COCOS (1989), 7, 21-25
Printed in Sri Lanka

A Method for Determining Leaf Area of One, Two and Three Year Old Coconut Seedlings (*Var.* CRIC 60)

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ABSTRACT

A rapid, non-destructive and accurate method for determining the leaf area of one, two and three year old coconut seedlings (*var.* CRIC 60) is proposed using three linear regression models $y = 5.9647 + 0.6314\ x$, $y = 3.9325 + 0.7044x$ and $y = 8.4507 + 0.6798x$ with reliabilities of 94.5%, 98.3% and 97.8% respectively, where x is the product of the length and breadth at the broadest position of the leaflet and y is the area of the leaflet. In order to study the relative performance of seedlings, a common model $y = 2.2138 + 0.7192\ x$ ($r^2 = 98.6\%$), which can be considered to be representative, could be used irrespective of the age of the seedling, if the third leaf is used.

INTRODUCTION

Leaf area of plants is frequently used in agronomic and physiological studies as it is an index of plant growth and is very useful in the evaluation of net assimilation rate, relative leaf growth, leaf area index and crop-growth rate. High correlation observed between these parameters and the growth of a plant indicate the importance of obtaining the leaf area with high degree of accuracy. The problem lies when the leaf area has to be measured without destruction.

Several non-destructive methods have been used in determining the leaf area of various crops; the most common method being the development of mathematical regression formulae using easily measurable leaf parameters (Ackley, *et al.*, 1958; McKee, 1964; Stickler, *et al.* 1961).

The vigour of the growth of a coconut seedling is indicated by the length and number of fronds, number of leaflets, etc. These are in effect related to the total leaf area of the palm which would be related to the degree of photosynthesis. Hence it has become necessary to find an accurate method of evaluating the leaf area by a non-destructive method.

Marar and Pappachan (1964) were the first to suggest a method for leaf area measurement for one-year old coconut seedlings (*var.* West Coast Tall). However, Satheesan *et al.* (1983) indicated that the leaf area computed by the method proposed by Marar and Pappachan (1964) was considerably different from the actual leaf area and proposed regression models to obtain the leaf area of one year old seedlings of the tall variety with reliabilities of over 90%.

This paper describes a fairly rapid, non-destructive and simple method of estimating leaf area of a large number of leaves of one, two and three-year old seedlings of coconut (*var.*CRIC 60 - tall x tall).

MATERIALS & METHODS

Leaf samples for various measurements were obtained from one, two and three-year old randomly selected coconut seedlings (*var.* CRIC 60). The age of the seedlings indicated was the period after transplantation from the nursery, where the seedling would have grown nine months after germination.

The unfolded flag leaf was numbered 1 and the leaves were counted downwards. As the number of leaves varied according to the age the measurements were taken for the first four, six and nine leaves of the three age groups. The length (l) and the width at the broadest position (w) for all leaves and leaflets were measured and the total leaf area was determined using an electronic leaf area meter, LI-COR 3000. Linear regression model of the form $y_i = a + bx_i$ where y_i is the area of the leaflet and x_i is the product of length and breadth, was used in evaluating the relationships between y_i and x_i*a* and *b* are constants.

RESULTS

Linear regression models involving *y* and *x* (l x w) for the leaflets of different leaf positions of one, two and three-year old seedlings are shown in Table 1.

Table 1. *Regression models showing relationships between leaf area (y)* & length x width (*x*)

Age of the seedling) (years)	Leaf No.	Regression equations	r^2 (%)	Sample size
1	1	$y_1 = 5.0014 + 0.6135x_1$	92.7	52
	2	$y_2 = 5.3226 + 0.6420x_2$	98.9	24
	3	$y_3 = 2.1414 + 0.7087x_3$	98.9	51
	4	$y_4 = 2.1557 + 0.6657x_4$	92.9	51
2	1	$y_1 = 2.7909 + 0.7043x_1$	97.0	66
	2	$y_2 = 2.7079 + 0.7040x_2$	99.0	82
	3	$y_3 = 2.2099 + 0.7180x_3$	98.6	96
	4	$y_4 = 3.4152 + 0.7049x_4$	98.1	98
	5	$y_5 = 7.7520 + 0.6902x_5$	98.7	98
	6	$y_6 = 4.9454 + 0.6813x_6$	96.8	87
3	1	$y_1 = 4.2424 + 0.6908x_1$	97.2	107
	2	$y_2 = 2.4111 + 0.7281x_2$	94.8	94
	3	$y_3 = 2.3810 + 0.7308x_3$	97.7	109
	4	$y_4 = 2.6733 + 0.7273x_4$	98.7	131
	5	$y_5 = 7.2323 + 0.6925x_5$	96.8	129
	6	$y_6 = 6.2391 + 0.7046x_6$	99.7	146
	7	$y_7 8.1725 + 0.6731x_7$	98.5	158
	8	$y_8 = 16.5705 + 0.6282x_8$	97.3	149
	9	$y_9 = 8.8153 + 0.6866x_9$	98.1	151

In one-year old seedlings, the regression models for the leaflets of the four leaves show '*a*' values ranging from 2.1414 to 5.3226 and '*b*' values ranging from 0.6135 to 0.6957. All the '*b*' values thus evaluated showed significant (p=0.001) dependency of *y on x*. High r^2 values ranging from 92.7% to 98.9% indicate the high predictive value of the four models and the extent to which the variation in *y* is explained by *x* for the one-year old seedlings.

