Morphological Plasticity of *Dracaena sanderana* 'Ribbon' in Response to Four Light Intensities

Svoboda V. Vladimirova¹, Dennis B. McConnell², and Michael E. Kane³
Department of Environmental Horticulture, University of Florida, Gainesville, FL 32611

Richard W. Henley²

Central Florida Research and Education Center, 2807 Binion Road, Apopka, FL 32703-8504

Additional index words. shade level, leaf variegation, growth rate

Abstract. Effects of four shade levels on the growth of *Dracaena sanderana* hort Sander ex Mast. 'Ribbon' were evaluated. The experiment was conducted using model structures providing four shade levels (47%, 63%, 80%, and 91%). *Dracaena sanderana* exhibited morphological plasticity in growth and development. Under 63% and 80% shade, plants grew faster and achieved greater biomass than those grown in 47% and 91% shade. The lowest (47%) and the highest shade (91%) provided supraoptimal and suboptimal light levels, respectively. More leaves with less leaf area, larger internodes, and larger root mass developed in plants grown in 63% shade. Fewer leaves with larger leaf areas, smaller internodes, and smaller root mass developed in plants grown in 80% shade. Plants grown in 47% or 63% shade were less variegated than those grown in 80% or 91% shade. Maximum leaf variegation occurred under 91% shade.

Foliage plant production represents an important agricultural industry in the United States with a net wholesale value of \$496 million in 1994 (U.S. Dept. of Agriculture, 1996). A large part of this industry is devoted to plants with multicolored foliage. Of 135 plant families reported to possess leaf color variegation, the genus *Dracaena* L. (Agavaceae), represents an economically important group. Commonly grown members of this genus are *D. fragrans* (L.) Ker-Gawl., *D. deremensis* L. Engl., *D. marginata* Lam., *D. surculosa* Lindl., and *D. sanderana* hort Sander ex Mast. Popularity of dracaenas can be attributed to their superior performance in interior environments and their diversely colorful foliage (Anderson, 1976), which is enhanced by various leaf variegation patterns. Variegated cultivars of *Dracaena* are usually most popular; however, varying environmental factors can change variegation from being strongly expressed to barely noticeable. Light intensity influences the amount of variegation in *Dracaena* sp. (Conover and Poole, 1981). General recommendation for light levels during production of smaller varieties is 280–350

$\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ (maximum) or 70% to 80% shade (Poole et al., 1991). *Dracaena sanderana* hort. Sander ex Mast. 'Ribbon' (Sander's *Dracaena*, Belgian Evergreen) belongs to a group of plants referred to as periclinal GWG chimeras (Stewart and Dermen, 1979). The notation GWG relates to the potential for chlorophyll development in the three histogenic shoot meristem layers: LI—green (G); LII—white (W); and LIII—green (G). Foliage growers have reported that *D. sanderana* 'Ribbon' had increased leaf variegation under shading exceeding 80%. The width of white marginal tissue also decreased as light levels increased (Conover and Poole, 1981). In contrast, two high light-adapted species, *Cordyline terminalis* (L.) Kunth. (Conover and Poole, 1981) and *Codiaeum variegatum* (L.) Blume (Carpenter and Nautiyal, 1969), both displayed increased color intensity, as well as increased amount of variegation, under higher light levels. Apparently, differences exist in variegated plant response to light intensity depending on the nature of the variegation and the plant's light intensity optima.

No detailed study on effects of light intensity on the growth and development of *D. sanderana* has been reported to date. This study was undertaken to investigate growth response and amount of variegation of *D. sanderana* 'Ribbon', a variegated shade oblige plant, to four light levels. Measures were taken to minimize other environmental variables under different shade levels.

Materials and Methods

This investigation was conducted at the Univ. of Florida's Environmental Horticulture Greenhouse complex (Gainesville).

