Pak. J. Bot., 37(4): 837-841, 2005.

NON-DESTRUCTIVE LEAF AREA ESTIMATION OF FLAX (*LINUN USITATISSIMUM* L.)

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Abstract

In this research, a model for predicting the leaf area was developed for flax by using Linda, Antares, Bionda, Avangard, Atalanta, Flanders, Dakota, Sarı-85, Ayancık and Windemore cultivars by measuring lamina width, length and leaf area without destroying in 2004. Two hundred leaves were collected from each line and an allometric relationship was derived between actual leaf area (ALA) measured using the Placom Digital Planimeter (Sokkisha Planimeter Inc., Model KP-90), leaf length (LL) and leaf width. Multiple regression analysis for the cultivars was performed. The proposed leaf area (LA) prediction model is LA (cm^2)=-0,7796+0,2678*L+2,2652*W +0,0120*α-0,0454*α*W, R^2 = 9697.

Introduction

Flax (*Linum usitatissimum* L.) is a perennial crop and one of the oldest cultivated plant species. Flax is widely used in textile and oil industry. Canada is a major producer, consumer and exporter of flax. The crop originated in the Mediterranean region and Western Europe (Durrant, 1976) and more than 30 countries now cultivate flax in Asia, Europe and America.

The most important photosynthetic organ of the plant is leaves (Wareing & Phillips, 1970). Leaf area (LA) is an indicator of crop growth and productivity, and many methods are available with which to estimate it. Recently, new instruments, such as hand scanners and laser optic apparatuses were developed for leaf area measurements. However, these are very expensive and complex devices for basic and simple studies. A non-destructive prediction of the leaf area saves time compared with geometric measurements, and no expensive instruments are needed (Robbins & Pharr, 1987). Several leaf area prediction models have been developed for different plant species (Wendt, 1967; Rajendran & Thamburaj, 1987; Dumas, 1990; Rai *et al*., 1990; Elsner & Jubb, 1988; Pedro *et al*., 1989; Yin, 1990; Payne *et al*., 1991; Ramkhelawan & Brathwaite, 1992; Uzun & Çelik, 1998; Kandiannan *et al*., 2002; Demirsoy *et al*., 2004) in previous studies. However, a leaf area prediction model is not available for flax to date. Therefore, in this paper, we have developed and tested an allometric relationship and propose a relatively simple method for estimating the LA of flax.

The allometric relation is a quantitative relationship between the relative growth rates of two or more plant organs (Richards, 1969). It may be possible to infer some aspects of the physiological status of a growing plant directly by analysis of allometric and other growth data. This method has the advantage of being relatively simple and inexpensive (Causton & Venus, 1981). If we assume that leaf blades have an invariant, genetically controlled shape and symmetry regardless of age and position on the plant, then variation of LA would be a result of proportional enlargement or reduction of this fixed shape. Leaf blade area has been found to be related to linear dimensions such as the length and width of the leaf.

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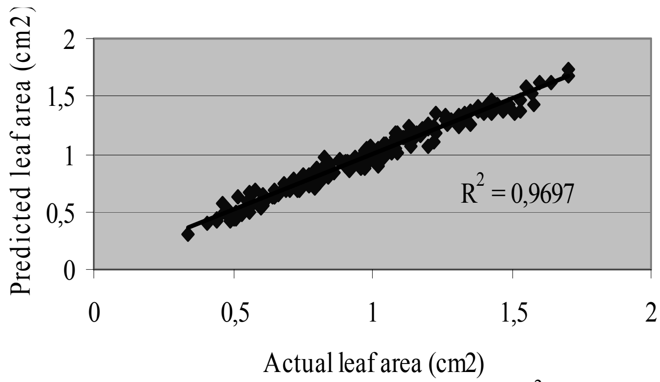

Fig. 1. The overall relationship between actual leaf area (cm^2) and predicted leaf area (cm^2) for the cultivars.

A non-destructive method in the estimation the LA of flax would be a useful tool for studying its growth and development. It is easier to measure leaf length than leaf width, and more observations can be made per unit time if only length is measured rather than both leaf length and width. The objectives of this study were to investigate the allometric relationship between measurement of leaf length (L) with leaf width (W) and the actual leaf area (ALA) measured with a planimeter and to use the developed model to predict LA.

