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Effects of effective microbes biofertilizer and curing time on powdery, granular and vermicompost maturity

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ABSTRACT

Compost maturity is a key factor before application of compost because an immature compost can harm plants, soil, and the environment. A pot experiment was conducted to investigate the stability of three types of composts (powdery, vermi and, granular compost) in the soil in Khorasan Razavi Agricultural Research and Education Center in Mashhad. Treatments included the three composts, at curing time of 0, 30, 60, 90 days, and three rats of EM (a set of effective microorganisms including lactic acid and photosynthetic bacteria and yeast) as compost additive (2, 4, 8 L per ton of compost). Main factors evaluated were: NH_4/NO_3 ،N ،EC ،pH ،C/N and OC. Results indicated that the effect of EM on compost maturity was not significant in three composts but the effect of curing time was significant on vermicompost and powdery compost maturity at 1% level. With their application two months after production giving the best results.

Keywords: Compost, maturity, effective microbes (EM), curing time, C/N ratio.

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INTRODUCTION

The application of organic fertilizers to improve soil is an essential practice in soils of arid and semi-arid regions. Compost is a source of organic fertilizers that is used widely. The correct use of this source is one of the most important goals in agriculture. Compost is the result of the biological activity of microorganisms that have the ability to break down large molecules of simple organic matter. Composting can produce environmentally stable soil amendments using oxygen-consuming bacteria and fungi. Good management of the following four elements: carbon: nitrogen ratio, moisture content, aeration and time will produce compost with significant pathogen mortality and a benign product that may be sold.

Compost from municipal waste is produced in both powdery and granular forms (enriched with sulfur). Another type of compost is vermicompost, which consists of vermiculite (earthworm) and compost (organic fertilizer) which called organic fertilizer and is derived from earthworm activity. The stability of the compost indicates the resistance of the organic matter to microbial degradation and is a factor that indicates the suitability of the compost for its final use. It is important for the compost to be matured and stable for use in the field and pot media and to be free of pathogens. Compost maturity and stability is one of the effective factors for success in agricultural compost application (Inbar et al., 1990). The amount of ammonium nitrogen is often the highest in the early stages of composting and then decreases and the compost stability increases. Also, nitrate build-up prevents temperatures to rise above 40°C. Nitrate and ammonium concentrations are strongly affected by drying and moistening in immature composts. Therefore, it is necessary to study the amount of compost used (Mashhad Recycling Organization produced composts) before evaluating the stability of compost in the soil. Maturity is a factor that indicates the suitability of compost for its ultimate use. The matured compost meets the standards set by the relevant organizations. Compost maturity is determined by chemical and phytotoxicity methods. The most important problems of raw compost include: 1- Bad smell during storage and possible fire and 2- Possibility of environmental pollution through phytotoxic substances. Nitrogen assimilation is an important problem for immature low-nitrogen composts because plants with immature compost where the nitrogen assimilation reaction takes place are often yellow and have symptoms of nitrogen deficiency. On the other hand, immature composts have high levels of available nitrogen and lose their nitrogen in the form of NH_3 during the composting process that is toxic for plants. Immature composts with ammonium concentrations greater than 1000 mg/kg can raise water-soluble ammonia to toxicity levels for the plant.

