Effect of phosphorus nutrition on growth and physiology of cotton grown under ambient and elevated atmospheric carbon dioxide concentrations

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Introduction

1. Phosphorous (P) deficiency in soil is a limiting growth factor in over 30% of crop lands, and a major production constraint in acidic soils comprising up to 70% worldwide.
2. In general, elevated CO_2 (eCO_2) stimulates cotton growth and photosynthesis, whereas phosphate (Pi) stress has an opposite effect.
3. However, the availability of soil nutrients such as Pi moderates plant response to rising atmospheric CO_2 concentration.
4. Moreover, eCO_2 may cause photosynthetic acclimation/down regulation due to physiological adjustment including dilution effect (low tissue nutrients, e.g. N) and reduced carboxylation efficiency (V_{Cmax}).
5. Therefore, nutrient availability will be critical to determine the magnitude and direction of plant response to CO_2 enriched environment.

Objective

❖ To determine the effect of Pi nutrition on growth and physiology of cotton grown under ambient and elevated CO_2.

Materials and Methods

1. Cotton (cv. DP 555) plants grown in six controlled environment chambers were maintained at a day/night temperature of 30/22 °C and 800 µmol m^{-2} s^{-1} photosynthetic photon flux density (PPFD, 14 h d^{-1}).
2. Plants were irrigated with full strength Hoagland's nutrient solution, except Pi concentration which, varied as 0.20, 0.05 and 0.01 mM at two levels of CO_2 [400, ambient (aCO_2); and 800, elevated (eCO_2) µmol mol^{-1}].
3. Treatments were initiated 34 days after planting (DAP).
4. Growth and photosynthetic rate (Pnet, at growth CO_2) were measured periodically, and V_{Cmax} (µmol CO_2 m^{-2} s^{-1}) was estimated using Pnet response to CO_2 curve.

