ABSTRACT

Assessment of environmental contamination on plants at population and molecular levels is important in risk quantification and remediation studies. This research compared the effects occurring at morphological, physiological and molecular level in rice plants at 10 mg/kg cadmium (Cd) and it assessed the effect of cattle manure and paddy straw on Cd accumulation of rice with sand culture.

The study was conducted in four separate pot experiments in the planthouse of the Faculty of Agriculture, Rajarata University of Sri Lanka. Twenty one different rice varieties were used in different combinations for the whole study at a Cd level of 10 mg/kg. Seventeen agro-morphological characters (i.e. vegetative: leaf length, leaf width, leaf blade pubescent, leaf blade color, basal leaf sheath color, penultimate leaf angle, ligule length, ligule color, culm length, culm number, culm angle, internodal color, ligule shape, auricle color; reproductive: flag leaf angle, panicle length and panicle exertion) and shoot and root dry weights were used for the diversity studies. Physiological parameters such as electrolyte leakage (EL), photosynthesis rate, stomatal conductance to H_2O, intercellular CO_2 concentration, transpiration rate, computed leaf temperature and maximum fluorescence emission were used in detecting Cd stress on rice plant physiology. Genomic template stability and band sharing index (BSI) were used in the detection of genotoxic effects of Cd. Plant height, leaf chlorophyll content, leaf area and ratio of dead leaves to total number of leaves per pot, grain, shoot and root Cd with above mentioned plant physiological parameters were implemented in assessing Cd stress alleviation by the addition of cattle manure and paddy straw at 0, 1 and 2 g/kg levels. Diversity of rice varieties was assessed

with principle component (PC) analysis, single linkage cluster analysis, and Multivariate analysis of variance (MANOVA). Other parameters were assessed with Analysis of variance.

Based on vegetative and reproductive characters, the selected rice varieties were classified in to significantly different four clusters. High variability was observed among the traditional varieties for their vegetative and reproductive parameters.

Cattle manure significantly improved plant growth and physiology of rice varieties in terms of plant height, leaf area, leaf chlorophyll content, photosynthetic rate, stomatal conductance to H_2O, EL and dead leaves to total number of leaves ($p \leq 0.05$). Both levels (1 and 2 g/kg) of organic matter (OM) used in the study significantly reduced the total amount of Cd in rice grains compared to no OM. A significant positive correlation between grain Cd and shoot Cd was resulted. The resulted variation was, grain Cd = 0.176 (Shoot Cd) + 0.445.

PC analysis of rice varieties to 0 and 10 mg/kg Cd treatments explained 75.5 and 87.2% of variation in the rice populations respectively. The grouping behavior of the rice varieties were different with 10 mg/kg Cd treatment compared to the control. *Suwandel* and cultivar 93-11 showed the closest morphological and physiological responses to 10 mg/kg Cd stress, and Bg 300 showed the most distinct responses.

The Random Amplified Polymorphic DNA (RAPD) assay produced a total of 49 reproducible polymorphic bands to 10 mg/kg Cd treatment. For every primer, all rice varieties had an altered RAPD profiles for 10 mg/kg Cd. Bg 350 had the highest percentage of average polymorphism to

Cd, while, Bg 352 had the least. Thus, Bg 352 was the genetically stable variety among the tested ones. Analysis of BSI revealed that Bg 352 and Bg 359 as the higher Cd tolerant varieties among others.

Application of cattle manure ≥ 1 g/kg alleviated the Cd stress thereby enhanced the growth and physiology of rice. Application of cattle manure or paddy straw ≥ 1g/kg significantly reduced the Cd accumulation in rice grains. Based on morphological and physiological parameters tested *Suwandel* and cultivar 93-11were the closely related rice varieties to 10 mg/kg Cd stress. Bg 352 was the highest Cd tolerant rice variety and Bg 350 was the least Cd tolerant rice variety. Different grouping behaviors and genotoxicity responses of rice varieties to 10 mg/kg Cd treatment indicated the varietal dependent responses of rice to 10 mg/kg Cd.

Keywords: Improved and traditional rice varieties, Cd, morphological diversity, physiological diversity, genotoxicity, multivariate analysis, cattle manure, paddy straw