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Qualitative Approach in Organic Soil Management - the Key Factor behind Development of Acid Tea Soils

Agriculture

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ABSTRACT

Quality of different on- farm produced compost viz. Vermicompost, Biodynamic, Indigenous, and Novcom compost were evaluated along with their post soil application effectivity during 2009-2012. The result showed better qualitative aspects of Novcom compost as compared to others in terms of total NPK content (13.0 %), total microbial count (at least 103 to 106 times higher c.f.u.) and germination index (21.3 % higher than the 2nd best value) as also substantiated by the high compost quality index. Simultaneously Soil Development Index (SDI), which indicated the variation/ enhancement in different soil quality parameters by a single understandable value; was found to be highest in case of Novcom compost applied plots (54.72) followed by plots receiving Biodynamic (37.81), Vermicompost (32.05) and Indigenous (24.82) compost. Evaluation of crop yield vis-a-vis SDI value under different types of compost application indicated strong positive correlation between the two.

INTRODUCTION

Organic soil management is becoming requisite not only for restoration of depleted soil character but most importantly to restrict the continuous decline of crop productivity. However, to meet the objectives without any time lag an effective soil management protocol will be essential, which can be achieved only through application of good quality, stable and mature compost. On-Farm compost production using locally available resources can ensure quality compost. Regular application of good quality compost can lead to rapid proliferation and activity of the native soil microflora population, which being the prime drivers behind all soil ecological processes serve for restoration of soil quality (Bera *et al.*, 2011). Hence, the present study was taken up to investigate how compost quality varies under different biodegradation processes *vis-à-vis* their impact on soil quality development in acid tea soils of Assam.

MATERIALS AND METHODS

The study was done as M.Sc. Project work, using data support from FAO-CFC-TBI project entitled 'Development, Production and Trade of Organic Tea', which was conducted at Maud tea estate (Assam) from 2008-09 to 2012-13. Analytical work was done partly in the Dept. of Agricultural Chemistry and Soil Science (Calcutta University) and at Inhana Biosciences laboratory, Kolkata. Mature tea plantation (8 years) was taken for the study and the treatments were placed as per randomized block design with three replications and individual plot size of 0.03 ha. Different compost *viz.* Vermicompost (VC), Biodynamic (BD), Indigenous (FYM) and Novcom (NOV) compost were applied (incorporated in soil) at a rate to supply 75 kg Nitrogen per hectare for plant uptake for 3 consecutive years.

***Production of different types of compost* :**

On-farm available common garden weeds and locally available cowdung were used for production of four different types of compost *viz.* Vermicompost (VC), Indigenous (FYM), Biodynamic (BD) and Novcom (NOV) compost at Maud tea estate (Assam) as per the standard processes (Bera *et al.*, 2013b). VC was produced within a period of 75 days, biodegradation period for FYM and BD was 90 days while that for NOV was 21 days.

Analysis of compost samples :

Three samples representing individual compost heaps were collected under each composting process (i.e., total 12 compost samples) and analyzed for different quality parameters following the methodology described in Seal *et al.* (2012). Compost Quality Index was calculated as per the methodology of Bera *et al.* (2013b).

Analysis of soil samples :

Samples from 0 to 50 cm soil depth were collected from all the experimental plots before initiation of experiment in the year 2009 and then after three years i.e. post completion of experiment. Soil physicochemical, fertility and microbial properties were analyzed as per standard methodology of Black (1965). Soil Development Index (SDI) was calculated as per the methodology suggested by Bera *et al.* (2013a).

$$\text{Soil Development Index (SDI)} = \frac{a}{n^2}\left\{\sum_{n=1}^{n}\frac{100\,(X_1-C_1)}{C_1}+\frac{100\,(X_2-C_2)}{C_2}+\ldots\ldots\ldots\ldots+\frac{100\,(X_n-C_n)}{C_n}\right\}$$

Where X = Value of Individual Soil Quality Parameter after Experimentation, C = Values of Individual Soil Quality Parameters before Experimentation; a = no. of Soil Quality Parameters showing increase over initial value.

RESULTS AND DISCUSSION

Evaluation of compost quality

Qualitative evaluation of compost samples was done in terms of physicochemical properties, nutrient content, microbial potential, stability and phytotoxicity parameters (Table 1). Total N, P_20_5 and K_20 content, which varied from 1.52 to 2.24 percent, 0.49 to 0.80 percent and 0.58 to 1.22 percent respectively in different types of compost samples, were higher than the reference range suggesting good nutrient content.

Table 1: Quality parameters of different on-farm compost (pooled data).

