Charting the Differences in Plant Growth between Gardens in the Open and Under Solar Panels

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Context

Amidst status quo land use planning that pits solar energy production and farming against one another, we hypothesize that collocating the systems in dryland areas may benefit both the solar panels and the plants growing beneath them. Building on previous research, **this project focuses on the differences in rates of photosynthesis and transpiration between plants grown in the open and under the solar panels**.

Terms & Metrics

Photosynthesis

An energy producing plant process that uses stomata (leaf pores) to pull carbon from the atmosphere, measured here as Daily Carbon Uptake in grams of CO_2 per day.

Transpiration

A plant hydration process that involves evaporation of water from saturated leaves into the dry atmosphere through stomata, measured in grams of H_20 per day. Air temperature and humidity affect the rate of evaporation that occurs during transpiration.

Water Use Efficiency (WUE)

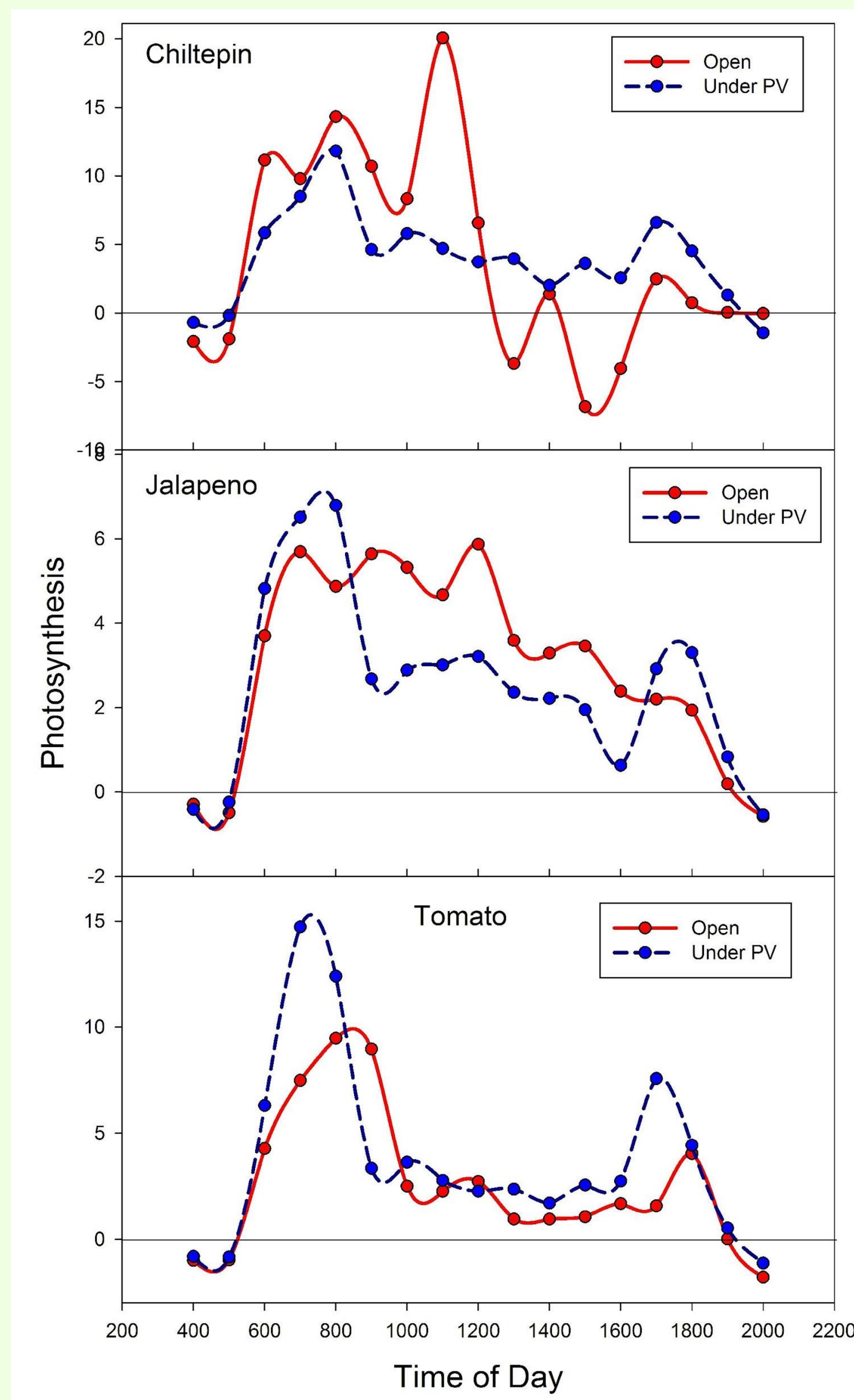
A metric used to compare plants across treatments, chosen because of the scarcity of water in the desert, calculated as photosynthesis rate / transpiration rate.

