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Leaf Area Prediction Model for Summer Snowflake (*Leucojum aestivum* L.)

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Abstract: In a previous study, we found a positive and significant correlation between leaf number per plant and bulb yield in *Leucojum aestivum*. In the present study, to develop a leaf area prediction model was aimed for this plant. To achieve this objective, a total of 200 leaves were selected randomly from *Leucojum aestivum* plants cultivated in experimental area of Black Sea Agricultural Research Institute, Turkey. Leaf width, length and leaf area were measured. The actual leaf area of the plant was measured by PLACOM Digital Planimeter and multiple regression analysis with Excel 7.0 was performed. The leaf area model developed was LA = (-5.902) + (-4.12xL) + (0.19xL^2) + [-4.8*(LxW^2)] + [0.201x(L^{2}xW^2)] + [-0.42x (L^{2}xW)] + [10.65 x (LxW) where LA is leaf area, L is leaf length, W is leaf width. R^2 value (0.97) and standard error were found to be significant at the $p<0.001$ level.

Key words: *Leucojum aestivum*, leaf area, modelling

INTRODUCTION

Medicinal plants, since times immemorial, have been used in virtually all cultures as a source of medicine. The widespread use of herbal remedies and healthcare preparations, as those described in ancient texts such as the Vedas and the Bible and obtained from commonly used traditional herbs and medicinal plants, has been traced to the occurrence of natural products with medicinal properties[1]. Today over 60% of the world's population, 80% in developing countries depends directly on plants for their medical purposes[2,3] and traditional medicine is still recognized as the primary health care system in many rural communities because of its effectiveness, lack of modern medical alternatives and cultural preferences[4,5]. Indeed, the market and public demand has been so great that there is a great risk that many medicinal plants today, face either extinction or loss of genetic diversity.

Summer snowflake (*Leucojum aestivum* L.) called as akçabardak, kabalak, sarıklı kökü by Turkish folk is 30-60 cm height and a perennial bulbous living in high and moist pastures of North Anatolia in our country and found naturally in Samsun province of Turkey[6]. This plant has been used in drug production industry intensively for last two decades and it is an important export material for our country. Likewise, 6.480.080 bulbs were exported in 2000. But this plant is face to face with extinction, because its exported bulbs are obtained rather than by collecting in pastures[7]. *Leucojum aestivum* has recently attracted scientific concern due to its various secondary metabolite contents. Its ethanol extract exhibits antiviral effect[8] and have some secondary metabolites, namely galanthamine, lectins and chelidonic acid, having multifunctional pharmacological effects[9]. Galanthamine found in whole plant and especially in bulbs is a dibenzofuran-type alkaloit[10] and its anticholineesterase[11], anaesthetic[12], analeptic and analgesic[13] effects were demonstrated by relevant studies. Besides, the alkaloid has been used in treatment of Alzheimer, infantile paralysis[14] and some kind of neurological disorders[12].

Biologically active components of *Leucojum aestivum*, namely galanthamine and lectins, were found in bulbs the most intensively[10]. In a three years field study, we found a positive and significant correlation between leaf number per plant and bulb yield in this plant. That is why; leaves are the most important organ of *Leucojum aestivum*. Leaf Area (LA) is an indicator of crop growth and productivity and many methods are available with which to estimate it[15]. Non-destructive estimation of plant leaf areas offers researchers 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

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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 mathematical model and equation from linear leaf measurement for predicting total or individual leaf area has been shown to be very useful in studying plant growth and development[16].

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[17,18].

MATERIALS AND METHODS

Leaf samples were randomly collected from *Leucojum aestivum* plants cultivated in experimental area of Black Sea Agricultural Research Institute-Turkey in February, 2004. A total of 200 leaves 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.

Multiple regression analysis was performed. A search for the best model for predicting leaf area (LA) was conducted with various subsets of the independent variables, namely, length (L), width (W) and length square * width (L^2 * W).

The best estimating equation for the leaf area (LA) of *Leucojum aestivum* was determined with the Excel 7.0. Multiple regression analysis was carried out until the least sum of square was obtained.

RESULTS AND DISCUSSION

Multiple regression analysis was used for determination of the best fitting equation for estimation of leaf area in *Leucojum aestivum* showed that most of the variation in leaf area values was explained by the selected parameters (Length and width) (Table 1). The variation explained by the parameters was 97%.

Table 1: The equation of leaf area for *Leucojum aestivum*

La[a]=	[-5,902] + [-4,12xLb] + [0,19xL²c] +[-4,8*[LxW²d]] + [0,201x[L²xW²]] + [-0,42x [L²xWe]] + [10,65 x [LxW]]			
Se[f]=	3.52***	0.84***	0.036***	0.813***
	0.034***	0.074***	1.744***	

aLA: leaf area, bL: leaf length, c L2: leaf length square, dW2: leaf width square, e W: leaf width, fSE: Standard Error. ***R^2 and all SE values are significant at $p<0.001$

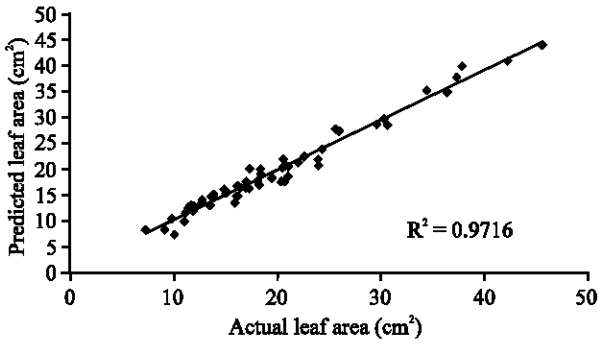

Fig. 1: Relationship between actual leaf area (cm^2) and predicated leaf area (cm^2) for *Leucojum aestivum*

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.)[19], orange (*Citrus aurantium* L.)[20,21], French bean (*Phaseolus vulgaris* L.)[22], coconut (*Cocos nucifera* L.)[23], Grape (*Vitis vinifera* L.)[16] and broad bean (*Vicia faba* L.)[24]. 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). We found that there was very close relationship between actual and predicted leaf area for *Leucojum aestivum* (Fig. 1).

Consequently, the present model can be evaluated with leaf samples gathered from different growing periods. As the understanding of plant growth and development has been increasing, such mathematical models as this shown in Table 1 will be very useful tools for prediction of leaf area for many plants without using of expensive devices. Model developing processes of this sort may be used for other field crops, plantation crops, vegetables and ornamentals.

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