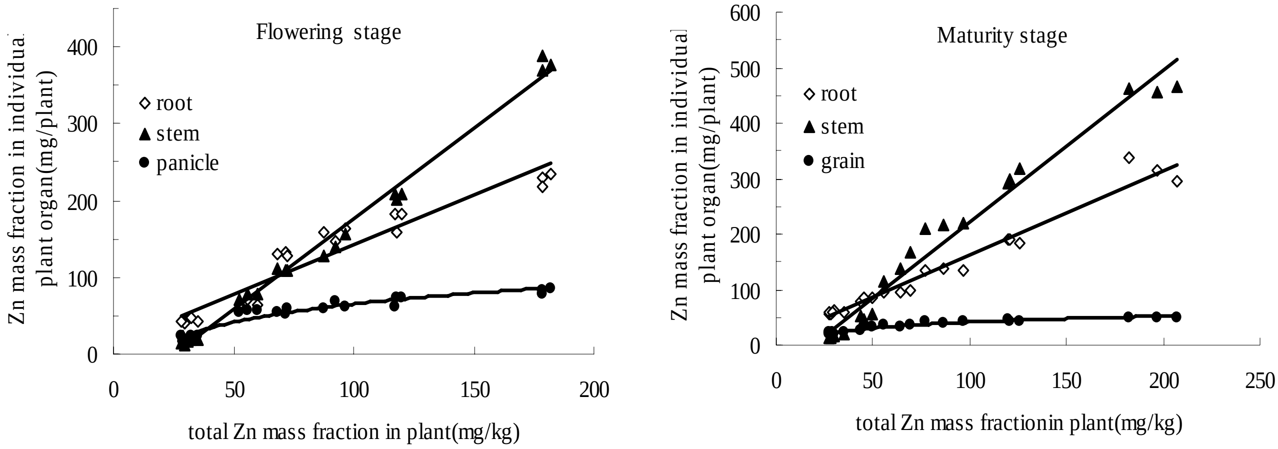

Fig. 2. The relationship between Zn mass fractions in individual plant organs and plant Zn mass fraction at flowering and at maturity.

RESULTS AND DISCUSSION

The organ Zn mass fractions were closely related to the Zn mass fraction of the total plant (Fig. 2). Relations were generally linear with the exception of those for the reproductive organs that clearly showed a less than proportional increase in Zn mass fraction with an increase in PIZnMF. The regression coefficients varied among development stages and between cultivars. Validation data sets are under construction to assess how well the model performs under different conditions.

CONCLUSIONS

The dynamics of Zn partitioning in rice could be described with a model based on the Zn mass fraction computation for individual organs as a function of the Zn mass fraction of the whole plant and a maximum distribution rate.

ACKNOWLEDGEMENTS

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