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Evaluation of green waste biochar and hydrochar application as soil amendment

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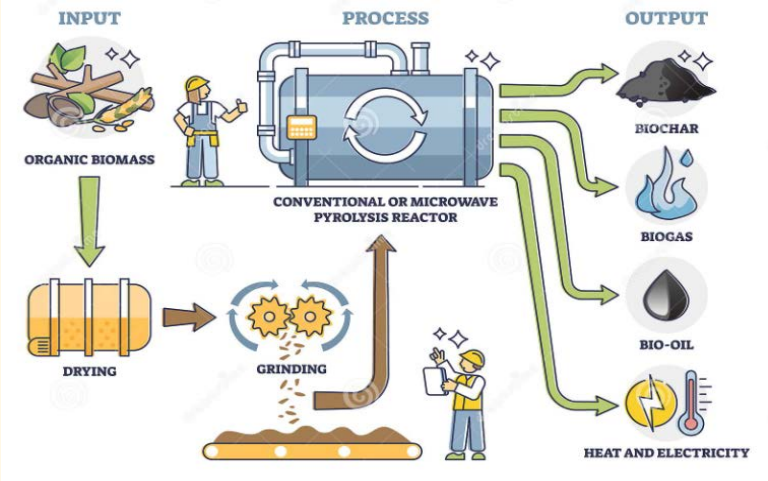
Invertimos en su futuro

- Thermochemical process (Exothermic)
- High temperature (above 300 ºC)
- Autogenous pressure



Pyrolysis

Biochar (BC) uses

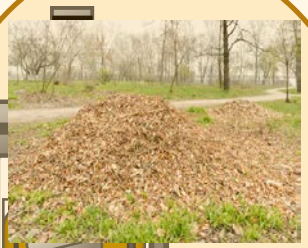
- Remediation of heavy metals
- Carbon sequestrator
- Catalytic
- Biocarbon
- Organic amendment

- Thermochemical process
- Mild temperature (150 - 300 ºC)
- Autogenous pressure
- Higher O/C and H/C ratios

Hydrothermal treatment

Sewage sludge

Food waste



Garden and park waste

Hydrochar (HC) uses

- Adsorbent
- Carbon sequestrator
- Catalytic
- Biocarbon
- Organic amendment

BC and HC amendments:

- Increase soil porosity
- Decrease bulk density
- Promote the formation and stability of soil aggregates

Fertilization ↑ Production ↑

Soil with **high carbon** content

Fresh Hydrochar (FHC)

¿Why the negative effects on germination?

Adsorption of dissolved organic compounds on HC (Bargmann et al. 2013)
Content of volatile fatty acids and phenols (Puccini et al., 2018).

HC post-treatments

Aging (AHC)

Washing (WHC)

Thermal treatment (THC)

OBJECTIVES

Evaluate the potential application of FHC, post-treated HCs and BC obtained from GPW thermal treatments as growth substrate or soil amendment.

Two experiments have been designed:

Evaluate the effect of FHC (2 – 15 %) on the plant-substrate seed by test germination index (GI) and plant growth of *Arabidopsis thaliana, quinoa and tomato.*

Analyze the effect of adding (1 – 5 %) of fresh and post treated HC, or BC to a marginal agricultural soil to establish their effect on tomato seed germination to determine their potential phytotoxic effects.

MATERIALS AND METHODS

Substrate mixture

4 different substrates

Peat

Vermiculite

Sand

Substrate name	Composition (% d.w.)			Concentration of HC (% d.w.)	Sterilize conditions (T; t)
	Peat	Vermiculite	River sand		
S1	100	-	-	Control, 2.5, 5, 10 and 15	115 ºC; 15 min
S2	80	-	20		
S3	75	25	-	Control, 1, 2, 2.5, 5, 10 and 15	120 ºC; 40 min
S4	60	20	20		

Biological test

- *Arabidopsis thaliana*

30-40 seeds

- Quinoa *(Chenopodium quinoa)*
- Marmande tomato (*Solanum Lycopersicum)* **(S3 and S4)**

8-10 seeds

Cold chamber
(4 °C; darkness)

Growth chamber
(24 °C day / 18 °C night; 12 h of light)

- Germination
- Leaf area
- Fresh and dry biomass

$$Germination\ index\ (\%) = \frac{grown\ cotyledons}{total\ seeds\ in\ pots} \times 100$$

