Investigating allelopathy and soil moisture as factors determining community composition of a Southern California black walnut woodland

Jose M. V. Marfori[1] and Erin J. Questad[1]

[1]Biological Science Department, California State Polytechnic University, Pomona

jvmarfori@cpp.edu

INTRODUCTION

Allelopathy

- Allelopathy is the chemical inhibition of one plant by another.
- *Juglans californica* is a Southern California endemic tree that is known to produce the allelochemical juglone. Juglone's effect on walnut understories has been studied for *J. nigra*[1] but only recently for *J. californica*.
- *Brassica nigra* produces the allelochemical allyl isothiocyanate and it is a common species in our walnut woodland.
- Despite allelopathy from both *J. californica* and *B. nigra*, invasive annuals dominate inside and outside the understory of the walnut woodland.

Soil Moisture

- Tree canopies reduce water loss from the soil through shading and litter accumulation[2].
- Since *J. californica* is a winter-deciduous tree, the relative importance of reducing soil water loss and allelopathy in the understory may be seasonal. In the understory of *J. regia*, concentrations of soil juglone were shown to be low when soil moisture was low[1].

Objectives

- To investigate whether invasive species are more tolerant of allelopathy than native species, and
- To investigate how the effects of allelopathy are altered by soil moisture.

METHODS

Greenhouse Experiment

Silybum marianum

Brassica nigra

Sambucus nigra ssp. *caerulea*

- 4 plants of each species were given one "mulch" treatment:
  - 0.5mM Allyl isothiocyanate
  - 0.5mM Juglone
  - Control
  - 15g *Brassica nigra* mulch
  - 15g *Juglans californica* mulch
  - 15g Coconut mulch
- Each plant was also given one watering treatment:
  - Wet = >30% volumetric water content
  - Dry = 15%-17% volumetric water content
- The chemical solutions were applied during watering.
- Volumetric water content (VWC) is measured three times weekly.
- Leaf water potential is measured monthly.
- Estimated biomass was calculated by summing the number of touches of each plant to a pole within a square foot quadrat.
- Chlorophyll fluorescence is measured monthly.

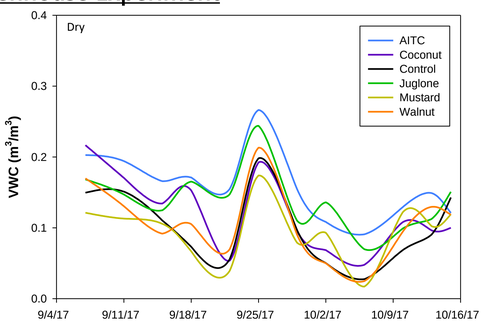
Germination Experiment

- 4 sets of 100 seeds of each species were treated in *Brassica nigra* leaf extract and *Juglans californica* leaf extract
- Concentrations of extract, in grams of fresh leaf tissue per 100mL of DI water, were:
  - 0, 4, 8, 12, 16, and 20

Phacelia distans

RESULTS

Greenhouse Experiment



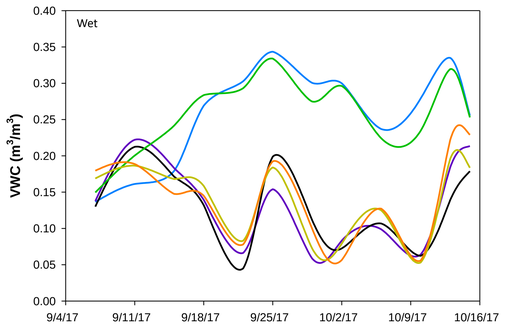


Fig 1. Soil volumetric water content (VWC) for *Sambucus*. Wet treatments had significantly higher VWC than Dry treatments (β = 0.06351, p < 0.05). Coconut (β = -0.08921), Control (β = -0.11276), Mustard (β = 0.05813), and Walnut (β = 0.10038, p <0.05) had significantly lower VWC than AITC.

