MUNICIPAL SOLID WASTE COMPOST UTILIZATION IN GREENHOUSE-CULTIVATED TOMATO

Fernando Madrid, Manuel J. Trasierra, Rafael López, José M. Murillo and Francisco Cabrera
Instituto de Recursos Naturales y Agrobiología de Sevilla
CSIC
Apartado 1052
41080 Sevilla
Spain

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Abstract

The effects of a municipal solid waste compost (MSWC) (from Villarrasa-Huelva-Spain) on growth, yield and mineral composition of tomato plants (*Lycopersicon esculentum* Miller, cv. Genaro) were studied. Results were compared with those observed both without the application of organic matter (Control) and with the application of a commercial compost AC (made from sheep manure). Soils of the three treatments also received N, P and K as a deep mineral fertilization (181 kg ha^{-1} N, 22 kg ha^{-1} P_2O_5, 108 kg ha^{-1} K_2O). The experiment was carried out in a greenhouse using a sandy soil and drip irrigation. The fertigation for all the treatments during the season was the usual one of the farmers of the region (120 kg ha^{-1} N, 20 kg ha^{-1} P_2O_5, and 60 kg ha^{-1} K_2O per week).

Treatments MSWC (21000 kg ha^{-1} dry weight; <10 mm, OM 26%, N 0.60%, P_2O_5 0.62%, K_2O 0.55%) and AC (5000 kg ha^{-1} dry weight; OM 52%, N 3.47%, P_2O_5 0.50%, K_2O 2.39%) increased the concentrations of K, Ca and Mg in tomato leaves and fruits, giving rise to higher EC values of the fruit juice. However, no effect of the organic treatments was observed in N and P contents of leaves and fruits. Mean fruit weight and yield increased noticeably in treatment AC (204 g; 104.6 Mg ha^{-1}), while increasing only slightly in MSWC (180 g; 92.3 Mg ha^{-1}) in comparison with the Control (166 g; 90.7 Mg ha^{-1}).

1. Introduction

The use of Municipal Solid Waste (MSW) composts as organic amendment for agricultural soils is one of the most interesting possibilities to reduce urban wastes volume. At the same time, intensive greenhouse cultivation is one of the agricultural practices most sensitive to soil organic matter level. To ensure high yields under greenhouse conditions it is necessary to apply organic matter throughout each of the cultivation periods. This is especially true in soils with low organic matter contents,such as are those of southern Spain where the present experiment was carried out.

Although there is abundant literature on the application of MSW composts to soils under different crops (Ozores-Hampton et al., 1994; Maynard, 1995; Sabrah et al., 1995), it is less frequent to find papers dealing with real-life, intensive conditions (i.e. intensive fertilization, 2 or 3 months of fruit production season) for tomato or many other greenhouse crops. The present paper studies the effects of applying an MSW compost on growth, yield and nutritional status of tomato plants growing in a sandy soil under greenhouse conditions. Results were compared with those obtained both without the application of organic matter and with the application of a commercial compost.

2. Materials and methods

Tomato plants (*Lycopersicon esculentum,* cv. Genaro) were cultivated on a plot of 31x75 m^2 of a sandy soil (Table 1) in a plastic greenhouse at a density of 25000 plants ha^{-1}. The plot was divided into three subplots. Two of the subplots received organic matter of different origin before planting: 21000 kg ha^{-1} (dry weight) of an MSW composts (<10 mm, Treatment MSWC) and 5000 kg ha^{-1} (dry weight) of a commercial compost made from sheep manure (Treatment AC). Table 2 shows the main characteristics of the composts. The third plot did not receive organic matter (Treatment Control). All the subplots also received N, P and K as a deep mineral fertilization (181 kg ha^{-1} N, 22 kgha^{-1} P_2O_5, 108 kg ha^{-1} K_2O). The plot was fertigated by drip irrigation, receiving 120 kg ha^{-1} N, 20 kg ha^{-1} P_2O_5, and 60 kg ha^{-1} K_2O per week. The fertilizer dose used was normal for tomato in intensive conditions in SW Spain.

