Yield, Fruit Quality and Plant Nutrition of Tomatoes Subjected to Elevated Carbon Dioxide

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INTRODUCTION

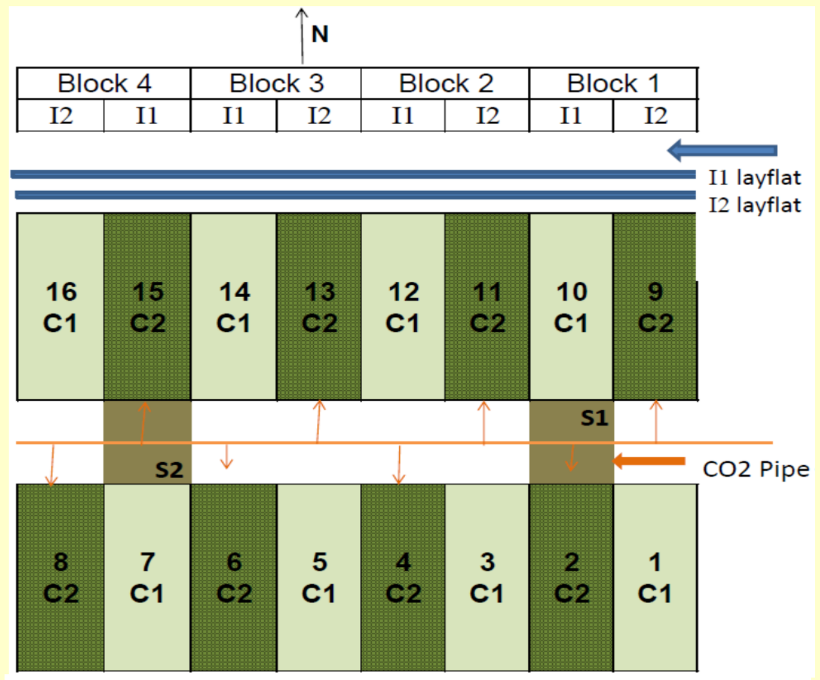
- Agricultural and industrial practices have increased anthropogenic carbon dioxide (CO_2) in the atmosphere leading to global climate change.
- However, this increase could be beneficial for plant growth as CO_2 can be sequestered by plant as a part of the biological carbon cycle.
- Plants combine CO_2 with water (H_2O) and light energy to produce carbon organic compounds and oxygen through the process of photosynthesis.
- Numerous studies have shown that elevated CO_2 levels enhances C_3 crop growth and yields (Kimball, 1983).
- Ewert et al. (2002) also showed that the effect of CO_2 enrichment on crops varies under different soil moisture regimes.
- Thus, it is important to consider the combined effects of varying CO_2 concentrations and water application rates when evaluating the impact of elevated CO_2 on crop production.

OBJECTIVE

- Overall goal: To evaluate the agronomic and environmental benefits of open-field CO_2 canopy enhancement on tomato productivity and water use efficiency.
- This Phase: To assess the effects of two CO_2 and water application levels on tomato yield, fruit quality and plant nutrient content.

Fig. 1. Open-top chambers with CO_2 delivery system

MATERIALS & METHODS



Treatments	Water	CO_2
I1 - C1	100% ET	Ambient
I1 - C2	100% ET	Elevated
I2 - C1	80% ET	Ambient
I2 - C2	80% ET	Elevated

Fig. 2. Plot layout and treatments

Study Description:

- Location: California State University, Fresno Farm
- Crop: Fresh-market tomatoes

Experimental Design:

- Split-plot design consisting of two irrigation regimes (main factor) and two CO_2 rates (secondary factor). Each treatment was replicated four times which resulted in 16 plots (Fig.2).
- Irrigation regimes consisted of water applications at 100% and 80% ET calculated based on CIMIS data.
- CO_2 application rates included ambient (380 ppm) and elevated (600 ppm) enrichment of crop canopy.

Field setup:

- To prevent CO_2 contamination from one treatment to the next, open-top chambers were built for each plot and installed as shown in Fig. 1.

