Estimation of leaf area in turmeric (*Curcuma longa* L.) under two agroecological conditions

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ABSTRACT

The total leaf area (TLA) at different stages of growth of tillers or clumps of turmeric (*Curcuma longa*) varieties raised under two agroecological conditions viz., in the open as a pure crop and in association with coconut, can be estimated using the regression equation $TLA = b_1 nB + b_2 L$. The total leaf area of the tiller or clump can be computed by taking the linear measurements ('L' and 'B') of only one leaf i.e., median leaf of the tiller or those of the median leaf of the tiller having maximum number of leaves, respectively, and counting the total number of leaves ('n') in the respective tiller or clump. Under both the ecological conditions studied and between the same, the regression coefficients were not homogenous over various stages of growth and for different varieties. Hence common mathematical formulae were not attempted to, with regard to varieties, age of the plant or ecological conditions.

Key words: agroecological conditions, *Curcuma longa*, leaf area, regression equation, turmeric.

Introduction

Measurements of leaf area are often required for agronomic, physiological and ecological studies. Miller (1938), McKee (1964) and Marshall (1968) reviewed various methods of measuring leaf areas, which can be classified into destructive, non-destructive, direct or indirect methods. One of the most accurate, non-destructive and indirect method for estimation of leaf area is by using mathematical formulae involving linear measurements (Marshall 1968; Kvet & Marshall 1971). Mathematical

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models for estimating leaf areas have been developed for numerous crops (Ashbey & Das 1963; McKee 1964; Wiersma & Bailey 1975; Shneiter, 1978; Satheesan, Narasimhayya & Ramadasan 1983). However, such information is not available for turmeric (*Curcuma longa* L.), an important spice crop of India. Turmeric is presently cultivated under different agroecological conditions especially in the open as a pure crop, and in association with other perennial and plantation crops. The objectives of the present study were to develop a rapid, accurate and non-destructive method for estimation of leaf area in turmeric grown under two agroecological conditions viz., in the open and in association with coconut; and to assess whether common equations could be used with regard to varieties, age of the plant and ecological conditions.

Materials and methods

Three varieties of turmeric viz., Cls. No.24, Cll. 328 Sugandham and Duggirala were grown under two agroecological conditions viz., in the open as a pure crop and in a mature coconut plantation. The crop was raised in the experimental farm of CPCRI, Kasaragod and the development of mathematical formulae for estimation of leaf area was carried out during 1990. The experiment was laid out in a Completely Randomized Design with five replications of five beds each. Each bed was of 1 m x 3 m size with 40 plants at a spacing of 25 cm x 30 cm. The only environmental variable found markedly and consistently different between these two conditions was solar radiation, the radiation input in the coconut plantation being 46% of that in the open.

Four plants in each row were harvested at random from each bed after one, two, three and four months after planting in the case of pure crop, and after three, four and five months in the case of planting under coconut. In the latter case, the growth of plants was slow and maximum leaf production was in the fifth month. Altogether 1260 plants / clumps consisting of 3500 tillers and 28,000 leaves were utilised in the study. The number of leaves, length and maximum breadth of each leaf were recorded. The actual leaf area of individual leaves was recorded using LI - 3000 Electronic Leaf Area Meter (LI-COR Inc., Nebraska, USA), and total leaf area of each tiller and clump were estimated by adding the leaf area of individual leaves.

To determine the diversity of experimental materials, an analysis of variance and test of significance of leaf length, width and area were conducted. Multiple regression of the form $Y = \sum bi\ xi$ with various linear combinations of number of leaves (n) in the tiller, the length (L) and maximum breadth (B) of the median leaf of the tiller were fitted to estimate the total leaf area (TLA) of the tiller/clump. The following regression equations were fitted separately for tillers and clumps:

$$TLA = b_1\ n + b_2\ L$$

$$TLA = b_1\ n + b_2\ B$$

$$TLA = b_1\ nL + b_2\ B$$

$$TLA = b_1\ nB + b_2\ L$$

$$TLA = b_1\ n + b_2\ LB$$

In the case of TLA for tillers, 'n' refers to the total number of leaves in the tiller, and 'L' and 'B' the linear measurements of median leaf of the tiller. In the case of TLA for clump, 'n' refers to the total number of leaves in the whole clump, and 'L' and 'B' are the linear

measurements of the median leaf of the tiller having maximum number of leaves. n/2th leaf or n+1/2th leaf from the top is considered as the median leaf according to the number of leaves, 'n' is even or odd, respectively.

