DETERMINATION OF CONSTANT FACTOR AND INDEX LEAF FOR RAPID LEAF AREA ESTIMATION IN TARO

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ABSTRACT

Five taro cultivars were selected from the germplasm at the Philippine Root Crop Research and Training Center in ViSCA, Baybay, Leyte to determine their estimated and actual leaf areas. Correlation analysis of the estimated and actual leaf areas revealed a high linear association between them. A general regression equation ($Y = -11.85 + 0.954X$) was developed and further verified to be accurate in determining the actual leaf area of taro by simply substituting the estimated leaf area (product of length x width) to the X in the equation. The same question can accurately determine the actual leaf area of different taro cultivars regardless of their stage of growth. The second leaf from the youngest open leaf was identified as the index leaf for both 3- and 4-leaf stage taro plants. The estimated area of the second leaf was highly correlated with the total plant leaf area. The regression equations $Y = 9.12 + 2.785X$ and $Y = 12.22 + 3.531X$ can be used to determine accurately the total leaf areas in 3- and 4-leaf stage taro plants, respectively.

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INTRODUCTION

Various physiological as well as agronomic evaluation of crop performance requires leaf area as an important parameter to assess plant growth and development. In establishing growth indices like leaf area index, leaf area duration, net assimilation rate and crop growth rate, the estimation of the total plant leaf area is very necessary. However, its estimation which may be done during different stages of growth is laborious and time-consuming. Although many devices have been developed and used for this purpose, e.g., air-flow planimeter and photoelectric apparatus, they do not seem to be practical under specific conditions. These instruments commonly involve destructive sampling of plant materials, i.e., the leaves have to be removed from the main plant for measurement, and may have many defects such as those resulting from differences in leaf thickness and migratory light from outside source (Vivekanandan, Gunasena and Sivanayagan, 1972).

Jain and Mishra (1966) recommended a leaf product method of estimating plant leaf area which involves using a constant factor to be multiplied with the product of the length and the maximum width of the leaf. Using this method, constant factors have been worked out for crops like tobacco (Tejwani, Kurup and Venkataraman, 1957), sorghum (Stickler, Wearden and Paul, 1961), and cotton (Ashley, Doss and Bennet, 1963).

MATERIALS AND METHODS

Five taro cultivars, namely, PR-G058, PR-G066, PR-G068, PR-G146 and PR-G147 were selected from the germplasm at the Philippine Root Crop Research and Training Center in ViSCA, Baybay, Leyte for leaf area determination. The different cultivars were planted in March 1980 and were about 5 months old at the time of sampling. The plants were fertilized with 60-60-60 kg NPK/ha at planting to ensure vigorous growth.

Twenty-five plants from each cultivar were selected at random in the field. All the leaves of the main plant were removed and numbered serially starting from the youngest open leaf to the oldest green leaf. The leaves were taken to the laboratory to determine their estimated and actual leaf areas. The estimated leaf area was determined by taking the product of the length and the maximum width of the leaf after measurement. The actual leaf area, on the other hand, was determined by measuring the entire leaf blade with the use of a polar planimeter (LIETZ Brand, Cali Mercantile Inc., P.O. Box 4263, Manila). Correlation analysis was worked out between the estimated leaf area and the actual leaf area of more than 70 leaf samples from each of the selected cultivar. A regression equation ($Y = a + bX$) was calculated for each cultivar. $\underline{Y}$ was the expression used to represent the actual leaf area while $\underline{X}$ represented the estimated leaf area; $\underline{a}$ was the regression constant and $\underline{b}$ the slope of the regression line (used as the constant factor to calculate the actual leaf area in the different taro cultivars).

To simplify the determination of the leaf area in taro, an index leaf was also determined to represent the total plant leaf area. This was done by correlating each of the individual leaf areas with the total area of one plant. The leaf with an area that was most significantly correlated with the total plant leaf area was considered as the index leaf. To determine the total plant leaf area, leaf area factor was calculated separately for the 3- and 4-leaf stage taro plants. Only those plants with 3 and 4 leaves were used since these were more common than taro plants with 2 or 5 leaves.

RESULTS AND DISCUSSION

Determination of Constant Factor.

The correlation analysis between the estimated leaf area and the actual leaf area revealed a very high degree of correlation between the two leaf areas. Correlation coefficients calculated for each of the 5 cultivars were all found to be significant at 1% level. This suggests that the estimated and the actual leaf areas are highly associated in a linear manner (Fig. 1). The values of the simple linear correlation coefficients of the 5 cultivars are presented in Table 1 together with the calculated factors (regression coefficients).

