Evaluation of Rice Genotypes for Zinc Efficiency under Acidic Flooded Condition

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Abstract
Zinc deficiency in the rice plant has been identified as the major cause of low yield. Flooding and submergence bring about a decline in available zinc due to pH changes and the formation of insoluble zinc compounds. A field experiment was conducted to evaluate the rice genotypes for zinc use efficiency. Six rice (*Oryza sativa* L) genotypes were tested at two (0 and 15 Kg/ha) levels of zinc. Genotypes differed significantly in grain yield and its components. Based on the grain yield efficiency index, genotypes were classified as efficient, medium efficient and most inefficient. The most zinc efficient genotype was: MR 106 and medium efficient were Seri Malaysia Dua, MR 220 and MR 219. The most inefficient genotypes were MR211 and Bahagia. Grain yield efficiency is the best tool to categorize the genotypes into efficient and inefficient groups.

Key Words
Rice genotypes, zinc efficiency, acidic flooded condition.

Introduction
Zinc deficiency is a widespread micronutrient deficiency and is one of the major constraints in world food production. It is therefore, essential to identify the zinc-deficient areas, and the different causes of deficiency. The submerged soils are well recognized for less zinc availability to the plants due reaction of zinc with free sulphide (Mikkelsen and Shiou 1977). Flooding and submergence bring about a decline in available zinc due to pH changes and the formation of insoluble zinc compounds. The soil pH rises with the onset of reducing (gleying) conditions and zinc solubility declines 100 times for each unit increase in pH (Lindsay 1972). The insoluble zinc compounds formed are likely to be with Mn and Fe hydroxides from the breakdown of oxides and adsorption on carbonate especially magnesium carbonate. Under the submerged conditions of rice cultivation, zinc (either native or applied) is changed into amorphous sesquioxide precipitates or franklinite; $ZnFe_2O_4$ (Sajwan and Lindsay 1988). Kedah and Kalantan states are the main paddy growing areas of Malaysia. The soils of Kalantan are low in zinc (Hafeez *et al.* 2009) and soil of Kedah is low in boron (Saleem *et al* .2009). Due to inadequate information available on the subject, cultivation of crops highly susceptible to zinc deficiency may aggravate the situation by adversely affecting the yield as well as human health. Research efforts are therefore, required to screen the rice genotypes on a zinc efficient and zinc inefficient basis, and develop the methods for improving zinc efficiency in rice (Lindsay *et al.*2000). Furthermore, no information is available on the zinc efficiency of Malaysian rice genotypes. Therefore this work was undertaken to screen the rice genotypes for zinc efficiency.

Materials and Methods
The genotypes included in this study were; Seri Malaysia Dua, MR 106, MR 219 and MR 220,MR 211 and Bahagia. The experiment was designed as randomized complete block with three replications. The field experiment was conducted on the Lankong (Typic Pelludert) soil series to compare the performance of six genotypes selected under the two levels of zinc (0 (Zn_0) and 5 (Zn_{15}) kg/ha). It had the following chemical and textural properties: EC 1353 µS/cm, pH 4.89(1:2.5 soil water ratio), Extractable P 2.20 mg/kg (Bray and Kurtz #2 extractants (Bray Kurtz, 1945), Organic carbon 20 g/kg of soil (Carbon analyzer), Cu 1.22 mg/kg, Fe 122 mg kg^{-1}, Mn 6 mg/kg and Zn 0.21 mg/kg (double acid method by using Atomic Absorption Lindsay and Cox (1985) the soil was silty clay in texture (Gee and Bauder 1986). The area of each plot was 12 m^2. All the plots received N at 140 kg/ha and P at 90 kg $P_2O_{5/ha}$. The grain yield efficiency index was calculated by formula (Graham 1984).
The accuracy of zinc analyses of the plant tissue was checked by comparing with certified zinc standard samples obtained from National Institute of Standards and Technology Standards Reference Materials, Gaithersburg, USA.

Results

The results indicate that there is significant effect of zinc levels on yield parameters of tropical rice genotypes. While genotypes has also significant effect on all the parameters except plant height, number of tillers and shoot dry weight. The zinc x genotype interaction was non-significant for all parameters studied (Table 1).

Table 1. The significance of F values derived from analysis of variance on the effect of zinc, genotypes and zinc x genotype interaction on plant characteristics and yield parameters.

