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Şeker Pancarı ve Hayvan Pancarında Yaprak Alanı Tahmin Modeli

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Özet: Bu çalışmada şeker pancarı (*Beta vulgaris* L.) ve hayvan pancarı (*Beta vulgaris var. crassa* Mansf.)'nda yaprak alanı modeli geliştirmek amaçlanmıştır. Bu amaçla iki şeker pancarı çeşidi Duetto ve Leilla ve iki hayvan pancarı çeşidi, Ecdogelb ve Ecdorot, Orta Karadeniz Bölgesi koşullarında 5 farklı lokasyonda (Bafra, Ladik, Suluova, Gümüşhacıköy ve Osmancık) 2004 yılı yetişme mevsiminde yetiştirilmiştir. Çalışmada şeker pancarında 4899 adet ve hayvan pancarında 5014 adet yaprakta yaprak eni, yaprak boyu ve yaprak alanı ölçülmüştür. Yaprak alanları Placom dijital planimetre ve Exel 7.0 programında çoklu regresyon analizleriyle belirlenmiştir. Çalışmada geliştirilen yaprak alanı modeli şeker pancarı için LA (cm^2)= (-11.84) + (7.29xW) – (0.34xW^2) + (0.147xL^2) + [0.048x(W^2xL)] - [0.0009x(W^2xL^2)], R^2=96.7 iken hayvan pancarı için LA (cm^2)= (-7.54) + (0.038xL^2) + [0.95x(LxW)] – [0.0089x(L^2xW)] - [0.0079x(LxW^2], R^2=96 olarak belirlenmiştir. LA yaprak alanını, W yaprak enini ve L yaprak boyunu ifade etmektedir.

Anahtar kelimeler: Şeker Pancarı, Hayvan Pancarı, Yaprak Alanı, Modelleme

Leaf Area Prediction Model for Sugar Beet and Fodder Beet

Abstract: In the present study, it was aimed to develop a leaf area prediction model for sugar beet (*Beta vulgaris* L.) and fodder beet (*Beta vulgaris var. crassa* Mansf.). Two sugar beet cultivars, Duetto and Leilla and two fodder beet cultivars, Ecdogelb and Ecdorot were grown at 5 locations (Bafra, Ladik, Suluova, Gümüşhacıköy and Osmancık) in the 2004 growing season in the Middle Black Sea Region conditions of Turkey. Totally, 4899 leaves for sugar beet and 5014 leaves for fodder beet were measured leaf width, length and leaf area. The actual leaf area of the plant was measured by PLACOM Digital Planimeter and multiple regression analysis with Excel 7.0 was performed. The produced leaf area prediction models in the present study are LA (cm^2)= (-11.84) + (7.29xW) – (0.34xW^2) + (0.147xL^2) + [0.048x(W^2xL)] - [0.0009x(W^2xL^2)], R^2=96.7 for sugar beet, LA (cm^2)= (-7.54) + (0.038xL^2) +[0.95x(LxW)] – [0.0089x(L^2xW)] - [0.0079x(LxW^2], R^2=96 for fodder beet where LA is leaf area, W is leaf width, L is leaf length.

Key words: Sugar Beet, Fodder Beet, Leaf Area, Modelling

Introduction

Sugar, very important essential food in human life, is produced from two important plants. Sugar beet supplies oxygen during its vegetation period. Its crop residues are used as forage and organic matter for soil. In addition to these benefits, its industrial residues have multi-use area (Çamaş and Esendal, 1999). According to many vegetal crop cultivated in the world, sugar beet also have contribution of development of used technology. Recently, 238 million tones sugar beet has been produced from 6 million ha production area in the world. However, 40 million tones sugar has been obtained from sugar beet, approximately occupy 27-30% of world sugar production (Anon, 2005). Turkey is one of the important sugar beet producer as well as Germany, France, Poland, Belgium, Russia, USA, and Ukraine. Turkey has produced about 14 million tones sugar beet from 330 000 ha production area. Turkey has also produced 2.5 million tones sugar from 14 million tones sugar beet (Anon, 2005). Middle Blacksea Region where this study was conducted is one of the important area of Turkey in respect of quality and yield. Middle Blacksea Region has 10.6% of total production of Turkey as well (Anon, 2004). Fodder beet is successively grown as a fodder crop in the coastal regions of many European countries. The crop is used as a valuable source of food for cattle (Albayrak and Çamaş, 2006). Due to its higher water and sugar contents, it increases milk production and is suitable forage for dairy cows. The fodder beet is usually fed as chopped and mixed with straw.

