Soybean Photosynthesis and Growth Responses to Temperature During Reproductive Stage under Elevated CO_2

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INTRODUCTION

- Soybean growth is more sensitive to high or low temperature stress especially during the reproductive stages.
- Due to the growth stimulation, elevated CO_2 (eCO_2) concentration might compensate the losses caused by temperature stress.
- However, the low or high temperature may exert distinct regulatory control upon the growth stimulation by eCO_2.
- Moreover, soybean acclimation to eCO_2 is commonly observed which might be driven by the processes that limit the photosynthetic capacity.

OBJECTIVE

➢ To evaluate the combined effect of temperature and CO_2 on photo-synthetic processes, carbohydrate metabolism and growth in soybean.

METHODS

1. Soybean (cv. NC-Roy) was grown in six controlled environmental growth chambers maintained at 12 h day/12 h night temperature of 28/24°C and half of the chambers assigned to either at ambient (400; **aCO_2**) or elevated CO_2 (800 µmol mol^{-1}; **eCO_2**) until flowering.
2. Thereafter, day/night temperature treatments of 28/24°C (**optimum temperature; OT**), and two temperature stress as 36/32°C (**high temperature; HT**) and 22/18°C (**low temperature; LT**) were initiated until maturity.
3. Growth, photosynthesis (*A*) responses to intercellular CO_2 concentration (A/C_i) and photosynthetically active radiation (A/PAR), and carbohydrate fractions were measured between 45 and 50 days after planting.

RESULTS

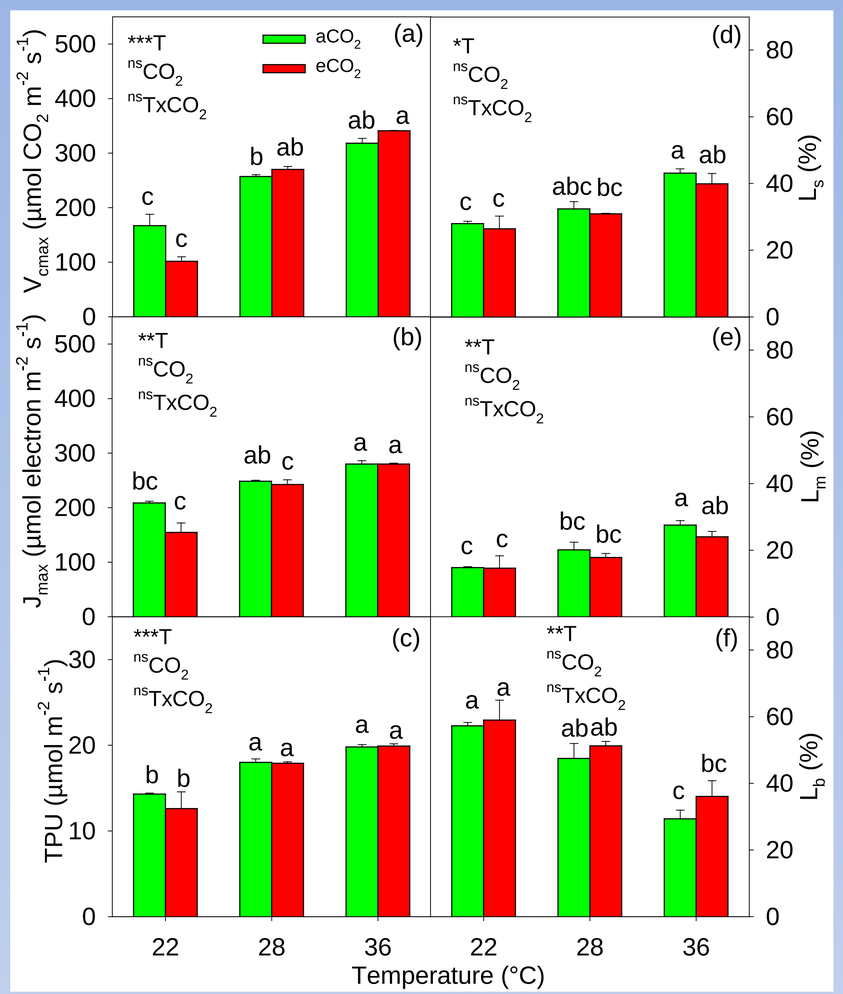

Fig.1 Effect of temperature on maximum rate of carboxylation (V_{Cmax}, a) and electron transport (J_{max}, b), triose phosphate utilization (TPU, c), and stomatal (L_s, d), mesophyll (L_m, e) and photo-biochemical (L_b, f) limitations to photosynthesis in soybean grown under aCO_2 and eCO_2.

