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Cation Exchange Capacity of different Fractions of Compost produced from Bacterial inoculation to Agro-wastes

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ABSTRACT: In-situ Agro-waste management become a challenge now a days. One of the best managements is to decompose the agro-waste by inoculation of microbes. In this experiment the three agro-wastes were decomposed by taking three isolated cellulose degrading bacterial strain. The experimental was carried out in Department of Soil Science and Agricultural Chemistry, College of Agriculture, Bhubaneswar, India. The different size fractions of matured compost were determined by sieving manually with 4 mm, 2 mm, 1 mm and 0.5 mm sieve and Cation exchange capacity was determined by ammonium acetate saturation method. The inoculation of CBC9, CBD4 and CBG2 to maize stover resulted into 92, 93 and 95% of <4mm, 83, 86 and 87% <2mm, 32, 35 and 36% <1mm and 5, 7 and 8% <0.5mm size compost. The smallest (<0.5 mm) size fraction compost was higher in vegetable waste followed by maize stover and paddy straw. The cation exchange capacity of all the size fractions were highest in CBG2 inoculated compost followed by CBD4, CBC9 and lowest was in uninoculated compost. Likewise, among the substrates highest cation exchange capacity was estimated in vegetable wastes followed by maize stover and paddy straw. Among all compost, lowest cation exchange capacity (45 cmol (p)+ kg^{-1}) was estimated in <4mm compost where paddy straw was not inoculated with any strains and highest (277 cmol (p)+ kg^{-1}) was estimated in the <0.5 mm size compost produced from vegetable wastes inoculated with CBG2 strain.

Keywords: Cation Exchange Capacity, Cellulose Degrading Bacteria, Composting, Size Fraction.

INTRODUCTION

With rapid increase in population of India, agricultural production is increasing, resulting in production of large amount of agro-wastes. Excess and injudicious use of chemical fertilizers to meet that production results indeterioration of soil health. In-situ nutrient recycling is a novel method of organic nutrient supplementation to crop (Pattanayak and Sethi 2022). For nutrient recycling, crop residues and raw manure are excellent sources of plant nutrients and organic matter (OM). Residue management of crops can enhance productivity and nutrient recovery with INM practices in cropping systems (Sahoo *et al*., 2022). The direct application of raw organic materials can lead to increased levels of greenhouse gas, foul odour emissions, accumulation of heavy metals and antibiotics, contamination of soil and groundwater, or spread of pathogens, weed seeds, ARGs, and toxic substances (Zubair *et al*., 2020).

Composting is an eco-friendly and economically feasible method which can be used to transform agro-waste into organic products containing higher nutrient concentration than that of substrates (Pandit *et al*., 2020). The agro-wastes are difficult to degrade as they contain lignocellulose materials and require longer time for composting with production of low-quality compost. Therefore, additives are added to reduce composting time and promote product quality (Wang *et al*., 2021; Pandit *et al*., 2020; Zhang and Sun 2019). Among different additives the microbes are the most effective and degrade the organic polymers of wastes (Greff *et al*., 2022). Although many microorganisms occurring in the feedstock are responsible for the degradation of compost materials (Dastpak *et al*., 2020), inadequate quantity or poor biodegradation capacity of autochthonous microbes may result in reduced composting efficiency and undesirable compost quality (Xu *et al*., 2019). The inoculated microbes not only degrade the organic substances but also act like plant growth promoting rhizobacteria. Inoculation of native strains enhances the growth, biomass production of crop (Sethi *et al*., 2021) and produces the exopolysaccharides which helps in biomass production (Sethi *et al*., 2019a) as well as rhizospheric activity (Sethi *et al*., 2019b).

The rate of degradation of organic materials depends on the nature of substrates and efficiency of microbes leading to production of composts of variables characteristics involving different maturity time. One of the most important chemical properties to characterize the maturity of compost is cation exchange capacity. In the backdrop of the above facts, the current study was undertaken to evaluate the different size fraction of composts produced from the agro-wastes inoculated with locally isolated cellulose degrading bacteria and the variation of cation exchange capacity with different particle size of compost.

MATERIALS AND METHODS

The composting experiment was conducted in the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar. Three substrates were taken for the study *i.e.* Paddy straw, Maize Stover and vegetable waste. The paddy straw and maize stover was collected from the nearby agriculture field and the vegetable waste was collected from the market near the college. The fresh substrates were collected and chopped into small pieces. Cellulose degrading bacteria were isolated from different sources and freshly prepared broth culture of three efficient strains was inoculated with the substrates.

The different size fractions of matured compost were determined by sieving manually with 4 mm, 2 mm, 1 mm and 0.5 mm sieve. First, compost was passed through 4 mm sieve and weight was taken. Then the compost which was passed through 4 mm sieve was again passed through 2 mm sieve and followed the same procedure with the other sieve and weights were recorded and the percent (%) size fraction was determined.

