

Preliminary leaf gas exchange and soil CO₂ efflux results for loblolly pine (*Pinus taeda* L.) plantations experiencing partial rainfall exclusion and fertilization in Oklahoma



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Introduction

As part of PINEMAP, the Tier III installations were established to determine the effects of fertilization and rainfall on stand growth and tree physiology. The Oklahoma Tier III site was implemented on a six-year old loblolly pine stand located in McCurtain county near Broken Bow, OK (Figure 1). The stand consists of an orchard mix of improved Western Gulf 1-0 bare-root seedlings at approximately a 7 by 10 foot spacing (~620 TPA).

More specifically, the objective of this study is to determine if fertilizer provides enough benefits to overcome effects of decreased water availability in loblolly pine plantations or whether fertilization increases loblolly pines susceptibility to water stress.



Figure 1. Tier III site in McCurtain county near Broken Bow, Oklahoma.

Hypothesis

The central hypothesis is that fertilizer added to a loblolly pine plantation experiencing reduced water availability will increase its susceptibility to drought such that the effects of nitrogen fertilizer are largely negated.

More specifically, we hypothesize that:

- Increased leaf area due to fertilization causes a greater reduction in leaf-level water use and no difference in whole-tree water use compared to non-fertilized stands when water availability is limited.
- Increased leaf area due to fertilization causes greater water stress and earlier leaf abscission than non-fertilized stands when water availability is limited.
- The combined effects of reduced leaf gas exchange and earlier leaf abscission of fertilized stands during drought will result in growth rates similar to non-fertilized stands.

Methods

- Loblolly pine leaf gas exchange and soil respiration were compared using a factorial design consisting of rainfall reduction excluders (Figure 2) and fertilizer treatments.
- Treatments consists of :
 - Water reduction (~30%) with fertilizer
 - Water reduction (~30%) without fertilizer
 - No water reduction with fertilizer
 - No water reduction without fertilizer
- Net photosynthesis and stomatal conductance were measured with a Li-Cor 6400 portable photosynthesis system (Li-Cor Environmental, Lincoln, NE). Measurements were conducted three times between October 2, 2012 and February 1, 2013. Needles from the first flush of the 2012 growing season were measured (Figure 3).
- Soil CO₂ efflux was measured with an infra-red gas analysis system (Li-Cor 6200, Li-Cor Environmental, Lincoln, NE) and attached cuvette (10 cm diameter). Measurements were conducted approximately every 6-8 weeks between May 29, 2012 and January 17, 2013 concurrent with measurements of soil temperature and moisture.



Figure 2. Rainfall reduction excluders on the Tier III site in Oklahoma.



Figure 3. Measuring leaf gas exchange on the Tier III site in Oklahoma.

Preliminary Results

Net photosynthesis and stomatal conductance

- Water reduction treatments decreased net photosynthesis in December. The water reduction plus fertilizer treatment decreased net photosynthesis in February (Figure 4A).
- Effects of treatments on stomatal conductance were similar to net photosynthesis in December and February (Figure 4B).

Soil CO₂ efflux and soil temperature

- Fertilizer reduced soil CO₂ efflux in August and October. Soil CO₂ efflux declined between May 29, 2012 and January 17, 2013 (Figure 5A).
- Seasonal changes in soil CO₂ efflux mirrored changes in soil temperature (Figure 5B).

