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TITLE:
The Effects of Green Light on Transpiration Rate in Mung Bean (Vigna radiate) Leaves

ABSTRACT:
219 words; 0 citations; 10 biology terms

Leaves open and close their stomata in response to environmental conditions which either favor or hinder photosynthesis, respectively. Since transpiration rates increase as stomata open, water loss is expected to be greater under conditions with higher photosynthetic potential. In this study the effect of light conditions (environmental factor) on plant transpiration rates was examined. If green light is not efficiently absorbed by chlorophyll then mung bean plants (Vigna radiate) exposed to green light, compared to those exposed to white light, were expected to exhibit lower transpiration rates. This hypothesis was tested by placing separate groups of mung bean plants under green light and white light of similar intensity (three plants under each condition) and measuring the change in mass of the plant +soil after 1.5 hours in order to estimate water loss. By then dividing water lost by leaf area and time, transpiration rates were be calculated for each plant and group means compared. Results supported our hypothesis, as plants exposed to green light exhibited 5-fold lower mean transpiration rates than plants under white light, a difference which was highly significant. These results suggest that plants which are grown in an environment rich in green light will likely exhibit reduced transpiration rates and such conditions may be less favorable for photosynthetic processes, potentially resulting in reduced plant growth over time.

INTRODUCTION:
331 words; 3 citations; 12 biology terms

In order for a plant to grow and reproduce, sufficient water, CO_2, and light must be acquired and processed into sugars in order to meet metabolic demands. The stomata play an integral role in this process, as they act as both the site of gas exchange with the environment and the site of water loss through transpiration. Since plants are often limited in one or more of these three resources, a delicate balance between gas exchange and water loss must be maintained in order to prevent depletion and enhance acquisition of each under a range of environmental conditions. For this reason, plants which carry out photosynthesis during the day typically open stomata when potential for photosynthesis is high, and close stomata when potential for photosynthesis is low in order to prevent unnecessary water loss.

Under high light conditions, for example, high levels of CO_2 are needed to accommodate increases in energy capture, and so stomata generally open (assuming sufficient water availability); likewise, under low light conditions, stomata generally close (Farquhar and Sharkey, 1982). Furthermore, when plants are exposed to high levels of red light and blue light, wavelengths which are strongly absorbed by chlorophylls, stomata are signaled to open (Sharkey and Ogawa 1987). However, when plants are exposed to high levels of green light, which chlorophyll does not strongly absor), stomata close (Talbott et al. 2002). The purpose of this study was to observe the effects of green light on stomatal opening and transpiration in mung bean plants. Since green light is not strongly absorbed by chlorophylls, the prediction was that stomata of mung bean plants (Vigna radiate) exposed to high levels of green light would close, resulting in decreased transpiration rates relative to a white light control (similar to the results shown by Talbott et al. 2002). This hypothesis was tested by comparing the mean transpiration rates of mung bean (Vigna radiate) plants grown under green light to those of mung bean plants grown under white light of similar intensity.

MATERIALS AND METHODS:
182 words; 0 citations; 8 biology terms

Six mung bean plants (Vigna radiate) of similar size were randomly selected from the greenhouse. Individual pots were placed inside ziplock bags to prevent water loss through soil evaporation, and the bags were sealed so that the stem and leaves were the only part of the plant exposed to the air. Each bag was then massed and three plants were placed beneath a metal halide bulb with no filter (the control group) while three were planed beneath a metal halide bulb with a green filter (the experimental group). Plants were arranged so that each was exposed to 1000 ± 25 μmol photons within their light environment. After 1.5 hours, plants were removed from the light environment and re-massed. Individual leaves were then removed from each plant, and placed on a transparent grid sheet in order to estimate leaf area per plant. Transpiration rates were then calculated using the formula:

$$\text{Transpiration rate } [g/(hr * cm2)] = \frac{[\text{Initial mass (g)} - \text{Final mass (g)}]}{\text{Time (hrs)} * \text{Area of leaves (cm2)}}$$

Group means were compared using a one-tailed t-test, with $p<0.05$ used to determine significance.

RESULTS:
34 words; 0 citations; 4 biology terms

The results obtained were consistent with the hypothesis. Plants grown under green light exhibited approximately 5-fold lower mean transpiration rates than plants grown under white light (Figure 1). This difference was highly significant ($p<0.001$).

DISCUSSION:
337 words; 2 citations; 10 biology terms

Consistent with our hypothesis, mung bean plants (Vigna radiate) grown under green light were found to exhibit significantly lower transpiration rates than plants grown under white light (Figure 1). From these results, we can infer that plants grown under a green light-rich environment will likely exhibit lower transpiration rates relative to plants grown under white light environments of similar intensity. Such an environment is often encountered by plants grown in the understory of forests, which typically experience a disproportionately high ratio of green: red + blue light, as much of red and blue wavelengths are screened out by leaves in the overstory (Burkey and Wells 1996). Furthermore, since CO_2 uptake is directly proportional to transpiration, we might also infer that plants grown in a green light-enriched environment would exhibit less growth than plants grown in a white light of similar light intensity, since less light is being captured by chlorophyll, and the stomata are not opening as much, thus limiting CO_2 uptake.

An additional observation made in this study which may be of interest in future studies was that plants with smaller leaves exhibited consistently higher overall transpiration rates than plants with larger leaves (data not shown). Although this may be due simply to error from the crude leaf area measuring technique used, it is also possible that the smaller leaves lost more water due to increased convection across their surfaces due to a thinner boundary layer. Previous studies have shown that leaves with smaller leaf area have a thinner boundary layer (a layer of still air adjacent to the surface caused by frictional drag) surrounding the leaf, which results in more mixing of moist air from the leaf with surrounding drier air (Meinzer et al. 1995). This increased mixing results in greater vapor pressure deficit adjacent to the leaf, and thus, increased transpiration compared to a leaf with a thicker boundary layer. Future studies may consider controlling for leaf size in their experimental design to ensure no variation in data due to the boundary layer effect.

LITERATURE CITED:

Burkey, K.O. and R. Wells. 1996. Effects of natural shade on soybean thylakoid membrane composition. Photosynthesis Research. 50: 149-158.

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Meinzer FC, G. Goldstein, P. Jackson, N.M. Holbrook, M.V. Gutierrez and J. Cavelier. 1995. Environmental and physiological regulation of transpiration in tropical forest gap species: the influence of boundary layer and hydraulic properties. Oecologia. 101: 514-522.

Sharkey T.D. and T. Ogawa. 1987. Stomatal response to light. In: Zeiger E, Farquhar GD, Cowan IR editors. Stomatal Function. Stanford: Stanford University Press. pp 195-208.

Talbott L.D., G. Nikolova, A. Ortiz, L. Shmayevich, and E. Zeiger. 2002. Green light reversal of blue-light stimulated stomatal opening is found in a diversity of plant species. American Journal of Botany. 89: 366-368.

TABLES:

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FIGURES:

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FIGURE LEGENDS:

Figure 1: Mean transpiration rates of mung bean plants exposed to green light (experimental group, n=3) vs white light (control group, n=3). Error bars represent +/- one standard deviation. T-test results showed transpiration rates to be much lower in green light conditions ($p<0.001$).

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Other Information:

DANIEL used the help option for info on how to write:

--> Methods

--> Literature Cited

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