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INVESTIGATION ON APPLICATION OF SYNTHETIC NUTRIENTS FOR AUGMENTING WORM GROWTH RATE IN VERMICOMPOSTING

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Abstract: An investigation was carried out to scan the influence of synthetic nutrients on Vermicomposting. A mixture of six nutrients (Iron, Manganese, Zinc, Copper, Molybdenum and Boron) was introduced to augment the growth of worms (Lumbricus rubellus) and to ensure the higher digestion rate of the pre-composted bio-degradable organic waste. Initially green waste was collected from the local vegetable market and pre-composted for about three weeks. Then the pre-composted waste was placed in two identical glass vermireactors. Each reactor was loaded with equal volume of waste (0.024 m^3) and worms (40 gm). The pre-composted waste was vermicomposted for a period of 21 days by applying nutrients in one reactor and the other was kept as control (without nutrient). The nutrients were applied in liquid form while moistening the reactor beds and the characteristics of the pre-composted waste, vermicasts and *vermi* growth rate were studied. Results revealed that the reactor added by nutrients performed better by achieving 41.34% higher waste volume reduction and 42% increase in the worm growth rate.

Keywords: Pre-composting (PC); vermicomposting with nutrients (VCN); vermicomposting without nutrients (VC); lumbricus rubellus

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INTRODUCTION

The technological and industrial revolution in World has shifted thousands of people from rural to urban areas. Meanwhile many places are urbanized, which lead to the high generation and concentration of solid waste in a particular area. India alone produce around 42 million tonnes of solid waste every year in which 45–55% are bio-degradable (this will change according to the dwellers and locations) and convertible as manure. Presently, major portion of organic waste is dumped in open yards, which creates organic load on ground water by leaching and also emits greenhouse gases on air (Manaf *et al*., 2009). Vermicomposting is one of the best methods for eliminating these problems. Earthworms have been used for waste stabilization for many years, all around the world (Martin & Lavelle 1992). According to science, vermicomposting is a process; combining the biotic and abiotic environment to digest the biodegradable solid waste into useful product (vermicast) with the help of worms (*vermi* in Latin).

Normally worms can digest organic waste equal to its body weight or half to its weight (varies according to the type of worm). But the generation rate of degradable waste is in thousand tonnes per day in which, only a few tonnes of waste get digested by the vermicomposting. This is because of the low digestion rate of worms. Hence a catalytic substance is much needed to enhance or speed up the digestion rate of *vermi*. To gear-up the digestion process, growth stimulants are much needed. Nutrients such as Zinc, Manganese, Copper and Iron were identified as essential nutrients for the growth of worms (Loren & Janet, 1998). The main objective of the study is to investigate the influence of micronutrients on vermicomposting with respect to waste volume reduction and *vermi* growth rate. The study also reveals the characteristics of the pre-composted waste and vermicasts.

MATERIALS AND METHODS

Earthworm culture and pre-composting the waste

Earthworms namely Red worms (Lumbricus rubellus) were collected from the local *vermi* culture market. Then the worms were fed with vegetable peels and cow dung in a controlled environment (temperature and moisture content) for about three weeks.

Simultaneously compost pile was generated to pre-compost the vegetable waste to avoid the shock load on worms. The solid waste collected from the local vegetable market was chopped to desirable size (less than or equal to 1 cm) and introduced in to composting unit. Windrow composting method was adopted for pre-composting the waste (MMSW, 2000).

During the composting period pH, temperature and moisture content were monitored using WET sensor kit. The heap was provided for about 21 days and turned twice with a span of seven days each.

Setting-up vermicomposting units

Two identical bench scale reactors made of glass, with geometry of 23 cm × 23 cm × 45 cm were used for the study. To protect the worms from predators and to avoid the direct contact of sunlight, the reactors were constantly monitored and kept at a higher ground with proper shading. Drain pipe was kept at the base of the reactor to drain excess water from vermin beds and to provide better aeration.

For bedding material, brick ballast was used as the first layer for ensuring proper drainage. Then a layer of pre-composted waste was spread evenly followed by a layer of garden soil mixed with cow dung and saw mill waste (2:1:1). Subsequently two identical layers were made and covered with dried leaves.