The regression models for the two year-old seedlings indicate '*a*' values ranging from 2.2099 to 7.7520 while '*b*' values indicating a range of 0.6902 to 0.7180. These were associated with very high reliability values (r_2) ranging from 96.8% to 99.0%.

Efficient predictive regression models were observed for three-year old seedlings too, having r_2 values ranging 94.8% to 99.7%. The lowest '*a*' value was 2.3818 for the third leaf, while the highest was 16.5705 for the 8th leaf. The '*b*' values ranged from 0.6282 to 0.7308.

DISCUSSION

The value of leaf area in the study of plant growth and other physiological aspects is well identified in research. This parameter is used in evaluating various growth indices. The value is so identified that researchers from time to time had tried various methods in evaluating leaf area of a plant. There are many situations where destructive sampling is not possible.

For such situations the most common method is by developing mathematical regression models.

Regression models were developed in this study for one, two and three-year old coconut seedlings of *var.* CRIC 60, and the predictions of the leaf area based on the regression models evaluated indicate a high degree of accuracy (Table 1).

The possibility of using a common model for all the age groups or a model for each of the three groups separately was studied. Table 2 shows the regression models developed by pooling the data of the three age groups.

Table 2. *Regression models showing relationships between y* and *x*.

Age of seedlings(years)	*Regression*	r^2 *(%)*	*Model*
1	$y=5.9647+0.6314x$	94.5	A
2	$y=3.9325+0.7044x$	98.3	B
3	$y=8.4507+0.6798x$	97.8	C
All	$y=5.4664+0.6911x$	98.0	D

Since a statistical test shows no significant difference between *a* and *b* values of the pooled regressions and the similar values of the individual regression models for the three age groups developed separately, it is possible to use the common model D. However, considering the importance of the leaf area in research and since separate models have been already evolved, it is recommended that the three models for the three age groups be used separately.

This is amply demonstrated by the comparative degree of percentage errors seen when the common regression model is compared with the other three models (Table 3). This table shows the % errors against the actual area and the expected areas based on the models A,B,C and D.

Table 3. *Percentage errors between the actual leaf area and the expected values for 20 randomly selected leaflets based on the different models A,B,C & D.*

Leaflet	*% error*					
	Three year old		*Two year old*		*One year old*	
	D	*C*	*D*	*B*	*D*	*A*
1	-1.3	-1.2	7.3	6.5	-6.1	2.2
2	0.3	0.8	3.2	2.1	-0.8	6.8
3	-1.4	-0.8	0.8	0.2	-14.1	-5.9
4	3.2	3.7	3.5	2.7	-13.4	-4.4
5	4.7	5.2	2.6	2.3	-0.7	7.1
6	1.3	3.8	-5.7	-3.6	-5.3	2.9
7	1.8	1.5	2.5	-1.5	-8.9	-1.4
8	2.7	3.0	2.4	1.5	-9.4	-1.0
9	-0.6	0.1	-2.5	-3.5	-5.9	2.3
10	1.7	2.1	-3.3	-4.2	-13.2	-4.6
11	3.4	3.6	-1.2	-1.6	-5.7	0.4
12	-4.8	-5.4	-0.9	0.7	-1.3	6.3
13	10.7	8.0	2.8	1.9	-7.5	0.8
14	-1.7	-1.1	-4.4	-5.6	-2.8	5.1
15	-0.1	0.5	1.8	0.6	-2.3	5.4
16	-1.5	-1.0	2.6	1.6	-9.5	1.7
17	-0.2	0.3	-2.5	-3.0	-12.6	-6.6
18	5.1	5.2	-4.4	-2.3	-6.7	1.4
19	1.2	-0.6	9.0	8.9	-1.2	6.6
20	6.5	5.9	7.1	6.3	-4.7	3.2

It is interesting to note from Table 1 that the third leaf in all the three age groups showed the lowest '*a*' values and the highest '*b*' values. These were associated with r^2 values of 98.9%, 98.6% and 97.7%. The three models for the 1,2 and 3 year old seedlings are $y = 2.1414 + 0.7087x$, $y = 2.2099 + 0.7180x$ and $y = 2.3810 + 0.7308x$ *respectively*. The similar values obtained in this experiment for *a* and *b* suggest that a common model could be used for the seedlings irrespective of the age if the third leaf is chosen. The leaf area of the third leaf could be used as an index of performance and the common model ($y = 2.2138 + 0.7192\ x$) with ($r^2 = 98.6\%$). Satheesan and others (1983) too found that the third leaf could be used to estimate the total leaf area of one year old seedlings(tall variety) with a reliability of 97.46%

The regression model developed for the third leaf in this paper was compared with that developed by Satheesan *et al.* (1983) for the tall variety.

The average of the % of errors (for 20 samples) obtained from the current model was 3.07 ($s^2 = 7.74$ and was only one fifth of that obtained from Satheesan's model, which was 15.65 ($s^2 = 12.84$). This accuracy indicates the possible use of models proposed in this paper for the evaluation of leaf area of one, two and three year old coconut seedlings (*var.* CRIC 60).

Based on the results, the following non-destructive method could be proposed for obtaining the leaf area of one, two and three-year old coconut seedlings in the field.

The length and width at the broadest position of each leaflet in the frond (pinnate leaf) are measured and used in the model developed for each of the age groups. The relative performance of seedlings, irrespective of the age, could be studied by using the third frond to obtain the measurements, thereby estimating the total leaf area of that leaf.

ACKNOWLEDGEMENTS

The authors wish to thank Mrs. D.M.T. Marasinghe, for typing the script and staff of the Biometry Unit of Coconut Research Institute for assistance in the computations.

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