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Plant water uptake and water use efficiency of greenhouse tomato cultivars irrigated with saline water

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Abstract

Effects of salinity on tomato (*Lycopersicon esculentum* Mill.) fruit yield, plant water uptake and water use efficiency (WUE) have been quantified in experiments carried out under greenhouse and soil-less cultivation with four cultivars (Floradade, L1, L5 and L9) and four salinity levels (0, 25, 50, and 75 mM NaCl). Fruit represented 70% of plant fresh weight while leaves and stems represented 22 and 8%, respectively. Fruit were the most sensitive part of the plant, with the four cultivars showing similar significant fruit yield reduction, namely about 28 g/mM NaCl or 290 g/dS m^{-1}. Yield threshold varied from 0 to 3.4 dS m^{-1}, values lower than or close to the electrical conductivity (EC) of nutrient solutions used in commercial greenhouses. Yield reduction from threshold to upper salinities was about 8% of maximum yield per dS m^{-1} increase. Blossom end rot increased with salinity although the pattern of increase depended on the cultivar. Tomato fruit grown under saline conditions had higher soluble solids and acid content than those from the control (0 mM) plants. Plants grown under the most saline conditions consumed, on average, 40% less water than control plants. The relationship between total plant water uptake and salinity was linear (negligible threshold) and salinity of the nutrient solution almost entirely explained the variations in plant water uptake (R^2 from 0.94 to 1); therefore, salinity of the irrigation water has to be taken into account when calculating tomato water requirements. However, significant differences in the negative slopes of the correlation lines indicate that decreases in plant water uptake, from 3.5 to 5% per dS m^{-1}, are cultivar-specific and cannot be generalised. Vegetative (stem and leaves) dry weight was a better indicator of tomato plant water uptake in saline conditions irrespective of cultivars than fruit yield or plant and fruit dry weight. Tomato plants in the control averaged a higher WUE than the most

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salinized plants when WUE was expressed as a function of fruit yield (25 and 13 g fruit L^{-1}); however WUE was independent of salinity if expressed as a function of plant and fruit dry matter (approximately 3.0 g dry matter L^{-1}). Tomato plants absorbed only a small proportion of the Na^+ present in the nutrient solution (from 2.3 to 3.2%) but there were significant differences among the four cultivars which suggest that plant ability to select ions is a trait to be taken into account when selecting tomato genotypes for salt tolerance.

Keywords: *Lycopersicon esculentum*; Yield; Fruit and plant dry weight; Fruit quality; Blossom end rot; Na^+ uptake

1. Introduction

The tomato crop is adapted to a wide variety of climates ranging from the tropics to within a few degrees of the Arctic Circle. However, in spite of its broad adaptation, horticultural production is concentrated in a few warm and rather dry areas: about 34% of world production comes from countries around the Mediterranean sea and about 14% from California and Mexico (FAO, 2002). These areas are also those where the highest yields are reached but also where salinity is a serious restraint not only for planting new lands to this crop but also for maintaining in high productivity those currently under irrigation (Ghassemi et al., 1995).

The increasing demand for domestic, industrial, environmental and recreational water will force agriculturists to manage irrigation water carefully, contributing to environmental preservation. In parallel, brackish and saline water resources not used nowadays could be employed for irrigation if greater knowledge of salt tolerance and proper technology are developed (Shannon and Grieve, 1999). In applying saline/brackish water for irrigation, an integrated approach, which should account for soil, crop and water management at the same time, should be adopted. This approach needs calculation of crop water requirements which are essential for water saving, controlling water table level and drainage volume, and of course the final yield (Ragab, 2002). Tomato could act as a model crop for brackish/saline water use because it is already grown in large areas with saline conditions, and because there is a wealth of important knowledge of the physiology and genetics of this species.

It is known that tomato plants irrigated with a saline solution transpire less water than when fresh water is used (Soria and Cuartero, 1997; Romero-Aranda et al., 2000), but it is necessary to quantify the decrease in plant water uptake in relation to salinity and investigate possible differences in water uptake between cultivars, as a part of the integrated approach described by Ragab (2002) to use saline irrigation water. In this paper, we report on our investigations of those aspects on four tomato cultivars and the relations between plant water uptake and yield and biomass. Water use efficiency (WUE) in agronomical and biological terms (gram fruit and gram dry matter per litre transpired water, respectively) have been also determined as higher efficiency in plant dry matter and fruit formation will lead to relatively less uptake of toxic ions (Na^+) (Cuartero and Fernandez-Muñoz, 1999). Finally, we have determined Na^+ concentrations in leaves, stem