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Leaf Area Estimation Model for Some Local Cherry Genotypes in Turkey

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Abstract: A leaf area estimation model was produced for 6 cherry cultivars namely, Karakiraz, Türkoğlu, Tabaniyarik, Köroğlu, Kargayüreği and Barama, grown in Turkey. Lamina width, length and leaf area were measured to develop the model. The developed leaf area estimation model in the present study is: LA=(6,84-2,36XL+0,14XL^2-0,016XWXL^2+0,84XWXL) (r^2=0.9809). 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. r^2 values for the relationships between actual and predicted leaf areas of the tried cherry cultivars were found to be 0.9757.

Key words: Leaf area, model, estimation, validation, local, cherry, cultivars, Turkey

Introduction

The origin of sweet cherry is Northern Anatolia in Turkey. It is apparently native in some parts of Northern Turkey (Davis, 1972; Faust and Suranyi, 1997). Turkey is second in worldwide cherry production with 200,000 metric tons. Cherry is essentially grown in regions such as the Marmara, Aegean and Black Sea regions. Besides, it is grown in some passageway regions such as Amasya and Tokat in Black Sea Region. These regions are one of the origins of cherry in Turkey. So, there are various sweet cherry genotypes in Amasya. These genotypes have got very different characteristics such as late blooming, early and late yield, fruit quality so on.

Several studies regarding horticultural science have shown that determining leaf area is an important criteria for horticultural experiments. Kersteins and Hawes (1994) measured leaf area in some cherry cultivars to investigate growth response and carbon allocation to elevated CO_2 in young cherry saplings in relation to root environment. Picchioni *et al.* (1995) also used leaf area measurements in a study for determining the retention and kinetics of uptake and export of boron by foliage-applying in apple, pear, prune and sweet cherry leaves. Particularly, leaf area measurements were carried out for studies regarding photosynthesis. Horsley and 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 were used leaf area criteria to investigate leaf growth and crown development of some species (Rieger and 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 etg. Reliable leaf area measurements make it easy for researchers investigating the effect of light, photosynthesis, respiration, plant water consumption and transpiration (Uzun, 1996). For example, Drutaa (2001) studied on 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 both some expensive instruments and developed leaf area prediction models. In several previous studies, linear measurements were 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 researches with many advantages in horticultural experiments. Moreover, these kind of models enable 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 and Pharr, 1987). Recently, new instruments, tools and machines such as hand scanner and laser optic apparatuses were 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 data, the leaf area prediction models were developed for crops such as persimmon, avocado, aubergine, grape, squash, blueberry, currant, onion and etg. in some experiments (Elsner and Jubb, 1988; NeSmith, 1991; Gamiely *et al.*, 1991; Uzun and Çelik, 1999). But there hasn't been any attempt to a leaf area prediction model for sweet cherry. We aimed to produce reliable equation which predicts leaf area through linear measurements in cherry plant. Model using has not already become widespread although they have great potentials for practical usage. Their common usage depends on its reliableness 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 6 different cherry cultivars in Amasya in Turkey in 2001-2002 to develop a leaf area estimation model and to validate the model. Karakiraz, Türkoğlu, Tabaniyarik, Köroğlu, Kargayüreği and Barama cvs which have economical importance in Amasya and the other parts of Turkey.

Model construction: Leaf samples were selected randomly from cherry trees from different levels of the canopy during summer growth period in 2001. A total of 450 leaves were measured and 75 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 (W) and length (L) of the leaf samples were also measured to be used for model construction. Leaf width (cm) was measured from tip to tip at the widest part of the lamina and leaf length (cm) 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, namely, length (L), length square (L^2), width (W), leaf width X leaf length square (WXL^2) and width X length (WXL) to develop the best model for predicting leaf area (LA) by using the Excell 7.0 package program. As procedure, multiple regression analysis was carried out until the least sum of squares was obtained.