Three samples of leaves (young and fully expanded) were collected in each subplot following planting: 30 days (L1), 87 days (L2, at the beginning of the flowering before the harvesting period) and 192 days (L3, at the end of the harvesting period). Each leaf sample was a composite sample made up from 20 plants chosen at random. Samples of marketable fruit were collected in each plot one week after beginning the harvest (F2) and at the end of the season (F3), 127 and 185 days respectively after planting. Each fruit sample was a composite sample made up from 5 plants chosen at random.

Plant material was decontaminated by washing with tap and deionized water. Afterwards fruits were ground and leaves were dried at 70°C and ground. Both fruits and leaves were kept in a refrigerator until analysis. Nitrogen was determined by the Kjeldahl method. For mineral element determinations, dry samples were ashed and ashes treated with conc. HCl on a hot plate. Phosphorus in solution was determined by the visible spectrophotometric method of the phosphovanadomolybdic complex. Sodium and K in plant material extracts were determined by flame emission spectrophotometry, and Ca, Mg, Fe, Cu, Mn and Zn by atomic absorption spectrophotometry.

To determine fruit quality, pH, electrical conductivity (EC) and titratable acidity (TA) were measured directly in fresh, ground samples the same day as the sampling. TA was determined by titration of tomato juice to pH 8.1 with 0.1 N NaOH, using 0.1% phenolphthalein as the end point indicator. Percent acidity was expressed as citric acid.

Yield was determined every 2 or 3 days in each subplot in 16 plants chosen at random, in which number, total weight and average weight of fruits were measured.

3. Results

3.1 Nutritional status of tomato leaves and fruits

Concentrations of nutrients in leaves and fruits are shown in Table 3. Nitrogen concentrations in leaves of the three treatments of samplings 2 and 3 were within the optimum range for tomato leaves (3-5%) reported by Hochmuth et al. (1991); however in sampling 1, N levels were slightly higher than the upper limit of this range. No significant differences ($P<0.05$) due to treatment were found in N concentration in leaves. Nitrogen concentration in fruits from treatment MSW and AC were higher ($P<0.05$) than in the control, although the differences were significant only in sampling 2 (F2). Gómez et al. (1992) reported similar levels of N in tomato fruits.

In samplings 1 and 2, the concentrations of P in leaves were within the optimum range for tomato leaves (0.3-0.6%) (Hochmuth et al., 1991). However, in sampling 3, P mean values were below the lower limit of this range. In the three samplings, mean values of P in leaves were higher in the Control than in the organic treatments, despite considerable amounts of P supplied by the composts. Although organic amendments generally increase P contents in crops (Steffen et al., 1995) and soils (Cabrera et al., 1991), other authors (Murillo et al., 1995) have also reported decreased P concentrations in plants treated with urban compost. No significant differences due to treatment were found in the P concentration in fruits.

Generally concentrations of K in both leaves and fruits were significantly higher ($P<0.05$) in plants from treatments MSWC and AC, as expected because of the K supplied by the two composts (Steffen et al., 1995; Gómez et al., 1992). However, K levels in leaves and fruits from the three treatments were always lower than those reported in the literature (Steffen et al., 1995; Pill & Lambeth, 1980). The optimum range of K in tomato leaves is 3.0-5.0 % (Hochmuth et al., 1991).

Concentrations of Ca in leaves were within the optimum range (1.0-2.0%; Hochmuth et al., 1991) in sampling 2, while in the other two samplings Ca mean values were higher than the upper limit of that range. Differences due to treatment were found only in sampling 3, where Ca mean value in leaves of the Control was significantly higher ($P<0.05$) than in the other two treatments. Similar trends were observed for Mg in leaves (optimum range 0.3-0.5 %, Hochmuth et al. (1991)).

