

Effects of Biochar Application in a Sorghum Crop under Greenhouse Conditions: Growth Parameters and Physicochemical Fertility

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SUPPORTING INFORMATION

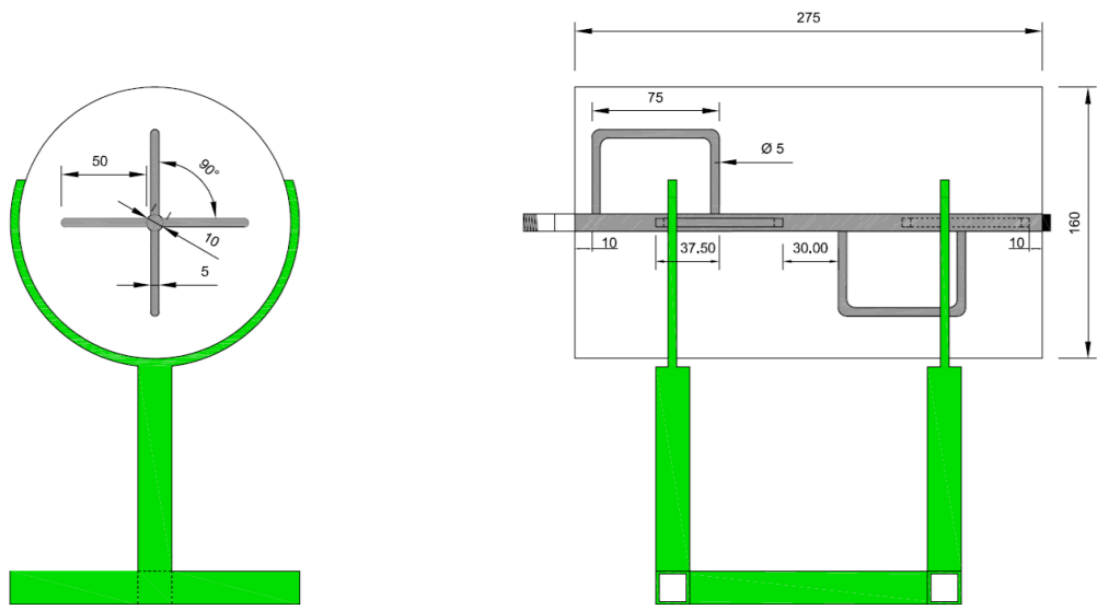


Figure S1. Scheme of the automatic remover used to process the biochar. Units: mm.

Table S1. Fertility analyses results of soils collected for the trial

Determination	Method	Unit	Soil 1	Soil 2
pH (1 : 2.5 water)	Potenciometry		8.0 ± 0.5	8.4 ± 0.5
Electrical conductivity (1 : 5)	Electrometry	dS m ⁻¹	0.20 ± 0.03	0.20 ± 0.03
Oxidable organic matter	Espectrofotometry	wt. %	3.04 ± 0.38	1.70 ± 0.21
N (N-NO ₃)	Espectrofotometry	mg kg ⁻¹	59 ± 8	12 ± 2
P (Olsen)	Espectrofotometry	mg kg ⁻¹	32 ± 3	29 ± 3
K	AAS	mg kg ⁻¹	232 ± 39	88 ± 15
Mg	AAS	mg kg ⁻¹	160 ± 33	252 ± 52
Water holding capacity	Gravimetry – Richards chamber	v %	5.41	10.22

Table S2. Proximate, elemental, X-Ray Fluorescence (XRF) analysis and biomass components of vine shoots

Proximate	Elemental (wt. % in daf ¹ basis) ²		Biomass components (wt. %)		
Ash (wt. % in dry basis)	2,46 ± 0,37	C	42,29 ± 0,49	Lignin + silica	20.16 ± 0.49
Moisture (wt. %)	10,47 ± 0,13	H	5,24 ± 0,06	Cellulose	34.18 ± 1.95
Volatile matter (wt. % in dry basis)	72,93 ± 1,64	N	13,52 ± 0,35	Carbohydrate + protein	33.02 ± 0.18
Fixed carbon (wt. % in dry basis)	14,14 ± 1,38	O	38,96 ± 0,45	Hemicellulose + acid soluble ash	8.10 ± 1.63
				Extractives	4.54 ± 0.05
Inorganic matter (wt. % of ash)					
CaO	58,30	PbO	0,26	MgO	6,66
K ₂ O	18,40	SnO ₂	0,26	TiO ₂	0,34
SiO ₂	5,73	CuO	0,09	Cl	0,47
Fe ₂ O ₃	3,51	MnO	0,53	SO ₃	0,60
Al ₂ O ₃	2,57	ZnO	0,33	P ₂ O ₅	1,24

¹ Dry-ash-free.

