Zn Re-translocation during Early Vegetative Growth Stage in Rice Plants: Mechanism for a High Internal Zn Use Efficiency?

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INTRODUCTION

Remobilization of a given nutrient varies greatly with plant species and genotypes. The identification of genotypes with a high remobilization rate from older to young leaves is of increasing interest for selecting and breeding genotypes with a high nutrient efficiency (Marschner 1995). Our knowledge about re-translocation of micronutrients from older to the youngest leaves and seeds is incomplete. The growth stage and nutritional status of plants as well as the extent of senescence can have pronounced effects on the rate of re-translocation (Loneragan et al. 1976). Our previous results show that uptake efficiency could not be considered as a mechanism for Zn efficiency in rice genotypes. Higher internal utilization efficiency in terms of a higher remobilization rate of Zn from old to young leaves, however, could be one of the important mechanisms for Zn efficiency of genotypes. In this work, the importance of Zn re-translocation in determining responses of rice genotypes to Zn deficiency was studied using three Zn-efficient and three Zn-inefficient rice genotypes.

METHODS

Six rice genotypes differing in Zn efficiency, as characterized in field and nutrient solution experiments, were used including IR26, Fajr and Tarom-Hashemi (Zn-inefficient), IR36, Amol and Shafagh (Zn-efficient). After pre-culture in low Zn (<0.05 µM) nutrient solutions, 14 day-old plants were transferred to a Zn-loading solution buffered with 5 mM MES at pH 6 with a Zn concentration of 1 µM. After 48 h loading, the roots were washed with 0.5 mM $CaSO_4$ for 1h, and after changing the holding sponges, plant bundles were transferred to the nutrient solution with low (<0.05 µM) or adequate (0.5 µM) Zn. The experiment continued for 21 days, and nutrient solutions were changed every four days. The same procedure was applied for the radio-isotope experiment, but the loading medium was labelled with ^{65}Zn with a specific activity of 4.4 Gbqmmol^{-1} Zn. The first harvest was performed at the beginning of the Zn supply after washing the roots. The following harvests were carried out each time after a new leaf emerged and partially expanded to a length of about 5 to 7 cm. Four replicates consisting of defined leaves of four plants were harvested for each treatment, genotype and harvest time. Zinc was determined by Atomic Absorption Spectroscopy (AAS) or liquid scintillation.

RESULTS AND DISCUSSION

A clear redistribution of Zn from the mature leaves to the youngest growing leaf was observed during the growth period with repeated harvest dates. Loaded Zn in the expanded leaves was depleted rapidly during the following experimental period, and this Zn was re-translocated to the youngest leaf as judged by a Zn depletion occurring simultaneously with the appearance of a new leaf. A high net re-translocation was particularly observed at low Zn supply. In addition, a clear genotypic difference was observed for the extent of re-translocation. Re-translocation of Zn was more pronounced in three Zn-efficient than in Zn-inefficient genotypes. The re-translocation (e.g. %reduction of Zn content) was as high as 70% in the leaves of Zn-efficient genotypes when supplied with low Zn (Table 1).

Table 1. Change in Zn content (ng leaf^{-1}) in distinct leaves of three Zn-efficient and three Zn-inefficient rice genotypes during an early growth stage. Negative values indicate an increase of Zn content.

	Zn-efficient genotypes			**Zn-inefficient genotypes**		
	IR 36	Amol	Shafagh	IR 26	Fajr	T. Hashemi
			Low Zn			
1st+2nd leaves						
ng plant part^{-1}	40	92	91	20	32	16
Change (%)	**20**	**65**	**68**	**11**	**20**	**14**
3rd+4th leaves						
ng plant part^{-1}	200	18	25	120	-21	-3
Change (%)	**32**	**33**	**26**	**21**	**-42**	**-7**
			Adequate Zn			
1st+2nd leaves						
ng plant part^{-1}	-130	66	52	-120	94	18
Change (%)	**-65**	**45**	**39**	**-63**	**59**	**14**
3rd+4th leaves						
ng plant part^{-1}	-450	-07	-3	-460	4	-14
Change (%)	**-236**	**-11**	**-3**	**-219**	**4**	**-16**

The experiment using the ^{65}Zn isotope also indicated a high rate of Zn re-translocation even from still not fully expanded leaves into the youngest leaf after emergence (Fig. 1).

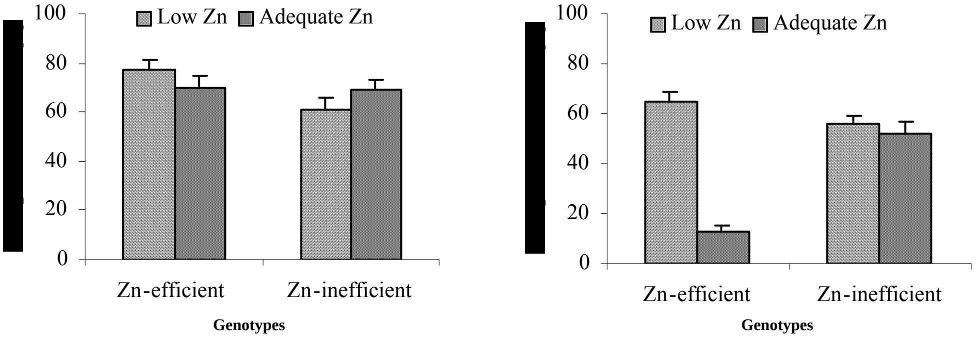

Fig. 1. Change in ^{65}Zn content of the 1st+2nd (left) and 3rd+4th (right) leaves of Zn-efficient (IR 36) and Zn-inefficient (IR26) rice genotypes during an early growth stage.

Our data indicates that the rice genotypes characterized as Zn-efficient under field conditions had a higher expression of Zn re-translocation than-Zn inefficient genotypes. It could be suggested that Zn re-translocation is another mechanism for adaptation to soils low in Zn via a higher internal Zn-use efficiency.

REFERENCES

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