



The crop mined phosphorus nutrition via modifying root traits and rhizosphere micro-food web to meet the increased growth demand under elevated CO₂

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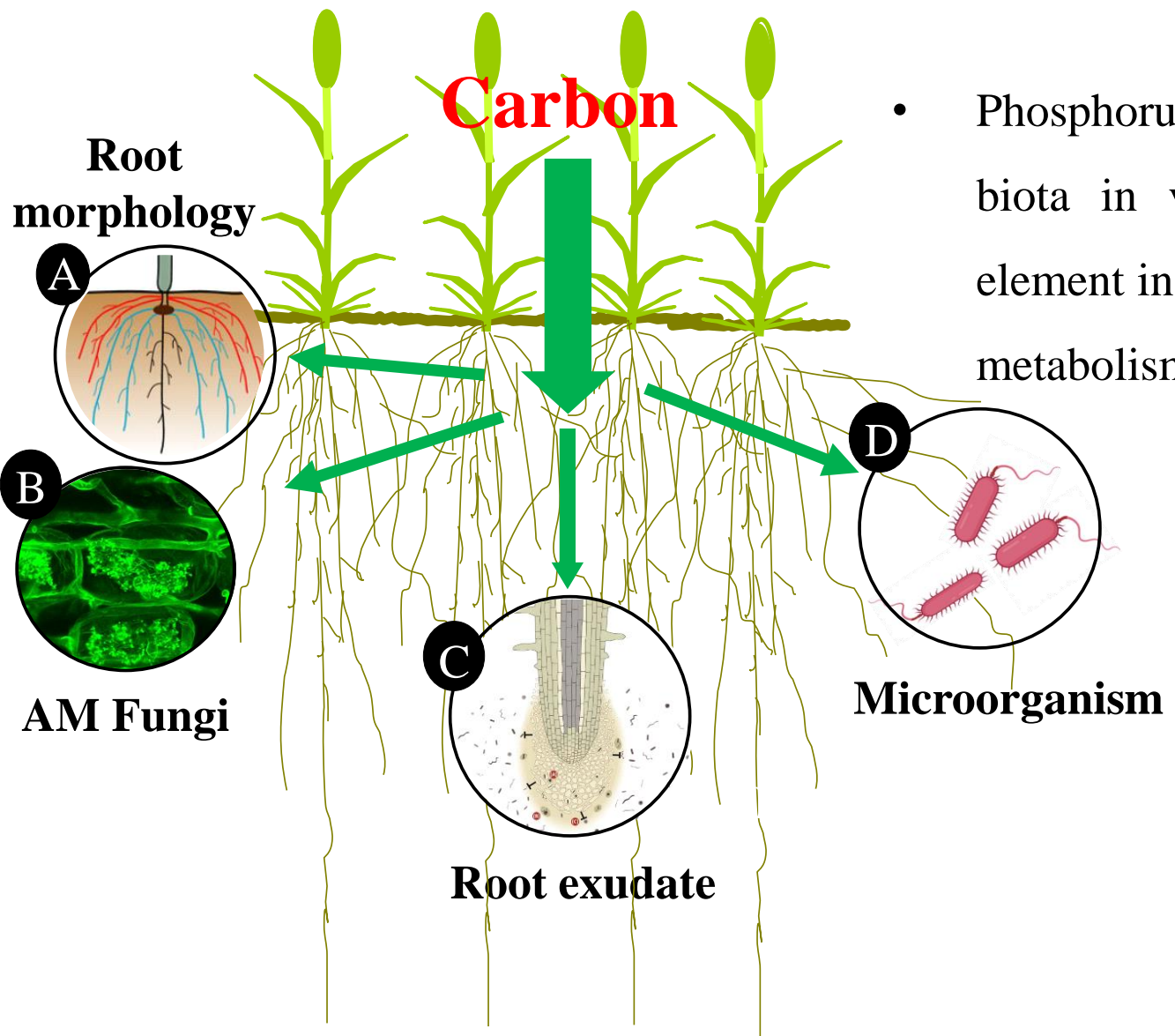
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Background