Sl. No.	Parameter	Analytical Value			
		Vermi compost	Biodynamic compost	Indigenous compost	Novcom compost
1.	Moisture percent (%)	50.36	52.23	44.55	54.20
2.	pH_{water} (1 : 5)	6.24	7.32	7.04	7.68
3.	EC (1 :5) dS/m	1.56	1.63	1.57	2.32
4.	Organic carbon (%)	23.07	32.03	25.97	27.07
5.	CMI[1]	2.54	1.32	2.05	1.89
6.	Total nitrogen (%)	1.68	1.82	1.52	2.24
7.	Total phosphorus (%)	0.56	0.72	0.49	0.80
8.	Total potassium (%)	0.79	1.22	0.58	1.21
9.	C/N ratio	14 : 1	18 : 1	17 : 1	12 : 1
10.	Total bacterial count[2]	43×10^{12}	62×10^{12}	49×10^{12}	53×10^{16}
11.	Total fungal count[2]	28×10^{10}	21×10^{12}	19×10^{11}	23×10^{16}
12.	Total actinomycetes count[2]	8×10^{10}	18×10^{11}	11×10^{11}	11×10^{14}
13.	CO_2 evolution rate ($mgCO_2$–C/g OM/day)	1.86	1.68	2.31	3.86
14.	Germination index	0.83	0.93	0.94	1.14

[1]CMI : Compost mineralization index; [2] per gm moist soil

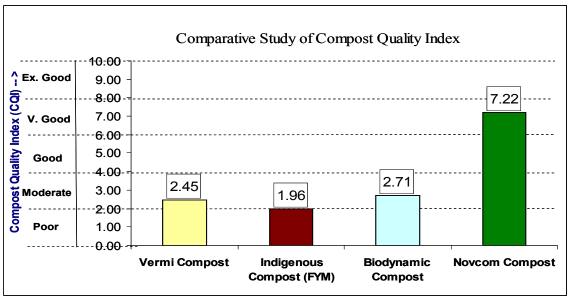

Fig. 1 : Quality Index (CQI) of different types of compost.

However, total nutrient ($N + P_2O_5 + K_2O$) content was highest in NOV (4.26 %) followed by BD (3.96 %), VC (3.03 %) and FYM (2.59 %). High nutrient status of Novcom compost might be due to due to its short biodegradation period (21 days), which ensured minimum nutrient loss along with appreciation of N content in final compost (Bera *et al.*, 2013b).

C/N ratio varied from 12:1 to 18:1 suggesting the completion of biodegradation in all the composing heaps. However, evaluation of microbial potential (total bacteria, total fungi and total actinomycetes) in different types of compost samples distinctly separated Novcom compost from the rest. While the population varied from 10^{10} to 10^{12} c.f.u. in case of VC, BD and FYM, status as high as 10^{14} to 10^{16} c.f.u. was recorded in case of Novcom compost.

Evaluation of stability (CO_2 evolution rate) and Maturity (germination index) parameters indicated all the compost samples to be stable and mature with no phytotoxic effect. The study clearly indicated superior quality of Novcom compost as compared to the others which was once again confirmed by its Quality Index i.e., CQI (Fig. 1).

Table 2: Variation in soil quality under application of different types of compost.

Soil Quality Parameters	Treatment plots (0 – 50 cm)				
	T_1	T_2	T_3	T_4	T_5
Physicochemical and fertility parameters					
pH (H_2O)	4.7 (4.5)	4.6 (4.7)	4.7 (4.7)	4.6 (4.8)	4.7 (4.9)
Organic carbon (gkg^{-1})	6.7 (6.6)	6.2 (8.2)	7.2 (7.8)	8.0 (9.6)	6.4 (9.6)
C.E.C. ($cmol(p^+)kg^{-1}$)	12.5 (13.1)	12.4 (13.4)	12.6 (15.1)	13.1 (13.4)	11.8 (13.7)
Available N ($kgha^{-1}$)	350 (326)	343 (399)	316 (381)	337 (400)	315 (424)
Available P_2O_5 ($kgha^{-1}$)	26 (27)	28 (36)	33 (42)	31 (40)	25 (48)
Available K_2O ($kgha^{-1}$)	184 (122)	205 (227)	201 (218)	189 (205)	173 (206)
Available SO_4 ($kgha^{-1}$)	28 (24)	29 (42)	33 (41)	31 (45)	25 (42)
Soil microbial population (per gm moist soil) [log_{10} value]					
Bacteria	5.93 (7.37)	5.86 (7.52)	5.44 (7.57)	5.53 (7.74)	5.63 (8.14)
Fungi	5.22 (5.46)	5.12 (5.79)	5.22 (5.81)	5.55 (6.19)	5.44 (6.23)
Actinomycetes	4.94 (5.13)	4.92 (5.32)	5.11 (5.78)	4.81 (5.58)	4.97 (6.03)
Ammonifiers	2.90 (4.28)	2.83 (5.06)	3.12 (5.03)	3.32 (5.19)	3.27 (4.24)
Nitrobactor	3.53 (5.01)	3.55 (5.00)	3.16 (4.20)	3.61 (4.30)	4.05 (4.77)
PSB[1]	4.03 (4.03)	4.01 (4.25)	4.32 (4.45)	2.77 (5.20)	2.75 (5.18)
Different forms of N ($kgha^{-1}$)					
Readily available N	159 (229)	155 (237)	154 (315)	184 (205)	154 (305)
Total Mineralizable N	310 (324)	291 (380)	299 (433)	337 (375)	287 (433)
Exchangeable NH_4	31 (32)	30 (38)	30 (39)	35 (37)	149 (169)
Exchangeable (NO_2+NO_3)	129 (197)	125 (199)	124 (275)	31 (38)	124 (267)
Soil Micronutrient ($mgkg^{-1}$)					
Available Zn	1.14 (1.06)	1.20 (1.39)	1.21 (1.30)	1.20 (1.22)	1.15 (1.39)
Available Cu	1.12 (1.23)	1.43 (1.38)	1.82 (1.38)	1.84 (1.33)	1.31 (1.33)

