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RESEARCH ARTICLE

Stability and maturity of maize stalks compost as affected by aeration rate, C/N ratio and moisture content

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Abstract

To estimate the order of importance of factors affecting the stability and maturation of compost, cow feces and maize stalks were co-composted at different aeration rates “AR” (22, 44 and 66 L kg^{-1} DM . min^{-1}) of C/N ratios (16, 19, 22), and moisture contents “MC” (60 %, 65 %, 70 %). A composting process was monitored by physical and chemical methods. The thermophilic phase with all treatments was long enough to meet sanitation requirements. The emitted carbon dioxide and the losses total organic carbon and total extractable carbon increased with increasing aeration rate, there was a significant difference between the treatments with low and high aeration rate, but no significant differences between those two treatments and the moderate aeration rate. The total nitrogen contents of all treatments decreased during the thermophilic phase, while it was increased after that for all treatments except T8. The compost with the highest initial C/N ratio was significantly different from the other treatments and had the highest values of humic substances, degree of humification and humification rate. The compost with the lowest initial C/N ratio was significantly different from the other treatments and had the lowest germination index (57–67%). Aeration rate was the main factor influencing compost stability, while the C/N ratio mainly contributed to compost maturity, and the moisture content had an insignificant effect on the compost quality. The recommended parameters for composting are an aeration rate of 0.44 L kg^{-1} DM. min^{-1} and a carbon to nitrogen ratio of 19 with moisture content of 60–70%.

Keywords: Composting, agricultural waste, compost, quality, stability, maturity

1. Introduction

The amount of cow waste generated in Egypt has increased dramatically with the rapid development of cow farms. These wastes can cause hygiene hazards, odor pollution, and ground and surface water pollution from the leaching of pollutants, if not properly treated. Also, increased use of animal waste has brought hygienic aspects into focus, particularly the need to significantly reduce pathogen content. Manure composting involves the breakdown of complex and simple organic materials by aerobic microorganisms (Novinscak *et al*, 2007). On the other hand, agricultural wastes in Egypt are considered a big problem facing farmers and officials. The amount of these wastes is about 14 million tons annually. These amounts of crop residues are burnt in several governorates. It is environmentally undesirable and is practiced by farmer. Average crop residues of maize stalk in Egypt are 4.1 million tons

(Badawi and Tantawi, 2004). Bulking agents are always required to modify the properties of animal manure during composting because of the high moisture contents, low C/N ratio and high density of animal manure. The maize straw is rich in carbon and has a low density and low moisture content, making it suitable for use as a bulking agent during composting (Kumar *et al*, 2010).

As an agricultural country, Egypt needs large amounts of organic fertilizers to improve crop yields and quality, and maintain or increase the nutrient status of soil and improve its structure. Fresh cow feces are a valuable resource for organic fertilizers because of their high organic matter and nutrient content. However, fresh cow waste is unsuitable for direct land application because of the unstable organic matter, pathogens, weed seeds and the difficulties associated with preservation and transportation. Composting is an effective and economical method for the treatment of animal manure prior to land application, in which pathogens and weed seeds are destroyed and the highly heterogeneous solid state organic matter is transformed to more stable and mature humic substance by the activity of bacteria, epiphytes and actinomycetes (Badawi and Tantawi, 2004). Also, stable and mature compost can be applied to soil as an organic amendment to improve plant growth and soil fertility, as well as enhancing the function of soil for carbon sequestration. However, the application of unstable and immature compost would fix nitrogen in the soil and restrict plant growth by competing for oxygen in the rhizosphere and releasing toxic substances (Bernal *et al*, 2009).

The stability and maturity of compost are often referred to as the compost quality. The stability typically refers to microbial activity and can be defined by the emitted carbon dioxide, the heat released, respiration index or the conversion of various chemical species in compost organic matter (Gao *et al*, 2010), while maturity refers to the amount of degradation of phytotoxic organic substances and is generally measured by the germination index or plant bioassays (Said-Pullicino *et al*, 2007). However none of these methods give an absolute parameter. Compost is a very heterogeneous biomass and the different chemical methods exploited to determine maturity level are only suitable for certain families of materials. Govi *et al*. (1993) reported a poor correlation between the degree of humification (DH), compost protein and hemicelluloses rich materials due to the formation of humic-like molecules. While Marco *et al*. (2004) found a high correlation between humification parameters and water-soluble carbon (WSC) that is possible to monitor the composting maturation process more easily and rapidly avoiding longer and more expensive analytical procedures.

The aeration rate (AR) is considered to be the most important factor influencing successful composting (Diaz *et al*, 2002). Insufficient aeration can lead to anaerobic conditions due to the lack of oxygen, while excessive aeration can increase costs and slow down the composting process via heat, water and ammonia losses. The optimal AR depends on the composition of the raw materials and ventilation methods (Bernal *et al*, 2009; Shen *et al*, 2011).