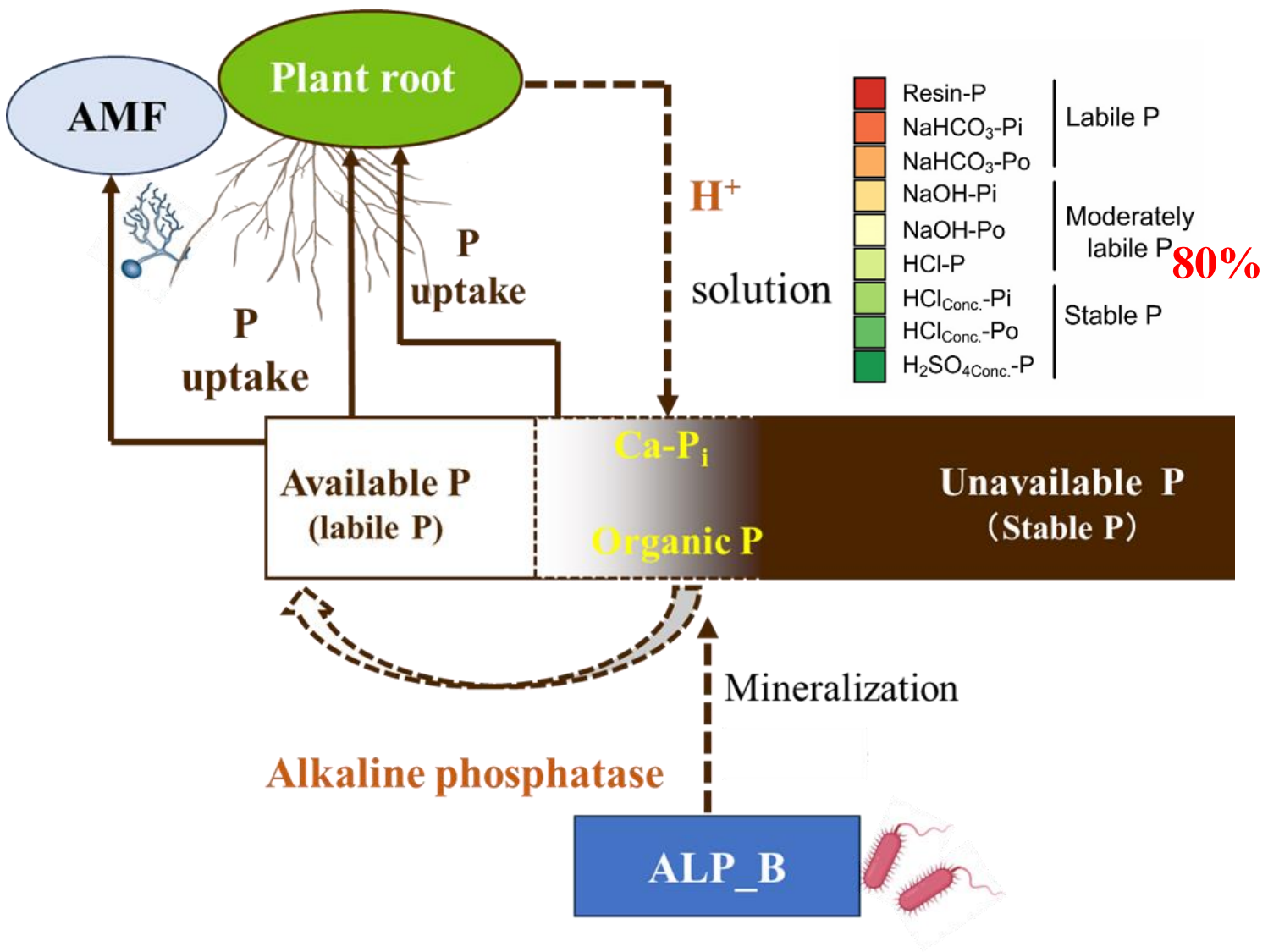
- Phosphorus is essential for growth of plants and soil biota in various environments, an important basic element in many physiological processes such as energy metabolism, photosynthesis and respiration in plants.

- Plants acquire soil nutrients (e.g., P) by regulating root morphology, physiology, mycorrhizal symbiosis, and rhizosphere microbial changes.

