Plant Archives Vol. 22, Special Issue (VSOG), 2022 pp. 260-264 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2022.v22.splecialissue.047

ESTIMATION OF SINGLE LEAF AREA IN MAJOR TASAR HOST PLANT SPECIES (ARJUN, ASAN AND JARUL) THROUGH NON-DESTRUCTIVE METHOD

Kumar, B., Mahto, R.K., Doss, S.G*., Aparna, K., Yadav, H. and K. Sathyanarayana
Host Plant Improvement Laboratory, Central Tasar Research and Training Institute,
PiskaNagri, Ranchi – 835 303. Jharkhand. India
*For correspondence – arboriculturectrti@gmail.com

ABSTRACT

In tasar host plants, estimation of leaf area is essential to evaluate and characterize the gene bank accessions for selecting suitable parental plants for crop improvement programme as well as to estimate the probable foliage area available at a given point of time prior to start silkworm rearing and also for studying plant canopy structure after pruning. Leaf area measurements usually done by sophisticated instruments or by manual method (graph sheet tracing) in which cost and laboriousness are limiting factors. To overcome these difficulties, an attempt was made to measure leaf area of Arjun, Asan and Jarul by utilizing a mobile app –"Petiole" with least expenditure coupled with high precision and to develop a model for leaf area estimation by regression equation. Fully expanded matured leaves from 6-12th, 8-12th and 6-8th position from shoot tip in Ajun, Asan and Jarul, respectively, were collected from the randomly selected branches of field grown plants in 10' x 6' spacing of the Farm section of CTRTI, Ranchi. Keeping 30 leaves per replication a total of 90 leaves in each species were considered for this study. Leaf morpho-metric parameters *viz.,* maximum lamina length (L), width (W) and their squares L^2, B^2, leaf area and lamina length x width (L x B) were recorded from each sampled leaves. Correlation and regression analysis has been done and species specific regression equation has been developed, which is useful to estimate leaf area of these tasar host plants in a non-destructive manner with low input cost and high precision.

***Keywords*:** Petiole- Mobile app; leaf area; leaf length, leaf breadth, correlation, regression.

Introduction

The major host plant viz. Arjun (*Terminalia arjuna*) Asan (*Terminalia tomentosa*) and Jarul *(Lagerstroemia speciosa*) are used to rear tropical tasar silkworm (*Antheraea mylitta*) which synthesizes tasar silk. These plants either existing in natural forests or in economic block plantation raised under community forests are utilized to do tasar culture by the forest fringe dwellers of major tasar growing states viz. Jharkhand, Bihar, Orissa, West Bengal, Maharashtra, Madhya Pradesh & Andhra Pradesh. In tasar host plant improvement programmes, it is essential to evaluate the host plant based on the leaf area which is essential for silkworm rearing. As leaf is the major economic product in tasar culture as leaf area vary between ecotypes and also linked with the plants ability to intercept solar radiation, photosynthesis, biomass accumulation, its transpiration & energy transfer by plant canopies (Jonckheere *et al.*, 2004). Leaf shape &its size are crucial factor for identification of ecotypes & species identification (Neto et.al, 2006; Du *et al.,* 2007) and are classified based on leaf morpho-metric characteristics (Singh *et al.*, 2000). Tasar host plants are utilized for tasar silkworm rearing from July- Feb. every year to rear BV&TV crops of silkworm (Jolly *et al.*, 1974) Leaf area estimation in the field either by manual or by instrument is difficult due to laborious nature & time consuming and thereafter often requires sophisticated instruments (Kumar & Sharma, 2010). Measurement of leaf area by non destructive method is the best option which is available for major tree species Viz. Chestnut (Sardar & Demirsoy, 2006), hazelnut (Christoferi *et al.*, 2007) Cherry (Demirsoy and Demirsoy, 2003), peach (Demirsoy *et al.*, 2004) palm (Nakamura *et al.*, 2005) som (Chattopadhyay *et al.*, 2011) and other horticultural crops (Uzun & Celik, 1999). In these studies different foliage morphometric traits are used to drive linear, quadratic or exponential functions and regression equations. Linear function-based prediction models are highly preferable due to their simplicity & easy to record data in the field (Montgomey & Peck, 1992). The information on the leaf area prediction models for major tasar host plants (Arjun, Asan& Jarul) is scanty. Therefore, the present study was under taken to unravel the interrelationships among the foliar morphometric parameters and to develop leaf area prediction models of these plants of tasar culture for field use.

