The crop mined phosphorus nutrition via modifying root traits and rhizosphere micro-food web to meet the increased growth demand under elevated CO_2

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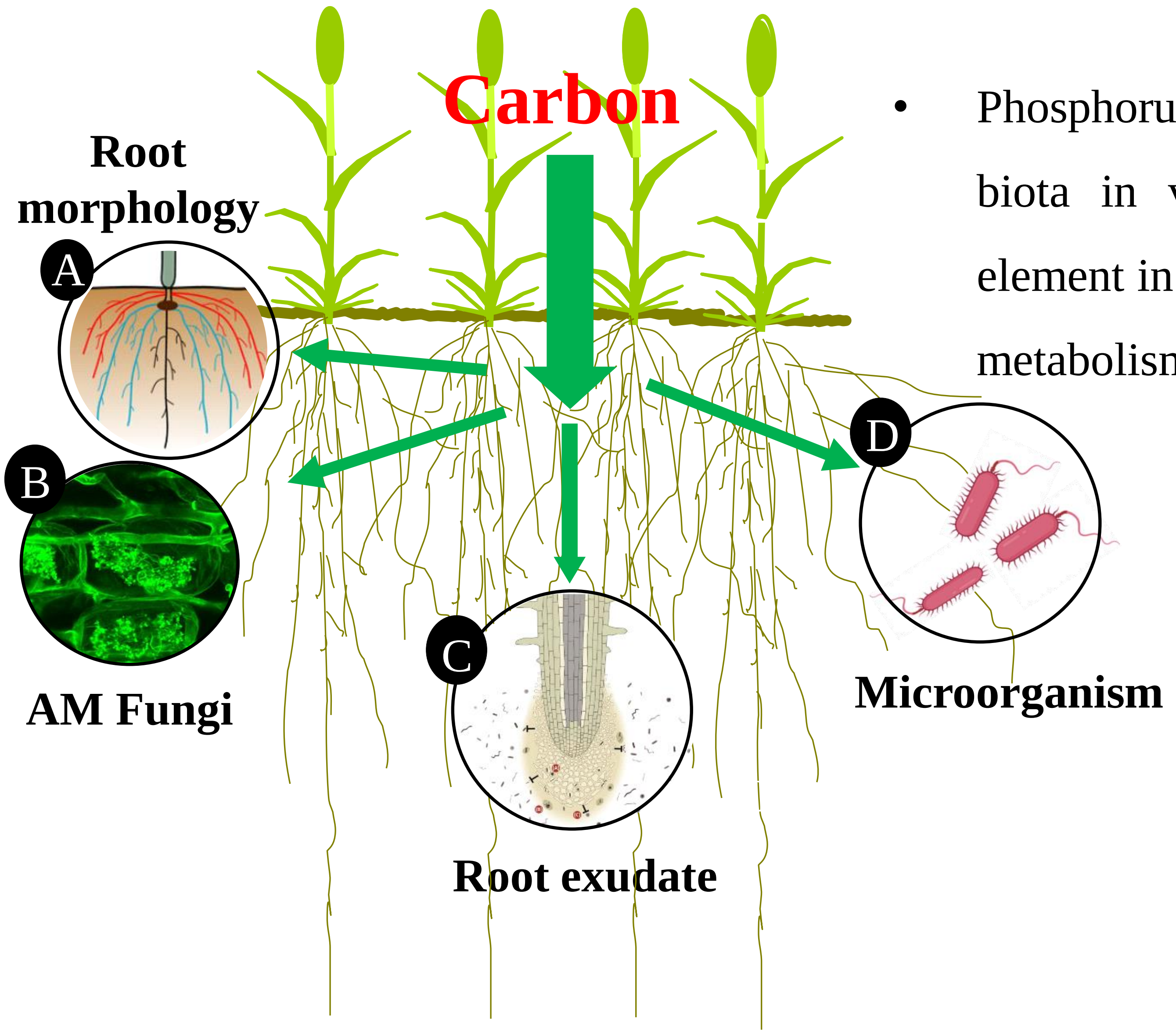
Background

