DOI: https://doi.org/10.3329/jbcbm.v10i2.82339 *J. biodivers. conserv. bioresour. manag.* **10**(2), 2024

RECLAMATION PERFORMANCE OF VERMICOMPOST AND TRICHOCOMPOST ON CHEMICAL AND MICROBIOLOGICAL PROPERTIES OF ACIDIC AND ALKALINE SOIL

Akter, A.* and S. Hossain

Department of Soil, Water and Environment, University of Dhaka, Dhaka-1000, Bangladesh

*Corresponding author: ayshaakter4119@gmail.com

Abstract

Use of biofertilizer to increase soil fertility for crop production is a general practice now but to reclaim soil acidity and alkalinity with it is somehow lesser known. This pot experiment was set up considering that idea for okra growth following completely randomized design (CRD) with three treatments (control, vermicompost, trichocompost) and three replications using acid soil (pH 4.77) and alkaline soil (pH 7.87). The results showed partial (pH 5.9) and complete (pH 6.4) neutralization of soil acidity by trichocompost and vermicompost whereas pH increased in alkaline soil but EC decreased significantly by both treatments. Besides, total OC, total N, total P, total K, total S all increased significantly ($P < 0.05$) in both soil (except S in alkaline soil) by both biofertilizer application but total Ca, Mg, Fe, Mn decreased in acid soil while results were mixed in alkaline soil. Application of both biofertilizer in both soils improved the abundance of soil quality indicator microbes (TABC, TCC, TFC), soil beneficial bacteria (PSB, PSF) and plant pathogen inhibitor significantly ($P < 0.05$).

Key words: Acidity reclamation; Salinity reclamation; Vermicompost; Trichocompost.

INTRODUCTION

Vermicompost is the product of the decomposition process using various species of worms, usually red wigglers, white worms and other earthworms to create a mixture of decomposing vegetable or food waste, bedding materials and vermicast (the end-product of the breakdown of organic matter by earthworms). These castings have been shown to contain reduced levels of contaminants and a higher saturation of nutrients than the organic materials before vermicomposting (Ndegwa *et al.* 1998). Vermicomposting has gained popularity in both industrial and domestic settings because, as compared with conventional composting, it provides a way to treat organic wastes more quickly. In manure composting, it also generates products that have lower salinity levels (Lazcano *et al*. 2008). *Trichoderma* spp. is a freeliving fungi that are common in soil and root systems and are well known to solubilize phosphates and micronutrients. They can produce phosphates and several organic acids, both phosphates and organic acids were found to solubilize insoluble phosphate. However, the ability of *Trichoderma* species depends on the kind and strain of *Trichoderma* and source of phosphate (Kapri and Tewari 2010). *Trichoderma* inoculation with trash mulch increased soil organic carbon by 5.08 Mg ha^{-1} over its initial content of 15.75 Mg ha^{-1} (Yadav *et al.* 2009). *Trichoderma* inoculants interact with a wide range of other soil microorganisms in the rhizosphere of plants. These interactions may be either stimulatory or inhibitory. These are stimulatory when they increase the growth response of the host in presence of other microorganisms and inhibitory when they control soil borne pathogens. Efficient use of

Trichoderma enriched biofertilizer may reduce soil borne pathogens and improve soil health (Rani 2013). Recently *Trichoderma* spp. was suggested as a plant growth promoting fungi due to their ability to produce siderophores, phosphate solubilizing enzymes and phytohormones. On the other hand, endophytic bacteria are microorganisms that live in the plant tissues and they may be responsible for the supply of biologically fixed nitrogen to their host plant. Endophytes also promote plant growth by a number of similar mechanisms as phosphate solubilization activity, indole acetic acid production and the production of a siderophores (Haidar *et al*. 2018).