Marginal agricultural soil characteristics

pH

8.4

Organic Matter

1%

Clay content

7%

HTT and Pyrolysis Treatments

Garden and Park Waste (GPW)

Grind

GPW ground to 3 mm

HTC - 180 °C; 1h

HTT
180 °C; 1h
Solid content (20%)

Fresh Hydrochar

FHC

Pyrolysis - 900 °C; 1h

Biochar

BC

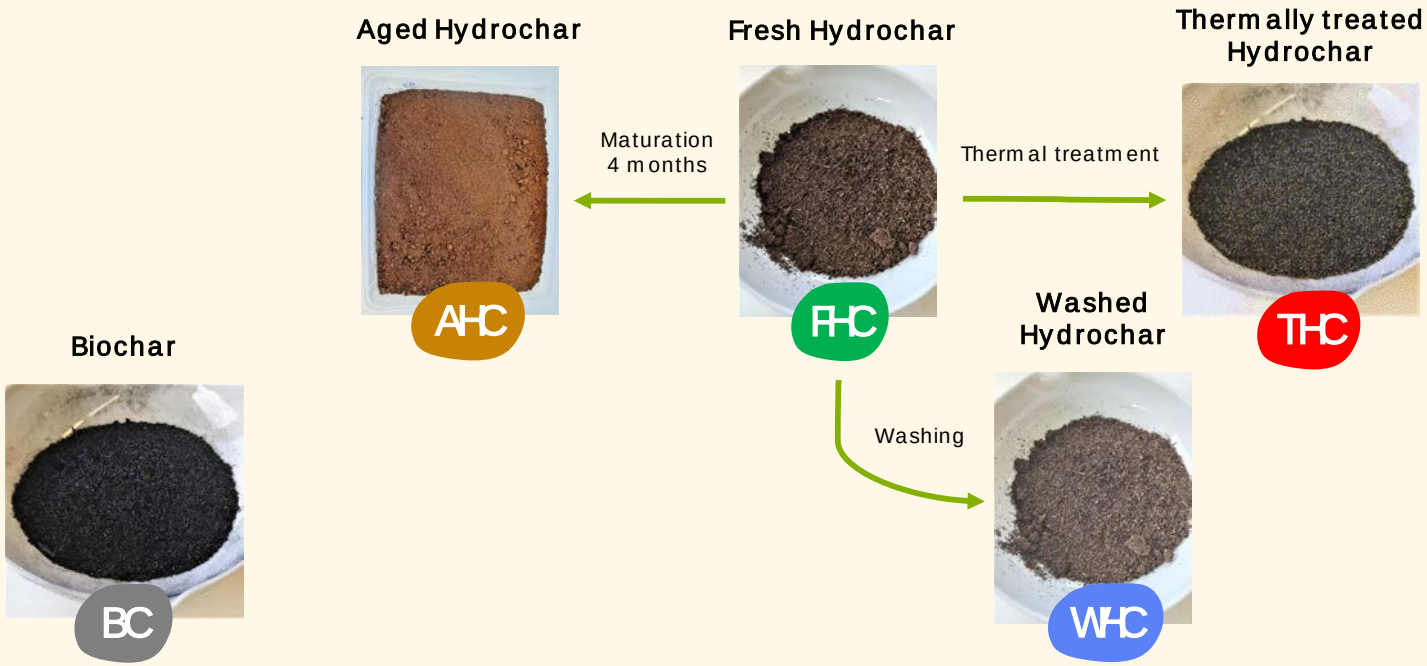
Characterization of feedstock

	Raw GPW	HC180
Moisture (%)	5.0	75.3
Total solids (%)	95.0	24.7
VM (% d.w.)	76.5	67.1
Ash (% d.w.)	5.1	3.3
pH	-	5.2
EC (mS/m)	-	61.2
FC (% d.w.)	18.4	29.6
C (% d.w.)	46.9	49.8
H (% d.w.)	6.1	5.3
N (% d.w.)	0.9	1.3
S (% d.w.)	0.4	0.2
O (% d.w.)*	40.6	40.1
COD(g/g)	1.1	0.5
C/N	54.9	38.6
H/C	1.6	1.3
O/C	0.7	0.6
N/P/K	0.9/0.9/4.9	1.3/1.2/3.4

