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Method for Leaf Area Determination in Chinese Potato (*Plectranthus rotundifolius*)

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Abstract

A method for leaf area determination in Chinese potato (*Plectranthus rotundifolius*) was developed at Central Tuber Crops Research Institute, Thiruvananthapuram, India. There was significant positive correlation (r = 0.97) between length (L) and area (A) and breadth (B) and area (A) of leaf (r = 0.97). The factor (F) of relationship between L and A of leaf was 3.412 and that between B and A of leaf was 4.59. The relation between product of length and breadth (P) and A of leaf was also significant (r = 0.99) and the F between P and A was 0.727. The linear regression equation between L and A, B and A and between P and A were Y = 5.949 x - 15.51, Y = 8.486 x - 17.81 and Y = 0.686 x + 1.114 respectively. The coefficient of determination (r^2) values between L and A, B and A and between P and A were 0.948, 0.726 and 0.987 respectively. The coefficient of determination (r^2) value observed between P and A near to 1 suggested that the regression equation was good fit. Therefore, using the F value derived from P, the total leaf area of a plant can be calculated by the formula: Total leaf area = P of a single leaf (average value of few observations) x 0.727 x total number of leaves per plant. The linear regression equation (y = 0.141 x + 7.833) and r^2 value (r^2 = 0.742) and significant positive correlation coefficient value (r = 0.861) between area and weight of dry leaf suggest that the dry leaf weight method can be also used for calculating leaf area of Chinese potato plant. The factor (F) derived between weight of dry leaf and area of leaf was 0.227. From the F value, the total area of a plant can be calculated by the formula: Total leaf area = weight of a single dry leaf (average of few leaves) x 0.227 x total number of leaves per plant.

Key words: Chinese potato, leaf area

Introduction

The total leaf area of a plant or the size of a canopy is an important determinant for light interception, growth, water use efficiency and gas exchange ability related to photosynthesis of the plant. The total dry matter produced by a plant per unit time is more dependent on the size of its total assimilatory system (Watson, 1952). Therefore, the determination of total leaf area per plant and the leaf area index (LAI) i.e. leaf area per unit area of land is essential for growth analysis studies. Among various methods available, use of leaf area meter to measure leaf area is the best due to rapidity, accuracy and convenience. However, this instrument is expensive and cannot be used for non-destructive growth analysis studies. Therefore, alternative methods have been developed by many researchers to determine the leaf area of plants. Although digital camera with image measurement and analysis software is accurate it is time consuming and expensive. The portable scanning planimeter is suitable only for small plants with few leaves but requires the excision of leaves from the plant (Nyakwende et al., 1997). An inexpensive, reliable, rapid and non-destructive linear measurement method based on the linear regression relationship between leaf length (L), leaf breadth (B) and product of leaf length and breadth (P) with leaf area (A) has been reported in several tropical tuber crops viz., tannia (Venkateswaralu and Birader, 1980), taro (Birader et al., 1978; Goenaga and

Singh, 1996), cassava and sweet potato (Ramanujam and Indira, 1978; Villegas et al., 1981), white yam, greater yam and lesser yam (Ravi and Roy Chowdhury, 1989) dwarf white yam (James George, 1992) and elephant foot yam (Ravi et al., 2010). The advantage of this method is that it can be used effectively to estimate the area of intact leaves which is vital in non-destructive growth analysis studies. The dry leaf weight method of determining area per unit weight of dry leaves and multiplied by total weight of dry leaves has been reported in wheat (Watson, 1937; Aase, 1978) and in jute (Palit and Bhattacharyya, 1978). The method is more suitable for plants with smaller leaves and more number of leaves. Hence, this paper reports the linear measurement method for determination of leaf area in Chinese potato (*Plectranthus rotundifolius*) which can be used for non-destructive growth analysis of this crop.

Materials and Methods

Chinese potato (*Plectranthus rotundifolius*) var. Sree Dhara was raised at the farm of Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram, Kerala, India, during July-September in 2010. Intercultural operations and package of practices were followed as recommended by CTCRI. One hundred fully expanded leaves representing different sizes were taken randomly from three months old plants. The leaf length (L) was measured from the leaf apex to the point of petiole attachment whereas maximum breadth (B) of leaf was measured across the margins. The leaves were also oven dried at 80°C for 72 h and the weight of dry leaves was recorded. The actual area (A) of individual leaf was recorded in a leaf area meter, LICOR, USA (Model. No. LI-3000C).

