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Preparation of Enriched Biochar Compost Through Proliferation of Aerobic Complex Microorganisms from Farm Waste Materials

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Abstract Recent interests in addition of enriched biochar to soil has many environmental and agricultural benefits, including waste reduction, energy production, carbon sequestration, water resource protection, and soil improvement. As a not fully understood newer concept, adding biochar as a bulking agent to animal manure composting has the potential to enhance the performance of composting process. The result indicated that the addition of biochar to the composting process does not improve the quality of compost as well as it increases the cost of production. The compost-A prepared with subabul is superior over rest of the other prepared composts. However if subabul can be utilized as a livestock fodder in that case the compost-B prepared with Gliricidia can be considered as a good alternative.

Keywords Biochar, Compost, Enriched, Farm waste.

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Introduction

The technology of carbonization of biomass wastes have been receiving attention in the field of biomass waste recycling. It was reported that the addition of charcoal to farm soils had a proliferative effect on symbiotic microorganisms such as root nodule bacteria and mycorrhizae [1]. It is well known that symbiotic microorganisms play important roles in growing plants. It was expected, therefore, that addition of charcoal to composting garbage enhances microorganism's proliferation, leading the composting time to be shortened Yoshizawa [2], Yoshizawa et al. [3] previously verified the successful composting of a mixture of charcoal and garbage from 55 houses over a 2-month period in the city of Suwa, Japan. The improvement is attributed to the high cation and anion exchange capacity of biochar as well as its positive influence on soil structure and microbial dynamics [4]. Biochar is a product of biomass pyrolysis (combustion in oxygen-limited environment). The sorption capacity, porosity and other physical properties vary depending on the pyrolysis temperature and type

Table 1. Experimental details.

Treatments	Bio-char	Rock-phos-phate	Calotropis *Calotropis gigantean*	Subabul *Leucaena leucocephala*	Sugar-cane trash	FYM	Gliricidia *Gliricidia sepium*	Biofertilizer (Azoto-bactor+PSB)	Total g/ 100 kg compost
T_1 Compost-A (without biochar+Subabul)	X	5% (125 g)	10% (250 g)	Dry 20% (500 g)	20% 500 g	5% 125 g	X	500 g/100 kg compost	2000 g
T_2 Compost-B (without biochar+*Gliricidia*)	X	5% (125 g)	10% (250 g)	X	20% 500 g	5% 125 g	Dry 20% (500 g)	500 g/100 kg compost	2000 g
T_3 Compost-C (with biochar+Subabul)	40% (1 kg)	5% (125 g)	10% (250 g)	Dry 20% (500 g)	20% 500 g	5% 125 g	X	500 g/100 kg compost	2000 g
T_4 Compost-D (with biochar+*Gliricidia*)	40% (1 kg)	5% (125 g)	10% (250 g)	X	20% 500 g	5% 125 g	Dry 20% (500 g)	500 g/100 kg compost	2000 g

of biomass used as feedstock [5, 6]. Numerous publications provide evidence on the multiple benefits of compost application to soil. Effects range from soil stabilization and amelioration to phyto-sanitary impacts of mature compost. Feedstock, compost maturity and compost quality can influence intensity and degree of effects on soil physical, chemical and biological properties. Application may trigger short-term improvements such as increasing microbial activity. Long-term effects on soil properties could be achieved by preservation and increase of the stable SOM pool [7]. In organic farming compost has been used successfully to supply nutrients to crops and to support efficient nutrient cycling through microbial biomass. However, under sub tropical conditions, the efficacy of compost amendments may be offset by high decomposition rates. To alleviate this problem, biochar added as a soil conditioner from locally available plant materials could be used as mineralization inhibitors to enhance plant growth and crop yield. The main objective of this study therefore was to investigate the effects of biochar as additives to composts.

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Materials and Methods

The trial of preparation of enriched biochar compost through proliferation of aerobic complex microorganisms from farm waste matetials during the year 2015 at Soil Science and Agricultural Chemistry Department, N M College of Agriculture, Navsari Agricultural University, Navsari, AES-I of South Gujarat heavy rain-

Table 2. Chemical analysis of raw materials.

No.	RAW	OC (%)	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Na (%)
1	Biochar	92.52	0.71	0.39	1.70	6.6	3.48	2.18	–
2	Rock phosphate	–	0.36	12.88	1.90	–	–	–	1.60
3	Calotropis	82	3.15	1.86	1.12	3.4	11.32	–	0.01
4	Subabul	85	5.13	1.37	0.853	1.68	2.72	–	0.62
5	Sugarcane trash	90	0.25	0.066	0.56	2.56	1.8	0.19	0.40
6	FYM	–	0.70	0.35	0.64	0.60	0.16	0.60	0.52
7	*Gliricidia*	92	2.76	0.215	2.15	1.78	0.60		0.71

Table 2. Continued.

