Comparative Evaluation of Compost Quality, Process Convenience and Cost under Different Composting Methods to assess their Large Scale Adoptability Potential as also Complemented by Compost Quality Index

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Abstract- Organic soil management has become the pressing need today for reversing the cycle of soil degradation and thereby putting a step forward towards soil and crop sustainability. At the same time sustainability has been far fetched even after application of organic soil inputs over a period of years. Practical experience has indicated three regulating avenues in the way of achieving the above set target i.e., i) quality of soil input ii) quantity of application and iii) unit cost. Hence, an effective composting method, which enables the production of good quality compost at an economical cost, can only meet the criteria for sustainable organic soil management The present study at Maud tea estate (Maud T.E.) in Assam, India under FAO-CFC-TBI Project, 2008-2011; was aimed at comparative evaluation of different available and practiced composting methods *viz.* Vermi, Indigenous, Biodynamic and Novcom composting in terms of their end product/ compost quality as well as respective cost. Study revealed that comparable values were obtained for all types of compost in terms of physical properties, organic carbon, C:N ratio, stability, maturity and phytotoxicity status. However, compost produced under Novcom composting method showed better results in terms of total NPK content (i.e. nutritional content) and microbial population, which being in the order of 10^{16} c.f.u. was significantly higher than the values obtained for rest other types of studied compost. Compost Quality Index (CQI) was formulated (using four specific compost quality parameters *viz.* total nutrient content, C/N ratio, microbial potential and germination percent) to classify the quality of different types of compost as good, moderate, poor etc. for easy understanding at the users' level. Study of convenience factor and cost of production also indicated comparatively higher potential of Novcom composting method.

Index Terms- Composting method, Microbial population, Compost quality index, Cost of production

I. INTRODUCTION

In the present agricultural scenario there has been a growing conviction that compost is the best option available to restore and enhance soil potential in order to attain sustainable soil and crop productivity. Research has conclusively established that long term application of organic manure competes well in production with direct application of chemical fertilizer (Briggs and Courtney, 1985). Present research proves that compost application has also been found to influence the microbial induced suppression of soil borne plant pathogens and diseases (Hadar and Mandelbaum, 1992; Hoitink *et al*., 1991). However, the above objectivities can be met only by application of good quality on- farm compost. This is because quality of soil input determines its dosage of application and thereby the related economics.

Off-farm soil inputs are mostly of non-uniform quality as well as highly priced, which leads to voluminous requirement and thereby huge capital investment. Considering the lower economic status of Indian farming community, high capital investment on the other hand often leads to lower quantity application. These are the reasons why application of organic soil inputs even over a period of years have not been able to regenerate soil health to the point where crop sustainability will be assured under organic soil management that too at an affordable cost. Selection of proper biodegradation process becomes imperative to ensure recycling of on- farm waste into quality compost, for which comparative evaluation and scientific documentation of different composting methods is necessary. Also an index for classification of compost quality in terms of good, moderate, poor etc. can enable the producer to get a fair idea about any compost choice and taking decision for soil management accordingly. Hence, the present study was taken up to evaluate the effectivity of different composting methods in terms of end product quality, process convenience and cost of production to assess their potential for large scale adoption along with rating of compost quality using Compost Quality Index (CQI).

II. METHODOLOGY

On-farm available green matter comprising common garden weeds *viz. Mikania micrantha***,** *Ageratum houstonianum***,** *Axonopus compressus*, *Digitaria setigera Roth*, *Clerodendrum viscosum Vent*., *Scoparia dulcis Linn.*, *Paspalum longifolium Roxb* etc. were used for making four different types of compost *viz*. vermi compost, Indigenous compost or Farm Yard Manure (FYM), Biodynamic compost and Novcom compost; as per their standard processes (described below) at Maud tea estate in Dibrugarh, Assam (India). Vermicompost was produced within a period of 75 days, the biodegradation period for Indigenous and Biodynamic compost was 90 days while that for Novcom compost was 21 days. Twelve heaps were made for each type of compost.

Vermi compost preparation at Maud T.E.

Raw materials used: Common garden weeds *viz. Mikania micrantha*, *Ageratum houstonianum*, *Axonopus compressus, Digitaria setigera Roth* etc. and cow dung at 60 : 40 ratio was used for making compost.

Earth worm: 4000 – 4500 earth worms (*Esenia foetida*) were required for each layer comprising about 600 to 650 kg of raw materials.

Vermi shed and Vermi compost pit : A plastic shed with bamboo structure was made for protecting the vermi pit from direct sunlight as well as rainfall. A vermi compost pit was prepared measuring 15 ft. in length, 4 ft. in breadth and 4 ft. in height. Base of the pit was soled with bricks followed by a sand layer. At the top of sand bed, thick cow dung slurry was sprayed.

