LEAF AREA ESTIMATES OF CUSTARD APPLE TREE PROGENIES[1]

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ABSTRACT – Leaf area measurements are required in several agronomical studies. Usually, there is an interest for measurement methods that are simple, quick and that will not destroy the leaf. The objectives of this work were to evaluate leaf area (*y*), length (*l*) and width (*w*) of 20 half-sibling progenies of custard apple tree (*Annona squamosa* L.), and to fit regression equations of the type y = a + bx, where x = *l.w*, that will allow *y* to be estimated based on *l* and *w*. The experiment was conducted as random blocks with five replicates and four plants per plot. Five mature leaves were randomly collected from each plant. Leaf area was measured with an automatic measuring device and leaf dimensions were determined with a ruler. All values of b were different from zero. Differences occurred only in 11% of the 190 possible comparison pairs between progenies, with regard to the estimates of b. No differences were observed between progenies with respect to leaf length, width and area. In view of this fact, the equation y = 0.72 x (R^2 = 0.77) was fitted for all progenies.
Index terms: *Annona squamosa*, sugar apple.

ESTIMATIVAS DA ÁREA FOLIAR DE PROGÊNIES DE PINHEIRAS

RESUMO - A mensuração da área foliar é requerida em vários estudos agronômicos. Comumente, existe interesse em métodos de mensuração simples, rápidos e que não destruam a folha. Os objetivos do trabalho foram avaliar a área (*y*), comprimento(*c*) e largura (*l*) foliares de 20 progênies de meias-irmãs da pinheira (*Annona squamosa* L.) e ajustar equações de regressão do tipo y = a + bx, onde x = *c.l* que permitam estimar *y* a partir de *c* e *l*. O experimento foi realizado em blocos ao acaso, com cinco repetições e quatro plantas por parcela. De cada planta, foram coletadas ao acaso cinco folhas maduras. A área foliar foi medida com medidor automático e as dimensões foliares, com uma régua. Todos os valores de *b* foram diferentes de zero. Em apenas 11 % dos 190 pares possíveis de comparação entre progênies, quanto às estimativas de *b*, ocorreram diferenças. Não existiram diferenças entre progênies quanto ao comprimento, largura e área da folha. Por isso, ajustou-se, para todas as progênies, a equação y = 0,72 x (R^2 = 0,77).
Termos para indexação: *Annona squamosa*, ateira

In the Brazilian Northeast, expansion of the area cultivated with fruit trees has sparked an increased interest of fruit growers by the custard apple tree, which has shown great adaptation to the conditions of that region. The increased demand for custard apple trees has encouraged the collection, characterization and evaluation of germplasm, aimed at obtaining cultivars (Sousa et al., 2001). A collection work has been carried out where 20 progenies are currently being evaluated, and interest exists in characterizing them. Leaf area is an indicator of the photosynthetic capacity of a plant, and its determination is important in nutrition, competition, and soil-water-plant relations studies.

A large number of methods, either destructive or not, have been developed to measure leaf area. Non-destructive methods, methods that do not require the leaves to be detached, are interesting because they allow measurements to be repeated during the plant's growth period, and reduce the variability associated with destructive sampling procedures. Automatic non-destructive leaf area measuring devices do exist, but their price is even higher than the automatic destructive measuring machines. For this reason, many researchers have developed other non-destructive methods for leaf area estimation (see references in Silva et al., 2000) in major crops, vegetables, fruit trees, ornamental plants, and even weeds. The most frequently used indirect method is one which tries to establish regression equations between the leaf area and linear leaf measurements, usually the maximum length and width. In other words, in a leaf sample, leaf area is determined by some precise mechanism. Length and width are measured on the same leaves. Equations of the type y = a + bx are then established, where *y* is the estimated leaf area and *x* is the product of length by width. The equations are then used in subsequent samples. This method is adopted by many researchers (see references in Kobayashi, 1988) and still shows recent interest for many groups of crops (Pinto et al., 2004).

