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A VALIDATED LEAF AREA PREDICTION MODEL FOR SOME CHERRY CULTIVARS IN TURKEY

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Abstract

A Leaf Area Prediction Model was developed for 12 cherry cultivars viz., (Hüsenba [1], Lambert [2], 0900 Ziraat [3], Van [4], Bing [5], Bella di Pistoia [6], Stella [7], Early Burlat [8], Karakirtik [9], Hafız Ahmet [10], Abdullah [11] and Napolyon [12] grown in Turkey (The numbers in square brackets represent the cultivars [Cv.] for the equation). Lamina width, length and leaf area were measured to develop the model. The actual leaf area of the cultivars were measured by PLACOM Digital planimeter, and multiple regression analysis with Excel 7.0 computer package program was performed for the cultivars separately. The produced Leaf Area Prediction Model in the present study is $LA=-22.45+2.59*W+4.76*L+0.36*Cv.-0.23*L^2+0.034*W*L^2-0.002*Cv.*L^2$ ($r^2=0.9554$) where LA is leaf area, W is leaf width, L is leaf length, Cv. is cultivar.

In addition to model producing procedure, the model was validated using the residual values between predicted and measured leaf areas from new leaf samples of different cherry orchards. Coefficient of determination r^2 values for the relationships between actual and predicted leaf areas of the tested cherry cultivars were found to be 0.9852, 0.9811, 0.989, 0.9856, 0.9894, 0.9841, 0.9794, 0.9962, 0.9909, 0.9759, 0.9867 and 0.9913 for Hüsenba [1], Lambert [2], 0900 Ziraat [3], Van [4], Bing [5], Bella di Pistoia [6], Stella [7], Early Burlat [8], Karakirtik [9], Hafız Ahmet [10], Abdullah [11] and Napolyon [12], respectively.

Introduction

Several studies regarding horticultural science have shown that determining leaf area is an important criteria for horticultural experiments. Kerstiens & Hawes (1994) measured leaf area in some cherry cultivars to investigate growth response and carbon allocation to elevated CO_2 levels in young cherry saplings in relation to root environment. Picchioni & Weinbaum (1995) also used leaf area measurements in a study for determining the retention and kinetics of uptake and export of foliage-applied boron in apple, pear, prune, and sweet cherry leaves. Particularly, leaf area measurements were carried out for studies regarding photosynthesis. Horsley & Gottschalk (1993) measured leaf area and net photosynthesis in black cherry seedlings to examine the relationship between leaf area and net photosynthesis during seedling development. Furthermore, in several studies such as comparison of drought resistance among *Prunus* species, improved growth and water use efficiency of cherry saplings under reduced light intensity leaf area was used to investigate leaf growth and crown development of some species (Rieger & Duemmel, 1992; Gottschalk, 1994; Centritto *et al.*, 2000).

Leaf area measurements can also be used for studies on cultural practices such as training, pruning, irrigation, fertilization etc. Reliable leaf area measurements make it easy for researchers investigating the effect of light, photosynthesis, respiration, plant water consumption and transpiration (Uzun, 1996). Druta (2001) studied the effect of long term exposure of leaves to high CO_2 levels on photosynthetic characteristics of *Prunus avium* L., plants using leaf area measurements. Venema *et al.*, (1999) also carried out a similar experiment to determine leaf area in wild *Lycopersicon* species.

The leaf area can be determined by using either some expensive instruments or by a developed leaf area prediction model. In several previous studies, linear measurements are used such as the criteria of leaf length, leaf width, petiole length, main and/or lateral vein length, and different combinations of these variables for producing leaf area prediction models. The leaf area prediction models which aim to predict plant leaf area non-destructively provide researchers with many advantages in horticultural experiments. Moreover, these models enable the researcher to carry out leaf area measurement for the same plants during plant growth period because of reduced variability in experiments (NeSmith, 1991, 1992; Gamiely *et al.*, 1991). On the other hand, non-destructive prediction of plant leaf area does not require expensive leaf area measurement instruments (Robbins & Pharr, 1987). Recently, new instruments, tools and machines such as hand scanner and laser optic apparatuses have been developed for leaf area measurements. But these are very expensive and complex devices for basic and simple studies. Furthermore, non-destructive prediction of plant leaf area saves time as compared with geometric measurements.

