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Effect of vermicompost with biodynamic formulated biochar on Carbon and Nitrogen mineralization in Ultisols and Alfisols

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Abstract— Organic amendments provide good nutritional input to the soil by maintaining environmental sustainability. Availability of nutrients are less due to soil salinization and acidity in Alfisols and Ultisols, respectively.Therefore, this study aims to assess the effect of vermicompost, biochar and biodynamic formulated biochar on C and N mineralization in Alfisols and Ultisols,the main soil types that cover land area in Sri Lanka. Vermicompost and biochar with and without biodynamic formulation were applied to soil types separately according to the specific rates. After incorporating the amendments, pH, EC, nitrate-N, ammonium-N and CO2 evolution were determined up to 63 days. Statistical analysis was done using SAS software. According to the results, the pH of Ultisols with inoculated biochar shows a lowering at the initial stage, however it was not significantly different with the control. Inoculated and non- inoculated biochar with vermicompost in Alfisols decreased the EC significantly ($p<0.05$) in later stages reducing the salinity compared to the control. In Ultisols and Alfisols, nitrate-N increased significantly ($p<0.05$) in both treatments. The evolved CO2 is significantly high ($p<0.05$) in microbial inoculated soil treatments when compared to non-microbial inoculated soil treatments in both soil types. It can be concluded that the N and C mineralization pattern varied among the treatment in Ultisols and Alfisols and the biodynamic formulated biochar with vermicompost showed an impact on mineralization. Soil amendments have both long term and short term effects. Therefore, it is recommended to do further studies to evaluate the long term effect of organic amendments.

Keywords— Biochar, inoculum, vermicompost

Introduction

In agriculture, soil management is essential to get adequate food production (Walpola & Wanniarachchi, 2003) as soil acts as the original nutrient resource. Due to the rapid growth of human population, there will be a problem in future on food accessibility due to poor agricultural practices.

Alfisols covers about 2.5 million hectares in Sri Lanka (Subasinghe, 2004). On the other hand, Ultisols are mostly found in wet zone of Sri Lanka. Due to the salinity, in the Hambantota district soil productivity has been reduced and the land degradation has been increased (Subasinghe, 2004). On the other hand, soil acidity is the main factor which acts as a barrier for amelioration of Ultisols (Li., et al. 2015).

To overcome these problems, applying eco–friendly sustainable organic methods and materials has become a good strategy (Singh and Tiwari, 2017). Further, the organic amendments will increase the nutrient availability by mineralization. This study thus aimed to assess the effect of vermicompost (VC), biochar (BC) and biodynamic formulated biochar (BDF biochar) on C and N mineralization in Alfisols and Ultisols.

Methodology

Alfisols and Ultisols were collected from Bandagiriya Agrarian Service Centre, Hambantota, Sri Lanka and Ultisols were collected from the Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, Sri Lanka. Samples were collected from three randomly selected places in each soil type. Meantime, soil samples were obtained for determining the bulk density. Composite soil samples were air dried and sieved by passing through 2mm mesh to make homogeneity. Basic soil properties such as pH, EC, moisture content (MC), bulk density (DB), particle density (pycnometer method) (DP) and texture (hydrometer method) of Ultisols and Alfisols (Bandyopadhyay et al.,2012) were determined at initial stage before mixing soil organic amendments (SOA).

The vermicompost was collected from a vermicomposter in Retreat hotel, Thalalla, Sri Lanka. It was sieved by a 2mm mesh to make homogeneity. BC was prepared by using rice husk at the Faculty premises using the pyrolysis method.

Biodynamic formulation (Jeevamrutha) (BDF) was prepared by mixing 500g cow dung, 250ml cow urine, 100g brown sugar, 100g green gram flour, handful of fertile soil in 10L of water (Jayappa et al., 2010). It was thoroughly mixed using a wooden stick once a day and incubated for 72 hours. Prepared BDF was applied to biochar at the rate of 500L/ acre and kept for 24 hours.

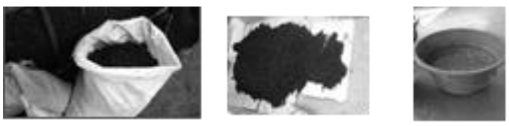

Figure1. Prepared vermicompost, biochar and biodynamic formulation for the experiment

The treatments were prepared by mixing amendments according to the Table 1. with VC and BC and BDF biochar with 2kg of soil sample each and mixed thoroughly. All the treatments were replicated four times, labelled and kept in the laboratory conditions.