² Oxygen is calculated by difference.

Table S3. Average value of pyrolysis product yield under two different temperature conditions (400 °C — B400 and 600 °C — B600)

Biochar	Number of experiments	Pyrolysis temperature (°C)	Total amount of feedstock (g)	Total amount of biochar (g)	Average product yield (y _{char})
B400	5	400	2.536,52	959,63	0,38
B600	8	600	4.083,69	1.206,74	0,29

Table S4. Results from productive parameters at the final of the first completed sorghum cycle¹ under different biochar and application rates (S1: substrate 1 sandy-loam; S2: substrate 2 clay-loam; B1: biochar 400 °C; B2: biochar 600 °C; D: biochar application rate, D0—0 wt. %, D1—1.5 wt. %, D2—3 wt. %)

Treatment	Plant length (cm)	Flag leaf length (cm)	Stem diameter (cm)	Dry aerial weight (g)	Grain dry weight (g)
S1D0	39.7 ± 1.6	27.0 ± 5.0	0.9 ± 0.2	8.1 ± 1.2	1.9 ± 1.3
S1B1D1	37.4 ± 2.1	20.6 ± 3.6	0.9 ± 0.6	6.7 ± 0.7	1.8 ± 1.6
S1B1D2	40.1 ± 3.8	21.1 ± 3.2	1.0 ± 0.3	8.1 ± 0.7	1.5 ± 0.9
S1B2D1	37.8 ± 3.0	19.9 ± 5.6	0.8 ± 0.5	7.9 ± 0.6	1.7 ± 1.2
S1B2D2	39.5 ± 5.0	19.7 ± 3.3	1.0 ± 0.4	7.1 ± 2.4	1.9 ± 1.0
S2D0	35.2 ± 2.9	17.1 ± 3.5	1.0 ± 0.6	5.8 ± 0.5	1.6 ± 0.6
S2B1D1	32.8 ± 3.8	17.6 ± 2.6	0.9 ± 0.8	5.4 ± 0.9	1.3 ± 0.8
S2B1D2	34.3 ± 0.9	19.4 ± 2.6	1.0 ± 0.2	8.1 ± 0.7	1.5 ± 1.1
S2B2D1	36.2 ± 2.8	21.0 ± 4.3	1.0 ± 0.6	5.5 ± 0.8	1.7 ± 0.3
S2B2D2	34.8 ± 5.1	19.5 ± 5.2	1.0 ± 0.8	5.5 ± 1.7	1.5 ± 0.4

¹First crop harvest: D₂₁₀.

Table S5. Nutrient concentrations both in sorghum leaves and growing media with different pyrolysis temperatures of biochar added (400°C — B400 and 600 °C — B600; S1: sandy-loam growing substrate; S2: clay-loam growing substrate)

Variable	S1			S2		
	Control	B400	B600	Control	B400	B600
pH	8.43 ± 0.14a	8.33 ± 0.15ab	8.27 ± 0.06c	8.09 ± 0.03a	8.09 ± 0.06a	8.21 ± 0.11a
CEC (cmol kg ⁻¹)	5.4 ± 0.6a	6.0 ± 0.3a	5.8 ± 0.2a	9.4 ± 0.2a	9.3 ± 0.5a	7.9 ± 2.1a
N-nitric (mg kg ⁻¹)	63.5 ± 11.4a	56.8 ± 4.7a	69.4 ± 13.7a	77.2 ± 5.5a	82.05 ± 9.0a	69.6 ± 10.5a
P (mg kg ⁻¹)	3.8 ± 0.7a	4.12 ± 0.4a	4.0 ± 0.5a	2.0 ± 0.2a	2.4 ± 0.4a	2.2 ± 0.3a
K (mg kg ⁻¹)	297.0 ± 31.0b	305 ± 8.9b	358.5 ± 18.7a	267.0 ± 51.0c	369.8 ± 26.7b	448.5 ± 61.6a
Mg (mg kg ⁻¹)	221.0 ± 15.0a	222.2 ± 5.6a	236.2 ± 15.0a	329.0 ± 3.0b	371.2 ± 16.5a	371.5 ± 21.9a
Ca (mg kg ⁻¹)	4329.0 ± 253.0a	3860.0 ± 142.5b	4191.2 ± 253.3a	6088.0 ± 123.0b	6154.3 ± 173.2a	5779.5 ± 281.7b
K/Ca	0.068 ± 0.004c	0.079 ± 0.003b	0.086 ± 0.004a	0.044 ± 0.009c	0.060 ± 0.005b	0.078 ± 0.014a
K/Mg	1.338 ± 0.058b	1.373 ± 0.036b	1.519 ± 0.036a	0.811 ± 0.150c	0.996 ± 0.036b	1.205 ± 0.124a
Na (mg kg ⁻¹)	30.0 ± 4.0a	27.5 ± 1.5ab	24.2 ± 2.3b	42.0 ± 7.0a	38.0 ± 3.0a	42.7 ± 14.2a
SOM (%)	2.1 ± 0.2a	2.1 ± 0.1a	2.0 ± 0.2a	1.4 ± 0.1a	1.4 ± 0.3a	1.3 ± 0.1a
P _{total} (mg kg ⁻¹)	546.0 ± 10.0a	578.2 ± 89.1a	592.5 ± 64.1a	566.0 ± 21.0b	514.8 ± 14.4a	569.8 ± 24.1b
N-leaf	1.13 ± 0.1a	1.19 ± 0.1a	1.1 ± 0.2a	1.06 ± 0.2a	1.1 ± 0.1a	1.2 ± 0.2a
P-leaf	0.03 ± 0.01a	0.04 ± 0.01a	0.06 ± 0.01a	0.04 ± 0.01a	0.04 ± 0.01a	0.04 ± 0.01a
K-leaf	2.5 ± 0.5a	2.2 ± 0.6a	2.6 ± 0.3a	2.1 ± 0.2b	2.4 ± 0.2a	2.3 ± 0.2a