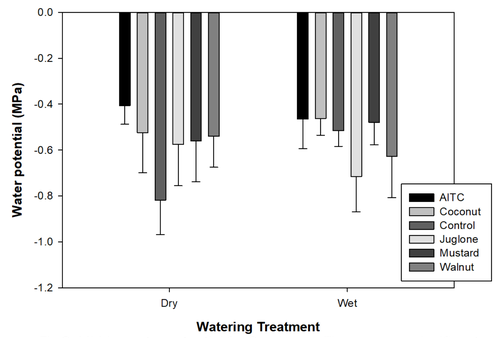


Fig 2. Midday water potential for *Sambucus*. There was no significant difference among the mulch treatments or the watering treatments.

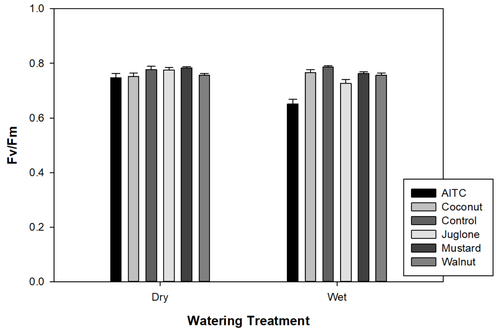
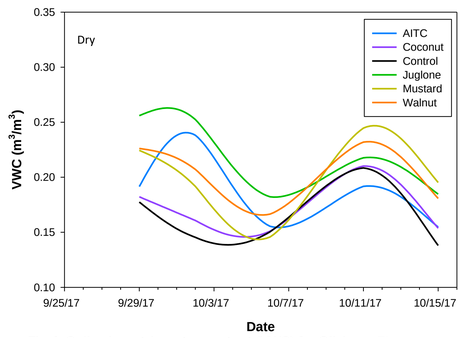


Fig 3. Midday Fv/Fm for *Sambucus*. Wet treatments had significantly lower Fv/Fm than Dry treatments (β = -0.0860, p < 0.05).



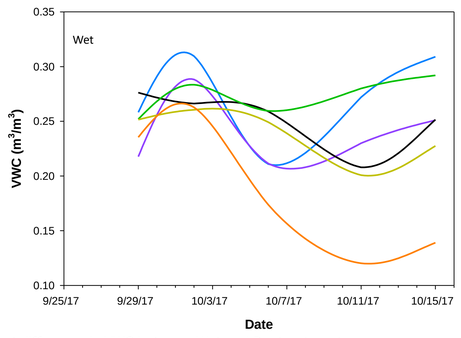


Fig 4. Soil volumetric water content (VWC) for *Silybum*. There was no significant difference in VWC between Wet and Dry treatments.

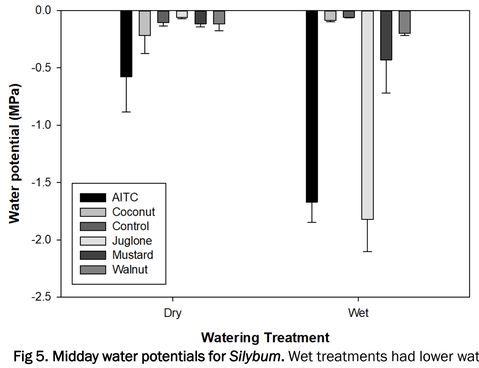


Fig 5. Midday water potentials for *Silybum*. Wet treatments had lower water potentials than Dry treatments (β = -1.095, p < 0.05), especially AITC, Juglone, and Mustard.

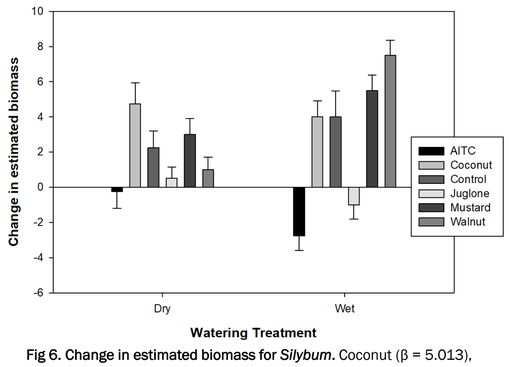


Fig 6. Change in estimated biomass for *Silybum*. Coconut (β = 5.013), Control (β = 2.666), and Mustard (β = 3.184) treatments had greater changes in biomass than AITC (p <0.05).