	Raw GPW	HC180
Ca (mg/kg)	5130.0	32700.0
Si (mg/kg)	7327.0	8630.0
K(mg/kg)	4860.0	3500.0
P (mg/kg)	930.0	1162.0
Fe (mg/kg)	-	694.9
Mg (mg/kg)	774.0	650.0
Al (mg/kg)	123.0	367.0
Na (mg/kg)	31.0	53.0
As (mg/kg)	-	0.7
Cd (mg/kg)	-	0.5
Co (mg/kg)	-	0.4
Cr (mg/kg)	-	70.0
Cu (mg/kg)	-	13.2
Zn (mg/kg)	20.0	29.0

Cr ≤ 70 mg/kg
Zn ≤ 200 mg/kg

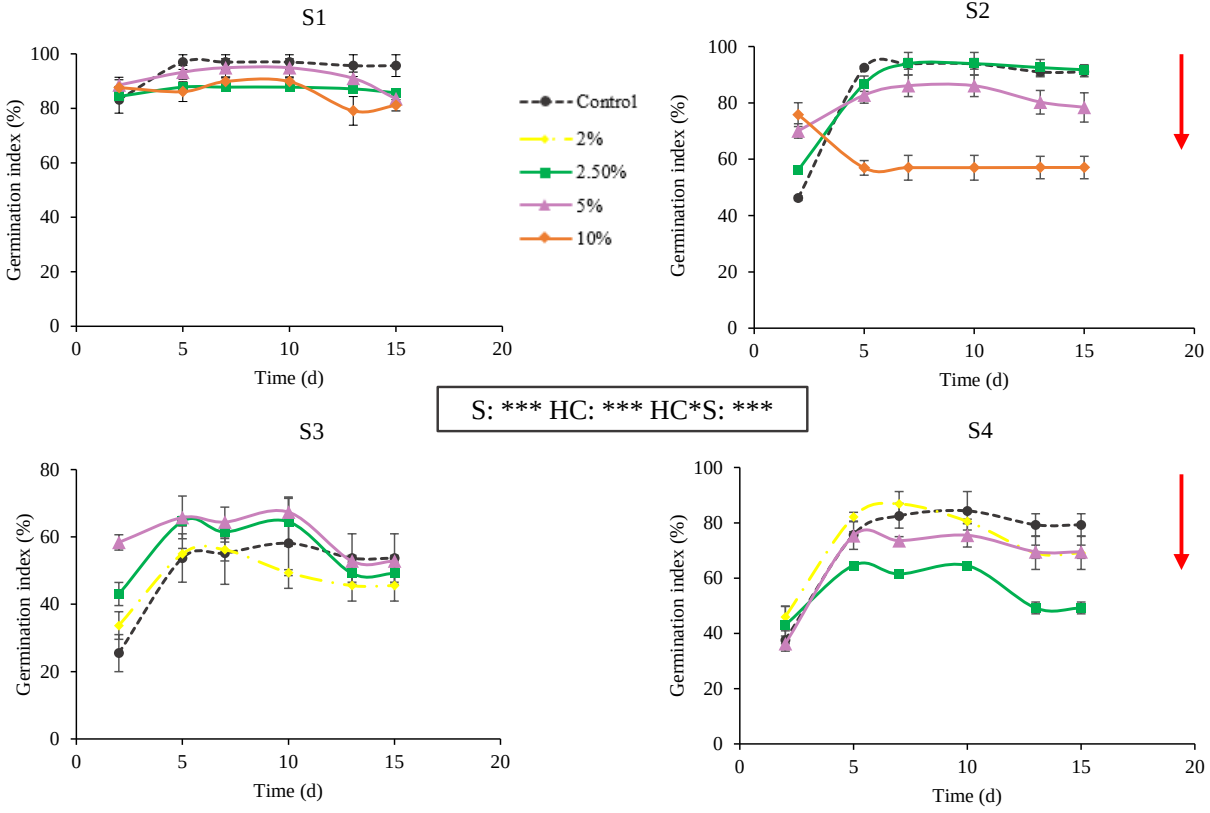
HYDROCHAR POST-TREATMENTS



Germination test process

Growth chamber
(26 °C day / 20 °C night; 13 h of light)