Separately, an incubation study was conducted. The treatments were prepared according to the Table 1 and mixed with 100g of soil. All the bottles were kept in a dark place according to the CRD method with the aim of determination of CO2 evolution. A bottle without soil and with NaOH and H2O was kept considering as a control.

Table1. Application amount of amendments according to the rate of application

Vermicompost	Application rate= 10MT/ha	Alfisols	For 2kg	12.55g
			For 100g	5.02g
		Ultisols	For 2kg	18.09g
			For 100g	0.91g
Biochar	Application rate= 5% (w/w) [wet weight basis]	Alfisols	For 2kg	100g
			For 100g	5g
		Ultisols	For 2kg	100g
			For 100g	5g
Biodynamic formulation (*Jeevamrutha*)	Application rate= 500L/acre	Alfisols	For 2kg	1.55ml
			For 100g	0.08ml
		Ultisols	For 2kg	2.24ml
			For 100g	0.12ml

The pH 1:2.5 (w/v soil:water)- (pH meter HANNA), EC 1:5 w/v sil:water)-(EC meter HANNA), Nitrate nitrogen (Salicilic acid method, UV-visible spectrophotometer UV160, Shimadzu, Japan), Ammonium nitrogen (Salicilic acid method, UV-visible spectrophotometer UV160, Shimadzu, Japan), (Markus et al., 1985) were determined in all treatments in days 1, 4, 7, 14, 21, 28, 35, 42, 49, 56, 63, after incorporating amendments. Carbon mineralization (CO2 evolution method) was determined by incubation study in days 1, 4, 7, 14, 21, 28, 35, 42, 49, 56, 63 after incorporating amendments. The evolved CO2 was determined by the titration method (Rubio, 2017).

Experimental Design

All the experimental units were kept following CRD method using four replicates for each treatment type. Statistical analysis was conducted using SAS method.

The treatments were prepared according to the rates of amendments described in Table 1 and named from T1 – T6 (Table 2).

Table 2. Treatments for the experimental study

Ultisols	Vermicompost+ Biochar (T1)	Vermicompost+ BDF Biochar(T2)	Control (T3)
Alfisols	Vermicompost+ Biochar (T4)	Vermicompost+ BDF Biochar(T5)	Control (T6)

Results

The physico-chemical characteristics of soils

Soil Property	Ultisols	Alfisols
Moisture content (%)	38.79 ± 3.11	19.59 ± 1.06
Bulk density (g/cm^3)	1.11 ± 0.09	1.59 ± 0.07
Particle-density (g/cm^3)	2.55 ± 0.08	2.6 ± 0.16
Texture Sand	67.11 ± 1.63	67.78 ± 0
silt	21.59 ± 1.63	9.85 ± 1.55
clay	11.28 ± 0	22.36 ± 1.55
	Sandy Loam	Sandy Clay Loam
pH	6.0 ± 0.10	7.6 ± 0.03
EC (dS/ cm)	0.3 ± 0	5.8 ± 0.68

were obtained before incorporating them with soil amendments (Table 3). When considering the pH values, Ultisols and Alfisols showed 6.0 and 7.6, respectively. Therefore, sampled Ultisols have slight acidic conditions and Alfisols have slight alkaline conditions. When considering EC values, Alfisols have high EC value than Ultisols showing higher soil salinity.

Table3. Physical and chemical properties of Ultisols and Alfisols at initial stage

The physico-chemical properties of soil amendments were given inTable 4.

Table 4. Chemical properties of organic amendments used in the study

Organic amendment	pH	EC (mS/cm)	NO_3^--N nitrogen (mg/kg)	NH_4^+-N (mg/kg)
Vermicompost	6.3	5.43	133.3	5.25
Biochar	7.5	0.38	31	2.7
BDF	4.4	1.0	50	63.6

The analysed results of pH, EC, Ammonium N, Nitrate N, and carbon dioxide evolution of the treatments are given in Figures 2 – 11.

