Zinc deficiency and toxicity-induced alterations of chloroplast pigments in acid lime [*Citrus aurantiifolia* (Christm.) Swingle]

Payel Das, Pradipto Kumar Mukherjee and Prahlad Deb

Department of Horticulture and Postharvest Technology
Institute of Agriculture, Visva-Bharati, Sriniktean – 731236, West Bengal
Email: debprld@yahoo.com

Receipt: 19.04.25 Revised: 10.05.25 Acceptance:12.05.25
DOI: 10.53552/ijmfmap.11.1.2025.235-245

ABSTRACT

Zinc is an essential micronutrient involved in various physiological processes in plants, particularly in chloroplast development and pigment biosynthesis. Although application of zinc have been widely studied in citrus crops, limited information exists on the chloroplast pigment response of acid lime to graded zinc levels applied through substrate under controlled greenhouse conditions. This study aimed to fill that gap by evaluating how zinc deficiency and toxicity affect chlorophyll a, chlorophyll b, total chlorophyll, chlorophyll a/b ratio, and carotenoid contents over a two-year period.A pot experiment was conducted using acid lime seedlings grown in acid-washed river sand under greenhouse conditions. Seven zinc concentrations (0.0 to 15.0 mM/l$ZnSO_4$) were applied at regular intervals, and pigment contents were quantified at six growth stages using spectrophotometry. The results demonstrated a biphasic zinc response, where moderate zinc application (particularly at 7.5 mM/l) significantly enhanced chlorophyll a, b, total chlorophyll, and maintained a balanced chlorophyll a/b ratio, indicative of optimal chloroplast function. Both zinc deficiency (0.0 mM/l) and toxicity (≥12.5 mM/l) led to pigment degradation, reduced photosynthetic efficiency, and signs of physiological stress. Carotenoid accumulation was elevated under Zinc-deficient and Zinc-toxic treatments, suggesting a photoprotective response against oxidative damage.In conclusion, the study identifies 7.5 mM/l zinc as the optimal concentration for maximizing chloroplast pigment stability and minimizing stress-induced degradation in acid lime.

Keywords:carotenoids, chloroplast pigments, *Citrus aurantiifolia*, deficiency, nutrient stress, toxicity, zinc,