To date, the leaf area prediction models are developed for crops such as persimmon, avocado, aubergine, grape, squash, blueberry, currant, onion etc., (Elsner & Jubb, 1988; NeSmith, 1991; Gamiely *et al.*, 1991; Uzun & Çelik, 1999). But there has not been any attempt to a leaf area prediction model for sweet cherry. We aimed to produce a reliable equation which predicts leaf area through linear measurements in cherry plant. The use of model is not widespread although they have great potentials for practical use. Their common usage depends on their reliability and usefulness. Therefore, validation of a developed leaf area model gains importance. In the present study, we validated our developed model for determining its performance.

Materials and Methods

This study was carried out on 12 different cherry cultivars in Amasya, Turkey in 2001 to develop a leaf area prediction model and to validate the model. Hüsenba [1], Lambert [2], 0900 Ziraat [3], Van [4], Bing [5], Bella di Pistoia [6], Stella [7], Early Burlat [8], Karakirtik [9], Hafız Ahmet [10], Abdullah [11] and Napolyon [12] cherry cvs which have economical importance in Turkey and the other parts of the world were used in this trial. The numbers given in square brackets represent the cultivars (Cv.) for the equation.

Model construction

Leaf samples were selected randomly from cherry trees from different levels of the canopy during summer growth period. A total of 480 leaves were measured and 40 leaf samples were used for each cultivar. At first, each leaf was placed on A3 sheet and then a Placom Digital Planimeter (Sokkisha Planimeter Inc., Model KP-90) was used to measure actual leaf area. The leaf width (cm) and length (cm) of the leaf samples were also measured to be used for model construction. Leaf width (W) was measured from tip to tip at the widest part of the lamina and leaf length was measured from lamina tip to the point of petiole intersection along the midrib. All values were recorded to the nearest 0.1 cm.

Multiple regression analysis of the data was performed for each cherry cultivar separately. For this reason, analysis was conducted with various subsets of the independent variables viz., length (L), length square (L^2), width (W), cultivar (Cv.), leaf width*leaf length square ($W*L^2$), cultivar*Leaf length square ($Cv.*L^2$) to develop the best model for predicting leaf area (LA) by using the Excel 7.0 package program. Multiple regression analysis was carried out till the deviation sum of squares was minimized.

Model validation

Leaf samples other than those used in model producing belonging to the tried cultivars in this research were taken from different cherry orchards during growing period for validating the developed leaf area prediction model. Thirty new leaf samples for each cultivar were used. Leaf width, length and actual leaf area of these leaf samples were measured as mentioned in the model construction section. For validation procedure, leaf area values obtained by using the model were plotted against actual leaf areas measured using a planimeter. The EXCELL 7.0 Package program was used for this procedure.

Results

Model construction

Multiple regression analysis was used for determination of the best fitting equation for leaf area prediction. Regression analysis in the studied cherry cultivars showed that most of the variation in the leaf area values was explained by the selected parameters (length and width). The overall variation explained by the parameters was 95.5 % for cherry cultivars (Table 1). There was a highly reliable relationship between actual and predicted leaf areas for the cherry cultivars (Fig. 1).

Table 1. The relationship between actual leaf area and the independent variables used in the model.

Model	r^2
$LA=-22{,}45 + 2{,}59*W + 4{,}76*L + 0{,}36*Cv. - 0{,}23*L^2 + 0{,}034*W*L^2 - 0{,}002*Cv.*L^2$	0.9554
SE (2.48)***(0.39)***(0.55)***(0.127)***(0.037)***(0.0026)*** (0.0092)***	

LA: leaf area, W: leaf width, L: leaf length, Cv: cultivar [given in the brackets] (Hüsenba [1], Lambert [2], 0900 Ziraat [3], Van [4], Bing [5], Bella di Pistoia [6], Stella [7], Early Burlat [8], Karakirtik [9], Hafiz Ahmet [10], Abdullah [11] and Napolyon [12]), SE: Standard error.

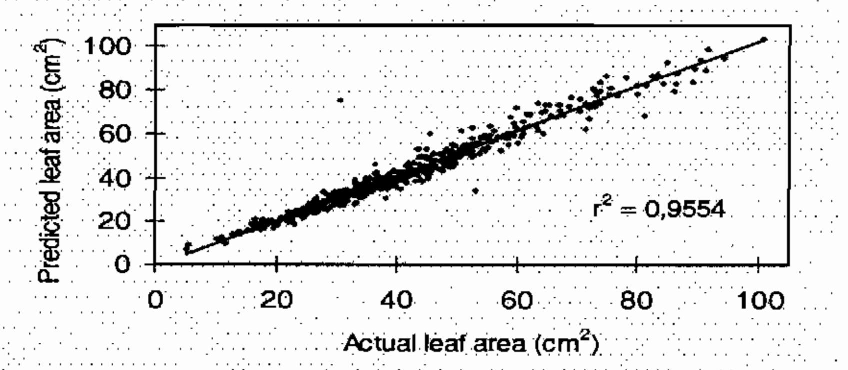

Fig. 1. The overall relationship between actual leaf area (cm^2) and predicted leaf area (cm^2) for the cultivars.

