

# ***Aglaonema commutatum* Schott (Araceae) leaf growth under limited light environments. Effect of plant size.**

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## **Abstract**

The effect of plant size (estimated as total dry weight) on leaf growth of *Aglaonema commutatum* Schott was studied under limited light conditions. Two different plant sizes were used. A significant positive regression was found between leaf area and plant size. However, distinct slope values were detected after production and complete expansion of three new leaves. Despite greater leaf size, there were no significant differences in leaf thickness and leaf tissue distribution between leaves expanded under high- (previous leaves) or low-light for both plant sets. We propose that for a long time under limited light, a decrease in *Aglaonema commutatum* leaf size would be associated to a reduced photosynthate translocation capacity of the resources stored in other plant organs. The effect of these results on ornamental industry is discussed too.

**Additional keywords:** Acclimation; leaf anatomy; ornamentals; shade leaves.

## **Resumo**

DI BENEDETTO, A.; BOSCHI, C.; KLASMAN, R.; MOLINARI, J. Crescimento foliar de *Aglaonema commutatum* Schott (Araceae) em ambientes com limitação de luz. Efeito do tamanho da planta. Científica, Jaboticabal, v.33, n.2, p. 160-164, 2005.

Estudou-se o efeito do tamanho da planta (estimado pela matéria seca total) sobre o crescimento foliar de *Aglaonema commutatum* Schott em condições de luz limitada. Foram utilizados dois tamanhos. Encontrou-se regressão positiva significativa entre a área foliar e o tamanho da planta. Entretanto, foram detectados valores de inclinação distintos depois da produção e da expansão completa de três folhas novas. Apesar de o tamanho da folha ser maior, não houve diferenças significativas na espessura da folha e na distribuição de tecido foliar entre as folhas expandidas sob maior luminosidade (primeiras folhas) ou menor luminosidade, para ambos os tamanhos de plantas. Nossa suposição é que, em períodos longos sob luz limitada, um decréscimo do tamanho da folha de *Aglaonema commutatum* estaria associado a uma menor capacidade de translocação de fotossintatos das reservas armazenadas em outros órgãos da planta. O efeito destes resultados na produção de plantas ornamentais também foi discutido.

**Palavras-chave adicionais:** aclimação; anatomia foliar; plantas ornamentais; folhagens de sombra.

## **Introduction**

Acclimation to a light stress is related to genetic capacity and cultural factors such as: nutrition, light level, temperature and water relations (BARBER, 1985; PERRY et al., 1986; SIMS & PEARCY, 1994). Irradiance level is not the main factor which changes initiation and expansion of leaves in ornamental shade plants (BOSCHI et al., 2004) although at high irradiances dicotyledonous plants show smaller leaves than those expanded under a lower light environment.

LICHTENTHALER (1985) proposed that for shade plants smaller leaves would be an adaptive feature. However, some papers are not in agreement with this hypothesis (DI BENEDETTO & COGLIATTI, 1990; DI BENEDETTO & GARCIA, 1992; DI BENEDETTO et al., 2003).

Plants acclimated under high-light environments and transferred to low-light ones showed anatomical changes that provide better use of low light conditions

(PERRY et al., 1986; VIDAL et al., 1990). Changes in leaf size under limited light were related to a decrease in total mesophyll thickness and an increase in air space between cells.

The study of the capacity for acclimation to a given stress under controlled environments generally requires a comparison between physiological and molecular changes in both stressed and control plants. It is not easy to explain those results when plants are grown at different growth rates. In such cases, tissues with the same chronological age but different growth stage are compared.

Comparative foliar histogenesis studies could show the changes in both meristematic activity and growth rates but, there are only limited papers in this subject for unifacial leaves (KAPLAN 1970).

The suggestion that plant 'size' would be associated to photoassimilate allocations is supported by the fact that allocation to resource-capturing organs has also been indicated to be correlated with competitive ability

to clonal dispersal (ABRAHAMSON, 1975; HARTNETT & BAZZAZ, 1983; BREWER et al., 1998).

The aim of this work was to analyze the effect of plant size as a variable related to carbohydrate availability on leaf characteristics of *Aglaonema commutatum* plants grown under limited light environments.

## Materials and methods

Thirty plants of the following plant sizes were used:

1) 'Size A' plants: with 9.3 + 1.9 mature, fully expanded leaves;

2) 'Size B' plants: with 6.4 + 1.6 mature, fully expanded leaves.