Twenty-four arch-shaped shade structures (1.85 × 0.8 × 0.8 m, length × width × height) were located on a gravel bed with their longitudinal axes oriented north–south. The structures consisted of polyvinyl (PVC) pipe frame covered with commercial shade fabric with three shade levels: 47%, 63%, and 80%. In addition, 63% and 80% shade fabrics were combined to obtain a shade factor of 91%. The lowest shade was selected after preliminary experiments with *D. sanderana* showed light intensities equal to or greater than 70% of full sun severely reduced growth. Each shade treatment was replicated six times in a completely randomized design. Light intensity and air temperature were monitored in 12 randomly selected structures, with three replicates for each treatment. Light intensity levels were measured using photosynthetically active radiation (PAR) sensors (Sunceram solar cell; Panasonic Co., Trenton, N.J.). Air temperatures were measured using copper-constantan thermocouples (AWG.20). The signals from the thermocouples and the solar cells were recorded hourly by a datalogger (CR-10; Campbell Scientific, Logan, Utah). Relative humidity was monitored using an aspirated wet bulb psychrometer. Details on experimental design and analysis of environmental variables are published elsewhere (Vladimirova et al., 1996).

Data analysis revealed air temperatures under shade were normally above ambient air temperature between 6:00 AM and 6:00 PM. Hourly observations revealed that air temperature differentials fluctuated from ambient by as much as 6 °C. However, when averaged over a 20-d period, maximum air temperature differentials between shade levels and ambient were 1.2 to 1.9 °C. Although air temperatures under shade exceeded ambient temperature, differences between shade treatments were small. Relative humidity was consistently above 80% from midnight to 7:00 AM. Plants received irrigation from three sources: natural precipitation, an overhead sprinkler system, and manual watering. The amount of natural precipitation and sprinkler irrigation penetrating the shade cloth was determined with a rain gauge positioned inside the shade structures. The amount of water applied manually was determined separately for each shade level. The base figure for each irrigation period was: natural precipitation plus sprinkler irrigation plus manual irrigation to equal 1 L per container per application. During the experiment, plants were watered three times a week in July and August and two times a week in September and October.

To ensure lower and more uniform root substrate temperatures, two measures were taken. Plants in 3.1-L (REB Plastics, Orlando, Fla.) containers were double-potted into 6.2-L containers. The space between containers was filled with pea gravel at the bottom and sand on the sides, and two 40 × 40-cm pieces of burlap and one piece of ground cover with a hole for the plant stem were placed on the top of each container. Substrate temperatures were monitored throughout July and August via handheld soil thermometers inserted 15 cm below

Received for publication 31 Oct. 1996. Accepted for publication 4 Mar. 1997. Florida Agricultural Experimental Station journal series no. R-05318. Based on part of a thesis accepted in partial fulfillment of the requirements for a MS degree at the Univ. of Florida. We thank R. Stamps and G. Knox for review of the manuscript and instructive criticism. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.

¹Graduate Student.

²Professor.

³Associate Professor.

the surface in each of the quadrants of the containers at 1:00 PM and 3:00 PM. Double potting and covering the container surface kept maximum substrate temperatures below 32 °C compared to 45 °C recorded for container-grown plants in full sun (Ingram, 1981). Based on statistical analysis of monitored environmental parameters under the four shade levels, light intensity, and slight to moderate increases in air and substrate temperatures, were the major factors that influenced *D. sanderana* growth in the shade structures.

The experiment was initiated 7 July 1994. Forty-eight rooted cuttings were transplanted from 10-cm containers into 3.1-L containers containing a commercial potting mix (Metro Mix 500; Grace Sierra, Milpitas, Calif.). The experimental unit consisted of two plants in every shade structure providing six replicates for each shade level. Plants were top-dressed with 5 g per pot 20N-8.7P-16.6K slow-release fertilizer (Grace Sierra) at experiment initiation, and every 6 weeks thereafter. The experiment was terminated 31 Oct. 1994. Leaf area measurements were taken with an area meter (ΔT Area Meter System; Decagon Devices, Pullman, Wash.). After determining total leaf area, the sensor sensitivity threshold was adjusted to measure only the green area. The amount of variegation was assessed by subtracting the green area from the total leaf area. During the course of the experiment, plant height was measured biweekly. Other measurements included shoot and root fresh and dry mass, number of roots, number of leaves, stem fresh and dry mass. Final measurements for individual leaves included leaf fresh and dry mass, leaf length and width, total leaf area, and white leaf area. Final measurements included individual internode length and diameter.

Statistical analysis of growth parameters and morphological characteristics was performed using the standard GLM for CRD procedure (SAS Institute, Cary, N.C.).