Materials and Methods

Arjun, Asan & Jarul ecotypes (Acc-102; Acc-502 & Acc-413) maintained in the gene bank of Central Tasar Research and Training Institute, Ranchi, India were considered for this study. Fully expended, matured leaves from tip, after summer pruning (Mar- April-2022) prior to start of 1st crop rearing (July 2022), and were collected randomly from field grown plants (Fig. 1) of 20 years old maintained in 8' x6' spacing with 2314 plants / ha. Leaf sampling was done after 90 days of growth of the pruned branches. The soil was alluvial with pH 5.2; OC- 0.65%, available N (100 Kg/ha); P (20 Kg/ha); K (250 Kg/ha) at the time of experimentation. The recommended dose of inorganic fertilizers viz. N as urea (48 g/plant/ year in 3 split doses) phosphorous as SSP (46 g/plant/year) and potassium as MOP (12 g/plant/year), were applied (Das et. al, 2020) after 60 days of pruning. Organic fertilizer either in form of FYM 1 kg / plant or vermicompost 1 kg / plant were applied (Das *et al.*, 2020). A total of 90 leaves were measured for all the 3 major tasar host plants. Actual leaf area was measured by using "Petiole"- mobile application available in the Play store of Android mobile. Leaf L was measured from the leaf base (lamina petiole juncture) to the leaf tip along the midrib and B was from the leaf edges at the maximal point of width of the leaves. Leaf morphometric parameter analyzed by ANOVA and Fisher's LSD were calculated when the F values were significant P<0.05) Gomez & Gomez, 1984) Multiple regression analysis was performed with pooled data of three different replication of independent variables (L, B, L^2, B^2 & L x B) using R-software. Interrelationships of LA with foliage parameter were derived by correlation analysis by Pearsons' method. Regression equation for accurate prediction of leaf area from the independent variables also derived. To validate the best fitted equation, predicted values were selected randomly for each tasar host plant and plotted against actual leaf area using same statistical software.

Mobile application ("Petiole") set up &estimation of leaf area

"Petiole" is a freely available mobile application downloaded from the google play store. After completion of installation, it was opened and allowed to use the google account of the user for authentication. This "Petiole" application connects through the mobile camera live image capture for measurement of leaf area. Before starting leaf area measurement, standardization of height was made with calibration pad (medium size) as all 3 plants leaf fall under medium category in which each square measure 1.4 cm. A random check by touching the square were made to confirm accurate area measurement by adjusting the height of the mobile phone in tripod support (Fig. 2–A). After standardization leaves were placed in the white background and by touching the leaf the area has been measured automatically and displayed were recorded for each leaf (Fig. 2-B, C & D).

Results and Discussion

To predict the LA of Arjun, Asan & Jarul, data of L, B, L^2, B^2, L x B of leaves of the respective species are utilized to derive simple linear regressions. Similar LA prediction models are reported in other tree species (Uzun & Click, 1999; Gamper, 2005; Tsialtas & Maslaris, 2008; Chattopadhyay *et al.*, 2011). The leaf shapes of the selected tasar host plant species measured as lamina length : width ratio (L/B) and it varied significantly among the species. Higher L/B ratio was observed in Arjun (4.00) followed by Jarul (3.33) and Asan (2.89) plants (Table 1). This variation in morpho metric characters are due to genetic influence of the respective species, which is in accordance with the findings of Tsialtas *et al.*, (2008) and Chattopadhyay *et al.* (2011) who reported the governance of leaf morphology in grapevine and som by genetic characteristic of the plants.

As far as the linear regression analysis to predict the leaf area of different species through prediction models is concerned, a simple linear relationship between LA and other lamina dimensions are preferable for easy and rapid measurement to predict the leaf area by non-destructive means (Lu *et al*., 2004; Chattopadhyay *et al*., 2011). The mean values for different measurements viz., L, L^2, B, B^2, L x B and LA of 3 major host plants varied drastically among themselves due to variations of leaf morphology and distinctiveness among these three species (Table 2). All the studied parameters are correlated with actual LA and linear regression equations are developed. The squares of leaf dimensions (L^2 & B^2) often are used for increased accuracy in linear models of LA predictions (Smith & Kleiver, 1984; Montero *et al*., 2000; Chattopadhyay *et al*., 2011). The regression analysis of LA and other leaf morpho metric characters showed (Table 3, 4 & 5) significant variations with all of the characters. However, relationship of LA with L and L^2 showed low R^2 values (0.541 & 0.537) and high SE of estimates (14.26 & 7.41), respectively, in Arjun. Similar trend also observed for these characters in Asan (R^2=0.376 & 0.542; SE=20.07 & 32.59) and in Jarul (R^2=0.362 & 0.516; SE=27.50 & 19.28) (Table 3, 4 &5). Therefore, models generated by using L & L^2 could not be beneficial for reliable LA predictions in these tasar host-plant species.