Biofertilizers serve as major food source for microbial populations thus keeping the soil alive. They also contribute to soil chemical conditions through improvement of nutrients availability in the soil, leaving free elements to facilitate their absorption by the root system, improved capacity of nutrients exchange in the soil resulting in favourable effects on the physicochemical stability of soils. As a result of the good structure and improved stability provided to the soil, root growth was promoted. The maintenance of good soil structure in all ecosystems is largely dependent on mycorrhizal fungi. The formation and maintenance of soil structure is influenced by soil properties, root architecture and management practices. The use of machines and fertilizers are considered to be responsible for soil degradation, which is a key component of soil structure (Malusa and Vassilev 2014). This study was designed to highlight the following objectives:

a) To assess the reclamation performance of vermicompost and trichocompost on chemical and microbiological properties of acidic and alkaline soil.
b) To assess acidic and alkaline soil on the basis of yield components.

MATERIAL AND METHODS

Acid soil sample was collected from Kalapara, an upazila of Patuakhali District in the Division of Barisal, Bangladesh. The sampling area belongs to the agro-ecological zone, AEZ-13. Alkaline soil sample was collected from Matuail Union, Jatrabari Thana of Dhaka metropolitan. The sampling area belongs to the agro-ecological zone, AEZ-19.

The pot experiment was conducted in the premises (net house) of the Department of Soil, Water and Environment, University of Dhaka. The experiment was set up following completely randomized design (CRD) with three treatments (control, vermicompost and trichocompost) and three replications each consisting of nine pots for each soil. Okra (*Abelmoschus esculentus)* was used as an indicator plant. Five kilogram of soil were taken in each seven kilogram plastic pot for the culture of 4 okra seeds and growth of okra plants. In order to study the effect of biofertilizer, vermicompost (27 g/pot) and trichocompost (27 g/pot) were applied.

The pH of soil samples was measured electrochemically by using a glass electrode pH meter (Jackson 1958). Electrical conductivity (EC) of soil samples was measured by an EC meter at a ratio soil samples to water as 1:5 as described by USSL staff (1954). Organic carbon (OC) of soil samples was determined by Wet Oxidation method (Walkley and Black 1934). Organic matter (OM) was calculated by multiplying the percentage of organic carbon with conventional van-Bemmelen's factor of 1.724 (Piper 1950). Total nitrogen of the soil samples was determined by Kjeldahl's digestion with concentrated sulfuric acid (H_2SO_4) (Jackson 1958). Total phosphorus of soil samples was determined by Vanado Yellow Colour method (Jackson 1973). Total potassium of soil samples was determined by a flame photometer (Jackson 1962). Other nutrients were analyzed following standard procedure (Huq and Alam 2005). Different yield parameter such as fresh weight, dry weight, harvest index were recorded. Harvest index was calculated using the formula:

Harvest index = weight of grain divided by dry weight of plant plus weight of grain (Ching 1973).

Identification and microbial colony count of microorganisms were carried out in The Centre for Advanced Research in Sciences (CARS), University of Dhaka. Each colony that appeared on the plates was considered as one Colony-Forming Unit (CFU) (Sau *et al.* 2017). All plates were incubated at their desired temperature for required hours and final counts of CFU taken after the completion of incubated period. CFU was calculated as:

$$\text{CFU/g} = (\text{number of colonies} \times \text{diluted factor}) / \text{volume of culture plate}$$

Microorganisms were isolated from their specific selective media at different optimum condition based on colony characteristics (Cappuccino and Sherman 2007). The data collected in the experiment were calculated and the calculated results were graphically evaluated by using Microsoft excel (version 2013). Calculated results were statistically analyzed in the form one way ANOVA, using Minitab 17. The isolated microorganisms were listed (Table 1).

Table 1. Isolated microorganisms growing on selective and non-selective media and their morphological characteristics on the petri-dish.

Microorganisms	Media	Colony	Incubation condition	
			Temperature (°C)	Duration (day)
Total Aerobic Bacteria (TABC)	Plate count agar	Creamy white, yellow, green color	37	1
Coliform	Chromocult agar	Creamy white	37	1
Escherichia coli	Chromocult agar	Dark blue to violet	37	1
Rhizobium spp.	Congo red yeast extract Mannitol agar	Pink	30-32	4-7
Azotobacter spp. and *Trichoderma* spp.	Nitrogen free agar	Whitish or cream color and white, yellowish-green or deep Green	30-32	4-7
Phosphate Solubilizing Bacteria (PSB) and Phosphate Solubilizing Fungi (PSF)	National Botanical Research Institute phosphate Bromo Phenol Blue (NBRIP-BPB) medium	Blue and white	30-32	4-7
Total Fungal Count (TFC)	Soya Dextrose Agar (SDA)	White, creamy White colony	30	1-2

