ESTIMATION OF LEAF AREA IN ONE-YEAR-OLD CARDAMOM PLANTS

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ABSTRACT

The area (P) of any individual leaf of a one-year-old cardamom seedling can be estimated by a linear function $P = 0.813B + 0.657$ L.B. ($R^2 = 0.984$) where L and B are the length and breadth of the leaf. The total functioning leaf area (Y) of a tiller with 'n' leaves can be estimated by a linear function $Y = -3.168\ L + 33.464\ n\ b$ ($R^2 = 0.976$) where 'n' is the total number of functioning leaves in the tiller and L and B are the linear measurements of median leaf. Further, the total functioning leaf area (A) of a whole clump consisting of several tillers can be estimated by a linear function. $A = 11.935\ L + 22.3\ N.B$ ($R^2 = 0.979$) where 'N' is the total number of leaves in the clump and L and B are the linear measurements of the median leaf of tiller having the maximum number of leaves.

INTRODUCTION

The importance of leaf area concept in crop physiology is well known. Due to the cumbersome and destructive nature of the procedure for leaf area measurements, which also involves destroying the leaves, non-destructive estimation procedures have been suggested in several crop plants (Krishnamarar and Pappachan, 1964; Palaniswamy and Gomez, 1974; Tejwani et al., 1957; Spencer, 1962; Narasimhayya and Murthy, 1977; Arkel, 1978). In this paper a non-destructive method to estimate leaf area in cardamom is proposed, based on linear measurements of a leaf.

MATERIALS AND METHODS

Twenty, one-year-old clumps of Malabar cultivar of cardamom with a total of 55 tillers were used for this study. The number of leaves per tiller varied from four to ten. The actual areas of individual leaves were measured using a Li-COR model electronic area meter. Four different regression equations of the form:

$$P_i = b_1 L + b_2 B$$
$$P_i = b_1 L + b_2 L.B.$$
$$P_i = b_1 B + b_2 L.B.$$
$$P_i = b_1 L + b_2 B + b_3 L.B.$$

were fitted to estimate the individual leaf area of any leaf. L and B refers to the usual notations of length and breadth, P_i denotes the estimated leaf area and b_i is the regression coefficient.

In order to study the positional effect of the leaves, separate regression equations were fitted for the first five leaf positions from the top and were tested for parallelism. The pooled regressions were also worked out for any leaf position.

To estimate the total leaf area (TLA) (A) of any tiller and total leaf area (TLA) (Y) of the whole clump based on linear measurements of any specified leaf, the following regression equations were fitted separately for tillers and clumps:

$$TLA = b_1 n + b_2 L$$
$$TLA = b_1 n + b_2 B$$
$$TLA = b_1 n.L + b_2 B$$
$$TLA = b_1 n.B + b_2 L$$
$$TLA = b_1 n + b_2 L.B.$$

In the case of TLA (A) for tillers, 'n' refers to the total number of leaves in the tiller, and L and B are the linear measurements of the median leaf of the tiller, whereas in the case of TLA (Y) for clump, 'n' refers to the total number of leaves in all the tillers of the clump and L and B the linear measurements of the median leaf of the tiller having the maximum number of leaves. $\frac{n\,th}{2}$ leaf or $\frac{(n+1)th}{2}$ leaf from the top is considered as the median leaf, depending on whether the number of leaves (n) is even or odd.

RESULTS AND DISCUSSION

A perusal of Table 1 shows that the area of any individual leaf from any position can be etimated with a high degree of precision by measuring its length and breadth (R^2 varying from 0.938 to 0.995). The regressions for different leaf positions were found parallel except in the first case where linear measurements of L and B alone were considered (Table 2). Pooling the regression equations (Table 3) the area of any individual cardamom leaf from any position can be estimated with reasonably good precision (0.984). It is seen from Tables 1 and 3 that all the three sets of regressions have almost the same degree of precision in estimating the leaf area (P) and hence there is no additional gain in taking the three variables, namely L, B and L.B. Any of the variables L or B and its products were found to give an equally precise estimate of the leaf area.

The total functioning leaf area of any tiller TLA (Y) can be estimated by counting the number of leaves (n) in the tiller, measuring the length (L) and breadth (B) of the median leaf and using the equations given in Table 4. The equation TLA (Y) $= -3.168\ L + 33.464\ n\ B$ gives a very precise ($R^2 = 0.976$) estimate of the total leaf area of any tiller with n leaves.