Materials and Methods

In this study, 10 flax cultivars viz., Dakota, Flanders, Ayancık, Antares, Linda, Nareum, Atalanta, Bionda, Sarı-85 and Avangard were used at the University of Ondokuz Mayıs, Faculty of Agriculture in Turkey. Leaf samples for each cultivar were selected randomly from the shoot during the summer growing season in 2004. A total of 2000 leaves were measured, 200 leaf samples for each cultivar. Each leaf was fixed on A4 sheet and photocopied after which the length, width and actual leaf areas were measured. Leaf length was measured to the nearest millimeter from the leaf tip to the point at which the lamina is attached to the petiole. Leaf width was measured from edge to edge at the widest part of the leaf lamina. The actual leaf area of individual leaves measured using Placom digital planimeter (Sokkisha Planimeter Inc., Model KP-90).

Multiple regression analysis of the data was performed for each cultivar separately. In this analysis was conducted with various subsets of the independent variables, namely leaf length*cultivar, (L*α), leaf width*cultivar (W*α), leaf length*leaf width (L*W) and square of leaf width*leaf length (L*W^2) and to develop the best model for predicting the leaf area (LA) by using the Excel 7.0 package program. The multiple regression analysis was carried out until the least sum of square was obtained.

Results and Discussion

Regression analysis showed that most of the variation in leaf area values explained by the parameters was 96.97% for all the cultivars (Fig. 1). The proposed leaf area (LA) prediction model is:

LA(cm^2)=	-0,7796+	0,2678L+	2,2652*W	+0,0120*α	-0,0454*α*W
S.E.	0,0371***	0,01265***	0,01158***	0,0055***	0,0132***
R^2 =	0,9697***				

where LA is leaf area (cm^2), L is leaf length (cm), W is a maximum width of the leaf (cm), ∝ is a constant for cultivars, S.E. is standard error of means

Table 1. Allometric relationship between actual leaf area (ALA) and predicted leaf are (PLA) for some linseed cultivars.

Flax cultivars	Constant for cultivars (α)	Actual leaf area (ALA) (cm^2)	Predicted leaf are (PLA) (cm^2)	R^2
Dakota	1	0,9404	0,9658	0.9760
Flanders	2	1,0035	1,0128	0.9663
Ayancık	3	1,1495	1,1727	0.9729
Antares	4	0,9725	0,9954	0.9500
Linda	5	0,8145	0,8110	0.9743
Nareum	6	0,9490	0,9573	0.9734
Atalanta	7	0,8775	0,9253	0.9672
Bionda	8	1,2386	1,2573	0.9787
Sarı-85	9	0,7753	0,8179	0.9729
Avangard	10	0,8268	0,8755	0.9500

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 (Fig. 2). It was found that the relationship (R^2 values) between actual and predicted leaf areas varied from 0.9787 in Bionda to 0.9500 in Antares and Avangard cultivars (from the highest to the lowest value). As it can be seen from the Fig. 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9 and 2.10, the model predicted leaf area of the tried flax cultivars were most reliable for Dakota (0.9760), Flanders (0.9663), Ayancık (0.9729), Antares (0.9500), Linda (0.9743), Nareum (0.9672), Atalanta (0.9672), Bionda (0.9787), Sarı-85 (0.9729) and Avangard (0.9500).

The relationship between ALA and leaf length (L) and leaf width (W) show that the correlation coefficient (R^2) was highly significant (p>0,9697). This equation predicts leaf area of flax by only measuring the leaf length (L) and the leaf width (W) of the leaves.

As seen in Table 1, there was a very close relationship between actual leaf area and predicted leaf area which suggests that it is highly reliable across a range of cultivars and is open to being evaluated.

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 cotton, caster, sorghum (Wendt, 1967), watermelon (Rajendran & Thamburaj, 1987), tomato (Dumas, 1990), bean (Rai *et al*., 1990), grape (Elsner & Jubb, 1988; Pedro *et al*., 1989; Yin, 1990), pearly millet (Payne *et al*., 1991), orange (Ramkhelawan & Brathwaite, 1992), avocado, kiwifruit, aubergine, cucumber, raspberry and grape (Uzun & Çelik, 1998) and peach (Demirsoy *et al*., 2004) show that there were close relationship between leaf width, leaf length and leaf area. Results from the present study were in accordance with some of the previous studies on establishing reliable equations for predicting leaf area through measuring leaf dimensions.

