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Determination of the most appropriate form factor equation for *Cupresus sempervirence* L. *var horizentalis* in the north of Iran

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ABSTRACT

To determine the best form factor equation for Cupresus semervirence afforestation in Abbas Abad of Behshahr, numbers of 40 trees were selected in terms of their diameter classes, from 8 to 16 cm in 2 cm diameter classes. Then diameter at breast height (1.3 m), diameter at 0.65 m and diameter at the stump area were measured. After cutting the tree, their height and diameter at breast height were measured by diameter tape in 2 meters intervals up 5 cm diameter of trees at 0.1, 0.3, 0.5, 0.7 and 0.9 lengths were measured from each sample tree. The real from factor (f_r) was compared with the mean of hohenadle (f_h), normal ($f_{0.1}$) and artificial ($f_{0.5}$) form factors by paired - sample t-test. The results of this research showed that there was significant differences at probability level of $\alpha = 0.005$ between mean of real form factor and mean of artificial from factor. Moreover there was significant differences between mean of real form factor and mean of Hohenadel from factor at probability level of $\alpha = 0.005$. Therefore, mean of real from factor could be replaced by normal form factor of Cupresus sempervirence L. Var horizentalis.

Key words: Form factor, *Cupresus sempervirence L.*, Sample t-test, Abbas Abad.

INTRODUCTION

Wood utilization of forest areas is increased that is due to destroy of forests in extensive areas, now days. Therefore, humans are afforesting with considering our knowledge and site conditions every region. With due attention to climate conditions of Iran that 65 % area includes arid and semi-arid and degradation rapid of north and west forests, afforestation is necessary of viewpoint resources conservation of water and soil because of degradation of natural resources will cause to degradation agricultural lands and human environmental. Specially, afforestation with needle leaves that have high production of wood and low utilization age, thus afforestation with these species is necessary for securing of wood needs in societies. [3, 4, 5, 6, 9, 12]

Zarbin (*Cupressus sempervirence* var. horzontalis) is endemic of Iran that areas of its natural stands decreased now days, and is forbidden of cut down. Natural habitat of Zarbin in North of Iran is estimated to be 0.2-0.7 m^3 per hectare volume increment, 1-4 mm per year radius increment and 6-18 m^2 per hectare basal area. This species is afforested in Abbas Abad region of Behshahr city (North of Iran) with 138.5 ha^{-1} areas, thus it is understood that for research in relation to afforestation with this species, total and comprehensive information's should be available with considering conditions of forest volume. [9, 10, 13]

The character of form factor is ratio of tree real volume to volume of one geometrical form such as cylinder, cone and or truncated cone that its diameter and height are near to tree (diameter of geometrical from is equal to diameter at breast height and its height is equal to tree height). Form factor is different with other inventories of tree forms as form factor should be calculated afterwards calculation of tree volume. Form factor is one method for harmony and relation between tree form and volume. Form factor is calculable for all of trees (stems and branches) and or for tree stem (that is usage for needle leaves). [15]

The real form factor value has descending trend with increasing of age in *lobally pine* stand. In a research in Changaz region located in the North of Iran it was concluded that the artificial ($f_{0.5}$), normal ($f_{0.1}$) and hohenadel (f_h) form factor values were 0.4205, 0.4529 and 0.4542, respectively. A similar research carried out in Lakan region (North of Iran) with respect to *pinus teada*. The values of above form factors calculated 0.4662, 0.5479 and 0.5121, respectively. In Kornika region located in polish it was proved that there was significant difference between the diameter at breast height ($f1.3$) and real form factors ($f_{0.5}$) for *Populus deltoides*. It was demonstrated that the real form factor is capable to replace with normal form factor of Zarbin in Kordkoy region (Golestan province - North of Iran). [1, 7, 8, 12, 14]

The aim of current research is determining the best form factor equation for *Cupresus semervirence* afforestation in Abbas Abad of Behshahr located in north of Iran.