Lambers *et al.* 2008

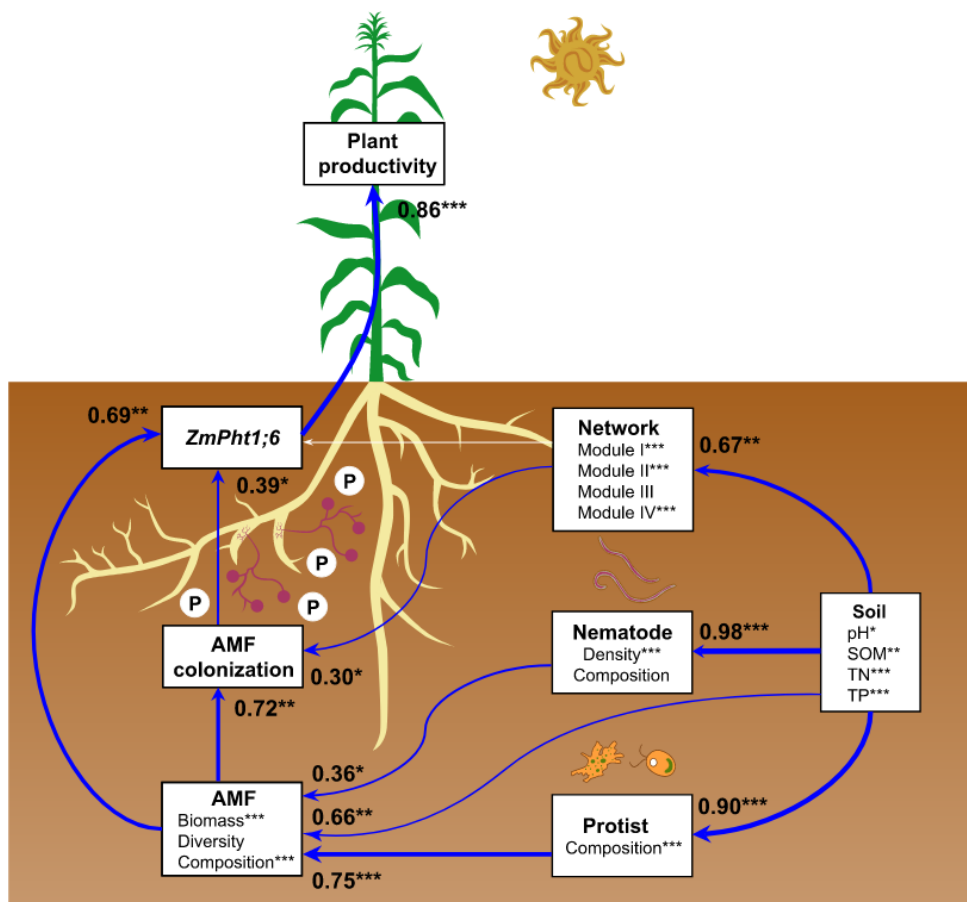


Background



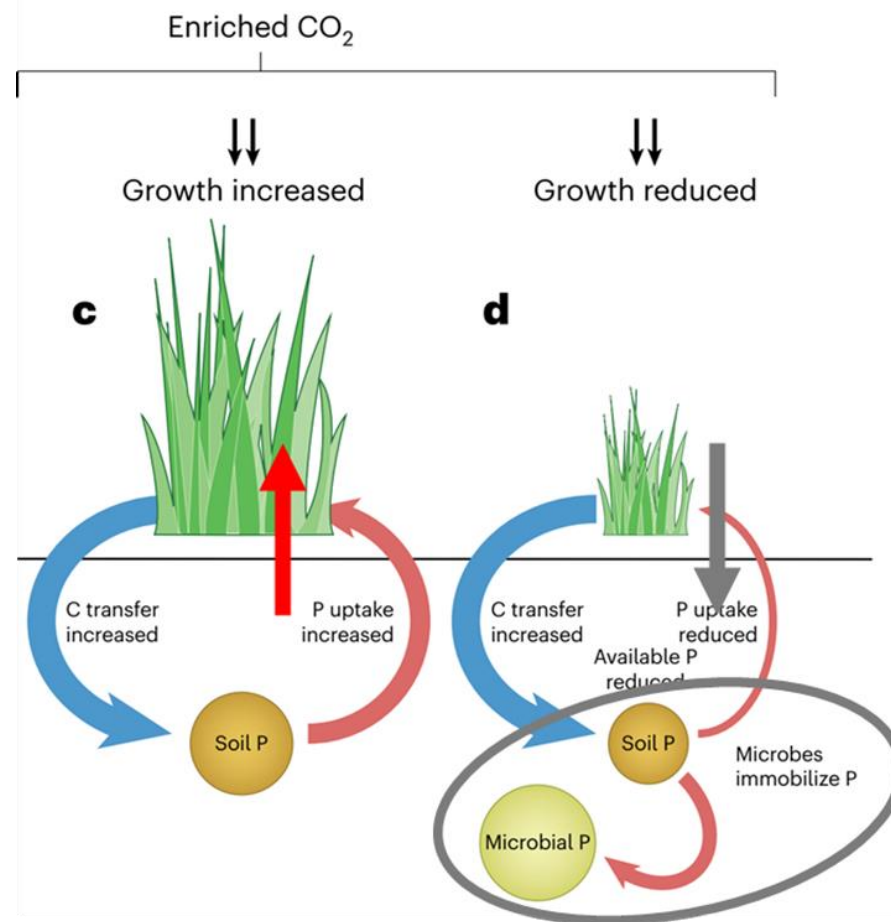
- Plant roots and mycorrhizal fungi directly absorb **available P** from the soil.
- For moderately unstable P, plant roots **mobilize P_i** by secreting organic acid ions.
- Soil microorganisms can **mineralize P_o** by secreting alkaline phosphatase.