No differences due to treatment were found between the mean concentrations of Ca in fruits, while mean values of Mg were lower in the Control. Mean values of Ca and Mg in fruits were similar to those reported by Gómez et al., (1992) and Pill and Lambeth (1980).

For Na, Fe, Cu Mn and Zn, no differences attributable to treatments were found.

3.2 Tomato fruit quality and yield.

Table 4 shows that organic fertilization did not affect the pH values of the tomato fruit juice, while it increased the EC of fruits in both F2 and F3, although differences among treatments were not always significant. EC values of tomatoes from the three treatments were similar to those reported by Navarro-Pedreño et al. (1994). Generally, TA mean values were slightly higher in fruits from treatments MSWC and AC than in those from the Control, although differences between treatments were not always significant. The percentage of TA in fruits from the three treatments was higher than 0.32 %, which is the minimum value for high quality tomato fruit (Kader et al., 1978).

Final cumulative fruit yield in treatment MSWC (92.3 Mg ha^{-1}) was slightly higher than in the Control (90.7 Mg ha^{-1}) and lower than that in treatment AC (104.6 Mg ha^{-1}) (Figure 1).

Generally, average fruit-weight throughout the 21 harvestings also followed the trend AC>MSWC>Control (Figure 2). The mean values of the average weights were 204 g in AC, 180 g in MSWC and 166 g in the Control. These results agree with those of Maynard (1995), Steffen et al. (1995), Del Río et al. (1994) and Navarro-Pedreño et al. (1994), who reported increases in fruit yields in tomato plants treated with organic fertilizers.

4. Discussion

Organic amendments with MSWC and AC caused an increase of OM and nutrients supplied to the soil compared with the Control. However, no increase in the supply of N and P was found in the leaves and fruits of tomato, probably because of the slow mineralization rate of the organic matter of both MSCW and AC (Martín-Olmedo et al., 1995a) In contrast, an increase was observed in the concentration of K, especially in fruit, possibly because K in the composts is in the form of soluble inorganic salts, readily available to plants.

Fruit quality also did not reflect a clear response to organic amendments, except by the slight increases in EC of the tomato juices in treatments MSWC and AC, related to concentrations of salts in the juice. It was found that EC was correlated with the sum of the concentrations of Na, K, Ca and Mg (r^2 = 0.92). On the other hand, amendment with AC notably improved average weight of fruits and yield compared with the Control, while amendment with MSWC gave average weight and yield only slightly higher than the Control.

The huge loadings of mineral fertilizers as deep fertilization and fertigation used in the present experiment could have masked tomato response to organic amendment with MSWC or AC. On the other hand, these composts have low rates of mineralization, so their positive effect is assumed to appear after periods of application longer than those used in the present experiment (Martín-Olmedo et al., 1995b).

5. References

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Table 1 - Soil characteristics

	0-25 cm	25-50 cm
pH	7.5	7.1
EC (1:5)(dS m^{-1})	0.32	0.27
OM (%)	1.50	0.87
N (mg kg^{-1})	830	530
Avail-P (mg kg^{-1})	54	26
Avail-K (mg kg^{-1})	105	77
Avail-Ca (mg kg^{-1})	1200	1370
Avail-Mg (mg kg^{-1})	230	214
Sand (%)	85.6	90.0
Silt (%)	10.7	2.2
Clay (%)	3.7	7.8

Table 2 - Compost characteristics (dw basis or * total weight basis.