Cation exchange capacity was determined by ammonium acetate saturation method (Black, 1965). One gram of oven dried compost was saturated with 10 mL of Neutral Normal Ammonium acetate (NH4OAc) and was shaken for 1 hr. The sample was filtered through Whatman no. 1 filter paper and washed with three to four ethanol washing. The sample was distilled with Kel-plus autoanalyser after ethanol washing. The exchangeable ammonium was titrated against standard 0.02N H_2SO_4 and CEC was calculated.

Statistics: The statistical analysis of data was done by using SPSS version 25 software. The graphical representation and standard error calculation was done by using Microsoft Excel.

RESULTS AND DISCUSSION

A. Different size fraction of compost

The different size fractions of compost due to inoculation of isolated strains have been presented in fig1. The compost of paddy straw from uninoculated control treatment contained 75 % of <4mm, 62 % <2mm, 24 % <1mm and 2% <0.5mm size fraction. The inoculation of strain CBC9 increased the size fractions *viz.*, 93 % of <4mm, 82 % <2mm, 43 % <1mm and 4% <0.5mm. Inoculation of strain CBD4 and CBG2 resulted in compost with 95 and 96 % of <4mm, 85 and 87 % <2mm, 45 and 49 % <1mm and 5 and 7% <0.5mm size fraction, respectively. In vegetable waste the uninoculated compost contained 85% of <4mm, 74 % <2mm, 29 % <1mm and 2% <0.5mm size fraction. Inoculation of CBC9, CBD4 and CBG2 resulted in compost with 94, 96 and 97% of <4mm, 86, 89 and 90 %<2mm, 35, 38 and 41 % <1mm and 5, 9 and 11% <0.5mm size fraction, respectively. In maize stover, the compost from uninoculated control had 78% of <4mm, 70% <2mm, 35 % <1mm and 3% <0.5mm size fraction. The inoculation of CBC9, CBD4 and CBG2 to maize stover resulted in compost with 92, 93 and 95% of <4mm, 83, 86 and 87% <2mm, 32, 35 and 36% <1mm and 5, 7 and 8% <0.5mm size fraction. The inoculation of cellulose degrading bacteria increased the small size fraction in comparison to that in uninoculated control in all substrates. Among the strains, the CBG2 increased smaller fraction in respective substrates. The smaller size fraction in inoculated compost was due to enhanced degradation of substrate by microorganisms. The present finding was corroborated with the work of Dev *et al*. (2018) where they reported that smallest size fractions of compost was produced due to inoculation with the cellulose-degrading microorganisms. Finer size fractions of compost provide larger surface area for better interaction on the application in crop production.

B. CEC of different size fractions of compost

The data related to the cation exchange capacity (CEC) of different fractions of compost has been presented in Table 1. The CEC of <4mm fractions of composts ranged from 45 cmol (p) + kg^{-1} to 72cmol (p) + kg^{-1}. Irrespective of the substrates, the mean CEC of < 4mm fractions of composts was varied between 52 cmol (p)+ kg^{-1} and 68 cmol (p)+ kg^{-1} due to inoculation with isolated strains of decomposers. The highest was on CBG2 strain inoculation and lowest was in uninoculated compost. Irrespective of the strain inoculation, the highest CEC was estimated in vegetable waste compost (66 cmol (p) + kg^{-1}) followed by maize stover (62 cmol (p)+ kg^{-1}) and paddy straw (57 cmol (p)+ kg^{-1}).

The CEC of <2mm size fractions of composts ranged from 65 cmol (p)+ kg^{-1} to 105 cmol (p)+ kg^{-1}. Irrespective of the substrates, the mean CEC of <2mm size fractions from strain inoculation varied between 73 cmol (p) + kg^{-1} and 96cmol (p) + kg^{-1}. The highest was estimated in CBG2 inoculated compost (96 cmol (p)+ kg^{-1}) followed by CBD4 (90 cmol (p)+ kg^{-1}), CBC9 (84 cmol (p) + kg^{-1}) and the lowest was in uninoculated compost (73 cmol (p)+ kg^{-1}). Likewise, among the substrates <2mm size compost recorded the highest mean CEC of 94 cmol (p) + kg^{-1} in vegetable wastes compost, followed by 85 cmol (p) + kg^{-1} in maize stover compost and the lowest of 79 cmol (p) + kg^{-1} in paddy straw compost. A similar trend was observed in <1mm and <0.5 mm size fractions of compost. The CEC was more in the smaller fraction of compost than lager fraction of compost. The CEC greater than 60 cmol (p+) kg^{-1} of ash-free material was considered to be the criteria for sufficient maturity of compost required for field application (Harada and Inoko 1980). The higher CEC in smaller fraction was due to higher specific area (Altland *et al*., 2014). The cation exchange capacity of compost depends on the substrates humification (Fornes *et al.,* 2012). The CEC is an important characteristic for measuring the maturity of the compost (Ameen *et al.,* 2016; Pandit *et al.,* 2020).