Improvements to the compost commercialization for different kinds of composts have not yet been implemented and the lack of an accepted standard to speed up compost evaluation is one of the problems that need to be resolved (De Nobili and Petussi, 1988.). Research in recent years has shown that the application of municipal waste compost increases soil organic matter and most of the essential nutrients of the plant and improves soil physical properties (Epelde et al., 2018). Compost maturity is one of the effective factors for success in agricultural compost application (Mathur et al., 1993). The term "compost maturity" is generally a degree of completion of the composting process. The terms "compost maturity and compost stability" are not synonymous (Iannotti et al., 1993). Maturity refers to a degree of material homophysis, but stability refers to the level of microbial mass activity (Butler et al., 2001). Since compost is a microbial process, its stability and maturation are the results of microbial activities. Therefore, it is important to note that the organic chemical composition of the composting material plays an important role in the microbial state (Wu and Ma, 2002). Compost maturity begins at the end of the heating phase and converts organic matter into humus (Chen and Inbar, 1993). Brewer and Sullivan (2003) evaluated the stability and maturity of compost in a 133-day period and stated that mature compost had characteristics such as C/N equal to 12 and NH_4/NO_3 less than4 and pH between 6-7 and CEC equal to 400(cmol/kg). Iwegbue et al. (2006) announced that a combination of methods can be used to evaluate compost maturity, and have stated seven evaluation analysis methods including 1- chemical analysis (C / N, CEC, and nitrification) 2- physical analysis (odor and temperature) 3- Spectroscopy; 4- Germination and plant growth; 5- Chromatographic analysis; 6-Degree of homophysis and 7- Microbial analysis can be used to test compost maturity. Raj and Antil (2011) in various experiments included physical properties (color, odor, temperature, organic matter depletion) and chemical properties of (C/N and NH_4/NO_3) and humic acid and folic acid ratio, homogenization index (HI), Cation Exchange Capacity (CEC)), total organic carbon ratio (TOC), and germination index (GI) were performed to evaluate compost maturity and its stability over a 150-day period. Five types of composts obtained from plant residues were studied. Treatments were: 1 – enrichment with nitrogen and no enrichment 2 - enrichment with phosphate rock and no enrichment 3 - inoculation of microorganism and no inoculation. The results showed that during the 120-day composting process, all composts were changed to a dark gray, odorless, and constant-temperature granularity Correlation analysis showed that the optimum values of the parameters were as follows, - Loss of organic matter by over 42%, - C/N ratio less than 15, humic acid to fulvic acid ratio more than 1.9, - humic index higher than 30, - CEC/TOC ratio [Cation Exchange Capacity / Total Organic Carbon] greater than 1.7, - water-soluble carbon to organic nitrogen ratio less than 55%. The composts enriched with nitrogen and phosphorus rock or nitrogen-enriched with phosphorus rock and microbial inoculation were matured after 150 and 120 days, respectively. However, non-enriched composts did not mature even after 150 days. Eshetu et al. (2013) believe that the type of compost influences the rate of decomposition in the soil, which in turn can affect the pH of OC, Ec and pH. Also the activity of soil microorganisms is effective in the rate of decomposition and release of nutrients. Eshetu et al. tested composts made from coffee, fruit and vegetable waste and reported that composting compounds improved clay formation and aggregation by adhering clay particles together. Also, high temperature compost had a greater effect on the increase of organic carbon (in clay rich soils). Kristine and Macartney (2010) believe that an independent experiment cannot be justified for stability and maturity, but rather a combination of experiments and that the best combination is still controversial. Improved composting problems have not yet been addressed for compost varieties, and the lack of a standard to speed up compost evaluation is one of the problems that must be resolved, and this measurement will lead to unreliable results in compost treatment (Denobili and Petossi, 1988). The aim of this experiment was to evaluate the effect of EM and curing time on maturity of three different compost.

MATERIALS AND METHODS

This project was conducted in the pot at a greenhouse in Mashhad Agricultural and Natural Resources Research Station. The aim of pot experiment was to obtain matured compost by adding different concentrations of EM (a set of effective microorganisms including lactic acid bacteria and photosynthetic bacteria and yeast) at three levels E0: Control (without EM) E1: EM, 2 L/ton fresh compost: E2 EM 4 L/ton fresh compost: E3: EM, 8 L/ton fresh compost into three types of powdered compost, vermicompost, and granular compost. The pot experiment was performed in 3 replications.

Sample time intervals

T0: Curing Time Zero; T1: Curing Time After 30 Days; T2: Curing Time After 60 Days; T3: Curingtime after 90 days. During this phase, samples about 300 g from each treatment were sent to the laboratory and the following tests were performed on them: OC

[Organic Carbon]; N-total; EC [Electrical Cunductivity]; pH; NH_4 [Ammonum] and NO_3 [Nitrate].

Temperature and humidity control

Since the activity of microorganisms in EM is directly related to moisture content, so, moisture content was kept constant at Field Capacity [FC]. Ambient and indoor temperatures were monitored by a mercury thermometer. In this case, the ambient temperature was 19°C and the temperature inside the pots was 22°C (15 cm depth). After obtaining the laboratory results, data were analyzed by Mstat-C software. Charts and graphs were drawn using excel software, fresh compost samples were used to determine compost chemical properties in soil and water lab (Table 1).