Preparation of Vermi Compost:

At a selected upland chopped green matter and cow dung was stacked in a heap measuring 10 ft. in length, 6 ft. in breadth and 4 ft. in height. Proper watering was done, so that decomposition was initiated. This was kept for about 20 to 25 days and frequent watering was done till the materials were semi decomposed and temperature of the heap came down. Then the materials were ready for using in the vermi pit. The semi decomposed raw materials were transferred into the vermi pit and vermi was added layer wise in the specific quantity. Watering on regular basis was done to keep the vermi pit moist. The vermi compost was ready in 40 to 50 days time.

Biodynamic compost preparation at Maud T.E.

Raw materials used: Common garden weeds *viz. Mikania micrantha*, *Ageratum houstonianum*, *Axonopus compressus, Digitaria setigera Roth* etc. and cow dung at 70 : 30 ratio was used for making compost.

Preparation of Biodynamic Compost:

At first 2 kg Cow Pat Pit (CPP) was mixed with some water and kept for 4-6 hours. After that at least 30 ltr. of water was added to it and stirred well. A plain land facing east- west direction was chosen for better effectivity. After cleaning the land, the soil was moistened by spraying water on the surface. A 15 ft. long bamboo strip was placed in the middle of the land with the help of two bricks. Two 2 ft. long bamboo strips (lying across) were placed at every 2ft. interval on the main strip. Dry grasses were spread over the bamboo structure (up to 6 inches height) and watered to make it wet. A layer of cow dung (about 3 inches thick) was made next and water was sprayed on it. 2 ltr. CPP mixture was sprayed on the layer. The processes of layering with grasses and cow dung were repeated until the height was raised up to 2 ft. Then a layer of fresh green matter was made over it (about 4 inches height) and 15 kg CaO was broadcasted on top of the layer. The process of layering with grass and cowdung was again repeated until the height of the heap reached to about 4 ft. The top layer of the heap was made of cow dung. 3 holes were made on the heap and some CPP mixture was poured in those holes. After that CPP mixture was used to moisten the heap. Concentrated cow dung slurry was prepared by mixing a certain amount of soil with cow dung and the entire heap was plastered by it.

Method for preparation of CPP :

A structure 1.5 ft. in length x 1.5 ft. in breadth x 1 ft. in height was made using bricks and the inner wall was pasted with fresh cow dung. The bottom of the structure was not lined with bricks. The pit was filled with fresh firm cow dung, eggshells and basalt dust was inserted into the dung (for 20kg of manure 65gms crushed eggshells and 166gm basalt dust was used) and spaded for an hour, next jaggery solution (100gm jaggery and one liter water) was sprinkled over it. After gently patting the cow dung six holes, 2 inches deep were made in it, followed by incorporation of Biodynamic preparations (1gm each of 503-506 and 1ml of 507). Fresh jute sack was placed over the pit to maintain moisture and to avoid excessive drying. The mixture was aerated once during a month with a garden fork. CPP gets ready in 60 days.

Indigenous compost (FYM) preparation at Maud T.E.

Raw materials used: Common garden weeds *viz. Mikania micrantha*, *Ageratum houstonianum*, *Axonopus compressus, Digitaria setigera Roth* etc. and cow dung at 70 : 30 ratio was used for making compost.

Preparation of Indigenous compost:

At a selected upland and flat area chopped green matter was spread to make a base layer measuring 15 ft. in length and 4 ft. wide. Green matter was chopped down to 1/2" Size and placed evenly till 1 ft. followed by a layer of cow dung. The process was repeated till the heap reached a height of about 5 ft. The heap was covered with clay mud. The heap was demolished and upturned once the height reduced below 4 ft. and reconstructed to a height of about 5 ft. Compost was ready in 3 months time.

Novcom compost preparation at Maud T.E.

Raw materials used: Common garden weeds *viz. Mikania micrantha*, *Ageratum houstonianum*, *Axonopus compressus, Digitaria setigera Roth* etc. and cow dung at 80 : 20 ratio was used for making compost.

Novcom solution: Biologically activated and potentized extract of Doob grass (*Cynodon dactylon*), Bel (*Sida cordifolia L*) and common Basil (*Ocimum bascilicum*).

Total requirement of Novcom solution: Total 250 ml Novcom solution is required for 1 ton of raw materials (100 ml on day 1 followed by 75 ml each, on day 7 and day 14).

Preparation of Novcom compost:

Day 1 : At a selected upland and flat area chopped green matter was spread to make a base layer measuring 10 ft. in length, 5 ft. in breadth and 1 ft. in thickness. This layer was sprinkled thoroughly with diluted Novcom solution (5 ml/ ltr.

of water) and over this layer, a layer of cow dung (3 inches in thickness) was made followed by a second layer of chopped green material, once again 1 ft. in thickness. The green matter layer was once again sprinkled with diluted Novcom solution (5 ml/ ltr. of water) and the process was continued till the total height reached to about 6 ft. After construction of each layer of green matter it was compressed downward from the top and inward from the sides for compactness.

