

Supplementary Information for

Salinity-associated disintegration of soil multitrophic networks decouples microbial carbon sequestration from biotic regulation

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This supplementary information contains:

4 Figures, 3 Tables

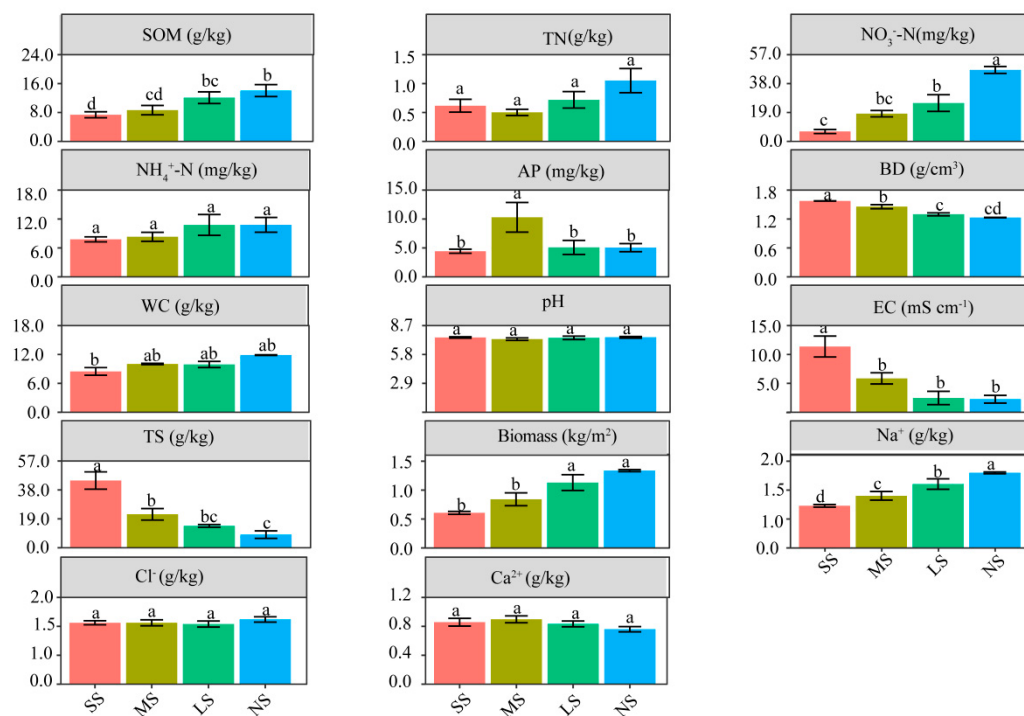


Fig. S1. Changes in soil properties and plant traits along the salinity gradients.

Abbreviations: SOM, soil organic matter; TN, total nitrogen; NO₃⁻-N, nitrate nitrogen; NH₄⁺-N, ammonium nitrogen; AP, available phosphorus; BD, bulk density; WC, water content; EC, electrical conductivity; TS, total salt content; Biomass refer to plant dry weight; Na⁺, Cl⁻, Ca²⁺ refer to soil base ions. Values are means $\pm$ SE. Different lowercase letters indicate significant differences among treatments (NS, LS, MS, SS) based on one-way ANOVA with Tukey's HSD test ($p < 0.05$).