Plants were grown during four months in a growth chamber with a photoperiod of 8 h, a temperature of 25 °C, and a quantum flux density (400-700 nm) of 6 mmol photons m<sup>-2</sup> s<sup>-1</sup> provided by fluorescent lamps.

Leaf area was determined by drawing around the leaves on paper, cutting out the shapes, weighing them and then calculating the area from the known weight per unit area of the paper. The following regression line of a sample of measured values of A (leaf area), w (leaf width) and l (leaf length) to estimate leaf area for Tables 1 and 2 data was used.

$$A \text{ (cm}^2 \text{ leaf}^{-1}\text{)} = -1.54 + 0.73 (w \cdot l) ; R^2 = 0.99$$

Samples for examination of leaf anatomy were collected and tissue from the middle region of the lamina was fixed in FAA, embedded in paraffin, sectioned at 10 or 20 μm on a rotary microtome and stained with safranin-crystal violet-fast green (JOHANSEN, 1940). Each leaf stage was the mean of ten replicates where leaf thickness, mesophyll layer, epidermal layer and intercellular spaces were recorded.

Plants were irrigated with a high quality tap water (pH: 6.64 and electrical conductivity of 0.486 dS m<sup>-1</sup>) and a weekly fertilization of 50 ppm N (1N:0.5P:1K:0.5Ca v/v) was used.

Data were subjected to analysis of variance and means were separated by the Tukey test (P < 0.05). Changes in leaf area (cm<sup>2</sup> leaf<sup>-1</sup>) and leaf expansion rate (cm<sup>2</sup> leaf week<sup>-1</sup>) during plant growth were estimated through a straight-line regression. The significance of differences was determined through the Test for zero slope and Test for zero intercept from KLEINBAUM & KUPPER (1978).

## Results

Positive regressions between the area of new leaves and previous plant sizes were found for both sizes A and B (Table 1). For 'Size A' (753.1 + 27.21 cm<sup>2</sup> leaf plant<sup>-1</sup>) and 'Size B' (391.2 + 20.40 cm<sup>2</sup> leaf plant<sup>-1</sup>) plants there was a slight, but statistically significant decrease

Table 1 – Changes in leaf area (cm<sup>2</sup> leaf<sup>-1</sup>) during plant growth for two *Aglaonema commutatum*

Plant size	α	β	R <sup>2</sup>
"Size A" - Plants			
Leaf N <sup>o</sup>	-1		
	1	11.70	0.109 Aa
	2	17.78	0.080 Ba
	3	10.22	0.082 Ba
		25.00	0.067 Ba
			0.68
			0.73
			0.71
			0.65
"Size B" - Plants			
Leaf N <sup>o</sup>	-1	34.84	0.120 Aa
	1	9.73	0.089 Ba
	2	12.83	0.081 Ba
	3	12.83	0.081 Ba
		16.96	0.044 Cb
			0.68
			0.68
			0.66

Different capital letters indicate statistically significant differences (P ≤ 0.05) between leaves within each plant size. Different lower case letters indicate statistically significant differences (P ≤ 0.05) for the same leaf between plant size treatment. The significance of differences was determined by regression analysis using the following straight-line regression: Leaf Area<sub>leaf</sub> = α + β [Leaf Area<sub>plant</sub>].

in slope for the new leaves expanded under low-light. The differences were greater when three leaves for the smaller plant size ('Size B') were expanded.

Comparisons revealed significant slope differences between plant type when three new leaves were produced under limited photosynthetic fluency rate. On the other hand, regression coefficients let us to explain between 65 to 78% of the found plant size variability.

When leaf expansion rate (cm<sup>2</sup> leaf week<sup>-1</sup>) was related to previous plant size, there was a slight but significant statistical difference for 'Size A' plants (Table 2); regression coefficients explain a high portion (77-86%) of plant size variability. A greater plant size let expand a significantly higher leaf area.

Leaf thickness increase pattern were the same for both high- and low-light leaves, with two strong increases between 20-40% and 90-100% of final leaf area and a phase of minor or no increase between them. This lag phase was larger for 'Size B' plants. However, there were no significant differences in leaf thickness

Table 2 – Changes in leaf expansion rate (cm<sup>2</sup> leaf week<sup>-1</sup>) for two *Aglaonema commutatum* Schott plant sizes.