Day 7 : On the 7th day compost heap was demolished and churned properly. The material was next laid layer wise and after making each layer diluted Novcom solution (5 ml/ ltr.) was sprinkled thoroughly as done on 1st day. After seven days the volume of the composting material decreased due to progress in decomposition process. Hence, to once again maintain the heap height to about 6 ft.; the length and breadth of the heap was maintained at 6 ft. x 6 ft. respectively. The heap was once again made compact as described earlier.

Day 14 : The same process was repeated as on day 7 and to maintain heap height to about 6 ft., the length and breadth of the heap was further reduced to 6 ft. x 4 ft. respectively.

Day 21 : The composting process was complete and compost was ready for use.

Raw materials and compost samples (12 samples from each type) were drawn from all the compost heaps during the period 2010 - 2012. The samples were analyzed for physicochemical properties, nutrient content, microbial status, stability, maturity and phytotoxicity parameters. Physicochemical properties of compost *viz.* moisture content, pH, electrical conductivity, organic carbon, total ash content and total volatile solids were analyzed according to the procedure of Trautmann and Krasny (1997). Total N, P and K content in compost was determined by acid digestion method (Jackson, 1973). Estimation of bacteria, fungi and actinomycetes were done using Thornton's media, Martin's media and Jensen's media respectively according to procedure outlined by Black (1965). Stability test of compost (*viz.* CO_2 evolution rate) and phytotoxicity bioassay test were performed according to the procedure suggested by Trautmann and Krasny (1997). Seedling emergence and root elongation (which are phytotoxicity bioassay parameters) were assessed under different compost (using compost tea as per the procedure suggested by Trautmann and Krasny, 1997) *vis-à-vis* control (where only water was used). Wheat (*Triticum aestivum*) was used as test seed for above analysis.

III. RESULT AND DISCUSSION

Physicochemical Parameters of Raw Materials :

Physicochemical properties of raw composting materials *viz.* green matter and cow dung are given in table 1. Average moisture content in green matter and cow dung varied from 70.40 to 84.65 and 76.81 to 86.62 percent with 43.58 to 31.04 percent organic carbon content respectively. Total nutrient content ($N+P_2O_5+K_2O$) in green matter and cow dung were 2.19 and 1.95 percent respectively.

Analysis of Final Compost :

To assess the comparative end product quality under different composting process *viz.* Vermi (VC), Biodynamic (BD), Indigenous (IC) and Novcom (NOV) composting method, final compost samples were evaluated for 35 different quality parameters covering physicochemical properties, nutrient content, microbial population, stability, maturity and phytotoxicity status (Table 2A and 2B).

Physical Properties of Compost Samples :

All the compost samples appeared dark brown in colour with an earthy smell, deemed necessary for mature compost (Epstein, 1997). Average moisture in compost samples varied from 46.87 to 55.42 percent, which may be placed in the high value range (40 to 50) as suggested by Evanylo, (2006). Bulk density of the compost samples (0.48 to 0.67 g/cc,) were well within the standard range (0.4 to 0.7 g/cc) as suggested by U.S Composting Council (2002). Porosity of the compost samples ranged from 50.82 to 67.22 percent (Table 1A). Water holding capacity values were 138.76, 126.86, 188.20 and 148.71 percent respectively in case of VC, BD, IC and NOV compost samples thereby representing high value range (standard range of 100 to 200 with preferred value of >100) as suggested by Evanylo, (2006).

Physicochemical Properties of Compost Samples :

The predominant use of compost is to mix it with soil in order to form a good growing medium for plants, for which pH forms an important criteria of consideration (Watson, 2003). pH value were 6.77, 7.51, 7.06 and 7.47 in case of VC, BD, IC and NOV compost respectively indicating that it was well within the stipulated range (7.2 to 8.5) only in case of Biodynamic and Novcom compost samples; as suggested by Jime`nez and Garcia (1989) for good quality and mature compost (Table 2A). Electrical conductivity value of all the compost samples ranged between 1.23 and 2.37 dSm^{-1}, indicating their high nutrient status, and at the same time being safely below (< 4.0 dSm^{-1}) the stipulated range for saline toxicity as per USCC, 2002 (Evanylo, 2006). However, highest EC value obtained in case of Novcom compost might indicate towards its comparatively higher nutritional content.

Organic carbon content in all the compost samples ranged between 22.24 and 28.68 percent, qualifying not only the criteria for field application (16 to 38) as per the range suggested by USCC (2002) but also the standard suggested value of >19.4 percent (Australian Standard 4454, 1999) for nursery application. Cation exchange capacity of different compost samples ranged between 120.43 and 187.53 cmol $(p+)kg^{-1}$, where the higher value was obtained in case of Novcom compost followed by Biodynamic and Indigenous compost. Compost mineralization index (CMI) expressed as ash content/ oxidizable carbon indicated the ready nutrient supplying potential of compost for plant uptake. The CMI values of the compost samples varied from 1.69 to 2.70 indicating their compliance with the standard range (0.79 to 4.38) as suggested by Rekha *et al.* (2005). Sorption capacity index, reflected the degree of maturity of specific humic compounds (Inbar *et al*., 1990) and in compost samples varied within 4.54 and 6.69 once again qualifying the criteria(>1.7) for well humified compost as described by Iglesias & Perez (1992).