Irrigation and CO_2 application:

- Water was applied daily through a subsurface drip irrigation system.
- In the enriched CO_2 chambers, carbon dioxide was applied daily through separate PVC lines from 8 AM to 4 PM and monitored with a gas analyzer (Fig. 1).

Data Measurements and Analyses:

- Plant: Leaf N, P and K content at DAT = 68 and after harvest.
- Fruit: Yield (Total, Red, Breakers, Green, Blossom End Rot) and Brix at harvest (DAT=92).
- All measurements were taken within open-top chambers.
- Statistical analyses (ANOVA) were conducted on above parameters using SPSS software.

RESULTS

- There was no significant difference ($\alpha \leq 0.10$) in yields of red and green tomatoes, and in incidence of blossom end rot. However, CO_2 and irrigation rate had a significant effect ($\alpha \leq 0.10$) on yield of breaker tomatoes, with greatest amount of breakers occurring within plots subjected to elevated CO_2 and 100% ET (Fig. 3).
- Elevated CO_2 did not have any significant effect on tomato Brix indices. However, Brix levels were greater under the 80% ET irrigation treatment (Fig.4).

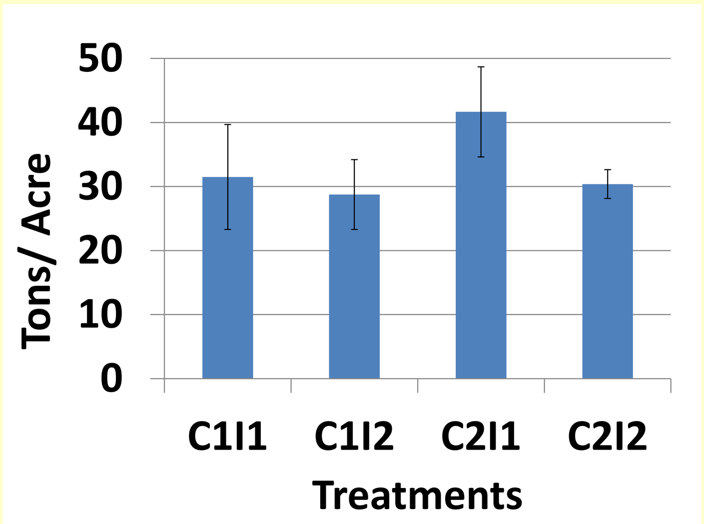


Fig.3. Mean yield of breaker tomatoes

Table.1. Total tomato yield

Treatments	Ton/Acre
C1I1	31.49
C1I2	28.74
C2I1	41.66
C2I2	30.38

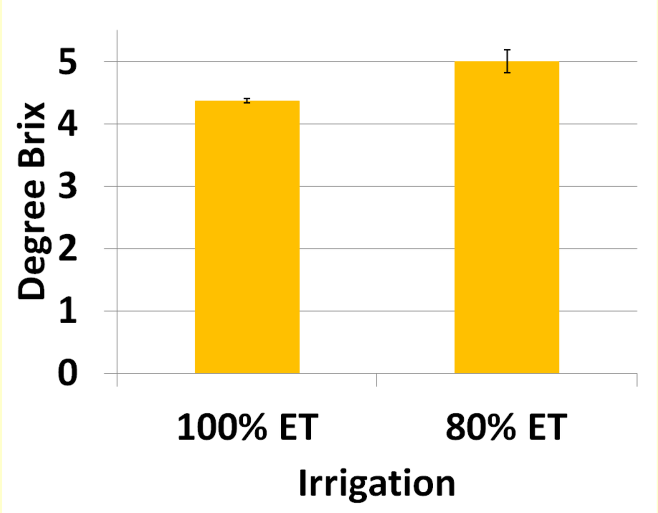


Fig.4. Brix of tomato fruit

RESULTS CONT'D

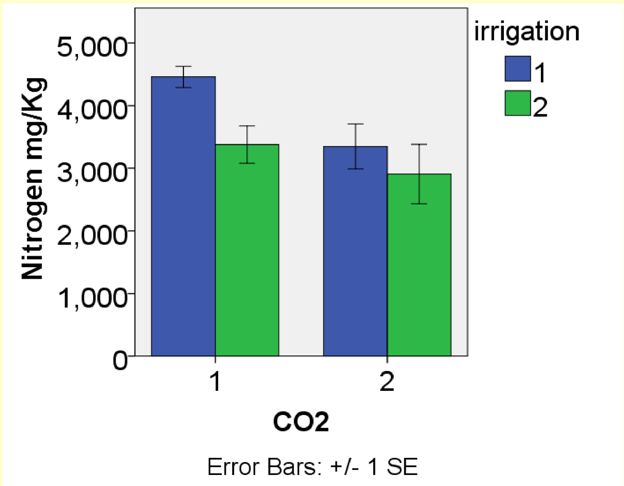


Fig.5. Leaf N content at DAT=68

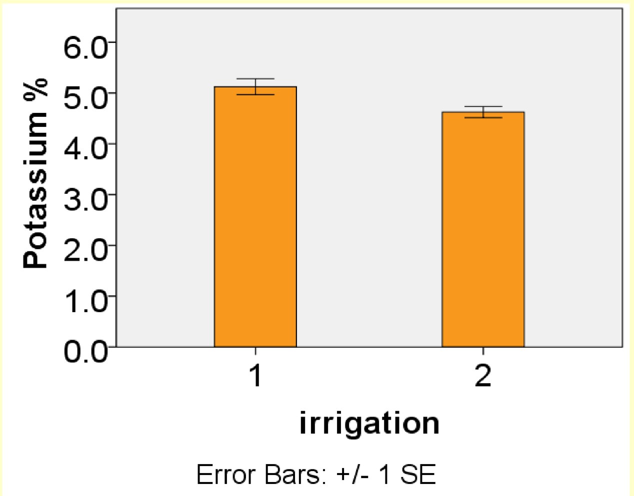