RESULTS AND DISCUSSION

Soil samples were analyzed before set up of the pot experiment. Acidic soil had a OC of 0.55%, OM 0.95%, EC 3.17 mS/m, total N 0.22%, total P 0.04%, total K 0.07%, total S 0.33%, total Ca 0.01%, total Mg 1.33%, total Na 0.27%, total Zn 0.004 %, total Fe 2.52%, total Mn 0.02% and alkaline soil had a OC of 0.41%, OM 0.71%, EC 0.27 mS/m, total N 0.16%, total P 0.07%, total K 0.02%, total S 0.18%, total Ca 0.02%, total Mg 0.13%, total Na

0.05%, total Zn 0.006%, total Fe 1.98% and total Mn 0.1%. Initial pH value revealed that vermicompost was acidic and trichocompost was alkaline in nature. Vermicompost had an OC of 3.86%, OM 6.64%, EC 2.76 mS/m, total N 1.03%, total P 0.14%, total K 0.93%, total S 0.78%, total Ca 0.87%, total Mg 0.55%, total Na 0.02%, total Zn 0.03%, total Fe 1.04% and total Mn 0.04%. Trichocompost had an OC of 4.08%, OM 7.01%, EC 2.96 mS/m, total N 0.76%, total P 0.12%, total K 0.72%, total S 0.62%, total Ca 2.69%, total Mg 0.46%, total Na 0.07%, total Zn 0.02%, total Fe 1.21% and total Mn 0.07%. Total Aerobic Bacterial Count (TABC), Total Fungal Count (TFC), Phosphate Solubilizing Bacteria (PSB), Phosphate Solubilizing Fungi (PSF), *Rhizobium* spp. count observed in both soils and biofertilizers. No total coliform count (TCC), *Escherichia coli* (*E. coli*), *Azotobacter* spp. count recorded in both soils and biofertilizers. Plant pathogen inhibitor *Trichoderma* spp. was observed in biofertilizers, but was not found in any initial soil (Table 2).

Table 2. Initial chemical and microbial properties of soils, vermicompost and trichocompost.

Chemical Properties	Acidic soil	Alkaline soil	Vermicompost	Trichocompost
pH	4.77	7.87	6.58	7.7
EC (mS/m)	3.17	0.27	2.76	2.96
Organic carbon (%)	0.55	0.41	3.86	4.08
Organic matter (%)	0.95	0.71	6.64	7.01
Total nitrogen (%)	0.22	0.16	1.03	0.76
Total phosphorus (%)	0.04	0.07	0.14	0.12
Total potassium (%)	0.07	0.02	0.93	0.72
Total sulfur (%)	0.33	0.18	0.78	0.62
Total calcium (%)	0.01	0.02	0.87	2.69
Total magnesium (%)	1.33	0.13	0.55	0.46
Total sodium (%)	0.27	0.05	0.02	0.07
Total zinc (%)	0.004	0.006	0.03	0.02
Total iron (%)	2.52	1.98	1.04	1.21
Total manganese (%)	0.02	0.10	0.04	0.07
Microbial Properties				
Total Aerobic Bacteria (TABC)	5.43	6.59	6.67	6.69
Total Coliform Count (TCC)	<1.0	<1.0	<1.0	<1.0
Total Fungal Count (TFC)	4.48	5.15	4.9	5.15
Escherichia coli (*E. coli*)	<1.0	<1.0	<1.0	<1.0
Rhizobium spp.	5.14	6.18	6.68	Not countable
Azotobacter spp.	<1.0	<1.0	<1.0	<1.0
Phosphate Solubilizing Bacteria (PSB)	4.95	6.57	7.11	Not countable
Phosphate Solubilizing Fungi (PSF)	4.30	4.85	5.85	6.42
Trichoderma spp.	<1.0	<1.0	5.15	5.17