Nutrient Content in Compost Samples :

The total nitrogen content in the compost samples ranged between 1.74 and 2.24 percent, which was well above the reference range (1.0 to 2.0 percent) as suggested by Alexander (1994) and Watson (2003). The highest content of Nitrogen (2.24 percent) as obtained in case of Novcom compost might indicate higher fixation of atmospheric N within compost heap during Novcom composting process (Seal *et al.*, 2011). Total Phosphate (0.61 to 0.81 percent) and total potash content (0.74 to 1.19 percent) were also higher than the minimum suggested standard (0.6 to 0.9 percent and 0.2 to 0.5 percent respectively) by Alexander (1994) and Watson (2003). Total phosphate content was found to be highest in Biodynamic compost (0.81 percent) closely followed by Novcom compost (0.80 percent). However total potash content was once against highest in Novcom compost (1.19 percent), as compared to the others. The comparatively higher nutrient content of Novcom compost (Fig. 1) might indicate towards an intense biodegradation process, which not only ensured minimum loss of inherent nutrients but also further appreciation in terms of specific nutrient like nitrogen (Fig. 2). C/N ratio varied from 12 : 1 in case of Indigenous Compost and 15 : 1 in case of Vermi Compost indicating that all the compost samples were mature and suitable for soil application.

Ready Nutrient Supplying Potential of Compost :

In the different compost samples water soluble carbon, varied from 0.25 to 0.43 percent, water soluble inorganic nitrogen ranged from 0.057 to 0.136 percent while water soluble organic nitrogen varied between 0.044 and 0.076, percent (Table 2B). Organic C/N ratio in compost water extract is considered to be one of the important index for compost maturity (Jimenez and Garica, 1989; Chanyasak *et al.*, 1982 and Bhattacharyya, 2001). The values (4.9 : 1 to 6.0 : 1) obtained for different compost samples were almost within the stipulated range of 5:1 to 6:1 as proposed by Hirai *et al.* (1985) and Chanyasak *et al.* (1982).

Microbial Properties of Compost Samples :

The microbial population in Novcom compost samples (in the order of 10^{16} c.f.u. for total bacteria, total fungi and total actinomycetes count) was significantly higher (at least 10^4 to 10^6 c.f.u. times) than the population obtained in case of other compost samples (Fig. 3). The population of ammonifiers, nitrifiers and phosphate solubilizing bacteria (PSB) was also evaluated and varied between 6.4×10^7 and 2.2×10^{14}, 31×10^7 and 4.2×10^{14} and 14×10^8 and 14×10^{14} c.f.u. respectively. The population of ammonifiers, nitrifiers and phosphate solubilizing bacteria (PSB) was also distinctly higher in the Novcom compost as compared to the other compost. Microbial biomass of compost is considered as an indicator of bio-maturity (Mathur *et al.*, 1993) and the values obtained for the different compost samples (0.43 to 1.09) were well within the critical limit of < 1.7 percent as proposed by Mondini *et al.* (1997) for compost maturity/ stability.

Stability, Maturity & Phytotoxicity Rating of Compost :

Microbial respiration forms an important parameter for determination of compost stability (Gómez *et al.*, 2006). Mean respiration or CO_2 evolution rate of all the types of compost (1.23 to 3.72 mg/day) was more or less within the stipulated range (2.0 - 5.0 mg/day) for stable compost as proposed by Trautmann and Krasny (1997) and Bartha and Pramer (1965). The value obtained was also in close conformity to the respirometry stability class rating of U.S Composting Council (2002) for compost stability (Thompson *et al*., 2002).

Free ammonia released from decaying organic matter inhibited seed germination (Okuda and Takahasi, 1961; Megie *et al.*, 1967; Wong and Chu, 1985), delayed shoot growth (Wong and Lau, 1983) and root elongation processes. Analytical interpretation of all the compost samples revealed that the values satisfied the critical limit (< 0.04 %) for NH_4^+-N (Zucconi and Bartoldi, 1987) and (> 0.03 %) for NO_3^-- N (Forster *et al*., 1993). The nitrification index (ratio of NH_4^+- N/ NO_3^-N) ranged between 0.25 and 0.84, which was in optimum conformity with the standard reference range (0.03 to 18.9) for compost maturity as suggested by Hirai *et al*. (1983) and USCC (2002). Most importantly the ratio was even much below the stipulated safety limits (< 7.14) for application in Nursery beds (AS 4454, 1999).

