Pak. J. Bot., 34(1): 41-46, 2002.

VALIDATION OF LEAF AREA ESTIMATION MODELS (UZCELIK-I) EVALUATED FOR SOME HORTICULTURAL PLANTS

HUSEYIN CELIK AND SEZGIN UZUN

Department of Horticulture, Faculty of Agriculture, University of Ondokuz Mayis, Samsun, Turkey.

Abstract

In this study, avocado, *Lotus* plum, selected persimmon (52 UN 13), Hayward kiwifruit, aubergine, pepper, cucumber, Black grape (*Vitis labrusca* L.), Narince (*Vitis vinifera* L.), red-currant, summer squash, runner bean, Heritage red raspberry and Chester blackberry plant species were used to validate the regression equations of UZCELIK-I. The actual leaf area of the plants were measured by PLACOM Digital Planimeter and predicted leaf area by using UZCELIK-I equations based on widest lamina width and length of leaves. The equations were validated using the residual values between predicted and measured leaf areas. R^2 values for the relations between actual and predicted leaf areas of the tested species were found to be 0.972, 0.918, 0.983, 0.971, 0.949, 0.988, 0.966, 0.846, 0.953, 0.953, 0.943, 0.950, 0.950 and 0.925 for avocado, *Lotus* plum, selected persimmon (52 UN 13), Hayward kiwifruit, aubergine, pepper, cucumber, Black grape (*Vitis labrusca* L.), Narince (*Vitis vinifera* L.), red-currant, summer squash, runner bean, Heritage red raspberry and Chester blackberry , respectively.

Introduction

Mathematical modelling provides a particularly powerful tool for the formulation of hypotheses and the quantitative description of plant function (Evans, 1972). As modelling techniques are being used increasingly in all areas of plant science, we think that leaf area prediction models are the first step to get into more detailed analyses of plants (Jones, 1992). Models have great potential for practical use but they have as yet not left the research environment (Seligman, 1990; Uzun, 1996). It is the first desire of model users that models testing results confirm the initial hypotheses of model makers. An equally important step, however, in the development of useful models is their validation and testing (Bindi *et al.*, 1997). Without proper experimental and statistical validation, models which attempt to predict any variable of plant growth must be viewed with caution. In regression analyses, the proportion of the variation accounted by a relationship is equivalent to the coefficient of determination (r^2) (Evans, 1972).

Validated and accurate, non-destructive methods of estimating leaf area are useful in the study of the relationship between leaf area and plant growth. On the other hand validated models eliminate the need for expensive leaf area meters or time-consuming for geometric reconstruction (Elsner & Jubb, 1988; NeSmith, 1991). Additionally, these methods permit repeated sampling of the same plant over time, thus reducing some of the experimental variability associated with destructive sampling procedures (NeSmith, 1992). Many researchers find it easy to construct a mathematical model based on regression analyses (Robbins & Pharr, 1987). However, the objective of regression analyses and modelling is to maximise the proportion of the variation accounted for by the model, whilst minimising the unattributable variation.

Corresponding author. e-mail: huscelik@omu.edu.tr

Leaf area is a critical parameter in the derivation of many indices of plant growth since an estimate of leaf area is required in most research efforts involving plant growth (Celik *et al.*, 1982). Some models for the simulation of leaf area in some horticultural plants were suggested by Uzun & Celik (1999) previously. These models were based on the relationship between leaf area and leaf length, leaf width and a fixed plant species number. In this paper, validation of these models were performed where the original model of Uzun & Celik (1999) (UZCELIK-I) was used to simulate the leaf area of some horticultural plants which were utilised to construct the above model.

