Dynamic composting optimization through C/N ratio variation as a start-up parameter

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Abstract

Different organic wastes (tomato, melon, olive mill wastes and sheep manure) were mixed to make better use of tomato waste. The objective of this study was to evaluate the effect of C/N ratio on the quality of the produced compost. The four studied C/N ratios (treatments) were: C/N=25; 30; 35 and 40. Results revealed that the treatment C/N=35 has resulted in the highest oxygen consumption and also, the longest thermophilic phase. Treatments C/N=25 and 35 have reached optimal C/N ratios at the end of the process (respectively 11.88 and 14.71). The effect of compost on Cresson and phytotoxicity test showed that treatment C/N=35 has produced the most mature compost. The amendment of compost has reduced the pH, increased the EC, and enriched soil with organic matter as far as the rate of the amendment is increasing (10; 20 and 30 Tonnes.ha-1). The quality of the produced compost depends largely on the level of C/N startup ratio and also the quality of its constituents within the mixture.

Introduction

In Souss Massa region, the production of plant by-product has reached 1 307 465 tons in 2011. The analysis of organic wastes macro elements (NPK), reveals that the economic loss to win has been evaluated to more than 6 M€ with about 4000 tons of nitrogen, 1000 tons of phosphorus and 9200 tons of potassium per year; what constitutes for soils a source of important fertilization backup. Compost quality is closely related to its stability and maturity, and their indicators that have been used in composting studies include C/N ratio, microbial activity, germination index, cation exchange capacity (CEC), humic substances content…etc. Generally, composting could be carried out under a wide range of initial C/N ratios, namely, 11 to 105, depending on the starting materials. Therefore, the aim of this study was to investigate the influence of different C/N ratios on dynamic composting piles of horticultural wastes in terms of compost quality tests and its agronomic performance.

Material and methods

<u>*Experimental site and raw material preparation*</u>

Experiments were carried out at the Centre of Technology Transfer (APEFEL professional Association) in Souss-Massa region (Morocco) 25 km to the south of Agadir city. The choice of wastes to be composted was based on their availability and the adoption of logic of recovery and the use of their additional carbon and nitrogen content. Four types of wastes were selected: end cycle tomato plants; melon wastes; olive mill wastes and sheep manure. Raw materials were ground using silage brewer, and representative triplicate samples were taken for physical and chemical analysis (table 1) prior to mixture using formula below given by Soudi (2005).

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Table 1. Physical and chemical characteristics of raw materials

Organic wastes	Total Carbon (%)	Total Nitrogen (%)	C/N ratio	Moisture content (%)
Tomato wastes	39.20 ± 0.65	0.78 ± 0.19	50.25 ± 0.68	26 ±1.98
Melon wastes	30.46 ± 0.53	1.47 ± 0.23	20.72 ± 0.79	17 ± 1.56
Sheep manure	38.00 ± 0.76	2.00 ± 0.27	19.00 ± 0.84	32 ± 1.78
Olive mill waste	34.62 ± 0.45	0.87 ± 0.14	39.79 ± 0.97	36 ± 2.21

$$\frac{C}{N}(mixture) = \frac{\sum_{n=1}^{\infty}(Q_n\,[C_n(100 - M_n)])}{\sum_{n=1}^{\infty}(Q_n\,[N_n(1 - M_n)])}$$

C/N (mixture): C/N ratio of the resulting materials to compost
Q_n: Quantity of the fresh materiel (n)
C_n: Total carbon content of the dry materiel (n)
M_n: moisture content of the fresh materiel (n)
N_n: Total nitrogen content of the dry materiel (n)

Experimental design & Treatments description
Using the previous formula has resulted in the composition (fresh weight/ fresh weight) of the following four treatments:

Table 2. Proportion of raw material used to constitute the treatments

Treatments (C/N ratio)	Proportion (% w/w of fresh matter)			
	Melon waste	Sheep manure	Olive mill waste	Tomato waste
25	10	55	5	30
30	10	30	20	40
35	5	20	20	55
40	5	10	15	70

Moisture content was adjusted to 55 % initially and maintained approximately between 50 to 60 % using fresh water. Aeration of the compost piles was done through periodic turning every 7 to 10 days, in addition to daily forced ventilation (2 hours per day). Samples were collected from at least 70 cm depth at the shaded pile side at 1, 11, 21, 53, 73, 109 and 172 days, through a composite 3 subsamples of 2 kg of each. All the samples were put in a plastic bag, weighted for moisture content after its drying at 105°C during 48 hours in the oven (Pétard, 1993) prior to laboratory analysis.

Monitoring parameters and quality of compost
Temperature, moisture content and oxygen percentage inside the pile were measured daily using multiparametric probes (Green Mountain Technologies, USA) at 1 meter depth in three point of each treatment pile. Samples were sieved (Ø= 2 mm) and analysed for following parameters; pH; EC; Total Organic Matter; NTK; Mineral nitrogen (N-NO3 and N-NH4); Phosphorus; Potassium; Calcium; Magnesium; Humic and fulvic acid content. The quality of compost was evaluated with three methods (i) germination assay (ii) cress test and (iii) green bean growth bioassay.

Statistical analysis

All statistical analyses were performed using Minitab 13.0 Fr software. The multiple comparisons of means were confirmed by Tukey's test (at $P < 0.05$).