The phytotoxicity bioassay test, as represented by germination index provided a means of measuring the combined toxicity of whatever contaminants may be present (Zucconi *et al.*, 1981). The test value indicated complete absence of any phytotoxic effect in all the different types of compost, as per the standard value of 0.8 to 1.0 suggested by Trautmann and Krasny (1997). At the same time germination index value of >1.0 as obtained in case of Novcom compost indicated not only the absence of phytotoxicity (Tiquia *et al.*, 1996) in the compost but moreover, it confirmed that the compost enhanced rather than impaired germination and radical growth (Trautmann and Krasny, 1997).

Pic. 1: Large scale Novcom composting programme at Maud T.E, Assam.

Table 1 : Physicochemical parameters of green matter and cow dung used as raw material for compost production during 2010-2012 (Pooled data of 12 samples).

Sl. No.	Parameter	Analytical Value	
		Green Matter	Cow dung
1.	Moisture percent (%)	70.40 - 84.65 (79.46)	76.81 - 86.62 (83.30)
2.	pH_{water} (1 : 5)	6.32 – 6.81 (6.61)	6.12 - 7.44 (6.78)
3.	EC (1 :5) dS/m	0.12 – 0.22 (0.15)	1.42 – 1.90 (1.69)
4.	Total Ash Content (%)	19.39 - 24.84 (21.55)	37.04 – 46.67 (40.48)
5.	Total Volatile Solids (%)	75.16 – 80.61 (78.45)	53.33 – 62.96 (60.65)
6.	Organic carbon (%)	41.75 - 44.79 (43.58)	29.63 – 34.98 (31.04)
7.	Total nitrogen (%)	0.92 – 1.23 (1.14)	0.74 – 1.08 (0.86)
8.	Total phosphorus (%)	0.33 – 0.49 (0.42)	0.47 – 0.64 (0.58)
9.	Total potassium (%)	0.50 – 0.74 (0.63)	0.41 – 0.60 (0.51)
10.	C/N ratio	35 : 1 – 43 : 1 (38 : 1)	30 : 1 – 39 : 1 (35 : 1)

Table 2A : Quality parameters of different types of compost produced at Maud tea estate (Assam) during 2010-2012 (Pooled data of 12 samples from each type of compost).

Sl. No.	Parameter	Analytical Value			
		Vermi compost	Biodynamic compost	Indigenous compost	Novcom compost
Physical Parameters					
1.	Moisture percent (%)	52.49	49.86	46.87	55.42
2.	Bulk density (g/cc)	0.67	0.61	0.48	0.60
3.	Porosity (%)	58.27	50.82	67.22	58.14
4.	WHC[1] (%)	138.76	126.86	188.20	148.71
Physicochemical Parameters					
5.	pH_{water} (1 : 5)	6.77	7.51	7.06	7.47
6.	EC (1 :5) dS/m	1.23	2.01	1.89	2.37
7.	Total Ash Content (%)	52.22	55.68	59.97	48.38
8.	Total Volatile Solids (%)	47.78	44.32	40.03	51.62
9.	Organic carbon (%)	26.54	24.62	22.24	28.68
10.	CEC $(cmol(p+)kg^{-1})$	120.43	157.41	148.69	187.53
11.	CMI[2]	1.97	2.26	2.70	1.69
12.	Sorption capacity index	4.54	6.39	6.69	6.54
Fertility Parameters					
13.	Total nitrogen (%)	1.73	1.87	1.80	2.24
14.	Total phosphorus (%)	0.61	0.81	0.56	0.80
15.	Total potassium (%)	0.74	1.05	0.75	1.19
16.	C/N ratio	15:1	13:1	12:1	13:1

[1]WHC : Water holding capacity; [2]CMI : Compost mineralization index

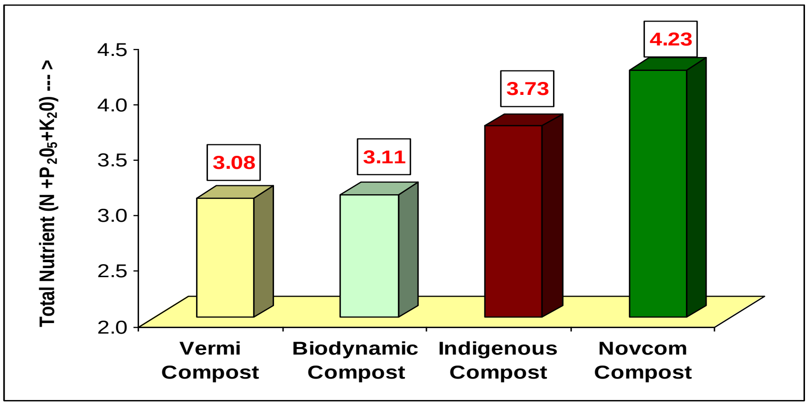

Fig. 1: Comparative study of total nutrient content in Vermi, Biodynamic, Indigenous and Novcom compost samples from Maud T.E., Assam.