Results

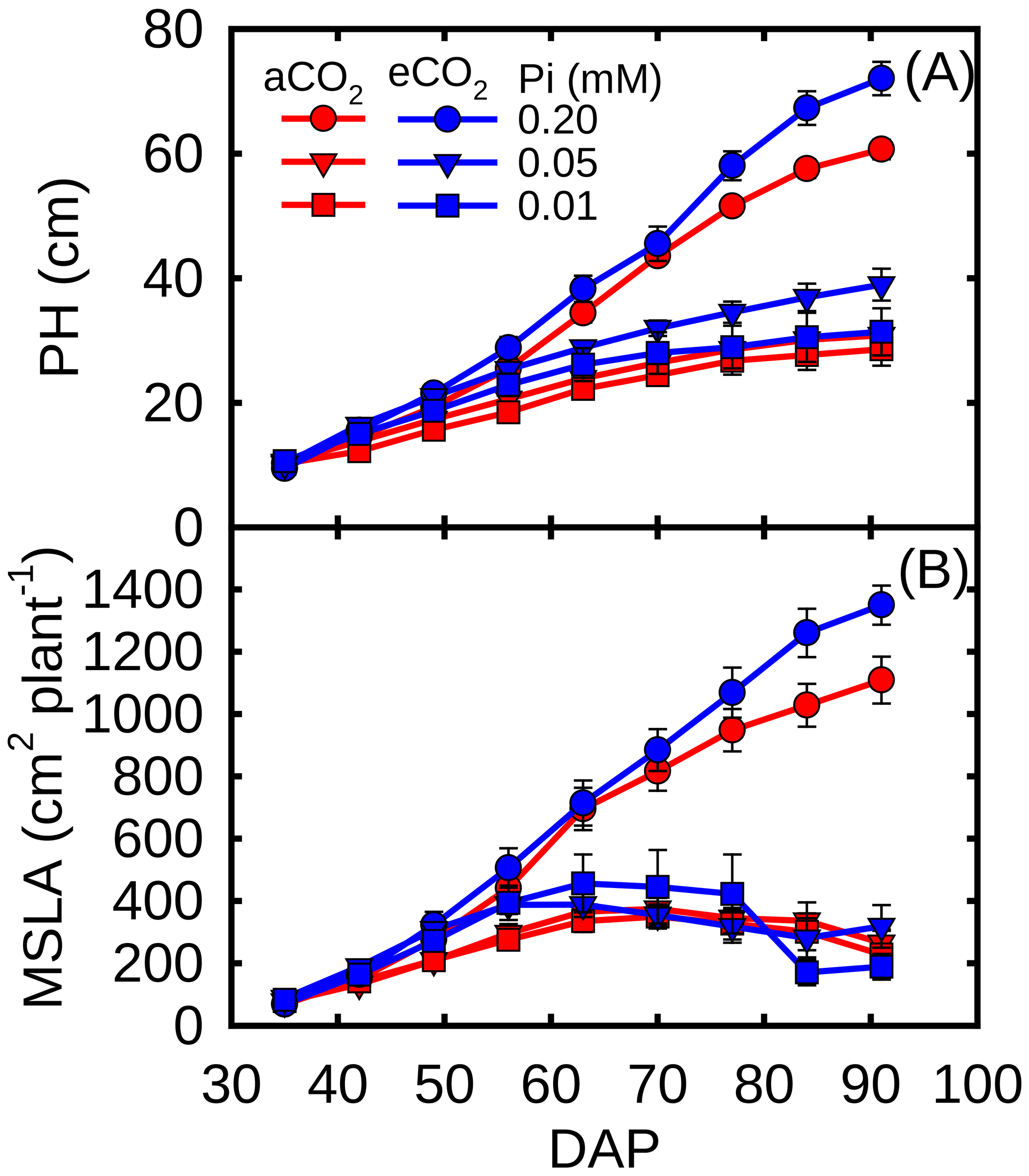

Fig. 1 . Days after planting (DAP) versus plant height (PH) and mainstem leaf area (MSLA) as affected by Pi supply and CO_2.