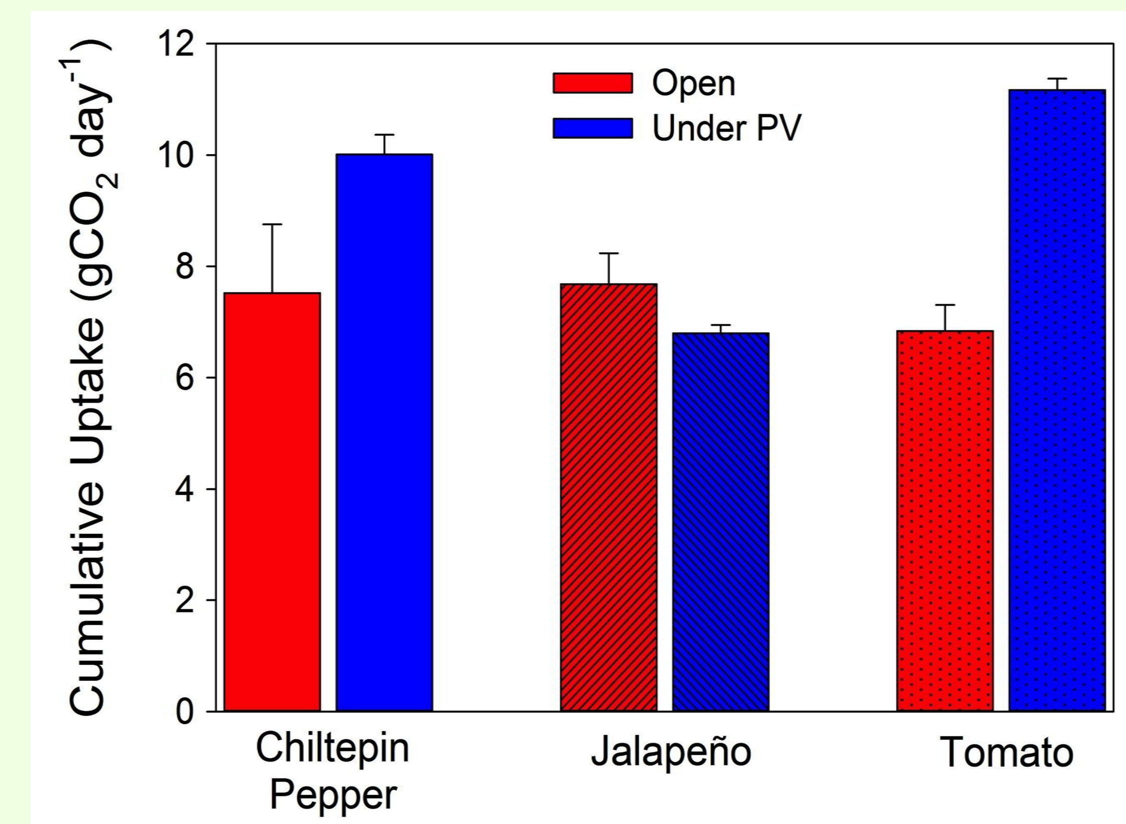
Limiting Factors of Photosynthesis

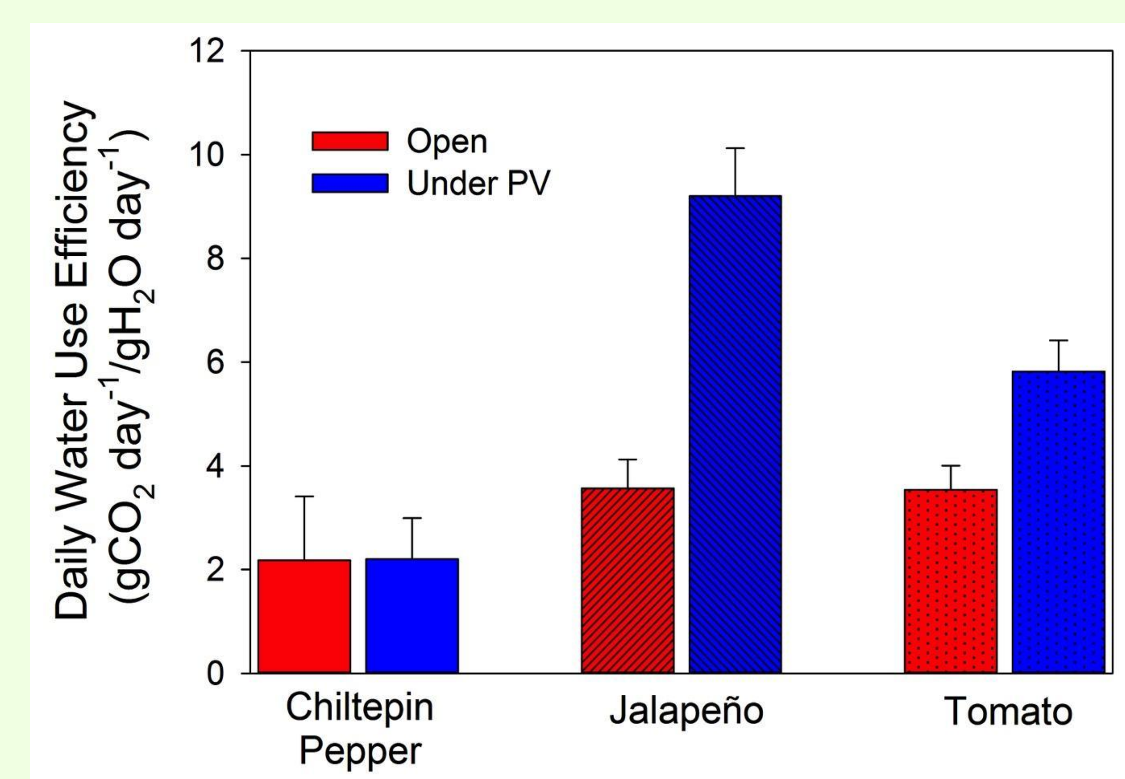
Temperature, Light, and CO_2 concentration. Temperature is a limiter in a fashion such that reaching the lower or upper limit results in photosynthetic shutdown. Here the upper temperature limit, where leaves close their stomata because the loss of water outweighs the gains of carbon, is at play.

Methods

We used LI-6400XT portable photosynthesis machines to measure the rates of photosynthesis and transpiration of 15 plants (5 chiltepins, 5 jalapeños, and 5 tomatoes) **in each treatment** (in the open and under solar panels) **throughout the day** (5 measurements on the hour from 4 AM to 8 PM). The measurements went through a process of averaging, charting, and summing to determine hourly trends and daily cumulative rates of the processes for each plant variety in both treatments.



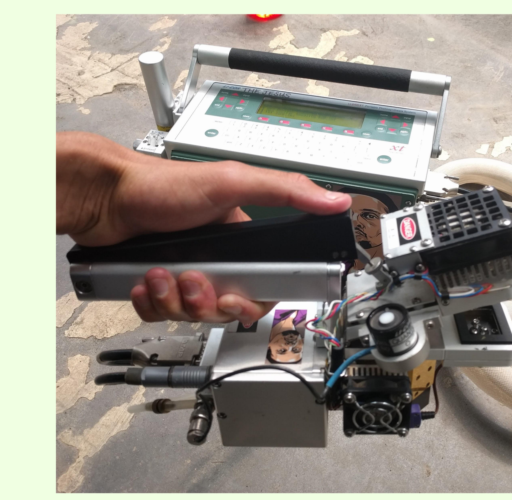




Left: Rates of photosynthesis in each plant throughout the day; Right: Cumulative daily rates of photosynthesis and water use efficiency in each plant.

Left: Garden beds under solar panels behind gardens in the open.

Right: LI-6400XT, the tool we used to measure rates of photosynthesis and transpiration.



Findings

Daily Cumulative Carbon Uptake

The chiltepin and tomato plants were greater under solar panels (by 33% and 65%), while the jalapeño plants were 11% greater in the open.

Daily Water Use Efficiency

The jalapeño and tomato plants were greater under solar panels (by 157% and 65%), while the chiltepin plants were equal across treatments. The rate of transpiration in the jalapeño plants was 65% less under solar panels, explaining the significant difference in WUE.

Conclusions

For the right plants, being grown under solar panels shows impressive **water savings while maintaining similar of photosynthesis**, an indicator of plant growth. This study pairs with the industry knowledge the underlying vegetation reduces drops in solar energy production efficiency as temperature increases. Termed "**agrivoltaics**" (agriculture + photovoltaics), the new ecosystem studied here is **a viable water-saving energy and food production method**. Further research may address the practicality of other plant species, benefits of working in the shade, or trade-offs in other climates.

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