The initial carbon to nitrogen (C/N) ratio is one of the most important factors influencing compost quality. In general, initial C/N ratios of 25–30 are considered ideal for composting (Kumar *et al*, 2010). However, recently some researchers have successfully carried out composting at lower initial C/N ratios (Ogunwande *et al*, 2008). Composting at lower initial C/N ratios can increase the amount of manure treated, but can also increase the loss of nitrogen as ammonia gas.

During composting, the moisture content (MC) is important for transporting the dissolved nutrients required for the physiological and metabolic activities of microorganisms. The optimum MC depends on the specific physicochemical properties and biological features of the materials being composted (Liang *et al*, 2003).

The interaction of these factors on composting has recently been studied by some researchers. The optimum MC was 60% during the composting of green waste and food waste at a low C/N ratio (19.6) (Kumar *et al*, 2010), while and the optimum conditions for the composting of poultry manure with wheat straw were an initial MC of 70% and an AR of 0.54 L min^{-1} kg^{-1} OM (Petric and Selimbašic, 2008).

Although several researchers have studied the effects of AR, C/N ratio and MC on the quality of compost, they have focused on one or two influential factors, with few studies designed to address the interaction and order of preference for different factors impacting the composting process. Therefore, an orthogonal test was used to investigate the main factors affecting the stability and maturity of composted cow manure and maize stalks; AR (0.22, 0.44 and 0.66 L kg^{-1} DM min^{-1}, DM: dry matter); C/N ratio (16, 19 and 22) and MC (60%, 65% and 70%).

2. Materials and Methods

2.1. Feedstocks composition

This study was carried out at the beginning of March 2013 in greenhouse of the Experimental Farm, Faculty of Agriculture, Menoufia University, Shebin El-Kom, Egypt. Cow feces were taken from a cow farm located in Faculty of Agriculture, Menoufia University. The feces were collected on three consecutive days before the trial started. Maize stalks were obtained from a research station at the Faculty of Agricultural, Menoufia University. The maize stalks were passed through a cutting mill by using threshing machine to generate pieces ranging from 1 to 5 cm. The moisture content (MC), total organic carbon (TOC), total nitrogen (TN), C/N ratio and total extractable carbon (TEC) of the feed stocks were determined before mixing to determine nitrogen ratios to be applied. The properties of compost raw materials were carried out according to Page *et al*. (1982) and the obtained data are shown in Table 1.

Table 1. Some properties of cow feces and maize stalks.

Materials	Moisture content (%)[a]	TOC (gkg^{-1})[b]	TN (gkg^{-1})[b]	C/N (-)	TEC (gkg^{-1})[b]
Cow feces	70.52 (1.5)[c]	353 (5.82)	26.50 (0.06)	13.32	180.5 (6.63)
Maize stalks	8.33 (0.01)	425 (8.30)	10.30 (0.12)	41.26	209.7 (7.42)

[a] Wet weight basis, [b] Dry weight basis, [C] Values in parentheses are standard errors (*n* = 3)

2.2. Experimental set-up and design

The composting reactors were 45 L plastic cylinders (57 cm high and 32 cm inner diameter) (Fig., 1). The vessels were consisted of two layers of plastic intermediated with a layer of glass wool to minimize heat loss. A removable plastic lid was fitted to the top of each vessel to facilitate filling with feed stocks and removing compost. On the lid, there were holes for inserting a temperature sensor and to connect the carbon dioxide trapping solution. The temperature sensor was connected to a temperature data logger (HI143 T-Logger) to auto-record the data. At the bottom of the reactors, a 3 mm plastic grid was installed to support the composting bed and insure uniform gas distribution. There were two holes in the bottom of the reactor for aeration (using a controllable aquarium pump) and leachate drainage.

This study was established as an orthogonal array test L_9 (3^4) lasting 60 days (Table, 2). Cow feces and the chopped maize stalks were mixed manually in different amounts to adjust the C/N ratios at 16, 19 or 22, and the initial MC values to 60%, 65% or 70%. Super phosphate (15.5 % P_2O_5) was mixed with all vessels by 7.0 kg/ton of each vessel as amendment. The ARs were 0.22, 0.44, and 0.66 L kg^{-1} DM min^{-1}. Air is entered through the compost mixture by aquarium pump. The aeration of all treatments was intermittent with 25 min of aeration followed by 5 min without aeration over the whole composting period (60 days). The compost vessels were turned on days 3, 7, 15, 30 and 45.

