Efficiency of adaptation mechanisms of rice to diverse conditions of iron toxicity

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Background

Iron toxicity differentially affects lowland rice as a function of the time of occurrence, the intensity and the duration of the Fe^{2+} stress. This stress is further modulated by the environment (i.e. soil and climatic conditions). Fe^{2+} taken up by roots follows the acropetal transport into the leaves via xylem flow which is linked to transpiration rate (→ air humidity).

The ability of rice cultivars to cope with Fe stress is hypothesized to further depend on growth stages and the efficiency of the geno-type-specific tolerance mechanisms. These may involve (a) Fe exclusion (oxidation in the rhizosphere), (b) apoplastic retention or immobilization (dumping in less active tissues) and (c) symplastic detoxification (radical scavenging enzymes).

We compared rice genotypes with contrasting Fe tolerance mechanisms under conditions of high and low air humidity regarding iron partitioning and speciation at different development stages.

Materials and Methods

Selected genotypes:

Oryza sativa indica: ITA 212, **TOX 3107, Pokkali**, TOX 4004, **CK 73, IR 31785**

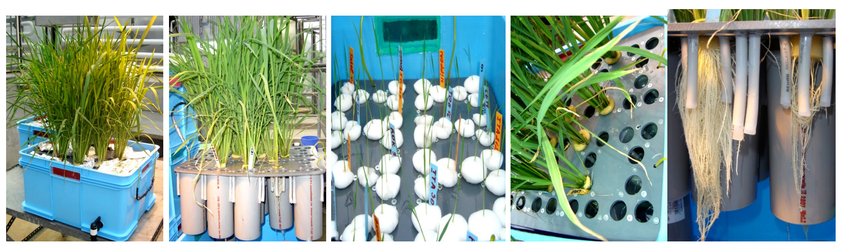
Oryza sativa japonica: **Nipponbare,** Azucena

NERICA: **WAS 161**, WAB 450

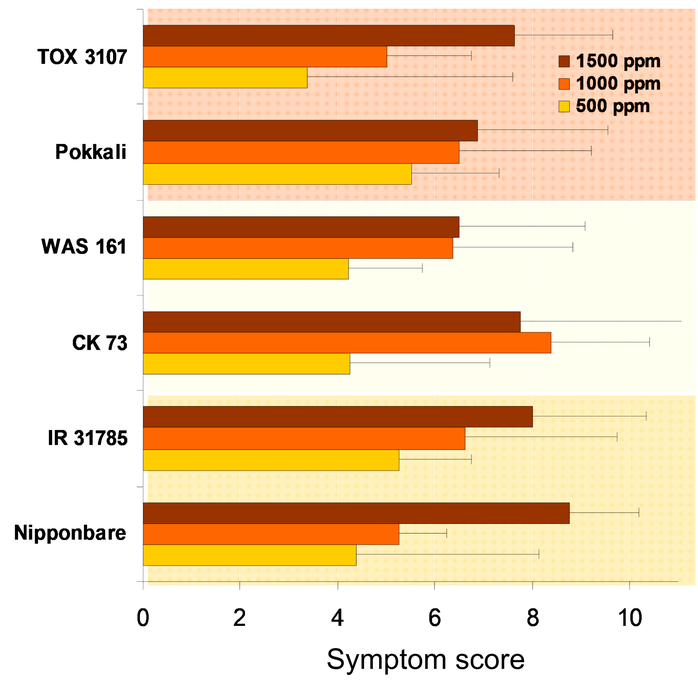
Oryza glaberrima *CG14, TOG 5681*

Growth stages and stress levels:

Seedling (4 wks), vegetative (6 wks), and late vegetative / early reproductive stages (8 wks);
$Fe_2SO_4 \cdot 7\ H_2O$ at 0, 500, 1000 and 1500 ppm Fe^2;
Leaf symptom scoring (2, 4, 6 days after Fe addition);
Fe^{3+} in root, stem, leaf (AAS) and root plaque (HCl);
Fe^{2+} in root, stem, leaf (Di-pyridyl method).



Symptom response at low humidity (40 %)



