EFFECTS OF THREE CONSECUTIVE APPLICATIONS OF MSW COMPOST ON SANDY SOIL UNDER INTENSIVE FERTILIZATION CONDITIONS

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ABSTRACT

Municipal Solid Waste Compost (sieved < 10 mm; MSWC) from Recycling Plant of Villarrasa (Huelva), was applied to 3 consecutive seasons of horticultural crops (Tomato, zucchini and green pepper) under greenhouse and intensive fertilization conditions. A Control treatment (no organic amendment), and a commercial compost (CC treatment) widely used by farmers in the area (Los Palacios, Sevilla) were applied as comparison. Effects on soil properties at the end of the 3 seasons were studied. Furthermore, residual effects of compost amendments at the end of the 4th season (Tomato), with no treatment applications were also study. Positive effects were observed in fertilizing parameters after MSW compost applications, compared to both Control and CC treatments. In this way, at the end of the 3rd season, MSWC increased Organic Matter, available-K, available-Ca and available-Mg in the soil, and avoided pH decrease observed in other treatments. Nevertheless, negative effects due to MSWC applications were also observed. MSWC increased NO_3-N content in the soil at the end of the 3rd season, what could become a problem, specially in sandy soils, because of the danger of groundwater contamination. After one season without treatment applications, high fertilization used to get high crop yield, masked all these positive and negative effects, and no significant differences were observed between plots of different treatments. Soil metal contents were also affected by treatments applied. After the 3rd application, MSWC increased total (HCl-HNO_3 digestion) and DTPA-extractable Cu, Zn, Ni and Pb in 0-25 cm layer, and even Zn and Pb in 25-50 cm layer. Soil metal accumulation was a more lasting effect than other parameters studied, and after the season without treatment applications, metal accumulation were still observed.

INTRODUCTION

High yield in a short time is the aim of agriculture under intensive conditions, and this is the reason because of very high rates of mineral fertilizers are needed. Maintaining these yields for successive seasons require adequate levels of Organic Matter (OM) in soil. By this way, use of compost from different origins as a supplier of both nutrients and OM, results in an interesting chance. In the South of Spain, where soils have low OM content and Mediterranean climate assure many sunny days, windrow composting of municipal solid wastes (MSW) is a feasible process, this treatment and its application to soil is a real alternative for recycling this type of residues. It is well known that OM added to soil help to improve chemical, physical and biological properties of soils, many of them related to fertility conditions (Whitbread et al. 2000).

In this paper, effects of the application of MSW compost for 3 consecutive seasons (2 years) to a greenhouse soil intensively fertilized is studied. MSW Compost treatment was compared with a commercial compost widely used in the area, and with a Control treatment that only received inorganic fertilization.

MATERIALS AND METHODS

The experiment was carried out in a greenhouse in Southern Spain, in Sevilla Province. Soil

characteristics are presented in Table 1.

Table 1. *Soil characteristics at the beginning of the experiment.*

	0-25 cm	25-40 cm
pH	7.5	7.1
OM (%)	1.50	0.87
Olsen-P (mg kg^{-1})	54	26
Available K (mg kg^{-1})	105	77
Available Ca (mg kg^{-1})	1200	1370
Available Mg (mg kg^{-1})	230	214
Sand (%)	85.6	90.0
Lime (%)	10.7	2.2
Clay (%)	3.7	7.8

The greenhouse was divided in three plots, and received different organic deep fertilization during three consecutive seasons. MSW Compost (sieved < 10 mm) was added at a rate of 3 kg m^{-2} (wet basis) at the beginning of the season (MSWC treatment). Sheep manure commercial compost widely used in the area was applied in the second plot (CC treatment) at a rate of 0.6, 0.4 and 0.34 kg m^{-2} at the beginning of the first, second and third season respectively (These rates were the ones usually applied by the farmer for each crop for this amendment. It is important to note that agricultural practices and timing were always done in the same conditions that the farmer usually worked for each crop). A Control treatment was prepared for comparison in the third plot, that did not receive any organic deep fertilization. Vegetable crops planted were successively Tomato, Zucchini and Green pepper. The following season (Tomato beginning the cycle of 3 crops) was also monitored. In this fourth season, none of the plots received deep fertilization to study residual effects. Compost characteristics are presented in Table 2 and fertirrigation was applied as presented in Table 3.