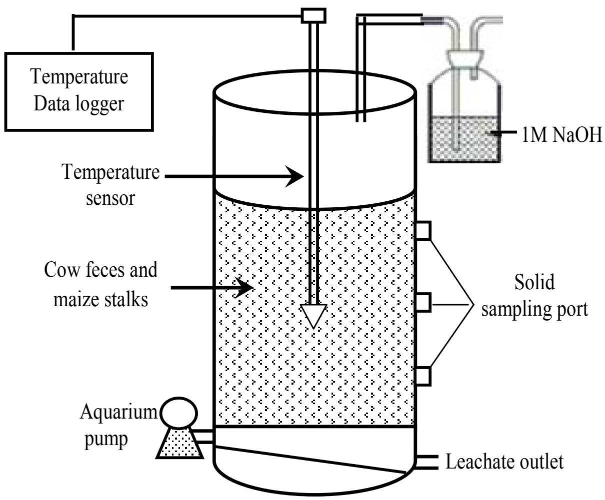

Figure 1. Schematic Diagram of the composting vessel.

Table 2. Design of experiment

Treatments	Moisture content (%)	Aeration rate[a] (L kg^{-1} DM min^{-1})	C/N ratio (-)
T1	60	0.22	16
T2	60	0.44	19
T3	60	0.66	22
T4	65	0.22	19
T5	65	0.44	22
T6	65	0.66	16
T7	70	0.22	22
T8	70	0.44	16
T9	70	0.66	19

[a] Aeration for 25 min, no aeration for 5 min

Table 3. Total organic carbon (TOC) and total nitrogen (TN) mass balance at the end of composting

Treatment	Total organic carbon (TOC)			Total nitrogen (TN)		
	Initial ($g\ kg^{-1}$ DM)	Final ($g\ kg^{-1}$ DM)	Δ TOC[a] (%)	Initial ($g\ kg^{-1}$ DM)	Final ($g\ kg^{-1}$ DM)	Δ TN[b] (%)
T1	369	315	44	23	27	22
T2	382	310	51	20	27	28
T3	398	345	54	18	26	32
T4	384	335	42	20	25	23
T5	404	361	56	18	28	29
T6	372	301	51	23	24	45
T7	406	360	47	18	26	19
T8	375	334	36	23	19	40
T9	385	332	50	20	25	36

[a] Based on initial carbon content, [b] Based on initial nitrogen content

2.3. Sample collection and analytical methods

Solid samples (about 200 g) were taken at the beginning, after each turning and end of composting. Five grams of each sample were taken for MC determination by drying at 105 ^{o}C to a constant weight. The remainder sample was divided into two parts. The first part stored at 4 ^{o}C and the second part was air-dried and grounded to pass through a 2 mm sieve. The dried and ground samples were analyzed in triplicate for total nitrogen (TN), total organic carbon (TOC) and total extractable carbon (TEC), humic-like acid fraction (HA) and fulvic-like acid fraction (FA). TOC was determined by the Walkley-Black Method; TN, by indophenols-blue method after the Kjeldahl digestion (Page *et al*, 1982).

Humic-like substances were extracted from the compost samples as described by Ciavatta *et al*. (1990) and the total extractable carbon (TEC) determined by wet dichromate oxidation. The extracts were fractionated into humic acids (HA) and fulvic acids (FA). After purification, the carbon content of each fraction was determined. Degree of humification (DH %) was calculated by using the following equation (Equation 1).

$$\mathrm{DH}\ (\%) = \left(\frac{\mathrm{HA+FA}}{\mathrm{TEC}}\right) \times 100 \qquad \text{(Eq. 1)}$$

Carbon dioxide produced by the compost is trapped by sodium hydroxide as sodium carbonate (Thompson *et al*, 2001). As shown in Figure 1, the carbon dioxide was trapped in a sodium hydroxide (1M NaOH) wash bottle (1 L) and then measured daily by titration with 1M HCl to a phenolphthalein endpoint, after adding excess 1M $BaCl_2$.

A water extract was prepared for the determination of the seed germination index (GI). Fresh compost samples taken at mixed with deionized water at a 1:10 ratio (mass ratio) and shaken for 1 h, then centrifuged at 4000 rpm for 20 min and filtered through 0.45 µm membrane filters. The GI was determined in triplicate using ten tomato seeds (*Lycopersicon esculentum* L.) and a water extract. Eight millilitre of the water extract was pipetted into Petri dishes (10 cm in diameter) packed with a piece of filter paper. Ten seeds were evenly scattered on the filter paper and incubated at 20 ± 1 ^{o}C for 48 h in the dark. Deionized water was used as a control. The GI was calculated by using the follows equation (Equation 2) (Rui *et al*, 2012).

$$GI\ (\%) = \left(\frac{\text{Seed germination of treatment (\%)} \times \text{root lenght of treatment}}{\text{Seed germination of control (\%)} \times \text{root length of control}}\right) \times 100 \quad \text{(Eq. 2)}$$

2.4. Statistical analysis

Data were analyzed by a one-way analysis of variance (ANOVA); the LSD-*t* test was used for significant difference testing. Pearson's correlation coefficient was used for the analysis of bivariate correlations. The SPSS 11.5 software for Windows was used for all statistical analyzes (SPSS Inc., 2002).