For the same kind of growing substrate, means followed by the same letter (within a row) are not significantly different at $p \leq 0.05$ (Tukey's test).

Table S6. Nutrient concentrations in sorghum leaves and growing substrate with different application rates of biochar (400°C — B400 and 600 °C — B600; D1: 1.5 wt. %; D2: 3 wt. %)

Variable	S1		S2	
	D1	D2	D1	D2
pH	8.36 ± 0.13a	8.25 ± 0.07a	8.13 ± 0.07a	8.17 ± 0.114a
CEC (cmol kg ⁻¹)	5.7 ± 0.3a	6.0 ± 0.2a	8.7 ± 1.8a	8.5 ± 1.7a
N-nitric (mg kg ⁻¹)	59.25 ± 13.8a	66.9 ± 8.8a	75.6 ± 15.5a	76.0 ± 6.7a
P (mg kg ⁻¹)	4.1 ± 0.3a	4.0 ± 0.5a	2.2 ± 0.3a	2.5 ± 0.3a
K (mg kg ⁻¹)	325.2 ± 26.0a	338.3 ± 36.9a	372.5 ± 33.6b	445.8 ± 62.1a
Mg (mg kg ⁻¹)	222.8 ± 13.3a	235.5 ± 10.1a	335.7 ± 9.1b	387.0 ± 8.8a
Ca (mg kg ⁻¹)	3990.7 ± 152.7a	4060.5 ± 352.2a	6099.8 ± 271.3a	5834.0 ± 278.7a
K/Ca	0.082 ± 0.006a	0.083 ± 0.003a	0.061 ± 0.008b	0.077 ± 1.153a
K/Mg	1.459 ± 0.076a	1.433 ± 0.096a	1.048 ± 0.096a	0.014 ± 0.165a
Na (mg kg ⁻¹)	25.0 ± 2.7a	26.7 ± 2.3a	43.7 ± 13.8a	37.0 ± 3.0a
SOM (%)	2.0 ± 0.2a	2.1 ± 0.1a	1.3 ± 0.2a	1.5 ± 0.1a
P _{total} (mg kg ⁻¹)	610.7 ± 91.4a	560.0 ± 47.8a	533.5 ± 27.9a	551.2 ± 40.5a
N-leaf	1.1 ± 0.1a	1.1 ± 0.2a	1.1 ± 0.2a	1.1 ± 0.1a
P-leaf	0.03 ± 0.01a	0.04 ± 0.01a	0.04 ± 0.01a	0.04 ± 0.01a
K-leaf	2.7 ± 0.3a	2.7 ± 0.2a	2.3 ± 0.2a	2.3 ± 0.1a

Means within a row followed by the same letter are not significantly different for the same kind of growing substrate at $p \leq 0.05$ (Tukey's test).