The result of the regression analysis between the estimated and actual leaf areas showed no significant difference between the slopes of the regression lines (the calculated factors in Table 1). This seemed to suggest that no salient differences exist between the leaves

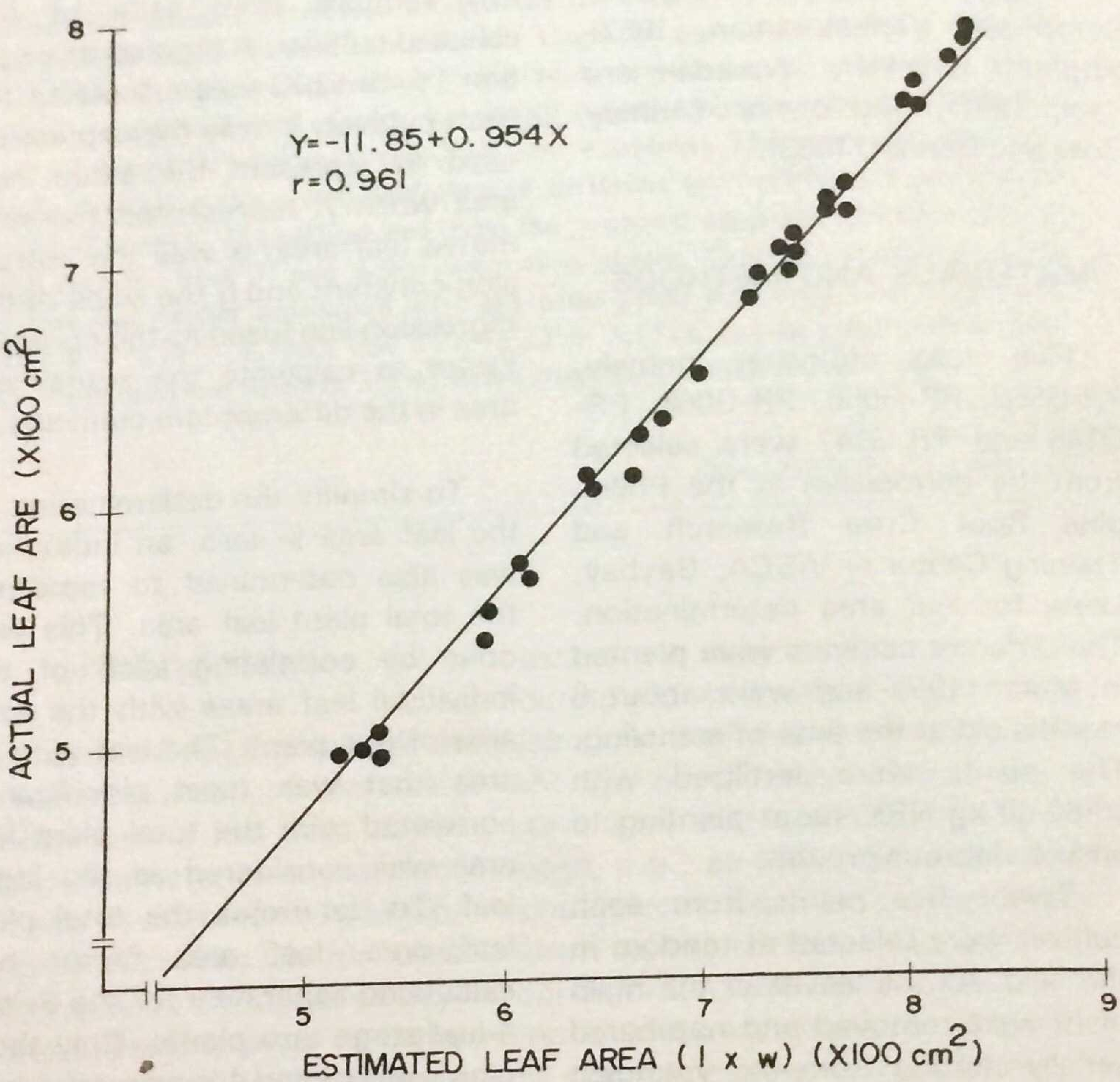

Fig. 1. Relationship between the estimated leaf area (l x w) and the actual leaf area of taro plant.

of different taro cultivars. Therefore, a single constant factor may be used in estimating the leaf area of taro regardless of the cultivar. For some crops, however, the leaf area varies with genotypes especially for those possessing contrasting leaf types (Rajappa *et al.*, 1972).

