Jl. Rubb. Res. Inst. Sri Lanka (1984) 62, 85 — 90

ON THE ESTIMATION OF LEAF AREAS OF SOME SELECTED *HEVEA* CLONES

By

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SUMMARY

The relationship between the observed area (Y) and the product (X) of the length (L) and maximum breadth (B), of a leaflet, was found to be a positive linear one for the 10 Hevea *clones, PB 86, GT 1, RRIC 45, IRCI 2, RRIC 101, RRIC 52, RRIC 88, RRIM 600, LCB* 870 *and RRIC 100. A straight line through the origin best fits the data.*

A common linear equation, $Y = 0.677X$, is suggested for estimating leaf area of these clones, when X is measured in c. g. s. units. Coefficients of the individual relationships varied very little among the clones and the coefficient of this variation was only 2%. The above expression is better than any available at present under local conditions. The non-linear relationship $Y = aL^{\alpha} B^{\beta}$, where a, α and β are constants, shows no superiority over the linear one.

INTRODUCTION

In plant growth analysis, the estimation of leaf areas is important. A rapid, non-destructive method would always be preferred to a destructive and accurate but slow method, for estimating leaf areas, especially in the studies of photosynthetic rates of leaves. One such accurate method in practice is to detach leaves and use the planimeter for measuring the area. Since this is tedious and time consuming, various workers have adopted simple methods where only a few measurements of the attached leaves would be necessary for a good approximation of the leaf area.

A very satisfactory method to estimate leaf areas of *Hevea* clones is through a simple linear regression equation derived by regressing the leaf area (Y) on the product (X) of the two parameters length (L) and maximum breadth (B) of the leaf (Lim and Narayanan, 1972; Waidyanatha and Goonesekera, 1975). This method involves taking L and B measurements of the attached leaves, in the field, and simply substituting these values in an already established linear equation to estimate the leaf area. Lim and Narayanan (1972) give a common linear equation, passing through origin, for estimating leaf areas of eight *Hevea* clones namely PB 86, GT 1, PR 107, Tjir 1, RRIM 701, RRIM 623, PB 5/51 and RRIC 36. As another method Goonesekera (1978) presents a general non-linear model of the form $Y = a L^{\alpha}B^{\beta}$, where a, α and β are coefficient to be estimated, for estimating leaf area. He had used Jak leaves for deriving the equation, using multiple linear regression procedures.

The objective of our investigation is to compare the above mentioned linear and non-linear equations, both involving the same parameters L and B. These comparisons are based on the results obtained from 10 *Hevea* clones namely, PB 86, GT 1, RRIC 45, IRCI 2, RRIC 101, RRIC 52, RRIC 88, RRIM 600, LCB 870 and RRIC 100. The possibility of a common equation for these clones, is investigated and the common linear equation given by Lim and Narayanan (1972) for estimating leaf areas of PB 86 and GT 1 is also compared with the relevant equation derived by us.

MATERIALS AND METHODS

Measurements of area (Y), length (L) and maximum breadth (B) of the leaves, of 1 year old plants of the 10 clones, PB 86, GT 1, RRIC 45, IRCI 2, RRIC 101, RRIC 52, RRIC 88, RRIM 600, LCB 870 and RRIC 100 were used for analysis. In all the 10 clones, 25 leaflets each from 10 plants selected at random giving a total of 250 leaflets were used for estimation. Leaf area was measured using a planimeter and the data were all converted to c. g. s. units before analysis.

The simple linear regression equation of the form $Y = bX$ (where Y = leaf area, $X = L \times B$, b is the regression coefficient) was tried on each clone using standard regression techniques (Snedecor and Cochran, 1980). After transforming Y, L and B to log scale, a multiple linear regression equation of the form $\log Y = \log A + \alpha \log L + \beta \log B$ was also fitted to each clone to find corresponding coefficients in the non-linear equation, $Y = aL^{\alpha} B^{\beta}$ (where a, α & β are the coefficients). Residual plots were used for detecting outliers and the models were updated. A regression analysis was done on each new model and for each clone using a computer. Residuals of the estimated leaf areas were presented as percentages of the observed area, for each clone. Finally a comparison of these percentage error distributions due to the linear and non-linear models, was made for each clone. Results are discussed in the next section.

RESULTS AND DISCUSSION

Upon plotting the observed leaf area (Y) against the product (X) of the two leaf parameters length (L) and maximum breadth (B), all measured in c. g. s. units, we observed approximately exact fits of straight lines through origin. The results of the fitted regression lines through origin are presented in Table 1.

According to Table 1, coefficients of determination for all the 10 clones were above 99% implying that 99% of the variability of the observed leaf area can be explained by the given linear relationship. This is more or less an exact linear fit. The regression coefficients also varied very little among the 10 clones, namely, they ranged from 0.662 to 0.693. The 95% confidence regions for each regression coefficient showed that the lowest lower limit was 0.654 while the highest upper limit was 0.696.