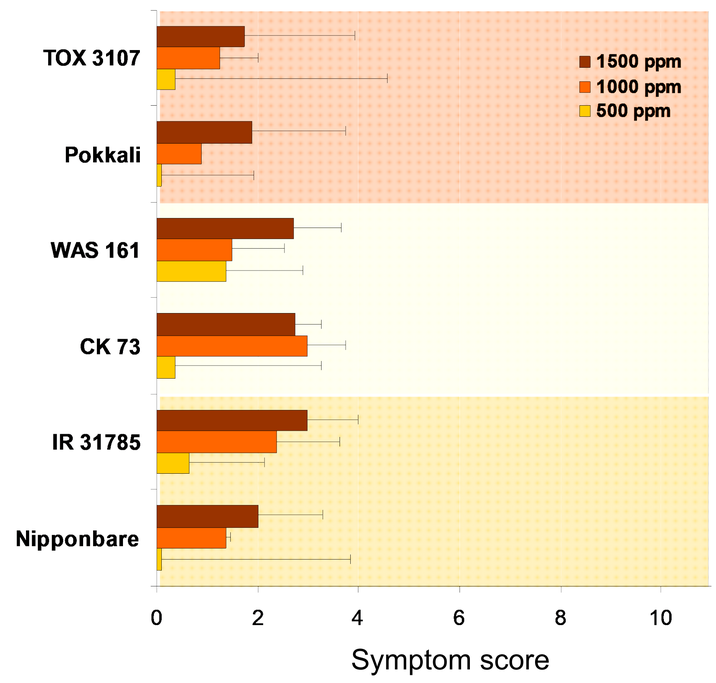
Increased transpiration enhances iron toxicity symptoms

Genotypes differ in Fe tolerance and tolerance meachnisms

Genotype tolerance ranking is affected by transpiration rate

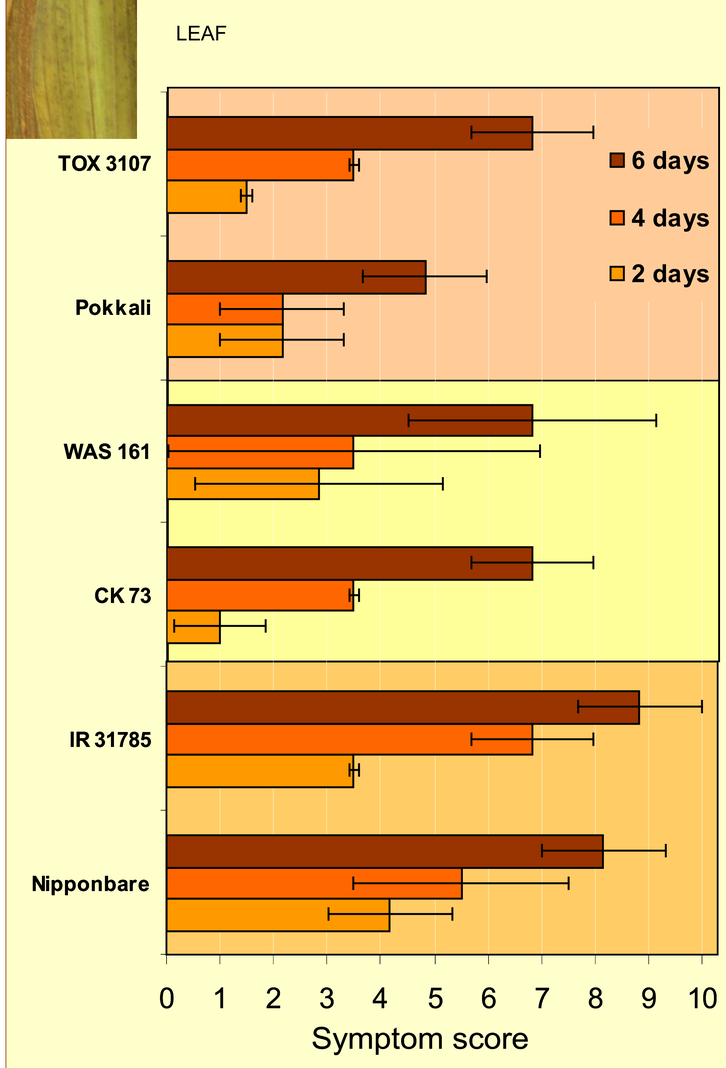
Combining symptom scoring with Fe speciation allows identification of tolerance mechanisms.

Symptom response at high humidity (80%)