Post-harvest soil samples were analyzed to evaluate the changes occurred in the physicochemical properties in different treatments. In acidic soil, highest pH value was 6.40, total N 0.28%, total P 0.06%, total 0.28% and total Na 1375.20 ppm recorded in vermicompost applied soil, highest EC value was 1.70 mS/m, OC 0.67%, OM 1.15%, total Mg 1.44%, total Mn 294.49 ppm and total Zn 75.21 ppm recorded in trichocompost applied soil, highest total K was 2.01%, total Ca 0.03%, total Fe 2.57% recorded in control. In acid soil pH, EC, OC, OM, total S, total Fe, total Mn, total Zn, total Na were differed statistically ($p < 0.01$ and $p < 0.05$). In alkaline soil, highest pH value was 8.12, OC 0.65%, OM 1.22%, total K 1.78%, total S 0.26%, total Mg 1.35%, total Fe 2.19%, total Na 1269.68 ppm recorded in vermicompost applied soil, highest EC value was 0.24 mS/m, total N 0.29%, total P 0.08%, total Ca 0.06%, total Zn 76.86 ppm recorded in trichocompost applied soil. Highest total Mn 228.50 ppm was recorded in control. In alkaline soil, OC, OM, total N, total P, total S, total Mg, total Fe, total Mn, total Zn, total Na differed statistically ($p < 0.01$ and $p < 0.05$) (Table 3).

Table 3. Chemical properties of post-harvest soil under different treatments.

Chemical properties	Acidic soil			P-value	Alkaline soil			P-value
	Control	Vermi	Tricho		Control	Vermi	Tricho	
pH	5.57	6.40	5.90	< 0.05	7.82	8.12	8.10	> 0.05
EC (mS/m)	0.53	0.89	1.70	< 0.01	0.20	0.19	0.24	> 0.05
OC (%)	0.51	0.66	0.67	< 0.01	0.51	0.65	0.59	< 0.01
OM (%)	0.87	1.13	1.15	< 0.05	0.90	1.22	1.02	< 0.05
Total N (%)	0.25	0.28	0.27	> 0.05	0.24	0.21	0.29	< 0.05
Total P (%)	0.05	0.06	0.05	> 0.05	0.07	0.05	0.08	< 0.05
Total K (%)	2.01	1.69	1.98	> 0.05	1.14	1.78	1.01	> 0.05
Total S (%)	0.25	0.28	0.27	< 0.01	0.16	0.26	0.14	< 0.01
Total Ca (%)	0.03	0.02	0.02	> 0.05	0.05	0.04	0.06	> 0.05
Total Mg (%)	1.40	1.15	1.44	> 0.05	0.01	1.35	0.11	> 0.01
Total Fe (%)	2.57	2.28	2.41	< 0.01	1.73	2.19	1.52	< 0.01
Total Mn (ppm)	204.50	178.43	249.49	< 0.01	228.50	212.20	223.34	< 0.01
Total Zn (ppm)	66.80	56.47	75.21	< 0.01	74.81	74.12	76.86	< 0.01
Total Na (ppm)	1046.40	1375.20	1175.20	< 0.01	359.60	1269.68	407.00	< 0.01

***< 0.01 = significant at 1%; **< 0.05 = significant at 5%; *> 0.05 = not significant

In acid soil, total viable count of specific bacteria and fungi in post-harvest soil samples showed highest TFC, *Rhizobium* spp., PSB, PSF count recorded in vermicompost applied soil and highest TABC and *Trichoderma* spp. count recorded in trichocompost applied soil. In acid soil, all the results (except PSB) varied significantly ($p < 0.01$ and $p < 0.05$). In alkaline soil, highest *Rhizobium* spp., PSB, PSF count recorded in vermicompost applied soil and highest TABC and *Trichoderma* spp. count recorded in trichocompost applied soil. In alkaline soil, all the results (except PSF) varied significantly ($p < 0.01$ and $p < 0.05$) (Table 4).

Table 4. Total viable count of post-harvest soil samples under different treatments.

