Research Brief: ReUseWaste ESR 6.2

Low temperature manure-derived biochars behave as fertilizers

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ReUseWaste News

July 2015

No. 21

Biochar is defined as a carbonaceous material when biomass such as wood, leaves, manures, sewage-sludge etc. are heated in an oxygen limited environment. Interest in biochar has intensified over the years. Biochar application to soil has generally shown positive effects in terms of increased crop productivity and soil fertility. However, the potential positive affects of biochar vary with specific biochar properties as influenced by feedstock type.

Table 1. Physico-chemical characteristics of biochars

Biochar type	C	N	VM	Ash	pH	P[a]	Ca[b]	Mg[b]	K[b]	CEC	Surface area
	- - - - - - / % - - - - - -				–	- - - - - / $g\ kg^{-1}$ - - - - - -				/ $cmol_c\ kg^{-1}$	/ $m^2\ g^{-1}$
PL400	52.1	5.85	44.9	25.3	9.5	12.25	28.3	17.3	38.8	30.2	5.4
PL600	52.8	4.01	24.7	35.4	10.4	15.40	35.9	24.0	58.8	27.5	6.3
SM400	54.9	2.23	29.9	27.5	10.0	9.70	20.3	15.7	16.2	52.5	5.8
SM600	57.9	1.79	17.8	34.5	10.4	15.55	28.9	21.3	35.3	18.6	10.6
WC	89.3	0.27	15.3	7.8	11.0	0.73	13.6	3.2	2.6	14.8	178.3

PL400, PL600- poultry litter biochars at 400 and 600 °C, SM400, SM600- swine manure biochars at 400 and 600 °C, WC- wood chip biochar at 1000 °C.
VM- volatile matter; CEC- cation exchange capacity; [a] available P, [b] total.

A plant growth experiment was carried out in a climatic chamber (at 20 °C) with an aim to assess the effect of manure-derived biochars on plant growth and yield. It was hypothesized that pyrolysis of manure feedstock would produce biochar with higher fertilizer value than standard wood-derived biochar. Two types of soils with contrasting textures and pH (alkaline sandy soil and acidic silt-loam) were used in the experiment. Four different types of manure-derived biochars from different feedstocks (poultry litter and swine manure) produced at different pyrolysis temperatures (400 or 600 °C) were mixed at 2% w/w soil dry weight basis (Table 1), and were compared with a commonly available standard biochar from wood chip (WC) produced at high temperature (1000 °C); and a control without amendment. No extra fertilizer was given to the treatments.

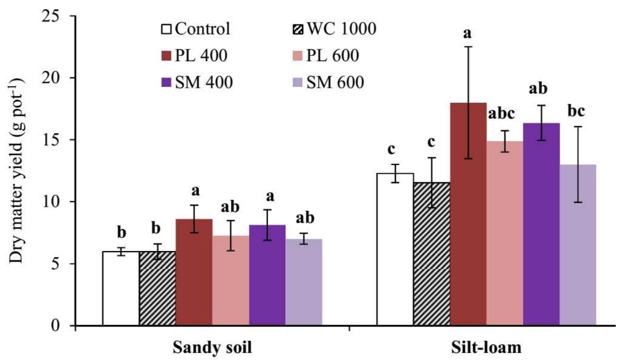

Figure 1. Total above ground dry matter production in two soils with different biochar treatments. Error bars represent standard errors (n = 4).

Results from ryegrass growth demonstrated that the low temperature manure-derived biochars significantly increased above-ground biomass yield compared to Control and other biochar treatments in both soils (Figure 1). All biochars also increased root yield compared to Control on silt-loam soil while the case was true for PL400 and SM400 treatments on sandy soil (results not shown). Both above and belowground biomass yield were significantly positively correlated with N content of the biochars ($n=5$, $P<0.05$, $r=0.867$ on average) on both soils. The highest shoot DM yield increase by 47.5% compared to Control was recorded in PL400 treated silt-loam soil, followed by 34.4% with SM400 treatment. Similarly, up to 127.2% increase of root biomass (DM) compared to control was observed for PL400 treated silt-loam soil followed by 93.8% increase with SM400 treatment. The increased biomass production on manure-derived biochar amended soils were result of direct nutrient (both macro and micro) additions from these chars plus increase in nutrient retention as well as availability on soil-biochar matrix.

The total dry matter yields of ryegrass (both above and belowground biomass) were related to both positive nutrients content of biochars and enhanced soil characteristics. Low temperature manure-derived biochars (PL400 and SM400) showed a good potential to be utilized as NPK-fertilizers with a significant value. This unique property of char could fulfill the additional NPK demand and can be benefitted by the crops. The results obtained in this study could thus be helpful in setting a new biochar guidelines based on biochar quality composition.

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