Variation in Chemical Composition of *Dracaena sanderiana* Leaves as Influenced by Leaf Maturity and Shade Intensity[1]

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INTRODUCTION

The exportation of ornamental plant specialties, foliage plants in particular, is an important item in our economy. Foliage specialties are such ornamentals as *Dracaena sanderiana, D. sanderiana borinquensis, D. marginata, D. fragans massangeana, D. godseffiana, Dieffenbachia* spp., *Aglaonema* spp. and others. The group in general is exported in several forms and sizes, but *D. sanderiana* surpasses all the others in importance.

The production of ornamental foliage plants in Puerto Rico for decorative purposes shows growth potential, but little research has been conducted for this group. Studies in Puerto Rico (2,4) with *D. sanderiana* and *godseffiana* reported the effects of mineral nutrition on growth and leaf mineral composition but did not indicate the type of leaf selected for the analyses. The authors reported that both affected and unaffected areas of the plants were represented in the samples but the data is not differentiated in the tables. Leaf maturity in guava terminals is a very important factor affecting mineral composition, as shown by Rodríquez (3).

This paper presents the results of studies undertaken to show how leaf maturity affects the chemical composition of *D. sanderiana* leaves grown at five shade intensities.

MATERIALS AND METHODS

Propagating material was obtained from a commercial nursery. The material was separated as to vigor, selecting 12- to 15-inch tops with an average length of 13½ inches. The tops were then rooted in a constant mist propagator before being transferred to concrete beds. The beds contained a mixture of peat and Cataño sand in a 1:1 proportion.

The rooted tops were placed under 47-, 51-, 63-, 76- and 92-percent actual shade. They were fertilized with a 16-4-8 mixture every 4 months

[1] This work was carried on as part of project H-248. Manuscript submitted for publication to Editorial Board September 1, 1972.

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at an approximate rate of 500 pounds of nitrogen per acre per year. The experiment was irrigated uniformly with sprinklers when evaporation of at least ½-inch was accumulated from a Livingstone atmometer attached to a graduated burette.

Seventy-five tops of *D. sanderiana* were selected and sampled from the same vigor and planting distance experiment, 15 each from five different shade intensities.

All fully opened leaf blades were separated from each top. Each one was coded with a number starting from zero through the one in which the node was all or partly visible. Numbers above that were designated as negative

TABLE 1.—*Effects of leaf position and actual shade intensity on leaf phosphorus content of* **D. sanderiana L.**[1]

Leaf position	Percent actual shade				
	92	76	63	51	47
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
−2	0.19	0.21	0.22	0.20	0.19
−1	.18	.21	.22	.19	.18
0	.17	.21	.23	.19	.17
1	.19	.23	.24	.20	.18
2	.18	.23	.24	.21	.18
3	.18	.23	.25	.20	.17
4	.16	.23	.25	.20	.18
5	.16	.23	.26	.20	.18
6	.17	.24	.26	.21	.18
7	.16	.23	.25	.20	.18
8	.16	.23	.24	.20	.18
9	.16	.21	.23	.19	.17
9+[2]	.16	.21	.23	.19	.17

[1] All values are on a dry-weight basis.
[2] Composite of leaves above 9th position.

and those below as positive. All the leaves from the 15 tops having the same number under the same light exposure were composited. A total of 15 leaf blades were analyzed in each light exposure. All leaves above the ninth position were put together in one sample. Foreign matter was carefully removed without wetting.

All the analyses presented on a dry-weight basis were made in the Central Analytical Laboratory of the Agricultural Experiment Station. The data was statistically analyzed through regression by fitting linear equations and second degree curves to the results.

RESULTS AND DISCUSSION

The results of the analyses of *D. sanderiana* leaves from plants grown at the different shade intensities show, as expected, that the different nutrients analyzed may increase or decrease with leaf maturity. The same tendency was observed for the different shade intensities.

Leaf phosphorus did not exhibit a great variation with age or at different shade intensity levels (table 1). Low values were recorded both at the 92- and 47-percent shade, the two extreme levels of the experiment. At each shade intensity level, leaf maturity did not consistently affect the leaf phosphorus. Cibes and Samuels reported values as high as 0.28 percent for *D. sanderiana* in the complete solution while in the minus phosphorus, the value dropped to 0.02 percent (2). Apparently there was an ample supply of phosphorus with the formulation used. Moreover, phosphorus is a relatively mobile element in the plant, and its deficiency symptom will be reflected first in the mature leaves. In our experiment, the older leaves showed phosphorus values as high as the younger ones.