Inoculating with earthworms

Adult earth worms (4–7 cm in length) from the culture unit were shifted to the reactors. About 40 gm worms were inoculated in each reactor, which approximately counts 75–85 by number. Then the reactors were kept for three days, as stabilization period in order to provide suitable environment for worms.

Applying nutrients

Commercially available nutrients were tested for its composition and used for the study and the percentage composition of commercial grade nutrients is given in **Table 1**. Out of the two reactors, one was fed by nutrient and the other kept as control. On a trial basis, about 1.5 gm of nutrients were diluted in 500 ml of potable water and fed to the reactor, while sustaining the optimal condition of moisture (60–70%). During the experimenting period pH, temperature and moisture content were monitored and maintained at desirable bunch to facilitate the digestion process by worms.

Table 1. Percentage of nutrients with respect to weight

Nutrients	(% W/W)
Iron	3.8
Manganese	6.1
Zinc	4.0
Copper	0.01
Molybdenum	0.35
Boron	2.1

Parameters	Principle / Method	Unit	Reference
Volatile solids	Ignition at 550°C	% (Dry basis)	Standard method (1980)
pH	Glass Electrode	–	–
		% (Dry basis)	Gottas 1956
TOC	Calculation %C = %VS/1.8	% (Dry basis)	E-105 ASTM (1996)
Nitrogen	Macro-Kjedahl method	PPM	Standard method (1980)
COD	Closed Reflux method		
BOD	Oxitop bottle	PPM	Standard method (1980)

Source: Tenzin (2002).

Analysing the samples

During pre-composting stage, the physicochemical parameters like temperature, EC and moisture content were measured using 'WET' sensor kit. For measuring the volatile solids (%), pH, total organic carbon (TOC), nitrogen (%), Chemical oxygen demand (COD) and Biochemical oxygen demand (BOD), samples were collected and dried in oven for 24 hours at 60°C to attain a constant weight, then grounded to a particle size less than 2 mm. The analytical tests carried out are briefly described in the **Table 2**.

Nutrient analysis

The nutrients in dried samples were digested with concentrated nitric acid and 30% of hydrogen peroxide and then determined by atomic absorption spectrophotometer (APHA, 1998).

RESULTS AND DISCUSSION

The pH in the waste decreased towards acidic while pre-composting **Fig. 1**. The reduction in pH while composting may be due to the production of CO_2 and organic acids during microbial metabolic activity (Hartenstein and Hartenstein, 1981). It is also attributed to the mineralization of nitrogen and phosphorus into nitrates/nitrites and ortho-phosphates, respectively, and the conversion of organic matter into CO_2 and humic by microorganism, monosaccharide, starch and lipids increases organic acids of the material. In the counterpart (VCN) the proteins are degraded to ammonium and increase may also be due to the addition of nutrients, which would result in an increase in pH.

EC *(Electrical conductivity)*

The electrical conductivity of the waste tended to rise with respect to the age of digested waste (**Fig. 2**). The

and release of mineral salts in available forms (Wong *et al*., 1997; Kaviraj & Sharma, 2003; Nath *et al*., 2009; Nair & Okamitsu, 2010). The shift of EC in the vermicast may be due to the water holding capacity (WHC) of it (Jadia & Fulekar, 2008). The electrical conductivity recorded high in the reactor aided by micro nutrient; this might be due to the adsorption/absorption of nutrients on the vermicast.

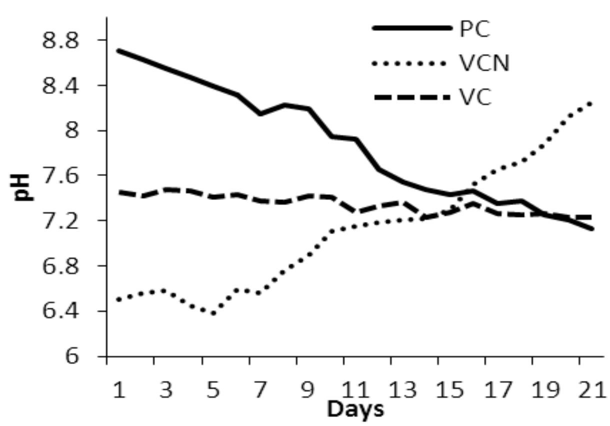

Fig. 1 Variation in pH at different stages of treatment of waste.

