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Management and Genotype Effects on Resistance to Iron Toxicity in Lowland Rice in Madagascar

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Abstract

Iron toxicity is one of the major abiotic stresses affecting irrigated rice production in tropical areas where submerged paddy field soils are often characterized by excess soluble Fe. In Madagascar, the yield losses recorded due to Fe toxicity are about 10 to 50 %. Although the use of tolerant varieties is generally the most prominent strategy to alleviate Fe toxicity, tolerance of the commonly disseminated and cultivated rice varieties remains non-elaborated. The aim of this study was to test the tolerance to Fe toxicity of a selection of local varieties and compare it to a selection of foreign varieties that had previously been ranked as tolerant or sensitive based on screening in hydroponics. Plants of 23 different genotypes were grown in a highly Fe toxic field site and in pots filled with Fe toxic soil (Fe total > 7%) placed in a greenhouse. Two different treatments involved (i) no fertiliser, and (ii) the recommended mineral and organic fertiliser dose, i.e. 10 t ha^{-1} farmyard manure, 300 kg ha^{-1} NPK, and 100 kg ha^{-1} urea. The performance of each variety was assessed by determination of leaf bronzing score (LBS), biomass yield, Fe shoot concentrations in different growth stages and lipid peroxidation (malondialdehyde concentration, MDA). Additionally, tolerance mechanisms to Fe toxicity were determined by total root weight, amount of Fe plaque on the root surface and dehydroascorbate reductase activity (DHAR). Fertiliser application significantly reduced Fe concentrations up to 84% in shoots, coincident with a significantly higher yield. Despite a better crop performance in the fertilised treatment, the LBS was not lower compared to that in the non-fertilised treatment. Shoot MDA concentrations showed genotypic differences, however, not significantly correlated with the yield loss. Genotypic differences could be also significantly determined in the amount of root plaque formation and dehydroascorbate reductase activity, enabling hypothesis for tolerance mechanisms. Additionally, Malagasy varieties generally tended to produce higher yields compared to foreign varieties irrespective of Fe toxicity tolerance ranking. These results clearly indicate that adaptation to local conditions needs to be considered when breeding for tolerance to Fe toxicity. Fertiliser application can greatly improve the yield performance in Fe toxic fields.

Keywords: Fertilisation, iron toxicity, rice, variety screening

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