Total leaf area has been recognized as one of the main indicators for high generative yield in many crops. Therefore, leaves are the most important organs of those plants (Odabaş vd., 2005). 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 (Robbins ve Pharr, 1987; Sepaskhah, 1977; Wicrsma and Bailey, 1975; Manivel and Weaver, 1974; Kvet and Marshall, 1971). Non-destructive estimation of plant leaf areas offers to researchers as more reliable and inexpensive alternatives in field experiments. Non-destructive leaf area or plant growth measurements are often desirable because continued use of the same plants over time can reduce variability in experiments as compared with destructive sampling. Additionally, the use of simple linear measurement for predicting the leaf area of field crops eliminates the need for expensive leaf area meters. For these reasons, the development of a mathematical model and equation from linear leaf measurement for predicting total or individual leaf area has been shown to be very useful in studying on plant growth and development (Uzun and Çelik, 1999).

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Common measurements for prediction equations in some models carried out previously have included leaf width, leaf length, petiole length, main and/or lateral vein length, and different combination of these variables. Some researchers have tried using new equipment and tools such as hand scanner or laser optic apparatuses for predicting plant growth non-destructively, but these are very expensive investments for basic and simple research (Ebert, 1995; Tsonev and Segiev, 1993).

In this research, we offer reliable equations that allows for the non-destructive estimation of leaf area through linear measurements of the sugar beet and fodder beet plants.

Materials and Methods

Sugar beet (*Beta vulgaris var* L.) cultivars, Duetto and Leilla and fodder beet (*Beta vulgaris var. crassa* Mansf.) cultivars Ecdogelb and Ecdorot were used as experimental material. Duetto has a conical root and low bifurcation, holes on the root and quite superficial. Growth over the soil surface is quite low. Leaves are long. Root yield is fairly good. Sugar yield and purity are high. It is resistant to drought and to Cercospora. Leilla cultivar has conical root, bifurcation is rather low, and growth over the soil surface is low. The leaves are long and upright, stalks are medium length. Root yield is high. It is over resistant to Rhizomania, and resistant to Cercospora. In regions where Rhizomania is prevalent, sugar yield is quite high.

Ecdogelb having wide leaf width, middle leaf length and semi erect leaf attitude, is diploid and multigerm variety. Leaf blade of Ecdogelb cultivar (width compared to length) is wide. It has also short root length and middle root width. Roots having cylindrical character are yellow. Ecdorot having wide leaf width, long leaf length and semi erect leaf attitude, is diploid and multigerm variety. Leaf blade of Ecdorot cultivar is wide. It has also short root length and wide root width. Roots having cylindirical character are red. Roots of Ecdogelb and Ecdorot cultivars grow close to surface.

Field experiments were established in Bafra (41° 35′ N, 35° 56′ E, 15 m elevation), Osmancik (40° 58′ N, 34° 51′ E, 449 m elevation), Suluova (40° 47′ N, 35° 41′ E, 484 m elevation), Gumushacikoy (40° 52′ N, 35° 14′ E, 785 m elevation) and Ladik (40° 56′ N, 35° 54′ E, 920 m elevation) in Middle Black Sea Region, Turkey, on 8-11 April 2004 and were carried out throughout the growing periods of the selected locations. During the growing season precipitation (April through September) is 445 mm at Bafra, 298 mm at Osmancik, 282.3 mm at Suluova, 281.8 mm at Gumushacikoy and 145 mm at Ladik. Mean temperature during this period correspond to 18.3, 19.6, 18.3, 17.6 and 14.1°C at Bafra, Osmancik, Suluova, Gumushacikoy and Ladik, respectively. Soil types are clay loam at Bafra, Suluova and Gumushacikoy, and silty clay loam at Osmancik and Ladik.