Table 2B: Quality parameters of different types of compost produced at Maud tea estate (Assam) during 2010-2012 (Pooled data of 12 samples from each type of compost).

Sl. No.	Parameter	Analytical Value			
		Vermi compost	Biodynamic compost	Indigenous compost	Novcom compost
Ready Nutrient Supplying Potential					
17.	Water soluble carbon (%)	0.25	0.26	0.35	0.43
18.	Water soluble inorganic N (%)	0.057	0.075	0.09	0.136
19.	Water soluble organic N (%)	0.044	0.053	0.058	0.076
20.	Organic C/N ratio	5.7 : 1	4.9 : 1	6.0 : 1	5.6:1
21.	Humification ratio	0.94	1.06	1.57	1.50
Microbial Parameters (per gm moist soil)					
22.	Total bacterial count[3]	48×10^{12}	69×10^{12}	53×10^{12}	61×10^{16}
23.	Total fungal count[3]	32×10^{10}	23×10^{12}	23×10^{11}	14×10^{16}
24.	Total actinomycetes[3] count	11×10^{10}	21×10^{12}	14×10^{11}	16×10^{16}
25.	Total ammonifiers[4]	6.4×10^{7}	8.4×10^{8}	2.6×10^{8}	2.2×10^{14}
26.	Total nitrifiers[4]	31×10^{7}	61×10^{8}	18×10^{8}	4.2×10^{14}
27.	Total PSB[4]	14×10^{8}	15×10^{10}	13×10^{10}	14×10^{14}
28.	MBC[4] (%)	0.43	0.84	0.88	1.09
Stability Parameters					
29.	CO_2 evolution rate ($mgCO_2$–C/g OM/day)	2.02	1.42	1.23	3.72
Maturity & Phytotoxicity Parameters					
30.	NH_4^+ - Nitrogen (%)	0.026	0.022	0.023	0.027
31.	NO_3^- - Nitrogen (%)	0.031	0.053	0.067	0.109
32.	Nitrification Index	0.84	0.42	0.34	0.25
33.	Seedling emergence (% of control)	87	92	98	109
34.	Root elongation (% of control)	95	97	90	105
35.	Germination index (phytotoxicity bioassay)	0.83	0.89	0.88	1.14

[3]Count in MPN method.;[4]MBC : Microbial biomass carbon

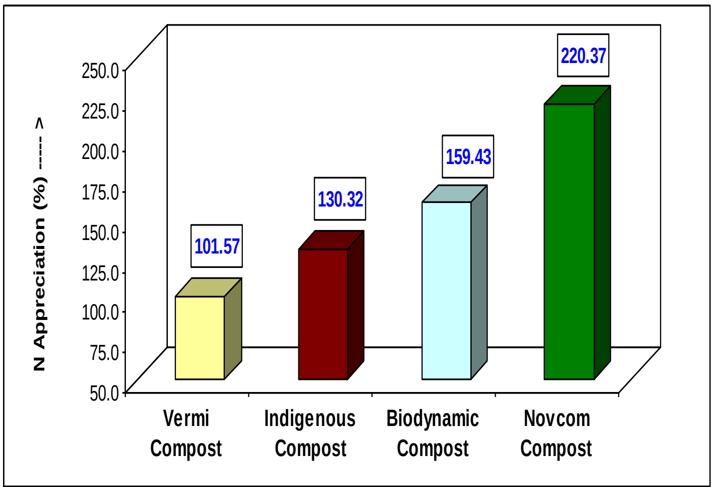

Fig. 2: Appreciation of total N value in final compost over total N value in raw material, under different composting methods at Maud T.E. (Assam) under FAO-CFC-TBI Project.

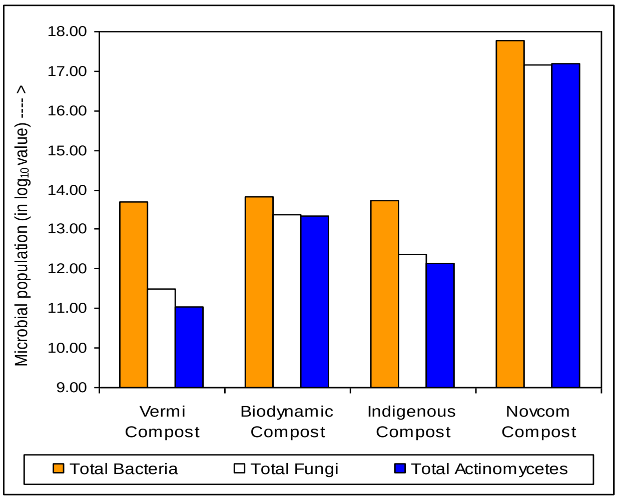

Fig. 3: Comparative study of differential microbial population *viz.* total count of bacteria, fungi and actinomycetes in Vermi, Biodynamic, Indigenous and Novcom compost samples.