The objectives of this work were to compare 20 custard apple tree progenies with regard to leaf length, width, and leaf area, and to establish regression equations that will allow leaf area estimation based on leaf length and width.

The experiment was performed using plants from 20 half-sibling progenies that are currently being evaluated at the "Rafael Fernandes" Experimental Farm of Escola Superior de Agricultura de Mossoró (ESAM) (latitude 5° 11'S, longitude 37° 20'W, and 18m altitude). The progenies were obtained at Aracati-CE, Mossoró-RN, and Serra do Mel-RN. Home orchards were visited and 20 matrices were selected. The plants from which the leaves were extracted for this work were approximately 2.5 years old. A random block design with five replicates was used. Each plot consisted of four plants. All plants in each plot were considered usable. Five apparently adult leaves were extracted from within or at the periphery of the mid third portion of the tree canopy, without evidences of attack by diseases or pests. Leaf collection was randomly, without, however, using a drawing mechanism. The maximum length and width measurements for each leaf were made with a ruler graduated in mm, and leaf area was determined with a model 3100 LICOR brand measuring device (LI-COP, Inc. Lincoln, Nebraska, USA). The analyses of variance and regression analyses were performed using the Table Curve software (Jandel Scientific, 1991).

For half of the progenies studied, the intercept value (*a*) was non-significant (Table 1). In those cases, the *a* value was discarded and a new equation was fitted containing only the slope coefficient value (*b*). Similar procedures have been adopted by other authors (Silva et al., 2000). The adoption of equations of the type y = bx, where x is the product of leaf blade length by leaf width, is obviously more practical than using equations of the type y = a + bx.

All slope coefficient (*b*) values were different from zero (Table 1). Differences occurred in 21 (between progenies numbered 1 and 7, 1 and 9, 1 and 10, 1 and 14, 1 and 17, 1 and 19, 1 and 20, 3 and 5, 3 and 6, 3

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and 13, 5 and 7, 5 and 9, 5 and 10, 5 and 11, 5 and 14, 6 and 9, 6 and 10, 9 and 13, 9 and 18, and 10 and 13) of the 190 possible comparison pairs between progenies, with regard to the estimates of *b*. Similar differences were verified between saffron cultivars (*Carthamus tinctorius* L.) (Sepaskhah, 1977) and between *Zinnia* species (Pinto et al., 2004). In those cases, it has been suggested that the same equation should not be used for leaf area estimation in the genotypes studied, because of differences between the regression coefficients obtained (Sepaskhah, 1977; Pinto et al., 2004). However, in addition to genotypic differences, other factors could determine differences between the estimated coefficients of regression, including the method used for estimation (Silva et al., 2000), the plant's developmental stage, and the environment under which the cultivars are evaluated (Robins & Pharr, 1987). In some cases, the exclusion of some cultivars allows the same equation to be used for the other cultivars in the group (Sepaskhah, 1977). In other cases, the adoption of another model provides accurate leaf area prediction for several environments, cultivation systems, and cultivars (Robins & Pharr, 1987).

The coefficient of determination value ranged from 0.80 to 0.97. Values with similar magnitude have been obtained by other authors (Silva et al., 2000; Pinto et al., 2004), but values ranging between 0.20 and 0.48 have been obtained in lychee (*Nephelium litchi* Lamk.) (Ray et al., 1992). The magnitude of the R^2 values seems to be dependent upon several factors, among which are the species and method used for leaf area estimation (Mielke et al., 1995), the characteristic included in the model (Ray et al., 1992) and obviously, the model itself.

