A SIMPLE METHOD FOR MEASUREMENT OF *Jatropha curcas* LEAF AREA

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ABSTRACT: Physic nut (*Jatropha curcas*) is an oilseed shrub very resistant to drought belonging to Euphorbiace family that has been pointed as an important alternative for oil supply in biodiesel programs in several countries around the world. Estimating leaf area is very important for research since this characteristic is closely related to the soil fertility and plant physiology conditions as well as it is related to the photosynthesis capacity. In order to develop a simple method for physic nut leaf area measurement, images of 250 leaves were captured in digital camera and processed in the software *ImageToll* where the leaf area, length and width were measured. Nine math models were evaluated in order to estimate the leaf area value from length or width leaf values. The models were evaluated considering the R^2 coefficient and the difference between calculated and measured leaf area values. Two simple and accurate equations were obtained. One is based only on leaf width (Area = $W^{1,87}$) and had R^2 = 0,97 and the other is based on width and length (Area = 0,84 $WL^{0,99}$) and had R^2 of 0,98. Both equations were accurate for estimating area of big, medium and small leaves.

Index terms: physic nut, physiology, oilseeds

MÉTODO PARA MEDIÇÃO DA ÁREA FOLIAR DE *Jatropha curcas*

RESUMO: O pinhão manso (*Jatropha curcas*) é uma planta arbustiva oleaginosa, muito resistente à seca, pertencente a família das Euforbiáceas e é apontada como importante alternativa para fornecimento de óleo para programas de produção de biodiesel em diversos países. Estimar a área foliar é uma importante ação para a pesquisa, pois esta característica é indicadora das condições de solo e fisiologia da planta, assim como corresponde à capacidade fotossintética da planta. Objetivando desenvolver um método simples para medição da área foliar do pinhão manso, 250 folhas foram fotografadas em câmera digital e as imagens processadas no *software ImageTool*, onde a área foliar, a largura e o comprimento foram medidos. Nove modelos teóricos foram avaliados quanto à precisão para estimar a área foliar a partir das medidas de largura ou comprimento. Os modelos foram avaliados considerando o coeficiente de determinação (R^2) e a diferença percentual entre os valores de área calculada e medida. Obtiveram-se duas equações simples e com boa precisão, sendo uma baseada apenas na largura da folha (Área = $W^{1,87}$), R^2 de 0,97, e outra baseada na largura e comprimento (Área = 0,84 $WL^{0,99}$), R^2 de 0,98. Ambas as equações foram precisas para estimar a área foliar de folhas grandes, médias e pequenas.

Termos para indexação: pinhão manso, fisiologia, oleaginosas

INTRODUCTION

Physic nut (*Jatropha curcas*) is an oilseed tropical tree, well adapted to several environments in Brazil, that has been recently promoted as an alternative supply for biodiesel

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industry. This specie is often planted in tropical countries as living fence. Several parts of the plant are used in traditional medicine, however, its seeds are toxic to humans and animals (HELLER, 1996).

Research with physic nut in Brazil is not significant. In the 1980's, governmental research company (EPAMIG – Empresa de Pesquisa Agropecuária de Minas Gerais) started some field trials with this crop (SATURNINO et al., 2005), but due to descontinuity in financial support, the project was stopped before getting any result. Nowadays, several Brazilian instituitions are starting studies in field and greenhouse.

Leaf area measurement is an important action in experimental procedure since it allows the researcher to estimate response to applied treatments and to handle a character closely related to the plant photosynthetic and light interception capacity, soil covering and competition among plants (SEVERINO et al., 2004). Frequently, leaf area is the most responsive characteristic to be evaluated in trials such as fertilization levels, soil acidity, water supply, salt stress resistance.

There are several methods for leaf area measurement, however, taking leaf measures, like width or length, and calculating the area by means of an equation is the most suitable method cause it is fast, simple, do not dependent on any complex device and it allows to make non destructive analysis. Several authors have proposed similar method for others species (BIANCO et al., 2005; MONTEIRO et al., 2005).

The method for estimating leaf area through equations works better when the measures to be taken can be easily and correctly identified and the equation is based on only one or few measures. The equation should estimate an area as close as possible to the real leaf area and should be stable when measuring leaves of different shapes and sizes.

The objective of this study was to develop an accurate, simple, fast and non-destructive method for estimating physic nut leaf area by means of an equation based on few leaf measures that could be easily identified and taken.

MATERIAL AND METHODS

Leaves of an undefined cultivar were obtained in a crop planted at Quixeramobim, CE, Brazil. 250 images were captured in digital camera in a white background with a length reference. The images, initially colored, were transformed into gray scale (8 bits) and analyzed in the software Image Tool® that identify the leaf blade and, based on the length reference present in the picture, returns the leaf area (Fig. 1). In the same software, measures of leaf length and width were estimated. Length was considered the distance between the petiole insertion and the leaf bottom extremity and width was the biggest dimension approximately perpendicular to the line of the length, as shown in Figure 2.