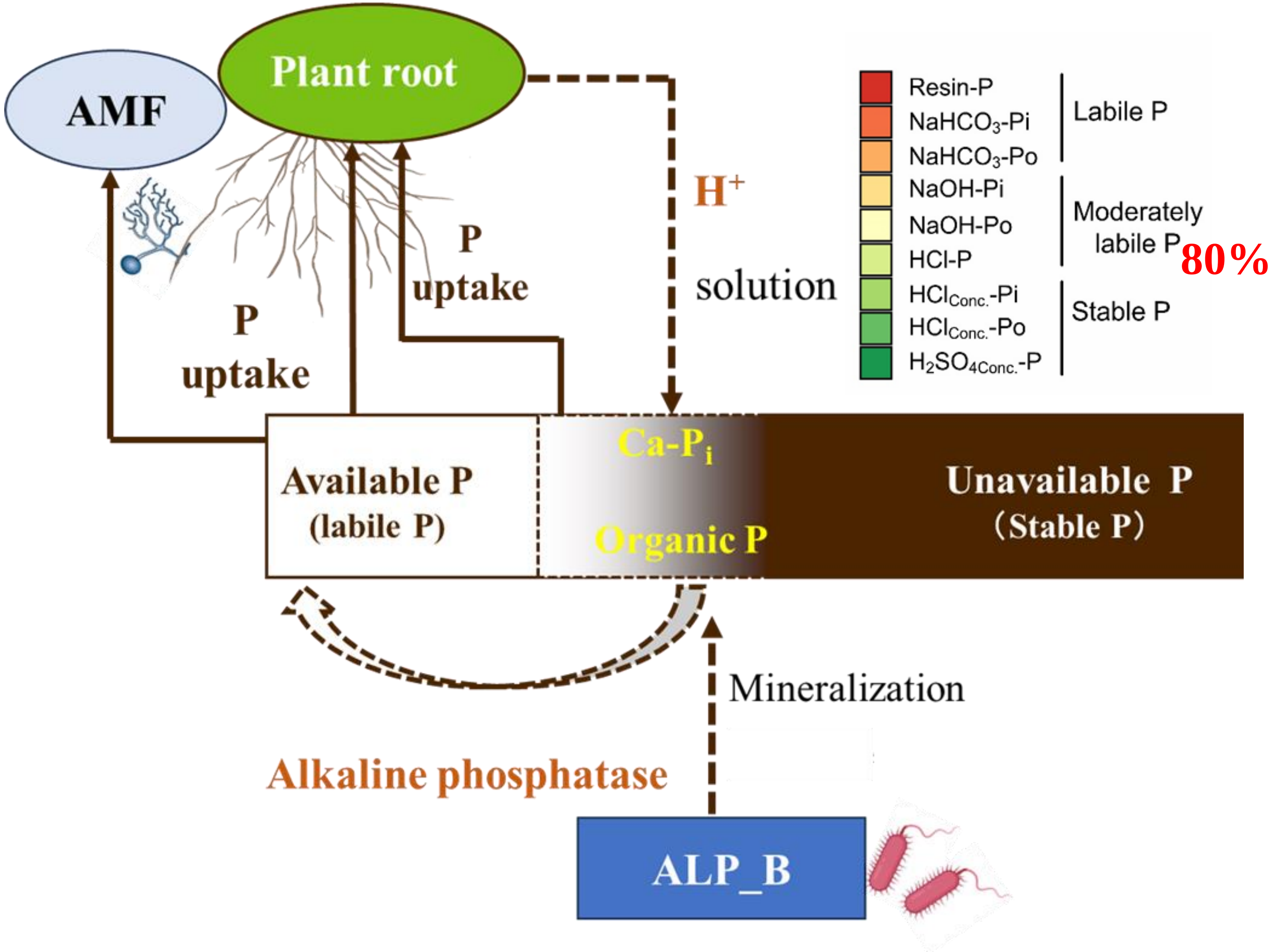


- Phosphorus is essential for growth of plants and soil biota in various environments , an important basic element in many physiological processes such as energy metabolism, photosynthesis and respiration in plants.