Materials and Methods

Leaf samples used in this research were selected randomly from fourteen different horticultural plants during the summer of 1999. Tropical, subtropical, currant, grape and berry-like (small fruit) plants were selected from the horticultural research area and vegetables from unheated greenhouses. A total of 206 leaves were measured from the selected plants that are widely grown under Samsun ecological condition and used in researches for Black Sea Region. Leaf samples of the plants tried in the present study and their fixed plant numbers were avocado [1], *Lotus* plum [2], selected persimmon (52 UN 13) [3], kiwifruit [4], aubergine [5] and pepper [6] for the first model; cucumber [7], Black grape (*Vitis labrusca* L.) [8], Narince (*Vitis vinifera* L.) [9], red-currant [10] and summer squash [11] for the second model; runner bean [13], Heritage red raspberry [14] and Chester blackberry [15] for the third model. The plant species (***PS*** *as numbered in the brackets*) and the models (Uzun & Celik, 1999) used to predict leaf areas of the different plant groups are as follows:

$LA = -50.63-1.353*L/W*PS+5.347*W+0.06*W^2*PS+5.489*L$ ..... (1) for avocado, *Lotus* plum, selected persimmon (52 UN 13), Hayward kiwifruit, aubergine and pepper.

$LA = -114.43-7.31*L/W*PS+0.651*W^2+210.86*L/W$ ..... (2) for cucumber, Black grape (*Vitis labrusca* L.), Narince (*Vitis vinifera* L.), red-currant and summer squash.

$LA = -148.65-2.39*LLL^2*PS+2.126*ULL*PS+29.72*LLL^2$ ..... (3) for runner bean, Heritage red raspberry and Chester blackberry, where LA is leaf area, L is leaf length, W is leaf width, ULL is upper leaf lobe length and LLL is lower leaflet length.

The leaves were held in a moist environment while being transported in the laboratory. Once in the laboratory, the leaves were removed from the petiole, placed on the photocopier desktop by holding flat and secure and copied on A_3 sheet (1:1) one by one. A Placom Digital Planimeter (SOKKISHA Planimeter Inc., Model KP-90) was used to obtain actual leaf area. In addition to the area measurement, a series of linear measurements such as leaf width (W), leaf length (L), were collected. Values for both of them were recorded to the nearest 0.1 cm. The EXCELL 7.0 package was used in model validation procedures.

Results

Plotting processes were carried out between actual being calculated by using PLACOM digital planimeter and predicted leaf areas of the tested plants that are

calculated by the model UZCELIK-I (Uzun & Celik, 1999) to find out the degree of accuracy of the mentioned model. Fig. 1 shows actual leaf area plotted against the values predicted by the model for avocado (a), *Lotus* plum (b), selected persimmon (52 UN 13) (c), Hayward kiwifruit (d), aubergine (e) and pepper (f). It was found that the relationship (r^2 values) between actual and predicted leaf areas varied from 0.918 in *Lotus* plum to 0.988 in pepper (from the lowest to the highest value). As it can be seen from the Fig. 1a, c, d and e, the Model 1 predicted leaf area of the plants reasonably well for avocado (0.972), selected persimmon (52 UN 13) (0.983), Hayward kiwifruit (0.971) and aubergine (0.949). In general, Model 1 predicted that leaf area of avocado and *Lotus* plum would be systematically greater than the measured values. On the other hand, the same model underestimated the leaf area for selected persimmon (52 UN 13), Hayward kiwifruit and aubergine. The predicted leaf area values in pepper closely resembled the measured data.