3. Results and Discussion

3.1. Temperature and carbon dioxide

Figure 2 shows the changes in the ambient temperature and composting temperature. The ambient temperature ranged from 20 ^{o}C to 30 ^{o}C. The composting materials went through the three typical degradation phases: mesophilic, thermophilic and curing. Increase temperature at the beginning may be due to high available carbon content which it provides a favourable condition for the growth and biological activity of microorganisms (Novinscak *et al*, 2007). The temperature tends to decrease after the thermophilic phase due to the loss of substrate and a decrease in microbial activity (Ogunwande *et al*, 2008). Because of the metabolism of the psychrophilic and mesophilic microbes, the temperatures of treatments with moderate and high ARs reached the thermophilic phase (>55 ^{o}C) within the first 1–7 d. The temperatures of the treatments with the low AR rose more slowly but remained above 60 ^{o}C for the longest time. This difference is because the lowest AR leads to a lower organic degradation rate and lower losses of moisture and heat. The thermophilic phase (>55 ^{o}C) for all treatments lasted longer than 7 d. After the easily degradable compounds were depleted, the composting entered the curing phase and the temperature slowly dropped (Shen *et al*, 2011). The statistical analysis showed that, the AR had a significant influence on the change in temperature (p = 0.021), but the MC and the C/N ratio did not significantly affect the temperature (p = 0.611, p = 0.133). The CO_2–C concentrations in the outlet air during composting (Figure 2) were significantly correlated to their temperatures (R = 0.350–0.941, p = 0.010–0.024). Carbon dioxide was mainly emitted during the thermophilic period because of the degradation of easily degradable carbon under vigorous bacterial and fungal activity. During the curing period, CO_2 emissions are related to the degradation of complex organic molecules such as lignin and lignocelluloses by some fungi and actinomycetes (Kumar *et al*, 2010). After composting, the CO_2 emissions from T1 to T9 were 180–470 g CO_2–C kg^{-1} of initial total carbon. Treatment T8 had the lowest CO_2 emissions indicating that a high MC and a low C/N ratio restricted organic degradation even at a high AR. This low degradation rate occurred because the large pieces of waste material (diameter 3 cm) combined with a low C/N ratio and high MC reduced the oxygen diffusion rate into the interior of the waste particles, reducing microbial activity (Shen *et al*, 2011; Rui *et al*, 2012). Also, the statistical analysis showed that neither the AR, C/N ratio nor the MC had a significant influence on CO_2 emissions. Wang *et al*. (2004) suggested that, the composts from cattle and pig manure were more stable when the respiration rates were below 1 mg CO_2–C g^{-1} DM d^{-1}. Higher CO_2 emissions indicate unstable compost that needs further decomposition. On day 40, the CO_2 emissions from treatments T1, T3, T5, T8 and T9 were 0.60–0.90 mg CO_2–C g^{-1} DM d^{-1}, but the emissions for the other treatments were 1.30–2.50 mg CO_2–C g^{-1} DM d^{-1}. The low CO_2 emission rate for treatment T8 was related to its low activity.

