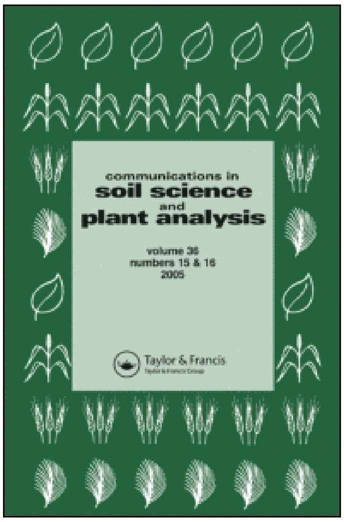

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Use of Composts Derived from Winery Wastes in Tomato Crop

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Abstract: The effects of fertigation levels on parameters related to fruit quality were studied, using compost derived from winery wastes as growing media for a tomato crop. We evaluated five growing substrates: perlite and four composts derived from winery-distillery residues. Two levels of fertigation were applied: a standard fertigation for tomato crop and a half-level of fertigation obtained by a 50/50 v/v dilution. Our objective was to evaluate the possibilities of winery waste composts as an alternative to perlite as growing substrate. We tried to measure the effect of these organic substrates on yield and on the parameters more strongly related with fruit quality: tomato solid soluble content and titratable acidity. The commercial F1 hybrid variety of tomato "Boludo" was used. Significant differences among the levels of fertigation were found, but only small differences among the substrates could be observed. These results have been obtained under two different fertigation levels, one of them probably causing a slight level of salinity. The composts evaluated have shown adequate characteristics when used as substrates for a tomato crop, indicating the suitability of winery waste composts as an alternative to the growing media currently used.

Keywords: Perlite, grape mark, sludge, hydroponic, growing media

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INTRODUCTION

In recent decades, the use of soilless substrates in horticulture has become common, not only for growing seedlings and propagation of plants but also for vegetable production. The cost and the declining availability of peat in high-demand Mediterranean countries make it necessary to look for alternative materials (Abad 1995), including substitution of perlite as one of the most demanded growth media (Olympios 1993; Abad 1995). The winery and distillery wastes are characterized by a low pH, similar electrical conductivity (EC) values, high organic matter, phosphorus (P) and potassium (K) contents, as well as low micronutrient and heavy-metal contents compared to the values found by other researchers for wastes usually used as organic fertilizers, such as manures, and urban wastes (Pascual et al. 1997; Moreno-Caselles et al. 2002). However, these wastes are also characterized by the presence of polyphenols, compounds related to phytotoxic and antimicrobial effects, which make conditioning treatments necessary before using these residues for agricultural purpose. Composting could be a feasible option for recycling these residues to take advantage of their nutritional and energy properties without causing environmental damage. In a recent study, similar results compared to mineral fertilization were observed in an experiment using exhausted grape marc composts as amendment to soil at 90 t fresh weight ha^{-1} (Moral et al. 2006).

The aim of this study was to evaluate the effect of the alternative use of composts derived from winery-distillery wastes, as ingredient of the growing media for tomato, in different fertigation scenarios, on yield and on parameters related with fruit quality such as tomato solid soluble content and titratable acidity.

MATERIALS AND METHODS

Substrates

Five growing substrates were evaluated: four composts derived from the winery-distillery residues (C3, C4, C5, and C6) and perlite as control treatment, because perlite is the most common hydroponic growing media used for tomato in southeast Spain. The most important characteristics of the composts appear in Table 1. The composts used in this study were obtained using the Rutgers static pile composting system, in which air is supplied to the pile by forced aeration. Four different piles were made by cocomposting winery-distillery wastes [grape stalk (GS), grape marc (GM), exhausted grape marc (EGM), and vinasse (V)] with other residues [sewage sludge (SS), cattle manure (C), and

Table 1. Agronomic characterization of the composts used

Parameter	C3	C4	C5	C6
pH	7.14	7.01	7.38	8.14
EC (dSm^{-1})	5.83	2.75	2.82	2.34
Total OM (%)	79.2	84.3	82.0	73.9
C_{ot} (%)	42.2	44.9	46.7	42.8
N_t (%)	2.39	2.40	2.91	4.12
C/N	17.7	18.8	15.5	10.5
N_{org} ($g\,Nkg^{-1}$)	23.7	23.8	28.9	41.0
NH_4^+-N ($mg\,Nkg^{-1}$)	58	40	57	50
NO_3^--N ($mg\,Nkg^{-1}$)	184	87	94	186
Water-soluble C (%)	2.62	2.28	1.38	1.24
Extracted C (%)	1.58	1.59	4.04	3.33
Humic acid–like C (%)	0.43	0.54	2.67	2.11
Fulvic acid–like C (%)	1.12	1.07	1.36	1.21
P (gkg^{-1})	4.84	5.20	5.38	9.61
Na (gkg^{-1})	1.15	1.47	5.0	3.2
K (gkg^{-1})	46	27	19	20
Ca (gkg^{-1})	30	24	32	64
Mg (gkg^{-1})	5.3	5.5	5.3	5.1
Fe (gkg^{-1})	7248	9486	1355	1028
Mn (gkg^{-1})	56	63	129	150
Cu (gkg^{-1})	61	68	36	45
Zn (gkg^{-1})	128	182	140	171

