TOTAL ORGANIC CARBON, TOTAL NITROGEN AND CHEMICAL CHARACTERISTICS OF AN HAPLIC CAMBISOL AFTER BIOCHAR INCORPORATION

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Biochar has been used as a soil conditioner to increase the soil organic carbon content and to improve the soil chemical characteristics. However, the effect of biochar on soil is still not clear and the soil type and biochar composition should also play an important role. In this context, the main objective of this work was to evaluate the effect of biochar application on the organic carbon (C) content and on chemical characteristics of subtropical Cambisol.

The field experiment was located at the State University of Centro-Oeste in Irati, Brazil, and the soil was classified as an Haplic Cambisol (Embrapa, 1999). The applied biochar was composed mainly by fine residues (70% < 2mm) of an eucalyptus biochar that was a waste of the local steel industry. In February 2010, four increasing doses of biochar were applied to the soil (T1 - 0 t ha^{-1}; T2 - 10 t ha^{-1}; T3 - 20 t ha^{-1} and T4 - 40 t ha^{-1}) with four replicates. Soil samples were composed by three subsamples collected within each plot. Biochar was applied on the soil surface and thereafter it was incorporated into a 0 - 10 cm soil depth with an harrow. Soil samples were collected in September 2011 at four soil depths: 0 - 5; 5 - 10; 10 - 20 and 20 - 30 cm. The samples were air dried and passed through a 2 mm sieve. Soil C and nitrogen (N) contents were determined by dry combustion and the soil characteristics assessed were: pH in water, available P, exchangeable K, Ca, Mg and Al, potential acidity (H + Al), cation exchange capacity (CEC), effective cation exchange capacity (ECEC) and base saturation (V%) (Tedesco et al., 1995). The mean values were compared using SAS software (Tukey 10%).

The main alterations in soil characteristics were observed in the superficial depth (0 - 5 cm) (Table 1) probably due to the permanence of the biochar fine particles at the soil surface. In this layer, the application of 40 t ha^{-1} of biochar (treatment T4) increased in 15.5 g kg^{-1} the C content in comparison to treatment T1. The treatments T2 and T3 also increased the C content, but the differences were not significant. N content was not affected by biochar application. The highest dose of biochar (treatment T4) promoted an increase of the C/N ratio from 12 to 16 at the 0-5 cm depth. Treatment T4 also increased the soil pH value in comparison to treatment T1. In addition, the contents of available P, exchangeable K and Ca where higher under treatment T4 in comparison to treatment T1 (Table 1). In opposition, exchangeable Mg content, Al+H, V% and CEC were not altered by any treatment, but T4 increased the ECEC in 3.1 $cmol_c$ dm^{-3} in comparison to T1. The results observed are probably due the high C and ash (26,5%) contents of biochar. A contribution of the functional groups on the surface of the biochar to the ECEC should not be excluded (Sparkes & Stoutjesdijk, 2011).

Our results indicate that after two years of biochar application an increase of soil organic carbon and a positive impact on the soil chemical characteristics at the soil surface were attained, but only with the highest tested dose (40 t ha^{-1}) .

Table 1. Total organic carbon (TOC), total nitrogen (TN), C/N ratio, pH (H_2O), available P, exchangeable K, Ca, Mg and Al, potential acidity (H+Al), cation exchange capacity (CEC), effective cation exchange capacity (ECEC) and base saturation (V) of an Haplic Cambisol after incorporation of increasing doses of biochar.