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

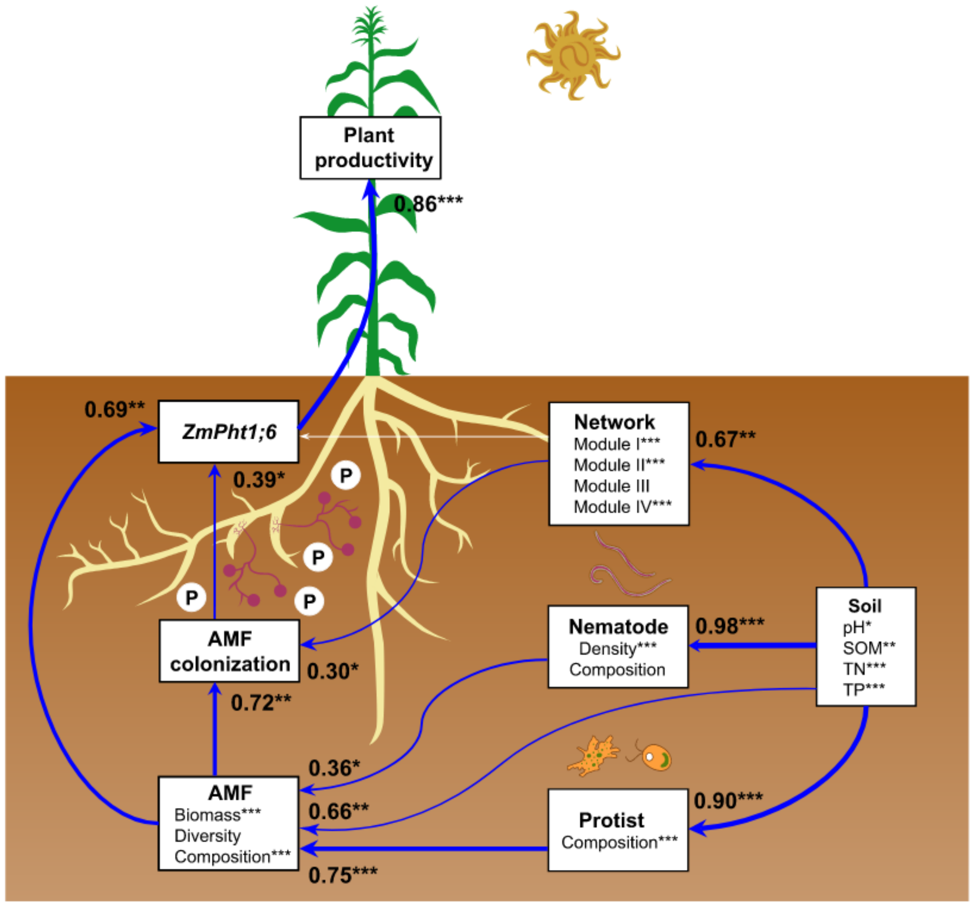
Lambers *et al*. 2008

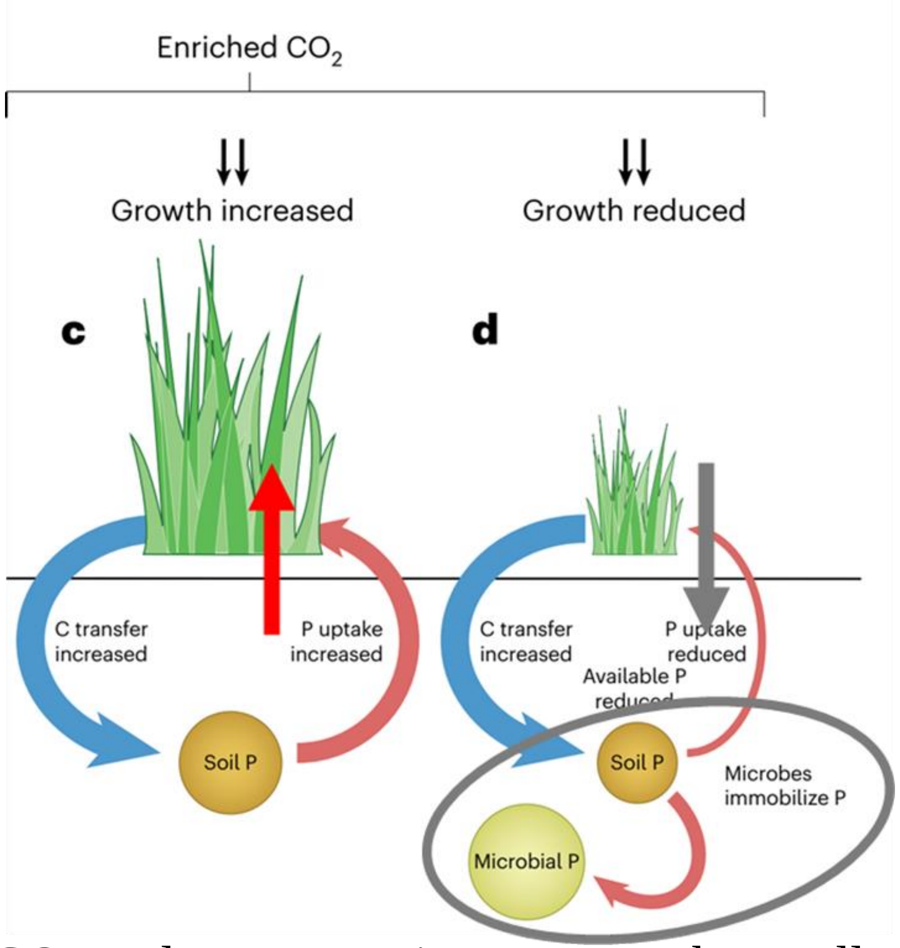
Background



- 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 eCO_2, 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 eCO_2 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 eCO_2?
