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ABSTRACT

Stomata are pores on specialized epidermal cells of plant leaves that facilitate photosynthesis and water transport. This research using geraniums, seeks to determine if stomata densities vary among developing and mature leaves. Epidermal leaf impressions were taken and stomata densities were calculated. Developing leaves were found to average 7.75 ± 0.79 and mature leaves 5.65 ± 0.44. This was found to be statistically significant and is thought to be a result of the maximization of growth potential by developing leaves balanced by a need to regulate water loss by mature leaves.

INTRODUCTION

Stomata are pores on specialized epidermal cells that allow for the transfer and regulation of carbon dioxide and oxygen; and the evapo-transpiration of water, between the plant and atmosphere. By their effects on these gases and water vapor, stomata regulate photosynthesis and water conduction. Both processes aid in plant growth; the first by generating a carbohydrate energy source, the second by providing hydrostatic pressure gradients that facilitate water translocation within the plant and between the plant and its environment. Water typically constitutes 80 to 95% of the mass of growing plant tissues (Taiz and Zeiger 2002) and a deficiency of it has been shown to be a limiting factor in growth of both mature and young plants (Castell and Terradas 1993). The appearance of these pores is believed to be a key evolutionary element in the successful colonization of land by plants that began roughly 475 million years ago (Gray and Hetherington 2004). Stomata enabled a plant to control its water content, allow for turgor driven cell expansion (growth) and minimize desiccation due to evapo-transpiration. The impact of the success of land plants on human existence should not be underestimated.

Humans, being heterotrophic, depend directly or indirectly on plants as their energy end nutritional source. Eighty percent of the consumed calories in the world are the result of only six crop plants: wheat, rice, corn, cassava, potatoes and sweet potatoes. Livestock raised for meat production are largely fed on grains as well (Campbell and Reece 2005). World imports of floricultural products alone represent a 5 billion dollar industry (Gunnerod 1991). Plants are primarily responsible for the oxygen used by humans and provide numerous medicinal compounds. Plant products such as wood are used the world over in construction (Campbell and Reece 2005).

Given the significance of plants in general and stomata to plant health, this study examines if stomata density is affected by the development age of the leaf using geraniums.

METHODS

Forty geranium plants were cultured under laboratory conditions (22°C, 15 hours of light / 9 hours of dark). Lighting consisted of four rows of 112 cm. long 40-watt wide spectrum fluorescent bulbs. A mature leaf (≥ 5cm.) and a developing leaf (≤ 3cm.) were randomly selected from each of

the 40 plants for use in stomata density counting.

The method to count stomata densities began with the application of a thick layer of clear nail polish to the lower epidermis of each leaf. The nail polish was allowed to dry. A section of clear tape was firmly stuck to the section of nail polish then carefully peeled away from the leaf, leaving a leaf impression. The impression was then placed on a slide and viewed under 400X magnification of a light microscope. A representative section of stomata density was chosen and the stomata densities were calculated.

A two tail t-test was used to test for significant differences in mean stomatal densities between developing leaves and mature leaves. Stomatal densities were first $\log_{10}$ transformed to meet normality.

RESULTS

Mean stomatal densities according to developmental stage of the geranium leaf are summarized in Table 1. The means differed significantly ($P = 0.042$; $t = 2.063$).

DISCUSSION

Differences in stomatal density between leaves of varying developmental stage may be just an artifact of allometric growth and have no particular selective value. However, there may be selective advantages to the changes in stomatal densities as observed using geraniums. Greater stomatal densities in young leaves could maximize photosynthetic exchange and water conductance before the eventual senescence of mature leaves. Higher ratio of carbon fixation and mineral transport through solvent drag provide the materials for leaf growth. Although water transport is essentially an energy free process, the maintenance of such regulatory organs are not and therefore energy could be conserved by reducing stomata density of organs that are soon to be lost (Taiz and Zeiger 2002). In fact, water conductance values were found to be reduced in mature leaves of various *Musa* by (Ekanayake, et al 1994).

The difference in stomatal density observed in this experiment are thought to be a result of the normal development of leaves as initiated by cell lineage patterning as noted in *Arabidopsis* by (Fenoli, et al 2002). However cell to cell signaling has also been shown to affect stomatal density between mature and young leaves; in response to environmental factors (Lake et al, 2002, Elagoz et al, 2006). This demonstrates that plants have developed stomata patterning plasticity and can alter densities to adapt to different environmental stresses; but the plants in this experiment were cultured under ideal laboratory conditions, without any identified stress, so if cell to cell signaling is at work here further research needs to be done to identify possible explanations.

Although stomatal densities were calculated, total stomata counts were not noted among the plants. As a result, it is not known whether the later growth was entirely stomata free or truly less stomata dense. Future research might be undertaken to uncover these results.

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Table 1. Summary (mean ± standard error) of stomatal densities according to developmental stage of the leaf. All n = 20.

Developmental Stage	Stomatal density (count/mm^2)
Developing leaf	7.75 ± 0.79
Mature leaf	5.65 ± 0.44