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Short communication. Validation of a leaf area estimation model for sweet cherry

H. Demirsoy[1]* and G. A. Lang[2]

[1] *Department of Horticulture. Faculty of Agriculture. Ondokuz Mayıs University. 55139 Kurupelit-Samsun. Turkey*
[2] *Department of Horticulture. Michigan State University. 48824 East Lansing (MI). USA*

Abstract

A leaf area (LA) estimation model developed in a temperate climate for sweet cherry (*Prunus avium* L.) was tested for validation on 'Regina' trees on two rootstocks of varying vigor, 'Gisela 5' (Gi5) and 'Gisela 6' (Gi6), in a cool temperate climate (the Great Lakes region of North America). To determine the degree of accuracy of the model, actual LA values measured by digital planimeter were plotted against predicted LAs calculated by the model. The relationships (r^2 values) were very high and varied little between rootstocks ($r^2 = 0.9886$ for Regina/Gi6 and $r^2 = 0.9849$ for Regina/Gi5). This study demonstrates that the model is valid for use by cherry researchers in different growing regions and for rootstocks that impart different levels of vigor scion, such as 'Regina'.

Additional key words: canopy light interception, leaf dimension, predictive equation, *Prunus avium* L.

Resumen

Comunicación corta. Validación de un modelo de estimación del área foliar para cerezo

Se ha probado para validación un modelo de estimación del área foliar (LA), desarrollado en un clima templado para el cerezo dulce (*Prunus avium* L.), en árboles 'Regina' sobre dos portainjertos de distinto vigor, 'Gisela 5' (Gi5) y 'Gisela 6' (Gi6), en un clima frío templado (la región de los Grandes Lagos de América del Norte). Para determinar el grado de precisión del modelo, se graficaron los valores reales de LA obtenidos mediante un planímetro digital contra LAs teóricos calculados mediante el modelo. Las relaciones (valores r^2) fueron muy altas y variaron poco entre los portainjertos ($r^2 = 0{,}9886$ para 'Regina'/Gi6 y $r^2 = 0{,}9849$ para Regina/Gi5. Este estudio demuestra que el modelo es válido para ser usado por investigadores de cerezo en diferentes regiones de cultivo y para portainjertos que proporcionan diferentes niveles de vigor del injerto, tales como 'Regina'.

Palabras clave adicionales: dimensiones de la hoja, ecuación de predicción, *Prunus avium* L., restricción lumínica con mallas de sombreo.

The measurement of leaf area (LA) is important for understanding photosynthesis, light interception, water and nutrient use, crop growth and yield. For this reason, LA is measured routinely in experiments with horticultural crops for which physiological phenomena such as light, photosynthesis, respiration, plant water consumption and transpiration are to be studied (Rieger and Duemmel, 1992; Horsley and Gottschalk, 1993; Picchioni *et al.,* 1995; Centritto *et al.,* 2000). In addition, estimation of leaf number and whole plant LA can be important for improving cultural practices such as pruning, irrigation, fertilization, etc. Leaf area can be determined by using either expensive instruments or prediction models. Models to predict LA non-destructively can provide researchers with many advantages in horticultural experiments (Manivel and Weaver, 1974; Robbins and Pharr, 1987; Gamiely *et al.,* 1991; NeSmith, 1991; Cristofori *et al.,* 2008; Fallovo *et al.,* 2008).

The objective of this study was to test the validation of a sweet cherry (*Prunus avium* L.) LA estimation model developed in Turkey, for a cultivar different from those on which it was developed, and under different ecological conditions (*i.e.,* Michigan, USA) as well as on two rootstocks that impart different levels of vigor

* Corresponding author: husnud@omu.edu.tr
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Abbreviations used: LA (leaf area), REA (relative error analysis).

to the scion. To our knowledge, this research is the first LA validation study carried across different continental climates and vigor-controlling rootstocks.

Six-year-old fruiting 'Regina' sweet cherry trees on 'Gisela 5' ('Gi 5') and 'Gisela 6' ('Gi 6') rootstocks, growing at Michigan State University's Clarksville Horticultural Experiment Station (latitude 42.9°N, longitude –85.3°W), were used in this study. Leaf samples from three trees of each scion/rootstock combination were selected randomly on 5, 14 and 23 May, 17 June, and 10 July 2007 from different locations within the canopy. A total of 229 leaves were used for validation (105 for Regina/Gisela 5 and 124 for Regina/Gisela 6). Each leaf was measured for length × width, photocopied, and then a Placom Digital Planimeter (Sokkisha Planimeter Inc., Model KP-90, Tokyo) was used to measure actual leaf area. For validation, LA values obtained using the model was plotted against actual LAs measured by the planimeter and tested for r^2 values. And also, relative error analysis was performed for the variations between actual and predicted leaf area values (Uzun, 2006). Relative error analysis (REA) was calculated as following: REA= (Predicted leaf area-Actual leaf area)/predicted leaf area.