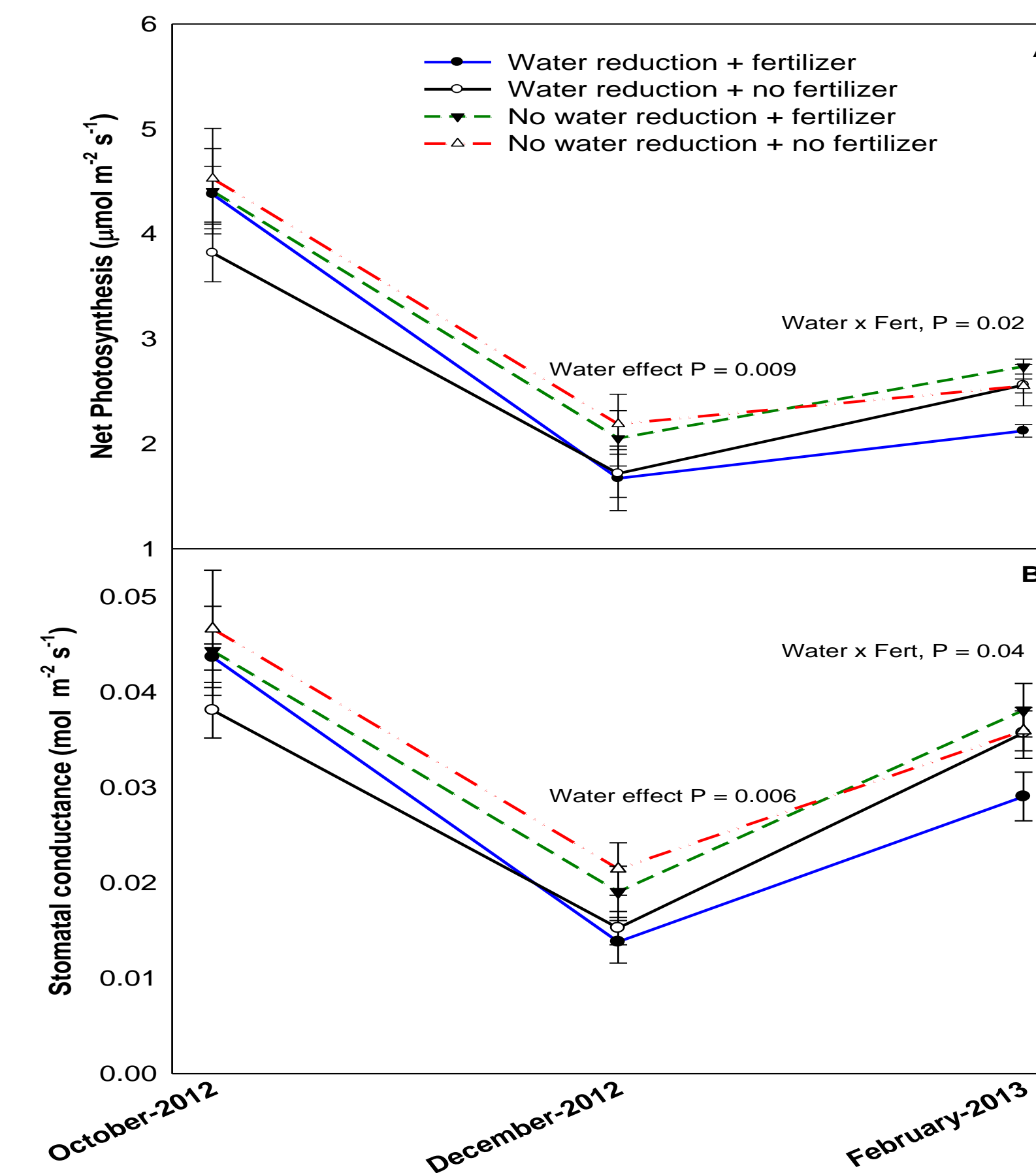


Figure 4. Net photosynthesis rate ($\mu\text{mol m}^{-2} \text{s}^{-1}$) (A) and stomatal conductance ($\text{mol m}^{-2} \text{s}^{-1}$) (B) by treatment type.

