Adaptation mechanisms in rice cultivars of different origin to iron toxic conditions

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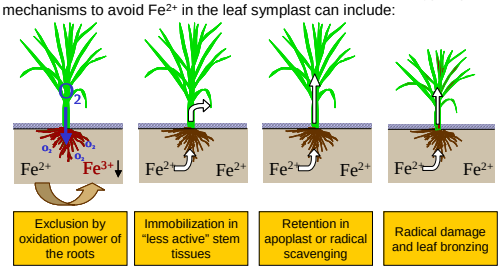
Rational

Iron toxicity is a nutritional disorder in lowland rice.
Soil conditions (Fe content, C_{org}, pH, Eh, CEC) and landscape factors (relief, rainfall, land use) determine the amount of Fe^{2+} in the field. Crop and climatic factors (VPD, transpiration) appoint mass flow of Fe^{2+} to the root. Consequently, the intensity and timing of the occurrence of excess Fe^{2+} is variable between sites and seasons and cultivars' tolerance mechanisms need to take into account this diversity. Genotype-specific mechanisms to avoid Fe^{2+} in the leaf symplast can include:



There is a need to: A) identify tolerant cultivars; B) classify tolerance mechanisms; and C) evaluate the effectiveness of mechanisms to Fe stress situations

Materials and Methods

Greenhouse:
30-35°C , 28-30 % air humidity
150-300 µmol s^{-1} m^{-2} light quantum

Germplasm:
Oryza sativa indica (15)
Oryza sativa japonica (2)
Oryza glaberrima (2)
Interspecific NERICA (2)

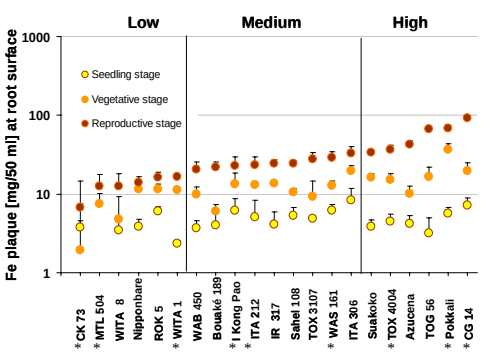
Culture solutions:
Yoshida nutrient solution
Iron application for 6 days (7.5 g L^{-1} Fe_2SO_4 7 H_2O
~ 1500 ppm Fe, changed every three days)

Growht stages with Fe stress:
Seedling stage (4 week old),
Early vegetative stage (6 weeks old),
Late vegetative / early reproductive stage (8 weeks old)

Parameters:
Visual symptom scoring (2, 4, and 6 days after Fe addition)
Fe determination (Fe –AAS in root, stem, leaf;
root plaque –HCl; Fe^{2+} –Di-pyridyl method in root, stem, leaf)

Varietal differences (mechanisms)

Oxidation power of the root system



- Fe^{2+} exclusion by O_2 release of the aerenchyma
- oxidation power increases with developmental stage

Fig. 1:
Iron plaque of the root surface [mg] washed in 50 ml HCl (n = 3) of rice cultivars at seedling, vegetative and reproductive stage.
Error bars indicate standard deviation.

Partitioning of Fe to plant organs

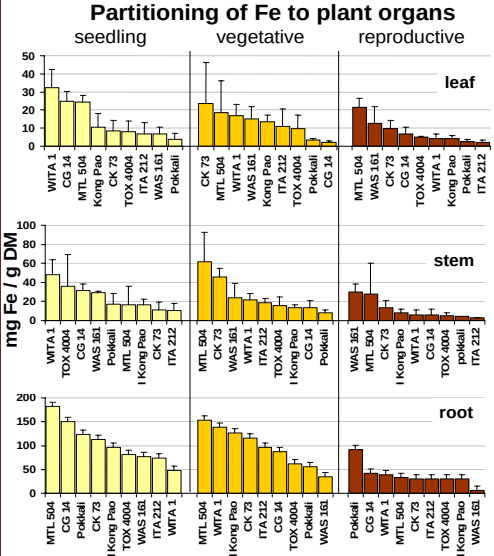


Fig. 2
Iron content [mg g^{-1}] in different plant organs (leaf, stem, root) of 9 selected rice cultivars (* figure 1) in different growth stages (seedling, vegetative, reproductive stage). Error bars indicate standard deviation.

Large diversity in Fe tolerance

- intensity of bronzing symptoms
- time of symptom expression
- differences between growth stages

Diverse tolerance mechanisms

- oxidation power
- tissue tolerance

Hydroponic system

- Providing flexibility
- Allows rice to reach maturity

Outlook / Ongoing Work

Objectivation of symptom scoring
→ ***Digital image recognition***

Iron translocation studies
→***Radio-isotopes***

Apoplastic Fe retention
→***Schollander bomb / DPD infiltration***

Radical-scavenging enzymes
→ ***Gel electrophoresis***

Flexible hydroponic set-up allowing for screening at seedling stage up to maturity.
Anaerobic conditions by bubbeling N_2 gas, removable tubing system, access to the roots, adjustable to different growth stages.

Varietal differences (symptoms)

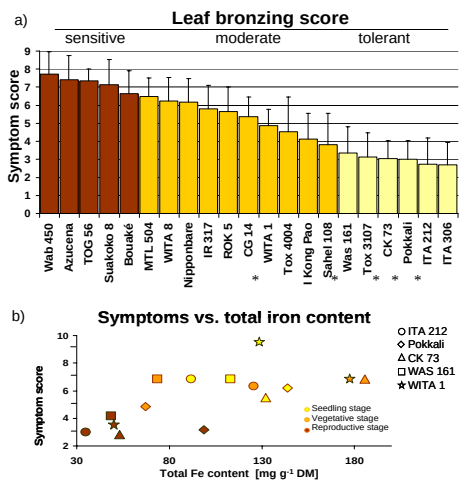


Fig. 3: a) Mean bronzing score of rice cultivars over 3 growth stages (n = 3 per stage) and 3 points in time. Error bars indicate standard error.
b) Symptoms dependence on total plant iron content [mg g^{-1}] of 5 selected cultivars (*figure a)).

Hydroponic set-up

25 l Yoshida nutrient solution for 60 seedlings with ∅ 40 mm tubes;

50 l Yoshida nutrient solution for 20 older plants with ∅ 90 mm tubes

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Katrin Engel [1], Mathias Becker [1], Folkard Asch [2]

[1] Department of Plant Nutrition, INRES, University of Bonn ; [2] Agricultural Ecology in the (Sub)Tropics of Hohenheim