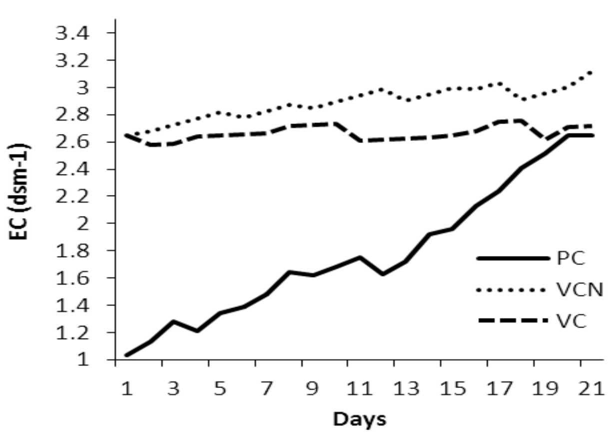

Fig. 2 Variation in Electrical conductivity.

Temperature

At the initial stage, the first organism which kicks the degradation process is psychrophilic bacteria. This organism prevails at a temperature between 20–25°C and start eating the fresh substrate. Due to the metabolic activity of the microorganism, the temperature shoots-up which inhibits the psychorophilic and support the mesophilic bacteria (25–45°C). Again due to the feeding and respiration by the later one causes carbon dioxide (CO_2) and energy in the form of heat.

Due to this the pile temperature suddenly rose greater than 56°C (**Fig. 3**). This condition soon starts killing the mesophilic. The next organism, the thermophilic (> 45°C) starts to vandalize the organic content. After the reduction of easily available carbon source, the population of thermophilic declined and the pile starts to cool down (Loren & Janet, 1998). In vermicomposting the temperature was regulated and maintained between 25–30°C by moistening the beds, to facilitate the suitable environment for *vermi* growth.

Total organic carbon

For the survival of each and every organism, carbon is a prime source. Microorganisms in the pile consume organic carbon from the substrate to involve in metabolic activity and evolve CO_2 at end of the action. At the end of pre-composting stage, the percentage of carbon dipped by 15% to the initial carbon content (**Fig. 4**). This is because of the carbon intake by psychrophilic, mesophilic, and thermophilic bacteria, followed by actinomycetes and fungi at respective pile temperature (Lore & Janet, 1998).

At the end of vermicomposting, the carbon content reduced with a high margin of 50% reduction compared to pre-composting. This is due to the high consumption of carbon by earthworms and this was evident by Elvira *et al*. (1998), who reported 20–40% loss of organic carbon in the form of CO_2 during vermicomposting. Further, Suthar (2007) reported that the body fluid and excreta secreted by worms (e.g., mucus, high concentration of organic matter, ammonium and urea) promote microbial growth in vermicomposting, which may also contribute in the reduction of carbon level. It was observed that there was no much difference in reduction of TOC between the two reactors (aided with and without nutrient).

Nitrogen

Reduction in the nitrogen content during the pre-composting period may be due to the microbial population. The organic material in form of cellulose or lignin which is insoluble and the nitrogen present in the 'lignin humus complexes' formed by microbes in composting process is not available unless lignin broke down and this results into nitrogen loss (Crawford, 1985).

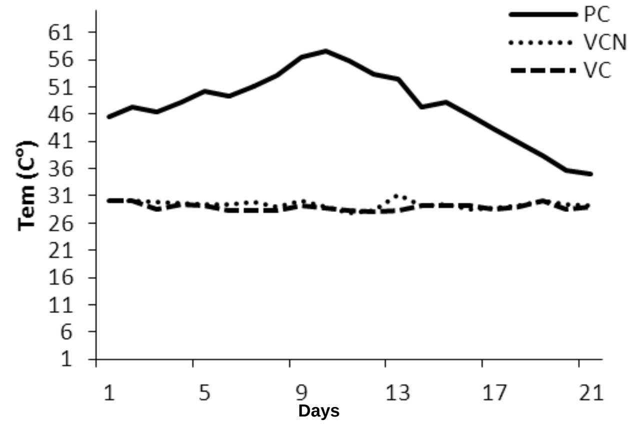

Fig. 3 Temperature recorder at various phase of waste treatment.