RESULTS AND DISCUSSION

The chemical properties of the compost samples varied greatly from one kind to another, Ec, O.C%, O.M% [Organic Matter], and N% [Nitrogen] were greater in vermicompost samples while granular compost had least moisture percentage (Table 1).

Results on the effect of EM and curing time on chemical properties of powdery compost

The analyzing variants show the effect of EM and curing time on the chemical properties of powdery compost. The time of curing had a significant effect on %O.C, %N and C/N ratio but the application of EM did not affect these factors significantly (Table 2).

Effect on organic carbon (OC)

The effect of curing time on the amount of organic carbon was statistically significant at 1% level. However, the effect of EM treatments on organic carbon was not significant (data was not shown), but the interaction effect of EM and time of curing on organic carbon content was significant at 1% level.
A comparison of means by Duncan's method showed that the highest amount of organic carbon was obtained at 30 days of curing. Over time, the amount of organic carbon decreased (Figure 1). Organic carbon decreased to about 13 at 60 days of curing and after that, it increased to 15% at day of 90 (Figure 1).

These results are consistent with the results of Keshavarz (2013), it can be concluded that carbon oxidation persists over time due to the activity of micro-organisms in the compost mass to the extent that simple organic compounds are present in the mass.

Interaction of curing time and the amount of EM biofertilizer on compost organic carbon was significant at 1% level (Figure 2). The results of the mean comparison showed that the highest amount of organic carbon in the compost mass was related to non-use of EM bio-fertilizer and at 30 days of curing time.

Figure 2 shows that the highest percentage of organic carbon obtained during 30 days of curing and decreased at 90 days at all rates of “EM “application.

Effect on nitrogen (N)

The effect of different amounts of EM biofertilizer on nitrogen (N) content and also the effect of curing time on EM biofertilizer were not significant. But the effect of curing time alone was significant at 1% level. The results of mean comparison showed that the highest nitrogen content was observed at 1.6% at 30 days of curing (Figure 3). Grifin and Hutchinson (2007) reported that the N mineralization rate during the first 48 days of aerobic incubation was strongly correlated (r=0.82 to 0.86) to compost fiber and liginin and to the maturity index.

Effect on C/N

C/N was influenced by treatments, using EM, and curing time at levels of 5% and 1%, respectively.

Effect of curing time on C/N: Comparing the means with Duncan's method, we find that the highest C/N (14.5) is related to zero-day curing time of being the lowest value (10.6) at 90 days curing time .It is observed that at 60 days of curing the C/N rate is closer to the desired 12 (Figure 4).

Effect of different amounts of EM biofertilizer on C/N ratio: Various amounts of EM bio fertilizer had significant effect on C/N at 5% level so that the highest C/N (12.9) was related to EM treatment at 8 liters per ton. But since the C/N limit is about 12, it can be concluded that the use of EM bio-fertilizer in municipal waste compost did not have a significant impact on compost maturity (Figure 5). Interaction between curing time and EM bio-fertilizer effect on C/N ratio was not significantly different at statistical levels.

Results on the effect of EM and curing time on chemical properties of granular compost

Table 3 shows effects of using EM (zero = EM0, 2 L per ton = EM1, 4 L per ton = EM2 and 8 L per ton = EM3) and curing time (T0 = zero, T1 = 30 days, T2 = 60 days, T3 = 90 days) on the chemical properties of granular compost.

Effect of EM and curing time on OC

The effect of curing time on OC value was statistically

Table 1. Selected chemical properties of tested compost samples.

Type of compost	EC (dS/m)	pH	Fe	P	K	Na	N	O.C	O.M	Moisture
			%							
Powdery compost	6	7	2.5	1.22	1.2	0.75	1.4	17	40	20
Granular compost	5	7	2.5	1	1.2	0.75	1.45	17	40	15
Vermi compost	13	7	0.6	0.43	0.76	0.75	1.46	20.4	50	20

Table 2. Analysis of variance of chemical properties of powdery compost.

