Water-deficit priming increases photosynthetic characteristics of papaya (*Carica papaya* L.)

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INTRODUCTION

Priming, the imposition of a defined duration of mild stress such as water-deficit stress during early plant development, is a relatively recent research focus with potential to improve crop stress tolerance. Relatively few studies have focused on abiotic stresses. Priming capacity has not been tested in many horticultural crops and the physiological mechanisms involved in priming have not been well described for any crop. In addition, there is little knowledge about priming "memory," or the duration of the primed state after the priming period has been completed. Hypothesized mechanisms for water-deficit priming include increased photosynthetic capacity, increased anti-oxidant capacity, and increased carbohydrate partitioning to roots, each of which may play a different role in priming memory. Papaya may be a good candidate for priming because Mahouachi et al. (2006) found that, after a prolonged severe water deficit, papaya leaves underwent a brief up-regulation in net CO_2 assimilation (A) above that of a fully irrigated control.

OBJECTIVES

1. **Test whether papaya has the potential to be primed with mild water-deficit stress.**
2. **Test whether priming elicits up-regulation of leaf gas exchange of vegetative plants.**
3. **Determine the relative duration of priming memory in papaya.**

MATERIALS AND METHODS

'Red Lady' papaya (*Carica papaya* L.) plants were germinated in a greenhouse in Gainesville, FL. Three-month old plants were transplanted and placed outside in 8-liter pots. The study was a randomized complete block design with each of six rows as a block. Soil water tension in the control treatment was maintained at an average of 4 kPa via daily irrigation. Supplemental water from rainfall was prevented by the installation of Styrofoam collars and plastic soil covers (Figure 1). Plants were subjected to one of 3 treatments:

1. **Early priming (EP) initiated 6 months after germination**
2. **Late priming (LP) initiated 7 months after germination**
3. **Non-primed control (NP)**

Priming treatments consisted of a 3-week period of reduced irrigation, which consisted of a daily application to each plant of sufficient water to reach 50% volumetric water content. Tensiometers were installed to monitor soil water tension, which averaged approximately 20 kPa during the priming period. Net CO_2 assimilation (A), stomatal conductance (g_s), transpiration (E), and the ratio of variable to maximum chlorophyll fluorescence (Fv/Fm) were measured once after the EP treatment, once during the LP treatment, then at 1-week intervals for 4 weeks, beginning 3 days after the completion of the LP treatment. One-way analysis of variance, with row as a random variable and treatment as a fixed variable, was performed on data collected after EP and during LP. Data collected after LP were analyzed as repeated measures. All data were analyzed with the lme command in the nlme package (Pinheiro et al., 2014), and plots were created using the ggplot2 package (Wickham, 2009) both in the R statistical package.

REFERENCES

Mahouachi, J., A.R. Socorro and M. Talón. 2006. Responses of papaya seedlings (*Carica papaya* L.) to water stress and re-hydration: growth, photosynthesis and mineral nutrient imbalance. Plant & Soil 281:137-146.

Pinheiro, J., D. Bates, S. DebRoy, D. Sarkar and R Core Team. 2014. *nlme: Linear and Nonlinear Mixed Effects Models.* R package version 3,1-117.

Wickham, H. 2009. ggplot2: elegant graphics for data analysis. Springer, New York.

Figure 1. 'Red Lady' papaya in the container, including reflective insulation to prevent heating, Styrofoam cup and trash bag to prevent entry of rainwater, and irrigation tubing for the drip emitter. The bag is pulled back to show tensiometer used to monitor soil tension.

RESULTS

Fv/Fm, a measure of integrity of photosystem 2 (PSII), was not different among treatments, which were all in the expected range for healthy plants (0.77-0.83, data not shown). Thus, fluorescence values indicated a lack of severe stress.

Gas exchange variables increased after both EP and LP. E and g_s increased early in the priming period (Fig. 2); A increase upon restoration of full irrigation (Fig. 3). A decreased toward the end of the priming period but upon resumption of full irrigation increased to levels 25% greater than the NP control.

Over time, A of the treatments converged. A in the EP treatment fell below that of the NP control after more than a month following the cessation of the EP period. E and g_s remained the same between the middle of the LP treatment and immediately after LP even though A increased (Fig. 3).