RESULTS AND DISCUSSION

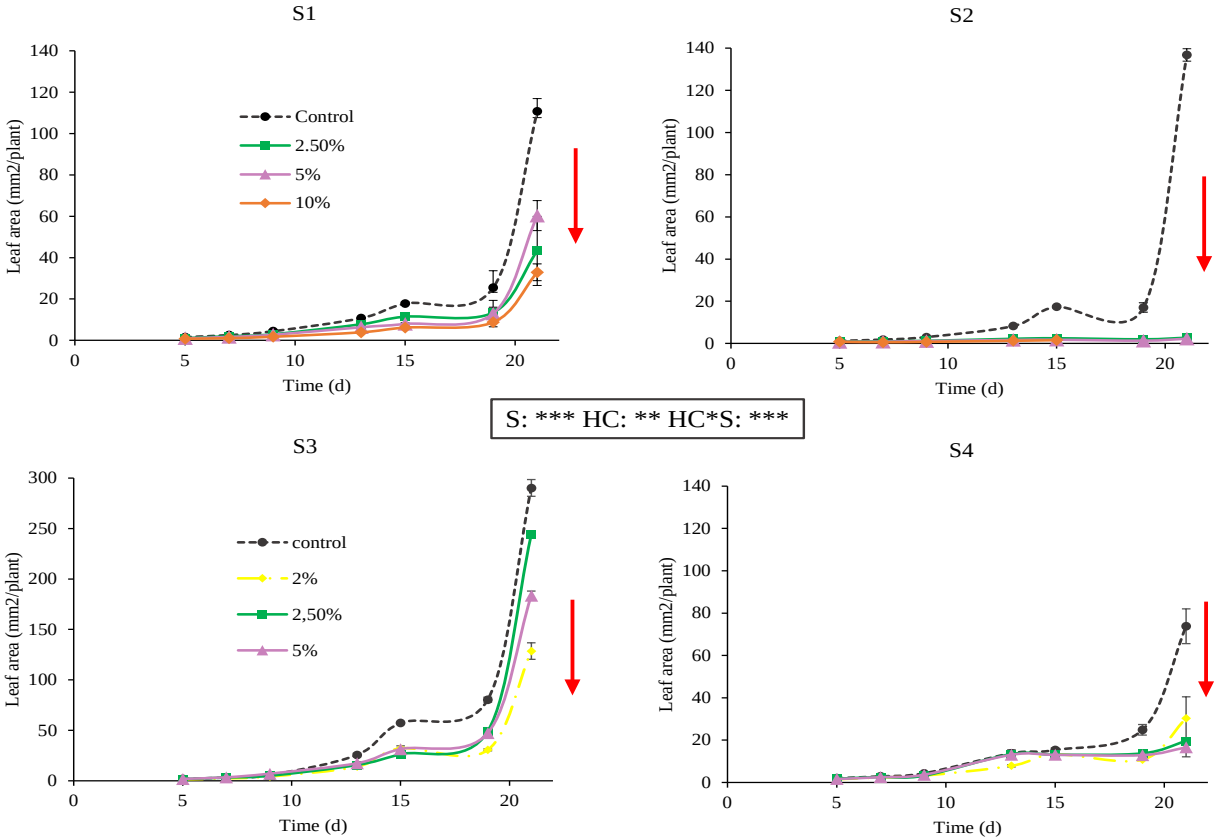


FHC effects on germination

S1: 100% peat
S2: 80% peat and 20% sand (% d.w.)
S3: Peat:vermiculite (3:1)
S4: 80% S3 and 20% sand (% d.w.)

Arabidopsis thaliana

- Best germination in substrates without vermiculite ($p<0.001$)
- ↑ HC concentration ↓ GI