Further, the total functioning leaf area TLA (A) of a whole clump consisting of several tillers can be estimated by counting the total number of leaves (n) in all the tillers of a clump, measuring the length and breadth of the median leaf from the tallest tiller (the tiller having the maximum number of leaves in the clump) and using the equations given in Table 5. A perusal of the Table 5 indicates that TLA (A) of a clump can be estimated reasonably precisely (R^2 0.97) simply by measuring the length or breadth of one leaf (median leaf from the biggest tiller) and counting the total number of leaves in the whole clump; even though the remaining equations give slightly more precise estimates, from the point of view of rapidity in estimation one might choose this equation (Table 5). Total leaf area TLA (Y) of the tiller can be estimated with a reasonably good degree of precision using the equation TLA (Y) $= 67.099\ n + 148.798$

Table 1. Multiple regression equations for estimating the leaf area (P) with length (L) and breadth (B) of the leaves

Equations		Leaf position				
		I	II	III	IV	V
$A = b_1L + b_2B$	b_1	3.1455	2.4277	2.9384	−0.5278	−0.0650
	b_2	6.1009	12.5030	10.7239	35.2939	34.5447
	R^2	0.938	0.949	0.966	0.969	0.977
$A = b_1L + b_2LB$	b_1	−0.6311	0.1918	−0.1479	−0.2595	0.2090
	b_2	0.7534	0.6488	0.6969	0.7079	0.6556
	R^2	0.970	0.964	0.987	0.994	0.995
$A = b_1B + b_2LB$	b_1	−0.0254	6.5442	0.8401	−3.6135	0.4232
	b_2	0.6581	0.5176	0.6569	0.7469	0.5754
	R^2	0.969	0.966	0.987	0.994	0.995
$A = b_1L + b_2B + b_3LB$	b_1	−0.9441	−0.6508	−0.2463	0.1177	0.3546
	b_2	2.1885	7.8113	1.3198	−4.4705	−2.2703
	b_3	0.7438	0.5828	0.6818	0.7484	0.6807
	R^2	0.970	0.967	0.987	0.994	0.995

Table 2. Summary of anova table (M.S.S.) of pooling regressions over the five different leaf positions

		Equation				
Source	df	$Y = b_1L + b_2B$	$Y = b_1L + b_2L.B.$	$Y = b_1B + b_2L.B.$	df	$Y = b_1L + b_2B + b_3L.B.$
Combined Reg.	2	4857671.69	5011270.46	5011156.04	3	3341346.28
Diff. of Reg.	8	12141.25*	329.62	919.31	12	659.51
Combined Res.	253	1469.55	628.82	611.08	248	614.18

*Significant at 1 per cent level.

Table 3. Pooled regressions for estimating the leaf area (P) of any leaf of a cardamom plant

Equations	Regression Coefficients			
	b_1	b_2	b_3	R^2
$P = b_1L + b_2L.B$	−0.1138	0.6909	—	0.984
$P = b_1B + b_2L.B$	0.8127	0.6568	—	0.984
$P = b_1L + b_2B + b_3L.B$	−0.2828	1.6913	0.6776	0.984

Table 4. Regression equations for estimating TLA (Y) in cm of a tiller with length (L) and breadth (B) of the median leaf (in cm)

Sl. No.	Equations	R^2
1.	TLA (Y) = 88.839 n + 18.751 L	0.911
2.	TLA (Y) = 67.099 n + 148.798 B	0.919
3.	TLA (Y) = –16.907 B + 4.928 nL	0.970
4.	TLA (Y) = –3.168 L + 35.464 nB	0.976
5.	TLA (Y) = 14.444 n + 4.3214 LB	0.969

n is the number of leaves in the tiller.

Table 5. Regression equations for estimating TLA (A) in cm² of a clump with length (L) and breadth (B) in cm of the median leaf of the tiller with maximum number of leaves

Sl. No.	Equations	R^2
1.	TLA (A) = 151.991 n + 18.948 L	0.970
2.	TLA (A) = 149.528 n + 128.809 B	0.970
3.	TLA (A) = 3.387 n.L + 85.347 B	0.977
4.	TLA (A) = 22.300 n.B + 11.935 L	0.979
5.	TLA (A) = 147.567 n + 2.692 L.B.	0.975

n is the total number of leaves in the clump.

B (R^2 = 0.919) (Table 4) when a litte precision can be sacrificed for a quick estimate of the TLA (Y) with just one linear measurement, namely the breadth of the leaf. The above procedure can be very well extended for estimating the leaf area and the total functioning leaf area of other zingiberaceous plants (turmeric, ginger and *Amomum acrepelus*).

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DISCUSSION

Q : When leaf area meter is available, why one should go in for a comprehensive method like this?

Ans: This is a method to find out the leaf area by measuring length and width when there are practical difficulties in using leaf area meter.

Q : What is the practical utility of this experiment?

Ans: This non-destructive method gives total leaf area with reasonable degree of precision. The methodology can be extended to other plants of Zingiberacea.