Background



The “microbial-protozoa-nematode” soil micro-food web plays a key role in promoting phosphorus cycling and plant growth.

Jiang *et al.* 2020



under eCO₂, plants can increase carbon allocation to belowground, and then regulate the phosphorus competition between plants and microorganisms, which may further affect the structure and function of the rhizosphere soil micro-food web.

Turner *et al.* 2023



Background

- How can eCO₂ impact wheat growth, plant P accumulation and P fractionation in wheat rhizosphere?
- Whether and how do plants coordinate the root morphological and physiological traits and the communities of ALP-producing bacteria and AMF to capture P under eCO₂?
- How and to what extent are protozoa and nematodes linked to their potential prey (ALP-producing bacteria and AMF community) under different CO₂ environments?



Experiment design

The FACE system was established at the experimental base of Institute of Agricultural Environment and Sustainable Development, Chinese Academy of Agricultural Sciences, Changping District, Beijing ($116^{\circ} 8' E$, $40^{\circ} 8' N$).

Experimental treatment:

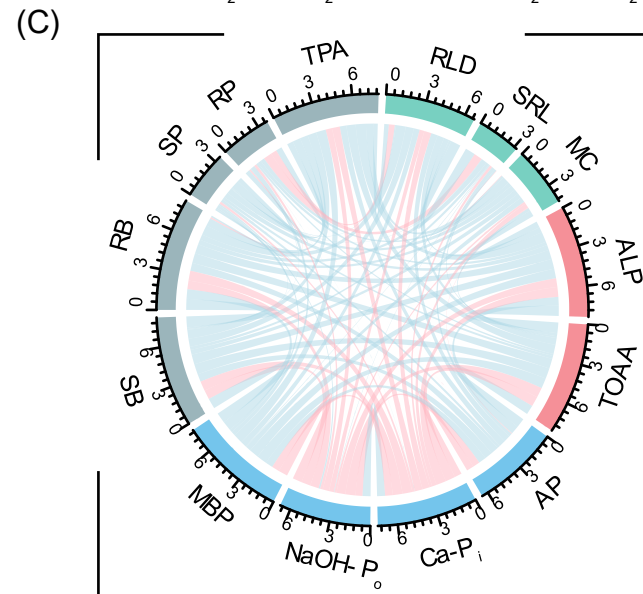
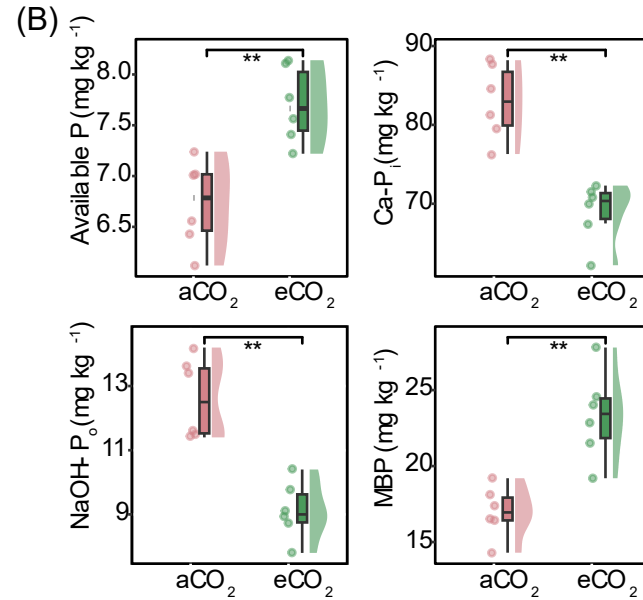
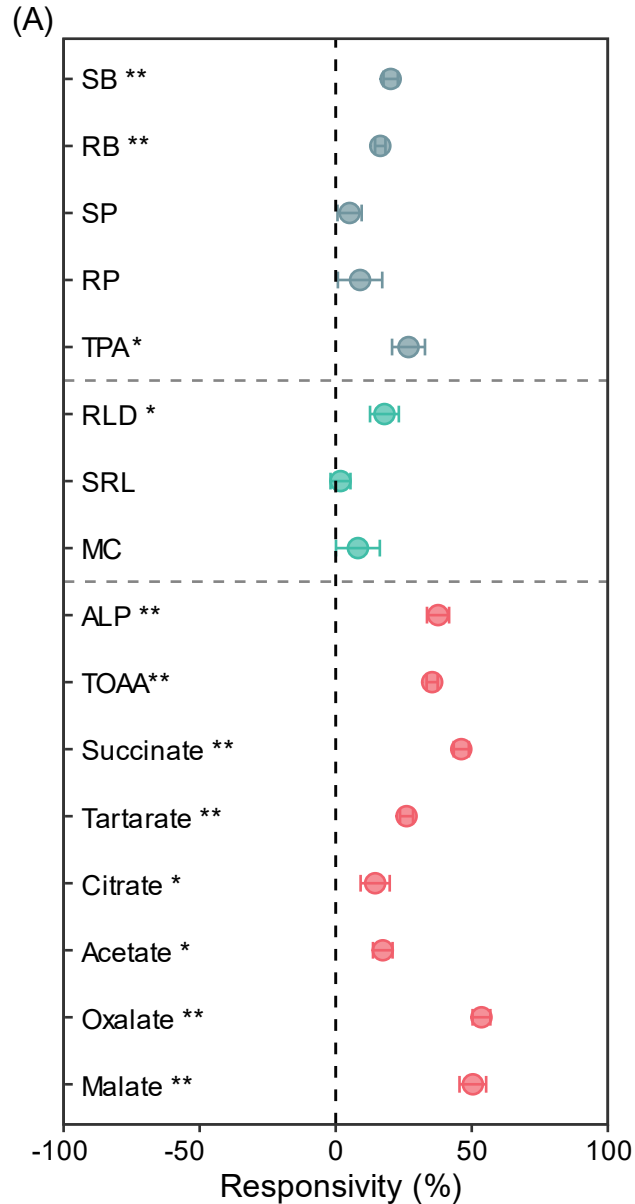
The planting pattern is a double cropping of wheat-soybean rotation, comprising two treatments:

Atmosphere CO_2 (\mathbf{aCO}_2 , $415 \pm 16 \mu\text{mol}\cdot\text{mol}^{-1}$)

Elevate CO_2 (\mathbf{eCO}_2 , $550 \pm 17 \mu\text{mol}\cdot\text{mol}^{-1}$)