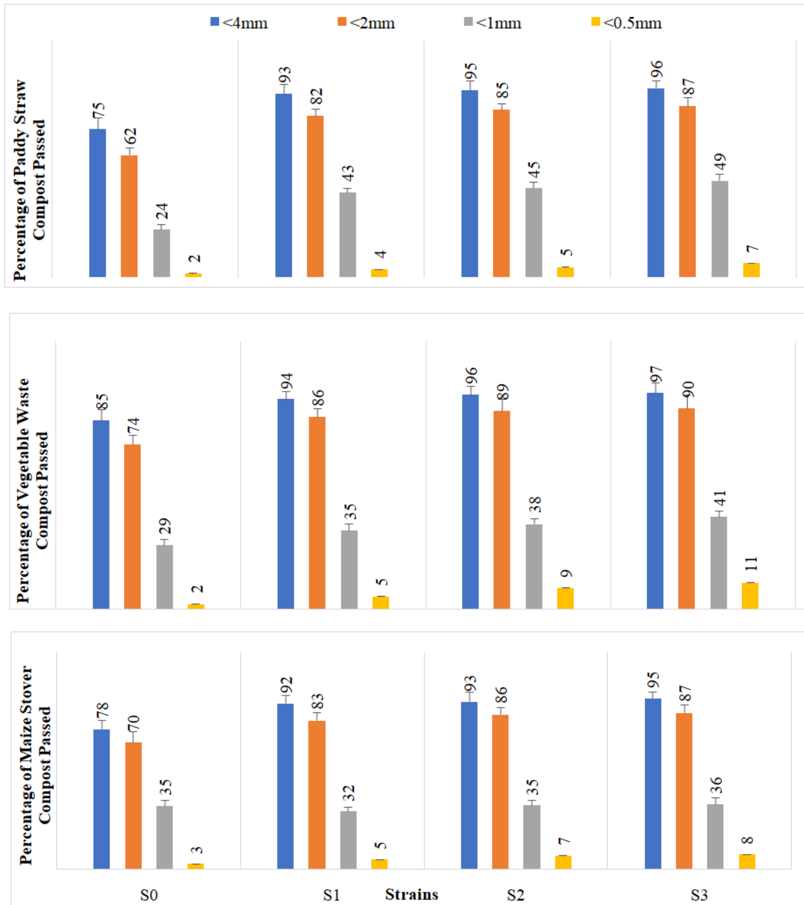

Fig. 1. Different size fractions of compost as influenced by cellulose degrading bacteria.

Table 1: CEC (cmol (p) + kg $^{-1}$) of different size fraction of compost due to inoculation with isolated decomposers.

<4mm					
Substrates	**Control***	**CBC9**	**CBD4**	**CBG2**	**Mean**
Paddy straw	45	57	62	65	57
Vegetable waste	57	65	69	72	66
Maize stover	55	61	65	67	62
Mean	52	61	65	68	
LSD (P=0.05): Strain-6.2; Substrate-7.0; Strain x Substrate-14.8CV (%):7					
<2mm					
Paddy straw	65	78	82	89	79
Vegetable waste	79	92	98	105	94
Maize stover	75	82	89	93	85
Mean	73	84	90	96	
LSD (P=0.05): Strain-8.4; Substrate-7.5; Strain x Substrate-16.4CV (%):6					
<1mm					
Paddy straw	98	108	115	119	110
Vegetable waste	115	121	129	137	126
Maize stover	110	116	121	125	118
Mean	108	115	122	127	
LSD (P=0.05): Strain-6.2; Substrate-10.7; Strain × Substrate- 18.1 CV (%):5					
<0.5mm					
Paddy straw	215	242	256	265	245
Vegetable waste	229	246	262	277	254
Maize stover	218	232	245	256	238
Mean	221	240	254	266	
LSD (P=0.05): Strain-17.9; Substrate-20.5; Strain × Substrate-40.1 CV (%):5					

*Control: No strains

CONCLUSION

Among three substrates, vegetable waste is better for production of compost with higher per cent of smaller fractions and higher cation exchange capacity. Among the strains CBG2 was most effective in production of compost with higher percent of smaller fraction and higher cation exchange capacity.

FUTURE SCOPE

The future research may be taken up with the other locally available organic sources to test and find out their suitability. The biological activity of different fraction of compost may be estimated.

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Conflict of Interest. None.

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