Effects of plant density and the number of emitters by styrofoam box on plant growth and nitrate concentration in spinach cultivated in substrate

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Abstract

The effects of plant density and the number of emitters per styrofoam box on plant growth and nitrate (NO_3^-) concentration were evaluated in spinach (*Spinacia oleracea* L. 'Tapir'). Spinach seedlings were transplanted at 45 days after emergence into styrofoam boxes filled with the substrate and were grown during winter in an unheated greenhouse with no supplemental lighting. The experiment was carried out with four treatments, including two plant densities (160 and 280 plants m^{-2}) and two numbers of emitters per styrofoam box (4 and 8 emitters). Each planting box was irrigated daily and fertigated with a complete nutrient solution. Shoot dry weight was not affected by plant density. However, yield increased with plant density and emitter number. Leaf-blade NO_3^- concentration was not affected by the interaction between plant density and number of emitters, but petioles NO_3^- concentration was greater in treatment with 160 plants m^{-2} and 8 emitters. Although leaf-blade NO_3^- concentration was not affected by plant density, it decreased with the number of emitters. On the other hand, petiole NO_3^- concentration was not affected by plant density or number of emitters. Leaf-blade NO_3^- concentration ranged from 2.23 to 4.1 mg g^{-1} fresh weight, occurring the highest value in the treatment with 280 plants m^{-2} and 4 emitters. Petiole NO_3^- concentration ranged from 3.5 to 5.3 mg g^{-1} fresh weight, values that were higher than allowed by EU regulation.

Keywords: *Spinacia oleracea*, soilless culture systems, nitrate, soil block, electrical conductivity

INTRODUCTION

Greenhouse spinach production in substrate, during the autumn and winter, is increasing worldwide. However, during this period, in greenhouse, the nitrate accumulation in spinach tissues tends to be higher than allowed by Regulation (EU) n°1258/2011 of the European Commission for fresh spinach (3.5 mg g^{-1} fresh weight) and the substrate type does not appear to be a means of preventing high shoot NO_3 concentrations in spinach (Barcelos et al., 2016). This is likely related to the environmental conditions in the greenhouse and the cultural techniques used. Light is one of the primary factors that affects plant growth and yield (Charles-Edwards, 1982) and the nitrate accumulation in spinach tissues (Cárdenas-Navarro et al., 1999; Santamaria, 2006; Anjana and Iqbal, 2007; Zhou et al., 2007; Marschner, 2012). Plant spacing affects the photosynthetic photon flux density (PPFD) interception, modifying the plant or stem density is a possible means to maximize light interception (Charles-Edwards, 1982; Papadopoulos and Pararajasingham, 1997).

The number of water emission points over the substrate influences the volume of the wetted substrate, the salt distribution and the leaching fraction (Ondrasek et al., 2008; Valdés et al., 2014, 2015), which may influence plant growth and nitrate accumulation in spinach tissues.

The objective of this study was to evaluate the effect of plant density and the number of

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