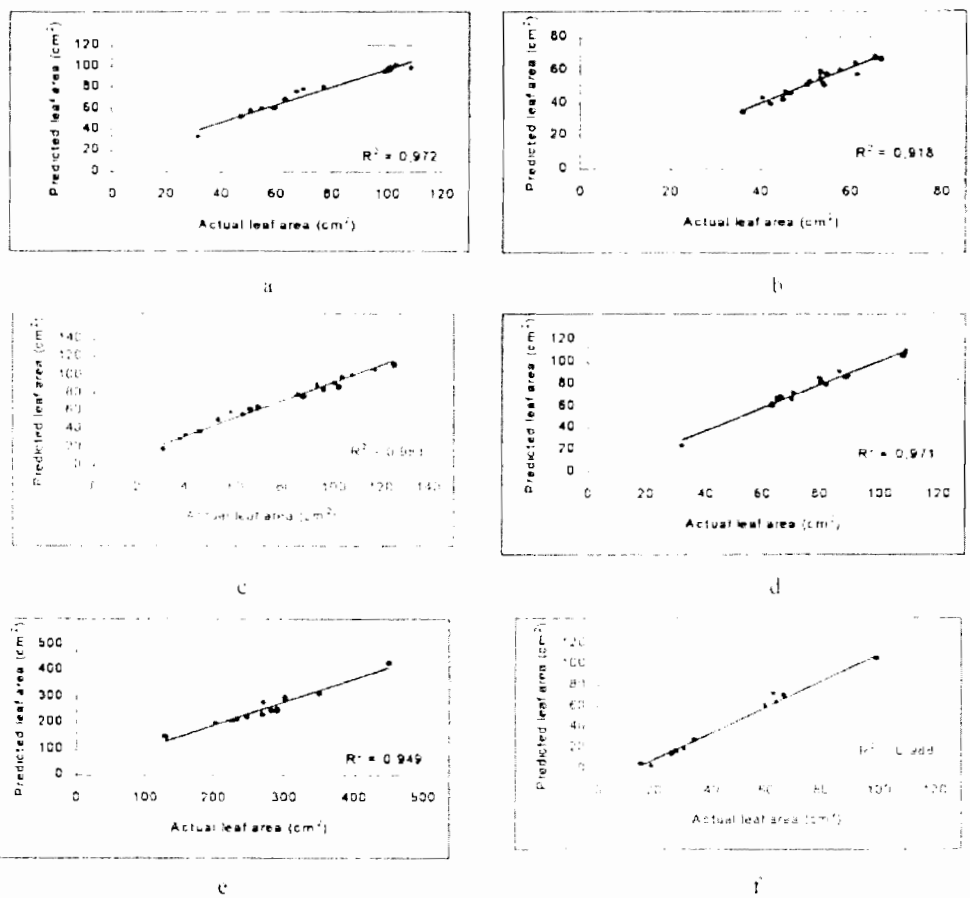

Fig. 1. Relationships between actual and predicted leaf area (cm^2) for the plants of group I, namely, avocado (a), *Lotus* plum (b), selected persimmon (52 UN 13) (c), Hayward kiwifruit (d), aubergine (e) and appear (f).

Model 2 was applied to the second plant group. As seen in Fig. 2a, b, c, d and e, the r^2 values showing the degree of relationship between actual and predicted leaf areas of cucumber, black grape (*Vitis labrusca* L.), narince (*Vitis vinifera* L.), red-currant and summer squash were found to be between 0.846 (in Black grape, *Vitis labrusca* L.) and 0.987 (in Narince, *Vitis vinifera* L.). However, the Model 2 overestimated leaf areas of tested plant species.

