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Effect of Biochar and Various Sources of Organic Manures on Soil Properties in Nawalparasi, Nepal

S. BHATTA
K. R. PANDE
B. R. KHANAL
Department of Soil Science and Agri-engineering
Agriculture and Forestry University, Rampur, Chitwan, Nepal
S. MARAHATTA
Department of Agronomy
Agriculture and Forestry University, Rampur, Chitwan, Nepal
SURYA DHUNGANA
Department of Plant Breeding and Genetics
Institute of Agriculture and Animal Science
Tribhuwan University, Kathmandu, Nepal

Abstract:

A field experiment was conducted to evaluate the effect of biochar with different sources of organic manures on soil properties, yield and yield attributing characteristics of cabbage (Brassica oleracea var capitata) at Jamuniya-1, Nawalparasi from October 2015 to January 2016. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 10 treatments i.e Control, biochar (100%), FYM (100 %), poultry manure (100%), vermicompost (100 %), biofertilizer (100%), biochar (50%) +FYM (50%), biochar (50%) + poultry manure (50 %), biochar (50%) + vermicompost (50 %), biochar (50%) + biofertilizer (50 %) replicated 3 times. Biochar was prepared from locally available rice husk under pyrolytic condition and applied in field together with other organic amendments before 15 days of transplanting. Analysis of primary nutrients of the organic manure and biochar was done and rate of manure was fixed on the basis of *their nutrient content. Biochar applied with organic manures significantly increased soil pH (6.5) and SOM (2.24 %) than the plots without biochar. The residual Nitrogen (0.143 %) was more in poultry manure plots whereas soil P (118.70 kg/ha), soil K (385.7 kg/ha), was more in biochar treated plots. This study showed that organic manure applied with biochar increased soil properties as compared to control. Biochar application provides an innovative method for handling excess organic wastes to sequester carbon and to improve soil health and plant productivity.*

Key words: Biochar, organic amendments, pyrolytic condition

INTRODUCTION

Biochar is the carbon-rich product obtained by heating biomass in a closed system under limited supply of oxygen. When used as a soil amendment, biochar has been reported to boost soil fertility and improve soil quality by raising soil pH, increasing moisture holding capacity, attracting more beneficial fungi and microbes, improving cation exchange capacity (CEC), and retaining nutrients in soil (Lehmann et al., 2006; Lehmann, 2007).Another major benefit associated with the use of biochar as a soil amendment is its ability to sequester carbon from the atmosphere-biosphere pool and transfer it to soil (Winsley, 2007; Guant & Lehmann, 2008; Laird, 2008).

Biochar may persist in soil for millennia because it is very resistant to microbial decomposition and mineralization. This particular characteristic of biochar depends strongly on its properties, which is affected in turn by the pyrolysis conditions and the type of feedstock used in its production. Previous studies indicate that a bioenergy strategy that includes the use of biochar in soil not only leads to a net sequestration of CO_2 (Woolf et al., 2010), but also may decrease emissions of other more potent greenhouse gases such as N_2O and CH_4 (Spokas et al., 2009).

Research has shown that the benefits of biochar include improvement in soil productivity, long-term soil carbon sequestration, reduction in greenhouse gas (GHG) emissions, and reduction in loss of nutrients by leaching (Lehmann et al., 2006). Biochar is particularly beneficial in sandy soils and highly weathered clay soils with low native CEC and AEC and low fertility. Biochar also acts as a source of small amounts of P, K, and other nutrients (Lehmann et al., 2003; Lehmann et al., 2002).

Soil pH is an important factor in determining the bioavailability of nutrients, and biochar is known to raise soil pH (Chan et al., 2008), thereby improving the availability of nutrients to crop plants. Biochar is also reported to enhance the microbial population (Wardle et al., 1998; Zackrisson et al., 1996), and improve moisture holding capacity and soil structure (Piccolo &Mbagwu, 1990; Piccolo et al., 1996).

Mixing biochar with other soil amendments such as manure, compost or lime before soil application can improve efficiency by reducing the number of field operations required. Since biochar has been shown to absorb nutrients and protect them against leaching (Major, 2009; Major et al., 2009; Novak et al., 2009a), mixing with biochar may improve the efficiency of manure or other amendment application.