RESULTS CONT.

Germination Experiment

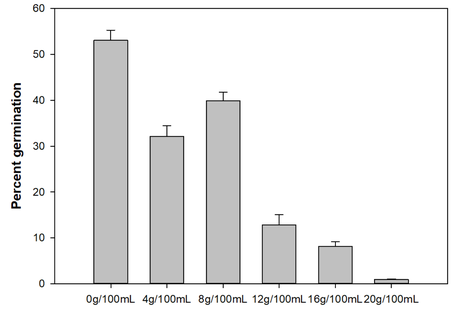


Fig 7. Final germination percentage of *Phacelia distans* in *Brassica nigra* extract. 12g (β = -3.75), 16g (β = -4.153), and 20g (β = -4.799) had significantly less germination than the control (p < 0.05).

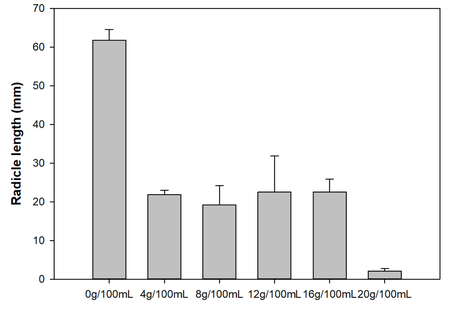


Fig 8. Final radicle length of *Phacelia distans* in *Brassica nigra* extract. 4g (β = -40), 8g (β = -42), 12g (β = -39.9), 16g (β = -40.3), and 20g (-59.7) had significantly shorter radicles than the control (p < 0.05).

Results are **preliminary** and the experiments are **ongoing**.

DISCUSSION

Sambucus

- Lower VWC of the other treatments when compared to AITC is likely due to root death. Those treated with AITC, and likely juglone, had fewer live roots to absorb water from the soil, leaving their VWC higher longer after watering.
- Lower chlorophyll fluorescence in wet treatments is likely caused by AITC and juglone treatments. These allelochemicals were added in a much larger quantity than in the dry treatments so they persisted longer in the soil allowing them to inhibit the plants for a longer period of time.
- It is too early in the experiment to tell whether *Sambucus* is tolerant of allelopathy from *Brassica nigra* or *Juglans californica*.

Silybum

- Wet treatments of *Silybum* were more water-stressed than dry treatments because of the AITC and juglone treatments. The allelochemicals caused root death preventing the plants from absorbing water. *Silybum* were treated while still relatively young and sensitive when compared to the *Sambucus* which had considerably more roots when the experiment began.
- Several individuals that were treated with AITC and juglone with the wet treatment had died soon after application. This suggests that *Silybum* is sensitive to these allelochemicals. However, since neither walnut nor mustard mulch treatments had lost biomass, it is likely the amount of allelochemicals in the mulch are not enough to inhibit *Silybum*.

Phacelia

- *Phacelia* tolerated *Brassica* extracts at the low concentrations, which is likely the concentration it will experience in field conditions.
- However, radicle length being reduced at even the lowest concentration suggests sensitivity to *Brassica*'s allelochemicals.

References

1. De Sciscio, B., D.J. Leopold, and D.C. Walton. 1990. Seasonal patterns of juglone in soil beneath Juglans nigra (black walnut) and influence of J. nigra on understory vegetation. Journal of Chemical Ecology 16(4): 1111-1130.
2. Breshears, D.D., J.W. Nyhan, C.E. Heil, and B.P. Wilcox. 1998. Effects of woody plants on microclimate in a semiarid woodland: soil temperature and evaporation in canopy and intercanopy patches. International Journal of Plant Sciences 159(6): 1010-1017.

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