B and its squares (B^2) were found relatively good predictors of LA than L & L^2 measurements, as revealed by better linear relationship with LA in Arjun ($y=-26.380+15.656x$; R2=0.767; $p\leq0.001$; n=88 and $y=25.154+1.167x$; R2=0.744; $p\leq0.001$), respectively. In both Asan & Jarul, the L & L^2 measurements showed trends as that of B & B^2 (Table 3, 4 & 5) and are also could not help in the prediction of LA in an accurate manner. However, LA prediction with maximum accuracy was obtained by a simple linear relation with L x B in Arjun (R^2=0.876), Asan (R^2=0.892) and Jarul (R^2=0.632) (Table 3, 4 & 5; Fig. 3. A, C & E). The findings of strong relationship between LA & L x B in this study is in accordance with the earlier reports in zucchini (Rouphael *et al*., 2006), hazelnut (Cristoforiel *et al*., 2007), beet (Tsialtas & Maslaris, 2008) and mulberry (Chattopadhyay *et al*., 2011). Although a lot of leaf area prediction models are devised for different plants, information on the validation of the developed model is still scanty (Serdor and Demirsoy, 2006; Tsialtas *et al*., 2006; Cemek *et al*., 2011 and Chattopadhyay *et al*., 2011). Therefore, an attempt to validate the devised linear model by comparing the relationship of actual and predicted LA values was made in the present study as that of Celik and Uzun (2002); Demirsoy *et al*. (2005) and Chattopadhyay *et al.* (2011). The comparison was carried out between actual and predicted leaf areas, of all measurements (n=90), for all the three tasar host-plants by substituting L & B values in the linear regression model and thus obtained values are plotted (Fig. 3, B, D & E). The relationship showed high correlation coefficient (R^2).

Conclusion

The findings of the study showed a highly applicable LA prediction model based on the linear relationship of L x B in all the studied tasar host-plant accessions, which can be used for leaf area estimation by measuring only the leaf length (L) and breadth (B) in a non-destructive manner. This method helps in quick and high precision measurement of LA without involving and costly instruments of these 3 important tasar host-plants for canopy and leaf availability predictions for tasar silkworm rearing in the field.

Table 1 : Leaf shape and interrelation of leaf morpho-metric traits of Arjun, Asan and Jarul leaves.

Plant species	L:B ratio			R^2	MSE (cm^2)
	Average	Minimum	Maximum		
Arjun	3.07	2.24	4.00	0.877	3.082
Asan	2.37	1.74	2.89	0.892	7.991
Jarul	2.51	1.82	3.33	0.631	11.993

Table 2 : Mean values of leaf morpho-metric traits in Arjun, Asan & Jarul plants.

Parameters	Arjun			Asan			Jarul		
	Mean	SD	SE	Mean	SD	SE	Mean	SD	SE
L (cm)	19.76	1.62	0.17	29.33	3.83	0.40	25.57	2.84	0.30
L^2 (cm^2)	393.18	62.53	6.59	874.75	226.93	23.92	661.74	153.20	16.15
B (cm)	6.51	0.90	0.10	12.44	1.31	0.14	10.30	1.44	0.15
B^2 (cm^2)	43.21	11.91	1.26	156.37	32.29	3.40	108.22	30.54	3.22
L x B (cm^2)	129.45	24.48	2.58	367.09	73.08	7.70	265.08	55.90	5.89
LA(cm^2)	75.58	16.11	1.70	211.14	47.40	5.00	144.55	35.65	3.76

Table 3 : Linear regression of leaf morpho-metric traits with Leaf Area prediction models in Arjun (*Terminalia arjuna*).