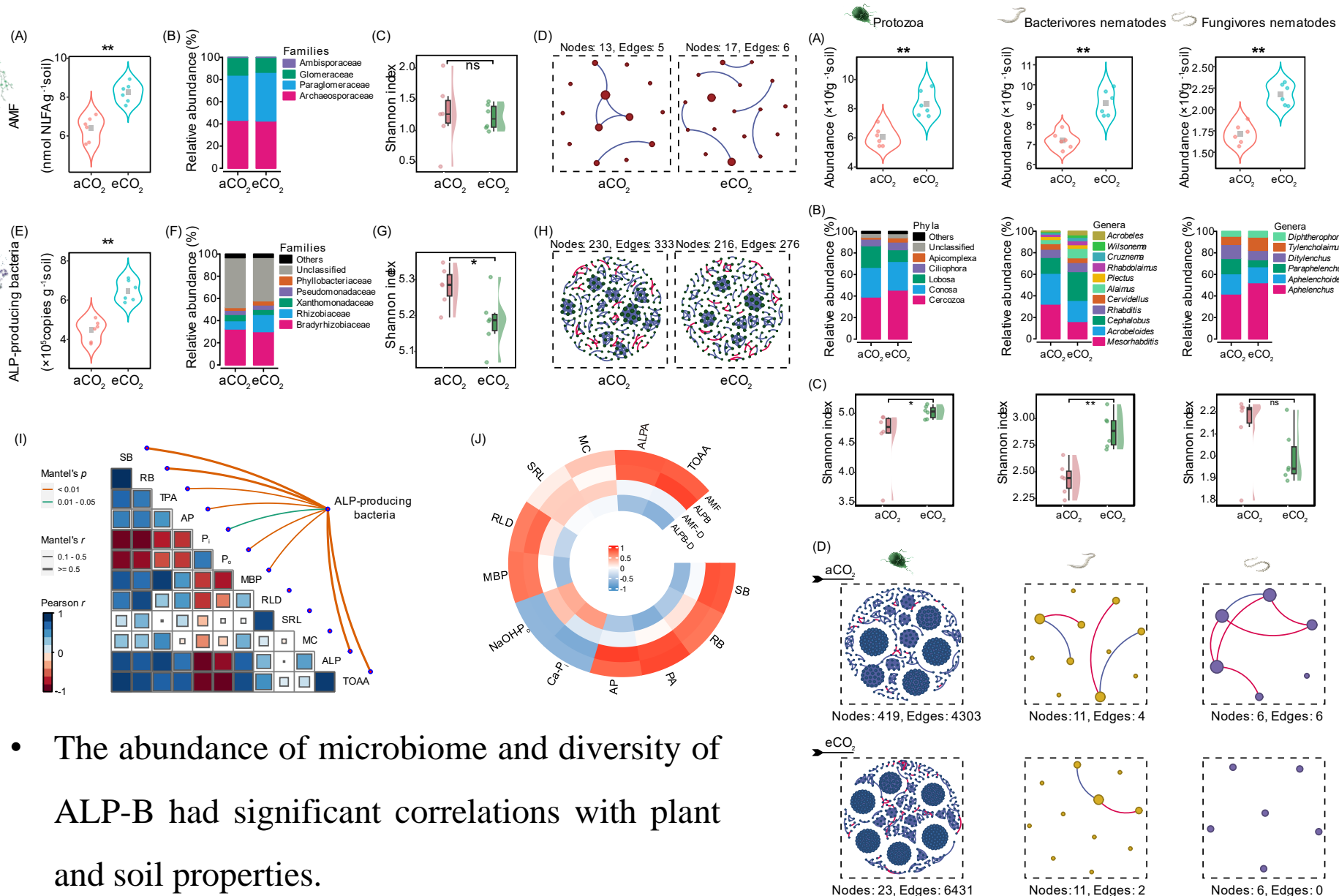


Result



- eCO₂ significantly increased the shoot biomass, root biomass and total plant P accumulation.
- The eCO₂ promoted root length density, ALP activity and the release of organic acids.
- eCO₂ increased available P and decreased the Ca-P_i fraction and NaOH-P_o.

Result



✓ The eCO₂ promoted the growth of root microbiome.

