Effects of treated wastewater irrigation on phenotypic plasticity of root characteristics of citrus in two contrasting soils

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Fresh water shortage is becoming a global issue limiting the development of agriculture. Consequently, the use of treated wastewater (TWW) for irrigation is becoming a popular agronomic practice. Because roots are in direct contact with the soil solution, they are the first to encounter water quality components and are potentially the first site of damage or line of defense. This study was conducted to determine the effects of TWW on root characteristics in the sapling and matures trees of grapefruit (*Citrus paradisae* l) on Volkameriana rootstock. Commercial field and lysimeter experiments were conducted with three different water qualities as a treatment. The field experiments were in clay soil, while both sandy loam and clay soil were used for lysimeter experiments. TWW irrigation reduced root growth (observed with a Minirizotron) up to 45 to 55% in clay of both experiments but not in sandy loam soil (<20%). Roots developed after TWW irrigation were sampled to quantify root order based phenotypic plasticity on morphology, anatomy, respiration, hydraulic conductivity, and mineral composition. Significant influences were observed after irrigation with TWW in clay. Additional salt treatments further increased respiration and decreased hydraulic conductivity of roots even in sandy loam soil. Increased in root diameter, decreased in root surface area, higher tissue density made 30-35% decreased in fine root system only after TWW irrigation in clay soil. Significant increase in as cortex area to root area was found in clay, while stale area and xylem vessel were plastic in sandy soil. Furthermore, significant increase in root segment respiration was found only in root orders of clay, and differences were not significant between soils. On the other hand, root hydraulic conductivity was severely reduced and TWW leads to further decreases in hydraulic conductivity in clay soils. Thus, moderate changes in morphology, fine changes in anatomy and physiology, and severe loss of hydraulic capacity were the possible region for lesser root growths in TWW irrigated clay compared to sandy loam soils.