Table 2. *MSWC and CC characteristics for the 3 seasons.*

	MSWC 1	CC 1	MSWC 2	CC 2	MSWC 3	CC 3
Inert	2.7	0.0	3.1	0.0	2.4	0
pH	6.63	7.0	6.53	7.0	7.54	6.38
OM (%)	26	52.4	34.8	52.4	24.1	49.9
C/N	23.5	8.2	22.5	8.2	15.5	19.2
N (%)	0.60	3.47	0.84	3.47	0.84	1.41
P_2O_5 (mg kg^{-1})	0.62	0.22	0.87	0.22	0.84	0.65
K_2O (mg kg^{-1})	0.55	2.24	0.63	2.24	0.36	1.47
Ca (mg kg^{-1})	3.18	1.45	4.97	1.45	5.24	4.43
Mg (mg kg^{-1})	0.18	0.50	0.34	0.50	0.33	0.90
Zn (mg kg^{-1})	261	122	494	122	512	141
Cu (mg kg^{-1})	128	76	312	76	244	94
Pb (mg kg^{-1})	98	20	172	20	203	24
Ni (mg kg^{-1})	23	8	54	8	39	13

Table 3. *Fertirrigation applied (g m^{-2} $week^{-1}$).*

	Crop	N	P_2O_5	K_2O
1st and 4th season	Tomato	12	2	6
2nd season	Zucchini	5	3	2
3rd season	Green pepper	4	2	4

RESULTS AND DISCUSSION

Soil characteristics at the end of the second, third and fourth seasons are presented in Table 4 (There were no significant differences at the end of the first season).

pH was affected by treatments. Control showed lower pH after the second season than MSWC treatment, and only after the fourth season, without application of amendments, values were not significantly different. This acidification is probably due to intense mineral fertirriga-

tion applied aiming the highest crop yields. Although all treatments suffered acidification during the experiment, MSW compost reduced this effect on soil.

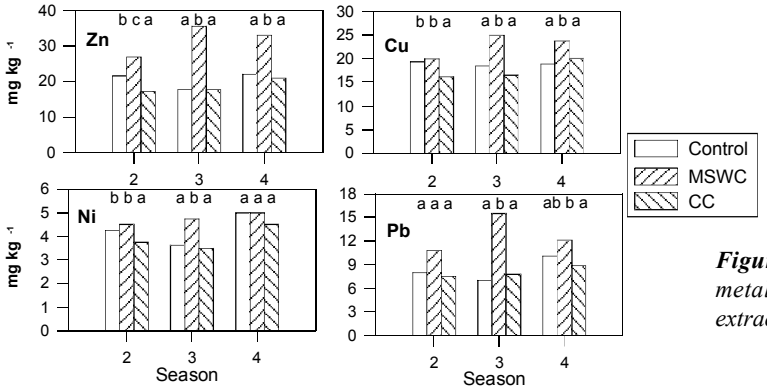
Table 4. *Soil characteristics (0-25 cm).*

	2nd season			3rd season			4th season		
	Control	MSWC	CC	Control	MSWC	CC	Control	MSWC	CC
pH	6.9 a	7.8 b	7.5 b	6.53 b	6.88 c	6.25 a	6.25 a	6.65 a	6.45 a
OM (%)	1.06 a	1.23 a	1.17 a	1.09 a	1.70 c	1.34 b	1.35 a	1.45 a	1.67 a
Olsen-P	53 a	51 a	54 a	52 a	69 a	64 a	45 a	54 a	61 a
Avail.-K	72 a	104 a	94 a	51 a	96 b	67 a	119 a	142 a	106 a
Avail.-Ca	1530 a	1820 b	1460 a	2010 a	3340 b	1880 a	1660 a	1930 a	1690 a
Avail.-Mg	159 a	184 b	169 a	167 a	258 b	187 a	195 a	187 a	161 a
NO_3-N	70 a	92 a	81 a	52 a	150 b	98 ab	172 a	205 a	98 a
NO_3-N (0-1 m)	53 a	66 a		46 a	94 b	57 a	72 a	91 a	61 a

Values of same season followed by same letter, are not statistically different (P<0.05). Values in mg kg^{-1}.