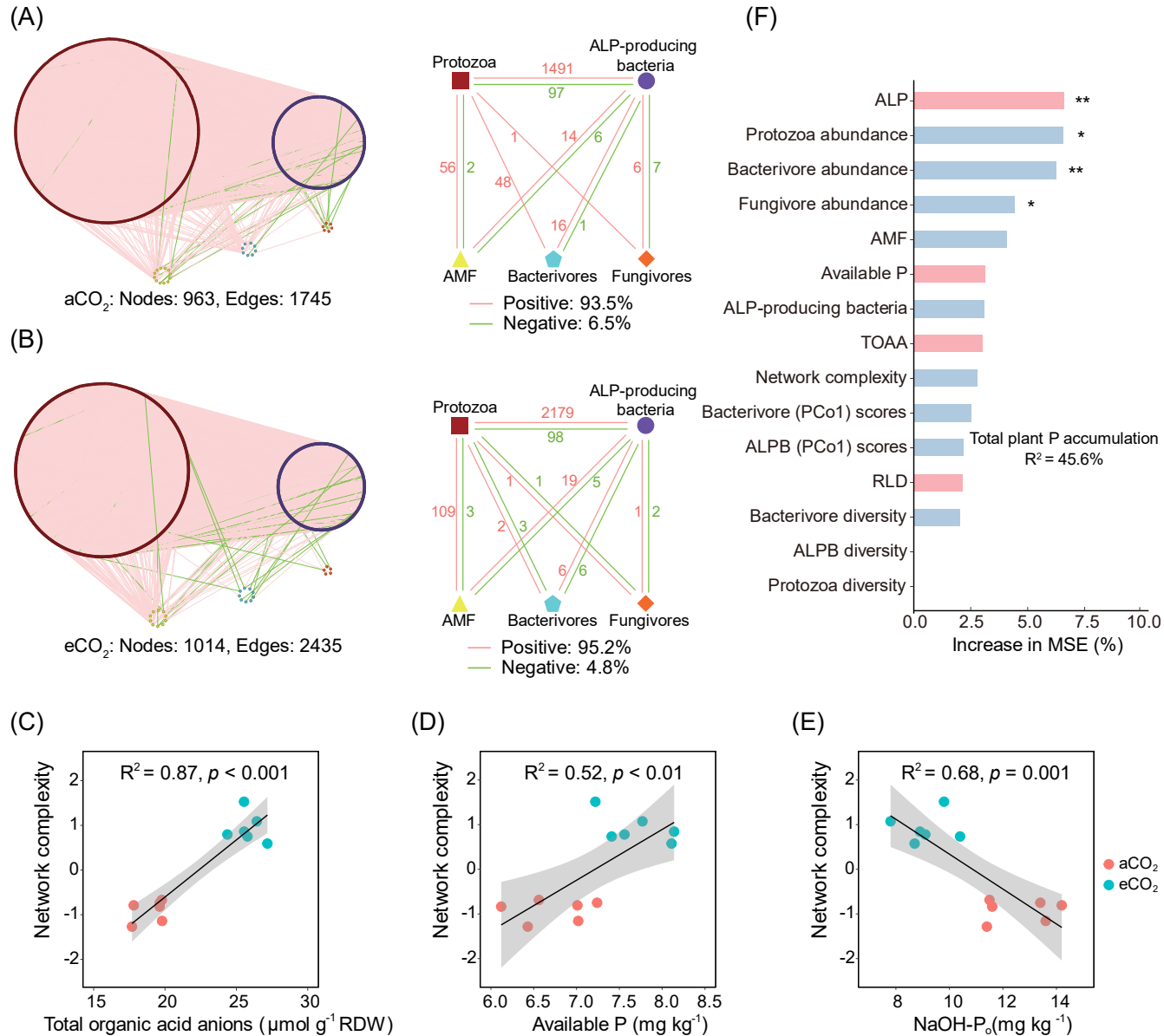
✓ eCO₂ promoted the abundance of ALP-B (Rhizobiaceae) and nematodes.

✓ The eCO₂ decreased the diversity of ALP-B, and increased the protozoa and bacterivorous nematode.

✓ eCO₂ reduced the network structure of AMF, ALP-B and nematodes, but enhanced the network structure of protozoa.

- The abundance of microbiome and diversity of ALP-B had significant correlations with plant and soil properties.