MATERIALS AND METHODS

A. Study Area

Afforestation area is located in Behshahr region that situated in Golestan province - North of Iran. Study area is situated between 36˚ 36´, 36˚ 45´ latitude, and between 53˚ 35´, 53˚ 38´ longitude. The mean elevation is about 450m. The average slope of forest field is about 10 % (Min. 5% and Max. 15%). Afforestation areas have covered of loss sediments, dominant soil type is brown with alkaline soil pH. Electricity conductivity (EC) is low in these stands. Soil texture of study area is loamy. The average annual temperature of study areas is about 17.9˚ C (Min. -12˚ C and Max. 45˚ C) and mean annual precipitation is 55.08 mm. Region climate was calculated using of classification formula of amperage (Q = 57.2), therefore, site climate was humidity moderate with dry and cold winters. [2]

B. Data collection

Study area afforested with Zarbin species in 1981 year with 138.5 ha^{-1} area and 2 × 2m density. Number of 50 sample plots with 200m^2 areas and circle form selected as random - systematic method with inventory network of 100 × 75 m. In next level, number of 40 trees selected in different diameter classes. Also, tree diameters were measured in 0.1, 0.3, 0.5, 0.7, 0.9 m of tree total height. Under parameters were measured afterwards measuring of aforementioned variables. For calculate of tree real volume, Smalian formula (Eq.1) was used and afterwards volume of every log was calculated of end to the height where diameter becomes 5cm. Total of logs volume were incorporated in calculations as real volume every trees. [11, 15]

$$V = \frac{g_1 + g_2}{2} h \qquad [1]$$

Where V, log volume (m^3); g_1, primary basal area (m^2); g_2, the end basal area (m^2); h, length of log (m). Real form factor for every tree is equal to ratio of tree volume to cylinder volume that its height is equal to height of tree and its basal area is equal to tree basal area in diameter at breast height that is obtained using Eq.2. [11]

$$f_r = \frac{v}{d_{1.3}^2 \times \frac{\pi}{4} \times h} = \frac{v}{g_{1.3} \times h} \qquad [2]$$

Where f_r, real form factor of trees; V, real volume for every tree; $g_{1.3}$, basal area for every tree in diameter at breast height and h, tree height. Artificial form factor for stand tree calculated using Eq.3. [11, 15]

$$f_{0.5} = \frac{d_{0.5}^2}{d_{1.3}^2} \qquad [3]$$

Where $f_{0.5}$, Artificial form factor; $d_{0.5}$, diameter at middle height of tree; $d_{1.3}$, diameter at breast height. Also, normal form factor for stand trees calculated using Eq. 4. [11, 15]

$$f_{0.1} = \frac{v}{v_{0.1}} = \frac{v}{g_{0.1} \times h} \qquad [4]$$

Where $f_{0.1}$, normal form factor for every tree; V, real volume for every tree (m^3) (that is equal to ratio of volume every tree to 2m logs and calculate volume of every log using Smalian formula); $v_{0.1}$, cylinder volume that its height is equal to tree height and its diameter is equal to diameter at 0.1 height of tree (m^3); $g_{0.1}$, basal area of tree in its height 0.1(m) and h, tree height (m). Hohenadel' s form factor was calculated using Eq. 5 [11, 15]

$$f_h = 0.2\left[1+\frac{d_{0.3}^2}{d_{0.1}^2}+\frac{d_{0.5}^2}{d_{0.1}^2}+\frac{d_{0.7}^2}{d_{0.1}^2}+\frac{d_{0.9}^2}{d_{0.1}^2}\right] \qquad [5]$$

Where f_h, Hohenadel' s form factor; $d_{0.1}$, $d_{0.3}$, $d_{0.5}$, $d_{0.7}$, $d_{0.9}$ are diameter at 0.1, 0.3, 0.5, 0.7, 0.9 heights of tree end.

RESULTS AND DISCUSSION

In this research tree real volume calculated for number of 40 trees using Smalian formula. Also, real (f_r), artificial ($f_{0.5}$), normal ($f_{0.1}$) and Hohenadel (f_h) form factors calculated for these trees. The statistic results of form factors for Zarbin in Abbas Abad region displayed in Table 1. To calculation of real form factor, trees should be cut down and theirs real volume should be calculated with measuring of pieces volume of one and two meter following the real form factor is calculable using real volume of trees. [8, 17]. Pay attention to calculation of real form factor isn't possible for ever (by reason of high cost) and relations of different form factor are presented with real form factor by many researchers thus with comparison of aforementioned form factor with real form factor, it is possible for selection of it's nearest and replacement of real form factor.