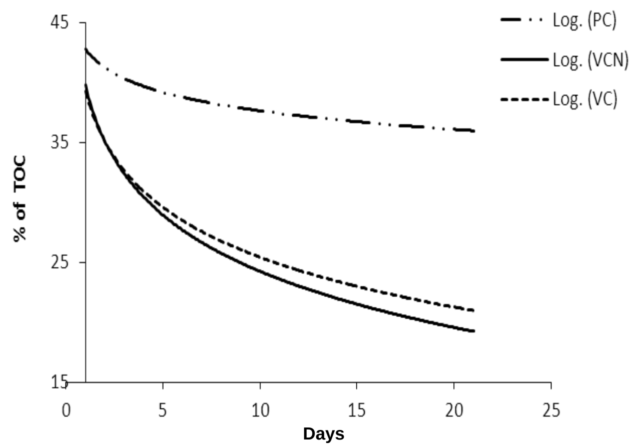

Fig. 4 Reduction in organic carbon at different treatment process.

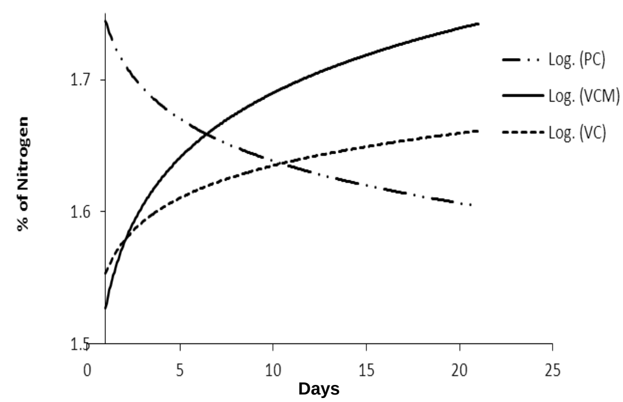

Fig. 5 Variations in Nitrogen content at different treatment process.

At the same time the nitrogen content increased in vermicomposting, this might be due to the nitrogen release by earthworm's metabolic product and dead tissues (Araujo *et al*., 2004). More over dip in the pH may also be a significant factor in nitrogen reduction as this element is lost as volatile ammonia at lower pH values (Hartenstein and Hartenstein, 1981). Athiyeh *et al*. (2000), reports that by enhancing nitrogen mineralization, earthworms have a greater impact on nitrogen transformation in manure, so that, nitrogen get

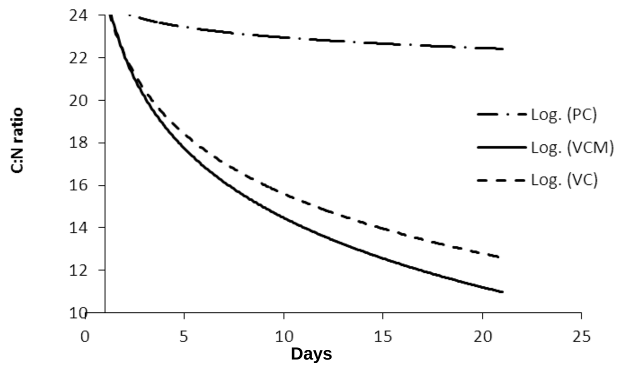

Fig. 6 Variations in Carbon**:** Nitrogen (C: N) content at different treatment process.

C/N ratio

The C/N ratio indicates the maturity of the organic waste. The ratio gets depleted with respect to consumption of organic carbon or loss by respiration through microbes and it may also be due to the addition of nitrogenous excretory material during decomposing process. Approximately 10% reduction in C/N was achieved in pre-composting stage. The reduction hiked up to 60% at the end of vermicomposting as shown in **Fig. 6**. The loss in C/N ratio may also be due to the respiration activity of the worms and microbes or due to the increase of nitrogen content by mineralisation of the organic matter and in addition with nitrogenous wastes generated by earthworms (Christy & Ramalingam, 2005).