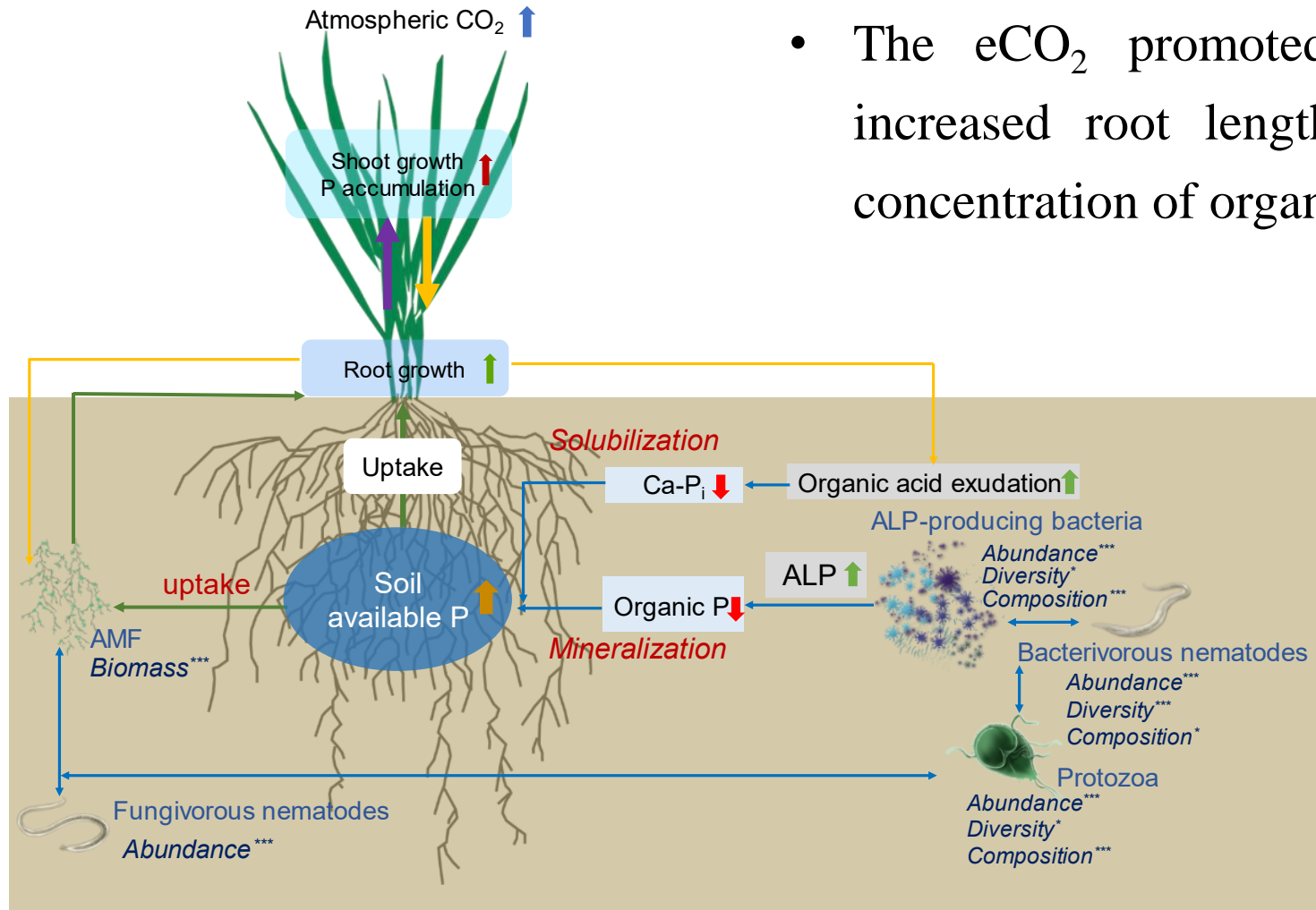
Result



For the whole microbiota community network:

- The points, edges, average degree, and connections of the microbiome network and altered the relationships between microbes.
- There were positive correlations between TOAA, the available P and the network complexity, and a negative correlation between NaOH-P₀ and the network complexity
- Wheat P accumulation was significantly influenced by ALP activity and microbial factors.

Conclusion



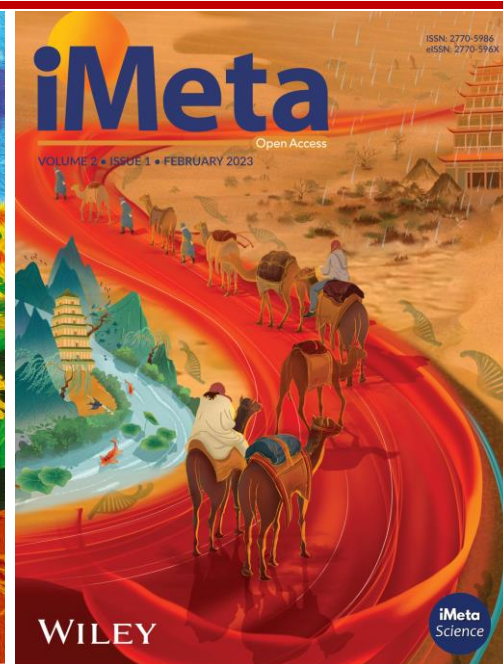
- The eCO₂ promoted wheat P accumulation through increased root length and AMF hyphal biomass, the concentration of organic acid anions and the ALP activity.

- The eCO₂ also increased the growth of ALP-producing bacteria, protozoa and bacterivorous and fungivorous nematodes in the rhizosphere, and strengthened their trophic interactions.

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