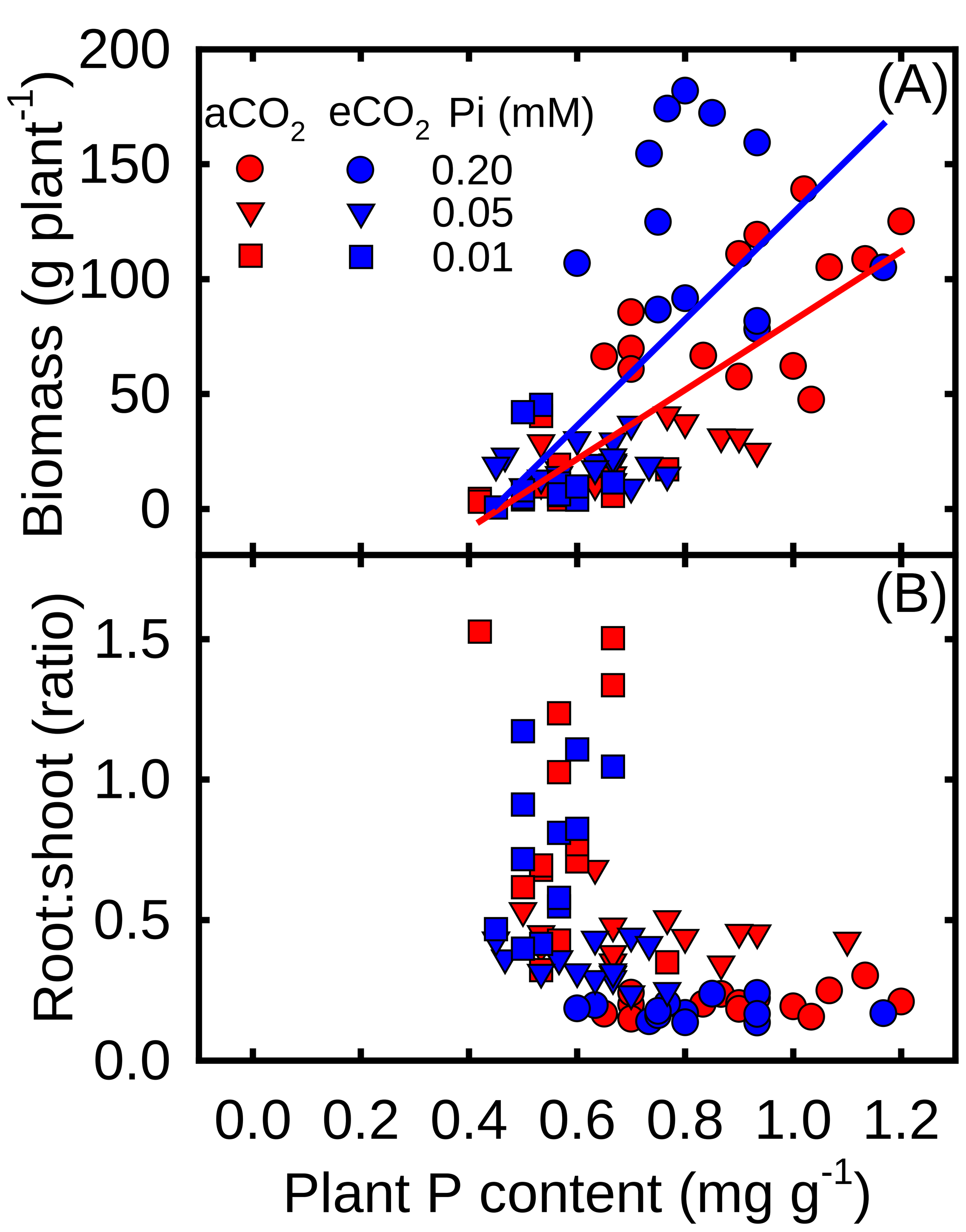

Fig. 2 . Plant tissue P content versus (A) biomass production and (B) root:shoot ratio of cotton plants as affected by Pi supply and CO_2.