Table 1. Statistic results of form factors for Zarbin in Abbas Abad region

Form factor	Mean $\bar{x}$	Standard deviation ± S_x (cm)	Standard error ± $S_{\bar{x}}$ (cm)	Confidence limit ± E% (cm)
f_r	0.4749	0.06397	0.01011	4.30
$f_{0.5}$	0.5184	0.08245	0.01304	5.08
$f_{0.1}$	0.4735	0.06694	0.01058	4.51
f_h	0.5278	0.06044	0.00956	3.65

Chi-square used for normality test of data at first. Afterwards, for confidence to normality of data, T-student used for mean of calculated form factors with real form factor in order to determine the most appropriate form factor for Zarbin species. Real form factor of Zarbin species in study area compared with artificial, normal, and hohenadel' s form factors using of pair sample T-test (Table 2). The obtained results showed that the maximum and minimum of form factor values devoted in Hohenadel (0.5278) and normal (0.4735) form factors, respectively. In this research the values of real, artificial, normal and hohenadel form factors were calculated 0.4749, 0.04735, 0.5184 and 0.5278, respectively. Paired-sample t-test showed no significant differences between normal and real form factors, thus it is possible for using this form factor instead of real form factor for There was significant differences at probability level of α = 0.005 between mean of real form factor and mean of artificial from factor. Moreover there was significant differences between mean of real form factor and mean of Hohenadel from factor at probability level of α = 0.005 (Table 2).

Table 2. Results from Pair sample T-test for different form factors in Abbas Abad region

Pairs tested	Mean	Standard deviation	Mean of standard error	Confidence limit (99%)		T	df	p
				Low limit	Upper limit			
$f_r - f_{0.1}$	0.00142	0.03028	0.00479	-0.00826	0.01111	-0.298	39	0.768
$f_r - f_{0.5}$	-0.04343	0.07065	0.01117	-0.06602	-0.02083	-3.887	39	0.000
$f_r - f_h$	-0.05285	0.04338	0.00686	-0.06672	-0.03898	-7.705	39	0.000

df: Degree of freedom; p: Significant level

Distribution of determined form factor in diameter classes for Zarbin is presented in Fig. 1. Pay attention to this figure, artificial and hohenadel form factors have uniform changes trend. With increasing diameter, the value of this form factors are reduced and have ascending trend to medium diameter classes and includes descending trend thereafter. This trend is uniform and repose from 14cm diameter class. Also, normal and real form factors have uniform changes trend as have ascending trend at the first and includes descending trend from medium diameter classes and then showing as uniform from medium classes.

The normal form factor is appropriate for replacing with real form factor for Zarbin species in Kordkoy region (North of Iran). The reason of these differences is due to species type, conditions of site and climate differences. Of course, the better results are available with more studies in various regions and species. This subject is mentionable that the most value considered in 12 diameter class and then includes repose form from 14 diameter class in every four form factors. This subject indicating that it is impossible for using form factor in trees with low diameter and or lower ages for trees with high diameter and or ages. It is possible to using form factor of trees with 14cm diameter for trees with higher diameter and or ages, certainly. [1, 8, 12, 16]

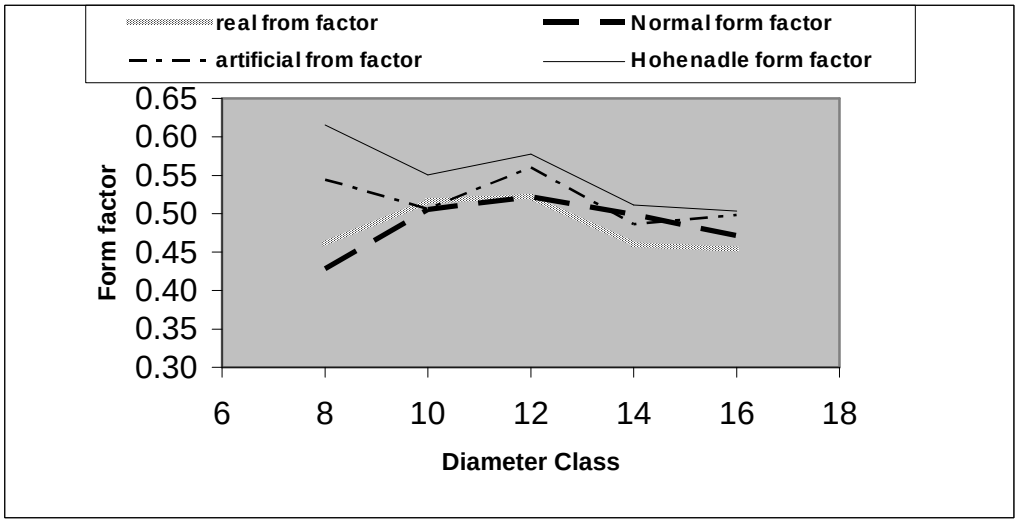

Fig.1. Distribution of form factors in diameter classes for Zarbin in Abbas Abad region

CONCLUSION

We concluded that there were significant differences between mean of real form factor and mean of artificial from factor. Moreover there were significant differences between mean of real form factor and mean of Hohenadel from factor. Therefore, mean of real from factor could be replaced by normal form factor of Cupresus sempervirence L. Var horizentalis.

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