TABLE 2.—*Effects of leaf position and actual shade intensity on leaf nitrogen content of* **D. sanderiana L.**[1]

Leaf position	Percent actual shade				
	92	76	63	51	47
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
−2	3.01	3.22	3.26	3.27	3.27
−1	3.18	3.37	3.33	3.38	3.41
0	3.35	3.48	3.42	3.46	3.33
1	3.42	3.53	3.36	3.58	3.37
2	3.43	3.44	3.26	3.50	3.34
3	3.37	3.32	3.13	3.45	3.24
4	3.22	3.07	3.10	3.37	3.19
5	3.04	3.24	3.03	3.27	3.09
6	3.08	3.14	2.92	3.27	3.00
7	3.01	2.97	2.79	3.17	2.92
8	2.81	2.87	2.73	3.04	2.75
9	2.89	2.64	2.74	2.84	2.60
9+[2]	2.60	2.48	2.50	2.61	2.27

[1] All values are on dry-weight basis.
[2] Composite of leaves above 9th position.

Nitrogen content varied markedly with leaf position. Leaf nitrogen tended to increase with age until the leaves were fully mature. The content dropped consistently with age from there on (table 2 and figs. 1,A, 2,A, 3,A, 4,A, and 5,A). The functional relationship fitted to the values between leaf position and nitrogen content explains a high percentage of the total variation in each of the shade intensity levels. Nitrogen is a mobile element within the plant with a greater accumulation in active areas. Nitrogen values in this experiment were somewhat higher than those obtained by Cibes and Samuels (2). Nitrogen is the element most affected by the harvesting of *D. sanderiana*, suggesting that an ample supply is needed for an adequate growth of the tops. A 9-inch top with an average weight of 18 g., 70 percent moisture and 3 percent nitrogen may remove around

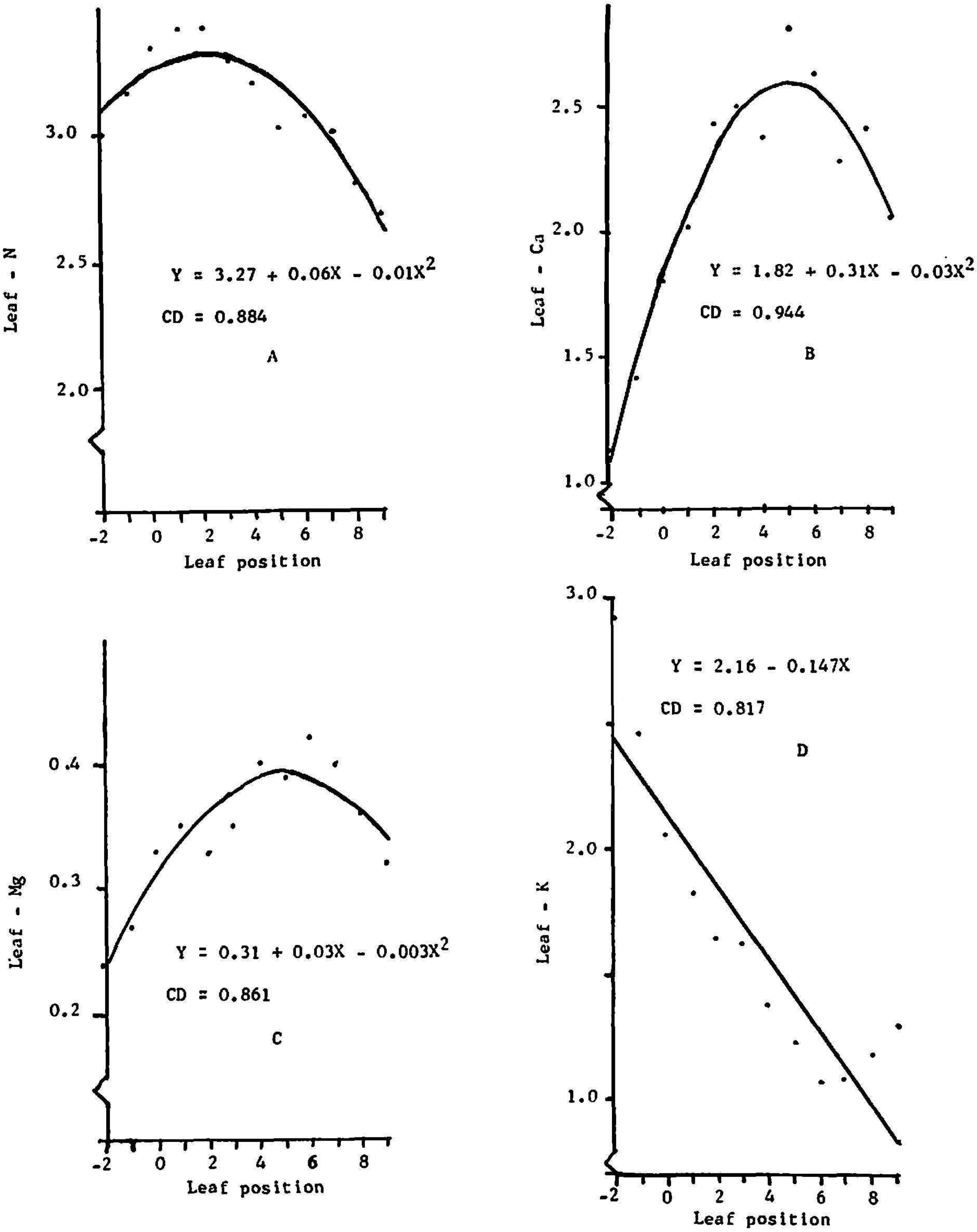

FIG. 1.—Relationship between leaf maturity and nutrient content at 92-percent shade intensity.

