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Research Article

MATHEMATICAL MODEL FOR MEASUREMENT OF LEAF AREA IN POMEGRANATE (*Punica granatum* L)

MESHRAM D.T.*, CHANDRA RAM, LAD S.A. AND WADANE S.S.
ICAR-National Research Centre on Pomegranate, NH- 65, Bypass Road, Kegaon, Solapur 413 255, India
*Corresponding Author: Email - gomesh1970@rediffmail.com

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Abstract: In this paper, a model for predicting the leaf area has been developed for pomegranate (*Punica granatum* L) using 44 genotypes. Multiple regression analysis for the pomegranate leaf area was performed. The proposed leaf area (LA) prediction model is: LA = -0.00682 + 0.152 x L + 0.235 x W + 0.6209 x L x W; R^2 = 0.95, where LA is leaf area, W is leaf width and L is leaf length. The model was validated by measuring leaf samples of pomegranate genotypes. The developed model can be estimated pomegranate leaf area without the use of expensive instruments and destructing the leaves of tree.

Keywords: Non-destructive method, pomegranate genotypes, regression model

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Introduction

Pomegranate is becoming an important fruit crop in temperate to tropical regions of the world [1-3]. Its commercial cultivation in India is mainly concentrated in Maharashtra followed by Karnataka and Andhra Pradesh. At present, India occupies first position in area and production of pomegranate in the world [4]. Interestingly, this crop has received enormous importance in recent years as a medicinal crop due to its anti-microbial [5], anti-cancer [6,7] anti-oxidant and anti-inflammatory [8,9] properties. Besides, its nutraceutical and ornamental values are likely to increase in years to come. Leaf area has been a subject of interest in different physiological parameters such as light, photosynthesis, respiration, plant water consumption, water use efficiency and transpiration [10, 11]. In addition, total leaf number and leaf area of plant plays vital role in training, pruning, estimation of leaf area index and crop coefficient, irrigation and fertigation etc. [12,13]. It has been reported by different workers that models for the non-destructive prediction of the leaf area are useful tools for researchers in horticultural experiments. Generally, the leaf area is determined with the help of instruments or prediction models. Recently, new instruments like hand scanners and laser optic apparatuses have been developed for leaf area measurements. Though, these instruments are very expensive and complex for basic and simple studies. Thus, a non-destructive prediction of the leaf area can save time as compared to geometric measurements [14]. In the past, several leaf area prediction models have been developed in fruit crops like grape, peach, tea, avocado, chestnut, citrus, almond, pecan, olive, mango, hazelnut and kiwifruit [15-20]. Interestingly, leaf area estimation model is still not available in pomegranate. In fact, the area of each leaf is closely related to length and width, which may be described by regression equations. In view of these, an attempt has been made to develop a simple, precise, non-destructive and fast predictive mathematical model to estimate the leaf area in pomegranate based on length and width of leaf lamina.

Materials and Methods

Study site

The study area located at ICAR-National Research Centre on Pomegranate (North latitude 17° 10' to 18°32' and East longitude by 74°42' to 76° 15'). The experiment was conducted for the estimation of leaf area using 44 accessions of pomegranate grown in light textured soil.

Leaf sampling

The leaf samples were collected from three years old pomegranate trees of germplasm repository planted at 4.5 x 4.0 m apart. Each genotype has four pomegranate trees from which three plants were randomly selected for the study. Sampling was made by harvesting three kinds of leaves (*i.e*., small, medium and large size) from selected trees. The leaves were taken from the shoots in the middle of the tree canopy located in the four cardinal points. For each sample, the maximum width (W) was measured from middle part of the leaf while the length (L) was determined from the base to the apex of the lamina [Fig-1]. Altogether, 4180 leaves from 44 genotypes were measured. The 44 genotypes are Bassin Seedless, Kabuli Kanoor, IC-1199, Tabesta, Bhagawa, Jallore Seedless, Jhodhpur Red, Surat Anar, Dholka, Bedana Suri, IC-318720, Spin Sakaharin, G-137, Co-White, Kabuli Yellow, Spendan Ader, IC-318728, Gulesha Red, Kalpitiya, Phule Arakta, Jodhpur Collection, IC-1196, Kandhari, Patna-5, IC-1201, Jyoti, Kasur1, P-26, Bedana Sedana, IC-318762, KRS, P-23, Boskalin Sl, Bedana Thinskin, Mridula, P-16, Dorsala, Damini, Muscat, P-13, Ganesh, IC-1203, Yereaud and Nana. Out of 4180 samples, 3960 samples were used for model development and 264 samples for validation. Each leaf was copied; then a digital leaf area meter (LI-3000 Licor Inc. Lincoln, NB, USA) was used to measure the actual leaf area. However, the leaf width and length of the leaf samples were measured for model construction and validation.

Model Construction

Multiple regression analysis of the combined data was performed for all 44 genotypes. A search of the best model for predicting leaf area was conducted with various leaf subsets of the independent variables, *viz*. Length (L), (L^2), Width (W), (W^2), Length and Width (L x W), (L^2 x W^2), L^2/W^2, L^2/W W^2/L and cultivars/genotypes (C). The best estimating equations for the leaf area (LA) of the genotypes tested were determined with the Excel 7.0. Multiple regression analysis was carried out until the least sum of square was obtained. For validation procedure, leaf area values obtained by using the model were plotted against actual leaf areas measured using a leaf area meter.

