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SCIENCE DIRECT
Agricultural water management
ELSEVIER
Agricultural Water Management 82 (2006) 99–117
www.elsevier.com/locate/agwat

Comparison of the subirrigation and drip-irrigation systems for greenhouse zucchini squash production using saline and non-saline nutrient solutions

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Accepted 19 July 2005
Available online 15 August 2005

Abstract

Soilless cultivation is a method that permits the achievement of high yields, good control of plant growth and development, and is currently in practice all over the world. Several irrigation systems have been developed for containerized-crops (drip-irrigation and subirrigation). Irrigation system can significantly impact the effect of irrigation water salinity on crop performance. Comparing the subirrigation and drip-irrigation systems using saline and non-saline nutrient solutions can be useful for developing optimal management strategies in semiarid regions which are characterized by the shortage of good quality water. A greenhouse experiment was carried out during the spring-summer season to determine the influence two irrigation systems (drip and subirrigation) and two nutrient solution concentrations (2.0 and 4.1 dS m^{-1}) on substrate electrical conductivity (EC_e), growth, yield, fruit quality (dry matter, carbohydrates, protein, Vitamin C), yield water use efficiency (WUE_y) and tissue mineral composition of zucchini squash (*Cucurbita pepo* L.). At the mid and at the end of the trial, plants grown with the subirrigation system resulted in a higher EC_e in the upper and lower parts of the substrate in comparison to the drip-irrigation system, especially at an EC of 4.1 dS m^{-1}. At an EC of 2.0 dS m^{-1}, zucchini yield (total and marketable) was 13% lower with the subirrigation than with the drip-irrigation systems but offered several benefits: higher fruit quality (dry matter, glucose, fructose, starch and total carbohydrates content) and WUE_y. The yield reduction with

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0378-3774/$ – see front matter
doi:10.1016/j.agwat.2005.07.018

subirrigation was more pronounced at an EC 4.1 dS m^{-1}, where the zucchini production with subirrigation was lower by 36% than with drip-irrigation. Increasing salinity from 2.0 to 4.1 dS m^{-1} improved fruit quality (high content of dry matter, reduced sugars, starch, total carbohydrates, and Vitamin C) in both irrigation systems. The results indicate that the choice of the irrigation system appears to be of foremost importance especially when using low quality irrigation water. Unlike subirrigation, using drip-irrigation with saline solution (4.1 dS m^{-1}) would be an attractive strategy in limiting yield reduction, taking advantage of the quality effect of saline water and improving the WUE_y.

Keywords: *Cucurbita pepo* L.; Irrigation systems; Water use efficiency; Fruit quality; Nutrient solution concentrations; Soilless

1. Introduction

Over the last 20 years, soilless growing systems have become increasingly popular among commercial growers since they improve production, quality, and provide disease-free start to cultivation (Van Os et al., 2002). However, soilless culture requires frequent irrigation and high fertilization rates, and when used with free drainage (open system) it can result in loss of water and nutrients leading to negative financial consequences and contamination of ground and surface water resources (Van Os, 1999). To solve this problem, growers had to adopt re-circulation of the nutrient solution (Reed, 1996).

Various types of closed soilless systems have been developed for containerized crops. The most widely used are the surface system (drip-irrigation) and the subirrigation system (Ebb-and-flow benches, capillary mats, trough benches and flooded floors) (Reed, 1996). The drip-irrigation system is the most popular system used in soilless culture (Schröder and Lieth, 2002). However, in the last years, subirrigation systems have gained popularity in pot and bedding crop production (Treder et al., 1999) since they offer additional advantages compared to drip-irrigation systems including the following: reduced labour costs; increased production area if combined with movable benches (Hanan, 1998), and reduced the diffusion of pathogens in closed soilless systems (Wohanka, 2000). Besides, subirrigation can simplify the closed loop management of the nutrient solution, because unlike the drip-irrigation system, the element that is not absorbed by the plant does not accumulate in the nutrient solution but in the substrate, especially in the upper part where roots are less present (Reed, 1996; Santamaria et al., 2003). Subirrigation systems have been studied and essentially proposed until now for ornamental crop production (Dole et al., 1994; Todd and Reed, 1998) while there is a lack of information about the validity of this system for growing fruits and vegetables, such as zucchini squash characterized by a high growth rate, and a high rate of removal of water and nutrients. However, lack of leaching and consequently the tendency for the salt to build up in the substrate represent a drawback for the subirrigation, since it may result in appreciable growth and yield reductions (Molitor, 1990; Kent and Reed, 1996) especially with long cultural cycles and during warm growing seasons (spring and summer seasons) characteristic of the Mediterranean region. Moreover, this negative effect (substrate salt accumulation) will intensify when growers are forced to use saline water (Lieth and Burger, 1989).