Note : T_1 : Control; T_2 : VC applied plots T_3 : BD applied plots; T_4 : FYM applied plots and T_5 : NC applied plots; *Data in parenthesis is post experiment soil analysis data, [1]PSB: Phosphate Solubilizing Bacteria

Variation of soil quality post compost application

Study of pre and post compost applied soil samples from the different experimental plots in Maud Tea Estate (Assam) revealed an increasing trend of fertility and soil microbial status post compost application (Table 2). Similar results were obtained by

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Stamatiadis *et al.* (1999) during their study regarding post soil application effectivity of compost. Correlation study showed significantly positive relation of crop yield with sixteen different soil quality parameters (Table 3).

Table 3 : Correlation coefficient between Yield and Soil Quality Parameters.

Crop Yield vs.	Org. C	0.657**	Crop Yield vs.	Ex. (NO_2+NO_3)	0.542*
	Av. N	0.758**		Bacteria	0.640**
	Av. P_2O_5	0.743**		Fungi	0.744**
	Av. K_2O	0.533*		Actinomycetes	0.497*
	Av. SO_4^{2-}	0.679**		Ammonifiers	0.566*
	Readily Av. N	0.591*		Nitrobactor	0.514*
	Total Min. N	0.634**		PSB	0.745**
	Ex. NH_4	0.792**		Av. Zn	0.671**

** Significant at 1% level; * Significant at 5 % level

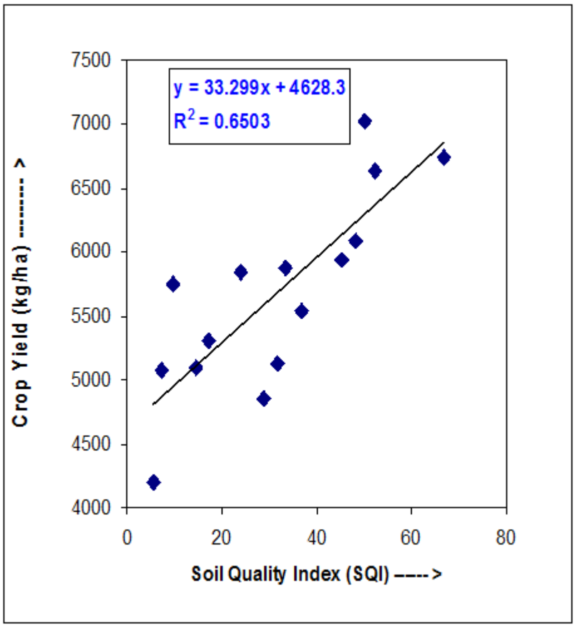

Fig. 2 : Relationship between Soil Development Index (SDI) and crop yield.

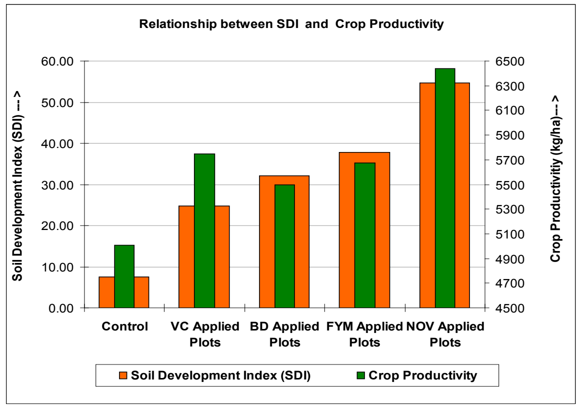

Fig. 3: Relationship between Soil Development Index (SDI) and crop yield in the different treatment plots.

Comparative variation in soil quality post application of different types of compost was assessed in terms of SDI and indicated highest soil development in case of NOV (SDI : 54.72) followed by BD (SDI : 37.81), VC (SDI : 32.05) and FYM (SDI : 24.82) applied plots (Fig. 2). Also positive and significant (r = 0.806**) correlation of SDI with crop performance indicated that it can used as a effective tool to judge soil status in relation to crop yield *vis-à-vis* the competence of on- going soil management programme (Fig. 3) towards bringing about the desired soil development.

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