EFFECT OF AN ORGANIC RESIDUE OBTAINED FROM CO-COMPOSTING WASTES FROM DIFFERENT SOURCES (HUMAN AND ANIMAL) ON AGRICULTURAL SOIL CHARACTERISTICS

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1 INTRODUCTION

In developed countries, particularly in the big European cities, large amounts of wastes are produced, mainly arising from the lifestyle and the intensification of production systems. These wastes have value in terms of nutrient and organic matter content, but require careful management to avoid pollution. There are various options for utilization of the waste, such as their application to agricultural land as soil amendments or as substitutes for mineral fertilizers, beside other uses such as feedstock for renewable energy or the production of chemicals. Intensive pig production produces large amounts of manures and slurries, which represent a valuable resource. Nevertheless the slurries from piggeries also pose a potential risk to the environment (soil and groundwater) (Yagüe and Quílez, 2010). Moreover, the use of pig slurry as fertilizer may expose crops to contamination by Zn and Cu (Berenguer et. al. 2008, Lloveras et al., 2004), and also organic compounds such as tetracycline (Migliore et al., 2010). Therefore, the large amounts of manure produced by pig farms require efficient treatments (Moral et al., 2009). A possible solution to mitigate odour and ammonia emissions could be a direct injection of slurry into the soil. However, this could lead to problems by increasing denitrification and N_2O emission rates, which would contribute to raise the global N_2O production by agricultural practices. Doelsch et. al., (2009) proposed careful control of the chemical quality of the added organic matter to the soil as an effective waste management option, because it offers a significant environmental saving at the global scale of resources, and reduces pollution. The quality of a manure as N fertilizer is difficult to predict, since manure composition may vary widely according to the diet, and other management factors (Van Kessel and Reeves, 2002). The pre-treatment of organic residues, such as manures and pig slurry, may improve their agricultural value and environmental quality. For example, aiming to preserve, as far as possible, the nutrients in the soil-plant system has the potential to mitigate greenhouse gas emissions and enhance carbon (C) sequestration. Composting is a cheap, efficient and sustainable treatment for solid wastes that is an effective process for reducing fly and odour problems in manures (Cook et al., 1997) and promoting a reduction in the proportion of C and N in soluble form (Gigliotti et al., 2002). Co-composting strategies and use of additives during composting are presented as feasible options for the improvement of compost quality. Co-composting results may be particularly interesting when two wastes of very different C:N ratios are combined, as in the case of olive mill waste and sewage sludge. Pig slurry has been co-composted with other wastes in recent years, using the solid phase of pig slurry and, for example, forestry wastes (Ribeiro et al. 2007). The co-composting of wastes from piggeries promoted a reduction in the risk of phytotoxicity by a decreasing Cu and Zn concentrations, and reducing the NH_4^+-N concentration (Tiquia and Tam, 1998). There are other wastes arising from urban lifestyles that have become serious problems in large cities, which have high nutrient contents of N, P and C. Thus these wastes could be co-composted with pig slurry and pig manure. Sewage sludge can supply an adequate amount of organic matter to enhance the beneficial values of pig slurry. Sewage sludge has been previously co-composted with other type of waste such as olive mill wastes (Sánchez-Arias et al. 2008), coal fly ash (Fang et al. 1999) or municipal solid waste (Lu et.al. 2009). The beneficial effects of composted sewage sludge on soil characteristics have been reported (Sastre et al. 1996). Usually studies relating to the effect of organic wastes on soil properties have been evaluated at particular intervals. There are few detailed studies on how amendments impact on soil processes determined by the crop cycle according to seasonal fluctuations. The synchronization of N supply from exogenous organic matter with plant requirements in agricultural systems can be particularly important, especially when mineral N inputs are limited or excluded (Palm et al. 2001). The aim of our study was to analyze the behaviour of the organic residue (X) over the seasons and different physiological states of almond tree plantation, evaluating the changes in the soil chemical characteristics.

