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A Rapid and Nondestructive Method for Estimating Leaf Area of Onions

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The development of mathematical models from linear leaf measurements for predicting total leaf area has been shown to be a useful tool in studying plant growth and development (Kvet and Marshall, 1971; Manivel and Weaver, 1974; Robbins and Pharr, 1987; Sepaskhah, 1977; Volkov and Selevtsev, 1959; Wiersma and Bailey, 1975). Simple, accurate models eliminate the need for expensive leaf area meters or time-consuming geometric reconstructions. Common measurements for prediction equations have been leaf length, leaf width, petiole length, or some combination of these variables.

Onion *(Allium cepa* L.) leaf and stem morphology differs from the morphology of plants used in previous leaf area models. Onion leaves develop from the upper surface of a broad, conical basal stem. Leaf blades are tubular and markedly flattened on the upper surface. As the onion plant grows, leaves will vary from long to short and thick to thin. Individual leaves will also vary in circumference from the leaf base to the leaf tip. Linear measurement(s) must, therefore, be representative of this variation to aid in the development of an accurate leaf area model. The objective of this study was to develop and evaluate linear regression models that would accurately predict onion leaf area using nondestructive and simple linear leaf measurements.

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Thirty leaves were chosen at random from plants growing in solution culture under greenhouse conditions at Athens, Ga. The short-day cultivar Granex 33 was used. Leaf length and leaf circumference at 25% (C_{25}, 50% (C_{50}), and 75% (C_{75}) of the leaf length were measured in centimeters. Leaf area was determined by dividing each leaf into one triangle and three trapezoids, tracing each piece onto paper, and calculating total area. The data then were subjected to multiple linear regression analyses using a stepwise technique (Goodnight, 1979). Model selection required a balance between the predictive qualities of the model and the economy of including the least number of variables necessary to accurately predict onion leaf area.

Evaluation of the coefficient of determination *(R^2)*, the F ratio, and the error mean square (MSE) for each calculated regression indicated that the best regression equation to predict onion leaf area was: A = – 93.1 + 1.83L + 38.6 C_{25}, (Table 1), where A = leaf area, L = leaf length, and C_{25} = leaf circumference at 25% distance from the leaf base. The coefficient of determination for this regression equation was high and statistically significant (R^2 = 0.96). Length alone and C_{25} alone were also good predictors of total leaf area, although the *R** was lower and the MSE was higher than with L and C_{25} in combination. Three and four variables in combination did not substantially improve the predictability of the equations. Use of C_{50} and C_{75} as single variables in the regression equations were less satisfactory for predicting total leaf area of onions, although the R^2 values also were highly significant.

These results demonstrate that onion leaf area can be predicted using simple linear measurements. However, environment has been shown to influence model development for cucumbers (Robbins and Pharr, 1987). Prediction equations, therefore, may need to be adjusted for onions grown-under various environmental conditions.

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Table 1. Correlations of calculated leaf area for onions, with area estimated using prediction models.

Variable	Model	R^2	MSE
Length (L)	A = −105.5 + 4.71L**	0.92**	33.1
C_{25}[z]	A = −73.3 + 60.3C_{25}[NS]	0.95**	26.5
C_{50}[z]	A = −122.6 + 102.2C_{50}[NS]	0.88**	40.2
C_{75}[z]	A = −182.3 + 193.2C_{75}[NS]	0.77**	56.3
L + C_{25}	A = −93.1 + 1.83L + 38.6C_{25}**	0.96**	22.4

[z]Leaf circumference at 25%, 50%, and 75% of the leaf length, respectively.
[NS,**]Not significant or significant at $P \geq 0.01$.