Formulation of Compost Quality Index (CQI) :

In order to classify the different types of compost, four specific quality parameters (which were combination of one or more properties that regulate the nutrient mineralization from compost as well as its post soil application effectivity) were taken up to formulate Compost Quality Index (CQI), which is represented by the following equation :

$$\text{Compost Quality Index (CQI)} : \frac{NV_{NPK} \times MP \times GI}{C/N \text{ ratio}}$$

Where NV_{NPK} = Total nutrient value in terms of total ($N+P_20_5+K_20$) percent.

MP = $\log_{10}$ value of total microbial population in terms of total bacteria, total fungi and total actinomycetes.

GI = Germination Index.

Classification of compost as per Compost Quality Index

Compost Quality Index (CQI)		Compost Quality Classification
> 2.00	:	Poor
2.00 – 4.00	:	Moderate
4.00 – 6.00	:	Good
6.00 – 8.00	:	Very Good
8.00 – 10.00	:	Extremely Good

Average CQI values (Fig. 4) obtained for different types of compost indicated Novcom compost (average CQI: 6.77) to be of very good quality. Biodynamic, Indigenous (average CQI: 3.54) and Vermi compost represented moderate quality status as reflected by their average CQI values of 3.54, 3.04 and 2.28 respectively.

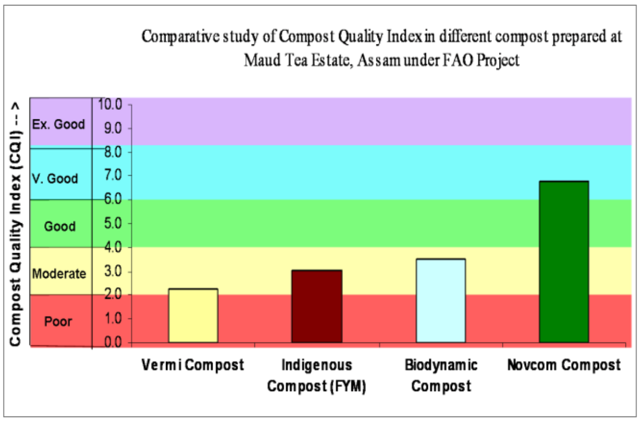

Fig. 4 : Quality rating of different types of compost as per Compost Quality Index (CQI).

Comparative Study of Convenience Factor of Different Composting Methods :

The degree of convenience or inconvenience associated with any composting method can be judged through different parameters *viz.* process simplicity, infrastructural requirement, raw material selectivity, biodegradation period, necessity/ frequency of monitoring required, sensitivity to external factors etc. The convenience factor forms one of the important regulating criteria towards choice of a composting process for large scale adoption. Comparative study of the different composting methods in terms of convenience factor is represented in table 3. The study reflected Novcom composting method as the most convenient option primarily because of its shortest biodegradation period besides clearing all the other judgmental criteria.

Pic. 2: Professors from Calcutta University visit Novcom composting site at Maud T.E.

Economics of Compost Production under Different Composting Methods :

Economics for the production of different types of compost was calculated using the data provided by Garden authority of Maud T.E. (Table 4, Fig. 5). As per calculation unit cost of compost production was lowest in case of Novcom compost (Rs 0.82/- per kg) followed by Indigenous compost (Rs. 0.97/- per kg) and Biodynamic compost (Rs. 1.08/- per kg). Cost of Vermi compost production was the highest with unit cost of Rs. 1.62/- per kg, excluding the capital expenditure involved. Finally cost of compost application is actually the cost of N, since compost dose is fixed as per the plant N requirement. In this respect also the lowest unit cost was obtained for Novcom compost, followed by Indigenous, Biodynamic and Vermi compost respectively.

Table 3 : Convenience factor of different composting methods at Maud T.E., Assam.

Parameters	Vermi compost	Biodynamic Compost	Indigenous Compost	Novcom compost
Requirement of infrastructure	Yes	Partly Yes	No	No
Biodegradation period	60 to 75 days	80 to 90 days	80 to 90 days	21 to 30 days
Selectivity of raw materials	Yes	No	No	No
Monitoring requirement.	Yes	Minimum	No	Minimum
Simplicity in composting process	Complex	Moderate	Simple	Simple
Sensitivity to external factors	Yes	No	No	No

Table 4 : Comparative evaluation of cost components under different composting methods.