Results and Discussion

Dracaena sanderana plants exhibited marked differences when grown under four shade treatments (Table 1, Fig. 1). All monitored growth parameters were significantly affected by shade level. Shoot fresh and dry

mass were greatest in plants grown under 80% shade, while root fresh and dry masses were highest under 63% shade. Plants grown under 91% shade had the lowest values for these growth parameters (Table 1). Shoot fresh and dry mass showed a significant quadratic response with increasing shade levels, both curves peaking at $\approx 66\%$ and 70% shade for shoot fresh and shoot dry mass, respectively. Root fresh and dry mass response curves were similar to shoot fresh and dry mass curves but peaked at $\approx 59\%$ and 68% shade, respectively.

In a study of 10 species, Whitcomb (1979) found different responses of shoot and root mass to light levels ranging from 25% to 73% shade, depending on light preferences of the species. Shoot and root mass of sun-requiring plants (*Juniperus chinensis* L. Lindl., *Pyra-cantha coccinea* M.J. Roem., *Euonymus japonica* Thunb., *Elaeagnus macrophylla* Thunb.) decreased as shade level increased. Shade-preferring *Rhododendron* sp. L., *Berberis julianae* C.K. Scheid., *Buxus sempervirens* L., *Abelia* $\times$ *grandiflora* (Andre) Rehd., and *Ilex cornuta* Lindl. & Paxt. had greater shoot and root mass as shade levels were increased to 30%, then shoot and root mass decreased at each increasing shade level. The shade obligate plant in the study, *Aucuba japonica* Thunb., displayed a different response. As shade levels increased to 63%, shoot and root mass increased. As shade levels increased above 63%, shoot mass increased and root mass decreased. Thus, the results of our work on a shade obligate plant is consistent with Whitcomb's (1979) report.

Dracaena sanderana shoot : root ratio (dry mass) was highest for plants grown under 80% shade, followed by 91% shade (Table 1). An increase in shoot : root ratio under lower light levels has frequently been reported for "sun" and "shade" plants. The shoot : root ratio of *Ficus benjamina* L. was higher under 80% than under 47% shade (Collard et al., 1977). Rice and Bazzaz (1989) proposed that the decrease in shoot : root ratio under increased light levels may serve as a means of providing an adequate water supply in response to increased transpiration rate. According to Aung (1974), shoot : root ratio decreases under stressful conditions. The increased root development (root fresh mass) under 47% and 63% shade in our study suggests that those light

levels exceeded the optimum for shoot growth of *D. sanderana*.

Plant height was also affected by light levels (Table 1, Fig. 1). Plants in 80% shade were tallest, followed by plants in 63%, 47%, and 91% shade. Plant height increased linearly over time (Fig. 2). The slopes of the lines were significantly different and showed two distinct rates of increase; 47% and 91% shade in one group and 63% and 80% shade in the other. The difference between final plant height within each group was less than 1.8 cm.

Number of leaves per plant varied with shade treatments (Table 1) and exhibited a quadratic response. Plants from 91% shade had the lowest number of leaves, and plants from 63% the highest (the difference was six leaves). Leaf number of *Leea coccinea* Planch. was not affected when plants were grown under shade levels varying from 0% to 92% (Sarracino et al., 1992). However, in the same study, leaf number in *L. rubra* Planch. was significantly affected by shade level and fewest leaves developed under 92% shade. *Syngonium podophyllum* Scott. had fewer leaves under 80% than under 47% shade (Chase and Poole, 1987). In contrast, number of *Butia capitata* (Mart.) Becc. and *Livistona chinensis* (Jacq.) R. Br. ex Mart. fronds remained unchanged when plants were grown under 30%, 63%, and 80% shade (Ingram and McConnell, 1980).

Leaf fresh and dry mass showed a quadratic response (Table 2); however, specific leaf mass was not significantly affected by shading. Leaf length and leaf width also displayed a quadratic response (Table 2) with longest and widest leaves in plants under 80% shade.

Total leaf area displayed a quadratic response with a peak at 80% shade (Table 2), and lowest values for leaves of plants grown under 47% and 63% shade. A similar curvilinear response to increased shade levels for total leaf area was found in *L. coccinea* Planch. (Sarracino et al., 1992); total leaf area increased with each incremental shade increase from 0% to 63% but drastically declined under 92% shade. In contrast, *L. rubra* Planch. developed largest leaf areas under 0% shade. Leaf areas of the tropical species *Theobroma cacao* L. and *Coffea* sp. L. exhibited a linear decrease as shade levels decreased from 85%

Table 1. Growth characteristics of *D. sanderana* plants under four shade levels.