The experimental design was a randomized complete block design with three replications and plot size was 10 m^2 (2 x 5 m) for sugar beet and fodder beet, separately. Seeding rate was 30 kg ha^{-1}. Sugar beet and fodder beet plants in each plot were harvested at five different periods for the five locations. Dates were June 3-5, June 21-23, July 11-13, August 5-7 and August 27-29 in 2004. A total of 4899 leaves for sugar beet and 5014 leaves for fodder beet were measured in the experiment. Each leaf was processed in the following manner. First, they were placed on the photocopier desktop by holding flat and secure and copied on A4 sheet (1:1) one by one. Second, Placom Digital Planimeter (SOKKISHA Planimeter Inc., Model KP-90) was used for estimation of leaf area. In addition to the leaf area measurements, a series of linear measurements was also performed. The measurements were leaf width (W) measured from tip to tip at the widest part of the lamina, and leaf length (L) measured from lamina tip to the point of petiole intersection along the lamina midrib.

A search for the best model for predicting leaf area (LA) was conducted with various subsets of the independent variables such as length (L), width (W), length x width (W x L), length square x width (L^2 x W) and length x width square (L x W^2). The best estimating equation for the leaf area (LA) of sugar beet and fodder beet were determined with the Excel 7.0. Multiple regression analysis was carried out until the least sum of square was obtained. Multiple regression analysis was used for determination of the best fitting equation for estimation of leaf area in sugar beet and fodder beet.

Results and Discussion

Multiple regression analysis showed that most of the variation in leaf area values was explained by the selected parameters (length and width) (Table 1. and Table 2.). The variation explained by the parameters was 96%.

Many researchers have also reported that leaf area can be estimated by linear measurements such as leaf width and leaf length in the following plants: Cucumbers (*Cucumis sativus* L.) (Robbins and Pharr, 1987), orange (*Citrus aurantium* L.) (Arias vd., 1989 and Ramkhelavan and Brathwaite, 1990), French bean (*Phaseolus vulgaris* L.) (Rai vd.,.1990), coconut (*Cocos nucifera* L.) (Mathes vd., 1990), Grape (*Vitis vinifera* L.) (Uzun and Çelik, 1999), and Broad bean (*Vicia faba* L.) (Odabaş, 2003). The same authors found that there were close relationship between leaf area value, leaf length and leaf width for these plants (r^2=0.76 to 0.99 for cucumber, r^2 = 0.89 to 0.93 for orange, r^2 = 0.99 for French bean, r^2 =0.95 to 0.98 for coconut, r^2 =0.98 for grapes, and r^2 =0.99 for broad bean). The present model of leaf area estimation by linear leaflet measurements in sugar beet and fodder beet can be used for physiological and quantitive studies.

Table 1. *The equation of leaf area for sugar beet.*

$LA^a =$	$(-11.84) + (7.29x\ ^bW) - (0.34x^cW^2) + (0.147x^dL^2) + [0.048x(^eW^2xL)] - [0.0009x(^fW^2xL^2)]$
$SE^g =$	1.86*** 0.75*** 0.088*** 0.006*** 0.003***
	0.0001***
	r^2= 0.96***

[a]LA: leaf area, [b]L: leaf width, [c]W^2: leaf width square, [d]L^2 : leaf length square,
[e]W^2xL : leaf width square x leaf length, [f]W^2xL^2 : leaf width square x leaf length square,
[g]SE: Standart Error ; ***r^2 and all SE values are significant at p<0.001.