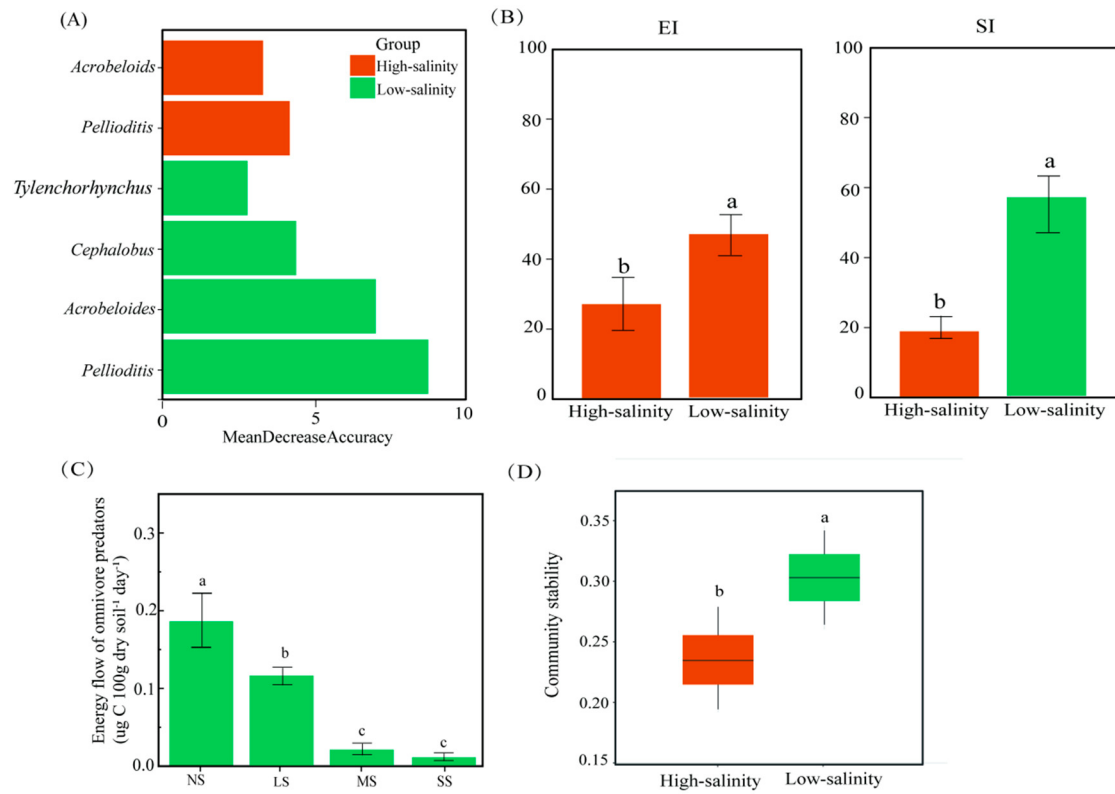
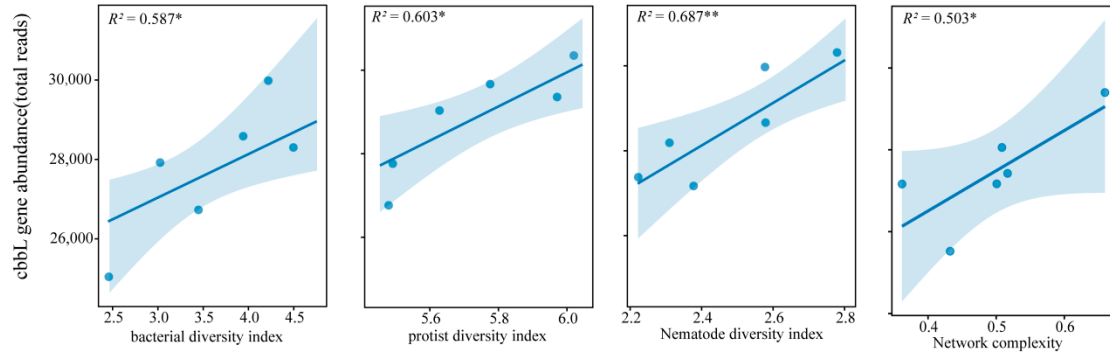


Fig. S2. Variations in soil nematode community characteristics along salinity gradients. (A) Indicator taxa driving differences in nematode community composition across salinity gradients, identified by random forest analysis. The x-axis shows mean decrease in accuracy, representing the importance of each taxon for distinguishing cultivation durations. (B) Changes in nematode enrichment index (EI) and structure index (SI) along the salinity gradients (low-salinity and high-salinity). Different lowercase letters indicate significant differences among treatments ($p < 0.05$, LSD test). (C) Energy flow across different salinity gradients within soil nematode communities; (D) Comparison of stability indices derived from the robustness analysis between low- and high-salinity groups. Different letters indicate significant differences ($p < 0.05$).