Notes. EC, electrical conductivity; OM, organic matter; C_{ot}, total organic C; N_t, total N; N_{org}, organic N.

poultry manure (P)] in the following proportions on a fresh-weight basis: compost C3: 44% GS + 18% EGM + 9% GM + 29% SS + 0.8 L V kg^{-1}; compost C4: 44% GS + 18% EGM + 9% GM + 29% SS; compost C5: 70% EGM + 30% C; and compost C6: 61% EGM + 39% P.

The cocomposting was done to achieve a suitable C/N relation in the initial mixtures.

Plant Material and Crop Conditions

The experiment was carried out in a spring–summer cycle in a hydroponic greenhouse with temperature control, under homogeneous conditions. Boludo F1 hybrid from Seminis Iberica Seeds was used. Forty-day-old seedlings were transplanted to plastic bags filled with perlite or with the four different substrates at the beginning of March. Plants were allowed to grow vertically with a single stem. Two fertigation levels were applied: a standard fertigation for tomato crop and a half-level of fertigation obtained by a 50/50 v/v dilution. The composition

($mmol\,L^{-1}$), the electrical conductivity, and the pH of the standard fertigation solution were the following: 12 nitrate (NO_3^-), 2 phosphoric acid ($H_2PO_4^-$), 2 sulfate (SO_4^{-2}), 0.5 bicarbonate (HCO_3^-), 0.5 ammonium (NH^{4+}), 5 K^+, 4 calcium (Ca^{+2}), 2 magnesium (Mg^{+2}), 2.5 dSm^{-1}, and pH 5.8, respectively (Cadahía 1995).

Parameters Studied

Fruits were individually harvested at commercial ripening state. Three harvests (H1 to H3) were carried out at intervals of 15 days. Only fruits weighting more than 50 g were considered as commercial yield. Yield per plant, number of fruits per plant, commercial yield per plant, and mean commercial fruit weights were calculated (Table 2). At least two fruits per plant of each harvest were analyzed. Two opposite slices from each fruit were homogenized, and the filtered juice was used for soluble-solids content (SSC) and titratable acidity (TA) determination. SSC was estimated by a digital refractometer (Atago Co. Ltd., Tokyo); the results were expressed in °Brix. TA was measured by titration with 0.1 N sodium hydroxide (NaOH) and presented as $g\,kg^{-1}$ of citric acid.

Experimental Design and Statistical Analysis

A complete randomized experiment design was adopted with three replicates. Each replicate consisted in six plants. A multifactor analysis of variance was performed to identify the significant factors and interactions between the factors. An LSD test was used for mean separation.

RESULTS AND DISCUSSION

Yield Parameters

No significant interactions were detected between the substrate type and the fertigation level for the four analyzed yield parameters (Table 2). The multifactor ANOVA showed only significant effects of the type of substrate for the parameter commercial yield per plant ($P < 0.05$) and only under the standard fertigation level. The substrate C3 gave a commercial yield of 2456 g per plant, 15% lower than the mean value of all the substrates. Under the semistandard fertigation level, the substrate C3 also produced the lowest commercial yield, but the differences were statistically nonsignificant. All the production parameters were significantly affected ($P < 0.001$) by the fertigation level. The results for both

Table 2. Effects of the use as substrate of winery-distillery composts (C3, C4, C5, C6) and perlite, and the fertigation (standard and semistandard), on yield parameters

Growth media	Yield per plant (g)	Number fruits plant^{-1}	Commercial yield per plant (g)	Mean commercial fruit weight (g)
		Standard fertirrigation		
Perlite	3390	63.9	2881 ab	61.0
C3	3023	65.2	2456 a	54.3
C4	3236	61.3	2839 ab	59.2
C5	3669	66.2	3265 b	64.5
C6	3490	61.6	3098 b	66.8
F-ANOVA	1.946 ns	0.222 ns	3.528*	2.518 ns
Mean	3362	63.6	2908	61.2
		Semistandard fertigation		
Perlite	4053	57.2	3793	79.0
C3	3573	48.8	3422	79.4
C4	3966	53.5	3736	81.6
C5	3891	54.2	3716	78.3
C6	3650	47.3	3531	81.6
F-ANOVA	1.401 ns	2.579 ns	0.729 ns	0.512 ns
Mean	3827	52.2	3640	80.0
Substrate (S)	2.145 ns	1.160 ns	2.547 *	1.966 ns
Fertigation (F)	17.9 ***	20.05 ***	46.363 ***	123.32 ***
S × F	1.182 ns	0.531 ns	1.302 ns	1.634 ns

*, **, *** Significantly different at $P < 0.05$, 0.01, and 0.001, respectively. ns: not significant at $P > 0.05$.