The mean regression coefficient (0.954) derived from the calculated regression coefficients (calculated factors) presented in Table 1 can be used as a constant factor to determine quickly and accurately the leaf area of taro. A general regression equation (Y = -11.85 + 0.954X) was developed after substituting the mean value of the regression constant (a) and the regression coefficient (b). In this way, the actual leaf area, Y, can be obtained very conveniently by simply adding the values of the regression constant to the product of the constant factor (0.954) and the substituted value of X (product of l x w) in the regression equation as presented above.

Table 1. Relationship between the actual plant leaf area and the estimated leaf area (product of l x w) in taro.

Cultivar	Correlation between estimated and actual leaf area	Calculated Factor
PR-G058	0.964	0.956
PR-G066	0.987	0.962
PR-G068	0.914	0.953
PR-G146	0.958	0.955
PR-G147	0.983	0.936

Validity of the Regression Equation.

The validity of the general regression equation Y = −11.85 + 0.954X was verified by taking at random 30 more leaves of different sizes from different taro cultivars. The leaf areas were obtained by using the general regression equation and the planimeter. The means of the leaf areas were compared by using the t-test. The calculated value of t for the difference between means of the 2-leaf areas was not significant (0.632) at 5% probability level. This indicates that the leaf areas obtained by both the regression equation and the planimeter do not differ significantly; thus, the general regression equation presented above can be used to determine accurately the leaf area of taro. Since only the linear parameters (length and width) of the leaves have to be measured in determining the leaf area, the use of the regression equation is very practical in determining the area of a large number of intact taro leaves of different sizes in the field. The information on leaf area can be obtained quickly and accurately without unnecessarily destroying plant materials.

Regression analysis between the estimated and the actual leaf areas of taro at 1, 3, 5 and 7 months of growth showed no significant difference in the slopes of the regression line (calculated factors) corresponding to different growth stages (Table 2). The mean slope (0.952) was not significantly different with the slope in the general regression equation

(0.954). Hence, the same equation (Y =-11.85 + 0.954X) may be used to determine the leaf area of taro regardless of the stage of growth.

Determination of Index Leaf.

To identify an index leaf in taro that could represent the total plant leaf area, the individual leaf area (product of l x w) was correlated with the total plant leaf area obtained by planimetry. Results showed that the area of the second leaf (the leaf next to the youngest open leaf) was highly correlated with the total leaf area of 3-leaf stage plants (Table 3). Likewise, the area of the second leaf in plants at 4-leaf stage was highly correlated with the total leaf area. Hence, the index leaf of taro plants at 3- and 4-leaf stages is the second leaf from the youngest open leaf. The relationships between the area of the second leaf and the total plant leaf area of 3- and 4-leaf stage plants are presented in Fig. 2 and 3. A constant factor was also calculated for the index leaf. Regression analysis between the area of the index leaf and the total plant leaf area for 3- and 4-leaf stage plants showed that the two require different factors. The regression equation developed for each of the two plants was likewise different: Y = 9.12 + 2.785X and Y = 12.22 + 531X for 3- and 4-leaf stage plants, respectively.

The validity of each regression equation was tested by getting 10 more 3- and 4-leaf plants selected at random from different cultivars in the germplasm. All the leaves of the main plant were removed and taken to the laboratory for leaf area determination. The index leaf area was the product of the length x width of the second open leaf while the total plant area was obtained by

Table 2. Relationship between the actual plant leaf area and the estimated leaf area at different stages of plant growth.

Plant Age (Month)	Correlation between estimated and actual leaf area	Calculated Factor
1	0.991	0.945
3	0.951	0.939
5	0.987	0.958
7	0.958	0.964
	Mean	0.952

Table 3. Correlation between the individual leaf area and the total plant leaf area in 3- and 4-leaf plants.