No.	RAW	Fe ppm	Mn ppm	Zn ppm	Cu ppm	Co ppm	Cd ppm	Pb ppm	Ni ppm
1	Biochar	318.6	29.6	10.0	10.8	–	73.0	56.1	22.6
2	Rock phosphate	7000	11.22	18.0	34.3	35.8	48	10.70	–
3	Calotropis	39.36	34.71	20.4	13.7	2.54	2.10	0.36	5.17
4	Subabul	40.96	36.1	14.6	15.5	2.8	0.72	0.00	22.2
5	Sugarcane trash	706.6	53	16.8	11.6	159.4	3.5	42.2	45.2
6	FYM	2840	165	45	15	12	1.4	75	0.090
7	*Gliricidia*	612	62	20	14	5.6	2.15	0.00	14.5

fall zone. Collection of farm waste like pigeon pea stalk and cotton stalk. The experiment comprised of four treatments with and without biochar i.e. T_1: compost-A (without biochar+Subabul), T_2: compost-B (without biochar+Gliricidia), T_3: compost-C (with biochar+Subabul) and T_4: compost-D (with biochar +Gliricidia). Preparation of biochar by Pyrolysis method.

Composting process

Initially biochar will be prepared from pigeon pea and cotton stalk by pyrolysis method. After preparation of biochar, enriched biochar compost (100 kg) will be prepared by mixing biochar (40%) + farm yard waste (20%) + rock phosphate (10%) + Calatropis leaves (5%) + Gliricidia leaves (5%) + soil microbes (Azotobactor + phosphate solubilizing bacteria + potassium solubilizing bacteria @ 0.5 kg each/100 kg compost) by heap method in shade. Experimental details presented in Table 1. Moisture will be maintained (50 to 55%) by sprinkling water. The heap will be covered with gunny bags and turned upside down at every two days interval to maintain proper temperature and aeration. Looking to the availability of Calatropis and Gliricidia leaves the above mentioned procedure could be modified with commonly available leaves for composting as per local needs.

Biofertilization are used in NAURAUJI liquid Azotobactor + phosphate solubilizing bacteria + potassium solubilizing bacteria @ 0.5 kg each/100 kg compost. Gliricidia (*Gliricidia sepium*) is a genus of flowering plants in the legume family, Fabaceae. It belongs to the sub family Faboideae. It is a small, deciduous, ornamental tree. The tree is leafless when in flower and bears fruits during April and May in India and countries with same climate. The small flow-

Table 3. Chemical properties of content of prepared compost A, B, C and D.

Treatments	$pH_{2.5}$	$EC_{2.5}$ dS m^{-1}	C:N	OC%	N%	P%	K%	Ca%	Mg%	S%
T_1 Compost-A (without biochar+ Subabul)	7.36	1.30	22.79	34.042	1.495	0.687	0.353	0.346	0.229	0.227
T_2 Compost-B (without biochar+ *Gliricidia*)	7.36	1.30	26.50	37.342	1.408	0.654	0.373	0.239	0.212	0.149
T_3 Compost-C (with biochar+ Subabul)	7.55	1.45	31.43	42.657	1.358	1.525	0.326	0.329	0.151	0.176
T_4 Compost-D (with biochar+ *Gliricidia*)	7.53	1.42	29.98	40.385	1.347	1.588	0.322	0.327	0.186	0.154
Mean	7.45	1.36	26.67	38.6065	1.402	1.1135	0.3435	0.31025	0.1945	0.189
SEm ±	0.190	0.005	0.92	1.942	0.008	0.022	0.0063	0.006	0.003	0.052
CD at 5%	0.055	0.015	0.66	3.485	0.026	0.063	0.018	0.017	0.009	NS
CV %	0.67	1.00	8.72	8.18	1.66	5.15	4.87	4.95	4.56	72.71

Table 4. Micro nutrient and heavy metal content of prepared compost A, B, C and D.

Treatments	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Cr (ppm)	Cd (ppm)	Pb (ppm)	Ni (ppm)
T_1	4088.42	338.34	172.57	47.98	75.02	0.73	73.48	45.43
T_2	3581.85	247.67	172.71	42.88	73.45	0.64	74.00	45.74
T_3	4356.84	364.71	174.00	45.18	74.35	0.71	72.55	42.84
T_4	3241.70	364.71	165.85	46.92	68.88	0.70	73.18	43.15
Mean	3817.20	328.85	171.28	45.74	72.92	0.695	73.30	44.29
SEm ±	185.41	9.09	1.29	0.63	0.447	0.010	0.444	0.298
CD at 5%	541.20	26.54	3.76	1.83	1.30	0.316	NS	0.87
CV %	12.85	7.32	1.99	3.63	1.62	4.10	1.60	1.78

ers (barely 2 cm long) are pale pink and they are borne in dense clusters on bare twigs. Flowers fade to white or a faint purple with age. Subabul (*Leucaena leucocephala*) is a small, fast-growing tree native to southern Mexico and northern Central America. Calotropis (*Calotropis gigantean*) is a genus of flowering plants in the dogbane family, Apocynaceae, first described as a genus in 1810. It is native to Southern Asia and North Africa. Chemical analyses of different raw materials are presented in Table 2.