Table 2 shows the coefficient estimates for the non-linear relationship of the form $Y = a L^{\alpha} B^{\beta}$, where Y, L & B are as explained before. a, α and β are the coefficient, of the model. Since Y is measured in cm^2, for this model to be dimensionally balanced

($\alpha + \beta$) should be equal to 2. Goonesekera (1978) claims that this is true for his model. In Table 2 also, we find that ($\alpha + \beta$) is approximately 2 for each clone. The exact equality was not observed, probably due to round-off errors. The non-linear model also explained about 99% of the variability of Y (Table 2).

Table 1. Estimates of the coefficients of the linear relationship between observed leaf area (Y) and length × breadth (X) and the extent of variability of Y explained by this relationship.

Clone	Equation: Y = bX		Coefficient of determination (R^2)
	b (± S. E.)	95% confidence interval for b	
PB 86	0.664 (± 0.002)	0.660, 0.669	0.997
GT 1	0.666 (± 0.002)	0.654, 0.662	0.998
RRIC 45	0.674 (± 0.002)	0.669, 0.678	0.997
IRCI 2	0.684 (± 0.002)	0.681, 0.688	0.998
RRIC 101	0.679 (± 0.002)	0.676, 0.682	0.999
RRIC 52	0.688 (± 0.002)	0.684, 0.691	0.998
RRIC 88	0.678 (± 0.002)	0.674, 0.682	0.998
RRIM 600	0.662 (± 0.002)	0.657, 0.667	0.997
LCB 870	0.680 (± 0.002)	0.676, 0.683	0.998
RRIC 100	0.693 (± 0.002)	0.690, 0.696	0.999

Table 2. Estimates of coefficients of the non-linear relationship between observed leaf area (Y) and length (L) and breadth (B) and the extent of the variability of (Y) explained by this relationship.

Clone	Equation: $Y = aL^{\alpha} B^{\beta}$			Coefficient of determination (R^2)
	a (± S.E.)	α (± S.E.)	β (± S.E.)	
PB 86	0.845 (±1.043)	0.770 (±0.033)	1.192 (±0.037)	0.985
GT 1	0.731 (±1.036)	0.780 (±0.026)	1.259 (±0.031)	0.990
RRIC 45	0.760 (±1.030)	0.824 (±0.024)	1.155 (±0.026)	0.992
IRCI 2	0.768 (±1.026)	0.869 (±0.023)	1.124 (±0.026)	0.995
RRIC 101	0.747 (±1.032)	0.884 (±0.028)	1.111 (±0.030)	0.993
RRIC 52	0.679 (±1.025)	0.961 (±0.023)	1.058 (±0.029)	0.994
RRIC 88	0.748 (±1.039)	0.875 (±0.029)	1.127 (±0.033)	0.984
RRIM 600	0.782 (±1.045)	0.811 (±0.033)	1.181 (±8.039)	0.979
LCB 870	0.702 (±1.033)	0.970 (±0.028)	1.027 (±0.031)	0.990
RRIC 100	0.681 (±1.025)	0.958 (±0.022)	1.065 (±0.028)	0.994

A comparison of the two relationships, linear and non-linear, with respect to the percentage distribution of leaves falling into selected ranges of percentage errors in estimating leaf area, is given in Table 3. Here, the percentage error is nothing but the difference (actual — estimated) as a percentage of the actual area. We found that only 3% of the leaves, on the average, showed an error greater than 10%, for both models. On the other hand, above 70% of the leaves, on the average, were associated with an error of only less than 5%, for both models. Therefore, no relationship showed superiority over the other, in this respect, over all 10 clones.

Table 3. Percentage of leaves falling into selected ranges of percentage error in estimating leaf area, using linear ($Y = bX$), and non-linear ($Y = aL^{\alpha} B^{\beta}$) models.

Clone	Model	% error in estimation 0—5	5.1—10	>10	Total No. of leaves in the sample
PB 86	$Y = .664X$	64.8	26.7	8.5	236
	$Y = .845L^{.77}B^{1.192}$	72.5	23.7	3.8	
GT 1	$Y = .666X$	63.2	29.8	7.0	242
	$Y = .731L^{.78}B^{1.259}$	73.2	23.1	3.7	
RRIC 45	$Y = .674X$	74.4	21.8	3.8	232
	$Y = .760L^{.82}B^{1.155}$	81.9	15.9	2.2	
IRCI 2	$Y = .684X$	77.0	21.8	1.2	239
	$Y = .768L^{.869}B^{1.124}$	80.3	18.8	0.9	
RRIC 101	$Y = .679X$	80.0	19.2	0.8	240
	$Y = .747L^{.884}B^{1.111}$	82.5	16.3	1.2	
RRIC 52	$Y = .688X$	76.3	22.4	1.3	241
	$Y = .679L^{.961}B^{1.058}$	76.4	22.4	1.2	
RRIC 88	$Y = .678X$	72.6	20.9	6.5	244
	$Y = .748\ ^{.875}B^{1.127}$	74.2	21.3	4.5	
RRIM 600	$Y = .662X$	62.4	32.7	4.9	245
	$Y = .782L^{.811}B^{1.181}$	64.1	30.6	5.3	
LCB 870	$Y = .680X$	77.4	19.2	3.4	234
	$Y = .702L^{.97}B^{1.027}$	77.3	19.7	3.0	
RRIC 100	$Y = .693X$	77.9	21.3	0.8	244
	$Y = .681L^{.958}B^{1.065}$	79.1	20.1	0.8	
Average	Linear	73	24	3	240
(round off)	Non-linear	76	21	3	