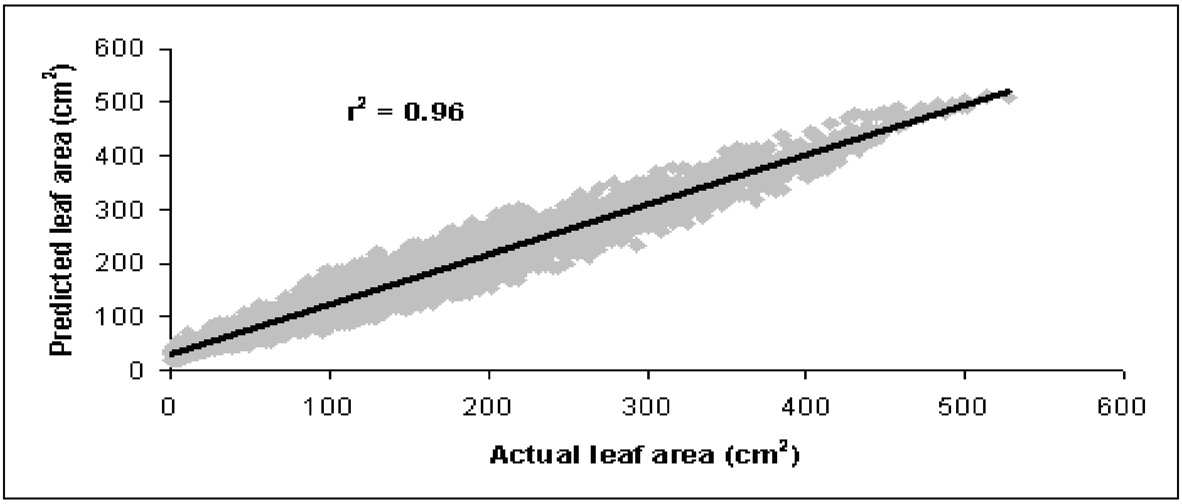

Figure 1. *The relationship between actual leaf area (cm^2) and predicted leaf area (cm^2) for sugar beet.*

Table 2. *The equation of leaf area for fodder beet.*

$LA^a =$	$(-7.54) + (0.038x^bL^2) + [\ 0.95x(^cLxW)] - [\ 0.0089x(^dL^2xW)] - [\ 0.0079x(^eLxW^2)]$
$SE^f =$	0.78*** 0.013*** 0.022*** 0.001*** 0.0017***
	r^2= 0.96***

[a]LA: leaf area, [b]L: leaf length square, [c] L x W: leaf length x leaf width, [d]L^2xW : leaf length square x leaf width,
[e]LxW^2 : leaf length x leaf width square, [f]SE: Standart Error
***r^2 and all SE values are significant at p<0.001.

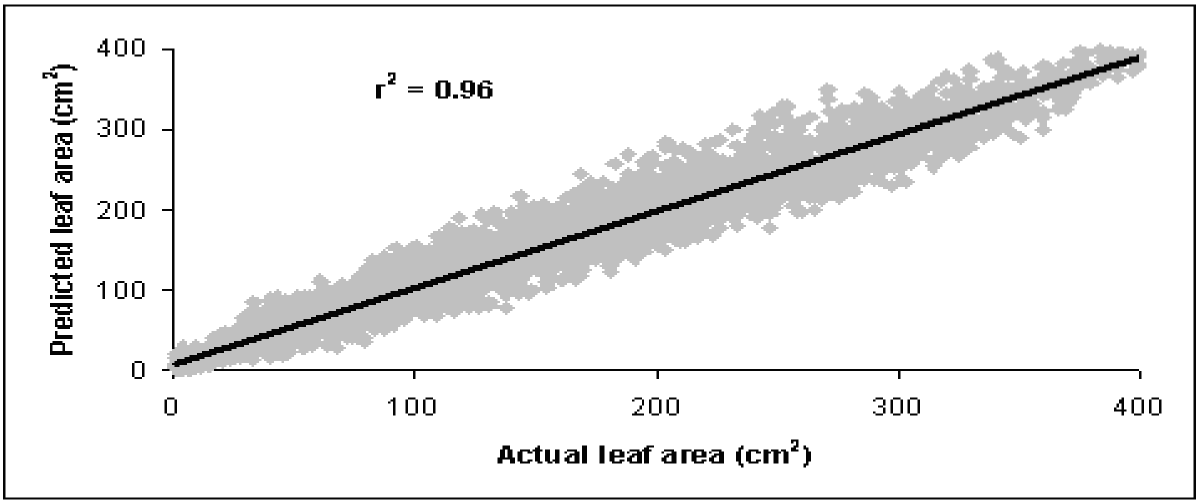

Figure 2. *The relationship between actual leaf area (cm²) and predicted leaf area (cm²) for fodder beet.*