There were differences due to treatments in the nutrient contents in the surface layer of soil (0-25 cm). After the second season, MSW compost increased available Ca and Mg compared to other treatments, and after the third season, available potassium was also higher as well as organic matter content. These increases improve fertility of sandy soils, as is the one used in this experiment, that usually present low cation exchange capacity. The increase of K was noticeable although the high fertilization rates applied with irrigation, suggesting that nutrients applied with MSW compost stay in the soil for a longer time than those applied with fertirrigation due to its lower solubility. Nitrate also showed higher levels with MSW compost. The high solubility and mobility of nitrate in soil caused leaching of this anion, and the increase was also significant considering the layer 0-100 cm after the third season. In this case, the increase of this nutrient have to be considered as a negative effect of MSW compost, because sandy characteristics of this soil, favoured nitrate leaching, what could result in contamination of groundwater. On contrary, no effect was observed for Olsen-phosphorous after any season. After the fourth season, when no organic amendment was applied, no differences were observed in soil. The intense fertilization applied with irrigation to get high yields, masked both positive and negative effects, and no significant differences were observed in fertility parameters of soil.

Trace and heavy metal accumulation in soil was also studied (Figures 1 and 2). Zn 'total content' (*aqua regia* extraction) for MSWC treatment was higher than Control and CC since the second season, while Cu, Pb and Ni also showed higher contents after the third season. These effects were more lasting than the other previously described, related to soil fertility, and most of the increases were still significant after the campaign without application of amendments. The increase was also noted for Zn and Pb in the layer 25-50 cm depth at the end of the third campaign, what would be related with a significant migration of a fraction of the metals applied through soil profile, due to the sandy characteristics and the intense irrigation applied. MSWC treatment showed higher available metal contents (DTPA extraction) than Control and CC. In this way, for the surface layer (0-25 cm) Zn, Ni and Pb presented higher levels since the second season until the end of the experiment, and Cu since the third one. For the layer 25-50 cm, as well as for the total metal contents, only Zn and Pb showed higher contents after the third season, but not at the end of the experiment. In general, relative increases (MSWC vs Control treatments) in available metal content were higher than relative increases in total metal content. Several authors have reported similar relation with MSW compost and sewage sludge application to soil (Cabrera et al. 1989, Tsadilas et al. 1995, Pinamonti et al. 1997).



Bars with the same letter, for each season, do not differ statistically (P<0.05)

Figure 1. *Soil (0-25 cm) metal content (aqua regia extraction)*

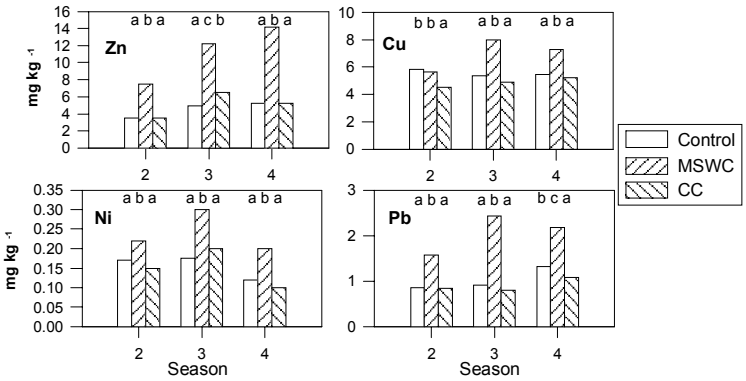


Figure 2. *Soil (0-25 cm) metal content (DTPA extraction)*

Bars with the same letter, for each season, do not differ statistically (P<0.05)

CONCLUSIONS

The application of MSW compost during three consecutive season improved soil fertility parameters compared to a sheep manure commercial compost and Control treatments.

MSW compost application increased risk of nitrate leaching to groundwater and metal accumulation (Cu, Zn, Pb and Ni) in soil.

One season with no treatment application masked effects on fertility parameters of soil, but higher metal content is soil was still significant for MSWC treatment.

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