Source of variation	df	MS		
		%OC	%N	C/N
Time of curing	3	46.26**	0.275**	31.625**
Amount of EM	3	0.329ns	0.017ns	1.936*
Time of curing* Amount of EM	9	0.84**	0.008ns	1.298ns
Error	24	0.116	0.006	0.589

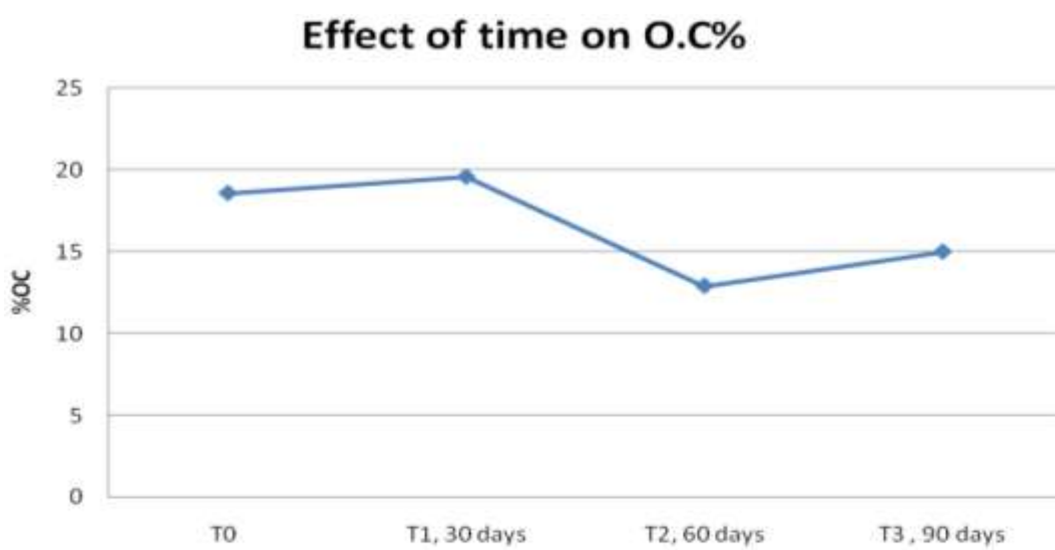

Figure 1. Effect of curing time on the amount of organic carbon (% OC) in powdery compost.

significant at 5% level. However, the effect of EM on OC was significant at 1% level, but the interaction of EM time on OC was not significant (Table 3).

Effect of curing time on OC

Comparison of means with Duncan's method shows that the highest OC was obtained at curing time 30 days and reached a minimum at 60 days and the least at 90 days (Figure 6).

Grifin and Hutchinson (2007) reported that the C mineralization rate durin the first 48 days of aerobic incubation was strongly correlated (r = 0.82 to 0.86) to compost fiber and liginin and to the maturity index.They didnot observe any differences in C mineralization between composts after 48 days.

Effect of EM on OC

Comparing the means with Duncan's method, it is observed that the highest OC was related to the zero value of EM (13.7%), and the lowest OC was related to EM4 (12.6%).

The effect of different EM values on N nitrogen and the effect of curingtime on EM content was not significant. But the effect of time was significant at 1% level. Mean comparison results showed that the highest amount of nitrogen in 30 days was 1.37. The least of these