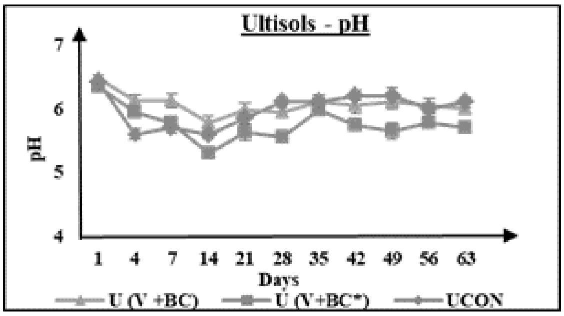

Figure2. Temporal variation of pH values in different treatments of Ultisols

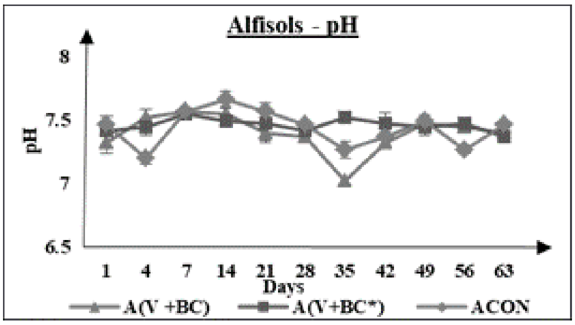

Figure 3. Temporal variation of pH values in different treatments of Alfisols

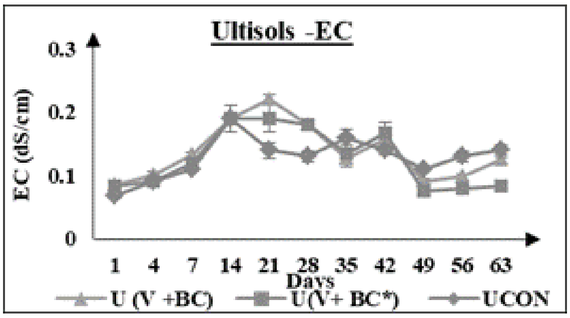

Figure 4. Temporal variation of EC values in different treatments of Ultisols

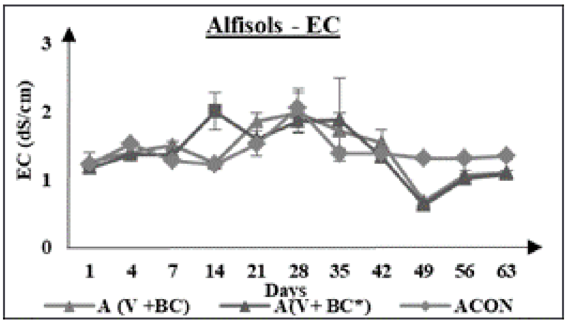

Figure 5. Temporal variation of EC values in different treatments of Alfisols

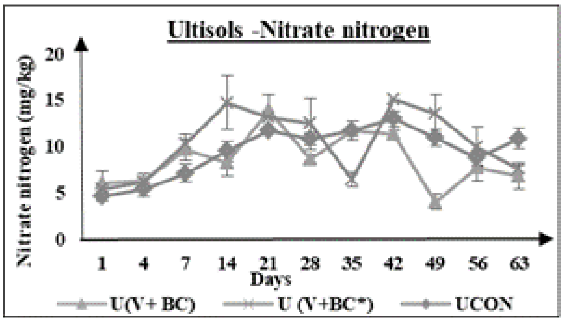

Figure 6. Temporal variation of nitrate nitrogen values in different treatments of Ultisols

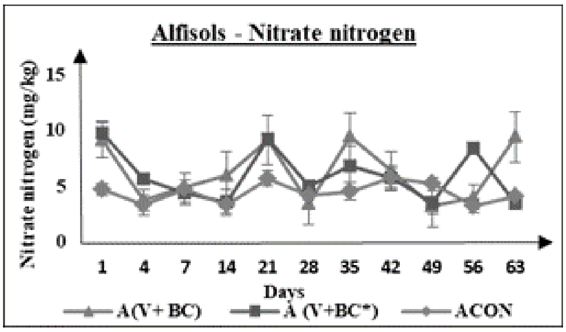

Figure 7. Temporal variation of nitrate nitrogen values in different treatments of Alfisols

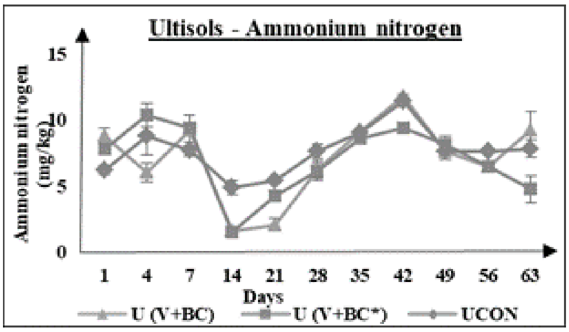

Figure 8. Temporal variation of ammonium nitrogen values in different treatments of Ultisols