(A) Low- salinity



(B) High- salinity

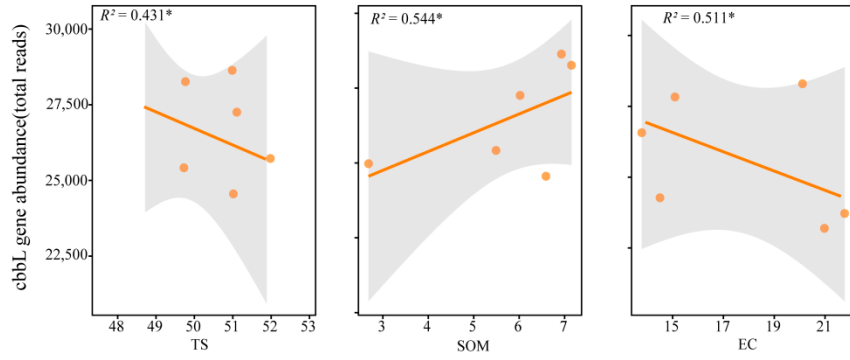


Fig. S3. Relationships between biodiversity, soil properties, and cbbL gene abundance across soil salinity gradients. (A) Linear regressions between Shannon diversity of bacteria, protist, and nematodes and cbbL gene abundance. (B) Linear regressions between TS, SOM, EC and cbbL gene abundance. Shaded areas indicate 95% confidence intervals. The coefficient of determination (R^2) and significance levels are shown (ns, not significant; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$).



Fig. S4. Total network reconstruction under low- and high-salinity gradient using multiple Spearman correlation thresholds. Networks were reconstructed using $|r| > 0.60$ (A), $|r| > 0.65$ (B), $|r| > 0.70$ (C), and $|r| > 0.75$ (D), while retaining the adjusted $p < 0.05$ criterion.

Table S1. Results of the PERMANOVA testing the effects of salinity gradient on community structure.

	Comparison	Df	F	R ²	P	Significance
a. Bacteria	Low-salinity_vs_High salinity	1	4.143	0.168	0.023	*
b. Fungi	Low-salinity_vs_High salinity	1	12.795	0.082	0.004	**
c. Protist	Low-salinity_vs_High salinity	1	2.435	0.354	0.015	*
d. Nematode	Low-salinity_vs_High salinity	1	9.675	0.484	0.001	**

Low-salinity group: non-salinized soil (NS) + lightly saline soil (LS);

High-salinity group: moderately saline soil (MS) + severely saline soil (SS);

Table S2. Shannon diversity indices of soil biotic communities in non-salinized (NS) and lightly saline (LS) soils, with corresponding statistical significance metrics.

Biotic community	NS (mean $\pm$ SD)	LS (mean $\pm$ SD)	NS→LS decrease rate (%)	One-way ANOVA overall test	Tukey HSD pairwise test (NS vs LS)	Significance grouping
Bacteria	5.32 $\pm$ 0.05	5.28 $\pm$ 0.06	0.75%	p < 0.05	p = 0.123	a/ab
Fungi	3.22 $\pm$ 0.04	3.01 $\pm$ 0.05	6.52%	p < 0.05	p = 0.087	a/a
Protist	3.15 $\pm$ 0.07	2.42 $\pm$ 0.05	74.20%	p < 0.05	p < 0.05	a/b
Nematode	2.20 $\pm$ 0.05	1.65 $\pm$ 0.04	50.40%	p < 0.05	p < 0.05	a/b

Table S3. Nematode abundance in soil along salinity gradients

sa mpl e	Gr ou p	Microdor ylaimus	Doryl aimus	Apor cella	Paratyl enchus	Helicoty lenchus	Belono laimus	Tylenchor hynchus	Panagro laimus	Pelli oditis	Cepha lobus	Protorh abditis	Acrobe loides	Acro beles	Filen chus	Aphele nchus
1	NS	2	0	1	3	2	2	6	11	8	28	0	3	19	2	5
2	NS	3	0	3	0	5	0	32	12	27	93	5	2	0	5	7
3	NS	5	2	0	6	0	0	0	15	21	60	5	0	0	3	8
4	LS	6	2	0	1	0	0	12	16	33	65	6	7	4	3	6
5	LS	4	3	1	7	1	2	34	18	26	86	4	5	0	1	11
6	LS	5	0	0	2	0	0	2	22	19	23	7	12	3	5	19
7	M S	0	0	0	0	1	0	0	3	55	0	0	0	0	0	0
8	M S	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0
9	M S	0	0	0	0	1	1	0	2	45	1	0	0	0	M	1
10	SS	0	0	0	0	0	0	0	6	40	5	5	0	0	2	5
11	SS	0	0	0	0	0	0	0	9	16	3	0	8	0	0	2
12	SS	0	0	0	0	2	0	25	42	0	126	3	0	2	3	25