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RESPONSE OF A SWEET PEPPER CROP GROWN IN NEW AND TWO-YEAR-OLD REUSED ROCKWOOL SLABS IN GREENHOUSE ON THE MEDITERRANEAN COAST OF SOUTH-EAST SPAIN

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Response of a sweet pepper crop grown in new and two-year-old reused rockwool slabs in greenhouse on the Mediterranean coast of South-east Spain

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Abstract

The response of a sweet pepper crop grown in new (LN) and two-year-old reused (LV) rockwool slabs was evaluated. The physical properties of the slabs were determined before starting the experiment. Total porosity was 97% on both substrates, however the air fill porosity in LV (47.2%) was higher than in LN (37.5%), whereas the easily available water was higher in LN (59%) than LV (46.6%). No significant differences between substrate types were found for the volumetric water content (CVA) and electric conductivity (EC) in this experiment: 41% and 3.5 dS m^{-1} for LN, and 48% and 3.2 dS m^{-1} for LV, respectively. However, differences between substrate types were found in the humidity distribution inside the slab. The variation coefficients were 10,3% for LN and 27.5% for LV respectively. Growth, total and marketable yield did not differ significantly with substrate age. Continuous measurements of leaf area index, plant length, production and yield components were made. The final marketable production was 8.5 and 8.8 k m^{-2} for LN and LV, respectively and the majority of the sweet pepper fruits were suitable for commercialization (>95%) for both treatments. The yield and the number of first category fruits were significantly higher in LV.

INTRODUCTION

Soilless culture, particularly substrate culture, is increasingly used in mild winter areas dedicated to greenhouse vegetable production, such as the Mediterranean coast of South-east Spain (Gomez, 2003). In this area, approximately 15% of current greenhouse cultivation is carried out using substrates as growth medium, mostly in open systems. In Almería, this percentage is about 20%, almost 5000 ha (Pérez-Parra and Céspedes, 2001) and the main substrates used are perlite (53%), rockwool (45%) and coir dust (2%).

In order to reduce the expenditure on substrates, rockwool slabs tend to be used for 2 to 3 growing seasons (i.e. 3 to 6 crop cycles) by commercial growers, although the slabs' lifespan varies according to growers' experience, which is still limited. Nevertheless, the quality of rockwool slabs and especially their physical properties deteriorate with time and use, which can affect crop management and behaviour (García, 2000). Research into substrate lifespan and its effects on productivity and quality of greenhouse horticultural crops is scarce and the available knowledge is based on the experience of growers, technical teams and substrate makers. This work presents some results obtained from an experiment carried out with a sweet pepper crop grown in new and two-year-old reused slabs of rockwool substrate.

MATERIAL AND METHODS

The experiment was carried out during the autumn-winter season 2003/2004 at ‘Las Palmerillas’ research station of Cajamar, in Almería, South-east Spain. The climate is Mediterranean with a mild winter and an average annual rainfall of 220 mm. A California-type sweet pepper crop (*Capsicum annuum* L. cv. ‘Bárdenas’) was grown in a typical Parral-type greenhouse of about 500 m^2 without climate control management systems. Plants at a density of 3.08 m^{-2} were grown in two different rockwool substrates, one of which was new (LN) and the other one two years old (LV), both of Med Horizontal Grodan (T502) type. The latter had been previously used commercially to grow cucumber (September to December 2001), melon (January to June 2002) and tomato (September 2002 to July 2003). The irrigation water was classified as C2-S1 (Richards, 1954) and the nutrient solution was supplied with an open system. Drainage water, electrical conductivity (EC) and pH were registered periodically in the nutrient solution and drainage water. Measured values of drainage water and EC were around 35% and 2.5 dS m^{-1}, respectively. This work is a part of a wider project that also includes oxygen nutrient solution management. A 2×2 factorial with 6 replications per treatment were arranged in a completely randomised experimental design. The experimental unit was a crop line. The two factors studied were the substrate age [new (LN) and reused slabs (LV)] and the dissolved oxygen concentration in the nutrient solution. The work analyses the crop response to the substrate age and the data presented are average values of both oxygen treatments.

Water retention curves were determined prior to starting the experiment in both substrate types (De Boodt, 1974). Volumetric water content (VWC) and EC of both substrates were measured during the pepper cycle with a FDR-type equipment (WCM, Grodan, The Netherlands), specifically calibrated for measuring in rockwool substrates. Measurements were taken at 8 different points in each slab.