Model validation: Leaf samples other than those used in model producing belong to the tried cultivars in this research were taken from different cherry orchards during growing period in 2002 for validating the developed leaf area prediction model. Fifty new leaf samples for each cultivar were used for this aim. Leaf width, length and actual leaf area of these leaf samples were measured as mentioned in the model construction. 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 programme 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 over all variation explained by the parameters was 98.09% for cherry cultivars (Table 1). In accordance with this result, it was found that there was a highly reliable relationship between actual and predicted leaf areas for the cherry cultivars (Fig. 1).

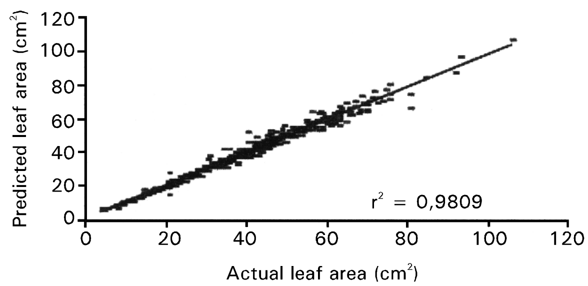

Fig. 1: The over all relationship between actual leaf area (cm^2) and predicted leaf area (cm^2) for the cultivars

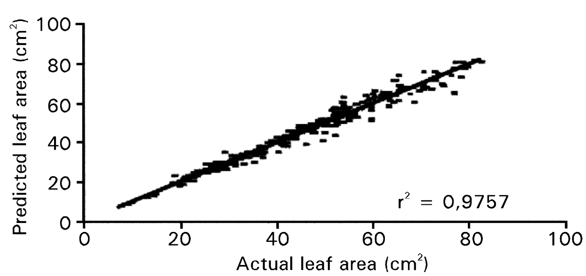

Fig. 2: Relationships between actual leaf area (cm^2) and predicted leaf area (cm^2) for the tried cherry cultivars

Model validation: Plotting processes were 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 in this research to determine the degree of accuracy of the model

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

Model					r^2
LA= (6,84 - 2,	36 X L+0,	14 X L^2-0,	016 X W X L^2+0,	84 X W X L)	0.9809
SE (2.18)*	(0.760)*	(0.048)*	(0.0054)*	(0.068)*	

LA : leaf area, W : leaf width, L: leaf length, SE: Standard error, *=significant at the level of 0.1%

(Fig. 2). It was found that the relationship (r^2 values) was 0.9757.

Discussion

Multiple regression analysis was used for developing the best equation for leaf area prediction. It was found that most of variation in the leaf area values for all the cultivars was explained by the selected parameters, namely leaf length and leaf width. The variation of selected parameters was 98.09% 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 and Çelik, 1999), cucumber (Robbins and Pharr, 1987; Uzun and Çelik, 1999), grapes (Elsner and Jubb, 1988; Yin, 1995; Pedro *et al.*, 1989; Uzun and Çelik, 1999), red currant species (Uzun and Çelik, 1999), squash (Elsner and Jubb, 1988; Ramkhelawan and Brathwaite, 1992; Uzun and Çelik, 1999), onion (Gamiely *et al.*, 1991), pecan (Whithworth *et al.*, 1992), rabbiteye bluberry (NeSmith, 1991), water melons (Rajendran and Thamburaj, 1987), orange (Ramkhelawan and Brathwaite, 1992; Arias *et al.*, 1989), French means (Rai *et al.*, 1990), coconut (Mathes *et al.*, 1990), bananas (Potdar and Pawar, 1991), gooseberry (Tamal *et al.*, 1988), tomato (Dumas, 1990), Muskmelon (Sirinivas and Hedge, 1993) and feijoa (Dettori, 1992) showed that there were close relationship between leaf width, leaf length and leaf area (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 analysis, 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 analysis 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 and Uzun (2002) 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). In the present study, it was found that the relationship (r^2 values) was 0.9757.

We developed a leaf area estimation model for 6 cherry cultivars which are important in Turkey 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 model and its validation. Therefore, coefficients for the model can 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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