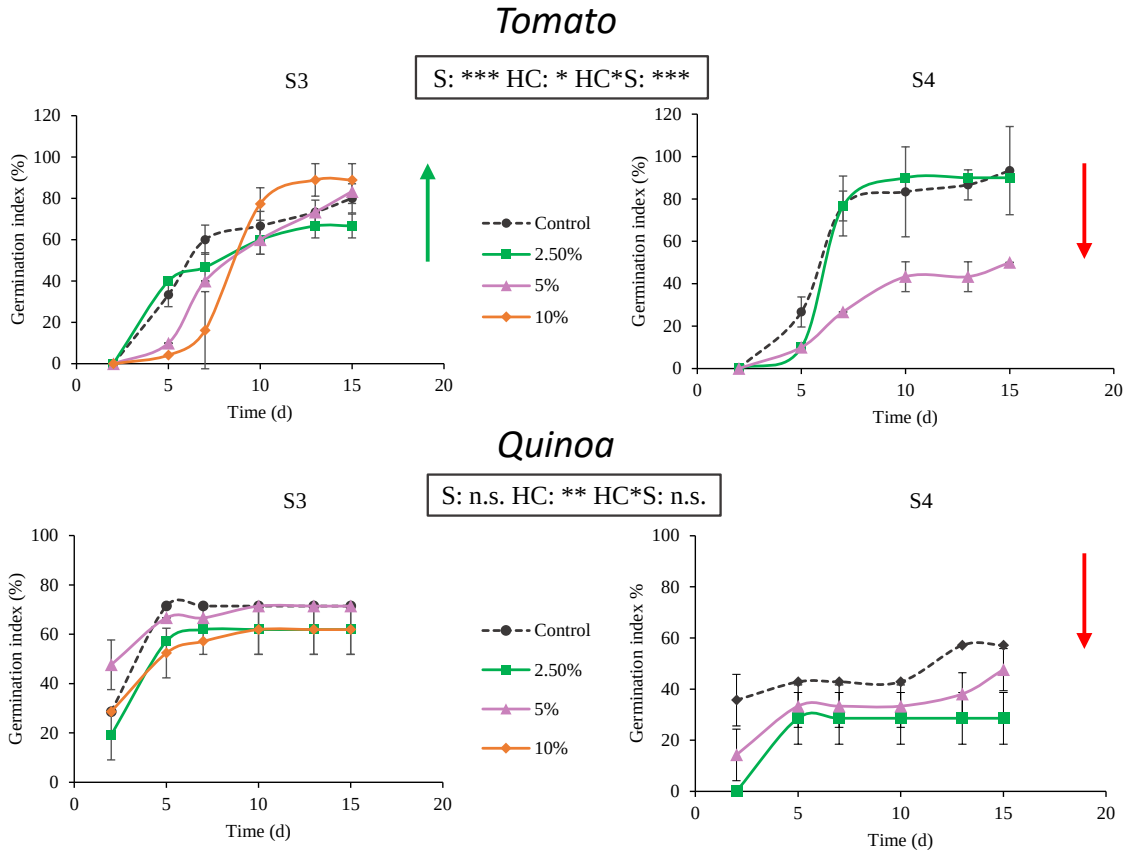


Plant growth

Arabidopsis thaliana

S1: 100% peat
S2: 80% peat and 20% sand (% d.w.)
S3: Peat:vermiculite (3:1)
S4: 80% S3 and 20% sand (% d.w.)

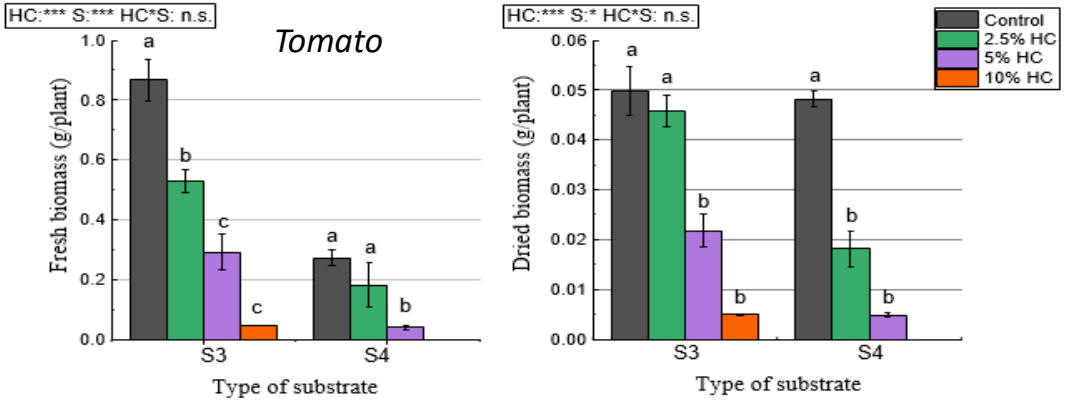
- HC addition inhibit the leaf growth specially in sandy soil → water repellency → Block the nutrient absorption