Plant size	α	β	R <sup>2</sup>
"Size A" - Plants			
	-1.72	0.032 A	0.86
"Size B" - Plants			
	-3.86	0.028 B	0.77

Different capital letters indicate statistically significant differences (P ≤ 0.05) plant sizes. The significance of differences was determined by regression analysis using the following straight-line regression: Leaf Expansion Rate = α + β [Leaf Area<sub>plant</sub>].

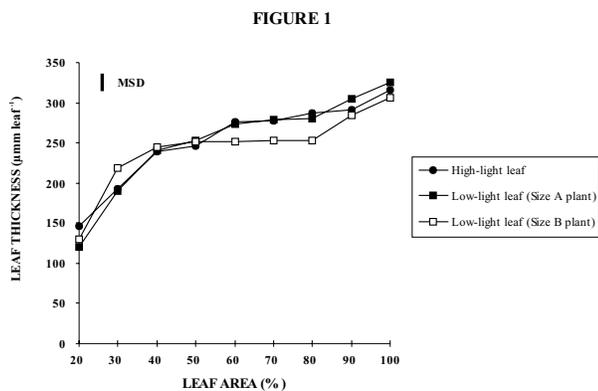


Figure 1 - Changes in leaf thickness ( $\mu\text{m leaf}^{-1}$ ) during leaf development for *Aglaonema commutatum* plants. Each leaf stage was the mean of ten replicates.

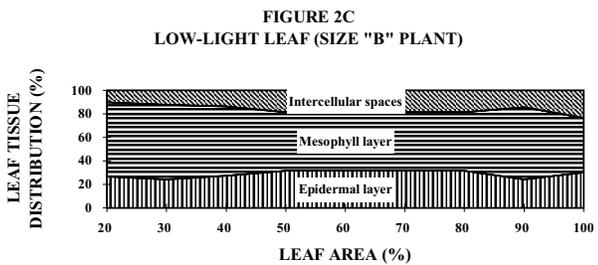
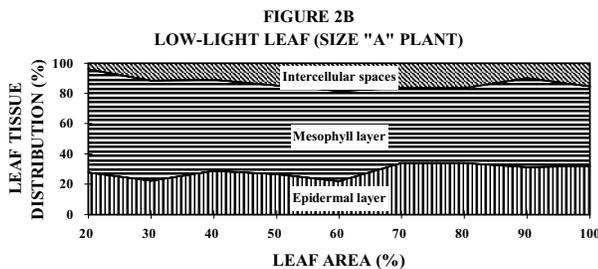
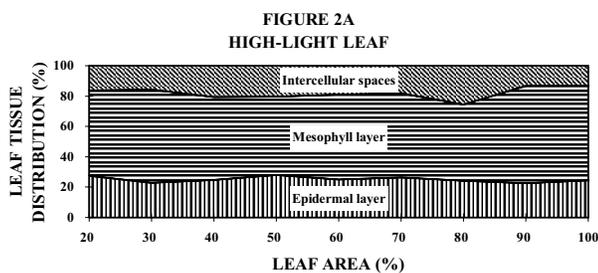


Figure 2 – A: Changes in leaf tissue distribution (%) during leaf development for *Aglaonema commutatum* high-light leaf. Each leaf stage was the mean of ten replicates. B: Changes in leaf tissue distribution (%) during leaf development for *Aglaonema commutatum* low-light leaf (Size A plant). Each leaf stage was the mean of ten replicates. C: Changes in leaf tissue distribution (%) during leaf development for *Aglaonema commutatum* low-light leaf (Size B plant). Each leaf stage was the mean of ten replicates.

when leaves were fully expanded (Figure 1).

Ontogeny revealed minor differences in tissue distribution between high and low-light leaves. Shade conditions induced a distinct leaf tissue distribution when compared to leaves grown under higher light conditions. In this study, there was an increase in the intercellular space volume for 'Size B' plants at expansion stages but not for 'Size A' plants (Figure 2 A-C).

## Discussion

In a previous report, DI BENEDETTO & COGLIATTI (1990) have shown that *A. commutatum* plants grown under low light conditions decreased leaf size. Morphophysiological responses of obligate shade plants like *A. commutatum* to light are usually dependent on stored reserves as well as on light conditions. In order to better understand these responses, the development of leaves from plants of distinct sizes should be accompanied under low light conditions.