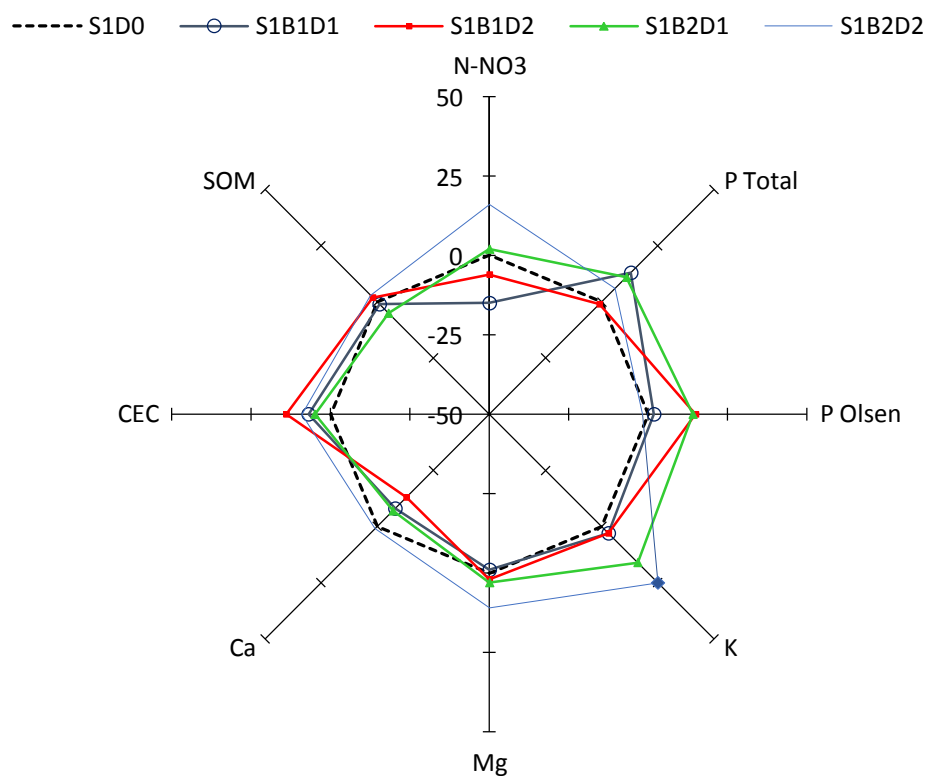


Figure S2. Nutrients concentration, SOM and CEC deviation of experimental treatments, under different temperatures of biochar (400°C — B400 and 600 °C — B600) and application rate (D1: 1.5 wt. %; D2: 3 wt. %), from control treatment (D0) in a sandy-loam growing substrate

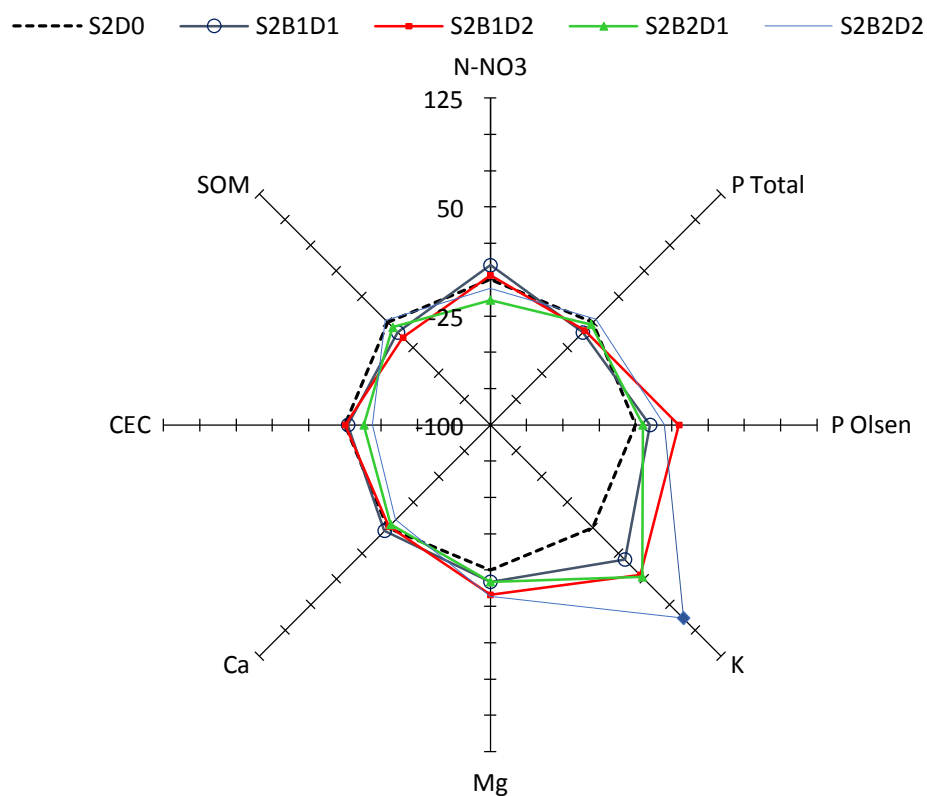


Figure S3. Nutrients concentration, SOM and CEC deviation of experimental treatments under different temperatures of biochar (400°C — B400 and 600 °C — B600) and application rate (D1: 1.5 wt. %; D2: 3 wt. %) from control treatment (D0) in a clay-loam growing substrate