The Excel 7.0 Package program was used for this analysis. The data belonging to the leaves of pomegranate was used to validate the equations. The fitting parameters were not adjusted during validation.

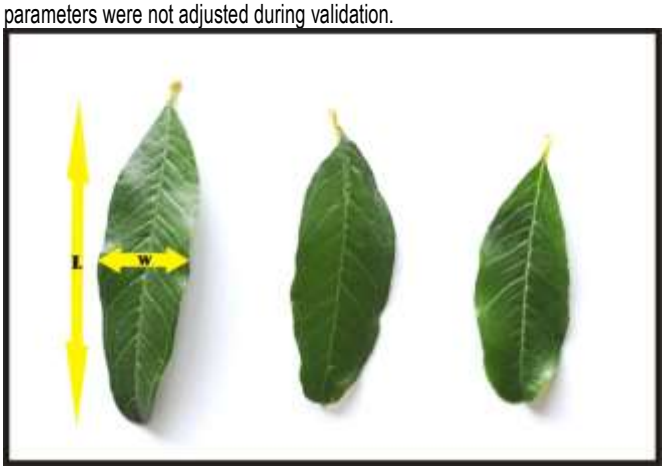

Fig-1 Leaf diagram of pomegranate (large, medium and small) showing the position of leaf length (L) and leaf width (W)

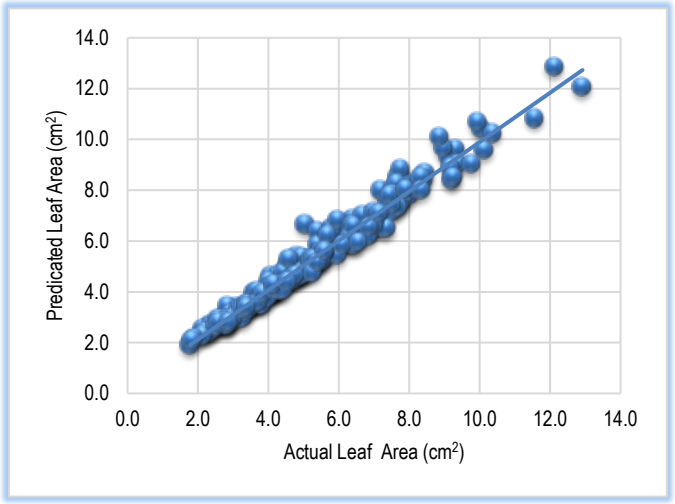

Fig-2 Relationship between actual leaf area (cm^2) and predicted leaf area (cm^2) in pomegranate genotypes

Results and discussion

The regression analysis used for determination of the best fitting equation for estimation of leaf area in pomegranate evaluated here showed that most of the variation in leaf area values was explained by selected parameters (*viz.* length, width and length and width). Various combinations of measurements and models relating linear dimensions to area have been utilized. Higher values of coefficient of determination were obtained from several models which shows that the leaf area is highly correlated with length, width and interaction term L x W. The best leaf area prediction model in the present study was, LA = -0.00682 + 0.152 x L + 0.235 x W + 0.6209 x L x W; R^2 =0.95 where, LA is leaf area, W is leaf width and L is leaf length. When the data for actual leaf area was plotted against the predicted leaf area values in the present model, it was found that the model estimated leaf area for all genotypes examined with a high determination [Fig-2]. The best results, in terms of statistics as well as visually, were obtained from above equation because it included length (L), width (W) and interaction term (L x W). Results showed that developed model is able to estimate individual leaf area with more precision. However, the method that could be chosen by an individual researcher will depend on the time available to take measurements and the level of precision required. While measurements of both width and length can be more precise than estimates based on one dimension, this method requires twice the number of measurements. Using the models obtained in this study, individual leaf area as well as LAI of pomegranate genotypes can be computed without using expensive instruments. Earlier, many studies were carried out to establish reliable relationships between leaf area and leaf dimensions of different plant species such as kiwifruit [1 and 19], cherry [13], orange [21,22], grapes [23] pecan [15] and onion [12] They found close relationships between leaf width, leaf length and leaf area with high R^2 values (0.985 for kiwifruit, 0.95 to 0.99 for cherry, 0.95 to 0.98 for coconut, 0.89 to 0.93 for orange, 0.98 to 0.99 for grapes, 0.93 for pecan). Even very high R^2 value (0.95) has also been obtained in the present study for pomegranate. Thus, our result is in close conformity with the results as reported in the previous studies on establishing reliable equations for predicting leaf area through measuring leaf dimensions. Interestingly, there were no significant differences among the genotypes in terms of being a parameter in the model. Therefore, the model can be used for pomegranate genotypes in the relevant studies.

Conclusion

A simple mathematical model for prediction of leaf area of pomegranate has been developed by taking its 44 genotypes. As the understanding of plant growth and development has been increasing, such model will be very useful tools for prediction of leaf area for many cultivars without using the expensive equipment's. Such equations would also allow researchers to estimate leaf area in relation to factors like crop coefficient, crop load, fertigation, drought stress, leaf area index, insect and bacterial blight (Oily spot) damage.

Application of research: Models produced in the present study can be used safely by pomegranate researchers and farmers for various genotypes.

Research Category: Pomegranate genotypes

Abbreviations:
L: Length, W: Width

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***Principle Investigator or Chairperson of research: Dr D.T. Meshram**
Institute: ICAR-National Research Centre on Pomegranate, NH- 65, Bypass Road, Kegaon, Solapur 413 255
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