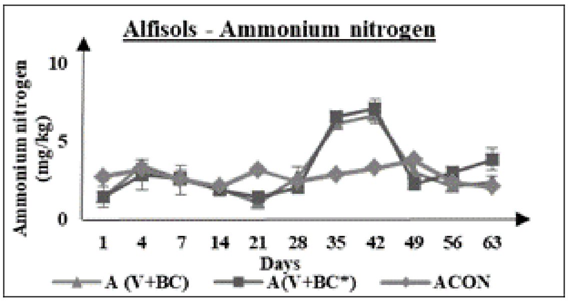

Figure 9. Temporal variation of ammonium nitrogen values in different treatments of Alfisols

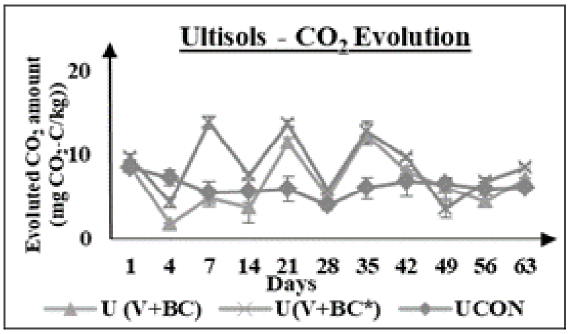

Figure 10. Temporal variation of carbon dioxide evolution in different treatments of Ultisols

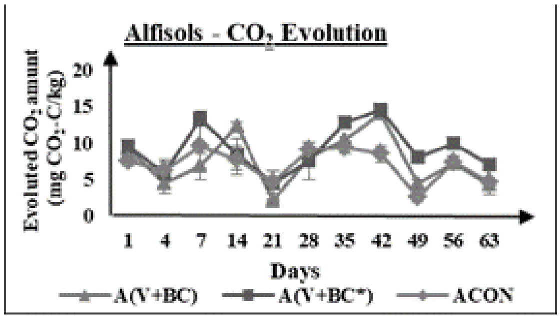

Figure 11. Temporal variation of carbon dioxide evolution in different treatments of Alfisols

Discussion

When considering pH, Ultisols with inoculated biochar and vermicompost [U(V+BC*)] showed a lower value compared to other treatments and the control (Figure 2). This may be due to microbial reactions. Further, microbial inoculated biochar and vermicompost [A(V+BC*)] in Alfisols have shown a stable pH value during the study period (Figure3). There was no significant difference between inoculated and non inoculated treatments in both soils amended by vermicompost.

When considering EC in Ultisols, it has no significant change in the initial stage, however the EC increased gradually from day 14 and decreased in both treatments (Figure 4). However, inoculated and non inoculated biochar with vermicompost in Alfisols decreased the EC significantly ($p<0.05$) in later stages reducing the salinity compared to the control (Figure 5). This shows that the incorporation of amendments may be effective at later stages than early stages during the mineralization.

When considering the nitrate-N in Ultisols and Alfisols, inoculated soil [U(V+BC*)] had a higher nitrate level compared to the control, however fluctuated with the time (Figure 6 & 7). However, the impact of biodynamic formulation was not observable clearly.The mineralization is lesser in Alfisols than the Ultisols. This may be due to the saline conditions in the soil.

When considering the ammonium-N in both soil treatments, the highest concentration was observed in day 42. Similarly, mineralization rate was low in Alfisols (Figure 9).

When considering the CO2 evolution in both Ultisols and Alfisols, with biodynamic formulation [U(V+BC*)] and [A(V+BC*)] have shown high CO2 evolution compared to other treatments. However, compared to Ultisols, Alfisols showed less amount of CO2 evoution due to salinity effect which may retard the microbial activity.

Conclusion

Based on the results, it can be concluded that, nitrogen mineralization pttern varied among the treatments of Ultisols and Alfisols. Ultisols and Alfisols showed lowering of pH with treatments.With both inoculated and non-inoculated biochar with vermicompost decreased the EC of Alfisols in later stages of the experiments. N mineralization showed higher effect in both treatments (inoculated and non-inoculated) of Ultisols than the Alfisols. This may be due to the Microbial activity which is higher in inoculated biochar and vermicompost treatment in Ultisols than Alfisols.

Recommendations

Further studies may be required with extending the time period to evaluate the long term effect of biochar, vermicompost, biodynamic formulated biochar on the enhancement of the overall soil quality in Ultisols and Alfisols.

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