Electronic Supplementary Material (ESI) for Environmental Science: Nano.

Supplementary Information

Biochar Nanoparticles Alleviate Salt-Stress in Tomato (*Solanum lycopersicum*) Seedlings

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Content

Nano-biochar physical properties

Particle size, pH and electrical conductivity

The two samples were characterized for particle size on a Particle Size Analyzer (90 Plus, Brookhaven, USA) and for electrical conductivity and pH by an Electronic Conductivity meter (Accumet™ XL200, Fisher Scientific, USA). The detailed information is below in Table S1.

Table S1: Biochar nanoparticles physical characteristics

Label	Description	Particle size（nm）	Zeta Potential（mV）	pH	EC (μS/cm)
RSB	Nano rice biochar - 350℃ treated	253.2	-43.80	9.40	74.75±0.82
CSB	Nano corn biochar - 350℃ treated	259.7	-38.47	9.42	72.38±2.49

Ash content and element analysis of nanoparticles

We used high temperature calcination to determine the ash content of each biochar sample and used an Elemental Analyzer (EA2400II, PerkinElmer, USA) to analyze the C, H, O, N, and S contents in biochar particles. The detailed information is below.

Table S2: Biochar nanoparticle ash content and element content

Label	Ash content（%）	C（%）	H（%）	O（%）	N（%）	S（%）
RSB	27.33	60.75	1.79	8.27	1.27	0.62
CSB	42.18	51.21	1.68	6.91	1.06	0.24

Determination of NaCl adsorption on biochar nanoparticles

In this study, we designed and implemented experiments for Na^+ adsorption on biochar nanoparticles in an aqueous system. We weighed 200mg of the two kinds of biochar nanoparticles and prepared 2 g/L NaCl solution. After the two solutions were fully stirred and mixed, they were shaken on a shaker at room temperature (25 ± 2℃) with the rotating speed of 180 rpm. The mixture solution was collected at 15min and 2, 4, 8, 16, 24, 48, 72 h. The collected solution was centrifuged (12,000 rpm, 25℃, 5 min; HT/20RZ, Hunan Herexi, China) and 200 μl of the supernatant was diluted to 10 ml to ensure that no biochar nanoparticles were present in the sample. We calculated and fitted the adsorption curves of biochar nanoparticles on Na^+ in Fig. S2.

In our results (Fig. S2), we found that the two biochar nanoparticles had similar ability to adsorb Na, reducing the concentration of Na^+ by 62.5% and 63.9%, respectively. The results also showed that equilibrium of the adsorption process was achieved quickly and was maintained over time.