Variable		Linear relationship Y =a+bx	SE of Estimation	R^2	P<*F*
Dependant	Independent				
LA (cm^2)	L (cm)	y = -69.228 + 7.327 x	14.26	0.541	0.001
LA (cm^2)	L^2 (cm^2)	y = 1.309 + 0.189 x	7.41	0.537	0.001
LA (cm^2)	B (cm)	y = -26.380 + 15.656 x	6.03	0.767	0.0001
LA (cm^2)	B^2 (cm^2)	y = 25.154 + 1.167 x	3.27	0.744	0.001
LA (cm^2)	L x B (cm^2)	y = -4.187 + 0.616 x	3.24	0.876	0.001

LA – Leaf Area; L – leaf lamina length; L2 – Square of L; B – leaf lamina breadth; B2 – square of B; L x B – lamina length x width; df for all estimation was 88.

Table 4 : Linear regression of leaf morpho-metric traits with Leaf Area prediction models in Asan (*Terminalia tomentosa*).

Variable		Linear relationship Y =a+bx	SE of Estimation	R^2	P<*F*
Dependant	Independent				
LA (cm^2)	L (cm)	y = -100.206 + 10.615 x	20.07	0.376	0.001
LA (cm^2)	L^2 (cm^2)	y = -119.526 + 26.588 x	32.59	0.542	0.001
LA (cm^2)	B (cm)	Y = 53.012 + 0.181 x	10.08	0.549	0.001
LA (cm^2)	B^2 (cm^2)	Y = 43.369 + 1.073 x	17.05	0.534	0.05
LA (cm^2)	L x B (cm^2)	Y = -13.787 + 0.613 x	8.49	0.892	0.001

Table 5 :. Linear regression of leaf morpho-metric traits with Leaf Area prediction models in Asan (*Lagerstroemia speciosa*).

Variable		Linear relationship Y=a+bx	SE of Estimation	R^2	P<*F*
Dependant	Independent				
LA (cm^2)	L (cm)	y = -48.541 + 7.552 x	27.50	0.362	0.001
LA (cm^2)	L^2 (cm^2)	y = -38.266 + 17.742 x	19.28	0.510	0.01
LA (cm^2)	B (cm)	y = 53.287 + 0.138 x	13.57	0.351	0.001
LA (cm^2)	B^2 (cm^2)	y = 53.976 + 0.837 x	9.75	0.514	0.001
LA (cm^2)	L x B (cm^2)	y = 10.211 + 0.507 x	6.18	0.632	0.001

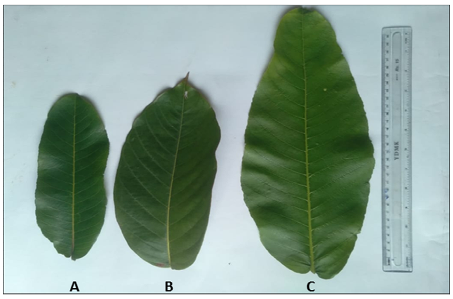

Fig. 1 : Variation in leaf morphology of Arjun (a), Jarul (b) and Asan (c) leaves.

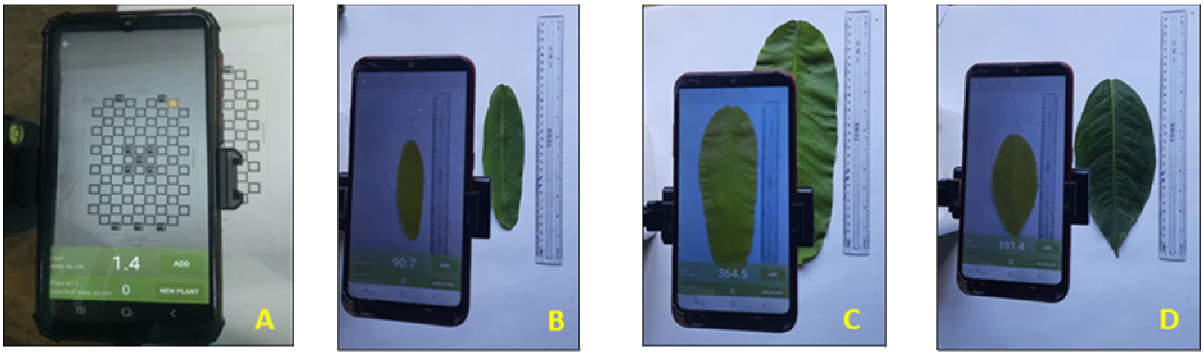

Fig. 2 : Standardization of area calibration with calibration Pad No. 15(A) of "Petiole App" and measurement of leaf area in Arjun (B), Asan (C) and Jarul (D) plants.

