PREDICTION MODEL OF LEAF AREA FOR *TRIGONELLA FOENUM GRAECUM L.*

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ABSTRACT

Reliable equations were offered to predict leaf area for *Trigonella foenum*. Lamina width, length and leaf area were measured without destroying plant to develop the models. All equations produced for leaf area were derived as affected by leaf length and leaf width. As a result of ANOVA and multi-regression analysis, it was found that there was close relationship between actual and predicted growth parameters. The produced leaf area prediction models in the present study are LA= (a) + (b x L) + (c x W) where LA is leaf area, W is leaf width, L is leaf length and a, b, c are co-efficiencies. R^2 values and standard errors were found to be significant at the $p<0.001$ significance level.

Key Words: modeling, fenugreek, leaf area

INTRODUCTION

Trigonella foenum-graecum L. (fenugreek) (Leguminosae), native to the Eastern Mediterranean, Central Asia and Eastern Africa has been employed as a worldwide food additive and herbal medicine (Tayyaba Zia et al., 2001). It is cultivated in Turkey, Pakistan, India and China (Morton, 1990). It is well known for its pungent aromatic properties (Max, 1992), and has been widely used in preparing some traditional Turkish foods such as "sucuk", "cemen" and "pastirma" (Develi Isikli and Karababa, 2005). In Egypt, fenugreek has been used as a supplement to wheat and maize flour for bread-making and in Yemen it is one of the main constituents of the normal daily diet of the public (Fleurentin and Pelt, 1982; Kawashty et al., 1998). Fenugreek has also been employed as herbal medicine in many parts of the world. Its seeds are used for their carminative, tonic and aphrodisiac effects. Recently it has been reported that a curative dose of fenugreek produces antiulcer action (Pandian et al., 2002).

Leaf area is routinely measured in experiments of interesting crops where some physiological phenomenon such as light, photosynthesis, respiration, plant water consumption and transpiration are being studied (Gottschalk, 1994; Kersteins and Hawes, 1994; Picchioni and Weinbaum, 1995; Centritto et al., 2000; Cirak et al. 2008). In addition, leaf number and area of a plant are important in terms of cultural practices such as training, pruning, irrigation, fertilization etc. The leaf area estimation models that aim to predict leaf area non-destructively can provide researchers with many advantages in the agricultural experiments. Moreover, these kinds of models enable researchers to carry out leaf area measurements on the same plants over the course of the study

(Gamiely et al., 1991; NeSmith, 1991; NeSmith, 1992). Leaf area can be determined by using expensive instruments and/or predictive models. Recently, new instruments, tools and machines such as hand scanners and laser optic apparatuses have been developed for leaf area and fruit measurements. These are very expensive and complex devices for both basic and simple studies. Furthermore, non-destructive estimation of leaf area saves time as compared with geometric measurements. For this reason, several leaf area prediction models have been produced for certain plant species in the previous studies (Odabas et al. 2005).

The leaf area estimation models aiming to predict leaf area non-destructively can provide researchers with many advantages in agricultural experiments. There have not been published reports concerning leaf area prediction model for *Trigonella foenum-graecum* L. Due to the lack of such information, we aimed to develop reliable equations that allow for the non-destructive estimation of leaf area through linear measurements on this plant.

MATERIALS AND METHODS

Material

A total of 10 *Trigonella foenum-graecum* L. genotypes, namely A0-A4-A6-A7-A8 were kindly supplied by Konya; A1 by Gaziantep, A2-A3-A5-A9 by the Kayseri Provincial Directorates of Agriculture were used as plant material.

Method

Sowing was performed on May 18, 2009 with plant space of 19 X 18.2 m in the experimental area of theAgricultural Faculty, Samsun, Turkey. Leaf samples (50 leaves for each origin) were collected. Thus, total of 500 leaves were processed at the same day as they were collected in the following manner. At first, they were placed on the photocopier desktop by holding flat and secure and copied on A3 sheet (at 1:1 ratio). Then, Placom Digital Planimeter (Sokkisha Planimeter Inc., Model KP-90) was used to measure actual leaf area of the copy. Selection of leaf dimensions for measurement was governed by variation in leaf characteristics (e.g., size, shape, and symmetry) and practical constraints (e.g., ease and accuracy of measurements under field conditions). Considering these factory maximum leaf width (W) and length (L) were selected to correlate with leaf area (mm^2). 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. The leaf positions were selected with regard to points that could be easily identified and used to facilitate the measurement of leaf length and width.