Nine math models were created combining the two measures obtained and different math models such as, linear, square and exponential (Table 1). The coefficients that better fit the equations against the measured area were calculated. For each equation was calculated a R^2 coefficient. In order to evaluate stability of the equations for estimating area of leaves with different sizes, the entire sample was divided into three groups according to leaf size (small, medium and big) and each equation was performed to estimate leaf area of these groups. The difference between measured and estimated areas in these groups was used as a criteria for equation evaluation.

The best equations were chosen by the highest R^2 and by the smallest difference between measured and calculated areas of the three groups of leaves (small, medium and big).

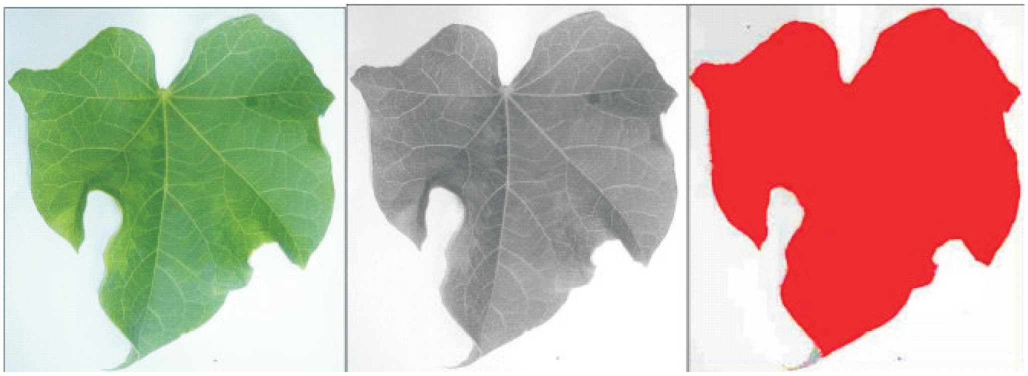

FIG. 1. Left to right: colored picture, gray scale picture and leaf area identified by the software Image Tool®.

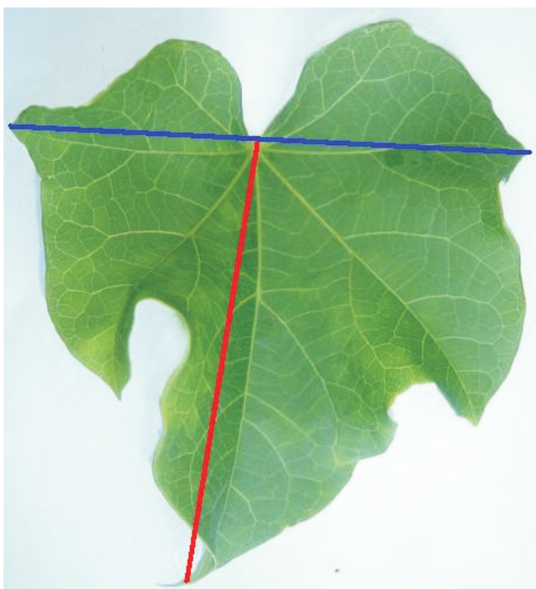

FIG. 2. Measures of length (red line) and width (blue line) of physic nuts leaf.

RESULTS AND DISCUSSION

Characterization of the leaf sample and the leaf groups regarding their size are shown in Table 2. The leaf area in the entire sample (n = 250) had values varying between 7,33 and 215,92 cm^2 with average of 93,79 cm^2. Each subgroup was composed by 83 leaves (except the big ones, with 84 leaves) with averages of 42,97 cm^2, 97,10 cm^2 and 140,73 cm^2 to small, medium and big leaves, respectvely (Table 2).

All equations with adjusted coefficients, R^2 and percentual difference calculated and measured area in three groups of leaves are presented in Table 3. Two equations resulted in values very close to the measured leaf area, as presented in Fig. 3 and 4. The first one {$A = 0{,}84\ (LW)^{0,99}$} is based in two measures and had $R^2 = 0{,}98$. When used for estimating area of small leaves, resulted in values only 1,55% higher than the measured values, 0,33% higher for medium leaves and 0,58% lower to big leaves. The second equation {$A = 1{,}00L^{1,87}$} is based only in the leaf width and had $R^2 = 0{,}97$. When used for estimating area of small leaves, resulted in values 2,17% higher than the measured values, 0,30% higher for medium leaves and 0,39% lower for big leaves.

Both equations are trustable for physic nut leaf area estimation. As the equation based in only one measure is stable with high R^2, it can preferably be used in most of the experimental procedures. The two-measures based equation can be chosen when the leaf area needs to be estimated with high accuracy.