Model validation

Plotting process was carried out between actual leaf area values measured by using PLACOM digital planimeter and predicted leaf areas of the tried cultivars calculated by the developed model to determine the degree of accuracy of the model (Fig. 2). It was found that the relationship (r^2 values) between actual and predicted leaf areas varied from 0.9962 in Early Burlat to 0.9759 in Hafız Ahmet cv. (from the highest to lowest the value). As it can be seen from the Fig. 2.1, 2.2, 2.3, 2.4, 2.5 and 2.6, the model predicted leaf area of the tried cherry cultivars were most reliably for Early Burlat (0.9962), Karakirtik (0.9909), Napolyon (0.9913), Bing (0.9894), 0900 Ziraat (0.989) and Abdullah (0.9867). r^2 Values for the relationships between actual and predicted leaf areas of the other cherry cultivars were found to be 0.9856, 0.9852, 0.9841, 0.9811, 0.9794 and 0.9759 for Van, Hüsenba, Bella Di Pistoia, Lambert, Stella and Hafız Ahmet, respectively (Fig. 2).

Discussion

Multiple regression analysis was used for developing the best equation for leaf area prediction. It was found that most of the variation in leaf area values for all the cultivars was explained by the selected parameters viz., leaf length and leaf width. The variati[illegible] selected parameters was 95.5 % for the combined data from all cherry cultivars.

In accordance with the present study, many studies carried out to establish reliable relationships between leaf area and leaf dimensions of different plant species such as avocado, lotus plum, kivifruit, aubergine, pepper (Uzun & Çelik, 1999), cucumber (Robbins & Pharr, 1987; Uzun & Çelik, 1999), grapes (Elsner & Jubb, 1988; Yin, 1995; Pedro Junior & Ribeiro, 1989; Uzun & Çelik, 1999), red currant species (Uzun & Çelik, 1999), squash (Elsner & Jubb, 1988; Ramkhelawan & Brathwaite, 1992; Uzun & Çelik, 1999), onion (Gamiely *et al.*, 1991), pecan (Whithworth *et al.*, 1992), rabbiteye bluberry (NeSmith, 1991), water melons (Rajendran & Thamburaj, 1987), orange (Ramkhelawan & Brathwaite, 1992; Arias *et al.*, 1989), French means (Rai *et al.*, 1990), coconut (Mathes *et al.*, 1990), bananas (Potdar & Pawar, 1991), gooseberry (Tamal *et al.*, 1988), tomato (Dumas, 1990), muskmelon (Sirinivas & Hedge, 1993) and feijoa (Dettori, 1992) showed that there was close relationship between leaf width, leaf length and leaf area (eg., r^2= 0.983 for avocado, lotus plum, kiwifruit, aubergine, and pepper; r^2= 0.76 to 0.99 for cucumber; r^2= 0.9841 to 0.9844 for grapes; r^2= 0.986 for red currant; r^2=0.976 to 0.986 for squash; r^2= 0.89 to 0.93 for oranges; r^2=0.99 for french bean and r^2= 0.95 to 0.98 for coconut).

Validation of a leaf area model is an important step to overcome the implications of produced equations for prediction of leaf area. After determining the level of usability of these kind of models, a trustable way would be given to the researchers to lead studies on plant growth phenomenon such as respiration, photosynthesis, transpiration without destructive leaf harvesting. 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 modeling is to maximize the proportion of the variation accounted by the model, whilst minimizing the unattributable variation. Many researchers validated their own developed leaf area prediction model. For example, Çelik & Uzun (2002) found that the relationship (r^2 values) between actual

