A NON-DESTRUCTIVE METHOD OF ESTIMATING LEAF AREA AND SHOOT DRY MASS IN SEEDLINGS OF COCONUT *(COCOS NUCIFERA)* HYBRIDS

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Linear regression equations were developed to estimate the leaf area and the shoot dry mass of seedlings of five hybrid coconut varieties. The area of bifurcate leaves was best estimated by using leaf length and width in the regression equation (r^2 = 86.5 — 97.3%). In the case of young pinnate leaves, the linear measurement of four leaflets, i.e. the bifurcate portion and the whole leaf, were necessary to obtain precise estimates of leaf area (r^2 = 89.7 — 98.8%).

Equations employing growth measurements namely, plant height, girth at collar, and total number of leaves, gave close estimates of shoot dry mass. The equations could be used to estimate LA & SDM of seedlings between six and 12 months of age.

INTRODUCTION

The yield potential of coconut could be predicted by selecting for high vigor at the juvenile stage of crop growth (Liyanage, 1955). In 1980, Ramadasan, Satheesan, and Balakrishnan showed that the rate of production of leaves and total shoot dry matter accumulated at the one-year-old stage of seedling growth, was highly correlated to plant vigor.

In their studies, they employed the non-destructive procedure of estimating leaf area (LA) and shoot dry mass (SDM) of West Coast Tall (WCT) seedlings from simple linear measurements (Satheesan, Narasimhayya, and Ramadasan, 1983). When these equations were used to estimate LA and SDM in seedlings of certain hybrid crosses developed at the Institute, however, large differences were found between the estimated and measured values. The observed variations were attributed mainly to (a) the differences in leaf size and shape, and (b) the changes in leaf morphology due to the early leaf splitting behaviour in these hybrids.

Changes in leaf morphology give rise to the production of a few young pinnate leaves as against only bifurcate leaves in the WCT cultivar.

Hence, in estimating for the total leaf area of the seedling beyond six months of growth in the nursery, two different equations for bifurcate and young pinnate leaves will have to be used.

With the above points in view, an attempt was made to develop regression equations using leaf and plant growth measurements, to non-destructively estimate the LA and SDM of seedlings. In this particular study, the following seedling crosses were used: Chowghat Dwarf Orange (CDO) x WCT, Malayan Dwarf Orange (MDO) x WCT, Malayan Dwarf Yellow (MDY) x WCT, MDY x Kenya Tall (KT), and MDY x Zanzibar Tall (ZT).

MATERIALS AND METHODS

The experimental materials used in the study were raised in sandbed nurseries. The seednuts were sown at a spacing of 0.3 m, and the time taken for germination was recorded. Ten seedlings of each hybrid cross were subjected to destructive analysis at six, eight, and 10 mo after germination. The plant height, girth at collar, and total number of leaves were recorded. The leaves were subsequently separated from the plant and then numbered. Measurements of the length and width of the young pinnate and bifurcate leaves were taken.

Bifurcate leaves

The length of the laminar portion (L) and the width (W) at the region across the lamina at right angles to the length, were measured to the nearest millimeter.

Young pinnate leaves

The length of the split leaflets (LL) and their maximum width (LW) were recorded on all the leaflets from the basal portion, on either side of the rachis. The following measurements were likewise

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recorded: length of the bifurcate portion (UL) and its maximum width (MW), and the total number of split leaflets (n).

Leaf area was measured using leaf area meter LI Cor 3000. Shoot dry mass was determined after drying the plant parts in an oven for 48 hr at 80°C.

Linear regression equations were worked out for the estimation of the leaf area of bifurcate leaves using linear measurements (L and W) of the leaf. For the young pinnate leaves, multiple regression equations were developed by including the following leaf measurements: LL, LW, ML, MW, UL, and UW. Regression equations to estimate SDM from plant height (H), girth at collar (G), number of leaves (N), and total leaf area (T) were also worked out.

RESULTS AND DISCUSSION

The regression equations to estimate leaf area of bifurcate leaves are shown in Table 1. The product of length and width of leaves gave the highest coefficient of determination (r^2) in all the hybrids ($r^2 = 86.5$ —97.3%). In the case of MDY x KT and CDO x WCT, leaf width alone gave a high r^2 value (80.7 —90.9%). Thus, leaf width alone could be used in leaf area estimations with little loss in predictive ability. Pooled analysis of the data of the three MDY hybrids showed homogeneity for the regression coefficient when the product of L and W was used (r^2—88.4%). Therefore, a single equation could be used to estimate leaf area of all the three MDY hybrids.

The equations developed to estimate leaf area of young pinnate leaves are presented in Table 2. The mean of the LL x LW of four leaflets on either side of the rachis multiplied by the total number of split leaflets gave the highest r^2 value (Table 2, Equations 3 and 12). The predictive ability reduced only marginally when the LL x LW of two or three leaflets were used for the estimations. The r^2 values were further improved by including other parameters like ML x MW (B) and UL x UW (C).

Equations to predict SDM using growth parameters, i.e. height, girth, number of leaves, and total leaf area, singly and in combination, were developed (Table 3). Equations employing height, girth, and total number of leaves gave high r^2 value

Table 1. Regression equations to estimate leaf area (Y) of bifurcate leaves in cm².