162 mg. of nitrogen. At that rate 1,000 tops will remove 162 g. of nitrogen from the soil. If they are planted 9 inches square, they will remove over 12 kg. per acre in each harvesting. The removal rate increases since more than one top is produced in each stump. However, enough nitrogen was applied to the plants in this experiment.

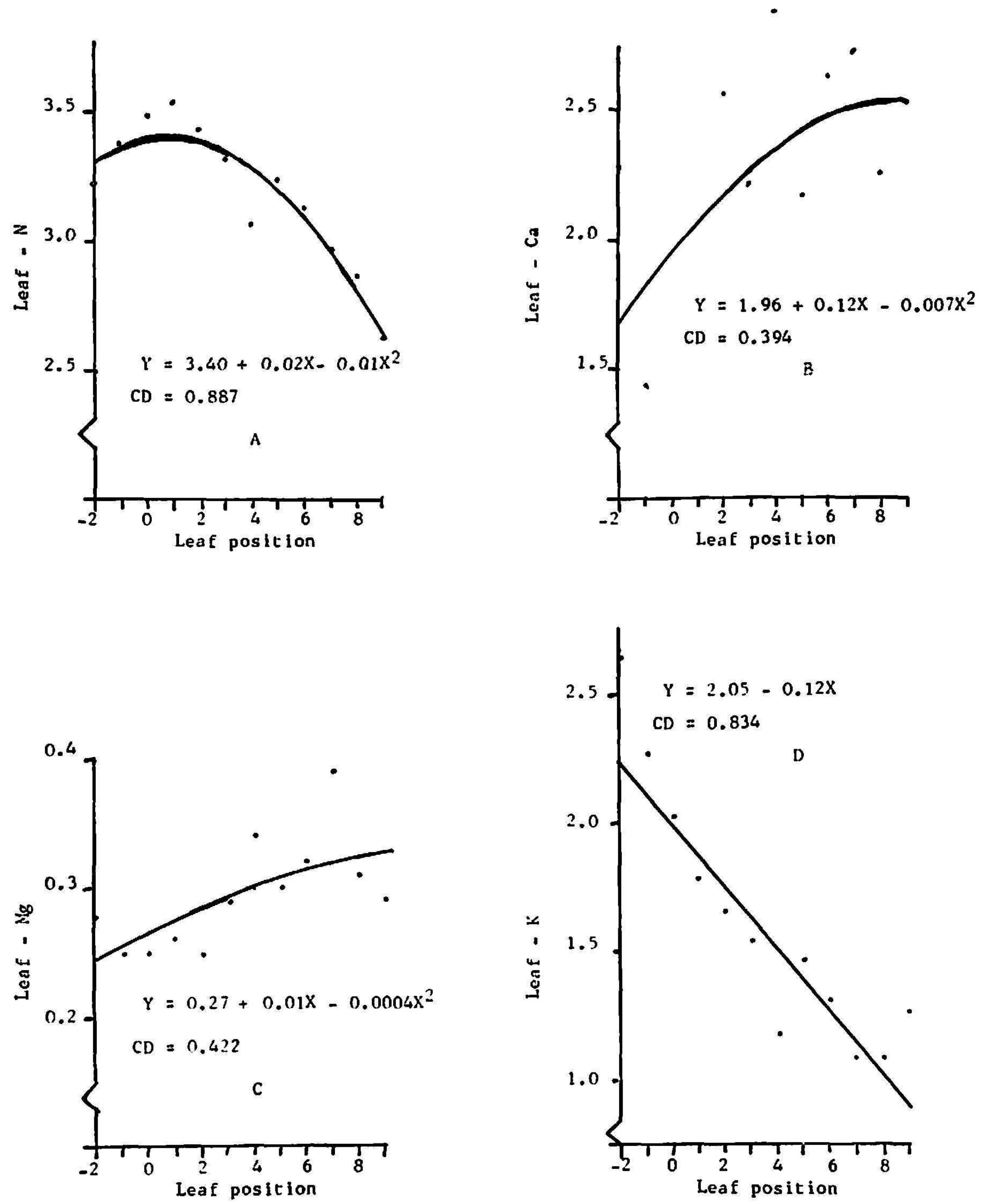

FIG. 2.—Relationship between leaf maturity and nutrient content at 76-percent shade intensity.

Shade intensity does not seem to affect the nitrogen content markedly although higher nitrogen values in the same leaf position were recorded for the lower shade levels in the young leaves, but not so in the older leaves. The higher the light intensity level, the more the growth activity and consequently the more the amount of nitrogen used.