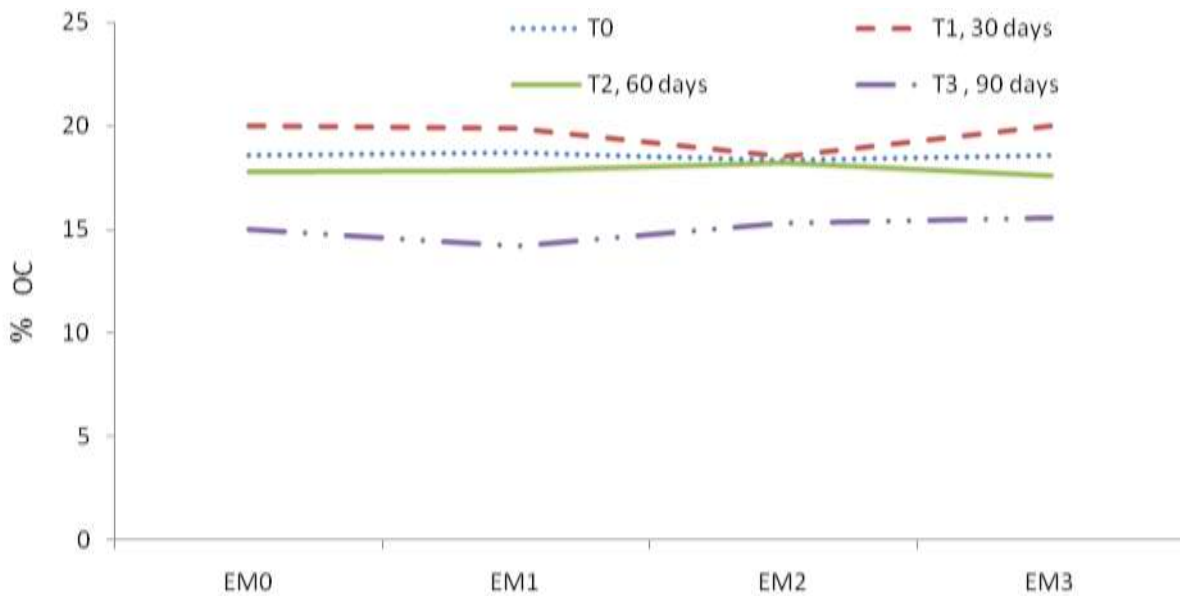

Figure 2. Interaction effect of curing time and EM bio-fertilizer rats on organic carbon (% OC) of powdery compost.

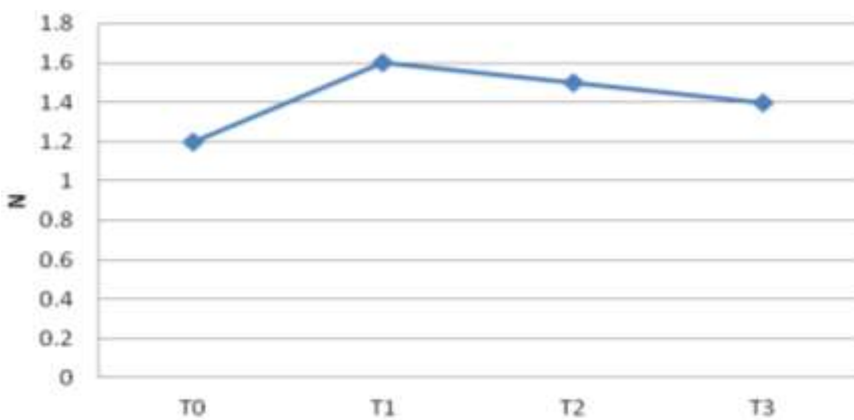

Figure 3. Effect of curing time on nitrogen (% N) powdery compost.

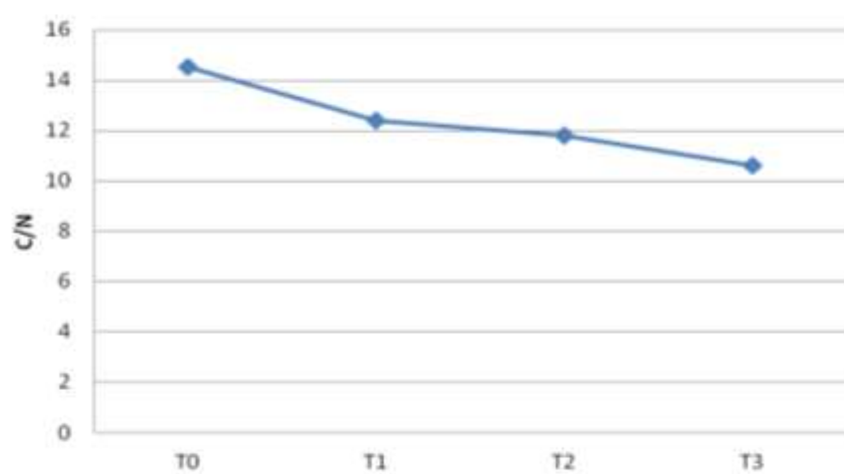

Figure 4. Influence of curing time on C/N of powdery compost.

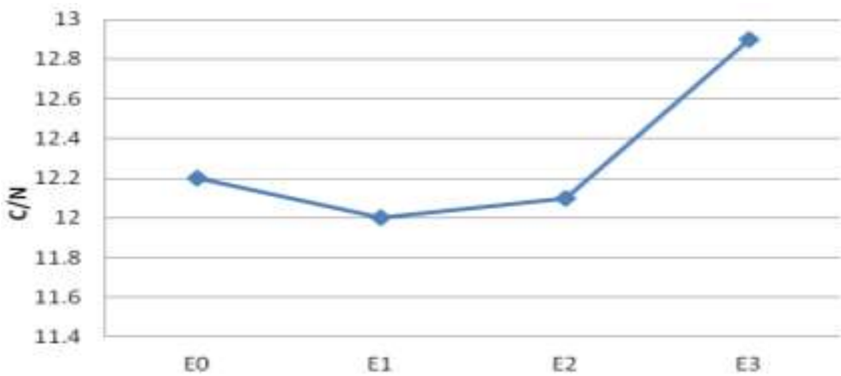

Figure 5. Effect of EM bioaccumulation on C/N ratio of powdery compost.