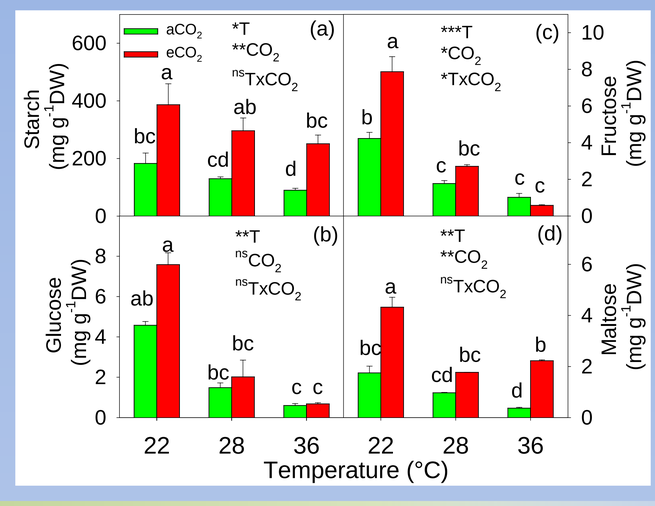

Fig.2 Effect of temperature on leaf starch (a), glucose (b) fructose (c), and maltose (d) concentrations of soybean under aCO_2 and eCO_2.

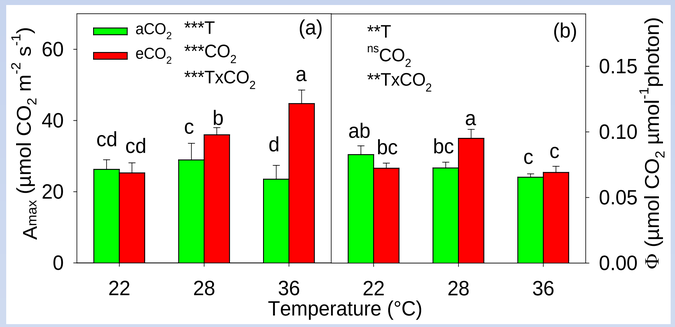

Fig.3 Effect of temperature on light saturated maximum rate of CO_2 assimilation (A_{max}, a) and maximum apparent quantum efficiency (Φ, b) of soybean under aCO_2 and eCO_2.

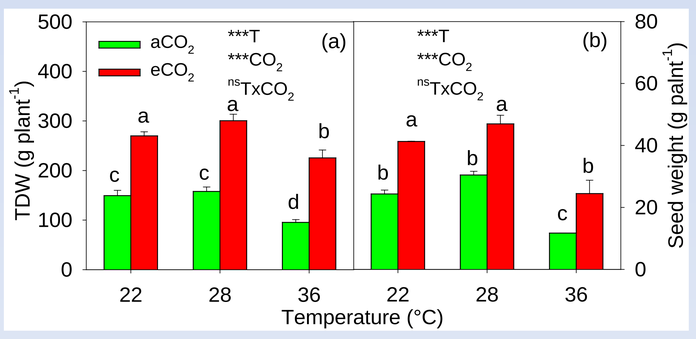

Fig.4 Effect of temperature on total dry weight (TDW, a) and seed weight (b) of soybean under aCO_2 and eCO_2 at maturity.

DISCUSSION AND CONCLUSIONS

1. Acclimation of soybean to eCO_2 was evident from it's insignificant effect on the key biochemical parameters of A/C_i curve (V_{Cmax}, J_{max} and TPU) and on the photosynthetic limitations (L_s, L_m and L_b) (**Fig.1**).
2. This might be due to the restricted utilization of the photosynthetic products as deduced from the accumulation of starch and carbohydrate fractions, glucose, fructose and maltose at eCO_2 (**Fig. 2**).
3. The V_{Cmax}, J_{max}, TPU, L_s and L_m showed an increasing pattern as temperature increased but L_b along with the starch and other carbohydrate fractions exhibited an opposite response suggesting the role of slower metabolic processes at LT and OT to inhibit photosynthetic capacity due to higher photo-biochemical limitations (**Fig.1 &2**).
4. The L_b was the main factor limiting A at LT and OT across CO_2. However, L_s contributed the most at HT.
5. The eCO_2 increased A_{max} and Φ, especially at OT and HT showing direct effect of eCO_2 on A (**Fig. 3**).
6. Despite the acclimation of A at eCO_2, the biomass and seed production increased substantially across temperature. This might be attributed to the overall increased growth, A_{max}, leaf area and canopy photosynthesis (**Fig. 4**).
7. Elevated CO_2, also compensated the decreased biomass and seed production caused by LT or HT at aCO_2. However, this compensation was more for biomass than seed production.
8. Thus, despite the stimulation of photosynthetic processes at HT, soybean biomass and seed production decreased at high temperature.
9. Moreover, the HT of 36°C appeared to be more detrimental to soybean than LT of 22°C as compared to OT of 28°C.