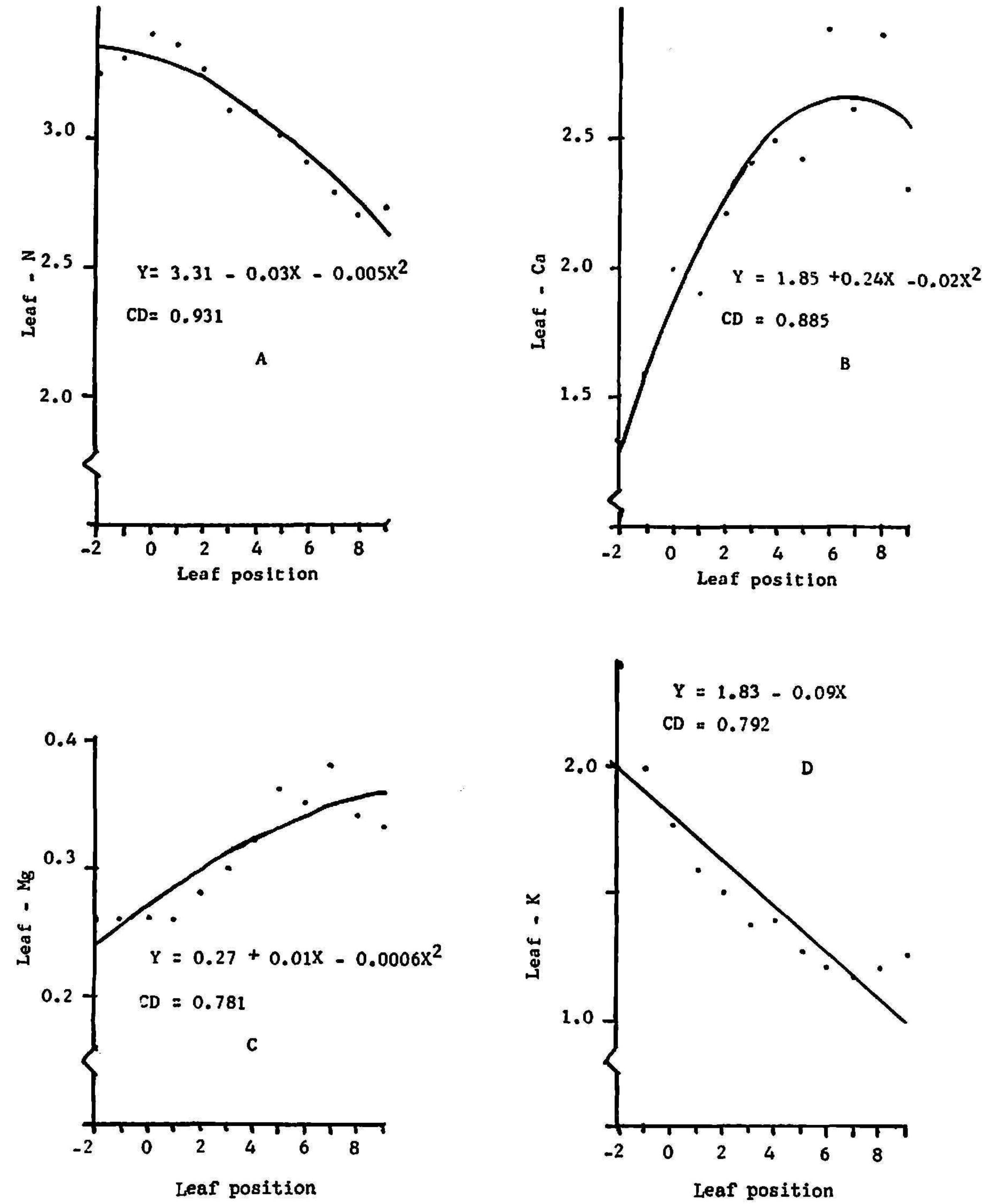

FIG. 3.—Relationship between leaf maturity and nutrient content at 63-percent shade intensity.

Leaf calcium content is presented in table 3 and figures 1,B, 2,B, 3,B 4,B and 5,B. The calcium content tended to increase with leaf maturity to a point at which a drop took place. That tendency was observed in all five shade intensities although at 76- and 47-percent shade the first leaf position exhibited an unexplained high calcium content. The functional relationship $Y = A + BX - CX^2$ explains a high percentage of the variation