Leaf area index (LAI) was determined indirectly by means of regression equations (R^2>0.97) relating the length and the surface of the leaves. Plant height was also measured. Both measurements were taken every 3-4 weeks from one plant per replication. Total dry matter (g m^{-2}) and final yield (kg m^{-2}) were measured in 4 plants per replication. Commercial fruit category was determined according to EC regulation 1455/1999 modify by EC regulation 2706/2000.

RESULTS AND DISCUSSION

Substrates

Water retention curves showed differences between new and reused rockwool slabs (Fig. 1). Total porosity was 97% for both (Martinez, 2001; Raviv et al., 2002), but air-filled porosity (AFP) was higher for LV slabs (47%) than for LN ones (37%), whereas the easily available water was clearly higher for LN (59%) than for LV (47%) slabs. AFP values could be sufficient to maintain adequate oxygen diffusion rates in both substrates and, therefore, avoid aeration problems in the root zone (Bunt, 1991). Values in the reused substrate are averages of three slab positions due to the variability of the physical properties within each slab. For the reused rockwool slab, the AFP varied between 39 and 52%, and the easily available water between 39 and 55%.

In general, values of VWC and EC within the rockwool slabs were similar for both substrate types throughout the measured crop cycle, although the VWC was slightly higher in LV (48%) than in LN (41%) slabs, and the opposite occurred for EC (3.5 and 3.2 dS m^{-1} for LN and LV, respectively). VWC values are near the bottom of the recommended VWC range for rockwool substrates (40-80%; Stradiot, 2001), above all the crop grown in new slabs. Values of VWC below 40 % make crop management harder and could result in lower crop growth (Stradiot, 2001). The relatively lower VWC for the LN slabs (Fig. 2) may be due to substrate compression during the third year of slab use, which would produce smaller pores and higher water retention. However, data for confirming this hypothesis are not available.

Differences between substrate types were found in the spatial distribution of VWC and EC within the slabs (Fig. 2). VWC values were higher around the dripper and more variable throughout the slab in LV. The variation coefficient of VWC within the slab was 26%, whereas LN slabs had a more uniform water distribution with a variation coefficient of 10%. The higher VWC variation in LV slabs was probably due to the greater variation observed in their physical properties already mentioned. This could be caused by the progressive loss of hydrophilic additives with time and use. The variation of the EC within the slab was smaller than the VCW, with variation coefficients of 10 and 14% for LN and LV, respectively.

Growth, yield and fruit quality

No significant differences between substrate types were found for the measured crop growth parameters (Fig. 3). At the end of the cycle, the crop height was 1.76 and 1.73 in LN and LV slabs, whereas the leaf area index was 3.0 and 3.1 m^2 m^{-2}, respectively.

Neither were there significant differences between substrate types for the aerial biomass or for the biomass allocation (data not shown). Mean values of final aerial biomass were 1470 g m^{-2} and 1502 g m^{-2} for LN and LV slabs respectively, whereas the crop harvest index was 0.61 and 0.62 g^{-1} g^{-1}. The latter values are slightly higher than those measured by Fernández (2000) and Gazquez (2003) in sandy soils ("enarenados") in the region.

No significant differences were found between substrate types for total and marketable production of peppers (Fig. 4). Mean values of final marketable production were 8.5 and 8.8 kg m^{-2} in LV and LN slabs, respectively, and most of the fruits were marketable (>95%). This crop productivity was relatively high for both substrate types compared to crops grown commercially in the region with a similar growth cycle (Junta de Andalucía, 2003; Posadas, 1993), but similar to that obtained by Perez et al. (2000) in a rockwool substrate. However, table 1 also shows that the crop grown in LV slabs produced significantly more first category fruits than the crop grown in LN slabs (6.4 vs. 5.8 kg m^{-2} and 29.3 vs. 27.1 fruits m^{-2}). These differences could be explained by the slightly higher VWC and lower EC of the crop grown in LV slabs that facilitate fruit setting and fruit growth. No significant differences were found between substrate types for the other measured crop production parameters (Table 1).

In conclusion, growth and productivity of a sweet pepper crop grown in new and two-year-old reused rockwool slabs did not differ significantly with substrate age. Both substrates showed similar water status throughout the pepper crop cycle, although it varied more within the reused slabs. Although, the higher variation of physical characteristics of the reused substrate did not affect the crop, it should be considered for crop management (Stradiot, 2001). Moreover, a better knowledge of the changing physical and chemical characteristics during the substrate lifespan is required.