Table 3. Analysis of variance of chemical properties of granular compost.

Source of variation	df	MS		
		%OC	%N	C/N
Time of curing	3	7.997*	0.046**	0.542ns
Amount of EM	3	3.069**	0.008ns	1.332ns
Time of curing* Amount of EM	9	0.933ns	0.010ns	1.163ns
Error	24	0.591	0.006	0.702

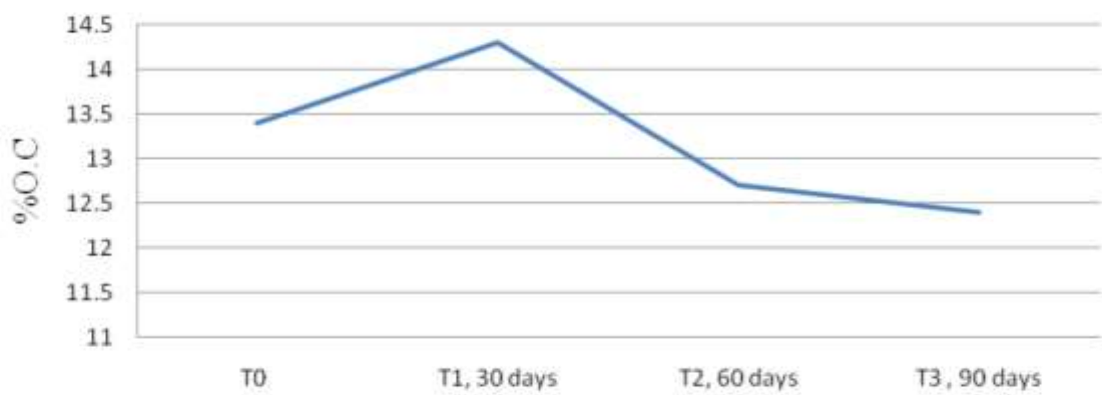

Figure 6. Influence of curing time on OC of granule compost.

treatments was 90 days' curing time, which was 1.23 N (Figure 7).

Effect on C/N

Treatment EM value as well as curing time; EM value had no significant effect on C/N at any statistical level.

Results of EM and curing time on chemical analysis of vermicompost

Figures 8, 9,10 and 11 show the effect of using EM (zero = EM0, 2 L per ton = EM1, 4 L per ton = EM2 and 8 L per ton = EM3) and curing time (T0 = zero, 30 days =T1, 60 days= T2, = 90 Day =T3) on the chemical properties of vermicompost.

Effect on OC

The effect of time on O.C value was statistically significant at 1% level. However, the effect of EM on OC was not significant but the interaction of EM time on OC was significant at 1% level.

By comparing the averages with Duncan's method, it is observed that the highest amount of OC occurred in the

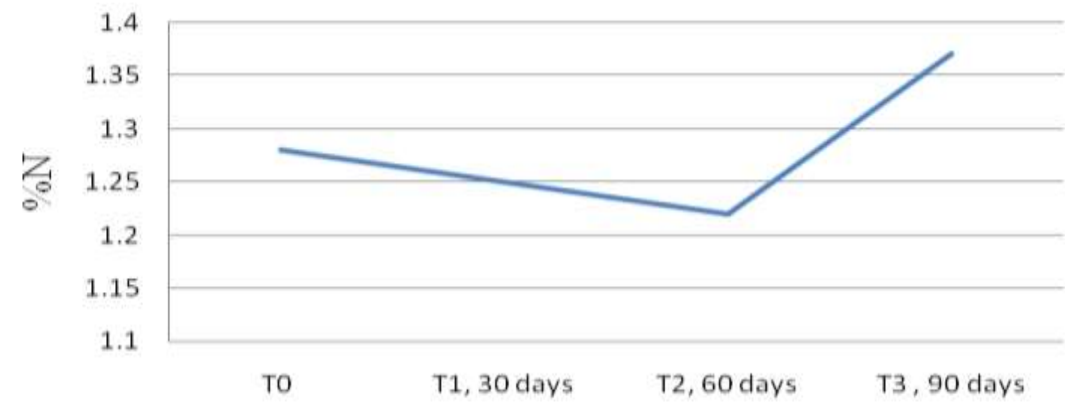

Figure 7. Influence of curing time on N granular compost.