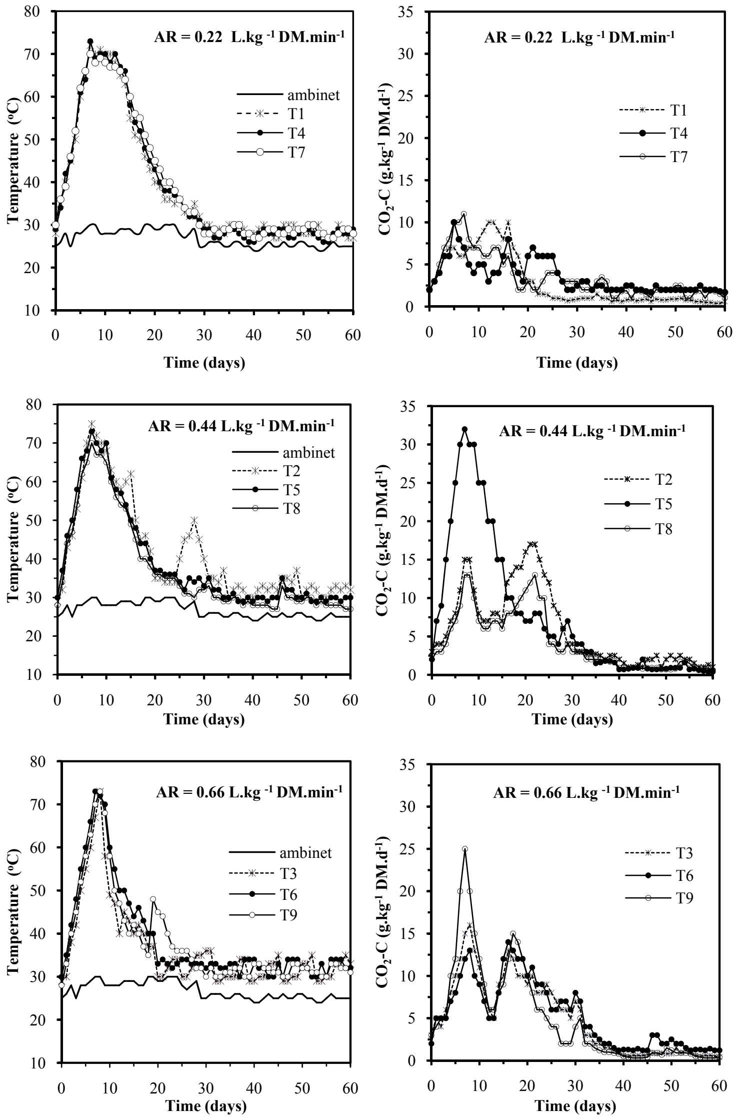

Figure 2. Temperature of the compost in the vessel and CO_2 content in the outlet air during composting (AR: aeration rate).

3.2. Total organic carbon and total nitrogen

The total organic carbon (TOC) contents of all treatments decreased during composting (is shown in Figure 3). As with the CO_2 emissions, the rates of decrease were greater during the thermophilic phase (60–95% of the total carbon loss) and less during the curing phase. Decreasing TOC content during composting process could be related to the mineralization of the organic matter by microorganisms. A total of 36–56% of the initial TOC (369–406 g kg^{-1} DM) was lost at the end of composting (Table 3). Higher TOC losses occurred with the higher AR except for treatment T8, which had low activity. At the end of composting, CO_2 was the main source of carbon loss, accounting for 70–85% of the total carbon losses. The remaining carbon losses were caused by the emission of CH_4 and other volatile organic compounds (such as methyl mercaptan and dimethyl sulphide) (Hanajima *et al*, 2010). The statistical analysis showed that AR (p = 0.032) had the most significant influence on the decreasing of TOC compared with the MC (p = 0.71) and C/N ratio (p = 0.42). There was a significant difference between the treatments with low and high ARs (p = 0.012), but no significant differences between those two treatments and the moderate AR (p = 0.075, p = 0.033). Thus, the obtained data conclude that higher ARs can cause higher organic carbon losses. These results are in agreement with those obtained by Rui *et al*. (2012). Figure 3 shows the variation in the TN content. The TN contents of treatments with moderate and high ARs decreased during the thermophilic phase because of intensive NH_3 volatilization, but only minor changes in TN were observed for treatments at the low AR. The TN increased after the thermophilic phase for all treatments except T8, because the rate of N loss as NH_3 was slower than, the rate of dry matter loss as CO_2 and water evaporation (Huang *et al*, 2006). The TN in treatment T8 decreased slightly, but had little variation after day 30, which is related to the minor losses of NH_3 by aeration coupled with the low carbon and vapour emissions due to the inactive state of the material. At the end of composting, the TN losses were 19% to 45% (Table 3). The statistical analysis showed that AR (p = 0.041) had the most significant influence on the nitrogen losses compared with the MC (p = 0.725) and C/N ratio (p = 0.437). There was a significant difference between the treatments with low and high ARs (p = 0.016), but no significant differences between those two treatments and the moderate AR (p = 0.472, p = 0.342). Thus, we conclude that higher ARs can cause higher nitrogen losses.