Even though many research works have been conducted on the subject dealt with in the present work, only a few (Sepaskhah, 1977; Wiersma & Bailey, 1975) present statistical analyses that compare leaf dimensions in different cultivars, at different leaf sampling stages, etc. In this work, no differences existed between progenies with regard to leaf length, width, and area (Table 1), which suggests that the same equation could be fitted for all progenies. The advantage of considering a single equation for all progenies is that, since several progenies from different origins were evaluated, the developed equation could be used for other custard apple trees in addition to those considered in this study. However, as previously mentioned, some authors are reluctant to use a single equation fitting under the argument that the regression coefficients are different between cultivars. In saffron, the tested cultivars were different with respect to the three mentioned characteristics, and different equations were established (Sepaskhah, 1977). In soybean, differences between cultivars with regard to those three leaf measurements have been observed, but a single equation was defined (Wiersma & Bailey, 1975), after comparing the regression equations. In the opinion of a few authors (Gomez & Gomez, 1984), it seems reasonable to adjust a single equation, if no differences exist between the means of the measured characteristics. One of the arguments used is that, if a researcher wants to determine whether a single regression curve could be used to represent several curves with homogeneous regression coefficients, he/she should make the appropriate comparison between treatments means. Another argument is that, if the regressions can be trusted to be linear, and the *b* values seem to be "roughly" the same in all strata, the combined estimate should be preferred. Considering what was just explained, the equation y = 0.72 x (R^2 = 0.77) was fitted for all progenies in this work, where x represents the product of leaf length by leaf width.

It can be then concluded that no differences exist between progenies with regard to leaf length (L), width (W), and area (A), and that A = 0.72 L.W.

TABLE 1 – Length (L), width (W) and area (A) of leaf blade of custard apple trees, and estimates for parameters *a* and *b*, of the equation y = a + bx, where x = L.W and y = A, Mossoró, Rio Grande do Norte, Brazil, 2003.

Progeny No.	Progeny	*a*	b^1	R^2	Length (L) (cm)	Width (W) (cm)	Area (A) (cm^2)
1	A1	4.73^{*}	0.61^{*}	0.88	11.7	4.7	39.5
2	A2	2.64^{*}	0.66^{*}	0.93	11.9	4.9	41.9
3	A3	0.64^{ns}	$(0.69^{*})\ 0.70^{*}$	0.95	12.0	4.9	42.4
4	A4	3.19^{*}	0.65^{*}	0.92	12.1	5.0	42.8
5	A5	4.28^{*}	0.62^{*}	0.88	12.0	4.8	40.3
6	A6	4.71^{*}	0.63^{*}	0.85	11.9	4.8	40.0
7	FE1	0.51^{ns}	$(0.69^{*})\ 0.69^{*}$	0.80	12.5	5.0	44.3
8	FE3	1.74^{*}	0.67^{*}	0.96	11.8	4.8	41.4
9	FE4	0.56^{ns}	$(0.69^{*})\ 0.70^{*}$	0.97	12.2	5.0	44.1
10	FE5	1.08^{ns}	$(0.69^{*})\ 0.71^{*}$	0.96	12.0	4.7	40.6
11	FJ1	1.46^{ns}	$(0.68^{*})\ 0.70^{*}$	0.94	12.1	4.8	41.2
12	FJ2	2.51^{*}	0.66^{*}	0.93	12.4	4.9	42.7
13	JG1	4.31^{*}	0.63^{*}	0.87	12.3	4.8	41.7
14	JG2	1.95^{ns}	$(0.68^{*})\ 0.72^{*}$	0.90	12.0	4.7	40.7
15	JG3	3.04^{*}	0.66^{*}	0.93	11.8	4.9	42.2
16	JG4	2.11^{ns}	$(0.66^{*})\ 0.69^{*}$	0.86	11.8	4.8	40.2
17	SM1	1.18^{ns}	$(0.67^{*})\ 0.70^{*}$	0.94	12.4	4.8	41.7
18	SM3	2.27^{*}	0.65^{*}	0.95	11.5	4.8	38.9
19	SM7	1.54^{ns}	$(0.67^{*})\ 0.70^{*}$	0.90	11.1	4.6	37.7
20	SM8	2.25^{ns}	$(0.67^{*})\ 0.70^{*}$	0.88	12.1	4.9	43.3
Means	-	-	-	-	12.0	4.8	41.4
Experimental coefficient of variation, %					5	6	10

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