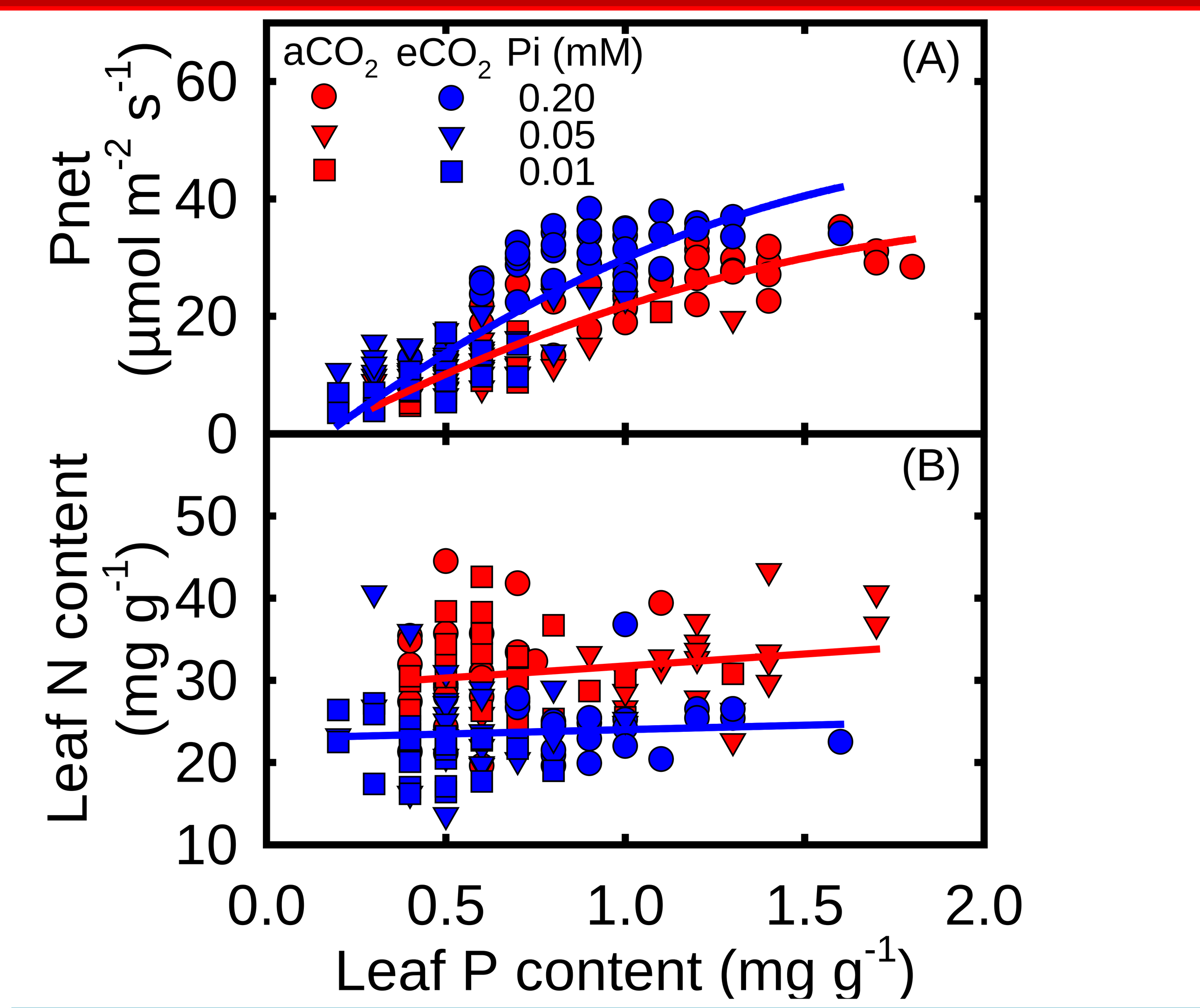

Fig. 3 . Leaf tissue P content versus (A) Pnet and (B) leaf tissue N content in top fully expanded leaves.

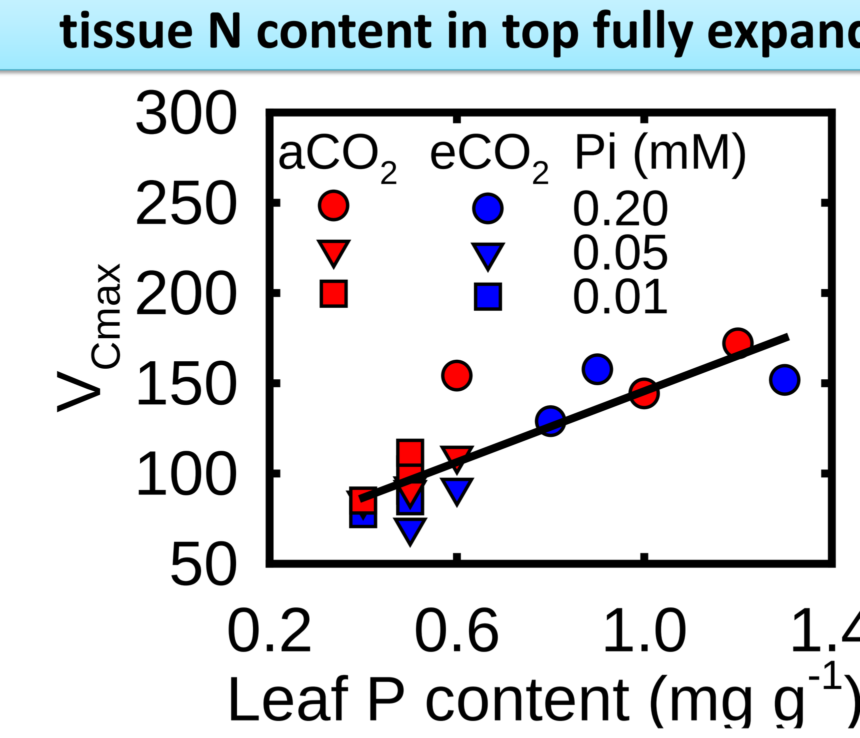

Fig. 4 . Leaf tissue P content versus carboxylation efficiency (V_{Cmax}) in top fully expanded leaves.

Conclusions

1. Elevated CO_2 stimulated growth and photosynthesis mainly at higher Pi supply.
2. Regardless of CO_2 levels, Pi-stress caused early leaf senescence.
3. Biomass increased with tissue P with greater extent at eCO_2 versus aCO_2.
4. Root:shoot ratio was not affected by CO_2 and increased as plant P content decreased.
5. Leaf N was lower at eCO_2 across Pi supply.
6. The irresponsiveness of V_{Cmax} to eCO_2 clearly suggested photosynthetic acclimation.
7. Regardless of Pi nutrition, the observed increase in biomass at eCO_2 was attributed to rapid growth and associated increase in total canopy photosynthesis.