3.3. Humic substances and humification parameters

The total extractable organic carbon (TEC) and humified humic-like substances (HA + FA) content is detailed in Figure 4. This figure shows that TEC of the compost displayed a similar trend to TOC, which decreased rapidly at the first 15 days after composting process initiation. It was followed by a gradual decrease to below after 45 days until the end of incubation period (60 days). The analytical results in Figure 4 show that, the TEC level decreased from 184 to 147 g/kg in T1, from 192 to 155 g/kg in T2, from 199 to 172 in T3, from 192 to 163 g/kg in T4, from 202 to 180 g/kg in T5, from 180 to 143 in T6, from 203 to 180 g/kg in T7, from 185 to 167 g/kg in T8 and from 190 to 160 g/kg in T9 treatment. The highest decreasing rate of TEC appeared in T6 (66 $L.kg^{-1}$ $Dm.min^{-1}$ AR, 16 C/N and 65% MC), while the lowest one noticed in T8 characterized by 0.44 $L.kg^{-1}$ $Dm.min^{-1}$, 16 C/N and 70% MC. The statistical analysis showed that AR (p = 0.021) and C/N ratio (p = 0.035) had the most significant influence on the TEC losses compared with the MC (p = 0.725). There was a significant difference between the treatments with low and high ARs (p = 0.016), but no significant differences between those two treatments and the moderate AR (p = 0.714, p = 0.342). Also, high significant difference was occurred between the treatments with low and high C/N ($p = 0.013$), and no significant differences between those two treatments and the moderate C/N ($p = 0.632$, $p = 0.542$). Thus, we conclude that higher ARs and low C/N ratio can accelerate the degradation of organic carbon, and consequently cause higher TEC losses. As reported by Ciavatta *et al*. (1990) and Marco *et al*. (2004), different studied treatments confirmed that TEC decreased predominantly during composting due to the intense mineralization process. TEC fraction included all the easily mineralizable organic fractions and other more humified and hence more biodegradation resistant fractions (Huang *et al*, 2006). The content of humic acid-like substances (HA + FA) in the composts increased during the first phase (15 days), which it were decreased slightly after that until the end of incubation period (Figure 4). This increasing in the first phase could be due to either the formation of humic acid-like substances or the separation of these substances from other more complex carbon compounds (Huang *et al*, 2006). While decreasing rate in the latter phase may be related to high amount of insoluble compounds (Figure 4). Throughout composting, the highest values of humic-like substances (HA+FA) accompanied the highest C/N ratio treatments (T3, T5, T7), followed by moderate C/N ratio (T2, T4, T9) and finally C/N ratio (T1, T6, T8) treatments. The statistical analysis showed that C/N ratio ($p = 0.041$) had the most significant influence on the humic-like substances (HA+FA) variations compared with the ARs ($p = 0.625$) and MC ($p = 0.537$). Also, the compost with the highest initial C/N ratio was significantly ($P = 0.021$) different from the other treatments and had the highest values of humic-like substances. There is no significant difference between the treatments with low and high ARs ($p = 0.651$) and between those two treatments and the moderate ARs ($p = 0.802$, $p = 0.402$). Likewise, there are no significant differences between the treatments under different moisture levels. However, high significant differences were observed between either T3 (60% moist) or T5 (65% moist) and T7 (70% moist) MC ($p = 0.032$, $p = 0.022$), but no significant differences between T3 and T5 MC ($P = 0.633$). Continuously, the degree of humification (DH, %) of compost samples is illustrated in Figure 5, which it was increased with increasing time (except T8). Composts T8 showed a low maturation level , since DH% was 58.6; composts T2, T3, T5, T6 and T9 resulted to have reached a high maturation level (DH% > 70), while composts T1, T4 and T7 showed intermediate values of DH% (68.0, 65.0 and 63.3 respectively), indicating an incomplete stabilization of this composts. Throughout composting, the highest values of DH% accompanied the highest C/N ratio treatments (T3, T5, T7) and/or the moderate C/N ratio (T2, T4, T9), while the lowest C/N ratio treatments (T1, T6, T8) comes later. Also, high DH values observed for the treatments that have the highest aeration rate (0.66 $L.kg^{-1}$ $DM.min^{-1}$), while the lowest one recorded to the lowest aeration rate (0.22 $L.kg^{-1}$ $DM.min^{-1}$). However, the treatments treated with moderate moisture (65%) gave the highest values of DH compared with the other two moisture rates (60% and 70%).

3.4. Germination index (GI)

The GI is a sensitive indicator of maturity and phytotoxicity (Rui *et al*, 2012). Figure 6 shows the changes in GI for all treatments. The GIs of all treatments decreased slowly during the early phase. This drop may be attributed to the production of low molecular weight short chain volatile fatty acids (primarily acetic acid) and the release of toxic concentration of ammonia (Fang *et al*, 1999). The GIs increased with the decomposition of these toxic materials. The statistical analysis showed that the C/N ratio had a significant influence on GI ($P = 0.005$), but MC ($P = 0.762$) and AR ($P = 0.864$) were not important influential factors. No significant differences were found between the treatments with C/N ratios of 19 and 22 ($P = 0.331$), but both of those were significantly different from the treatments with a C/N ratio of 16 ($P = 0.003$, $P = 0.005$).

A GI of more than 80% indicates phytotoxic-free and mature compost (Rui *et al*, 2012). At the end of composting (60 days), the GIs for treatments with a C/N ratio of 22 (T3, T5, T7) were higher than treatments with a C/N ratio of 19 (T2, T4, T9) at the same AR, except the lowest aeration rate where the treatment with C/N ratio of 19 was higher than the treatment with a 22 C/N ratio. While both the treatments with C/N ratios of 19 and 22 were much higher than treatments with a C/N ratio of 16. The GIs of the treatments at the lowest C/N ratio (T1, T6, T8) were 57–67%, suggesting that a longer time was required to form mature compost when a low C/N ratio was used. This result is similar to that found by Huang *et al.* (2006), who used two static aerobic piles (initial C/N ratios of 15 and 30) to compost pig manure, and found that at day 63, the GIs were 46% and 85% for C/N ratios of 15 and 30, respectively. The GIs of all treatments with moderate and high C/N ratios except T7 exceeded 80%. The high MC (70%) and low AR (0.22 L kg^{-1} DM min^{-1}) in treatment T7 restricted the decomposition of toxic compounds.