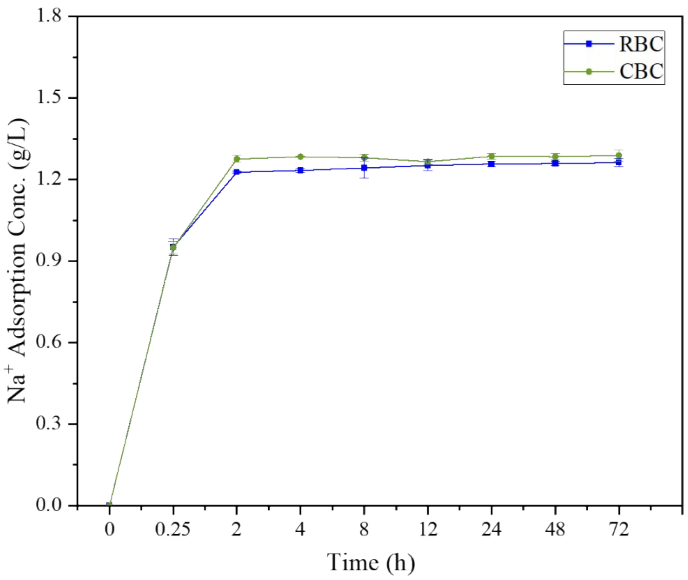

Figure S1: Na^+ adsorption curve by biochar nanoparticles in 72h

Dry weight and elemental content of plants in greenhouse experiments

Table S3: Elemental content of tomato seedlings

Label	Element Content In Root (g kg^{-1})						In Shoot (g kg^{-1})					
	Na	Ca	K	Mg	P	S	Na	Ca	K	Mg	P	S
CK	1.55±0.01	4.04±0.29	11.51±3.57	3.66±0.26	1.64±0.08	2.18±0.08	0.73±0.14	9.53±0.01	20.11±1.52	1.71±0.10	3.28±0.30	4.64±0.86
NaCl	4.03±0.19	4.86±0.17	13.04±0.90	3.08±0.16	2.00±0.04	2.00±0.13	2.91±0.06	12.28±1.50	17.09±2.27	1.93±0.15	2.69±0.25	3.87±0.47
T1	1.86±0.05	5.01±0.57	14.98±0.46	3.87±0.22	2.33±0.16	2.33±0.16	0.79±0.05	11.12±1.07	22.12±0.58	1.88±0.15	3.32±0.13	4.63±0.52
T2	4.09±0.05	4.00±0.45	12.62±1.10	3.72±0.21	2.45±0.16	2.45±0.16	1.89±0.22	12.57±1.31	17.61±0.47	1.73±0.08	3.14±0.09	3.95±0.61
T3	2.91±0.09	5.50±1.37	15.32±0.44	3.67±0.28	1.69±0.15	2.19±0.19	1.17±0.04	11.57±1.44	18.94±0.88	1.86±0.26	3.62±0.07	4.03±0.07
T4	1.62±0.07	4.44±0.20	16.49±0.98	4.20±0.21	1.58±0.19	2.50±0.07	0.76±0.04	12.41±1.05	22.52±2.89	1.75±0.03	3.53±0.27	5.05±0.12
T5	4.08±0.21	4.80±0.54	13.06±1.86	3.93±0.80	1.42±0.09	2.31±0.12	2.67±0.25	10.00±0.55	10.03±0.82	1.50±0.06	2.71±0.09	3.47±0.29
T6	2.58±0.14	4.42±0.26	12.95±0.25	3.36±0.18	1.42±0.17	2.27±0.16	1.09±0.06	12.47±1.31	15.10±1.04	1.59±0.12	3.13±0.14	3.91±0.43

Note: CK, control; NaCl, NaCl 2000 mg kg^{-1}; T1, 2000 mg kg^{-1} rice straw biochar NPs; T2, 2000 mg kg^{-1} rice straw biochar NPs + 2000 mg kg^{-1} NaCl; T3, 2000 mg kg^{-1} rice straw biochar NPs + 1000 mg kg^{-1} NaCl; T4, 2000 mg kg^{-1} corn straw biochar NPs; T5, 2000 mg kg^{-1} corn straw biochar NPs +2000 mg kg^{-1} NaCl; T6, 2000 mg kg^{-1} corn straw biochar NPs +1000 mg kg^{-1} NaCl.

Dry weight of tomato seedlings

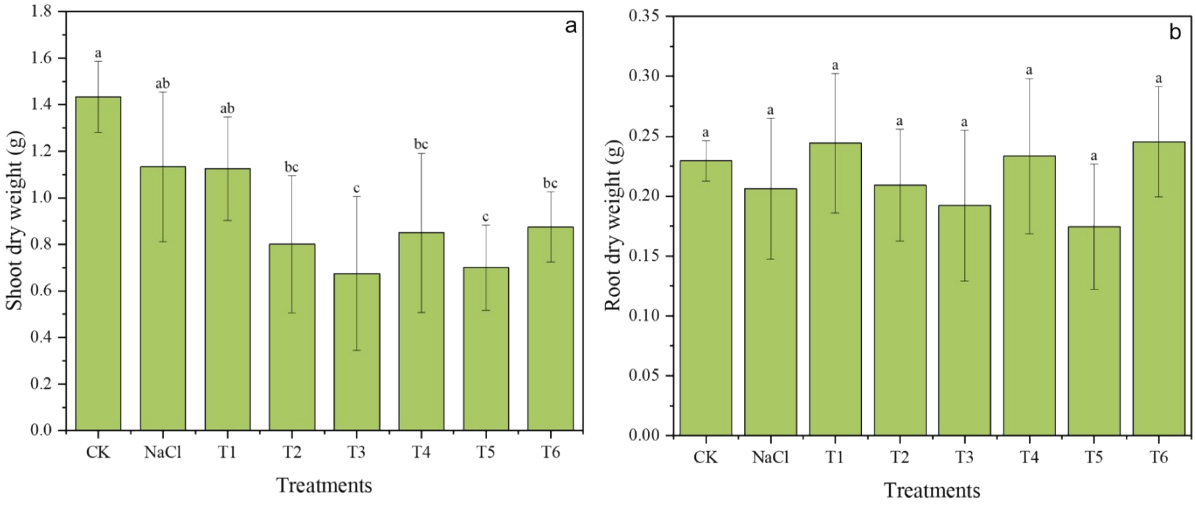

Figure S2: Dry weight of tomato seedlings (a)shoot and (b)root.

Note: CK, untreated control; NaCl, NaCl 2000 mg kg^{-1}; T1, 2000 mg kg^{-1} rice straw biochar NPs; T2, 2000 mg kg^{-1} rice straw biochar NPs + 2000 mg kg^{-1} NaCl; T3, 2000 mg kg^{-1} rice straw biochar NPs + 1000 mg kg^{-1} NaCl; T4, 2000 mg kg^{-1} corn straw biochar NPs; T5, 2000 mg kg^{-1} corn straw biochar NPs +2000 mg kg^{-1} NaCl; T6, 2000 mg kg^{-1} corn straw biochar NPs +1000 mg kg^{-1} NaCl.