Three-leaf plant		Four-leaf plant	
Leaf Number[1]	Correlation	Leaf Number[1]	Correlation
1	0.726	1	0.510
2	0.956	2	0.986
3	0.949	3	0.909
		4	0.962

[1] Youngest to oldest leaf.

planimetry. The area of index leaf was substituted to X in the regression equation and was multiplied to the constant factor to get the total leaf area. For 3- and 4-leaf stage plants, the total leaf area determined with the use of the regression equation was compared with the total leaf area obtained with the aid of a planimeter. The means of the leaf areas obtained with the two methods were compared with the use of t-test. For the 3-leaf stage plant, the result showed that the difference of the two leaf areas obtained with the regression equation Y = 9.12 + 2.785x and with the planimeter were not significant (0.467) at 5% probability level. Likewise, for the 4-leaf stage plant, the result of the t-test showed that the means of the total leaf area obtained with the regression equation Y = 12.22 + 3.531X and by planimetry were not significant (0.142) at 5% level.

The above results indicate that the total plant area (Y) can be

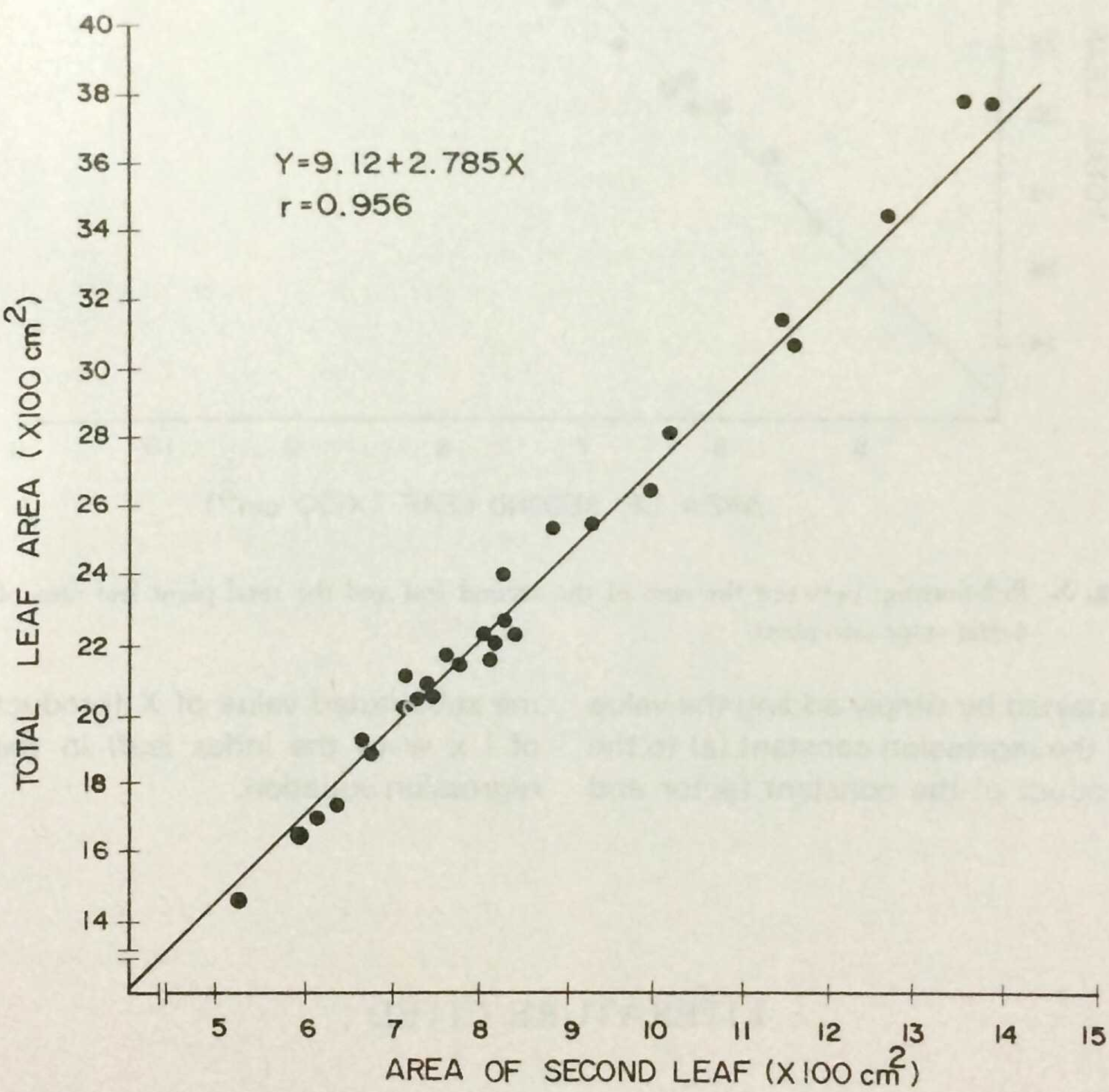

Fig. 2. Relationship between the area of the second leaf and the total plant leaf area of 3-leaf stage taro plant.