There are strong links between resource availability, the ability of plants to use resources for carbon gain and productivity, and, at the population level, parameters such as size, survival, and reproductive output (BAZZAZ et al., 1987; PEARCY et al., 1987). In many species, the rate of export of photoassimilates from leaves and leaf photosynthesis rate are influenced by the assimilate demand from other parts of the plants (MENDEZ & OBESO, 1993). The distribution of biomass among plant organs is not fixed (GERRY & WILSON, 1995); BREWER et al. (1998) have indicated the best belowground competitors should allocate the greatest fraction of resources to roots. HARTNETT and BAZZAZ (1983) have indicated that if the expansion of shade leaves is supported by assimilate import, there would be an increase in growth, reproduction, and survivorship.

In a young leaf, the photosynthetic apparatus is not capable yet of providing all the food the leaf needs for normal growth so that it makes use of photoassimilates stored in other organs such as older leaves, roots, and stems (TURGEON, 1989). When photosynthetic balance increase it begins to export to new, immature, expanding leaves (ZOTZ, 1997). GULMON & CHU (1981) have indicated that when a stress that limits plant growth occurs, leaf growth decreases. Our results (Table 1) are in agreement with this hypothesis.

The hypothesis that leaf growth was limited by photoassimilate availability was supported by the fact that there was a higher positive regression between leaf growth and previous plant size for 'Size A' related to 'Size B' plants but, only when the 3rd leaf was expanded under low-light. The response of the leaves of *A. commutatum* plants is generally slow; ten to twelve months and three to five leaves were required to show changes in leaf size when plants were transferred

from high to low light intensities (DI BENEDETTO & COGLIATTI, 1990).

A quantitative analysis of leaf anatomy for the study of relationships between both leaf structure and leaf function are needed. By example, main attention to leaf anatomy and photosynthetic level relationships was made by VIDAL et al. (1990) and SIMS & PEARCY (1992).

The main limitation for leaf ontogeny studies is that observations of growth cannot be made nondestructively overtime. In the absence of such direct observations, inferences about developmental rates are usually made by sacrificing individuals from an experimental population and correlating the developmental observations to the chronological age of the sample (e.g., days from sowing) (WILLIAMS 1975; HUNT & CORNELISSEN 1997). However, plants of equivalent chronological age are often at different developmental stages so that plants in any particular sample will not be strictly comparable (HILL & LORD, 1990).

To avoid these methodological limitations we have referred each leaf stage as a proportion to final leaf area. No increase in thickness was observed when leaves were between 55 to 80% of its final area for 'Size B' plants (Figure 1). Thickness of completely expanded leaves was the same for sizes A and B plants, showing no relations between stored reserves and necessity of carbon economy indicated by leaf anatomy. When plants are growing under high irradiances this lag phase in leaf thickness pattern is not found.

Leaf development is characterized by substantial changes in morphology and anatomy that are the product of differential cell/tissue expansion and growth. Such growth in developing leaf tissue results in the enlargement of specific tissues and the separation of cells that were closely associated during early stages of development. The latter process results in the development of air spaces within the leaf. These changes presumably facilitate the physiological function of the leaf and represent an important aspect of leaf function (MAKSYMOWYCH, 1973).

Unlike the response showed by facultative shade plants, a deep light stress in *A. commutatum* affect leaf expansion (Tables 1 and 2) in a greater proportion than other anatomical attributes in response to a decrease in photosynthate availability. Anatomical changes from shade species have been contradictorily reported; an increase in leaf thickness under low light was found in *Aphelandra squarrosa* (obligate shade plant) (McCONNELL et al., 1984) and *Fatsia japonica* (relatively light-tolerant shade plant) (ARAUS et al., 1986; VIDAL et al., 1990). On the other hand, ARAUS et al. (1986) reported a low anatomical adaptation pattern in the obligate shade plant *Philodendron scandens*. Our

results (Figure 2) are in agreement with ARAUS et al. (1986) and the fact that anatomical changes under a low-light environment were not significant related to previous high-light leaves for two *A. commutatum* plant size (Figure 2) would suggest that the leaf structure would be not a limiting factor when light availability is increasing during spring and summer months.

## Conclusion

Ornamental plant growers commonly pack small plants densely during winter for energy saving. A possible consequence is a decrease in leaf expansion rate due to low light conditions. Considering the results obtained here for *A. commutatum*, this strategy should be replaced by packing bigger plants grown during high light conditions: its higher photoassimilate reserves would limit possible decreases on leaf expansion rate.

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