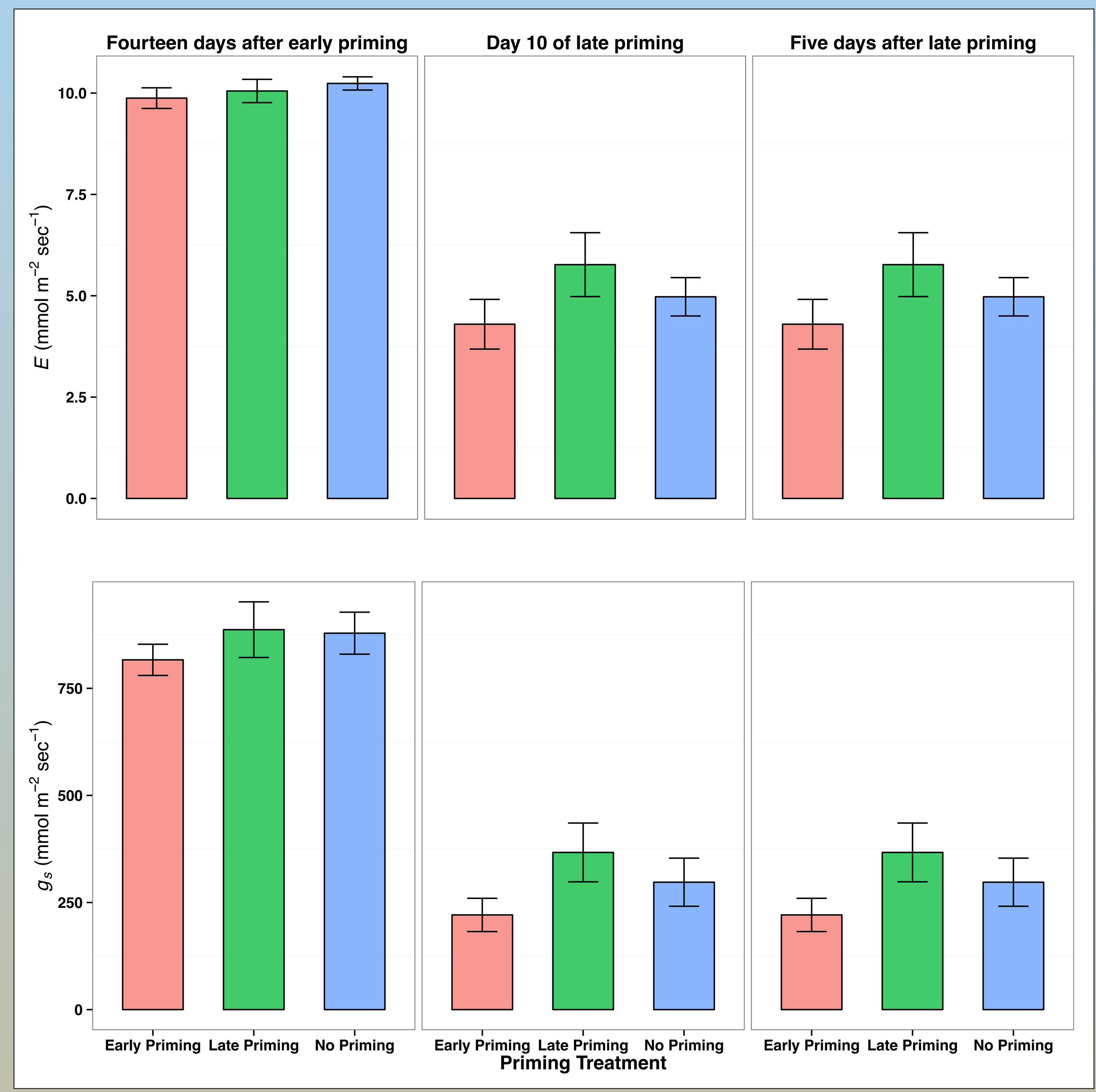

Figure 2. Transpiration (E) and stomatal conductance (g_s) of 'Red Lady' papaya during and after water-deficit priming. Shaded bars represent mean values and error bars represent standard errors.