Effect of nutrients on vermicomposting

The nutrient content in the pre-composted waste is shown in **Fig. 7**. Jadia & Fulekar (2008) reported that the nutrients concentration was high in the composted waste than the raw or vemicomposted waste. A similar increase in the nutrient status had been reported by Dickerson (1999).

In another study by Paoletti *et al*. (2003) the nutrient content of earthworms was analysed and the results revealed that the samples contained large amount of protein (64.5–72.9% of dry weight), amino acids, calcium and iron together with notable quantities of other important elements like Cu, Mg, and Zn. It is evident that nutrient content plays an important role in growth of worm.

Reduction of nutrient content in vermicast from the reactor without nutrients may be due to the consumption of natural nutrients by worms and microbes. At the same time the nutrient content was at higher rate in the reactor added by micronutrients, this may be due to the adsorption of dissolved nutrients in the vermicast. **Table 3** shows the impact of catalytic substances on *vermi* growth rate.

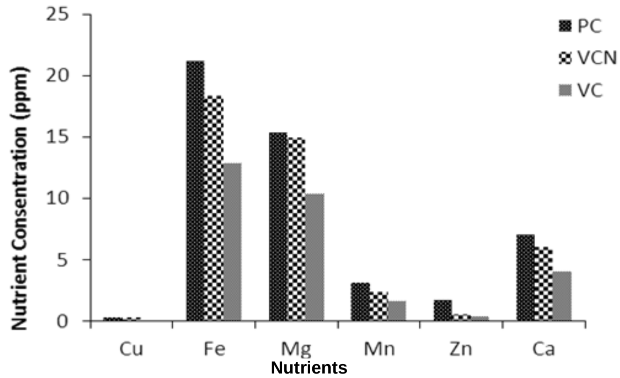

Fig. 7 Nutrients compositions in the end product.

Table 3. Impact of catalytic substances on *vermi* growth rate

Vermi reactor	Duration (days)	Growth rate (R/day)	Initial worms weight (gm)	Final worms weight (gms)
With nutrients	14	1.50	40	76.86
Without nutrients	14	0.87	40	64.58

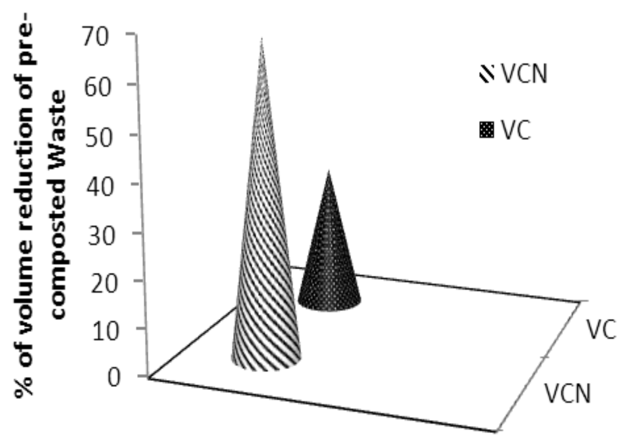

Fig. 8 Volume reduction of the pre-composted waste.

The secondary impact of the growth stimulants was the volume reduction (**Fig. 8**) of the pre-composted waste. The volume reduction was determined by:

$$\% \text{ volume reduction} = [(\text{Initial height} - \text{Final height})/\text{Initial height}] \times 100$$

CONCLUSION

The results show that worms grow better with the aid nutrients. Out of the six nutrients, (Iron, Manganese, Zinc, Copper, Molybdenum and Boron) the much needed one for the biomass growth are Iron and calcium also high in the reactor added by micro nutrients. It is concluded from the present study, adding nutrients in vermicomposting will enhance the process effectively and the nutrient level of the vermicast. Approximately 43% higher volume reduction was achieved in the reactor added by the nutrients and the growth rate of vermin was increased by 42% in the same.

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