Soil biochar application: first experiences in North Italy with gasification plants product

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Key words: *Biochar, Soil, Gasification*

Introduction

Soil biochar application is often reported as a technique able to increase agricultural productivity, but variability in charcoal characteristics (depending mainly on feedstock type and process conditions) is generally high and moreover it is not clear yet under what kind of soil and climatic conditions, besides plant species, high or low yields can be expected [1].

The knowledge is even more limited for temperate climates; in fact, most researches derive from tropical and savannah lands [2].

In order to better understand the soil dynamics and the growing effects of the biochar amendment, in the year 2009, c/o the Minoprio Foundation (Vertemate con Minoprio – Como – North Italy), some field and laboratory activities were carried out with the aim to investigate the fine-grained, highly porous charcoal co-produced from gasification process in a fixed-bed, down-draft, open core, innovative gasifiers of small size (300 kW electric power unit).

Biochar was obtained from two different kind of fuel biomass, poplar wood from short rotation forestry and conifer wood from forest management.

The materials, produced in two different plants, showed different moisture content, since the poplar charcoal was originally wet to prevent fire hazards. This treatment has ensured an easer soil application especially with relation to the dust lack.

Poplar charcoal showed higher conductivity and ash content; conifer charcoal had higher pH, contained more than 10% more of total organic carbon and its particle size distribution was wider than poplar charcoal.

Undisturbed native topsoil (silty-loam, acid, organic matter normal content) was mixed with the two different types of biochar at the same dose per hectare (130 Mg dry matter) and it was sown with maize (*Zea mais* L.). The experimental plant consisted of three treatments (control, poplar and conifer biochar) in triplicate replication each, therefore nine randomized plots; a 10 by 4 meter unit size was used.

At corn silage maturity crop productivity was measured by recording fresh and dry matter data; moreover soil samples (0-30 cm) were analyzed in laboratory with the aim to investigate the main physical, chemical and biochemical [3] parameters, the latter able to assess the microbial biomass and understand its vitality.

Dried production and laboratory results were evaluated by analysis of variance (ANOVA) and mean separation was done using Duncan test (P=95%).

Results and Discussions

The corn productivity increased in the plot conditioned with biochar, especially with the one from conifer, but only in absolute value and not statistically.

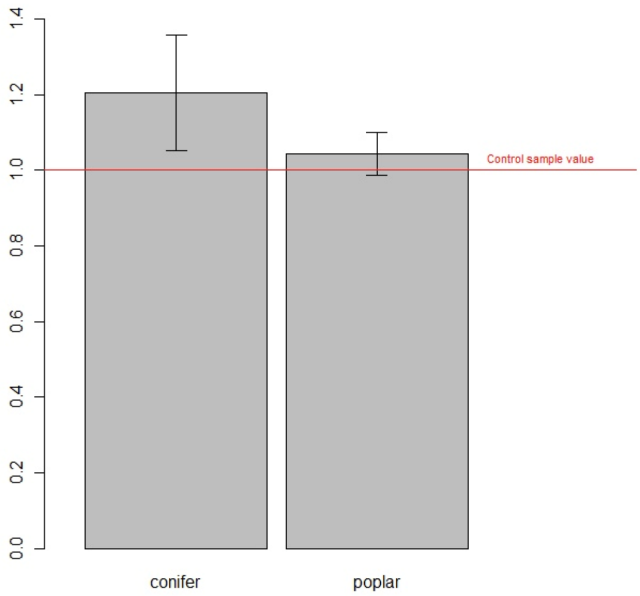

Figure 1. Corn production index

The laboratory tests showed a moderate reduction of acidity in the carbon-soil, a high improvement in organic carbon (total carbon analysis with C/N analyzer), soil exchange capacity (CEC) and soil macro porosity (mainly with conifer biochar) (Table 1).

The biochemical data, recorded after only five months of biochar application, did not score a sudden change of the soil microbial life, but certainly they showed an alteration of the system and a gradual change is expected.

Table 1. Main laboratory results*

Parameter	Control		Conifer		Poplar	
pH (H_2O)	6,4	a	6,9	ab	7,3	b
pH ($CaCl_2$)	5,7	a	6,3	ab	6,6	b
TOC (g kg^{-1})	16,6	a	55,7	b	40,6	b
$OC_{(C/N\ Analyzer)}$ (g kg^{-1})	14	a	59	b	39	b
$OC_{(Walkley-Black)}$ (g kg^{-1})	14	a	16	a	17	a
$N_{(C/N\ Analyzer)}$ (g kg^{-1})	1,5	a	1,5	a	1,8	b
$C/N_{(C/N\ Analyzer)}$	9,7	a	38,4	c	21,1	b
C.E.C. $_{(BaCl2)}$ ($cmol_c$ kg^{-1})	15,6	a	17,0	b	16,6	ab
$Ca_{(Exchangeable)}$ ($cmol_c$ kg^{-1})	4,1	a	4,7	ab	6,0	b
$Mg_{(Exchangeable)}$ ($cmol_c$ kg^{-1})	0,6	a	0,5	a	0,7	a
$K_{(Exchangeable)}$ ($cmol_c$ kg^{-1})	0,4	a	0,6	ab	0,8	b
$Na_{(Exchangeable)}$ ($cmol_c$ kg^{-1})	<0,1	a	0,1	ab	0,1	b
Basic cation saturation ratio (%)	32	a	34	a	46	b
Mg/K ratio	1,4	b	0,9	a	1,0	ab
$ESP_{(Exchangeable\ Sodium\ Percentage)}$ (%)	0,1	a	0,5	ab	0,9	b
$P_2O_{5(Assimilable - Olsen\ method)}$ (mg kg^{-1})	210,0	a	213,0	a	232,0	a
$Salinity_{(1:5)}$ (mS cm^{-1})	<0,1	a	<0,1	a	0,1	b
Microbial biomass carbon[a] (ppm C)	83,4	a	77,2	a	81,0	a
Basal respiration[b] (ppm C-CO_2)	6,3	a	8,9	a	9,8	a
Cumulative respiration[c](ppmC-CO_2)	246,0	a	287,0	a	284,0	a
Metabolic quotient[d] (% h)	0,3	a	0,5	a	0,6	a
Mineralization quotient[e] (%)	1,5	b	0,5	a	0,8	a
Dry bulk density (g l^{-1})	1,3	a	1,1	a	1,1	a
Water retention at 1,5 pF (%)	36,2	a	44,0	a	42,7	a
Capillary porosity (%)	45,8	a	46,8	a	48,1	a
Macro porosity (%)	4,0	a	11,3	b	4,2	a

*For each line the values marked by the same letter are not statistically different.

a) Microbial biomass carbon estimates the content of microbial biomass in the soil.

b) Basal respiration describes the activity in standard laboratory conditions.

c) Cumulative respiration estimates the mineralization speed of the labile fraction of organic matter.

d) Metabolic quotient (b)/a) ratio) considers the metabolic efficiency of active microorganisms.

e) Mineralization quotient (c)/TOC ratio) gives information about organic matter labile fraction mineralization by microorganisms activity.

Conclusions

The soil application of biochar resulting from gasification process for bioenergy production is an interesting agricultural practice, thanks to the characteristics of the contained organic matter.

The charcoal production in small size gasifiers for electric micro generation enables to solve both problems of product availability and practice profitability. In fact, the diffusion of biochar soil application requires a good supply with moderate costs.

The aim is to improve global fertility and crop productivity also by restoring degraded land after intensive agriculture and helping the farmer profitability, without forgetting C sequestration from the atmosphere.

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