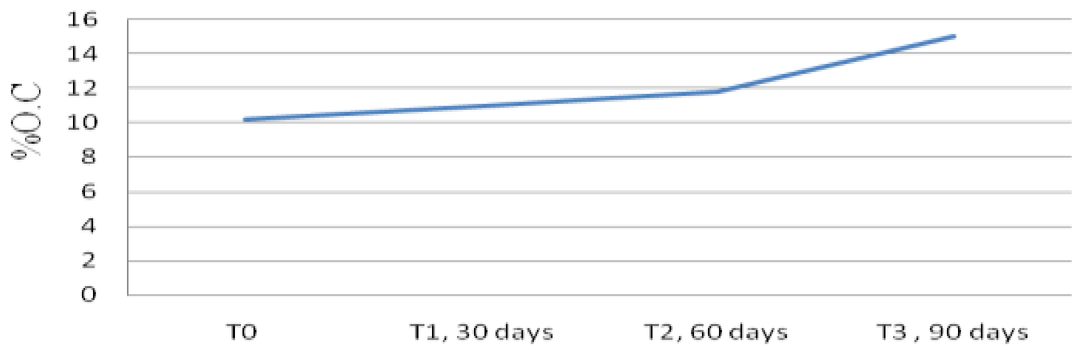

Figure 8. Influence of curing time on vermicompost OC.

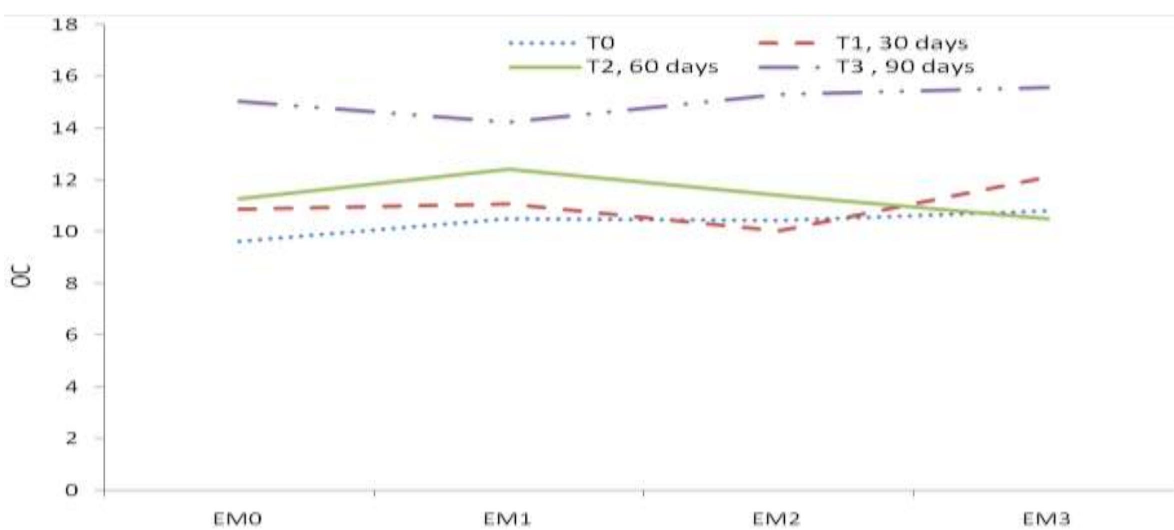

Figure 9. Interaction between curing time and EM on OC vermicompost.

last 90 days and has increased over time. It shows a 50% increase over time zero (Figure 8). This increase in OC over time is consistent with the results of Rana and colleagues (2015).