Biochar is a charred carbon-enriched material intended to be used as a soil amendment to sequester carbon and enhance soil quality. Sustainable biochar is produced from waste biomass using modern thermo chemical technologies. Addition of sustainable biochar to soil has many environmental and agricultural benefits, including waste reduction, energy production, carbon sequestration, water resource protection, and soil improvement. Therefore, the use of sustainable biochar as a soil amendment is an innovative and highly promising practice for sustainable agriculture. Thus a field experiment was conducted to evaluate the effect of biochar and various sources of organic manures on different soil properties and yield of cabbage in Jaminiya, Nawalparasi from January 2015 to April 2015.

MATERIALS AND METHODS

A field experimentation consisting of the 10 treatments i.e Control, Biochar (100%), FYM (100%), Poultry manure (100%), Vermicompost (100%), Biofertilizer (100%), Biochar (50%) +FYM (50%), Biochar (50%) +Poultry manure (50 %), Biochar (50%) +Vermicompost (50 %), Biochar (50%) +Biofertilizer (50 %) and four replication was accomplished in the Jamuniya-1, Nawalparasi . The experiment was carried out in one factor RCBD with Four Replications. The site of the experiment research site was sandy loam in texture and slightly acidic ,Total nitrogen (0.069 %) and soil available phosphorous was found to be lower (48 kg/ha) .potassium (185.6 kg/ha) and organic matter (1.57 %). The maximum and minimum temperatures and rainfall data during the cropping periods and historical weather records were collected from the National Climatic observatory of National wheat research Program, Bhairahawa. The soil properties and yield data obtaining from field experiment was analyzed with the M-Stat-C package and SPSS.

RESULTS AND DISCUSSIONS

1. Effect of treatments on soil pH and soil organic matter

The effect of biochar and various organic manures on soil organic matter content after crop harvest is presented in Table 13. Organic matter content was found to have significant difference. The grand mean of organic matter was found 1.711. Highest organic matter content was found in plots with biochar only followed by, biochar 50% + poultry manure 50% and poultry manure only.

Highest organic matter content was found in plots with biochar only. Increase in soil organic carbon due to increase in application rates of biochar also reported by several researchers .Lehman (2007) and Van Zwiten et al., (2010) reported high organic carbon in soil treated with biochar. Solomon et al. (2007) and Liang et al.(2006) also revealed higher organic carbon at ancient terra preta compared with adjacent soils. Laird (2008) also reported that biochar application to soil is an effective means of carbon sequestration and that biochar improves soil quality and increases crop yield.

Among all treatments plot with biochar had the highest pH. The increase in soil pH due to biochar application was generally attributed ash residues which contain carbonates of alkali and alkaline earth metals, silica, heavy metals sesquioxides phosphates and organic and inorganic nitrogen (Raison, 1979).Another increase in soil pH could be due to high surface area and porous nature of biochar that increased cation exchange capacity of soil (Nigussie, Kissi, Misganaw&Ambaw,2010). Masulili, Utomo & Syechfani (2010) also reported that there was decrease in exchangeable Al and soluble Fe in biochar amended soil. The liming effect which decreased soil acidity had been suggested as one of the main mechanism through which biochar was able to increase growth of plants (Verheijen, Jeffery, Bastos,Van der Velde. &Diafas , 2010)

Treatment	OM %	pH
Control	1.190[c]	5.823[g]
Biochar only	2.240[a]	6.910[a]
FYM only	1.720[b]	6.243[e]
Poultry Manure Only	2.023[ab]	6.090[f]
Vermicompost only	1.240[c]	6.433[d]
Biofertilizer only	1.280[c]	6.433[d]
Biochar 50 %+FYM 50%	1.790[b]	6.643[c]
Biochar 50% +Poultry manure 50 %	2.140[a]	6.433[d]

Biochar 50%+Vermicompost 50%	1.733[b]	6.700[bc]
Biochar 50%+Biofertilizer 50%	1.757[b]	6.790[ab]
GM	1.711	6.451
SEM (±)	0.110	0.058
$LSD_{0.05}$	0.327	0.121
CV%	21.1	11.1

Treatment means followed by common letter (s) within a column are not significantly different among the treatments (DMRT at 5 % level of significance).