TABLE 1 **Soil and compost physicochemical characteristics**

	pH	E.C.	N	P	O.M.	C/N	K	Na	Ca	Mg	Cd	Cu	Pb	Zn	Ni	Cr
		dS/m	%	mg/kg	%			mg/kg					mg/kg			
Soil	8.58	0.20	0.11	21.80	1.43	7.23	374	17	9708	142	0.48	14.93	9.99	41.13	21.20	70.63
Compost	7.74	10.90	2.04	740.12	28.25	8.03	5123	1777	13334	2185	0.79	383	87	411	23	32
									Compost classification according to heavy metal content RD							
										Groups	**Cd**	**Cu**	**Pb**	**Zn**	**Ni**	**Cr**
										A	0.7	70	45	200	25	70
										B	2	300	150	500	90	250
										C	3	400	200	1000	100	300

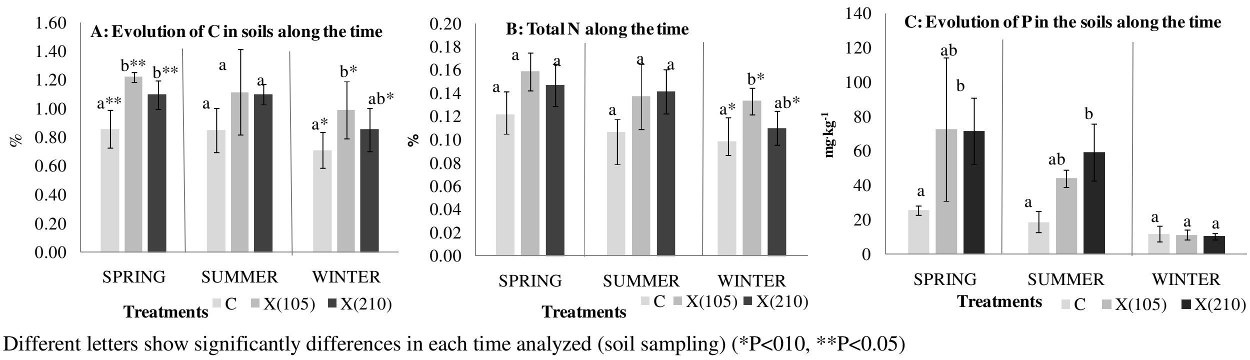
2 MATERIAL AND METHODS

<u>Site descripticon and soil sample collection.</u> A field study was established in Son Cos (Majorca), in a field of almond trees (*Prunus dulcis* (Miller), var. Ferragnes. An experiment with 9 plots of 420 m^2 was conducted from February 2008 to February 2009 on a highly calcareous loam soil developed over limestone, (Table 1). For each soil sampling event, 4 soil sub-samples were taken from each plot to a depth of 30 cm and bulked.

<u>Organic waste characterization.</u> The organic residue obtained after of co-composting had an alkaline pH and EC of c. 10 dS/m. The co-composting increased the values of N (2%) and P (740 mg kg^{-1}) compared to those values of each waste alone. The heavy metal concentrations were also increased, with concentrations of Zn and Cu equivalent to group C according to RD 824/2005 (Table 1). At these values of heavy metals, compost application should be restricted. However, this was a short term experiment to evaluate the suitability of the compost as a fertilizer.

<u>Treatments and measurements</u>. Compost (X) was applied by a roto-tilling in the Son Cos´soil at two rates of application based on the N content of the organic waste (105 and 205 kg N ha^{-1}). Each compost treatment was in triplicate and there were three plots without organic fertilization used as control soil (C).

The soil chemical characteristics – pH, EC, total nitrogen, phosphorus, available nutrients (Ca, Mg, Na and K) and heavy metals were analyzed according to the Spanish Soil Methodology (MAPA, 1994). The NO_3^- in soil was extracted by 2 M KCl in a ratio 1:10 (g/ml) and analyzed by a colorimetric method through a LACHAT Autosampler (XYZ Autosampler, ASX-400 series). Data were analyzed using a one-way ANOVA through the statistical programme STATGRAPHIC 4.1.. Means were separated by Duncan's comparison of mean at the P < 0.05 and P<0.10 levels.