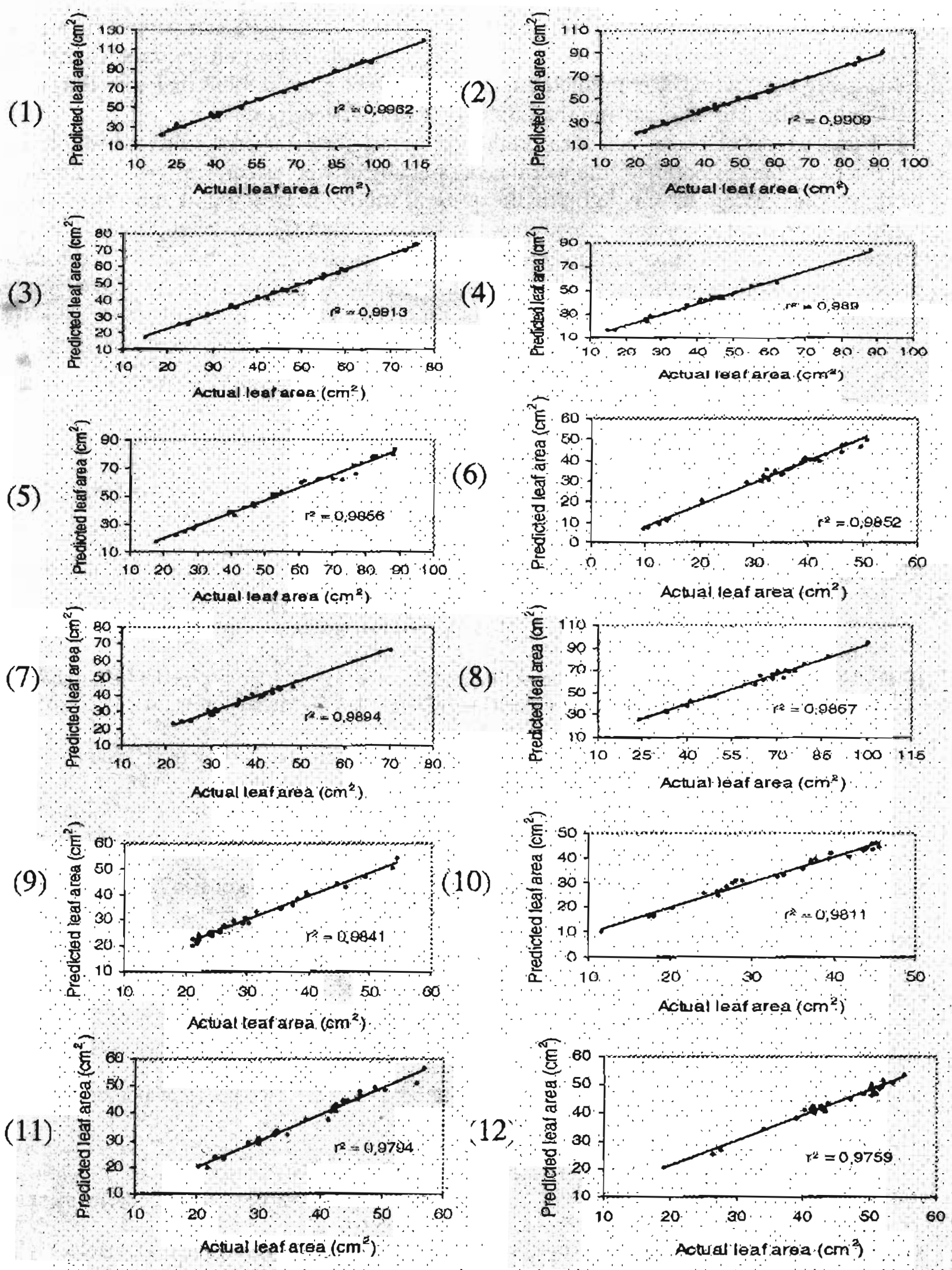

Fig. 2. The relationships between actual leaf area (cm^2) and predicted leaf area (cm^2) for the Early Burlat (1), Karakirtik (2), Napolyon (3), 0900 Ziraat (4), Bing (5), Abdullah (6), Van (7), Hitsenba (8), Bella di Postoia (9), Lambert (10), Stella (11), Hafiz Ahmet (12).

and predicted leaf areas varied from 0.918 in Lotus plum to 0.988 in pepper (from the lowest to the highest value). In the present study, it was found that the relationship (r^2 values) between actual and predicted leaf areas varied from 0.9962 in Early Burlat to 0.9759 in Hafız Ahmet cv. (from the highest to the lowest value).

Here, we developed a leaf area prediction model for 12 cherry cultivars which are important in Turkey and over the world economically as well as carrying out a validation work of the model. In the light of the present study, it was found that there were significant differences among the cultivars in terms of both the model and its validation. Therefore, coefficients concerning the cultivar must be used for each cultivar separately in developed model for the most reliable result. The model produced in the present study can be used safely by cherry researchers for the cultivars used in this research. On the other hand, different models can be developed by researches studying on cherry different from those used in the present study.

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