- How and to what extent are protozoa and nematodes linked to their potential prey (ALP-producing bacteria and AMF community) under different CO_2 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° 8′ E, 40° 8′ N).

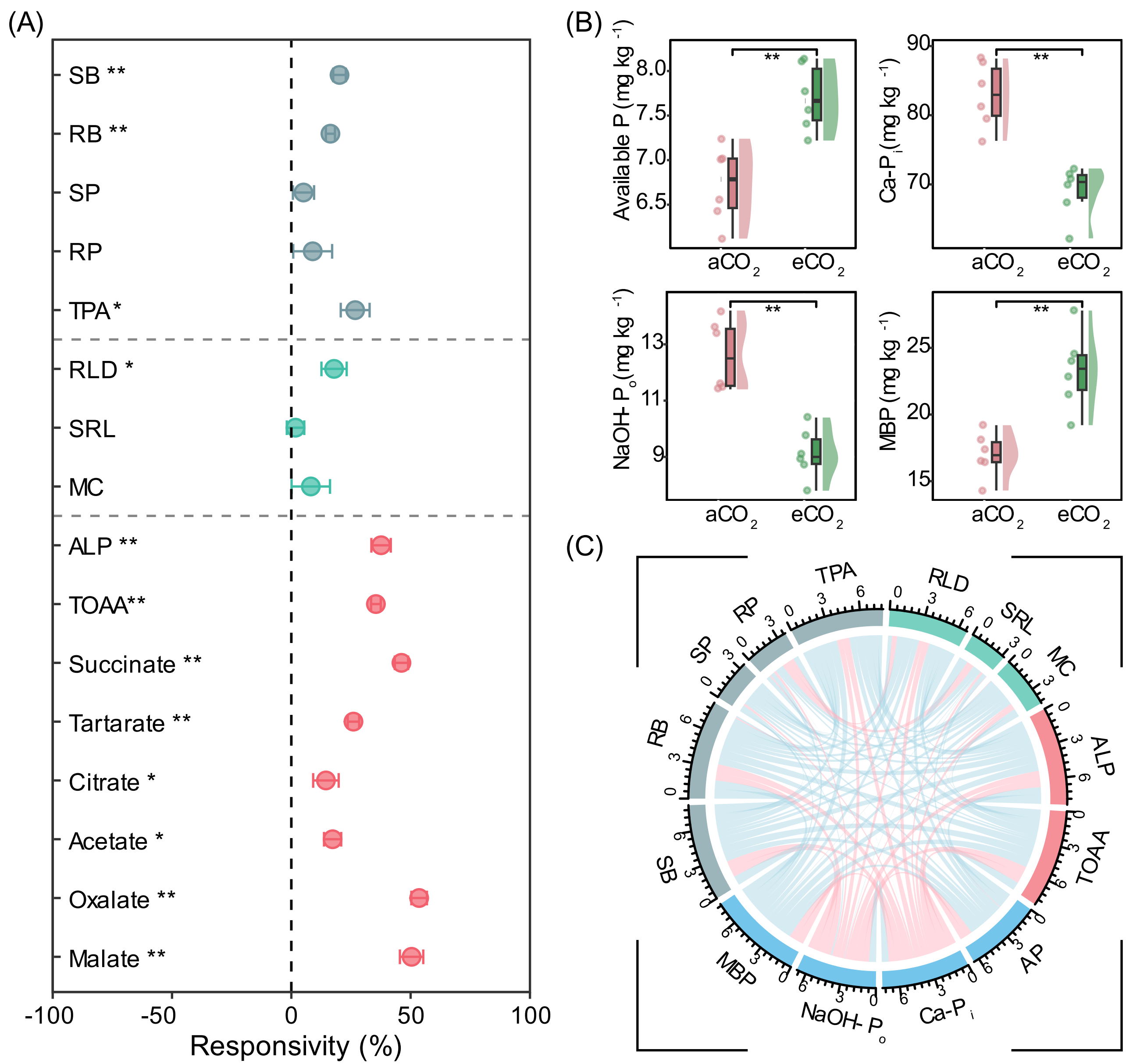
Experimental treatment:

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

Atmosphere CO_2 (**aCO_2**, 415±16μmol·mol^{-1})

Elevate CO_2 (**eCO_2**, 550±17μmol·mol^{-1})

Result

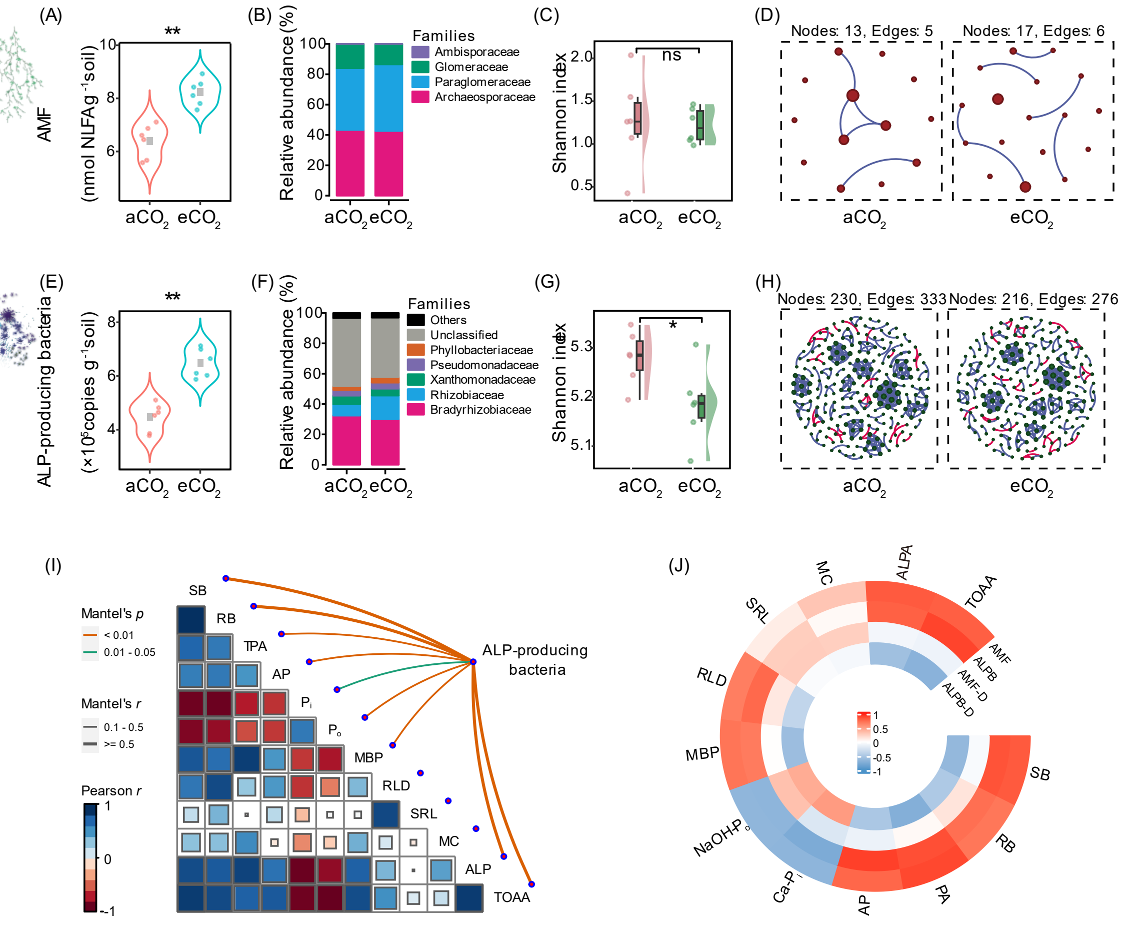


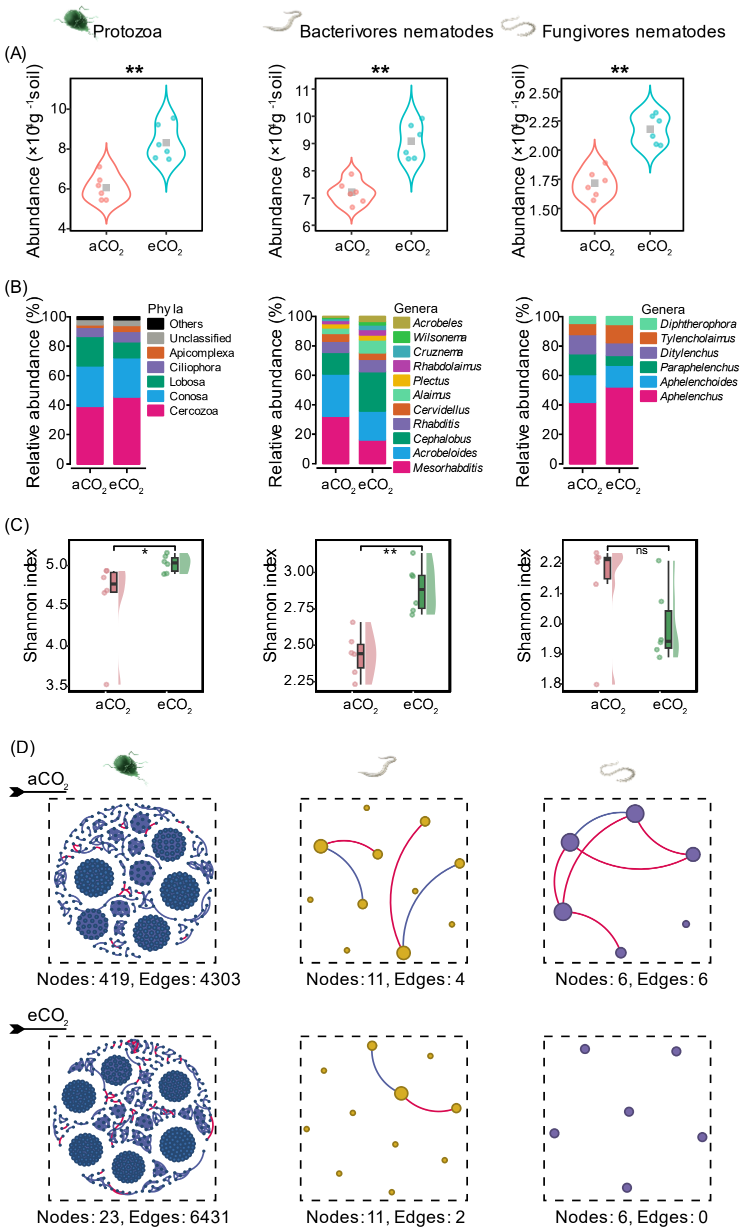
- eCO_2 significantly increased the shoot biomass, root biomass and total plant P accumulation.

- The eCO_2 promoted root length density, ALP activity and the release of organic acids.

- eCO_2 increased available P and decreased the $Ca\text{-}P_i$ fraction and $NaOH\text{-}P_o$.