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Tables and figures

Table 1. Yield and number of fruits, both classified by fruit category, and mean fruit weight of a sweet pepper crop grown in new (LN) and two-year-old reused rockwool slabs (LV). Values followed by the same letters are not significantly different at P<0.05.

	Yield (kg m^{-2})		Fruits number (fruit m^{-2})		Mean fruit weight
	Category		Category		(g $fruit^{-1}$)
	1st	2nd	1st	2nd	
LN	5.8 a	2.7 a	27.1 a	17.4 a	193.1 a
LV	6.4 b	2.4 a	29.3 b	15.7 a	198.3 b

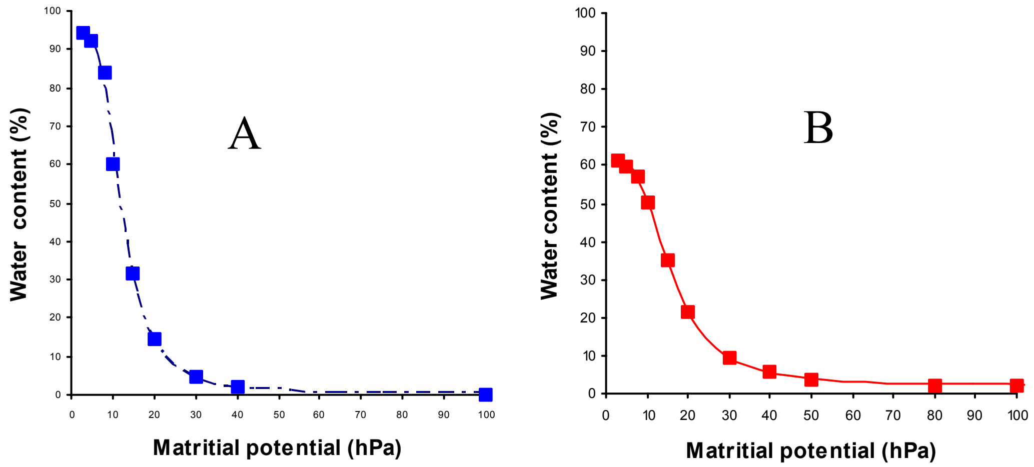

Fig. 1. Water retention curves in new (A) and reused (B) rockwool slabs. Relation between water content and matritial potential (hPa). Representation according Van Genuchten's analytical model (1978).

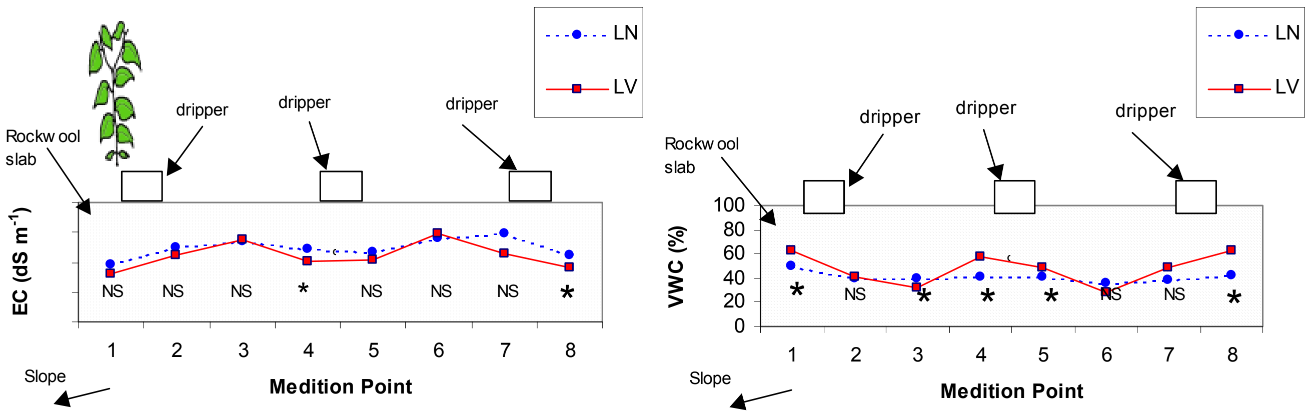

Fig. 2. Spatial distribution of the Electric Conductivity, EC, (A) and the Volumetric Water Content, VWC, (B) and in new and two-year-old reused rockwool slabs. *: Values significantly different (P<0.05); NS: Values not significantly different.