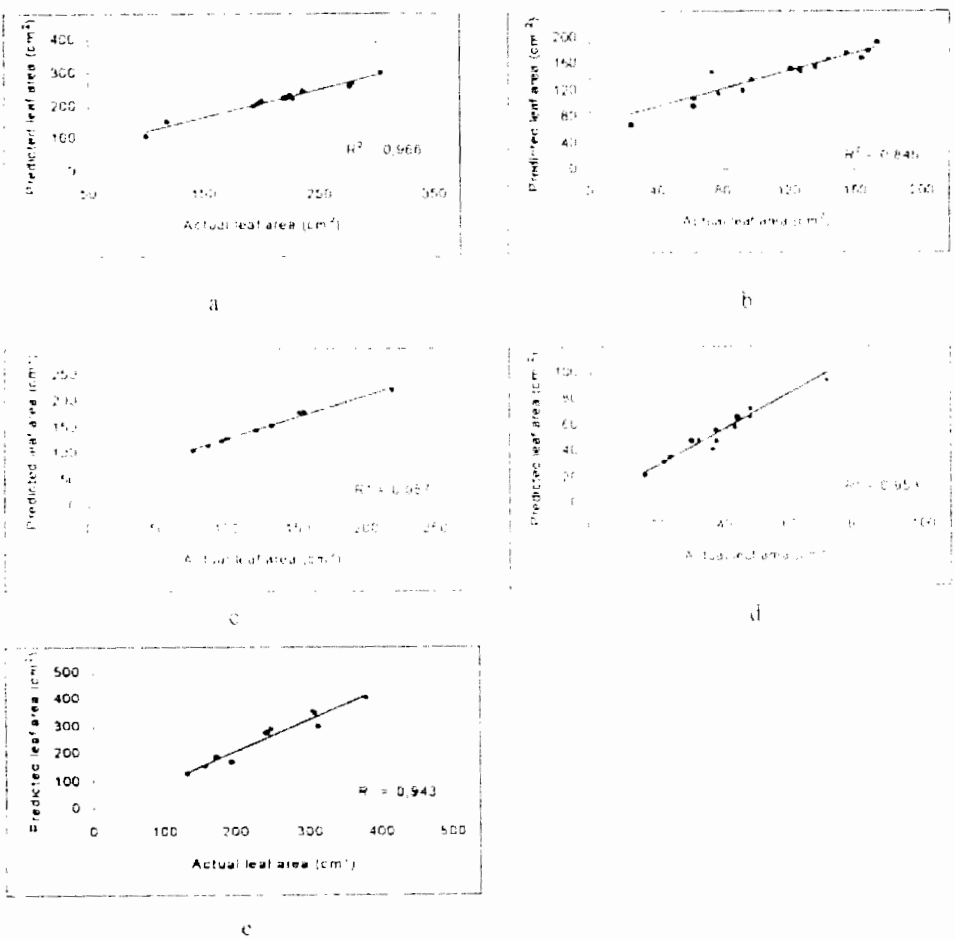

Fig. 2. Relationships between actual and predicted leaf area (cm^2) for the plants of group II, namely, cucumber (a), black grape (*Vitis labrusca* L.) (b), Narince (*Vitis vinifera* L.) (c), red-currant (d) and summer squash (e).

Model 3 was applied to the third plant group. As seen in Fig. 3a, b and c, the r^2 values was between 0.925 (in Chester blackberry) and 0.950 (in runner bean and Heritage red raspberry). On the other hand the same model underestimated the leaf area for Chester blackberry and runner bean while overestimated the leaf area for Heritage red raspberry.