Result





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

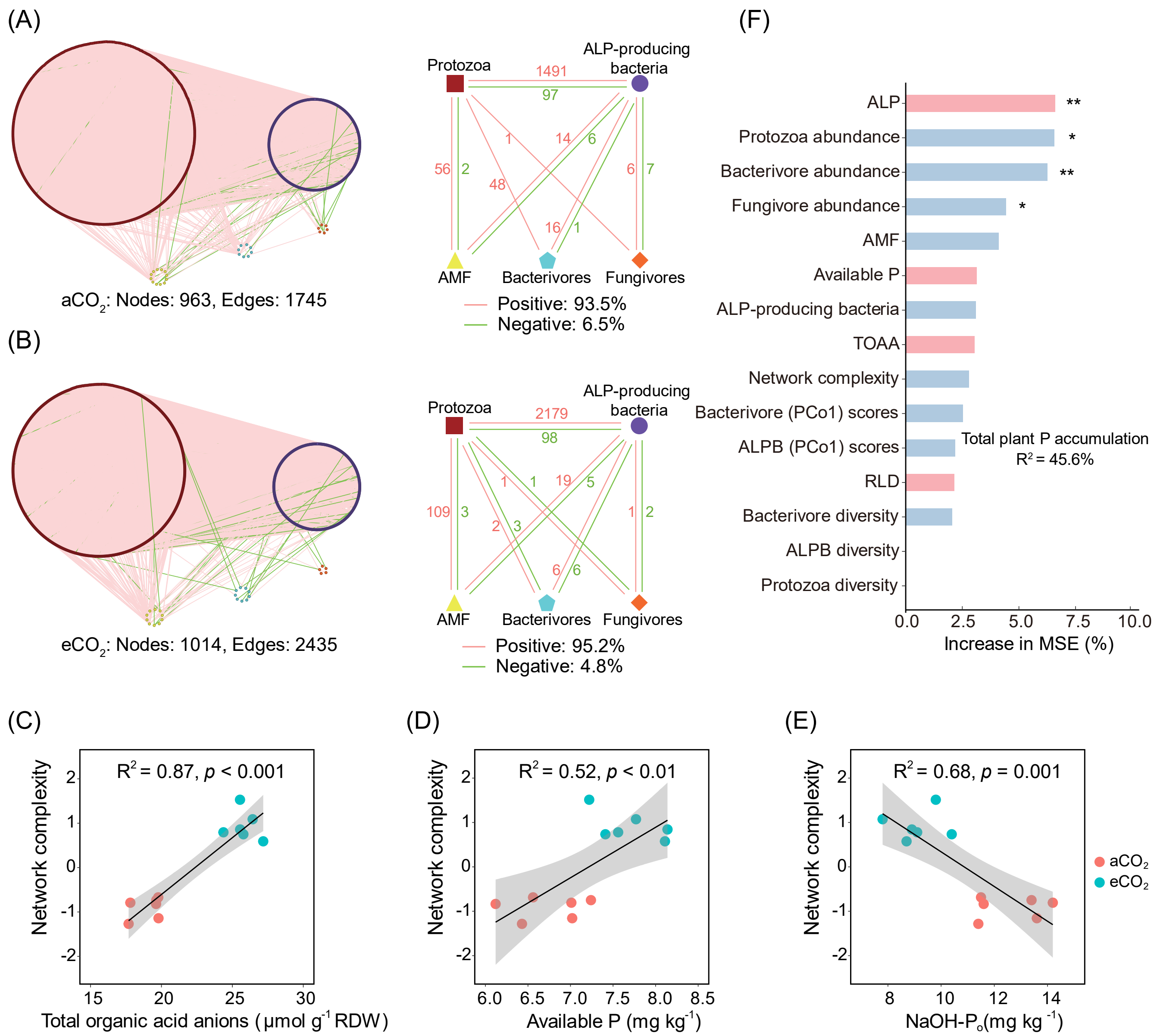
✓ The eCO_2 promoted the growth of root microbiome.

✓ eCO_2 promoted the abundance of ALP-B (Rhizobiaceae) and nematodes.

✓ The eCO_2 decreased the diversity of ALP-B, and increased the protozoa and bacterivorous nematode.

✓ eCO_2 reduced the network structure of AMF, ALP-B and nematodes, but enhanced the network structure of protozoa.