Interaction of curing time and EM value on OC

Interaction of curing time and EM value on OC showed significant difference at 1% level. Mean comparison

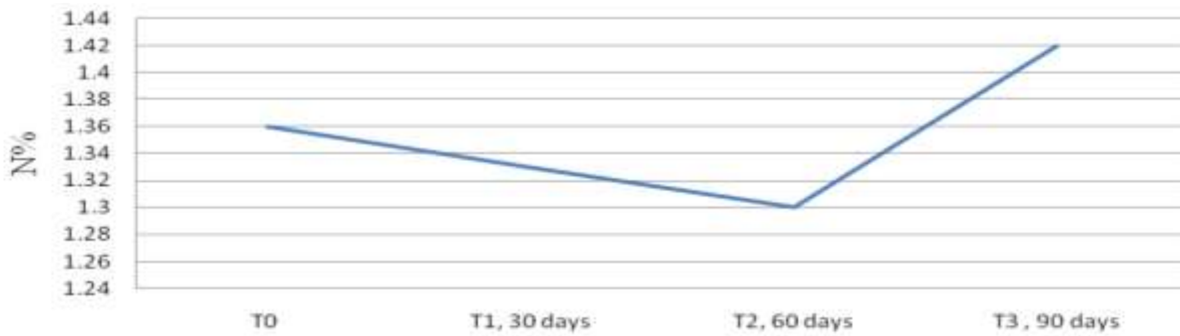

Figure 10. Influence of curing time on N vermicompost.

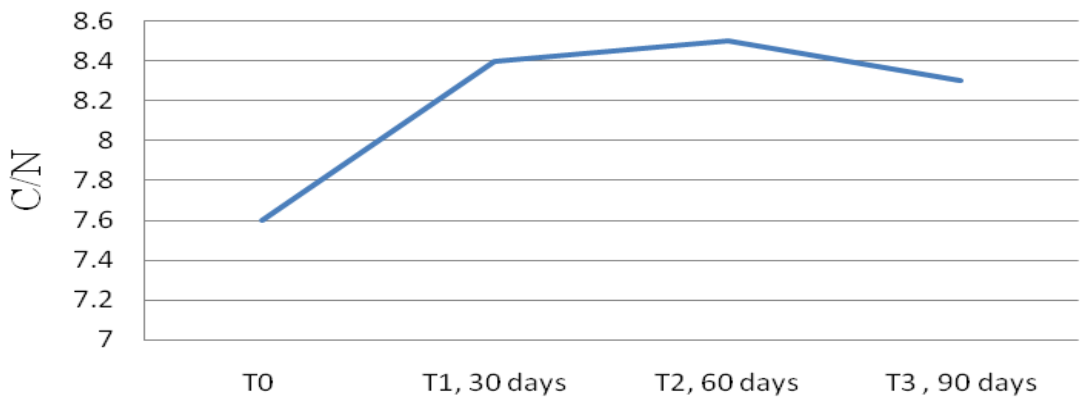

Figure 11. Influence of curing time on vermicompost C/N.

results showed that the highest OC was related to the highest amount of EM (i.e. 8 L/ton) at 90 days curing time and all EM concentrations had the highest organic carbon at 90 days curing (Figure 9).

Effect on N

The effect of different EM values on N nitrogen and the effect of curing time on EM content were not significant. But the effect of curing time alone was significant at 5% level. The results of mean comparison showed that the highest amount of nitrogen at 90 days was 1.42 (Figure 10). This increase in nitrogen over time is in line with the results of the researches by Mirblock et al. (2012).

Effect on C/N

C/N was affected by 1% curing time and EM values as well as curing time; EM values at no level had a significant effect on C/N. The results showed that at 60 days it had the highest C/N of 8.7. This increase in C/N over time is consistent with the results of Rana et al. (2015).

In the case of vermicompost, vermicompost use is the best after two months (60 days) of production without the presence of EM.

Conclusion

The main index of compost maturity in this study was C/N ratios. According to the results of the pot phase, the use of EM (effective microorganisms) additives was insignificant in all three types of compost treatments and seems to be due to the high masses of microbial populations and competition among them in the compost. The effect of curing time on the processing of granular compost was not significant. This means that granular compost fertilizer can be consumed at any time (after production) and its application or curing time will not affect its properties. But the effect of curing time on compost maturity was significant in vermicompost and powdery compost. The results of this step showed that the consumption of powdery compost and vermicompost compost after 2 months of production presents the best results in maturity. Therefore, it is suggested that compost plant production can be consumed after 2 months of production (vermicompost and powdery compost). More researches are needed in that trend in the future.

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