Rice defense mechanisms against the presence of excess amount of Al3+ and Fe2+ in the water

ABSTRACT

Rice grown on an acid sulfate soil is subjected to Al3+ and Fe2+ toxicity. The stress encountered by the rice plant is usually alleviated by applying ground magnesium limestone (GML). A study was conducted to explain how rice planted on acid sulfate soils can overcome the stress caused by Al3+ and Fe2+ toxicity. The rice variety tested in this study was MR 219. Seed (under H+ and/or Al3+ stress) germination experiments were conducted in the laboratory in which root length, root surface area and organic acids excretion were determined. This study was followed by a liming trial in the field. The results from the laboratory experiments showed that high Al concentration in the water severely affected root length of rice seedlings and caused the release of organic acids by rice roots. Field trial results showed that when GML was applied under flooded condition at the rate of 4 t ha-1, water pH increased from 3 to 4.5. The pKa of Al was 5 and Al concentration was still high in the water, which was most probably existed in the form of Al3+. Although under stress, the rice was able to grow and consequently produced a reasonable yield. This was probably due to excretion of citric, oxalic and malic acids when Al3+ was on the surface of the roots, which subsequently chelated the Al3+, thus enabling the rice to defend itself against Al3+ toxicity. Rice defends itself against Fe2+ via another mechanism. The pKa of Fe is 3. Due to liming at 4 t GML ha -1, the pH of the water increased to pH above 3. The Fe was precipitated as brown crust, coating the surface of the rice roots, and subsequently prevented or reduced the uptake of Fe2+, thus the overall effect of Fe2+ toxicity on rice plant was less severe. To grow rice on acid sulfate soils, it is recommended that GML should be applied at the rate so that water pH is increased to above 5 to get rid of Al3+ and Fe2+ although it might be costly.

Keyword: Acid sulfate soil; Aluminum toxicity; Ground magnesium limestone; Iron toxicity; Rice