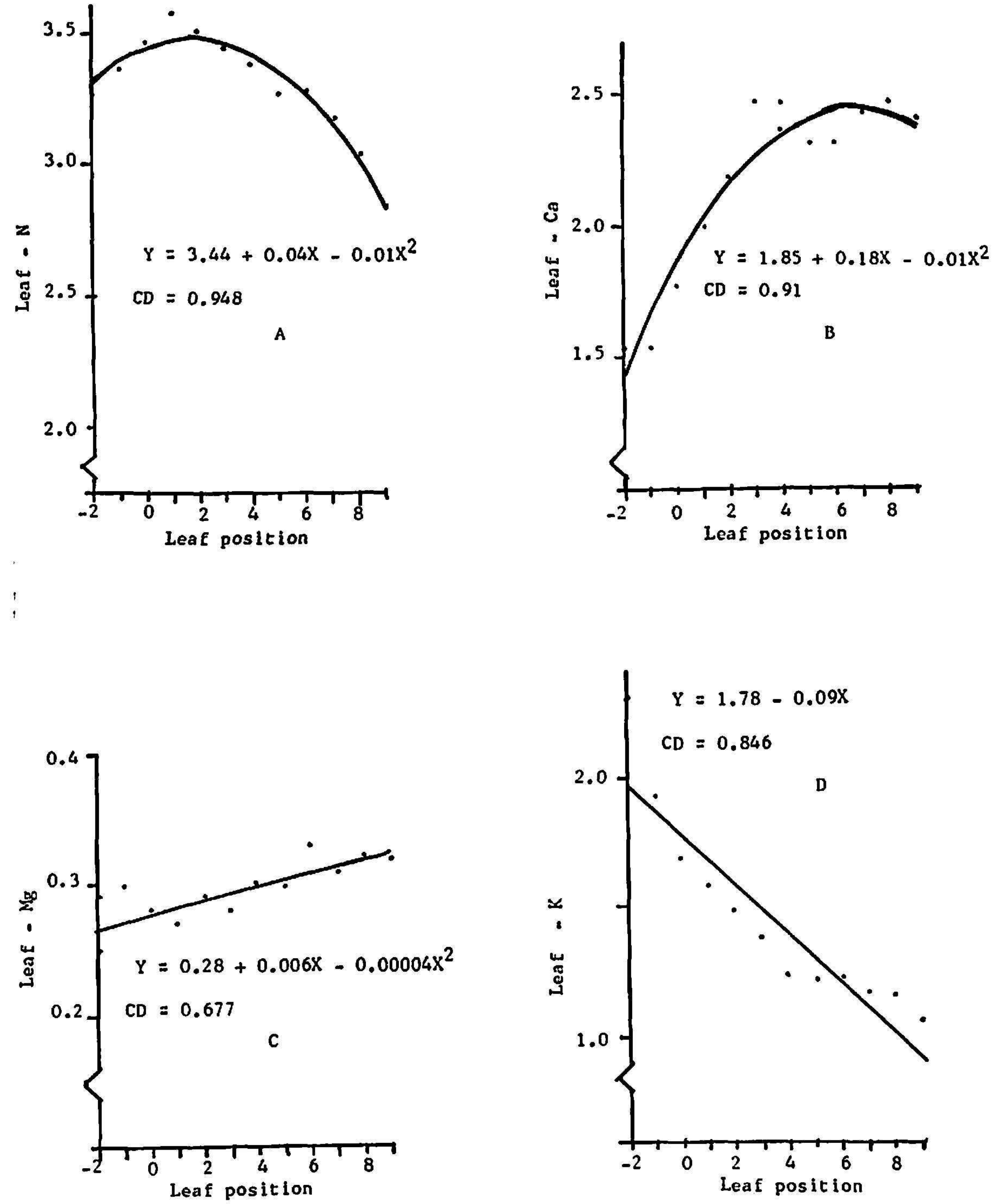

FIG. 4.—Relationship between leaf maturity and nutrient content at 51-percent hade intensity.

for the 92-, 63- and 51-percent shade but not so for the other two cases. Calcium is a component of the cell walls in the form of pectate, with very little mobility. Most of the leaf calcium values in the experiment were higher than those obtained by Cibes and Samuels under controlled controlled conditions (2). The variation in composition between shade intensities does not follow a definite pattern.

Leaf magnesium values are presented in table 4 and figures 1,C, 2,C, C,3, 4,C, and 5,C. As in the case of nitrogen and calcium, there was an increase