2. Effect of treatments on total soil nitrogen, available phosphorous and available potassium

The effect of biochar and various organic manures on soil nitrogen content after crop harvest is presented in Table 14. The total nitrogen in the soil after harvest was found significant among all treatments. The plots treated with poultry manure only had highest residual nitrogen (0.143%) which was significantly greater than biochar 50% + poultry manure 50 %, FYM only vermicompost only, biofertilizer only, biochar 50%+ vermicompost 50%, biochar 50%+ biofertilizer 50%, biochar only and control. The grand mean of nitrogen was 0.092 %.

The plots treated with poultry manure only had highest residual nitrogen (0.143). Biochar based on plant materials often have lower concentration of nutrients and minerals such as N and P, but a higher C content when compared to biochar based on manure (Lehmann et al., 2003; Chan et al.,2008a; Chan et al., 2008b; Waters et al., 2011). Poultry manure is rich organic manure, since liquid and solid excreta are excreted without urine loss, It contains relatively higher percentage of nitrogen and phosphorus (Ewulo, 2005) and thus has a valuable potential uses beyond the traditional one of fertilizer (Bird, 1982). It is an efficient organic fertilizer because of high nutrient content and is an important soil amendment to improve soil physical properties (Reddy and Reddi, 1995). About 30 % of nitrogen from poultry litter was in nitrate or ammonical form and thus was readily available to plant species

(Sunassee, 2001). The effect of biochar and various organic manures on soil phosphorous content after crop harvest is presented in Table 15. The grand mean of phosphorous was found 83.3 kg/ha. Among all treatments plots treated with biochar only was found to have highest available phosphorous (118.70) which was significantly at par with biochar 50% +poultry manure 50 %.

Among all treatments plots treated with biochar only was found to have highest available phosphorous (118.70). Timilsina,(2015) reported that increase in soil pH and CEC reduced the activity of iron an aluminium in soil contributed to the highest content of available phosphorous in soil treated with biochar. Van Zwieten et al, (2010) and Chan et al, (2008) also reported the increase in available phosphorous after application of biochar.Similarly, The plots treated with biochar only was found to have highest potassium content. Chan et al. (2008) and Chan et.al. (2007) reported that the addition of biochar to soil increased available potassium in soil.

The effect of biochar and various organic manures on available soil potassium content after crop harvest is presented in Table 16. The grand mean of potassium was found to be 314.90 kg/ha. Among all treatments, biochar and biochar 50% +FYM 50% was found to have highest potassium content (321 kg/ha).

Treatment	Total N	Available P	Available K
Control	0.053^{f}	38.00^{c}	180.30^{f}
Biochar only	0.077^{e}	118.70^{a}	385.70^{a}
FYM only	0.103^{c}	68.70^{b}	350.00^{b}
Poultry Manure Only	0.143^{a}	82.60^{b}	300.00^{d}
Vermicompost only	0.090^{d}	76.30^{b}	279.30^{e}
Biofertilizer only	0.087^{de}	77.60^{b}	293.30^{de}
Biochar 50 %+FYM 50%	0.093^{cd}	84.30^{b}	380.00^{a}
Biochar 50% +Poultry manure 50 %	0.117^{b}	113.70^{a}	321.00^{c}
Biochar 50%+Vermicompost 50%	0.083^{de}	87.30^{b}	329.30^{c}
Biochar 50%+Biofertilizer 50%	0.077^{e}	86.00^{b}	330.00^{c}
GM	0.092	83.30	314.90
SEM (±)	0.005	8.080	6.750

$LSD_{0.05}$	0.010	16.970	14.170
CV%	6.4	11.9	2.6

Treatment means followed by common letter (s) within a column are not significantly different among the treatments (DMRT at 5 % level of significance).

CONCLUSION

The results found in the study revealed that there were improvements in soil physical and chemical properties with the application of biochar together with organic manures. Primary nutrients in soil, soil organic matter was increased in plots amended with biochar and organic manures compared to control. Based on the overall review of the results of the study it can be concluded that addition of biochar to soil would be imperative to increase soil fertility and yield of cabbage. Biochar not only addressed the soil reclamation but also the measure for environment conservation through carbon sequestration. Thus it can be concluded that biochar application provides an innovative method for handling excess organic wastes to sequester carbon and potentially improve soil and plant productivity which ultimately leads to sustainable soil management.

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