The correlation coefficients (r) and the coefficient of determination (r^2) and the regression equation $Y = a + bx$ between leaf length (L) and area (A), breadth (B) and leaf area (A) and product of length and breadth (P) and leaf area (A) and between weight of dry leaf and leaf area (A) were calculated and the leaf factor was derived from the formula:

Factor (F) = Area of leaf (A) / leaf length (L) or leaf breadth (B) or product of leaf length and breadth (P) or weight of dry leaf as described by Ramanujam and Indira (1978).

Results and Discussion

The Chinese potato plant has several solitary leaves attached to the stem. The area of leaves varied between 7.47 and 36.69 cm^2 with the average area of 22.19 cm^2. The length of leaves varied between 3.2 and 8.7 cm and the average length was 6.34 cm. The breadth of leaves varied between 2.9 and 6.4 cm with the average of 4.71 cm. In the present study, the total number of leaves was between 938 and 1625 per plant and the average number of total leaves per plant was 1389.

Linear measurement method

The regression equation between length (L) and area (A) of leaves ($y = 5.949 x – 15.51$) and the coefficient of determination (r^2) value ($r^2 = 0.948$) and the correlation coefficient value ($r = 0.974$) ($p = < 0.01$) showed that there was a highly significant positive correlation between L and A of a leaf. The factor (F) derived between length and area of leaf was 3.412 (Table 1). The regression equation between breadth (B) and area (A) of leaf ($y = 8.486 x – 17.81$) and the coefficient of determination(r^2) value ($r^2 = 0.726$) and the correlation coefficient value ($r = 0.974$) ($p = < 0.01$) showed that there was a highly significant positive correlation between B and A of a leaf. The factor (F) derived between breadth and area of leaf was 4.59 (Table 1). The regression coefficient equation for the relation between product of length and breadth (P) and area (A) of leaf was calculated and the leaf factor (F) was derived by the linear measurement method. The regression equation between P and A ($y = 0.686 x + 1.114$), the coefficient of determination (r^2) value ($r^2 = 0.987$) and the correlation coefficient value ($r = 0.993$) ($p = < 0.01$) clearly showed that there was a significant positive correlation between P and A of a leaf (Fig. 1, Table 1). This suggested the suitability of linear measurement method for determining area of lamina of Chinese potato. High positive correlation between P and A has been reported elsewhere in tannia (Chapman, 1964; Venkateswaralu and Birader, 1980; Agueguia, 1993), taro (Birader et al., 1978; Lu et al., 2004), cassava and sweet potato (Ramanujam and Indira, 1978; Lockard et al., 1985), white yam, greater yam and lesser yam (Ravi and Roy Chowdhury, 1989), dwarf white yam (James George, 1992) and in elephant foot yam (Ravi et al., 2010). The factor (F) derived between product of

Table 1. The regression equation, coefficient of determination, correlation coefficient and factor (F) between length and area, breadth and area and product of length and breadth and area of leaf

Leaf parameter	Regression equation ($y = a + bx$)	Coefficient of determination (r^2)	Correlation coefficient (r)	Factor (F)
Length versus area	5.949 x – 15.51	0.948	0.974	3.412
Breadth versus area	8.486 x – 17.81	0.726	0.974	4.59
Product of length and breadth versus area	0.686 x + 1.114	0.987	0.993	0.727
Weight of dry leaf versus area	0.141 x + 7.833	0.742	0.861	0.227

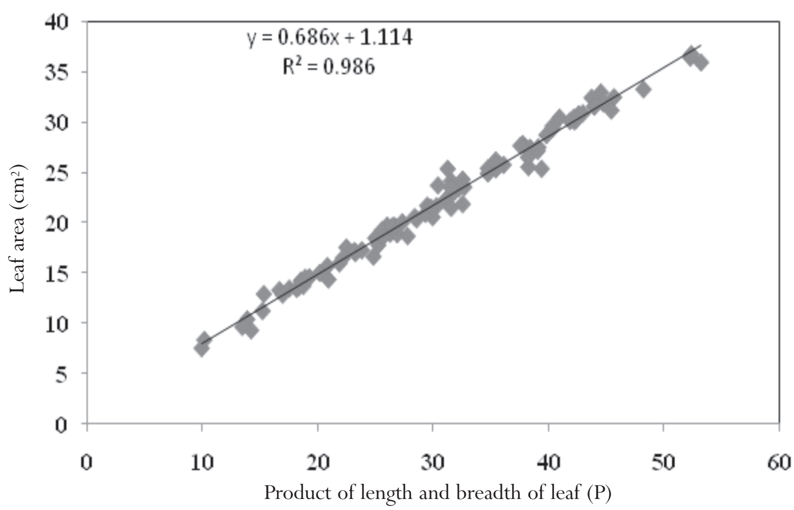

Fig. 1. The linear regression equation and coefficient of determination between product of length and breadth (P) of leaf and area (A)