Parameters	Vermi compost	Biodynamic Compost	Indigenous Compost	Novcom compost
Relevant Data Regarding Standard Compost Heap				
Total raw material used	2600 kg	2200 kg	2700 kg	4500 kg
Recovery percent	48.89 %	56.82 %	50.74 %	68.67 %
Mandays used	6.5	4.2	6.2	8.2
Cost Component per Standard Compost Heap				
Green matter (@ Rs. 0.25/- per kg)	Rs. 400/-	Rs. 375/-	Rs. 500/-	Rs. 875/-
Cowdung (@ Rs. 0.40/- per kg)	Rs. 400/-	Rs. 280/-	Rs. 280/-	Rs. 400/-
Mandays (@ Rs. 89/- per day)	Rs. 579/-	Rs. 374/-	Rs. 552/-	Rs. 730/-
Cost of other inputs /heap	Rs. 685/-*	Rs. 317/-	-	Rs. 525/-
Total Cost	Rs. 2064	Rs. 1346/-	Rs. 1332/-	Rs. 2530/-
Total compost Produced	1271 kg	1250 kg	1370 kg	3090 kg
Cost of 1 kg Compost	Rs. 1.62/-	Rs. 1.08/-	Rs. 0.97/-	Rs. 0.82/-
Cost of Compost on Equivalent Moisture Basis (*considering Novcom compost, which has the highest moisture content*)				
Cost of compost per kg (Rs.) (Considering that all types of compost contain 55.42 % moisture)	Rs.1.52/-	Rs.0.96/-	Rs.0.82/-	Rs.0.82/-
Cost for supplying 1 kg N (on dry weight basis)				
Total N content in 1 ton final Compost (kg)	8.22 kg	9.38 kg	9.56 kg	9.99 kg
Cost for supplying 1 kg N (Rs.)	Rs. 198/-	Rs. 115/-	Rs. 102/-	Rs. 82/-

* Infrastructural cost is not included.
Extra mandays required for chopping of raw material in all the four methods has not been included in the above cost calculation.
Note : 100 Indian Rupees equivalent to 1.83 American dollar / 1.85 Australian dollar / 1.20 British pound as on 15th May, 2013.

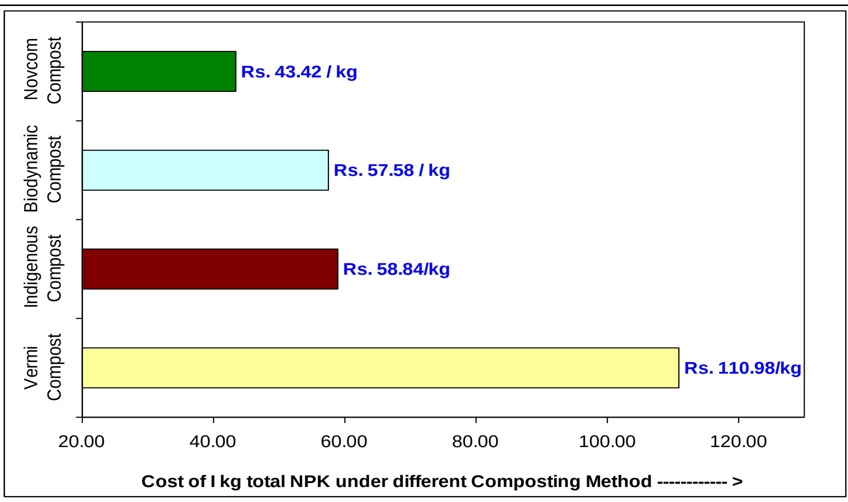

Fig. 5: Variation in unit cost of macro nutrients in the end product under different composting methods at Maud T.E., Assam.

Pic. 3: Regular monitoring of temperature of Novcom compost heap ensures compost quality.

Pic. 4 : Officials from CFC & TBI witnessing large scale Novcom Composing Programme at Maud Tea.

IV. CONCLUSION

Comparative evaluation of four different types of compost *viz.* Vermi compost, Biodynamic compost, Indigenous compost or Farm Yard Manure (FYM) and Novcom compost; indicated that they were of more or less similar quality in terms of physicochemical properties (except for C.E.C, which was comparatively higher in case of Novcom compost), stability and phytotoxicity rating. However, a major difference was noted in case of nutrient content (N+P+K), where Novcom compost recorded about 19 to 29 percent and 13 to 37 percent higher value in terms of total N and total nutrients (N+P+K) respectively; when compared with the rest other types of studied compost. The higher nutrient/ N content in Novcom compost along with about 10^4 to 10^6 times higher microbial population status (total bacteria, fungi and actinomycetes), reflected its comparatively higher potential towards mineralization of plant nutrients as well as restoration and enhancement of the native soil microflora, post soil application. Biodynamic and Indigenous (FYM) compost represented similar microbial potential but when compared in terms of nutrient content, the former definitely scored higher. Assessment of the convenience factor and cost of compost production, which are the determinant criteria for large scale adoptability of any composting process, indicated Novcom composting method as a convenient process with lowest unit cost (Rs. 0.82/- for 1kg compost and Rs. 82 for supplying 1kg N) while vermicompost came out as a costly proposition with highest unit cost (Rs. 1.62/- for 1kg compost and Rs. 198 for supplying 1kg N) *vis-à-vis* lowest nutrient content and microbial potential.

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Pic. 5: Indigenous composting (FYM) programme at Maud T.E. under FAO-CFC-TBI Project.

Pic. 6: Biodynamic composting programme at Maud T.E. under FAO-CFC-TBI Project.

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