

Table S1 Basic properties of biochar.

Raw Material	Pyrolysis Temperature	Heating Type	pH	Carbon Content (%)	Ash Content (%)	Particle Size (mesh)	Specific surface area (m ² /g)
Straw	550-600°C	Oxygen-free, Nitrogen Gas Protected Sintering	7-7.5	≥95%	5-10%	100	900-1300

Table S2 Impact trends of soil physicochemical properties under different restoration treatments.

Recovery measures	Mini-moisture content (g/kg)	Bulk density (g/cm ³)	Max-moisture content (g/kg)	Capillary moisture content (g/kg)	No capillary porosity /%	Capillary porosity /%	Total porosity /%
CK	259.75±20.39d	1.38±0.13a	309.44±42.81d	280.28±21.49c	3.83±2.72a	38.6±1.65c	42.43±2.11c
F	368.59±56.22bc	1.13±0.11bc	457.2±75.94bc	397.21±40.48b	6.53±4.22a	44.77±0.91b	51.3±3.98b
J	347.96±32.03bcd	1.16±0.08bc	426.71±56.37bc	387.41±53.09b	4.53±1.65a	44.8±3.41b	49.33±2.94b
C	480.11±80.22a	0.96±0.05c	584.9±54.51a	551.52±52.37a	3.2±2.12a	52.93±2.58a	56.13±2.57a
JC	380.14±50.95b	1.05±0.16c	487.31±75.09ab	450.21±58.81b	3.73±1.63a	46.63±1.27b	50.37±1.95b

CK: enclosure control, F: ploughing, J: application of *B. thuringiensis* NL-11, C: application of biochar, JC: application of *B. thuringiensis* NL-11 + biochar. Different letters indicate significant differences between different restoration measures ($P < 0.05$)

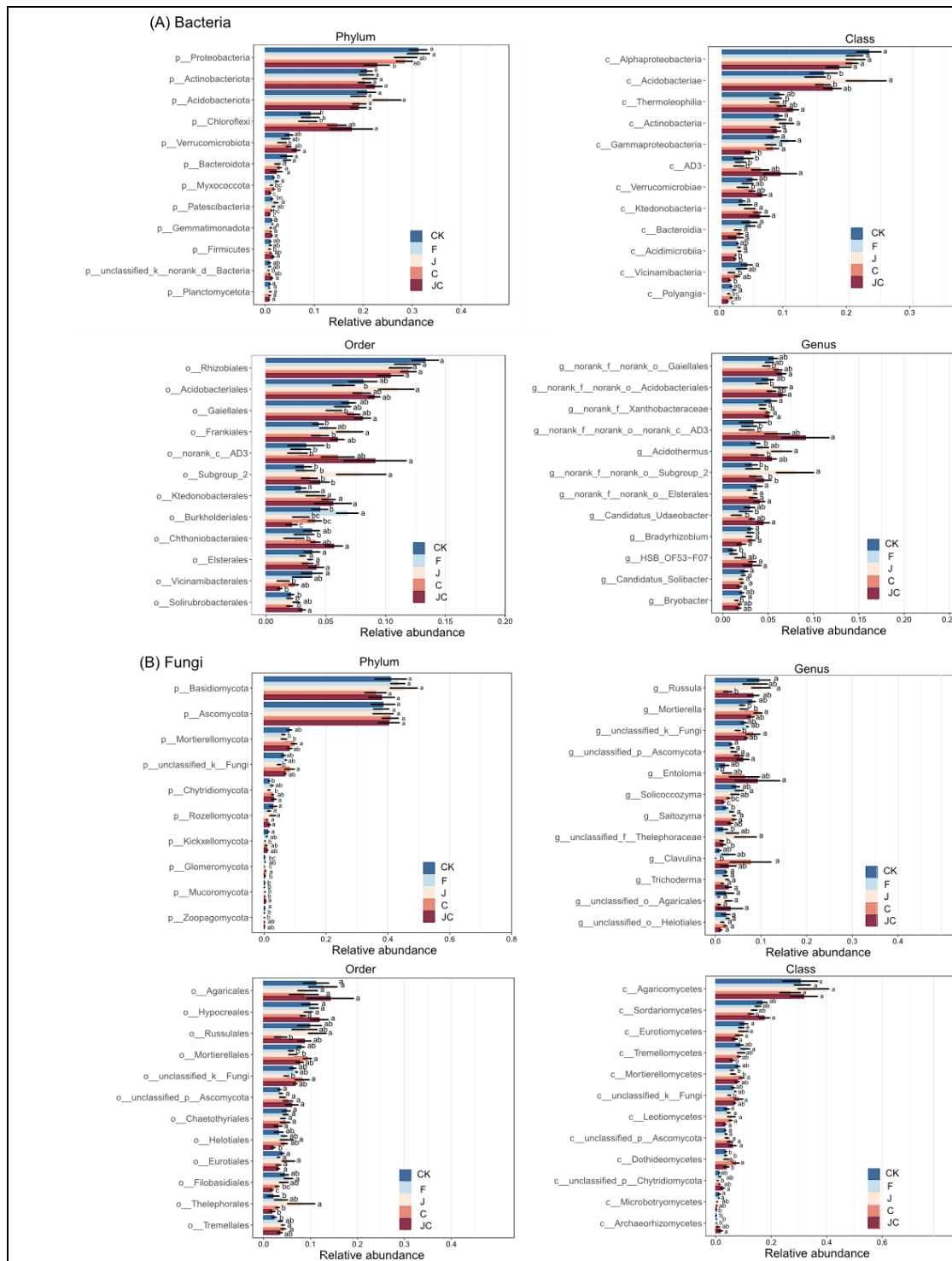


Figure S2 Differential abundance analysis across taxonomic ranks, with node coloration (red) indicating significantly differential taxa (DESeq2 test, Benjamini–Hochberg corrected $P < 0.05$), different letters showed significant differences between different treatments ($P < 0.05$).