Variables	Zinc levels	Genotypes	Zinc x G	CV (%)
Plant height	NS	NS	NS	11.69
Number of tillers	S	S	NS	8.5
Number of grains/panicle	S	S	NS	23.26
Panicle numbers per 10 plants	S	S	NS	12.17
Grain yield	S	S	NS	11.06
Shoot dry weight	S	S	S	14.23
1000 grain weight	S	S	NS	9.26

The number of grains per panicle is an important yield component of rice; it contributes towards the yield capacity of a crop. The zinc level had significant effect on the number of grains per panicle (Table 2), the maximum (116.55) number of grains per panicle was found in MR 106 genotype and minimum (70.78) was in Seri Malaysia Dua genotype. Panicle numbers per ten plants ranged from 10.10 to 16.06 among the six genotypes. Genotype MR 106 had highest (16.06) panicle number as compared with the other genotypes. Similarly, genotype Seri Malaysia Dua had the lowest (10.10) panicle number per ten plants as compared with other rice genotypes. The increase in grains per panicle with the application of zinc was attributed to adequate supply of zinc that might have increase the availability and uptake of other essential nutrients resulting in improvement in metabolic activities (Sharma *et al* .1990). Pandey *et al.* (2001) reported that the floral development of zinc deficient plants is also severely affected due to low enzymatic activity.

The results on the grain yield of six rice genotypes as influenced by the application of zinc are presented in Table 2. The grain yield was significantly affected by zinc application. Grain yield variation was significant among genotypes and varied from 2.15 to 7.05 tons ha $^{-1}$. Maximum grain yield (7.05 tons ha $^{-1}$) was produced by Bahagia rice genotype which is a 47% increase as compared to the control. MR 211 genotype produced the significantly lowest (2.15 ton ha $^{-1}$) grain yield as compared with the other six rice genotypes. The results indicate that zinc application increased the yield of all six genotypes as compare with no application which might be due to the effect of zinc on the proliferation of roots so the uptake rate from soil was increased and supplying it the aerial parts of the plant. Rehman *et al.* (2001) reported similar results. Pandey *et al.* (1995, 2001, and 2005) were also of the view that poor grains could be produced in zinc deficient plants.

Table 2. Yield and yield components of 6 tropical rice genotypes affected by two levels of zinc.

Genotypes	Number grains/panicle	Grain yield (ton/ha)	Shoot dry weight kg/1m^2	Grain yield efficiency index 0.74-0.81 range
Seri Malaysia Dua	86ab	5.52b	1.71a	0.90b
MR 106	116.55a	6.94a	1.44ab	1.50a
MR 219	93.65ab	6.83a	1.51ab	1.39a
MR220	99.20ab	5.86b	1.24b	1.91ab
MR 211	73.72b	4.15c	1.25b	0.69c
Bahagia	119.62a	7.05a	1.66a	0.45c

Statistical analysis showed that the effect of zinc on various rice genotypes on shoot dry weight was significant at the 5% level of probability. Shoot dry weight varied from 1.24 to 1.71Kg m^2. On average for all genotypes shoot dry weight was 1.46 kg/m^2. The highest dry matter yield 1.71 kg/m^2 was observed for Seri Malaysia Dua and lowest 1.24 Kg 1 m^2 was for MR 220 rice genotype. Dry matter significantly increased with the application of zinc fertilizer and might be due to the development of longer and thin plants (Graham and Rengel 1993) or may due to plant absorbing more zinc and translocating it to shoots for dry matter production. Similar results were observed by Yaseen *et al.* (2000).

Grain yield efficiency is the best tool to categorize the genotypes into efficient and inefficient groups. Genotype having a grain efficiency more than 0.81 are considered as most efficient and those lower than 0.71 are considered as most inefficient genotypes, whereas, the genotypes in between these two limits are considered medium in zinc-use efficiency. According to this criterion, the most zinc efficient genotype was: MR 106 and medium efficient were Seri Malaysia Dua, MR 220 and MR 219. The most inefficient genotypes were MR211 and Bahagia.

Acknowledgment
The authors are very grateful to Dr. Ariffin Tawang Director,Rice and Industrial Crops Research Centre MARDI, 43400 Serdang and Dr. Othman Omar, Rice breeder at Penang Research station for providing the rice genotypes in due time.

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