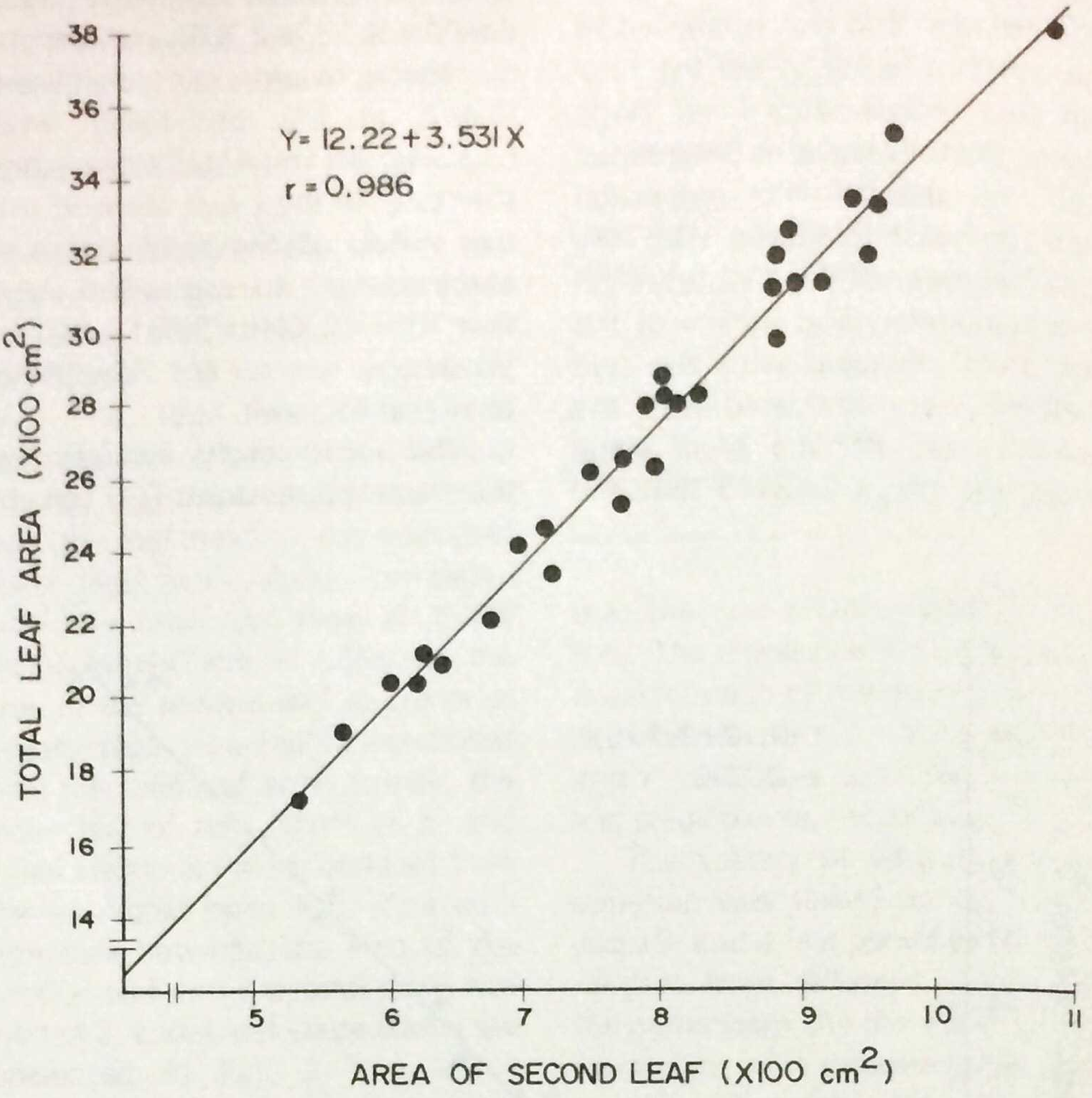

Fig. 3. Relationship between the area of the second leaf and the total plant leaf area of 4-leaf stage taro plant.

obtained by simply adding the value of the regression constant (a) to the product of the constant factor and the substituted value of X (product of l x w of the index leaf) in the regression equation.

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