Soil	Treatment	Mean log value of CFU/g of organisms								
		Soil quality indicator			Pathogen	Soil beneficial bacteria				Pathogen inhibitor
		TABC	TCC	TFC	*E. coli*	*Rhizobium* spp.	PSB	PSF	*Azotobacter* spp.	*Trichoderma* spp.
Acidic soil	Control	4.78	<1.0	4.3	<1.0	6.02	5.69	5.15	<1.0	3
	Vermi-compost	5.81	<1.0	5.15	<1.0	6.09	5.8	5.26	<1.0	5.41
	Tricho-compost	5.92	<1.0	4.7	<1.0	6.02	5.79	5.17	<1.0	5.43
	P-value	$<0.01^{***}$	-	$<0.05^{**}$	-	$>0.05^{*}$	$<0.05^{**}$	$<0.01^{***}$		$<0.05^{**}$
Alkaline soil	Control	5.41	<1.0	4.85	<1.0	6.02	6.14	4.6	<1.0	2.3
	Vermi-compost	5.56	<1.0	4.7	<1.0	6.49	6.16	4.9	<1.0	4.3
	Tricho-compost	6.31	<1.0	4.6	<1.0	6.06	6.01	4.7	<1.0	4.47
	P-value	$<0.01^{***}$	-	$<0.1^{***}$	-	$< 0.01^{***}$	$<0.1^{***}$	$< 0.05^{**}$		$< 0.05^{**}$

***< 0.01 = significant at 1%; **< 0.05 = significant at 5%; * > 0.05 = not significant

Significantly higher fresh weight ($p < 0.01$), dry weight ($p < 0.01$) and harvest index ($p < 0.01$, $p < 0.05$) of yield components were recorded in biofertilizers treated soils over control.

In acidic soil, vermicompost treated soil increased 27.67% over control and trichocompost treated soil increased 15.61% over control. In alkaline soil, vermicompost treated soil increased 92.75% over control and trichocompost treated soil increased 58.50% over control (Table 5). This might be due to the application of biofertilizers activated the plant growth promoting hormones and nutrient availability as observed by Akhter *et al.* (2018) and Kota *et al.* (2022).

Table 5. Yield components of *Abelmoschus esculentus* L.

Soil	Treatment	Fresh weight (gpot^{-1})	Increased over control (IOC)	Dry weight (gpot^{1})	Increased over control (IOC)	Harvest Index %
Acidic	Control	No grain	-	No grain	-	-
Soil	Vermicompost	12.92	27.67	6.33	22.67	1.64
	Trichocompost	11.70	15.61	5.59	7.75	1.10
P-value		<0.01***	-	<0.01***	-	<0.05**
Alkaline	Control					
Soil	Vermicompost	24.71	92.75	12.94	97.55	1.98
	Trichocompost	20.32	58.50	10.45	59.54	1.72
P-value		<0.01***	-	<0.01***	-	<0.01***

***<0.01 = significant at 1%; **<0.05= significant at 5%; * >0.05 = not significant

The present study indicates that in both acidic and alkaline soils, vermicompost and trichocompost applied soil showed increased values of pH, OC, OM, total N and almost all nutrients over the control. This might be due to the initial properties of both vermicompost and trichocompost added with soil. Nitrogen fixing microbes in biofertilizers might also enhanced the N content in soil. Similar results found by Azarmi *et al*. (2008) and Tharmaraj *et al*. (2011). On the other hand, only total K in acid soil showed the higher value in control than biofertilizers applied soil. This might be due to the increase of soil organic matter resulted in decrease K fixation and subsequent increase K availability (Olk and Cassman 1993). Results indicate that biofertilizer applications in both the soils significantly improved the abundance of soil beneficial bacteria, soil quality indicator and plant pathogen inhibitor over the control. Similar results were found by Ramalakshmi *et al.* (2008). It can be stated that, for both soils, the application of two types of biofertilzers was appeared to be effective on maintaining soil physicochemical properties and soil beneficial microbes over the control. Here, comparing two types of biofertilizers, vermicompost appeared better than trichocompost in maintaining soil physicochemical properties, soil beneficial microbes and yield components of okra.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the financial support for conducting the research by the Ministry of Science and Technology, Government of the People's Republic of Bangladesh.

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(Manuscript received on 22 October, 2024)