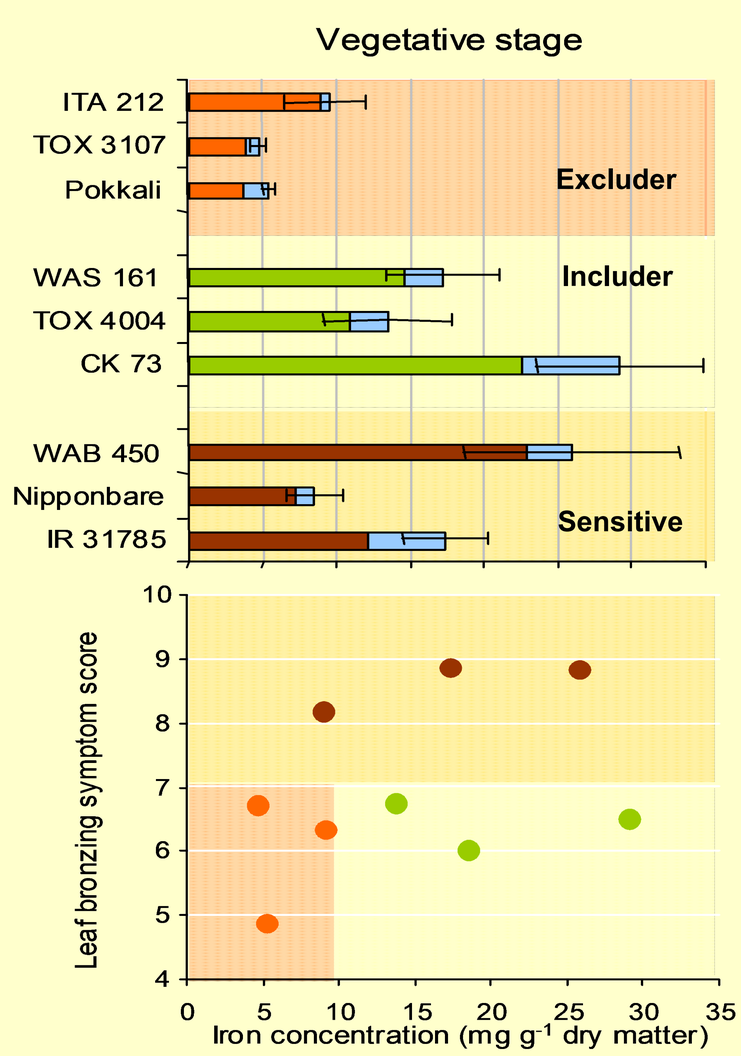


Classification of genotypes by leaf symptom score 6 days after application of 500, 1000 and 1500 ppm Fe(II) at the vegetative growth stage and relative air humidities of 40 and 80%.

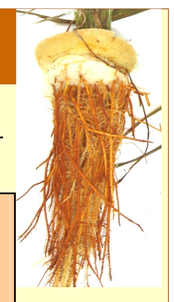
Symptom development

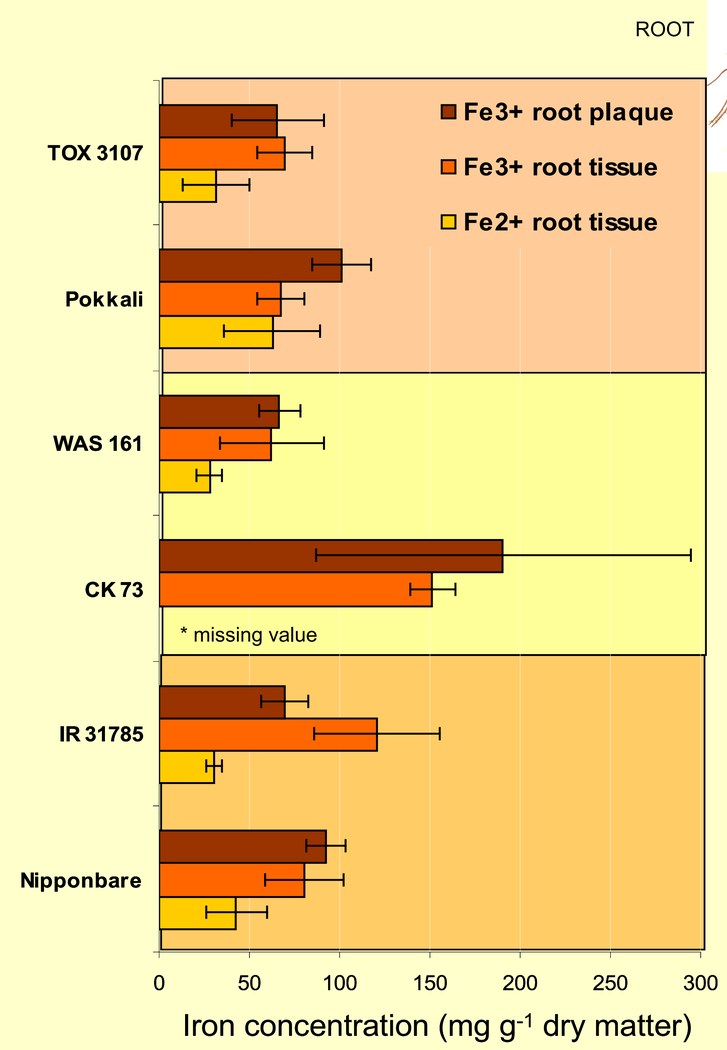


Iron speciation



Plaque and root iron





Classification of genotypes at the vegetative stage and Fe stress level of 1500 ppm by leaf symptom evaluation, iron speciation and partitioning into different plant tissues (Fe^{2+} / Fe^{3+} in leaves and roots).

Deutsche Forschungsgemeinschaft
BE-2491/3-1 DFG

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