Note. Means within a column followed by the same letter are not different at $P < 0.05$ (LSD test).

fertigation levels showed that for three of the parameters analyzed, the values obtained with the semistandard fertigation were higher than those obtained with the standard level. The use of this level decreased yield per plant by 12%, commercial yield per plant by 20%, and mean commercial fruit weight by 23%. Although this standard level has been used in other experiments with satisfactory results, it seems that the standard level of fertigation was somewhat high under the conditions of the present experiment, probably causing a slight degree of saline stress. This hypothesis would be supported by the higher number of fruits obtained with the standard level. Decreases in yield, but increases in the number of fruit per plant in response to low salinity, have been reported in several crops, such as melon (Mendlinger and Pasternak 1992; Nerson 1992) and pepino (Ruiz and Nuez 1997), and have also been described in tomato

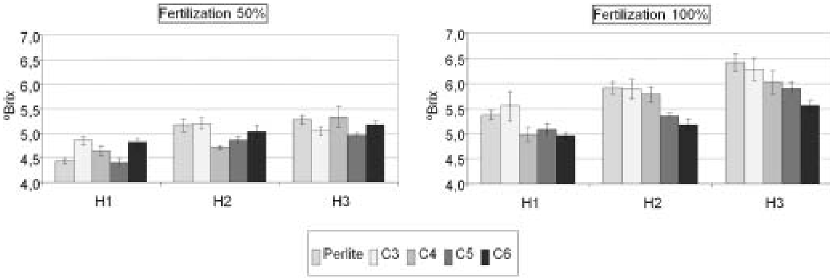

Figure 1. Soluble solids content of the fruit at two fertilization levels, five different substrates, and three harvests, H1 to H3 (each 15 days).

(Satti and López 1994). This explanation seems to be further supported by the C3 substrate, the most saline, giving the lowest significant yield values, commercial yield, and mean commercial fruit weight under the standard fertigation level but not under the semistandard level.

For both fertigation levels, no significant effects ($P > 0.05$) of the different substrates were found on yield per plant, number of fruits, and mean commercial weight. Therefore, although some differences among the substrates could be observed with the LSD test (data not shown), it cannot be considered that the type of substrate significantly affected these parameters.

Soluble Solids Content and Total Acidity

Some differences among the substrates used could be observed (Figures 1 and 2), but the multifactor analysis of varience (ANOVA) performed showed no significant effect of the substrate on titratable acidity and soluble solids content. In addition, no clear tendencies could be observed among the substrates, because all of them showed a similar behavior for the two analyzed parameters. However, the time of harvest and the level

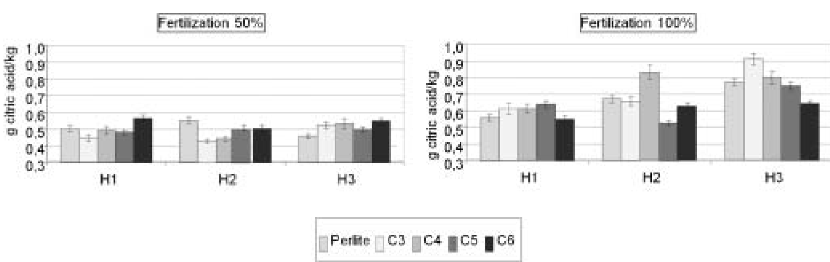

Figure 2. Titratable acidity of the fruit at two fertilization levels, five different substrates, and three harvests, H1 to H3 (each 15 days).

of fertilization significantly affected both soluble solid content and total acidity. These results also seem to confirm that the standard level of fertigation was indeed somewhat high in the present experiment, causing a slight level of saline stress. Low salinity levels in tomato usually determine higher content of soluble solids of the fruits in tomato and other crops (Mizrahi and Pasternak 1985; Mitchell et al. 1991). This effect was even more marked for the titratable acidity, which showed a higher increase (Figure 2).

CONCLUSIONS

Significant differences between the substrates have not been found for the majority of the parameters analyzed. These results have been obtained under two different fertigation levels, one of them probably causing a slight level of salinity. Thus, it can be concluded that the composts derived from winery wastes used in this study did not show worse properties than perlite, the most common hydroponic growing media used for tomato in southeast Spain. Although more investigations are needed, our results indicate the suitability of winery wastes composts as a growing substrate.

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