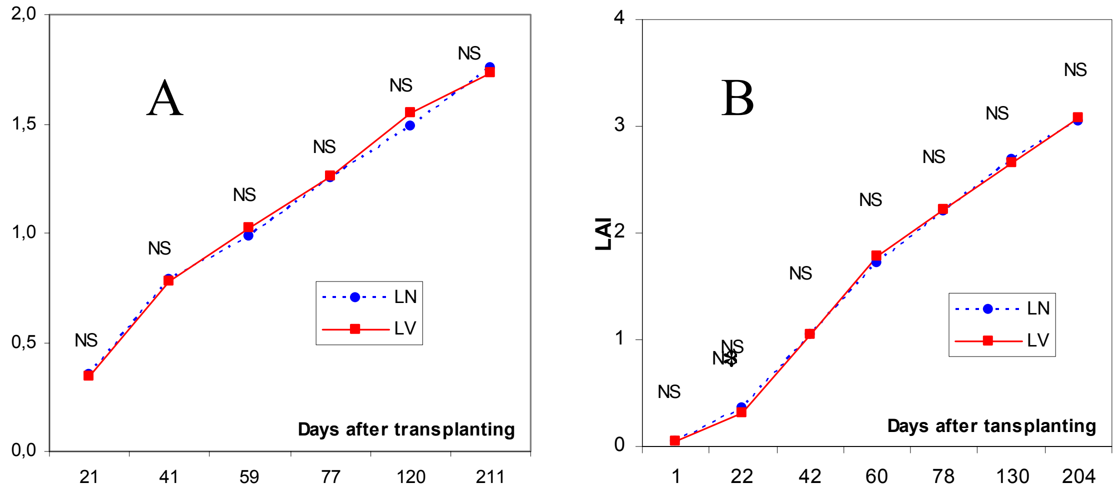

Fig. 3. Height (A) and Leaf Area Index (B) of a sweet pepper crop grown in new (LN) and two-year-old reused rockwool slabs (LV). *: Values significantly different (P<0.05); NS: Values not significantly different.

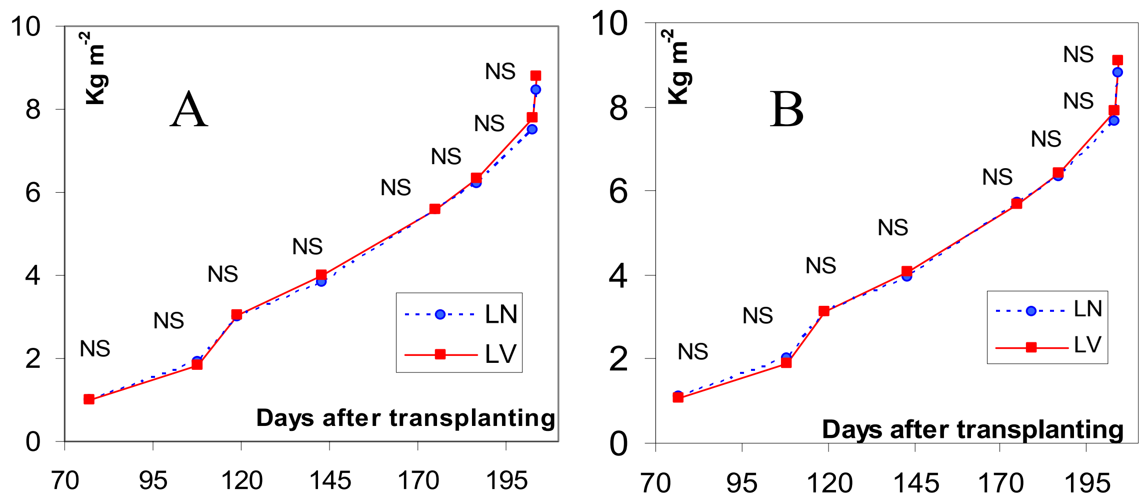

Fig. 4 Cumulative marketable (A) and total yield (B) of sweet pepper crop grown in new (LN) and two-year-old reused rockwool slabs (LV). *: Values significantly different (P<0.05); NS: Values not significantly different.