Equation No.	Hybrid Cross	Equation for leaf area (Y)*	r^2(%)**
1	MDO x WCT	—473.63 + 21.55 L	82.4
2		—373.89 + 66.49 W	88.1
3		— 2.74 + 0.681 LW	94.5
4	MDY x WCT	—497.94 + 23.21 L	74.0
5		—450.57 + 61.54 W	80.7
6		— 35.91 + 0.672 LW	86.5
7	MDY x ZT	—345.29 + 19.86 L	83.0
8		—307.67 + 50.99 W	90.9
9		— 1.82 + 0.6387 LW	97.3
10	MDY x KT	—451.26 + 22.48 L	84.5
11		—413.90 + 63.50 W	78.5
12		— 28.81 + 0.715 LW	89.4
13	MDY x WCT MDY x ZT and MDY x KT	— 27.27 + 0.6755 LW	88.4
14	CDO x WCT	—391.96 + 19.68 L	86.8
15		—120.33 + 38.22 W	66.3
16		— 6.71 + 0.5863 LW	96.0

L = Length of the leaf
W = Width of the leaf
L.W = Product of length and width
*All correlation coefficients in the equations are significant at 1% level.
**r^2values are significant at 1% level.

ble 2. Regression equations to estimate leaf area of young pinnate leaves in cm^2.

uation No.	(Mean x W)n	Hybrid Cross	Equation for leaf area (Y)*	R^2 (%)
1	2	MDY x WCT	658.79 + 1.0092 A	89.7
2	3	MDY x KT and	657.62 + 0.8906 A	91.1
3	4	MDY x ZT	643.56 + 0.8288 A	92.3
4	2		263.96 + 1.0007 A + 0.0956 B	93.7
5	3		312.98 + 0.8800 A + 0.0846 B	94.2
6	4		347.40 + 0.8171 A + 0.0738 B	94.6
7	2		80.19 + 1.0051 A + 0.063 B + 0.2915 C	96.7
8	3		103.14 + 0.8883 A + 0.0479 B + 0.3269 C	98.0
9	4		124.63 + 0.8270 A + 0.0349 B + 0.3442 C	98.8
10	2	MDO x WCT	839.86 + 0.8705 A	86.5
11	3		790.93 + 0.8230 A	87.3
12	4		763.61 + 0.7838 A	87.3
13	2		638.94 + 0.7983 A + 0.0638 B	88.5
14	3		595.89 + 0.7559 A + 0.0631 B	89.3
15	4		566.89 + 0.7191 A + 0.0642 B	89.4
16	2		626.64 + 0.8251 A + 0.0388 B + 0.0864 C	88.8
17	3		579.19 + 0.7868 A + 0.0330 B + 0.1088 C	89.7
18	4		551.19 + 0.7449 A + 0.0375 B + 0.0923 C	89.7

*R values are significant at 1% level.

A = (Mean of LL x LW of 2,3, or 4 leaflets) x Total No. of split leaflets on either side of rachis (n)
B = ML x MW
C = UL x UW

Table 3. Regression equations to estimate shoot dry mass in grams.

Equation No.	Hybrid Cross	Equation for SDM*	R^2 (%)
1	MDY x WCT	—145.35 + 0.9845 H + 5.6446 G + 8.1499 N	88.9
	MDY x KT		
2	MDY x ZT	— 89.27 + 0.6352 + 3.4520 G + 4.5932 N + 0.0082 T	92.4
3	MDO x WCT	—190.73 + 0.5008 H + 14.4846 G + 5.4247 N	96.7
4		—131.46 + 0.3877 H + 11.2137 G + 0.6960 N + 0.0052 T	97.3
5	CDO x WCT	— 54.09 + 1.0129 H + 1.6698 G — 2.1348 N	89.4
6		— 30.39 + 0.0743 H + 4.3726 G — 0.9101 N + 0.0124 T	95.0

H = Height of seedling (cm)
G = Girth at collar (cm)
N = Total number of functional leaves
T = Total leaf area (m^2)
*R^2 values are significant at 1% level.

(r^2 = 88.9–96.7%). The highest r^2 value, was however, obtained when total leaf area was also introduced in the equations (r^2 = 92.4–97.3%). The most preferrable equations to use that give accurate SDM estimates are equation numbers 3 and 5 (Table 3).

To test the equations for their accuracy of estimations, 25 seedlings in the age group of 6-12 months were destructively sampled with the estimated values (Table 4). The straight line passing through the origin at an angle of 45% represents the

Table 4. Paired 't'* test of observed and expected values of leaf area and shoot dry mass.

	MDO x WCT	MDY x WCT	CDO x WCT
	I. Pinnate leaves		
Mean differences (cm^2)	4.18	9.60	—
't' value	0.09	0.45	—
df	10	9	—
	II. Bifurcate leaves		
Mean differences (cm^2)	23.55	0.3	12.33
't' value	1.61	0.02	1.83
df	19	19	17
	III. Shoot dry mass		
Mean differences (g)	0.19	2.87	4.93
't' value	0.08	0.80	0.12
df	9	9	9

*None of the 't' values are significant at 5% level.

ideal situation in which a 1:1 correlation between the actual and estimated values are obtained.

It is, therefore obvious that for any given hybrid cross, two equations are required to estimate the area of all bifurcate and pinnate leaves irrespective of the leaf size and shape. Although equations using one or more measurements for the estimations of LA and SDM have been presented, one could choose from among them, depending upon the accuracy needed in estimations.

CONCLUSION

The equations developed from this study could be applied to studies of growth analysis, and in the evaluation of hybrids at the seedling stage for their potential to accumulate dry matter.

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