Fig.6. Leaf K content at DAT=68

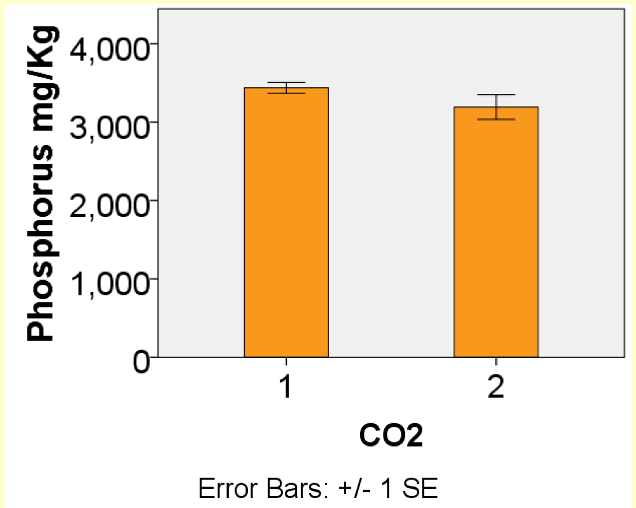


Fig.7. Leaf P content at DAT=68

- CO_2 and irrigation treatments had a significant effect on leaf N, P and K content at DAT=68 when plants were at fruiting stage.
- Leaf N was significantly greater for plants subjected to ambient CO_2 and 100% ET (Fig. 5).
- Leaf K was significantly higher for plants grown in 100% ET plots (Fig. 6).
- Elevated CO_2 significantly reduced leaf P content (Fig. 7).
- There was no significant difference in leaf N, P, and K content at end of season.

Figs.8. Tomato harvest

CONCLUSIONS

- In this study, no differences were observed among the four treatments in total yield and amount of red tomatoes but there was a significant difference in the number of breakers.
- CO_2 and irrigation treatments affected leaf nutrient status when plants were at fruiting stage.
- These results are a major contribution to the overall goal of our ongoing research aimed at evaluating productivity, quality and water use efficiency for vegetable crops subjected to elevated CO_2 levels.

References:

- Ewert, F., et al., 2002. Effects of elevated CO_2 and drought on wheat: testing crop simulation models for different experimental and climatic conditions. Agric. Ecosyst. Environ. 93,249-266.
- Kimball, B.A., 1983. Carbon dioxide and agricultural yield: an assemblage and analysis of 430 prior observations. Agron. J.75, 779-788.

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