As seen in Figure 1. and Figure 2., there was a very close relationship between actual leaf area and predicted leaf area higly reliably and is open to being evaluated. Consequently, the present model can be evaluated with leaf samples gathered at different growing periods. As the understanding of plant growth and development has been increasing, such mathematical models as this shown in Table 1. and Table 2. will be very useful tools for prediction of leaf area for many plants without using of expensive devices. These results demonstrate that sugar beet and fodder beet leaf area can be predicted using simple linear measurements. Present study equations would also allow researchers to estimate leaf area in relation to factors like crop load, drought stress, and insect damage. Therefore, the leaf area of an individual of sugar beet and fodder beet can be calculated from leaf width and leaf length measurement alone using the non-destructive models derived in this study.

References

Albayrak, S and Çamaş, N. 2006. Yield Components of Fodder Beet (*Beta vulgaris var. crassa* Mansf.) under the Middle Black Sea Region Conditions. Ankara Üniv. Zir.Fak. Tarım Bilimleri Dergisi, 12(1), 65-69.

Anonymous, 2005. FAO. Food Agricultural Organization Year Book.

Anonymous 2004. DİE. Tarım İstatistikleri Özeti. T.C. Başbakanlık Devlet İstatistik Enstitüsü. Ankara.

Arias, E., Fernandez, M and Telleria, T. 1989. Modified Method for Determining Foliar Area Leaf Samples of Valencia orange. Horticultural Abstract, 59, 9508.

Çamaş N, and Esendal, E. 1999. Effects of Planting Times and Seedling Transplanting on Sugarbeet (*Beta vulgaris* L.) Cultivars. OMU Journal of Agric.,14, 31-42.

Ebert G. 1996. Leaf Area Measurement with Laser Optics. Hort. Abst., 66, 2808.

Kvet, K. and Marshall, J.K. 1971. Assessment of Leaf Area and Other Assimilating Surfaces, p. 517-555. In: 2. Scstak, J. Datsky, and P.G. Jarvis (eds.). Plant Photosynthetic Production: Manual of Methods. Junk, The Hague, Netherlands.

Manivel, L. and Wcavcr, R.J. 1974. Biometric Correlations bctwccn Leaf Area and Leaf Length Measurements of 'Grcnachc' Grape Leaves. Hort. Science 9, 27-28.

Mathes, D., Liyanage, L. V. K., and Randeni, G. 1990. A Method for Determining Leaf Area of One, Two and Three Year Old Coconut Seedlings (Var. CRIC60). Hort. Abst. 60, 9366.

Odabaş, M.S., Kevsereoğlu, K., Çırak, C and Sağlam, B. 2005. Non-destructive Estimation of Leaf Area in Some Medicinal Plants. Turkish Journal of Field Crops, 10, 29-36.

Odabaş, M. S. 2003. The Quantitative Effect of Temperature and Light on Growth, Development and Yield of Broad Bean (*Vicia faba* L.). Unpublished Ph.D thesis.

Rai, A., Alipit, P. V., and Toledo, M. B. 1990. Estimation of Leaf Area of French Bean (*Phaseolus vulgaris* L.) Using Linear Measurements. Hort. Abst., 60, 3405.

Ramkhelawan, E., and Brathwaite, R. A. I. 1990. Leaf Area Estimation by Non-destructive Methods in Sour Orange (*Citrus aurantium* L.). Trop. Agric., 67, 203–206.

Robbins, N. S., and Pharr, D. M. 1987. Leaf Area Prediction Model for Cucumber from Linear Measurement. Hort. Science, 22, 1264-1266.

Sepaskhah, A.R. 1977. Estimation of İndividual and Total Leaf Areas of Safflowers. Agron. J., 69,783-785.

Tsonev, T. and Segiev, I. 1994. Leaf Area Measurement Using Hand Scanner, Hort. Abst., 64, 9165.

Uzun, S. and Çelik, H. 1999. Leaf Area Prediction Models (Uzçelik-I) for Different Horticultural Plants., Tr. J. of Agriculture and Forestry, 23, 645-650.

Wicrsima, J.V. and Bailey, T.B. 1975. Estimation of Leaf, Trifoliatc, and Total Leaf Areas of Soybeans. Agronomy Journal, 67, 26-30.