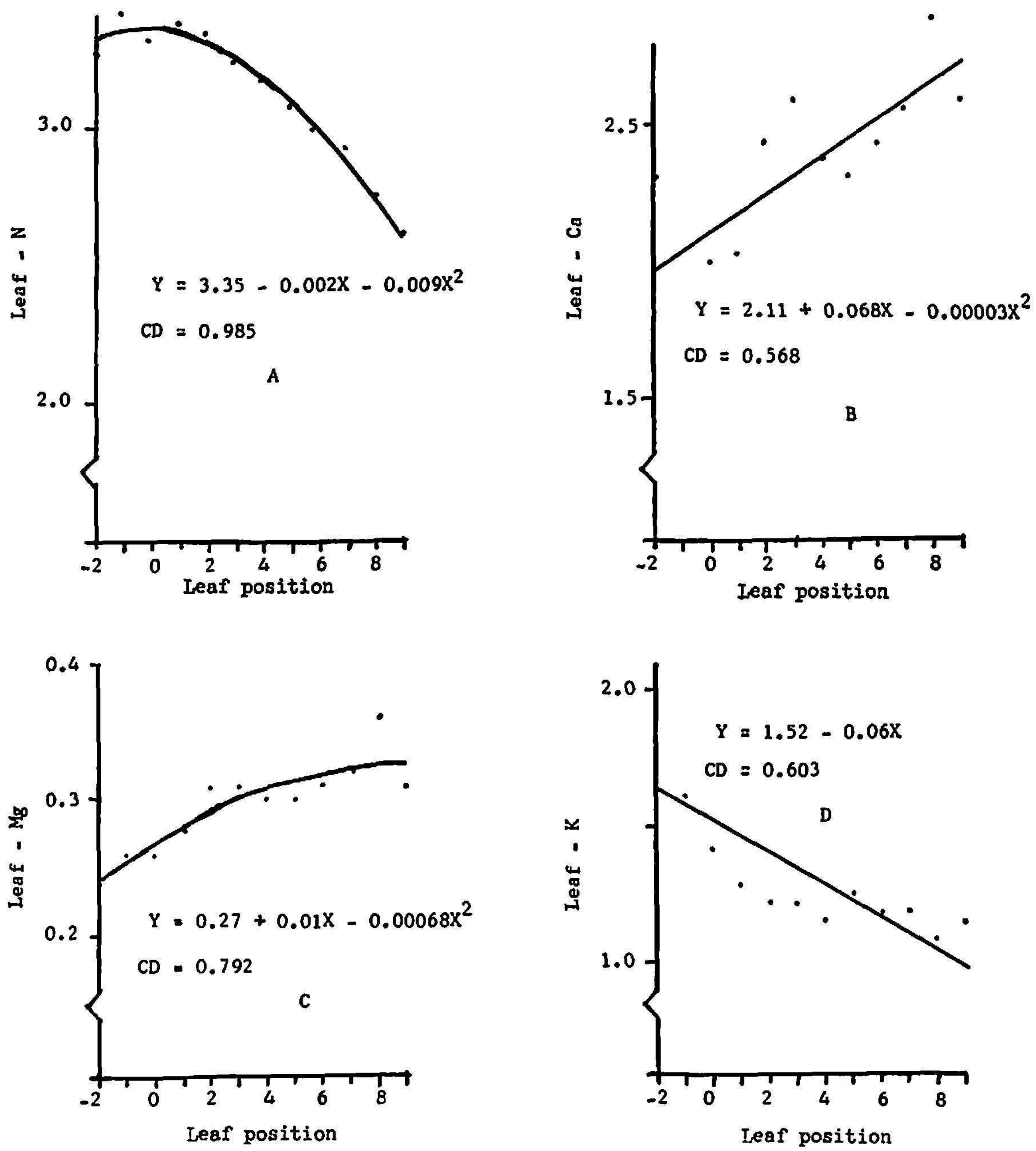

FIG. 5.—Relationship of leaf maturity and nutrient content at 47-percent shade intensity.

in content with leaf maturity, with a drop thereafter for all shade levels. The level in the leaf composite sample above the ninth position exhibited the lowest magnesium values in all cases. Those values were expected because senescence reduced magnesium content. Some workers claim its movement to younger areas while others attribute it to leaching. In all cases, the values in our experiment were lower than those observed by Cibes and Samuels for the complete solution (2), suggesting possible leaching because their work was conducted under greenhouse conditions; ours under plastic shade. The statistical function did not fit the results so well in each shade intensity.

TABLE 3.—*Effects of leaf position and actual shade intensity on leaf calcium content of* **D. sanderiana L.**[1]

Leaf position	Percent actual shade				
	92	76	63	51	47
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
−2	1.13	2.27	1.31	1.53	2.31
−1	1.41	1.44	1.59	1.53	1.66
0	1.81	1.56	2.00	1.78	2.00
1	2.03	1.66	1.91	2.00	2.03
2	2.41	2.56	2.22	2.19	2.44
3	2.50	2.22	2.41	2.47	2.59
4	2.38	2.88	2.50	2.47	2.38
5	2.81	2.16	2.44	2.31	2.31
6	2.63	2.63	2.94	2.31	2.44
7	2.28	2.72	2.63	2.44	2.56
8	2.41	2.25	2.91	2.47	2.88
9	2.06	2.53	2.31	2.41	2.59
9+[2]	1.59	2.25	2.25	2.22	2.41

[1] All values are on dry-weight basis.
[2] Composite of leaves above 9th position.

Magnesium is a chlorophyll component. Fully matured leaves should therefore show the highest magnesium content. In most cases the higher leaf magnesium content, especially in the fully developed ones, was recorded under the 92-percent shade. Those leaves were visually greener in color suggesting a higher chlorophyll content for a greater light absorbance under that shade.

Leaf potassium values are presented in table 5 and figures 1,D, 2,D, 3,D, 4,D, and 5,D. In addition, a second degree equation was fitted to the results and presented in figure 6.