Since the linear relationship is practically easier than the non-linear one, we believe that there is no point in adopting the non-linear method for estimating leaf area of *Hevea* clones. It will also be easier if we can establish a common linear equation for all these clones without loss of generality. Since the regression coefficients varied very little among the 10 clones and the coefficient of variation was only 2%, the average of these 10 coefficients, 0.667, was tried as the common regression coefficient. This coefficient 0.677 is compared with that (0.654) of Lim and Narayanan (1972) with respect to the error in estimation. This comparison is given in Table 4.

Table 4. Comparison of the two linear equations Y=.677X and Y=.654X with respect to percentage error distribution in the estimation of leaf areas of 10 Hevea *clones. (percentage of leaves)*

Clone	% error using Y=0.677X			% error using Y=0.654X			Total No. of leaves in the sample
	0—5	5.1—10	>10	0—5	5.1—10	>10	
PB 86	63.6	29.7	6.7	61.0	30.5	8.5	236
GT 1	61.6	31.8	6.6	64.9	28.5	6.6	242
RRIC 45	75.2	20.9	3.9	58.6	33.2	8.2	232
IRCI 2	75.7	23.0	1.3	55.6	33.5	10.9	239
RRIC 101	80.4	18.8	0.8	66.3	30.4	3.3	240
RRIC 52	76.8	22.0	1.2	59.8	29.5	10.7	241
RRIC 88	72.6	20.9	6.5	63.5	24.2	12.3	244
RRIM 600	59.6	33.5	6.9	64.5	29.8	5.7	245
LCB 870	75.7	20.5	3.8	62.8	28.2	9.0	234
RRIC 100	74.6	23.4	2.0	49.2	38.1	12.7	244
Average (round off)	72	24	4	61	30	9	240

According to Table 4, our equation Y=0.677X was responsible for an average of only 4% of the leaves, over all clones, to have an error greater than 10%. On the other hand, an average of 72% of the leaves, over all 10 clones, showed only less than 5% error in estimating leaf area. Twenty four percent of the leaves were associated with an error between 5% and 10%. These results showed that our assumption of a common coefficient 0.677 for all the 10 clones makes no substantial difference, compared to the individual coefficients. Errors in the estimation using Y=0.677X compared to that of Y=0.654X, were also considerably small. It is seen from Table 4 that, our equation Y=0.677X tend to estimate leaf areas with a considerably large percentage of leaves associated with less error (less than 5%) and a small percentage associated with large errors (greater than 10%). This compares favourably with the equation Y=0.654X of Lim and Narayanan (1972). For the clones tested in this study common coefficient derived by us gives a better estimate of leaf areas than that of Lim and Narayanan (1972).

In conclusion, we recommend the simple linear equation $Y=0.677X$, where Y is the actual area (cm^2) to be estimated, and X is the product of length (cm) and the maximum breadth (cm), of the leaflet, for estimating the leaf area of the 10 *Hevea* clones that were studied. It may be that this relationship holds true for other *Hevea* clones in Sri Lanka. However, further studies should be contemplated before making a firm recommendation, especially for the newly introduced RRIC hundred series clones.

ACKNOWLEDGEMENTS

The authors wish to thank Miss C. W. Ranasinghe and Mr L. S. Kariyawasam, both of the Plant Science Department, for technical assistance and Miss J. D. Nandani of the Biometry Section for assisting in data analysis. We are also grateful to Dr. Rex Clements, of the Faculty of Agriculture, Peradeniya, for reading the script and for helpful suggestions.

REFERENCES

GOONESEKERA, G. A. J. P. R. (1978). A general regression equation for the estimation of leaf areas. *Jl. Rubb. Res. Inst.* Sri Lanka, **55,** pp 29 - 33.

LIM, T. M. and Narayanan, R. (1972). Estimation of the area of rubber leaves (*Hevea brasiliensis* Muell Arg.) using two leaflet parameters. *Exp. Agric.* **8,** pp 311 - 313.

SNEDECOR, G. W. and COCHRAN, W. G. (1980). *Statstical methods* (7th edition), The Iowa State University Press, Ames, Iowa.

WAIDYANATHA, U. P. de S. and GOONESEKERA, G. A. J. P. R. (1975). Some methods for determining leaf areas in *Hevea*. *Jl. Rubb. Res. Inst.* Sri Lanka, **52,** pp 10 - 19.