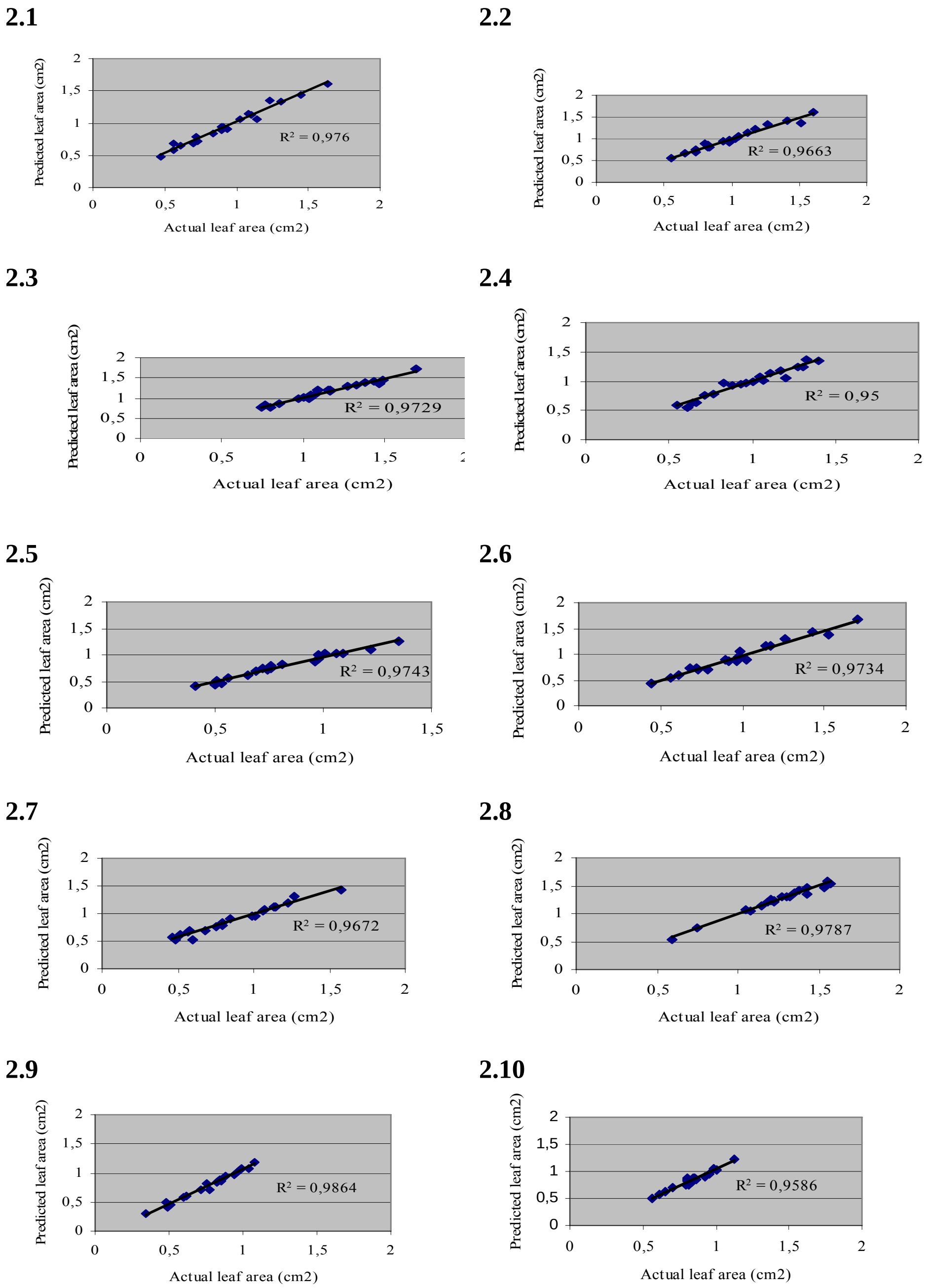

Fig. 2. Relationships between actual leaf area (cm^2) and predicted leaf area (cm^2) for Dakota (2.1), Flanders (2.2), Ayancık (2.3), Antares (2.4), Linda (2.5), Nareum (2.6), Atalanta (2.7), Bionda (2.8), Sarı-85 (2.9) and Avangard (2.10).

In the study, the simple model for predicting leaf area was developed for flax. There were no significant differences among the cultivars in terms of being a parameter in the model. Therefore, the model can be used for physiological and quantitative studies in flax. However, care and caution must be taken when the models are extrapolated to other cultivars.

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(Received for publication 11 May 2005)