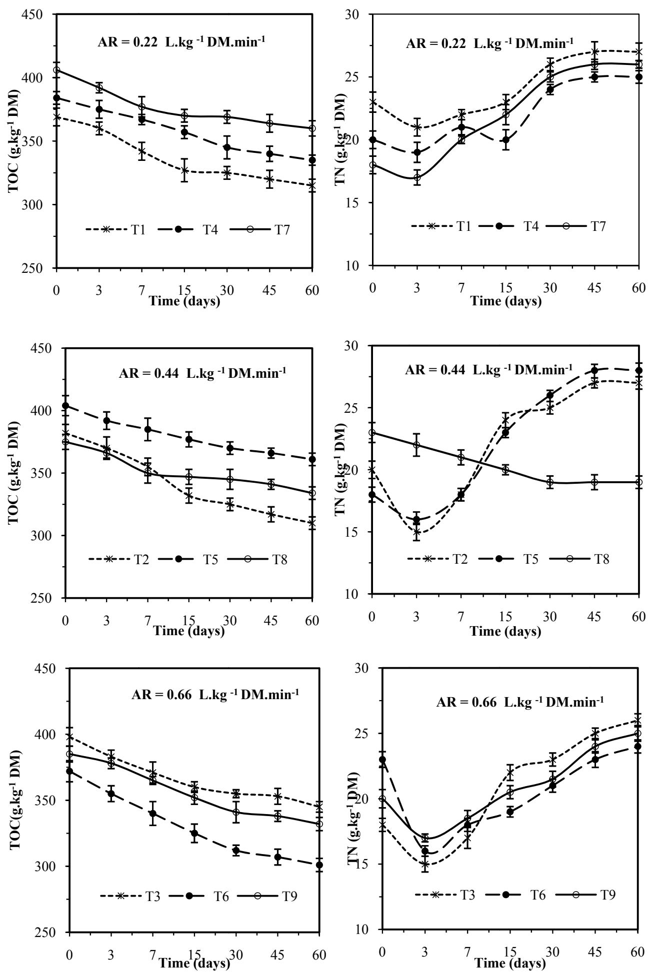

Figure 3. Total organic carbon (TOC) and total nitrogen (TN) during composting (AR: aeration rate).Values are means ± standard error (*n* = 3).