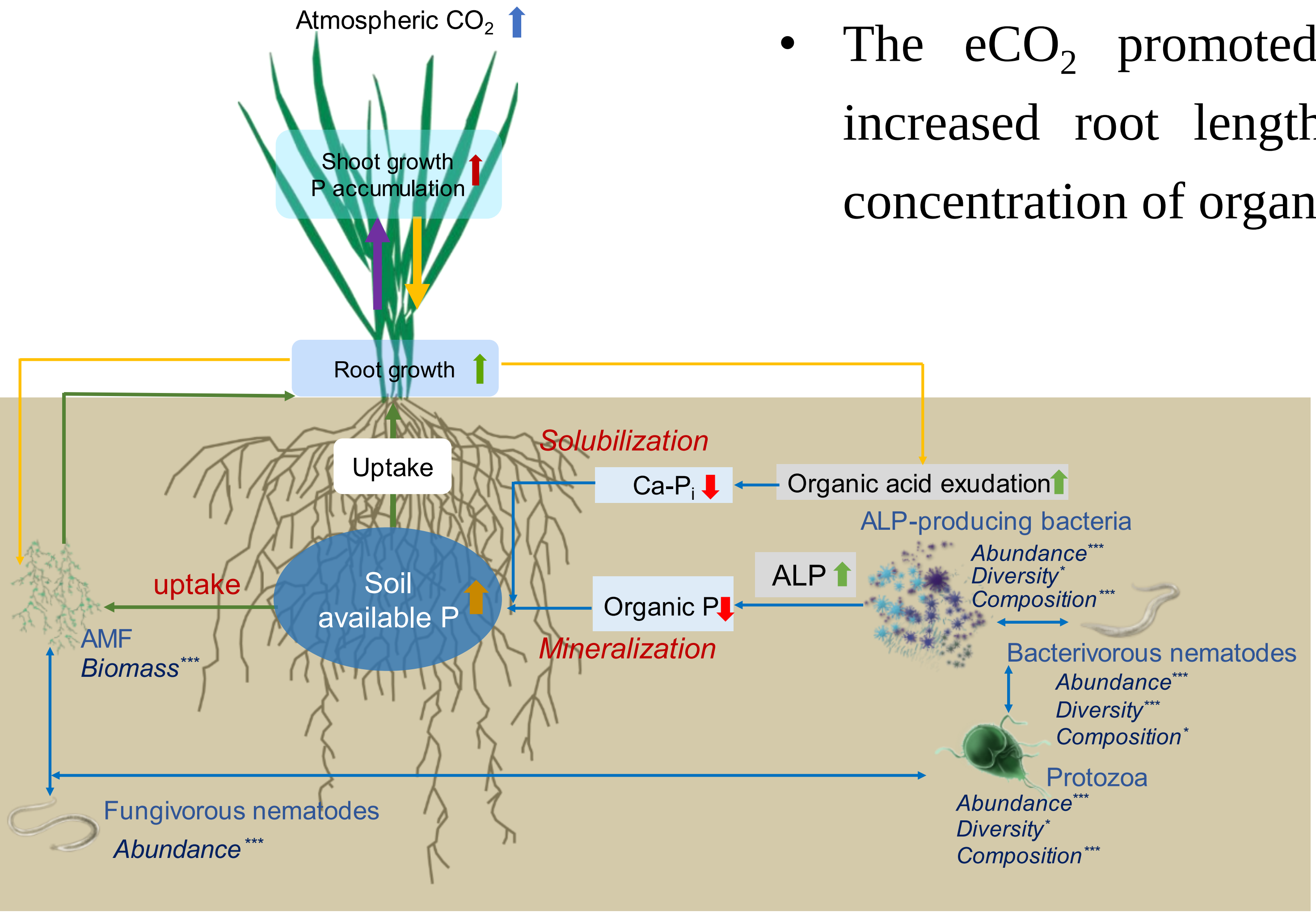
Result



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-P_o and the network complexity
- Wheat P accumulation was significantly influenced by ALP activity and microbial factors.

Conclusion



- The eCO_2 promoted wheat P accumulation through increased root length and AMF hyphal biomass, the concentration of organic acid anions and the ALP activity.

- The eCO_2 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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