Results

The evolution of the temperature at the beginning of the composting process shows that the temperature is different depending on the composition of the pile (Figure 1). Thus the temperature is higher for the lowest C/N ratio with 65, 56, 54 and 47 °C respectively for C/N 25, C/N 30, C/N 35 and C/N 40. Thermophile phase (T°>60 °C) lasted 5, 7, 11 and 7 days respectively with C/N 25, C/N 30, C/N 35 and C/N 40.

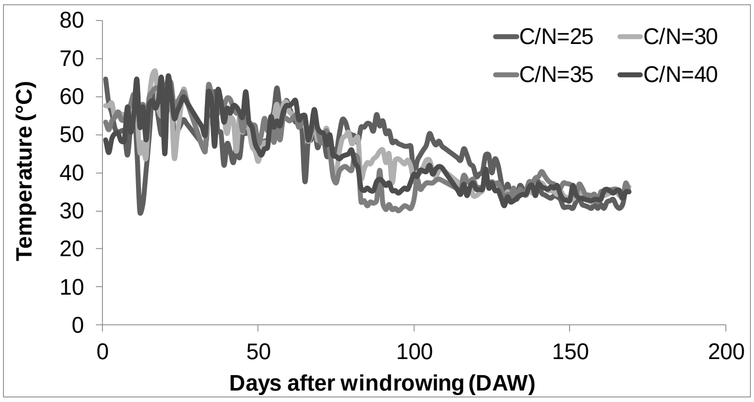

Figure 1. Temperature evolution at piles center

After windrowing, a drastic decrease of C/N ratio is observed for the all the treatments till the 20th DAW. During the composting process, the C/N ratio decreases slightly in all the treatments to 11.88, 17.93, 14.70 and 18.84 respectively for initial C/N ratios C/N 25, C/N 30, C/N 35 and C/N 40. All the evolution patterns conserve their order with respect to their initial C/N ratio.

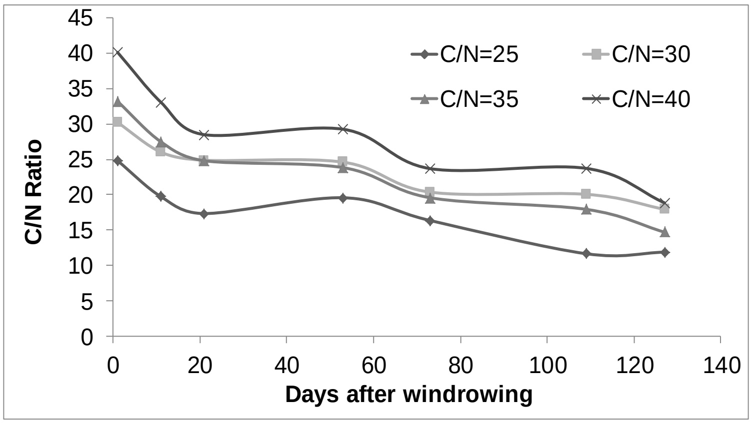

Figure 2. C/N ratio evolution

Germination assay (Table 3) has shown that C/N 35 compost has resulted in the highest percentage of germination among all the treatments with 60 % of germinated seeds. Similarly, C/N 35 has resulted in the highest germination percentage of the cress test with respect to the other treatments with about 90 % after 7 days culture of watercress seeds.

Table 3. Percentage of cress seeds germination after 3 and 7 days seeding

Treatments	3 days after seeding	7 days after seeding
Control (peat moss)	62 ± 2,31 **ab *****	86 ± 2,31 **a*****
C/N 25	61 ± 3,83 **b**	74 ± 9,52 **ab**
C/N 30	69 ± 3,83 **a**	82 ± 5,16 **a**
C/N 35	69 ± 5,03 **a**	90 ± 8,33 **a**
C/N 40	44 ± 4,62 **c**	54 ± 9,62 **b**

Discussion

The difference in piles temperature can be explained by the ratio of manure that increase while initial C/N decreases. Manure contains high nitrogen level and already fermentable what promotes early microbial activity with lowest C/N ration. The decrease of the C/N ratio observed during the first 20 DAW is in conformity with Mustin (1987) who stated that C/N ratio decrease due to the release of carbon as CO_2. The treatments of initial C/N ratio 40 has kept his order as the highest C/N ratio after windrowing, and this can be explained by its high value of recalcitrant organic matter in comparison with the other treatments. Treatments C/N 30 and 35 has resulted in the highest germination percentage, and were comparable to the control, this effect is maybe due to the high level of stability reached after composting.

Suggestions to tackle with the future challenges of organic animal husbandry

The economic growth and the rising of consumption demand in the world, have led to more and more important production of manure due to an important of the animal husbandry intensification. This unmanaged manure, can lead to serious sanitary and environmental complications. Composting is a type of waste processing that has gained increasing acceptance over the years thanks to the carbon sequestration to the depleted soils. Consequently, compost maturity is the most essential criterion in recycling animal manure, as well as its marketing and utilization in agriculture as organic amendments.

References

Mustin, M., 1987. Le compost: La gestion de la matière organique. Francois Dubusc, Paris. 954p.

Pétard, J. (1993). Les méthodes d'analyse -Tome1- analyses de sols. L'institut français de recherche scientifique pour le développement en coopération centre de Nouméa.

Sanchez-Monedero, M. A., A. Roig, C. Paredes, et M. P. Bernal. (2001). Nitrogen transformation during organic waste composting by the rugers system and its effects on pH, EC, and maturity of the composting mixtures. Bioressource Technology, 78:301-308.

Soudi, B. (2005). The composting of cattle manure and crop residues from greenhouse production system. Newsletter of Transfer of Technology in Agriculture, PNTTA N°129, June 2005.