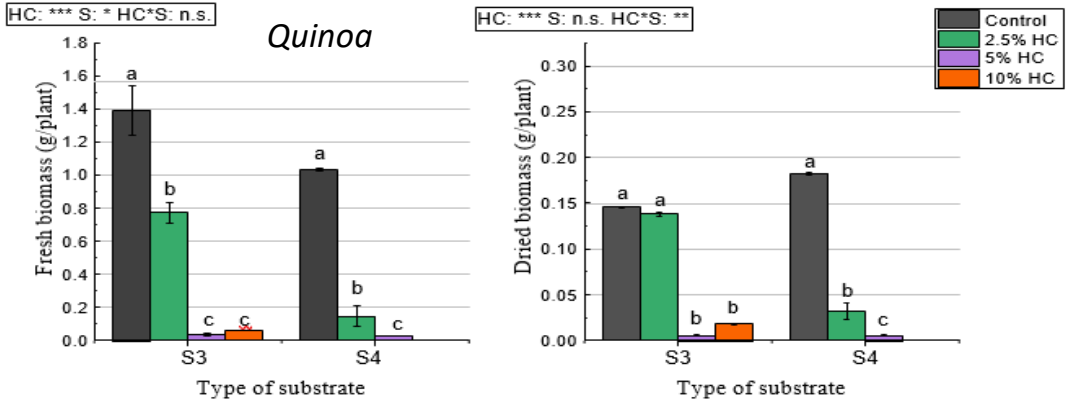


FHC effects on germination

S3: Peat:vermiculite (3:1)
S4: 80% S3 and 20% sand (% d.w.)

- FHC increased GI on tomato and had no effect on quinoa using S3.
- Sandy soil (S4) and FHC application reported negative effect on quinoa and tomato GI.