Observation	Shade level (%)				Significance <i>P</i> > <i>F</i>	Equation	<i>R</i> ²
	47	63	80	91			
Fresh mass (g)							
Shoot	59.9 ^a	65.8	66.8	46.1	0.02	$y = -6.67x^2 + 29.33x + 36.45$	0.95
Root	11.6	13.1	10.9	8.4	0.01	$y = -0.97x^2 + 3.68x + 9.04$	0.95
Stem	30.0	31.9	31.5	19.6	0.01	$y = -3.44x^2 + 14.06x + 18.89$	0.96
Dry mass (g)							
Shoot	9.0	10.9	11.4	7.9	0.05	$y = -1.34x^2 + 6.43x + 3.83$	0.95
Root	1.7	2.4	1.7	1.3	0.02	$y = -0.32x^2 + 1.42x + 0.71$	0.65
Stem	3.6	4.5	5.4	3.0	0.01	$y = -0.82x^2 + 4.03x + 0.23$	0.83
Shoot : root ratio (dry mass)	5.4	4.6	6.7	5.8	0.05	$y = 0.38x + 4.58$	0.23
Plant height (cm)	51.3	60.7	61.7	49.6	0.01	$y = -5.36x^2 + 26.38x + 30.07$	0.99
Leaf number	28.7	29.3	26.7	23.3	0.05	$y = -x^2 + 3.12x + 26.7$	0.99
Root number	22.7	27.1	26.7	27.2	0.05	$y = -0.98x^2 + 6.18x + 17.82$	0.89

^a Means based on a sample of six replicates.

Fig. 1. Representative plants of *D. sanderana* after 15 weeks of growth under 47%, 63%, 80%, or 91% shade. Bar = 5 cm.

Fig. 2. Plant height of *D. sanderana* as affected by shade level after 15 weeks of growth. Lines calculated using mean values.

to 0% shade (Murray and Nikols, 1966).

Leaf variegation differed in *D. sanderana* plants under the four shade levels (Fig. 3). Other investigators have reported highly variegated plants turned green when exposed to low light levels. Examples were *Codiaeum variegatum* (L.) Blume (Bequette et al., 1985; Carpenter and Nautiyal, 1969), *Ligustrum ovalifolium* var. *aureum* Hassk. (Kunst, 1983; Kunst and Wrischer, 1984), and *Fraxinus excelsior* var. *aurea* L. (Wrischer et al., 1986). In contrast, when white leaf area was expressed as percent of total leaf area, leaves of *D. sanderana* grown in the highest shade level (91%) had the highest percent white area ($\approx 35\%$) (Table 2). Leaves were smaller under 91% than under 80% shade, but the white area was larger. Although the difference in total leaf area of plants grown under 47% vs. 80% shade was $\approx 7 \text{ cm}^2$, the difference in variegated leaf area expressed as a percent of total area was only $\approx 4\%$. The percent leaf variegation of *Peperomia obtusifolia* (L.) A. Dietr., also a periclinal GWG chimera, increased as shade levels increased from 27% to 73% (Shen and Seeley, 1984). The dissimilarity in the nature of both plants (*P. obtusifolia* is a dicot and *D. sanderana*, a monocot), and the similarity of light levels in their natural habitats, and their response to increasing shade levels suggest a common response mechanism of periclinal GWG chimeral shade obligate plants to low light levels.

Shading affected internode length and diameter (Table 2). Internode length exhibited a quadratic response and peaked at 80% shade, then decreased slightly in stems of plants grown under 91% shade. Thickest internodes developed in plants grown under 47% shade. Plants grown in shaded habitats develop longer and narrower internodes than their full sun counterparts (Doley, 1978). Conover and Poole (1977) reported significant decreases in trunk caliper of *F. benjamina* L. as shading increased from 0% to 80%. Similarly, stems of *Theobroma cacao* L. displayed a curvilinear response to shading (Murray and Nichols, 1966). In the range from 0% to 75% shade, the stem diameter was largest under 25% shade, and smallest under 75% shade. Our results indicated that a shade obligate plant exhibited a similar decrease in internode diameter as

