Soil and Plant Gas Exchange in Relation to Tree Canopies in a Restored Walnut Woodland

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Abstract

Southern California black walnut (*Juglands californica*) trees produce juglone, an allelochemical, which occurs in all members of the Juglandaceae and can be toxic to certain plants and microbes. To determine how walnuts affected soil and native landscaping plants, gas exchange was measured under the canopy, at the dripline, and in the open spaces between the canopies of walnuts. For the Southern California native species *Frangula californica, Heteromeles arbutifolia, and Salvia apiana,* photosynthesis, stomatal conductance, and chlorophyll fluorescence were measured fall 2018-winter 2019. Over the same period, soil CO_2 efflux (respiration) and temperature were also measured. The hypothesis was that juglone negatively affects plant and soil gas exchange under the canopy the most, followed by the dripline and open spaces. Gas exchange for plants at the canopy and dripline differed from those in the open. Under canopies, gas exchange did not differ among species, but there were differences at the dripline and in the open. Soil respiration at the dripline and canopy were higher than in the open, where the soil was drier. Soil respiration at the dripline and soil temperature also differed with time. Thus, *J. californica* coverage influences both plant and soil gas exchange but not necessarily negatively.

Introduction

Juglans californica is the most prominent tree at Cal Poly Pomona and the dominant species in Southern California walnut woodlands. It produces a chemical called juglone which can prevent establishment and limit plant growth of certain species (Schmidt 1988; Jose and Gillespie 1998). The purpose of this study is to determine how proximity to *Juglans californica* affects the physiology of native plants and soil biota.

Hypothesis

The gas exchange of native plants and soil biota will be most affected by juglone underneath the canopy of *Juglans californica* followed by the dripline and the open areas.

Materials & Methods

The experiment was performed in the walnut woodland at the Lyle Center for Regenerative Studies at Cal Poly Pomona. Gas exchange for the following three native shrub species was measured under the canopy, at the drip line, and in the open space between walnut trees using a LI-COR 6800 photosynthesis machine: *Frangula californica*, *Heteromeles arbutifolia*, and *Salvia apiana*. Four individuals of each species were measured at each location in the walnut woodland. Soil respiration and temperature were also measured under the canopy, at the dripline, and in the open (N=4) using a LI-COR 6400 with a soil respiration chamber. Soil respiration and temperature were measured in September and November 2018 and plant gas exchange was measured in October 2018. F_v/F_M was measured using an Opti-Sciences modulated chlorophyll fluorometer (F_v/F_M meter) in October 2018.

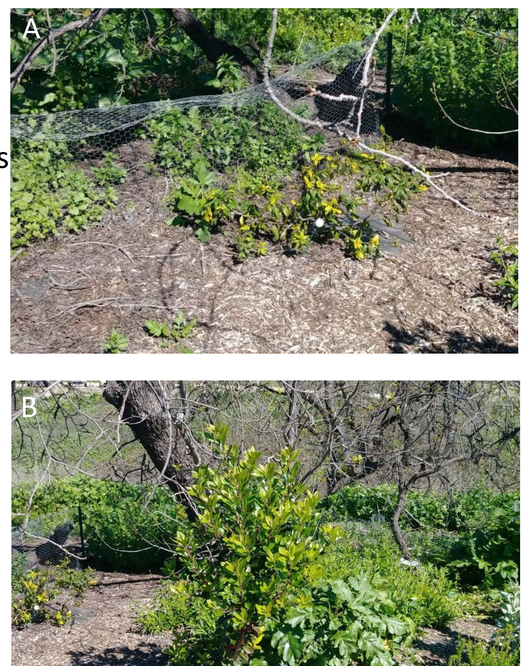


Fig. 1 *Frangula californica* (A) *Heteromeles arbutifolia* (B) *Salvia apiana* (C) at the dripline of *Juglans californica* in a restored walnut woodland at the Lyle Center for Regenerative Studies.

Fig. 2 Picture showing all 3 treatments (open, dripline, canopy) at the walnut woodland.

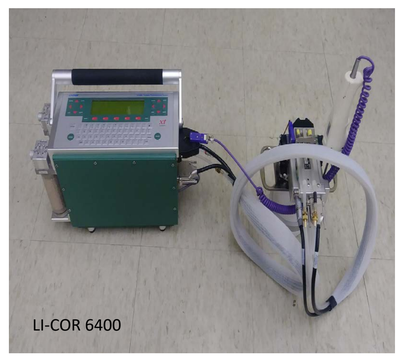
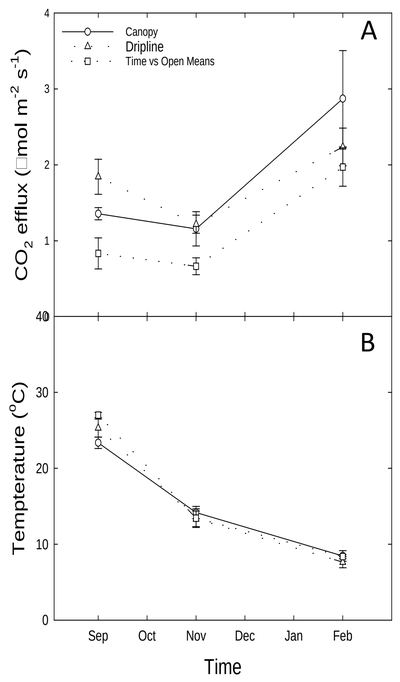


Fig. 3 CO_2 efflux (A) and temperature (B) for soil under the canopy, at the dripline, and in the open areas between *J. californica* trees in a walnut woodland.