Similar methods for measuring leaf area has been developed for several species such as *Kalanchoe blossfeldiana* (PEITER et al., 2006), *Mangifera indica* (ARAÚJO et al., 2005), *Citrus latifolia* (COELHO FILHO et al., 2005) and *Cocos nucifera* (SOUSA et al., 2005). In some of these

TABLE 1. Math models for estimating physic nut leaf area (A) by using measures of length (L) and width (W).

1) $A = a L^b$	4) $A = a W^b$	7) $A = a L W^b$
2) $A = a L^2 + b L$	5) $A = a W^2 + b W$	8) $A = a L W^2 + b W P$
3) $A = a L$	6) $A = a W$	9) $A = a L W$

a and *b* are the equation coefficients to be calculated

TABLE 2. Details of the sample of *Jatropha curcas* leaf area used in the study.

Description	Number of leaf area values	Leaf area average (cm^2)	Minimum value (cm^2)	Maximun value (cm^2)
Entire sample	250	93,79	7,33	215,92
Small leaves	83	42,97	7,33	76,89
Medium leaves	83	97,10	76,92	115,41
Big leaves	84	140,73	115,56	215,92

TABLE 3. Equations, R-square (R^2) and percentual difference between calculated and measured values in groups of small, medium and big leaves

Equation	R^2	Small leaves	Medium leaves	Big leaves
		Δ (%)		
$A = 0,89L^{2,00}$	0,94	6,60	-0,32	-3,51
$A = 0,75L^2 + 1,67L$	0,91	22,45	1,53	-4,36
$A = 9,97L$	0,78	97,56	7,26	-11,97
$A = 1,00W^{1,87}$	0,97	2,17	0,39	-0,39
$A = 0,53W^2 + 2,34W$	0,94	17,26	0,87	-2,31
$A = 8,96W$	0,83	84,59	7,29	-9,81
$A = 0,84\ (LW)^{0,99}$	0,98	1,55	0,33	-0,58
$A = 0,00046(LW)^2 + 0,88LW$	0,96	11,91	-15,44	17,78
$A = 0,8LW$	0,96	-0,21	-0,52	-1,13

A: leaf area. L: leaf length. W: leaf width

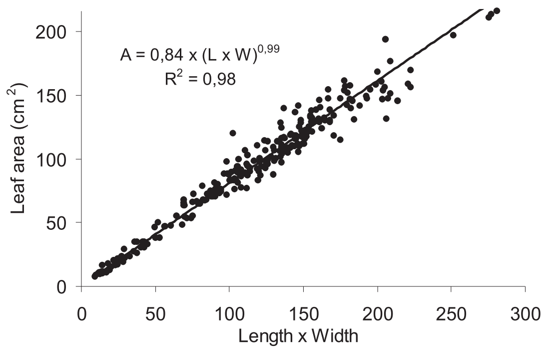

FIG. 3. Equations for physic nut leaf area estimation (A) based on values of length (L) and width (W).

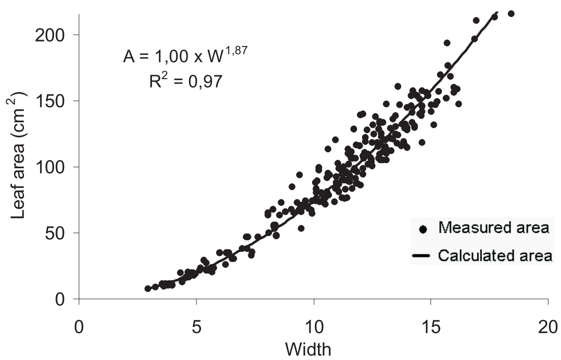

FIG. 4. Equations for physic nut leaf area estimation (A) based on values of width (W).

methods it was not posible to measure all the leaves, such as on coconut palms, and the method was developed based on length of only some leaves, considering the number of leaves in the whole plant.

In some species, measuring leaves one-by-one is a hard work, since the number of leaves is too high. In this case, estimation of total leaf area can alternativelly be made based on lateral pictures of the canopy (plant silhouette), like in the method proposed by Coelho Filho et al. (2005). Following the same trend, the present method proposed for *Jatropha curcas* leaves is easy to apply on small plants like those growed in vases or young trees, but can be very time consuming when used for big trees with large number of leaves. For this case, a method based on average of leaf area multiplied by number of leaves or using photographs needed to be developed.

CONCLUSIONS

Two equations for physic nut leaf area estimation are suggested: one based only on lenght {$A = 1{,}00L^{1,87}$} and other based on length and widht {$A = 0{,}84\ (LW)^{0,99}$}. Both equations have high R^2 and can be used for estimating the area of small, medium and big leaves.

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