Agronomic use of compost from decentralised urban composting models in lettuce production: yield and crop development

C. Álvarez-Alonso[1], M.D. Pérez-Murcia[1], N. Manrique[1], E. Martínez-Sabater[1], S. Sánchez-Méndez[1], F.J. Andreu-Rodríguez[1], I. Irigoien[2], M. López[3], Raúl Moral[1], M.A. Bustamante[1]

[1]CIAGRO, Miguel Hernández University, EPS-Orihuela, ctra. Beniel, Km 3.2, 03312, Orihuela, Alicante.
[2] Department of Agricultural Production, Public University of Navarre (UPNA-NUP), Pamplona, Spain
[3] Universitat Politècnica de Catalunya (UPC), Campus del Baix Llobregat, Edifici D4, C. Esteve Terradas, 8 08860, Castelldefels, Spain

Keywords: compost, community composting, agriculture, fertilization, crop, SPAD, CANOPY.
Presenting author email: cristina.alvareza@umh.es

Introduction

In recent years, there has been a shift in municipal organic waste management models from a linear model based on resource consumption and waste generation to a circular model where waste is considered as a new resource. This shift, together with new European policies aimed at increasing recycled bio-waste streams, has led to the emergence of new composting models (Storino et al. 2018). Decentralised urban composting models, as a method of managing separately collected organic waste, allows us to reduce environmental pollution from unsustainable management, recover essential nutrients for crops, and thus reduce the consumption of chemical fertilisers in agriculture (Álvarez-Alonso et al. 2023). In this work, the composts obtained from these new composting models (community composting and decentralised urban composting) was used for lettuce production to demonstrate its ability to replace inorganic fertilisers without compromising optimal crop development.

Material and methods

Four composts (2 from community composting and 2 from decentralised urban composting) were prepared from the organic fraction collected separately from municipal waste (OFMSW) mixed with urban pruning waste (UP). OFMSW and the respective UP came from the decentralised composting plants located at Lumbier (Navarra) and Sort (Catalonia), respectively, whereas for the community composting model the wastes came from the municipalities of Fontanars de Alforins and Carrícola (Valencian Community). The main agronomic characteristics of these composts are shown in Table 1.

Table 1: Agronomic characteristics of compost on a dry weight basis.

Parameters	Lumbier	Sort	Fontanars	Carrícola
pH	7.7	8.1	8.2	8.7
EC (dS m^{-1})	1.1	5.2	3.2	6.1
TOC/TN	13.0	11.1	13.3	12.0
TN (%)	1.9	2.9	1.8	2.1
P_2O_5 (%)	1.5	1.3	2.1	1.7
K_2O (%)	0.9	2.2	1.1	2.5
Na (g kg^{-1})	1.3	5.5	3.3	7.0
Ca (%)	11.3	5.1	15.3	13.7
Mg (%)	0.4	0.3	0.9	1.4
Potentially toxic elements				
Cu (mg kg^{-1})	32.0	39.1	20.8	56.9
Zn (mg kg^{-1})	104	102	66.1	83.7
Cr (mg kg^{-1})	70.7	52.8	22.0	54.2
Cd (mg kg^{-1})	0.3	0.5	0.4	0.3
Pb (mg kg^{-1})	15.1	15.9	9.1	20.6
Ni (mg kg^{-1})	19.4	18.6	7.3	18.2
Maturity and stability parameters				
CEC (mep $100g^{-1}$ OM)	89.9	99.5	101	102
GI (%)	115	99.1	109	51

Self-heating test (Brinton et al. 1995)	V, Stable	V, Stable	V, Stable	V, Stable

EC: electrical conductivity; OM: organic matter; TOC: total organic carbon; TN: total nitrogen.