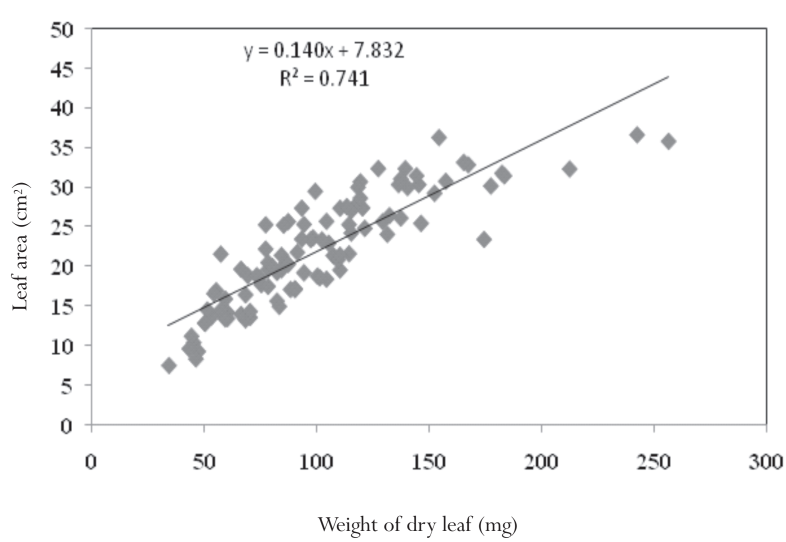

Fig. 2. The linear regression equation between weight of dry leaf and leaf area

length and breadth (P) and area of leaf by linear measurement method was 0.727. The coefficient of derermination (r^2) value observed between P and A was near to 1 indicating that the regression equation was good fit. When the values of leaf area (A) based on leaf factor (F) derived from L, B and P were calculated and matched with the actual value of the leaf area recorded in the area meter, the difference was not significant and was minimum in the case of product of length and breadth (P) of leaf. Therefore, from the F derived for P, total leaf area of Chinese potato can be calculated by using the following formula:

Total leaf area = P (average value of few observations) x F x total number of leaves per plant

Dry leaf weight method

The weight of individual dry leaf varied between 34 and 256 mg and the average weight of dry leaf was 101.89 mg. The leaf area and weight of dry leaf showed a significant positive correlation coefficient r value ($r = 0.861$) significant at $p = < 0.01$ and were associated linearly ($Y = 0.141 x + 7.832$), r^2 value ($r^2 = 0.742$) (Table 1). This suggested that the weight of dry leaf method can also be used for calculating leaf area of Chinese potato. The factor (F) derived between dry leaf weight and area of leaflet was 0.227 (Fig. 2, Table 1). From the F value the total leaf area of Chinese potato plant can be calculated by the formula:

Total leaf area = Weight of (average of few leaves) single dry leaf x F x total number of leaves per plant

A positive correlation between weight of dry leaf and area has been reported in other crops like cotton (Ashley et al., 1963), cassava and sweet potato (Ramanujam and Indira, 1978), taro (Biradar et al., 1978) and elephant foot yam (Ravi et al. 2010).

Therefore, comparing the above two methods, the linear measurement method based on P seems to be more feasible for the calculation of leaf area in Chinese potato due to positive association between the P and A of leaf. The factor (F) derived by this method can be directly used for leaf area calculation in non-destructive growth analysis studies. Furthermore, the F derived by linear measurement method for leaf area measurement remains constant with age of the plant under wide environmental conditions (Ramanujam and Indira, 1978). Although the dry leaf weight method as per the present study can be used for determining the leaf area it cannot be used for non-destructive growth analysis studies. Moreover, since the leaf weight changes with the age of the crop and environmental conditions, the factor (F) and the relation of leaf area to weight of dry leaf may vary with the age of the crop and prevailing environmental conditions.

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