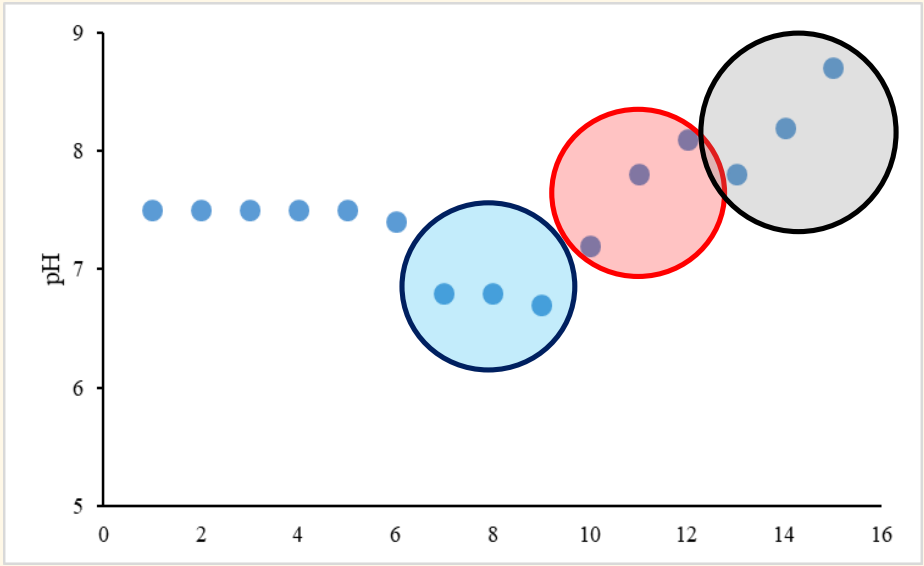


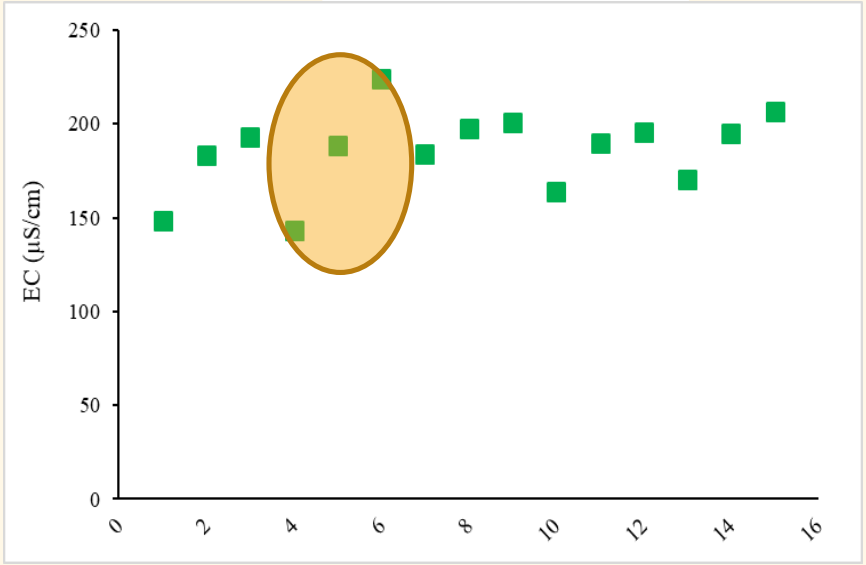
Plant growth

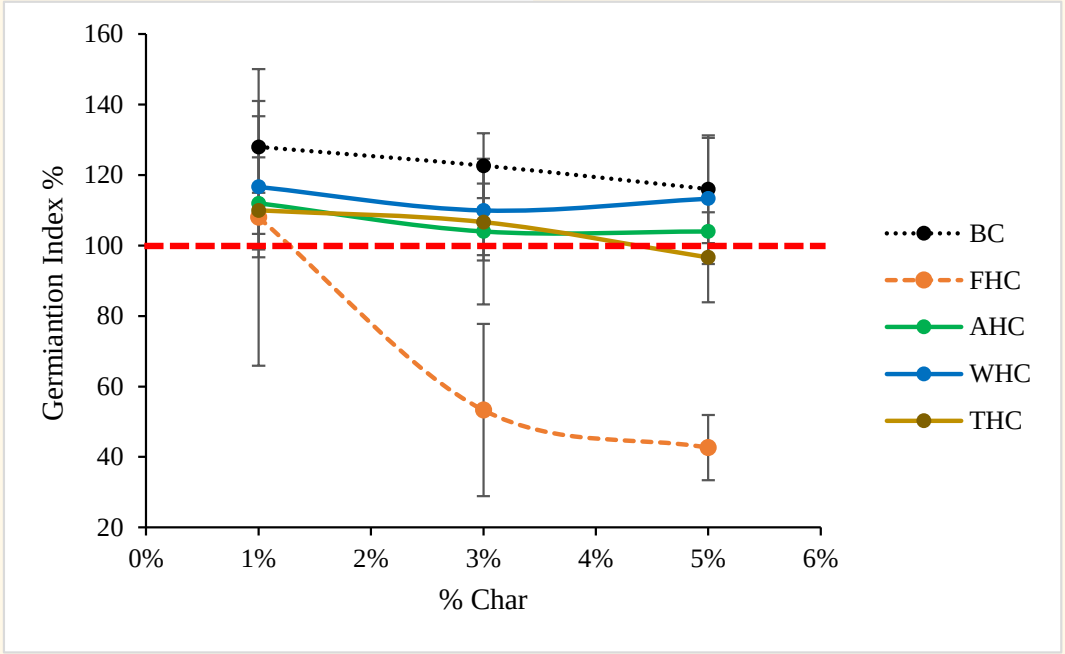
S3: Peat:vermiculite (3:1)
S4: 80% S3 and 20% sand (% d.w.)

- FHC negative effect (*p<0.001*) on growth specially in quinoa on S4.
- Sandy soil → Increase drainage → lower water retention → lower fresh weight

Effect of char application on marginal agricultural soil







Germination test

- FHC caused a significant reduction in GI for doses higher than 1%.
- WHC and BC mixtures improved the GI.
- THC also improved GI it at low dosage (1%).
- AHC did not showed negative effects upon GI at any dosage.

CONCLUSIONS

- HTT results in an effective method for valorizing lignocellulosic residues to produce an HC that presents good chemical characteristics to be used as soil conditioner.
- FHC application on peat-based substrates, especially those containing sand, caused inhibition of both, germination and plant growth.
- Post treatments of FHC alleviated the germiantion inhibition of tomato seeds on marginal agricultural soil.
- Considering the celerity and techno-economical requirements of the procedure, WHC resulted in the best post treatment.

Acknowledgments

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