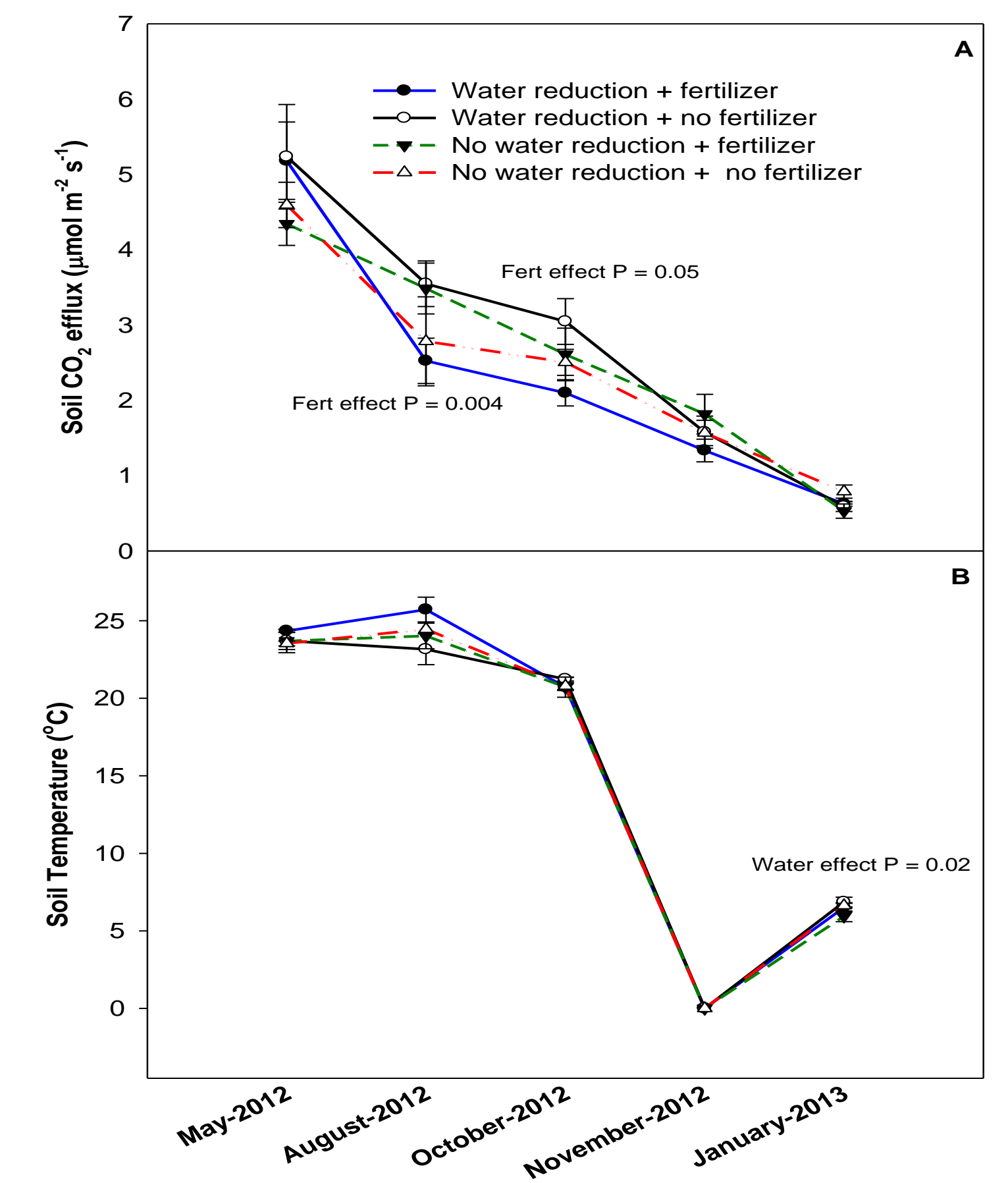


Figure 5. Soil CO₂ efflux ($\mu\text{mol m}^{-2} \text{s}^{-1}$) (A) and Soil temperature ($^{\circ}\text{C}$) (B) by treatment type overtime.

Conclusion

- Preliminary results suggest that the reduction of net photosynthesis and stomatal conductance is associated with decreased water availability, particularly in the water reduction + fertilizer treatment.
- Using fertilizer appears to suppress Soil CO₂ efflux during the growing season after application.

Remainder of the Study

- Leaf area dynamics will be measured by a combination of frequently collected litter trap samples and measurements of leaf growth phenology.
- Whole-tree water use will be measured with thermal dissipation probes.
- Leaf-level water use will be estimated with periodic measurements using a Li-Cor 6400 portable photosynthesis system.
- Water use efficiency will be estimated by a combination of leaf-level gas exchange measurements and carbon isotope discrimination.

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