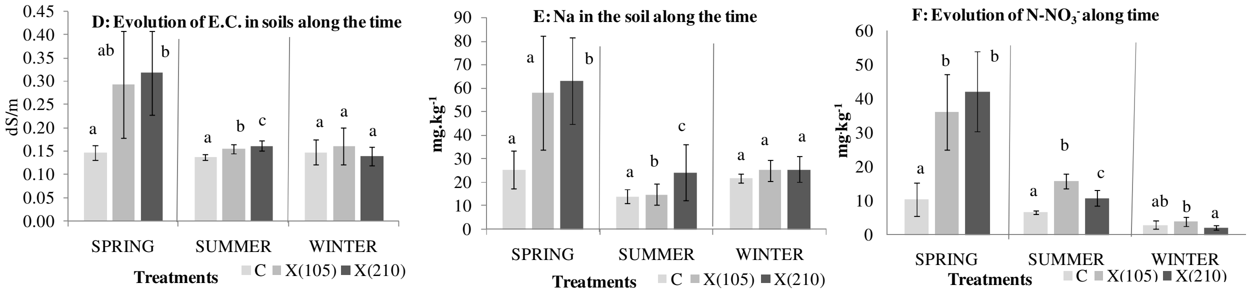
Different letters show significantly differences in each time analyzed (soil sampling) (*P<010, **P<0.05)

FIGURE 1 **Evolution of soil nutrients over time**.

3 RESULTS

Differences among treatments (105 and 210 kg N ha^{-1}) varied for the measured soil properties according to time of sampling. For example, both treatments increased soil C when sampled in spring, but there were no differences at the summer sampling. At the winter sampling, soil C was higher for X105, but not for X210 (figure 1A). The same applied for soil total N at the winter sampling (figure 1B). Among the soil macro-nutrients, uniquely, available P concentration significantly increased in spring and summer following compost incorporation into the soil, with no effect of application rate (figure 1C). In spring, the incorporation of X significantly increased soil EC (figure 2D), with a significant effect of rate at the summer sampling. Similar results were observed for soil nitrate (figure 2F).

Highest concentrations of available Na were from the higher application rate (X210) during the spring soil sampling (figure 2E). There were significant interactions between the three factors analyzed (treatment with organic residue, application rate and the soil sampling time) ($P<0.05$) for some of the soil chemical characteristics. For available Ca and K there was no significant effect of compost application within in each soil sampling, but across all timings the concentrations in the soil treated with X at both rates in the spring were significantly different from the rest.



Different letters show significantly differences in each time (soil sampling), $P<0.05$.

FIGURE 2 **Soil parameters over time**.

TABLE 2 **Heavy metals content in soils after 1 year of the X application**

	Cd	Zn	Ni	Cr	Pb	Cu
	mg .kg^{-1}					
C	0.26±0.07a	49.67±8.19a	34.20±7.71a	41.27±14.57a	11.31±3.82a	19.21±1.58a
X(105)	0.33±0.17a	47.63±3.66a	25.60±4.47a	30.30±7.46a	12.00±1.00a	18.33±3.21a
X(210)	0.23±0.04a	46.62±5.67a	26.39±8.59a	29.13±5.91a	9.24±2.56a	21.26±3.66a

Compost application at a rate of 105 kg N ha^{-1} (corresponding to 5 t ha^{-1}) over 1 year significantly increased ($P<0.10$) the soil N and organic matter content, compared with the untreated soil (figure 1B). The rest of the soil parameters analyzed (pH, EC, available cations and phosphorous, heavy metals (table 2) and nitrate content), did not show significant changes in comparison to the soil without organic fertilization.

4 CONCLUSIONS

A year of compost application promoted soil C and N, without adversely affecting the heavy metals content of the soil. Available phosphorus, uniquely, increased over the short to medium term following organic residue application (spring and summer). The compost application rate only had a significant effect on the EC, available Na and NO_3^- content in summer. The application of pig residue (slurry and manure) previously co-composted with sewage sludge to the soil may be a viable management option, improving the quality of the soil amendment and reducing the polluting potential of the pig slurry.

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