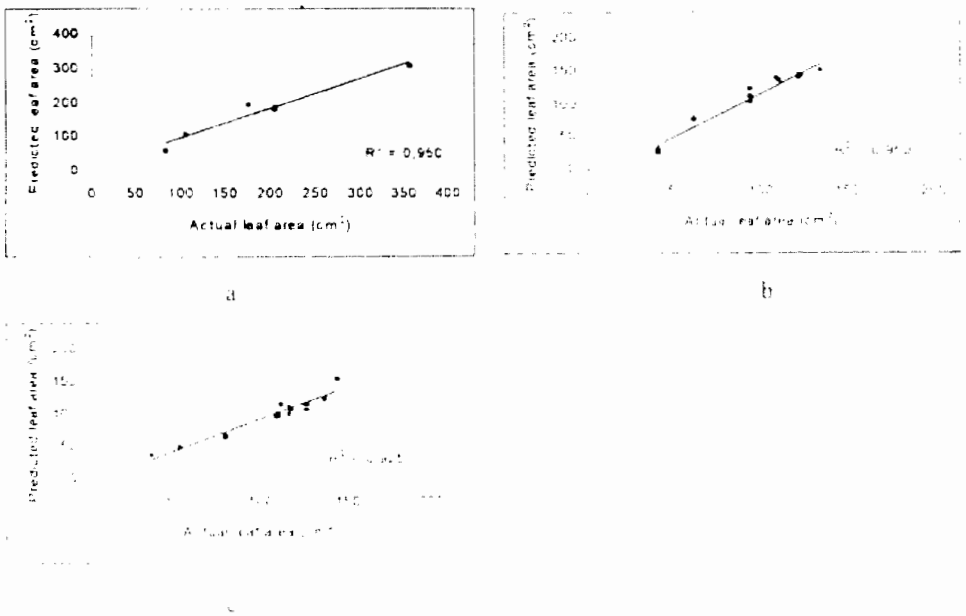

Fig. 3. Relationships between actual and predicted leaf area (cm^2) for the plants of group III, namely, runner bean (a), Heritage red raspberry (b) and Chester blackberry (c).

Discussion

It is obvious that without proper experimental and statistical validation, models which attempt to predict leaf area of the crops must be viewed with caution. In regression analyses, the proportion of the variation accounted by a relationship is equivalent to the coefficient of determination (r^2) (Bindi *et al.*, 1997). The objective of regression analyses and modelling is to maximise the proportion of the variation accounted for by the model.

The models used in the present study performed reasonably well when used to simulate leaf area of tested plant species with an exception that r^2 value of the relationship between actual and predicted leaf area of Black grape (*Vitis labrusca* L.), (0.846). We suggest that the constructed models (UZCELIK-I) can be used to calculate the leaf areas of mentioned plant species although there are slight tendencies of the models to over or underestimate the leaf areas depending on tried plant species. Moreover, the models can be of value in the evolution of new models which can be thought of by the researchers in this field.

References

Bindi, M., F. Miglietta, B. Gozzini, S. Orlandini and I. Seghi. 1997. A simple model for simulation of growth and development in grapevine (*Vitis vinifera* L.). II. Model validation. *Vitis*, 36: 73-76.

Celik, S., Y. Fidan and M.S. Tamer. 1982. Asma cesitlerinde yaprak alani katsayilarinin saptanmasi ve bunlarla asma yaprak alaninin bulunmasi. *BAHCE*, 11: 38-43.

Elsner, E.A. and G.L. JR. Jubb. 1988. Leaf area estimation of concord grape leaves from simple linear measurements. *American Journal of Enology & Viticulture*, 39: 95-97.

Evans, G.C. 1972. *The Quantitative Analysis of Plant Growth*. Univ. of California Press, Berkeley, California.

Jones, H.G. 1992. *Plants and Microclimate. A quantitative approach to environmental plant physiology*. Cambridge Univ. Press., Second Ed.

NeSmith, D.S. 1991. Non-destructive leaf area estimation of rabbiteye blueberries. *HortScience*, 26: 1332.

NeSmith, D.S. 1992. Estimating summer squash leaf area non-destructively. *HortScience*, 27: 77.

Robbins, N.S. and D.M. Pharr. 1987. Leaf area prediction models for cucumber from linear measurements. *HortScience*, 22: 1264-1266.

Seligman, N.G. 1990. The crop model record: promise or poor show. *In: Theoretical Production Ecology Reflections and Prospects*. (Eds.): R. Rabbinge, J. Goudriaan, H. Van Keulen, F.W.T .Penning de Vries and H.H. van Lear. pp. 249-263 (Pudoc, Wageningen)

Uzun, S. 1996. *The quantitative effects of temperature and light on the growth, development and yield of tomato and aubergine*. Ph.D. Thesis, Reading University, U.K., 223p.

Uzun, S. and H. Celik. 1999. Leaf area prediction models (UZCELIK-1) for some horticultural plants. *Turkish Journal of Agriculture and Forestry*, 23: 645-650.

(Received for publication 21 June 2001)