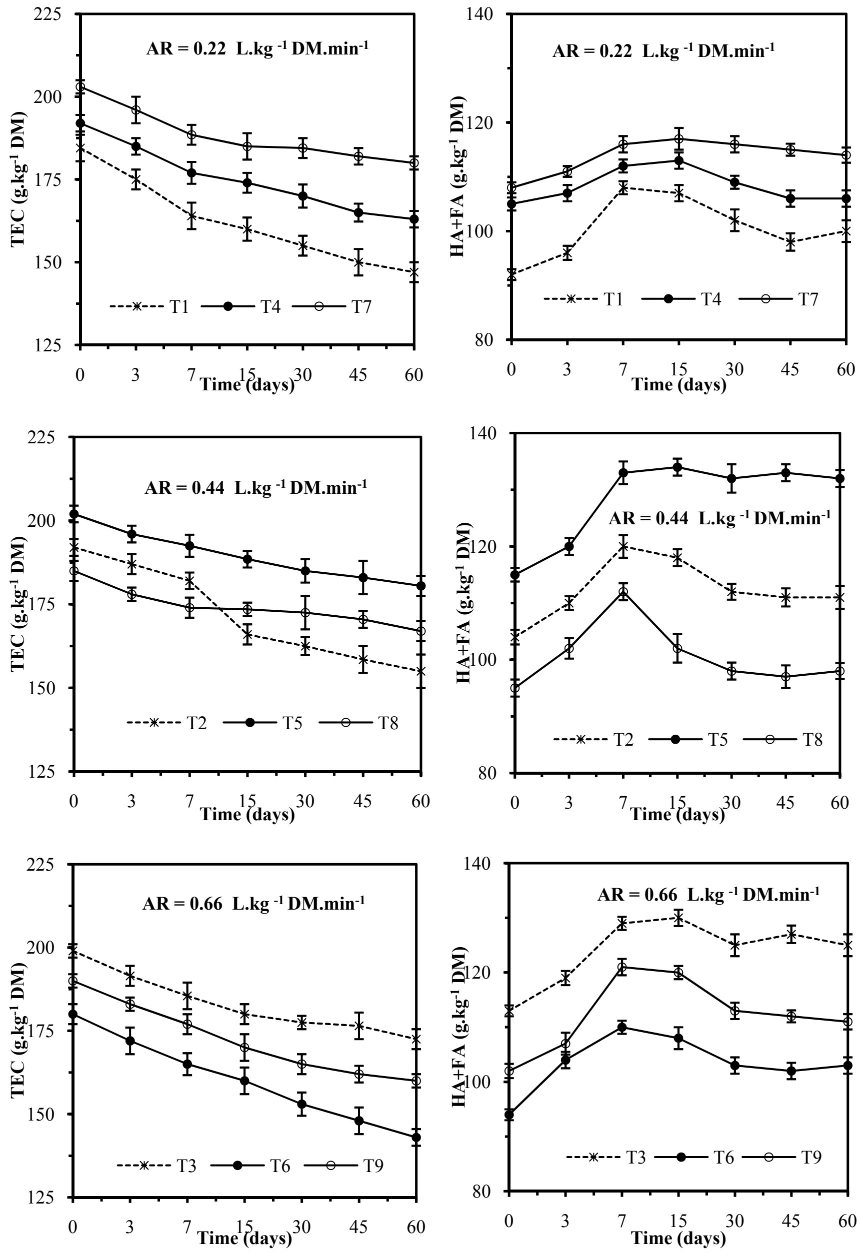

Figure 4. Total extractable carbon (TEC) and humic and fulvic acids (HA+FA) during composting (AR: aeration rate). Values are means ± standard error (n = 3).

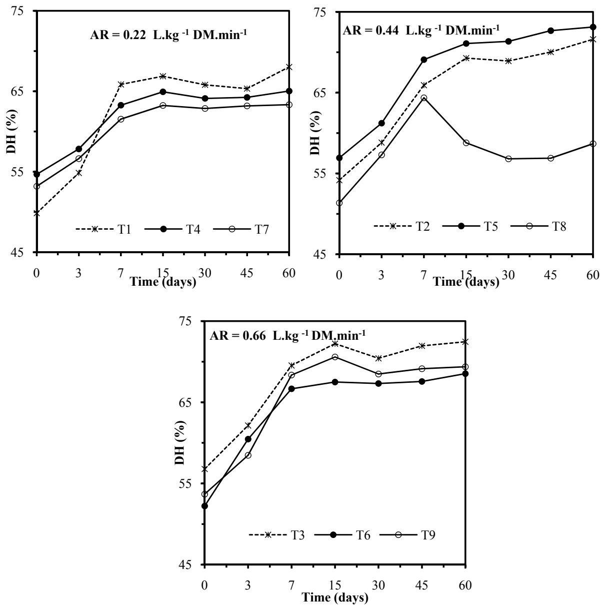

Figure 5. Degree of humification (DH) during composting (AR: aeration rate)

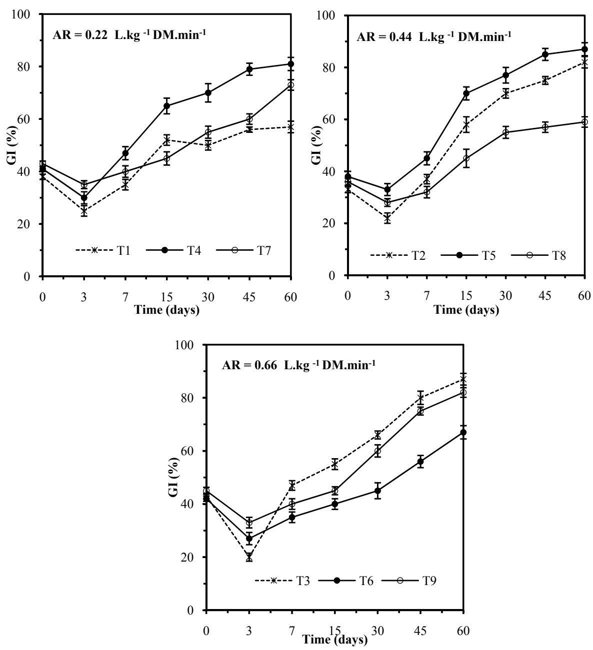

Figure 6. Germination index (GI) during composting (AR: aeration rate).Values are means ± standard error (*n* = 3).

4. Conclusions

Aeration rates (AR), moisture contents (MC) and C/N ratios during composting of maize stalks and cow feces could be used as suitable indicators for evolution of the compost stability and maturity. The AR was the major factor influencing the stability of compost, while the initial C/N ratio mainly influenced the maturity of the final compost. The MC can affect the quality of compost but not significantly. To economically treat the increasing quantities of cow manure, composting with an AR of 0.44 L kg^{-1} DM min^{-1} and a C/N ratio of 19 is recommended with a MC ranging from 60% to 70%.

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