The potassium content decreased consistently with leaf maturity and a levelling off with senescence, suggesting a constant movement to areas of high metabolic activity. Potassium is highly mobile within the plant systems. Furthermore, it is quite leachable from the plant because of its lack of boundness into organic compounds. Our values are somewhat lower than those of Cibes and Samuels for the complete solution (2). The high values at the overmature stage (positions 9 and 9+) may be ascribed to the low magnesium values due to their negative interrelationship (5). Both a straight line relationship and a second degree curve explain a high percentage of the total variation exhibited by potassium.

The potassium values were somewhat higher at the high shade intensity, particularly in young leaves. The contrary was recorded in the overmature

TABLE 4.—*Effects of leaf position and actual shade intensity on leaf magnesium of* **D. sanderiana L.**[1]

Leaf position	Percent Actual Shade				
	92	76	63	51	47
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
−2	0.24	0.28	0.26	0.25	0.24
−1	.27	.25	.26	.30	.26
0	.33	.25	.26	.28	.26
1	.35	.26	.26	.27	.28
2	.33	.25	.28	.29	.31
3	.35	.29	.30	.28	.31
4	.40	.34	.32	.30	.30
5	.39	.30	.36	.30	.30
6	.42	.32	.35	.33	.31
7	.40	.39	.38	.31	.32
8	.36	.31	.34	.32	.36
9	.32	.29	.33	.32	.31
9+[2]	.21	.21	.23	.25	.22

[1] All values are on a dry-weight basis.
[2] Composite of leaves above 9th position.

leaves. At high light intensities there is more activity, which requires a constant movement of the elements such as potassium, which are known to be essential in sugar transfer.

The overall functional relationships of leaf position and nutrient content are presented in table 6 and figure 6,F. In all cases the relationship was found, statistically, highly significant but not always a high percentage of the variability was explained by the function. There is a possibility of a better explanation through other types of mathematical relationships because nutrient values in nature do not drop to zero (1). The same is true for the individual graphical representations of the results. Nevertheless, in most cases a high percentage of the total variation was explained by the

TABLE 5.—*Effects of leaf position and actual shade intensity on leaf potassium of* **D. sanderiana L.**[1]

Leaf position	Percent actual shade				
	92	76	63	51	47
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
−2	2.92	2.64	2.38	2.31	2.08
−1	2.46	2.28	1.97	1.93	1.61
0	2.06	2.03	1.77	1.69	1.41
1	1.83	1.78	1.59	1.58	1.28
2	1.64	1.65	1.50	1.48	1.22
3	1.62	1.54	1.38	1.38	1.21
4	1.38	1.18	1.40	1.24	1.15
5	1.22	1.46	1.26	1.22	1.24
6	1.06	1.30	1.21	1.23	1.17
7	1.08	1.09	1.17	1.17	1.17
8	1.16	1.08	1.20	1.15	1.08
9	1.27	1.26	1.26	1.06	1.15
9+[2]	1.66	1.48	1.43	1.26	1.41

[1] All values are on a dry-weight basis.
[2] Composite of leaves above 9th position.

TABLE 6.—*Overall functional relationship of leaf nutrient to leaf position in a stem not considering the shade intensity factor*

Leaf nutrient content	Functional relationship[1]	Determination coefficient
Nitrogen	$Y=3.3567+0.0176X-0.0104X^2$	0.8016
Calcium	$Y=1.9192+0.1874X-0.0142X^2$	.6452
Magnesium	$Y=0.2795+0.0152X-0.0010X^2$	.4778
Potassium	$Y=1.8678-0.1037X$	.6880

[1] Y is the dependent variable (in our case the percent leaf nutrient shown in the left column) while X, the independent variable, the leaf position in the stem. All values were highly significant.

functional relationship fitted. In fact, the application of a second degree curve to the leaf potassium values increased the coefficient of determination. It can be concluded that leaf samples midway in the stem are suitable for analysis. Possibly, leaves of the 2d, 3d or 4th position will reflect the nutritional status of the plant.

SUMMARY

Seventy-five tops of *D. sanderiana* were grown and harvested, 15 from each of five different shade intensities. The leaf blades of each top were separated as to position in the stem. Composite samples of the leaves having the same numbered position in the 15 tops at each level of shade were chem-

ically analyzed for nitrogen, phosphorus, potassium, calcium, and magnesium. Leaf position definitely influenced the chemical content of the leaves. The immature leaves showed lower values of nitrogen, calcium and phosphorus. The values increased with age. There was a reduction in the chemical content farther down in the stem. Leaf potassium was high in the young leaves with a definite decrease with age, until it became stabilized