Results and discussion

Statistical analysis showed that the turmeric varieties and the individual leaves at different stages of growth differed significantly in leaf length, width and area over the two agroecological conditions studied indicating a wide diversity in the material. The total leaf area of any tiller/clump could be estimated with high precision by measuring the length and breadth of median leaf and counting the total number of leaves in the tiller/clump, under both the conditions using any of the linear conbinations of n, L; n, B; nL, B; nB, L and n, LB (R^2 varying from 0.793 to 0.996 for tillers and from 0.930 to 0.996 for clumps). The highest predictive ability was for the linear combination of nB, L (R^2 varying from 0.944 to 0.994). The regression equations ($TLA = b_1 nB + b_2 L$) for estimating the total leaf area of the tiller/clump separately for each variety at different stages of growth under both the agroecological conditions are presented in Tables 1 and 2.

Table 1. Multiple regression equation for estimating total leaf area of any tiller or clump of turmeric varieties grown as a pure crop in the open

Varieties/ Stages of growth	Regression equations for tiller			Regression equations for clump		
	L	nB	R^2	L	nB	R^2
Cls. No. 24						
1st month *(N = 21, 4)	9.506	6.795	0.986	9.506	6.795	0.986
2nd month (N = 82, 23)	-4.533	19.902	0.988	7.462	14.303	0.985
3rd month (N = 84, 24)	-2.972	18.860	0.984	20.158	11.719	0.978
4th month (N = 126, 23)	-5.196	22.027	0.978	33.479	8.481	0.961
Cll. 328 Sugandham						
1st month (N = 11, 10)	-3.489	11.829	0.991	-3.489	11.829	0.991
2nd month (N = 31, 18)	-5.623	22.698	0.977	-2.638	19.758	0.986
3rd month (N = 35, 18)	-3.251	21.363	0.985	10.476	16.459	0.991
4th month (N = 36, 19)	-9.414	28.537	0.987	25.020	13.160	0.987
Duggirala						
1st month (N = 12, 12)	-3.988	15.777	0.976	-3.988	15.777	0.976
2nd month (N = 35,11)	-6.984	23.355	0.984	32.649	13.331	0.957
3rd month (N = 37, 11)	-3.191	20.189	0.985	41.349	9.662	0.983
4th month (N = 42, 11)	-5.937	24.870	0.984	21.075	12.514	0.985

* No. of tillers and clumps sampled (N) are given in parentheses

Table 2. Multiple regression equation for estimating total leaf area of any tiller or clump of turmeric varieties grown in association with coconut

Varieties/ Stages of growth	Regression equations for tiller			Regression equations for clump		
	L	nB	R^2	L	nB	R^2
Cls. No. 24						
3rd month *(N = 69, 21)	5.073	19.954	0.979	17.312	12.398	0.990
4th month (N = 81, 24)	-2.864	19.614	0.990	24.486	10.898	0.989
5th month (N = 95, 23)	-6.507	23.702	0.980	25.897	10.916	0.982
Cll. 328 Sugandham						
3rd month (N = 37, 16)	-2.778	21.248	0.970	31.720	12.073	0.944
4th month (N = 26, 19)	-7.981	24.647	0.992	15.791	15.866	0.985
5th month (N = 25, 16)	-4.339	26.525	0.980	30.203	13.410	0.971
Duggirala						
3rd month (N = 24, 11)	-1.327	22.222	0.966	9.594	16.910	0.994
4th month (N = 26, 10)	-0.744	23.841	0.992	11.964	18.578	0.991
5th month (N = 29, 10)	-6.892	28.298	0.993	17.688	15.265	0.986

* No. of tillers and clumps sampled (N) are given in parentheses

Linear measurements of only the median leaf of the tiller and total number of leaves in the tiller are needed for estimating TLA of tiller. For estimating the total leaf area of the whole clump also, the parameters to be recorded are linear measurements of the median leaf of the tiller having maximum number of leaves and total number of leaves in the clump. Under both the ecological conditions, the regression coefficients were not homogenous over various stages of growth and for different varieties. Between the two conditions also, the regression coefficients were not homogenous. Hence common formulae were not attempted to, with regard to varieties, age of the plant or ecological conditions.

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