Table 2. Morphological features of leaves and internodes of *D. sanderana* grown under four shade levels.^z

Observation	Shade level (%)				Significance <i>P</i> > <i>F</i>	Equation	<i>R</i> ²
	47%	63%	80%	91%			
Leaf							
Fresh mass (g)	1.2	1.2	1.4	1.1	0.03	$y = -0.09x^2 + 0.45x + 0.73$	0.67
Dry mass (g)	0.21	0.22	0.24	0.20	0.05	$y = -0.01x^2 + 0.08x + 0.13$	0.84
Specific mass (g·cm ²)	0.032	0.031	0.031	0.030	NS	NS	
Length (cm)	15.1	15.0	17.8	15.5	0.05	$y = -0.062x^2 + 0.37x + 2.38$	0.63
Width (cm)	2.7	2.8	3.0	2.8	0.05	$y = -0.53x^2 + 3.07x + 12.17$	0.38
Leaf area (cm ²)							
Total	35.0	36.4	41.7	38.3	0.02	$y = -1.22x^2 + 7.63x + 27.91$	0.68
White	8.2	8.1	11.6	12.8	0.05	$y = 0.32x^2 + 0.13x + 7.43$	0.90
White (% of total) ^y	21.6	21.0	25.7	34.5	0.05	$y = 2.35x^2 - 7.41x + 26.6$	0.99
Internode							
Internode length (cm)	1.59	1.68	1.87	1.70	0.05	$y = -0.065x^2 + 0.38x + 1.25$	0.74
Internode diameter (cm)	1.07	1.04	1.02	0.89	0.05	$y = -0.025x^2 + 0.07x + 1.02$	0.96

^zValues represent means of a combined sample of all individual leaves and internodes developed under experimental conditions.

^yData were subjected to arcsin transformation prior to analysis.

Fig. 3. Leaf variegation of representative plants of *D. sanderana* grown under 47% (A), 63% (B), 80% (C), and 91% (D) shade after 15 weeks of growth.

shade levels increased; however, the response was shifted toward higher shade.

The ability of a plant to change its morphology, anatomy, and physiology in response to changes in surrounding environment is termed plasticity. The extent of plasticity varies from one species to another. Preliminary experiments proved that light levels in excess of 30% shade caused severe growth reduction and death in *D. sanderana*. Based on these results, the light levels used in this study ranged from 47% to 91% shade. According to Smith (1982), light levels under dense plant canopies can be reduced to as little as 5% of the incident light above the canopy. In our experiment, only the last treatment (91% shade) was close to the light intensity of a densely shaded habitat.

Our results indicated that the highest shade level (91%) significantly reduced the growth rate of both below and aboveground plant biomass. Plants grown under 91% shade had shorter stems and fewer leaves than plants grown under 80%, 63%, and 47% shade levels. Plants from 47% shade were intermediate between plants from 91% shade and counterparts from 63% and 80% shade. As indicated in Table 1, this was true for all examined morphological features except number of roots, for which 47% shade plants had the lowest value. In this experiment, apparently the growth rate of *D. sanderana* was optimal under maximum light levels in the range 500 to 1000 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ (63% to 80%) shade.

In conclusion, for optimal growth rate and

marketable variegation, *D. sanderana* 'Rib-bon', when grown in shade structures, should be provided with light levels of 500 to 600 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ (80% shade). However, if $\approx 35\%$ variegation of the leaf area is desired, light levels should be between 200 to 250 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ (91% shade).