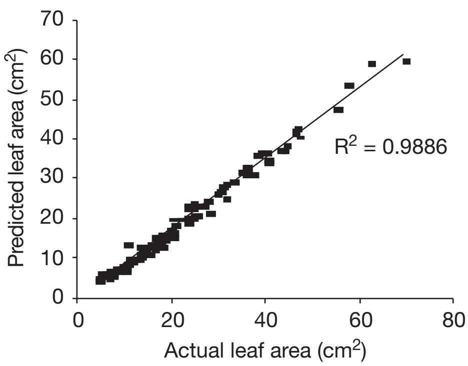
The sweet cherry LA estimation model produced by Demirsoy and Demirsoy (2003) was: $LA = 6.84 - 2.36L + 0.14L^2 - 0.016WL^2 + 0.84WL$ ($r^2 = 0.9809$), where LA = leaf area (cm^2), L = leaf length (cm) measured along the midrib from lamina tip to the point of petiole intersection, W = leaf width (cm) measured from edge to edge at the widest part of the lamina.

Six local cherry cultivars ('Karakiraz', 'Turkoglu', 'Tabaniyarik', 'Koroglu', 'Kargayuregi' and 'Barama') from North Central Anatolia (latitude 40.39°N, longitude 35.51°E) grafted onto mazzard seedling in producing this model were used. The model was calibrated by using width and length measurements of 450 leaves (75 leaf samples for each cultivar) selected at the different times and from different locations of the canopy during summer in 2001 and confirmed by using 50 leaf samples for each cultivar taken from a different cherry orchard during growing period in 2002. In the confirmation process, r^2 was 0.9757.

When the actual sweet cherry LA values measured by digital planimeter were plotted against the predicted LAs, the r^2 values were 0.9886 for 'Regina'/'Gi 6' (Fig. 1a) and 0.9849 for 'Regina'/'Gi 5' (Fig. 1b). Relative error analysis showed that the variation between predicted and actual leaf area varied from 0.07 to 16.87 % (average 9.5%) for 'Regina'/'Gi 5' and from 0.08 to 18.90 % (average 9.0%) for 'Regina'/'Gi 6'. Therefore, it can be said the model estimates LA with a high predictiveness. Sweet cherry scion growth on 'Gi 6' is vigorous, and growth on 'Gi 5' is considered to be dwarfing or 30 to 50% less than 'Gi 6'. The model predicted LA accurately for 'Regina' sweet cherry regardless of the differential scion vigor imparted by these different rootstocks. Also, although the model predictive equation was developed from other sweet cherry varieties on other rootstocks grown in a temperate climate, it was readily applicable and accurate for 'Regina' grown in Michigan's temperate continental climate.

Validation of LA models is an important step for determining the usefulness and accuracy of LA estimation methods. Researchers have validated LA prediction models for other species, such as grapevine (*Vitis vinifera* L.), avocado (*Persea americana* Mill.) (Çelik and Uzun, 2002), chestnut (*Castanea sativa* P. Mill.) (Serdar and Demirsoy, 2006), peach [*Prunus persica* (Batsch.) L.] (Demirsoy *et al.,* 2004), strawberry (*Fragaria* × *ananassa* L.) (Demirsoy *et al.,* 2005), kiwi (*Actinidia deliciosa* Lindl.) (Mendoza-de Gyves *et al.,* 2007),

a)



b)

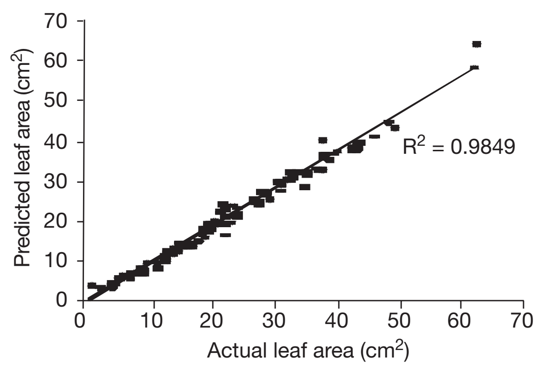


Figure 1. Relationship between actual and predicted leaf area (cm^2) for a) 'Regina'/'Gisela 6' (n = 124) and b) 'Regina'/'Gisela 5' (n = 105).

persimmon (*Diospyros kaki* L. f) (Cristofori *et al.,* 2008) and hazelnut (*Corylus avellana* L.) (Cristofori *et al.,* 2007). The model validated in this study can be used confidently by cherry researchers for 'Regina' and other sweet cherry cultivars (though it should be calibrated for each new cultivar) and will be useful for studies of sweet cherry growth phenomena such as respiration, photosynthesis, transpiration, etc. without destructive leaf sampling. In addition, this study has shown that the model produced by local cultivars on vigorous mazzard (height of the trees with 6-9 m) grown in a part with longer vegetation period and drier summer of North Central Anatolia, which is the origin of sweet cherry, will be used for Regina cultivar on Gi5 and Gi6 dwarfing rootstocks in Michigan, colder and more humidity.

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