Treatment	Depth	TOC	TN	C/N	pH(H_2O)	P	K	Ca	Mg	Al	H+Al	CEC	ECEC	V
	cm	-----------g kg^{-1}---------				-------------mg dm^{-3}-----------		--c mol_c dm^{-3}--						%
0 biochar	0 – 5	41.1 Ab	3.3 Aa	12.4	4.85 Ab	6.4 Ab	278.3 Ab	6.3 Ab	3.7 Aa	1.9 Da	20.0 Ba	30.6 Ba	12.5 Ab	37.3 Aa
	5 – 10	36.2 Ba	2.4 ABa	14.9	4.70 Ba	5.5 Ba	201.3 Ba	4.2 Ba	2.4 Ba	3.7 Ca	26.6 ABa	33.6 ABa	10.8 Aba	23.0 Ba
	10 – 20	29.3 Cb	2.1 Bab	13.7	4.50 Ca	4.3 Ca	149.5 BCa	2.7 Ca	1.3 Ca	5.3 Ba	35.2 Aa	39.6 Aa	9.7 Ba	11.8 BCa
	20 – 30	24.8 Da	1.9 Ba	12.8	4.43 Ca	3.0 Da	128.5 Ca	2.1 Ca	1.0 Ca	6.3 Aa	35.8 Aa	39.2 Aa	9.7 Ba	9.0 Ca
10 t ha^{-1}	0 – 5	45.0 Ab	3.0 Aa	15.0	5.05 Aab	8.3 Ab	298.3 Ab	6.9 Aab	4.2 Aa	1.5 Cab	15.1 Ba	26.9 Ca	13.3 Aab	46.5 Aa
	5 – 10	36.9 ABa	2.5 Ba	15.1	4.80 Ba	5.5 Ba	206.0 Ba	4.5 Ba	2.8 Ba	2.7 Ca	21.3 Ba	29.1 BCa	10.5 Ba	28.3 ABa
	10 – 20	30.8 BCab	2.1 Bab	14.5	4.63 BCa	4.4 Ba	150.8 Ba	2.9 BCa	1.6 BCa	4.4 Ba	32.7 Aa	37.4 ABa	9.2 Ba	13.3 BCa
	20 – 30	28.3 Ca	2.0 Ba	14.9	4.55 Ca	3.9 Ba	136.3 Ba	1.8 Ca	1.1 Ca	6.1 Aa	35.8 Aa	39.1 Aa	9.4 Ba	8.3 Ca
20 t ha^{-1}	0 – 5	46.0 Ab	3.1 Aa	14.8	5.05 Aab	7.3 Ab	338.0 Aab	7.2 Aab	4.4 Aa	1.1 Bab	14.0 Ba	26.5 Ba	13.5 Aab	48.3 Aa
	5 – 10	38.6 Ba	2.8 Aa	14.0	4.80 Ba	6.0 Ba	269.3 Ba	6.1 Aa	3.7 Ba	2.0 Ba	19.6 Ba	30.0 Ba	12.4 Aa	36.0 Ba
	10 – 20	31.4 Cab	2.1 Bb	15.3	4.63 Ca	5.2 Ca	177.5 Ca	3.6 Ba	2.1 Ca	4.0 Aa	33.0 Aa	39.1 Aa	10.2 Ba	17.0 Ca
	20 – 30	23.7 Da	1.8 Ba	13.3	4.53 Ca	3.5 Ca	134.8 Ca	2.4 Ca	1.4 Ca	5.6 Aa	36.2 Aa	40.3 Aa	9.7 Ba	11.0 Ca
40 t ha^{-1}	0 – 5	56.6 Aa	3.5 Aa	16.2	5.20 Aa	11.8 Aa	391.3 Aa	9.1 Aa	4.9 Aa	0.7 Cb	12.1 Ca	27.1 Ca	15.6 Aa	56.3 Aa
	5 – 10	40.8 Ba	2.8 Ba	14.7	4.75 Ba	5.5 Ba	278.0 Ba	4.8 Ba	2.6 Ba	3.0 Ba	25.8 Ba	33.9 BCa	11.1 Ba	25.3 Ba
	10 – 20	36.0 Ba	2.4 BCa	15.3	4.60 BCa	4.5 Ba	174.0 Ca	3.2 Ca	1.6 Ca	5.0 Aa	35.2 Aa	40.4 ABa	10.2 Ba	14.0 Ca
	20 – 30	28.8 Ca	2.0 Ca	14.8	4.50 Ca	3.3 Ba	120.3 Ca	2.8 Ca	1.4 Ca	5.3 Aa	37.0 Aa	41.5 Aa	9.8 Ba	12.5 Ca

Means with the same capital letter do not differ within the same treatment and means with the same lowercase letter do not differ within depth (Tukey test, $p < 0.10$)

REFERENCES

EMBRAPA – Empresa Brasileira de Pesquisa Agropecuária. **Sistema brasileiro de classificação de solos**. Brasília: Embrapa. Centro Nacional de Pesquisa de Solos, 1999. 412 p.

Citation in the text: (Embrapa, 1999)

Sparkes, J., Stoutjesdijk. 2011. Biochar: implications for agricultural productivity. Australian Government Department of Agriculture, Fisheries and Forestry. 63p.

Citation in the text: "(Sparkes & Stoutjesdijk, 2011)"

Tedesco. M.J., Gianello. C., Bissani. C.A., Bohnen. H., Volkweiss. S.J., 1995. Análise de solo. plantas e outros materiais. 2.ed. Porto Alegre. Universidade Federal do Rio Grande do Sul. 174p.

Citation in the text: (Tedesco et al., 1995)