Total nitrogen (N) content in fleshy fungi is determined by Micro-Kjeldhal method [8]. Organic carbon was determined by the Walkely and Black rapid titration method [9]. The minerals nutrients of plants contents were determined after wet digestion of the powdered compost samples. Determination of K [9] was performed on the flame photometer. Photoelectric colorimeter of Systronics, model 104 was utilized for phosphorus analysis following the vanadomolybdo phosphoric acid yellow color method [9]. The micro-nutrient (Fe, Mn, Zn, and Cu) and heavy metals (Ni, Cr, Cd and Pb) content of the samples were analyzed by atomic absorption spectrophotometer [10] and total Ca and Mg content was analyzed by complexometric method [11]. Sulfur was determined by Turbidimetric method [12]. The field experiment was conducted in CRD and data were analyzed statistically by using computer package MSTATC [13] and tested at 5% level of significance for finding the effects.

Results and Discussion

Among the prepared compost significantly lower C:N ratio higher N was obtained under compost-A i.e. under compost with subabul but without biochar (Table 1). Significantly higher content of P was obtained under compost-D (1.588%) i.e. compost with Gliricidia and biochar added in it, followed by compost-C i.e. compost with subabul and biochar (1.525%). Significantly higher K content (0.373%) was obtained under compost-B i.e. compost with Gliricidia but without biochar (Table 2). Significantly higher content of Ca (0.346%) content was obtained under the compost-A i.e. under compost with subabul leaves but without biochar followed by compost-C and D (Table 3). Significantly higher Mn content (0.229%) was obtained under the compost-A i.e. under compost with subabul leaves but without biochar. No significantly difference in the content of S was observed under prepared compost.

Significantly higher content of Fe was obtained under compost-C (4356.84 ppm) i.e. compost with subabul but without biochar added in it, followed by compost-A i.e. compost with subabul but without biochar (4088.42 ppm) (Table 4). Significantly higher content of Mn was obtained under compost-D (364.71 ppm) and C (364.71 ppm) i.e. compost with subabul + biochar and compost with Gliricidia + biochar respectively, followed by compost-A i.e. compost with subabul but without biochar (338.33 ppm).

Significantly higher content of Zn was obtained under compost-C (174.00 ppm) i.e. compost with subabul + biochar followed by compost-D i.e. compost with Gliricidia but without biochar (172.71 ppm).Significantly higher content of Cu was obtained under compost-A (47.98 ppm) i.e. compost with subabul but without followed by compost-D i.e. com-

Table 5. Economics of different treatments. Price for biochar: Rs 5/- per bag.

Compost No.	Yield (kg/bed)	Return (Rs)	Cost	BCR
T_1-Compost-A	45	225	121	1.85
T_2-Compost-B	45	225	121	1.85
T_3-Compost-C	39	195	141	1.38
T_4-Compost-D	39	195	141	1.38

Cost		Expenditure	
Biochar:	Rs 20/-per bed	Labor cost for sugarcane trash	Rs 20/-per bed
Dung:	Rs 20/-per bed	Labor cost for Subabul	Rs 20/-per bed
Rock Phosphate:	Rs 6/-per bed	Labor cost for Calotropis	Rs 20/-per bed
Biofertilizer:	Rs 25/-per bed	Labor cost for *Gliricidia*	Rs 20/-per bed
FYM	Rs 5/-per bed	–	–

post with Gliricidia but with biochar (46.92 ppm).

Significantly lower content of Cr was obtained under compost-D (68.88 ppm) i.e. compost with Gliricidia + biochar followed by compost-B i.e. compost with Gliricidia but without biochar (73.45 ppm) (Table 5). Significantly lower content of Cd was obtained compost-B (0.64 ppm) i.e. compost with Gliricidia but without biochar followed by compost-D compost with Gliricidia + biochar (0.70 ppm). Significantly lower content of Ni was obtained compost-C (42.84 ppm) i.e. compost with subabul + biochar followed by compost-D compost with Gliricidia + biochar (43.15 ppm). Significantly lower comtent of Co was obtained compost-B (24.28 ppm) i.e. compost with Gliricidia but without biochar followed by compost-A i.e. compost with subabul but without biochar (24.71 ppm). No significant difference in the content of Pb was observed under prepared compost.

In general, when C:N ratio and higher N are considered as major indicator for quality of compost, the end product of compost was superior under compost-A. The prepared compost-A have higher N content, lowest C:N ratio and marginally adequate macro, secondary and micronutrient. However except cobalt the heavy metal content was higher as compared to over other prepared compost, but well below the permissible limit and hence is considered as the most superior compost.

Economics

In the preparation of compost-A, B respectively, gave higher return as well as higher BCR in rest of the prepared compost (C, D). Though the BCR value is same in compost A and B. The compost A is superior to other compost-B in respect of lower C:N ratio higher N also.

Conclusion

It can be concluded that addition of biochar to the composting process does not improve the quality of compost as well as it increases the cost of production. The compost-A prepared with subabul is superior over rest of the other prepared composts. However if subabul can be utilized as a livestock fodder in that case the compost-B prepared with Gliricidia can be considered as a good alternative.

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