	MSC	AC
Moisture (%)*	29.7	30.0
Inert (%)	2.7	
OM (%)	26.0	52.4
pH (1:5)	6.63	7.0
EC (1:5) (dS m^{-1})	6.38	
C/N	21.7	
N (%)	0.60	3.47
P_2O_5 (%)	0.62	0.50
K_2O (%)	0.55	2.39
Ca (%)	3.18	
Mg (%)	0.18	0.50
Na (%)	0.55	
Fe (%)	1.13	
Cu (mg kg^{-1})	128	
Zn (mg kg^{-1})	261	
Mn (mg kg^{-1})	122	
Cr (mg kg^{-1})	74	
Pb (mg kg^{-1})	98	
Ni (mg kg^{-1})	23	
Cd (mg kg^{-1})	<1	

Table 3 - Nutrient concentrations in tomato leaves and fruits. Data per treatment showing different suffix letters, (a or b), are significantly different (p<0.05)

	Treatment.	Sampling 1	Sampling 2		Sampling 3	
		Leaves	Leaves	Fruits	Leaves	Fruits
		L1	L2	F2	L3	F3
Days		30	87	127	192	185
N (%)	Control	5.73 a	3.49 a	1.79 a	4.52 a	1.65 a
	MSWC	5.58 a	3.53 a	2.11 ab	4.37 a	1.82 a
	AC	5.75 a	3.61 a	2.60 b	4.04 a	1.73 a
P (%)	Control	0.56 b	0.57 b	0.49 a	0.30 c	0.29 a
	MSWC	0.41 a	0.51 ab	0.47 a	0.20 a	0.26 a
	AC	0.46 ab	0.48 a	0.49 a	0.25 b	0.29 a
K (%)	Control	1.63 a	1.06 a	2.51 a	0.81 a	1.70 a
	MSWC	2.14 a	1.27 b	3.02 ab	0.63 a	2.07 b
	AC	1.96 a	1.25 b	3.49 b	0.74 a	2.64 c
Ca (%)	Control	3.55 a	1.77 a	0.20 a	3.43 a	0.16 a
	MSWC	3.26 a	2.02 a	0.25 a	4.89 b	0.19 a
	AC	2.99 a	1.91 a	0.27 a	4.65 b	0.20 a
Mg (%)	Control	0.80 a	0.27 a	0.100 a	0.73 a	0.093 a
	MSC	0.71 a	0.29 a	0.117 ab	0.93 b	0.103 a
	AC	0.72 a	0.31 a	0.130 b	0.91 b	0.117 b

Table 4 - Quality parameters of tomato fruits.

	Treatment	Sampling2	Sampling3
		F2	F3
Days		127	185
pH	Control	3.93 a	3.91 a
	MSWC	3.92 a	3.89 a
	AC	3.98 a	3.94 a
EC ($dS\ m^{-1}$)	Control	3.18 a	2.85 a
	MSWC	3.49 ab	3.17 b
	AC	4.07 b	3.28 b
TA (% citric acid)	Control	0.50 a	0.47 a
	MSWC	0.52 a	0.49 a
	AC	0.54 b	0.47 a

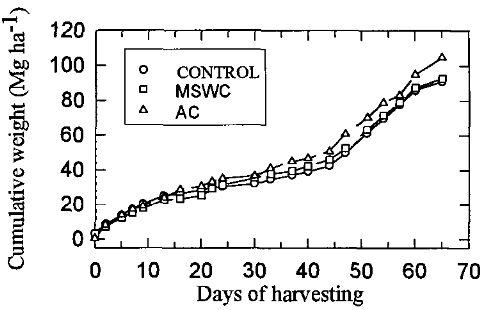

Figure 1. Cumulative yield of tomatoes

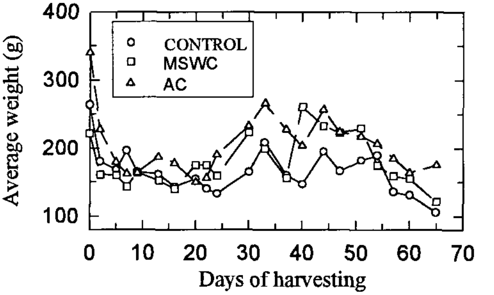

Figure 2. Average weight of tomatoes