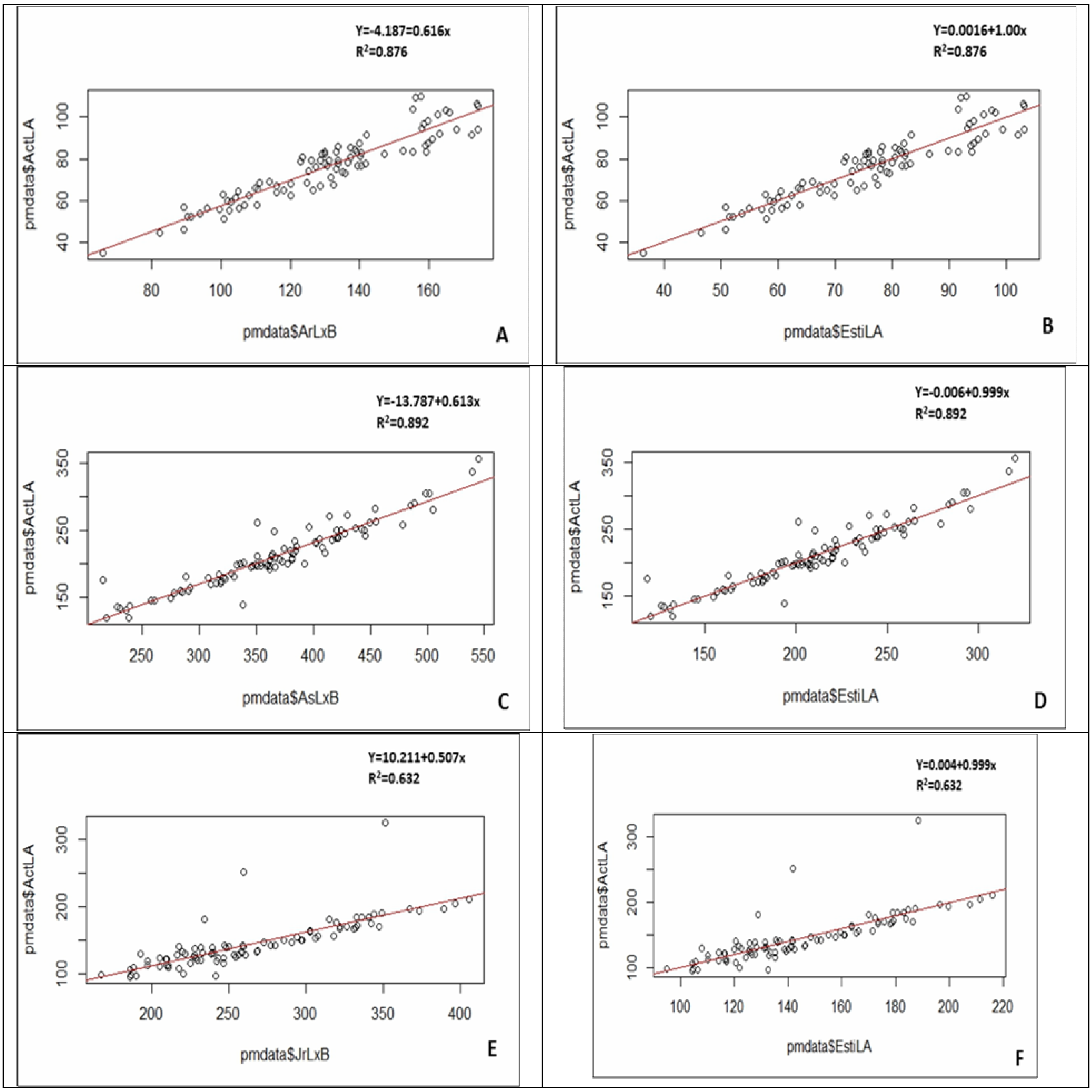

Fig. 3 : The relationship between actual leaf area (LA) with leaf length x breadth (LxB) (A, C & E) and between actual leaf area with predicted LA (B, D & F) in Arjun, Asan & Jarul, respectively.