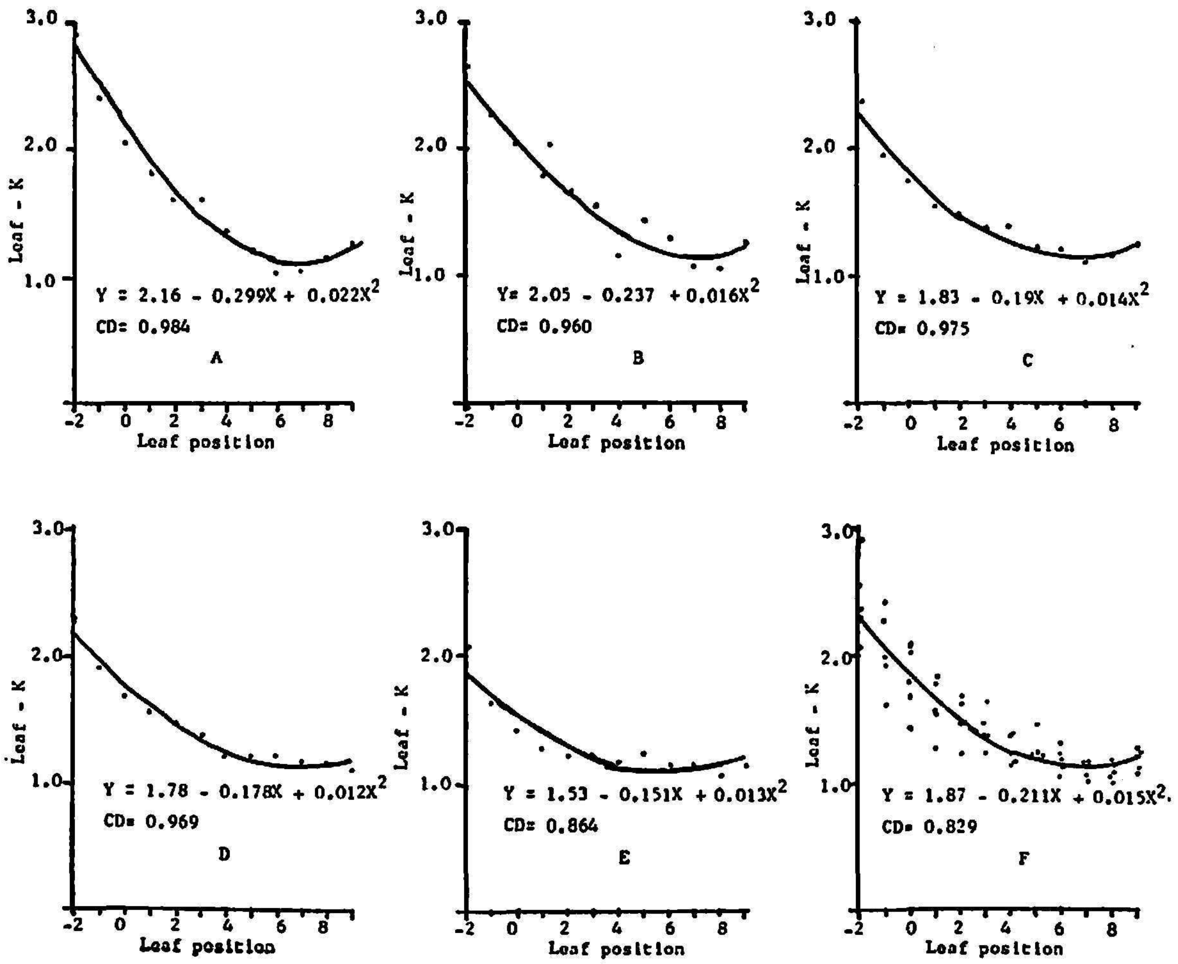

FIG. 6.—Relationship of leaf position to leaf potassium content at different shade intensities: A, 92 percent, B, 76 percent, C, 63 percent, D, 51 percent, E, 47 percent, and F, overall effect.

or it increased in the old leaves. Leaf phosphorus did not seem to vary with age. The shade intensities did not seem to affect the leaf nutrient content markedly, except potassium and magnesium to some extent, expecially in immature leaves.

Functional relationships were established for leaf position and leaf nutrient content, with a high percentage of explanation of the variability.

It can be concluded that leaf samples midway in the stem are suitable for analysis. Leaves of the 2d, 3d or 4th position will possibly reflect the nutritional status of the plant.

RESUMEN

Se analizó químicamente el contenido en nitrógeno, fósforo, potasio, calcio y magnesio de las hojas de una muestra de 75 tallos de *Dracaena sanderiana*, que comprendía 15 tallos de cada una de cinco intensidades de sombra. Se desprendieron las hojas de los tallos, juntándose en grupos según su posición en el tallo.

Los análisis reflejaron una variación en el contenido con respecto a la posición de la hoja. El nitrógeno, el calcio y el magnesio comenzaron con valores bajos, que luego aumentaron hasta cierto límite, según el grado de madurez de la hoja. El potasio comenzó también con valores altos, que luego disminuyeron con el envejecimiento de la hoja hasta llegar a un punto en que se estabilizaron o comenzaron a ascender levemente. El contenido en fósforo no pareció afectarse por la edad de la hoja. El grado de intensidad de la sombra no afectó marcadamente el contenido excepto en el caso del potasio y el magnesio en las hojas nuevas.

Las distintas funciones matemáticas de la relación entre la posición y el contenido de la hoja explicaron un alto porciento de la variación total en su contenido químico.

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