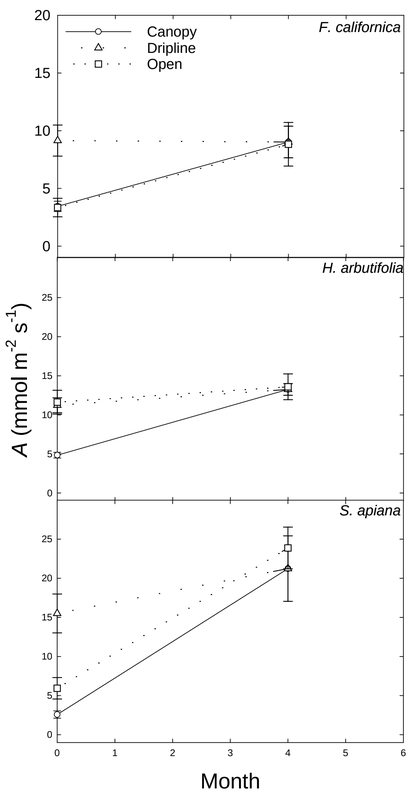


Fig. 4 Photosynthesis or (*A*) *F. californica*, *H. arbutifolia*, and *S.apiana* at each canopy position in the walnut woodland.

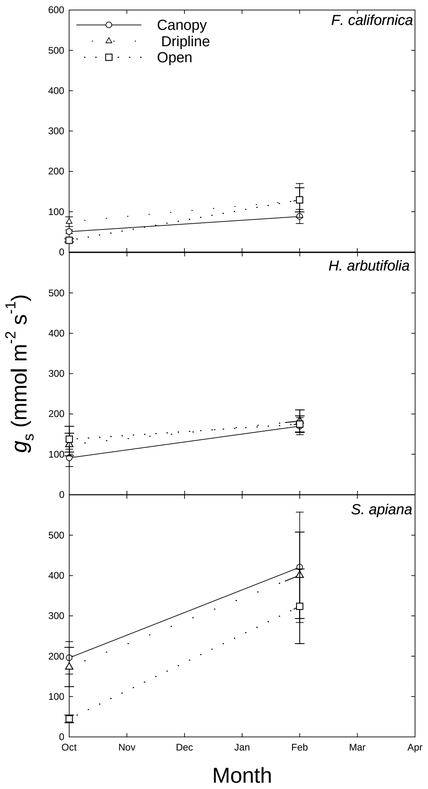


Fig. 5 Stomatal conductance (g_s) for *F. californica*, *H. arbutifolia*, and *S.apiana* at each canopy position in the walnut woodland.

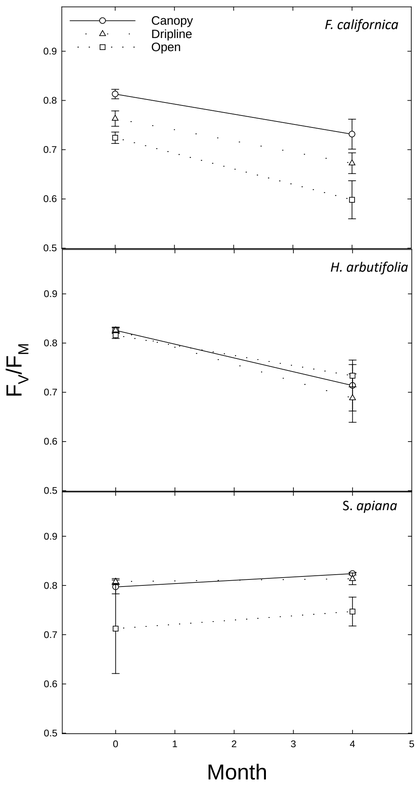


Fig. 6 F_V/F_M for *F. californica*, *H. arbutifolia*, and *S.apiana* at each canopy position in the walnut woodland.

Results

- Soil respiration was lowest in September and November and increased almost twice as much in February after the winter rains for all locations.
- Soil temperature was highest in September and decreased by approximately 15 °C by February.
- Photosynthesis was lowest in the canopy for all of the species. *Heteromeles arbutifolia* had its highest photosynthesis in the open, whereas photosynthesis was highest for the other two species at the dripline.
- Stomatal conductance was lowest for *Salvia apiana* and *F. californica* in the open. Stomatal conductance for *H. arbutifolia* did not differ with exposure.
- F_v/F_M decreased over time with each exposure over time for *F. californica* and *H. arbutifolia*. It increased over time for *S. apiana*.

Conclusions

- Open areas had lower respiration rates because of decreased amount of microorganisms and roots in the soil, as well as much drier soil.
- Soil respiration increased after rainfall. It appears that soil respiration is more dependent on water availability than temperature based on the measurements in February after the winter rains.
- All three species responded differently in the different locations. *Salvia apiana* had the lowest photosynthetic rate under the canopy due to low light. They usually occur in open spaces. All species did well at the dripline. Only *H. arbutifolia* had high photosynthetic rates in the open.
- Stomatal conductance showed similar patterns as photosynthetic rates except for *S. apiana*.
- *H. arbutifolia* was the only species whose F_v/F_M was not affected by canopy position.
- The F_v/F_M of *S. apiana* and *F. californica* was affected by position.
- *H. arbutifolia* performs the best in all three canopy positions