Literature Cited

- Anderson, T. 1976. *Dracaenas*. Bul. Fairchild Trop. vol. 5:3-15.
- Aung, L.H. 1974. Root-shoot relationships, p. 29-61. In: E.W. Carson (ed.). The plant root and its environment. University Press, Virginia Polytechnic Inst., Blacksburg.
- Bequette, B.L., T.M. Blessington, and J.A. Price. 1985. Influence of lighting systematics on the interior performance of two croton cultivars. *HortScience* 20:927-931.
- Carpenter, W.J. and J.P. Nautiyal. 1969. Light intensity and air movement effects on leaf temperature and growth of shade requiring greenhouse crops. *J. Amer. Soc. Hort. Sci.* 94:212-214.
- Chase, A.R. and R.T. Poole. 1987. Effect of fertilizer, temperature and light level on growth of *Syngonium podophyllum* 'White Butterfly'. *J. Amer. Soc. Hort. Sci.* 112:296-300.
- Collard, R.M., J.N. Joiner, C.A. Conover, and D.B. McConnell. 1977. Influence of shade and fertilizer on light compensation point of *Ficus benjamina*. *J. Amer. Soc. Hort. Sci.* 20:900-902.
- Conover, C.A. and R.T. Poole. 1977. Influence of shade and fertilizer source and level on growth quality and foliar content of *Philodendron oxycardium* Schott. *J. Amer. Soc. Hort. Sci.* 99:150-152.
- Conover, C.A. and R.T. Poole. 1981. Environmental factors, p. 269-283. In: J. Joiner (ed.). Foliage plant production. Prentice-Hall, Englewood Cliffs, N.J.
- Doley, D. 1978. Effects of shade on gas exchange and growth in seedlings of *Eucalyptus grandis* Hillex Maiden. *Austral. J. Plant Physiol.* 5:723-738.
- Ingram, D.L. 1981. Characterization of temperature fluctuations and woody plant growth in white poly bags and conventional black containers. *HortScience* 16:762-763.
- Ingram, D.L. and D.B. McConnell. 1980. Effect of production shade and fertilization levels on establishment of palms in the landscape. *Proc. Fla. State Hort. Soc.* 93:72-74.
- Kunst, L. 1983. Plastid development in leaves of *Ligustrum ovalifolium* Hassk. var. *aureum* at high and low light conditions. *Acta Bot. Croat.* 42:29-36.
- Kunst, L. and M. Wrisher. 1984. Adaptational changes of plastids in the leaves of *Ligustrum ovalifolium* Hassk. var. *aureum* at different light levels. *Protoplasma* 122:132-137.
- Murray, D.B. and R. Nikols. 1966. Light, shade and growth in some tropical plants, p. 249-261. In: R. Bainbridge, G.C. Evans, and O. Rackham (eds.). Light as an ecological factor. Blackwell, Oxford.
- Poole, R.T., A.R. Chase, and L.S. Osborne. 1991. *Dracaena*, CFREC—A foliage plant research note. RH-85-D. Inst. Food Agr. Sci., Univ. of Florida, Gainesville.
- Rice, S.A. and F.A. Bazzaz. 1989. Growth consequences of plasticity of plant traits in response to light conditions. *Oecologia* 78:508-512.
- Sarracino, J.M.R., M.R. Merritt, and C.K. Chin. 1992. Morphological and physiological characteristics of *Leea coccinea* and *Leea rubra* in response to light flux. *HortScience* 27:400-403.
- Shen, G.W. and J.G. Seeley. 1984. The effect of shading and nutrient supply on variegation and nutrient content of variegated cultivars of *Peperomia obtusifolia*. *J. Amer. Soc. Hort. Sci.* 108:429-433.
- Smith, H. 1982. Light quality, photoreception, and plant strategy. *Annu. Rev. Plant Physiol.* 33:481-518.
- Stewart, R.N., and H. Dermen. 1979. Ontogeny in monocotyledonous plants as revealed by studies of the developmental anatomy of periclinal chimeras. *Amer. J. Bot.* 66:47-48.
- U.S. Dept. of Agriculture. 1996. Floriculture crops: 1995 summary. U.S. Dept. Agr., Natl. Agr. Stat. Serv. Sp. Cr. 6-1(96). Washington, D.C.
- Vladimirova, S.V., R.A. Bucklin, and D.B. McConnell. 1996. Influence of shade level, wind velocity, and wind direction on interior air temperatures of model shade structures. *Trans. ASAE* 39:1825-1830.
- Whitcomb, C.E. 1979. Growing media, p. 432-459. In: C.E. Whitcomb (ed.). Plant production in containers. Lacebark Publ., Cambridge, Mass.
- Wrisher, M., K. Hlousek-Rodojic, L. Kunst, and N. Ljubecic. 1986. Differentiation of chloroplasts in leaves of aurea plants, p. 685-690. In: G. Akoyunoglou and H. Senger (eds.). Regulation of chloroplast differentiation. Alan R. Liss, New York.