References

Camargo Neto, J.; Meyer, G.E.; Jones, D.D. and Samal, A.K. (2006). Plant species identification using elliptic fourier leaf shape analysis. – *Comp. Electron. Agr*., 50: 121–134.

Chattopadhyay, S.; Tikader, A. and Das, N.K. (2011). Nondestructive, simple, and accurate model for estimation of the individual leaf area of som (*Perseabombycina*). *Photosynthetica*. 49(4): 627-632.

Cristofori, V.; Fallovo C.; Mendoza-de Gyves, E.; Rivera, C.M.; Bignami, C. and Rouphael, Y. (2008). Non-destructive, analogue model for leaf area estimation in persimmon (Diospyros kaki L.f.) based on leaf length and width measurement. – *Europ. J. Hort. Sci.,* 73: 216-221.

Cristofori, V.; Rouphael, Y.; Mendoza-de Gyves, E.; Bignami, C. (2007). A simple model for estimating leaf area of hazelnut from linear measurements. *Scientia Hort*., 113: 221-225.

Das, S.; Srivastava, P.P.; Pandiyaraj, T. and Sahay, A. (2020). Soil health and nutrient management. In– Current status and recent technology in tasar culture.; Sahay, A (ed), CTRTI, Ranchi, pp. 10-31.

Du, J.X.; Wang, X.F. and Zhang, G.J. (2007). Leaf shape based plant species recognition. – *Appl. Math. Comput*. 185: 883-893.

Gamper, H. (2005). Non-destructive estimates of leaf area in white clover using predictive formulae: The contribution of genotype identity to trifoliate leaf area. *Crop Science,* 45: 2552- 2556.

Jolly, M.S.; Sen, S.K. and Das, M.C. (1974). In - Tasar culture. Ambika Publishers, Bombay. Pp. 134-147.

Jonckheere, I.; Fleck, S.; Nackaerts, K.; Muys, B.; Coppin, P.; Weiss, M.; Baret, F. (2004). Review of methods for in situ leaf area index determination. Part I. Theories, sensors and hemispherical photography, *Agr. Forest. Meteor*., 121: 19-35.

Kumar, R. and Sharma, S. (2010). Allometric model for nondestructive leaf area estimation in clay sage (*Salvia sclarea* L.), *Photosynthetica,* 48: 313-316.

Lu, H.-Y.; Lu, C.-T.; Wei, M.-L. and Chen, L.-F. (2004). Comparison of different models for non-destructive leaf area estimation in taro, *Agronomy Journal*. 96: 448-453.

Montero, F.J.; Juan, J.A.; Cuesta, A. and Brasa, A. (2000). Non-destructive methods to estimate leaf area in *Vitis vinifera* L., *Horticultural Science*, 35: 699-698.

Montgomery, D.C. and Peck, E.A. (1992). Introduction to linear regression analysis. John Wiley and sons, New York.

Nakamura, S.; Nitta, Y.; Watanabe, M. and Goto, Y. (2005). Analysis of leaflet shape and area for improvement of leaf area estimation method for sago palm (*Metroxylon sagu* Roxb.), *Plant Prod. Sci*., 8: 27-31.

Serdar, U. and Demirsoy, H. (2006). Non-destructive leaf area estimation in chestnut, *Scientia Hort*., 108: 227-230.

Singh, K.; Srivatava, A.; Prakash, D.; Das, P.K.; Siddiqui, A.A. and Raghuvanshi, S.S. (2000). Ranking of foliar constituents in morphotypes of muga food plants *Machilus bombycina* King., *Sericologia,* 40: 279-283.

Smith, R.J. and Kliewer, W.M. (1984). Estimation of Thompson seedless grapevine leaf area, *Amer. J. Enol. Vitie*., 35: 16-22.

Tsialtas, J.T.; Koundouras, S. and Zioziou, E. (2008). Leaf area estimation by simple measurements and evaluation of leaf area prediction models in Cabernet- Sauvignon grapevine leaves, *Photosynthetica*, 46: 452- 456.

Tsialtas, J.T. and Maslaris, N. (2008). Leaf area prediction model for sugar beet (*Beta vulgaris* L.) cultivars, *Photosynthetica,* 46: 291-293.

Uzun, S. and Celik, H. (1999). Leaf area prediction models (ureclik -1) for different horticultural plants, *Tropical Journal of Agriculture and Forestry*, 23: 645-650.