Multiple regression analysis of the data was performed for each plant separately. A search for the best model for predicting leaf area (LA) was conducted with various subsets of the independent variables, namely, leaf length (L) and leaf width (W). Statistical significance of the results was tested by one-way analysis of variance (ANOVA).The best estimating equations for the leaf area (LA) of the plants tested were determined with the Excel program. Multiple regression analysis was carried out until the least sum of square was obtained (Cirak et al. 2005).

RESULTS

Multiple regression analysis was used for determination of the best fitting equation for estimation of the leaf area in fenugreek. It was found that most of the variations in leaf area values were explained by the selected parameters which are leaf length and leaf width (Table 1).

Table 1: The equation of leaf area (LA= a + (b x L) + (c x W) for *Trigonella sp.* Tested

Genotypes	a±SE	b±SE	c±SE	R^2
A0	-8.634 ± 1.19***	5.498 ± 0.87***	10.312 ± 0.92***	0.87
A1	-10.524 ± 2.00***	6.098 ± 1.15***	12.239± 1.30***	0.84
A2	-5.233 ± 1.26***	3.961 ± 0.58***	9.527± 1.17***	0.75
A3	-5.798 ± 1.44***	5.513 ± 0.73***	7.237± 1.18***	0.77
A4	-8.087 ± 1.73***	6.234 ± 0.76***	9.467± 1.28***	0.73
A5	-13.672 ± 1.97***	7.376 ± 1.05***	14.113± 1.11***	0.88
A6	-7.020 ± 0.90***	6.771 ± 0.76***	7.235± 0.86***	0.92
A7	-13.659 ± 1.43***	7.496 ± 0.77***	14.026± 0.74***	0.96
A8	-5.791 ± 1.77***	4.212 ± 1.34***	10.761± 1.19***	0.82
A9	-6.422 ± 2.45***	3.906 ± 1.61***	12.498± 1.93***	0.74

LA: leaf area, L: leaf lenght, W: leaf width, SE: Standart Error. ***R^2 and all SE values are significant at $P<0.001$

The variation in the parameters was between 73 % for A4, 96 % for A7. The produced leaf area prediction models in the present study are shown in Table 1.

LA=(-8.634) + (5.498 x L) + (10.312 x W) for A0,
LA=(-10.524) + (6.098 x L) + (12.239 x W) for A1,
LA=(-5.233) + (3.961 x L) + (9.527 x W) for A2,
LA=(-5.798) + (5.513 x L) + (7.237 x W) for A3,
LA=(-8.087) + (6.234 x L) + (9.467 x W) for A4,
LA=(-13.672) + (7.376 x L) + (14.113 x W) for A5,
LA=(-7.020) + (6.771 x L) + (7.235 x W) for A6,
LA=(-13.659) + (7.496 x L) + (14.026 x W) for A7,
LA=(-5.791) + (4.212 x L) + (10.761 x W) for A8
LA=(-6.422) + (3.906 x L) + (12.498 x W) for A9.

DISCUSSION

Although to correlate leaf length and width with leaf area have been widely used (Elsner and Jubb, 1988), but some studies have also include petiole length and leaf weight (Montero et al., 2000). However, regression equations that incorporate leaf length and width. Length and width have been generally chosen for their simplicity and accuracy. Since, these measurements are non-destructive. A very close relationship between actual and predicted leaf area for fenugreek was found in this study (Figure 1).