A pot experiment was carried out with a lettuce crop (*Lactuca sativa L.*) var. *Little Gem Incitatos*. The soil used was a clay loam soil collected from the Experimental Farm of the University Miguel Hernández (Orihuela, Spain), after passing through a 5 mm sieve to remove large particles and possible plant debris. The pots used (1178.4 cm^3) were filled with 1000 g of the above soil and then the appropriate quantities of each treatment were added and mixed to meet the nutrient requirements of the crop (210 kg N ha^{-1}). In addition to the compost treatments of both models, an inorganic fertiliser NPK 15-15-15 and a control treatment without fertilisation were also established. The water status of the crop was maintained at 50% of the water holding capacity of the soil by adding at the beginning of the experiment the amount of water necessary to maintain these conditions (140 g H_2O pot^{-1}). The pots were placed in a controlled environment room with an average temperature of 21°C, 60% relative humidity and a 12 h photoperiod with artificial lighting. The treatments were carried out in triplicate, with pots randomly arranged in the chamber and watered twice a week. During the experiment, parameters indicative of crop development, such as plant cover (CANOPY) and leaf chlorophyll intensity (SPAD) were monitored every 15 days. The duration of the experiment was 60 days, after which the lettuce plants were harvested to determine the crop yield.

Results and discussion

The use of the different composts on lettuce production showed a general improvement in crop development, as it was previously observed by other researchers (Vico et al. 2020). CANOPY showed a gradual increase in all treatments during the 60 days of the experiment. The final values in all treatments were higher than in the control treatment, which shows a better development of the crop (Wang et al. 2024). The compost treatments of the community model were the ones with the best final values. In the case of leaf SPAD, an increase was also observed over the course of the experiment. However, the final SPAD values obtained were higher than in the control treatment only for the composts from the community composting model and with the inorganic fertiliser treatment. Finally, plant yield at harvest was higher in all treatments compared to the control treatment without fertilisation.

Conclusions

The management of bio-waste through decentralised urban composting and community composting models makes it possible to obtain final composts with fertilising capacity and physico-chemical, chemical and biological characteristics compatible with their use in agriculture, without causing risks to human health and the environment. The agronomic use of this type of compost is presented not only as a sustainable management method, but also as an alternative to the use of mineral fertilisers in lettuce cultivation, allowing us not only to use a wasted waste stream, but also to increase the circularity of agriculture reducing the consumption of inorganic fertilisers.

Acknowledgements

This research has been financed in the framework of the research project NEOCOMP (ref. PID2020-113228RB-I00) funded by MCIN/ AEI /10.13039/501100011033 and, also it was supported by the Spanish Ministry of Science and Innovation with a PhD scholarship to the first author (FPU21/01207). The authors would also like to thank the Consorcio de Residuos COR-V5, JoseneaBio S.L.U. and Pallars Sobirá Composting Plant for its participation in this study.

References

Alvarez-Alonso, C., Pérez-Murcia, M.D., Sánchez-Méndez, S., Martínez-Sabater, E., Irigoyen, I., López, M., Nogues, I., Paredes, C., Orden, L., García-Rández, A., M. A. Bustamante, 2023. Municipal solid waste management in a decentralized composting scenario: assessment of the process reproducibility and quality of the obtained composts. Agronomy 2024, 14, 54. https://doi.org/10.3390/agronomy14010054

Brinton W.F., Evans E., Droffner M.L., Brinton R.B. 1995. A standardized Dewar test for evaluation of compost self-heating. Biocycle. 36.

Storino, F., Plana, R., Usanos, M., Morales, D., Aparicio-Tejo, P., Muro, J., Irigoyen, I., 2018. Integration of a Communal Henhouse and Community Composter to Increase Motivation in Recycling Programs: Overview of a Three-Year Pilot Experience in Noáin (Spain). Sustainability 10, 690. doi:10.3390/su10030690

Vico, A., Sáez, J.A., Pérez-Murcia, M.D., Martínez-Tomé, J., Andreu-Rodríguez, J., Agulló, E., Bustamante, M.A., Sanz-Cobena, A., R. Moral. 2020. Production of spinach in intensive Mediterranean horticultural systems can be sustained by organic-based fertilizers without yield penalties and with low environmental impacts. Agricultural Systems, 178, 102765. https://doi.org/10.1016/j.agsy.2019.102765

Wang, Z.; Nie, T.; Lu, D.; Zhang, P.; Li, J.; Li, F.; Zhang, Z.; Chen, P.; Jiang, L.; Dai, C. 2024. Effects of Different Irrigation Management and Nitrogen Rate on Sorghum (Sorghum bicolor L.) Growth, Yield and Soil Nitrogen Accumulation with Drip Irrigation. Agronomy 2024, 14, 215. https://doi.org/10.3390/agronomy14010215