CONCLUSIONS

- **Papaya can be primed, and priming memory lasted approximately 1-month.**
- **E and g_s up-regulation begin early in the priming period.**
- **A increases following a priming treatment after full irrigation is restored.**
- **Because stomatal components of priming increase during the priming period, and A increases after the end of the priming period, the up-regulation may include independent stomatal and non-stomatal factors.**

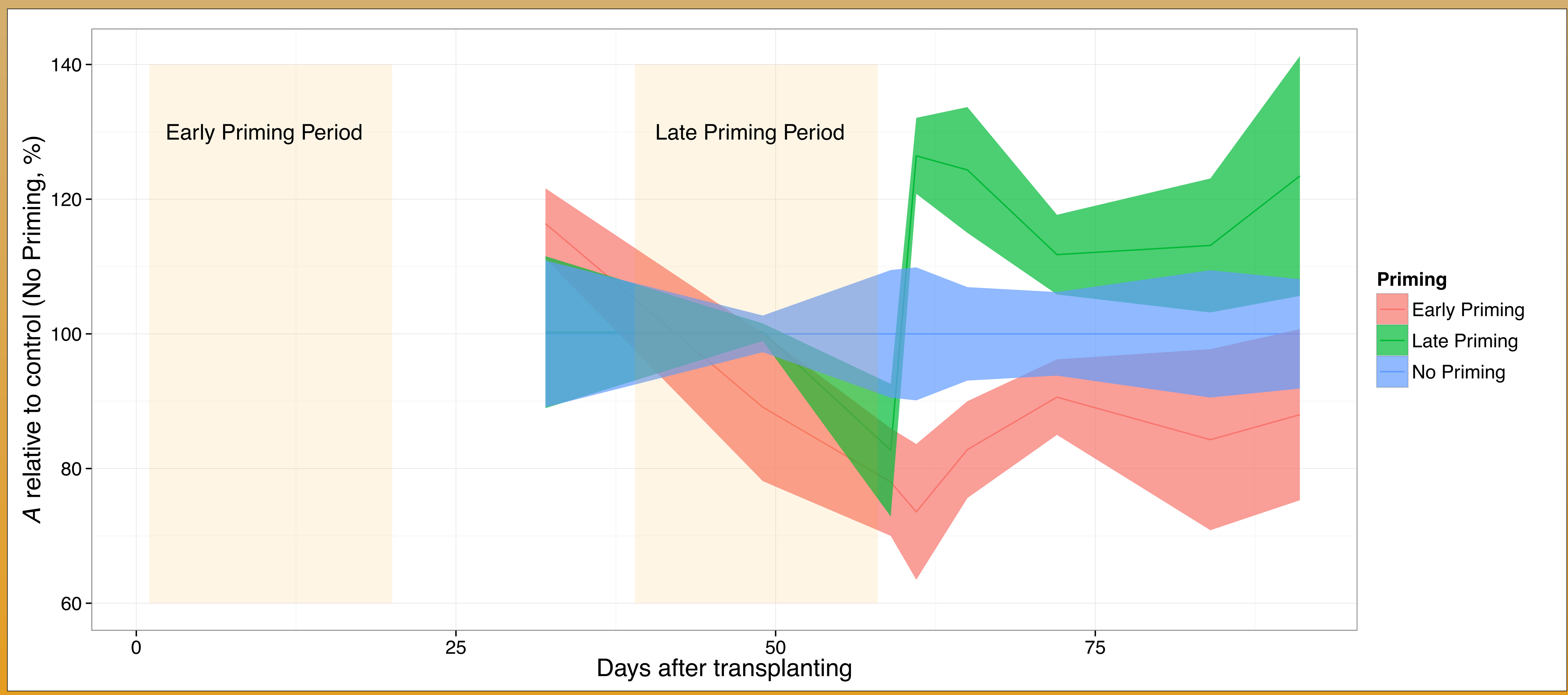

Figure 3. Relative net CO_2 assimilation (A) of 'Red Lady' papaya exposed to different timing of water-deficit priming. Lines represent means as a percent of non-primed control. Shaded banners represent standard error.