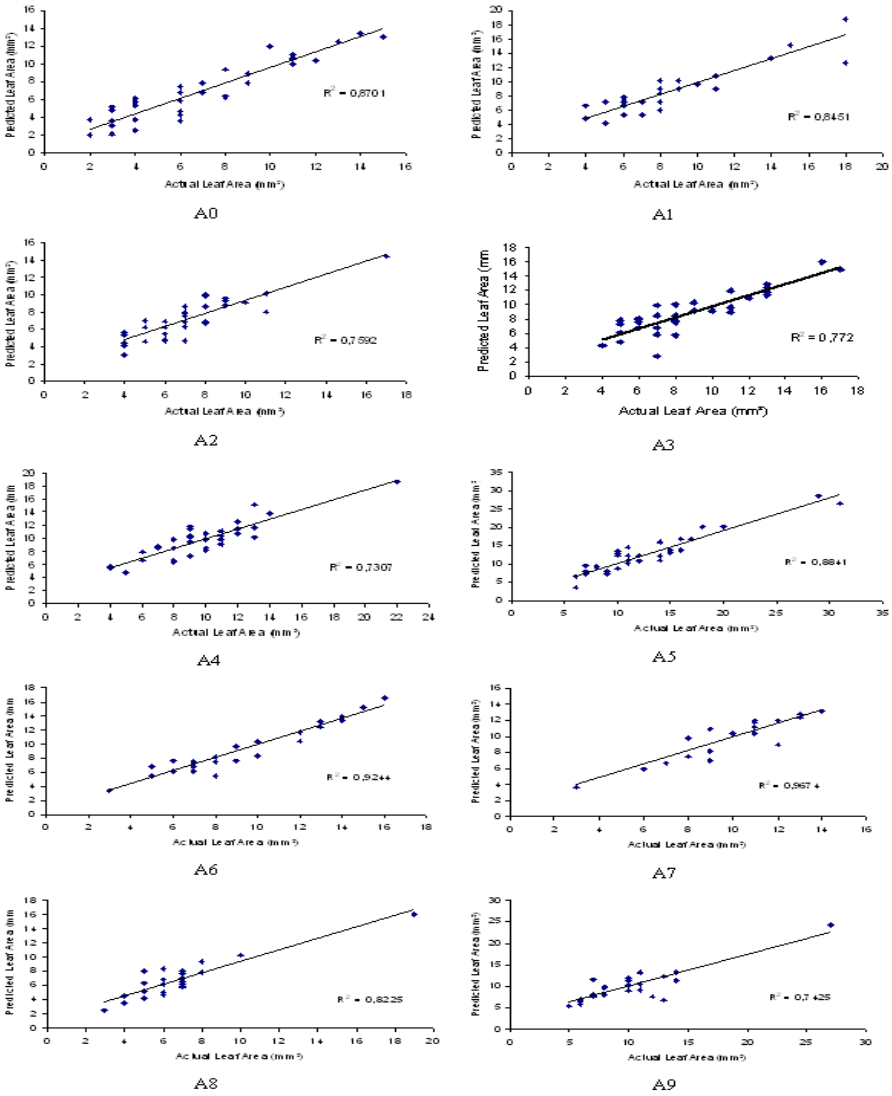

Figure1. Relationship between actual (x - axis) and predicted (y - axis) leaf area in *Trigonella sp.*

Our results were similar to another studies mentioned above that used linear measurements of leaves from different plants for estimating leaf area. Coefficients of determination were generally high for the best-fit models in the current and previous studies. However, the differences among the fenugreek genotypes observed in the present study were not surprising due to differences in size and shape of leaves of the genotypes. Likewise, using the grapevine cultivars “Niagara” and “DeChaunac”, Willams and Martinson (2003) found that the product of maximum leaf length and width was most highly correlated with leaf area, but r^2 values of cultivars were different (0.99 for Niagara and 0.96 for Dechaunac).

CONCLUSION

The simple models for predicting leaf area were developed for fenugreek an important plant species in Turkey and all over the world. Mathematical models shown in Table 1 would be useful tools for prediction of leaf area for many plants without using expensive devices. Since the maximum leaf width and length are dimensions that can be easily measured in the field, use of these equations would enable researchers to make non-destructive measurements or repeated measurements on the same leaves. Such equations would also allow researchers to estimate leaf area in relation to factors like crop load, drought stress, and insect damage. Therefore, the models produced in the present study could be used safely by the engaged in fenugreek researchers.

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