Research paper

The Effect of Seed Source on the Leaf Morphology of *Acer velutinum* (Boiss.) Seedlings

Masoud Tabari,[1,3] Hamed Yosef-Zadeh,[1]
Kambiz Espahbodi,[2] Gholam Ali Jalali[1]

【Summary】

An examination was carried out to study leaf morphology variability of *Acer velutinum* (Boiss.) populations along the eastern part (with 3 populations), central part (with 4 populations), and western part (with 4 populations) of the Caspian Forests (northern Iran). After collecting seed from these populations and sowing them in a mountain nursery, the leaf area, leaf mass, leaf number, photosynthetic areas, and leaf mass/leaf area (LMA) of seedlings were determined in the first growing season. Results indicated that leaf mass, photosynthetic area, leaf numbers, and leaf area differed among the seed sources (populations), but the LMA did not significantly differ. The progenies of eastern origins (Pasand 1 and 2) had lower leaf masses than those of western origins. The largest leaf area was found from middle-elevation sources, especially Ladjim. Seed sources from higher elevations (Sangdeh and Ashak) presented smaller photosynthetic areas and lower leaf numbers. Leaf morphology was significantly correlated with the seed source. It can be concluded that, Ladjim is a better choice of a seed source, owing to superior values of morphological characteristics of the leaf.

Key words: *Acer velutinum*, leaf morphology, leaf area, photosynthetic area, population.

Tabari M, Yosef-Zadeh H, Espahbodi K, Jalali GA. 2008. The effect of seed source on the leaf morphology of *Acer velutinum* (Boiss.) seedlings. Taiwan J For Sci 23(1):13-9.

研究報告

種源對茸毛槭種子苗葉形態之影響

Masoud Tabari,[1,3] Hamed Yosef-Zadeh,[1]
Kambiz Espahbodi,[2] Gholam Ali Jalali[1]

摘　要

[1] Department of Forestry, Faculty of Natural Resources and Marine Sciences, Tarbiat Modares University, Noor, Iran. 伊朗，塔爾比阿特莫達瑞斯大學，自然資源及海洋科學學院，森林系。

[2] Research Centre of Animal Affairs and Natural Resources of Mazandaran, Sari, Iran. 伊朗，馬贊達蘭動物事務及自然資源研究中心。

[3] Corresponding author, e-mail:masoudtabari@yahoo.com 通訊作者。

Received April 2007, Accepted July 2007. 2007年4月送審 2007年7月通過。

本研究旨在探討分布在伊朗(Iran)北部裏海濱森林(Caspian Forest)之茸毛槭(*Acer velutinum* Boiss.)自東部(3族群)、中部(4族群)至西部(4族群)各族群葉形態之變異性。種子自各族群採集後播種在山區苗圃，經過第一生長季後，調查葉面積、葉乾重、葉數、光合作用面積及葉乾重／葉面積比值(LMA)。結果為葉乾重、光合作用面積、葉數及葉面積因種源(族群)而異，惟LMA則未有顯著差異。東部種源(Pasand 1及Pasand 2)後裔的葉乾重較西部種源輕，葉面積最大者來自中海拔種源，尤其是Ladjim種源最大。來自較高海拔種源(Sangdeh及Ashak)的光合作用面積較小，葉數也少。葉形態與種源具有顯著的相關性。自所得結果認為種子採集時，Ladjim種源為最佳的選擇，原因是葉的形態特性顯示具有較大的測定。

關鍵詞：茸毛槭、葉形態、葉面積、光合作用面積、族群。

Masoud Tabari, Hamed Yosef-Zadeh, Kambiz Espahbodi, Gholam Ali Jalali。2008。種源對茸毛槭種子苗葉形態之影響。台灣林業科學23(1):13-9。

INTRODUCTION

Acer velutinum (Boiss.) is a light-demanding species which mainly grows as individuals and occasionally as a group in the Caspian Forests located in the plains and mountains (up to 2000 m elevation) of south of the Caspian Sea, northern Iran (Sabeti 1984). It usually appears as a dominant and co-dominant in forests (Anonymous 2003). Variations in morphological and genetic attributes of this species have been found, due to geographical varieties in different habitats. Therefore, determining the genetic and ecology variety using morphological characteristics can be an effective way to improve its populations. One of the essential and significant components in this regard is the leaf morphology. Leaves have various and very important functions in the life of a plant, photosynthesis being the most important one. Growth of leaves includes dry-mass accumulation that is dependent of environmental factors, like temperature, moisture content, minerals, and radiation supply. The leaf area receives light and absorbs carbon gas when the leaf is exposed. Photosynthesis and dry matter increase as the leaf area increases. Obviously, the potential for growth is higher with a bigger leaf area. Therefore, leaf area is an important and effective character for evaluating plant growth. In this connection, it should be noted that increasing the biomass through physiological improvement methods is one of the most important functions of forest breeders. Likewise, because of the close relationship between photosynthesis and biomass, there is much interest in increasing the photosynthetic capacity using breeding methods.

Considerations in this study are focused on direct measurements of photosynthetic and leaf areas and other characteristics of the leaf. In the case of many species, significant genetic variations in leaf area and other important leaf characteristics have been reported (Ceulemans et al. 1984, Isebarands et al. 1988, Barigah et al. 1994). For example, the number of stomata in populations of American poplar (*Populus nigra*) and Euro-American poplar (*P. tremula* L.×*P. tremuloides* Michx.) grown on various soil conditions showed a significant genetic variety (Guzina et al. 1995).

It seems that leaves have significant effects on wood production processes. Because wood production is dependent on the absorption of water and minerals (induced by roots, transmission in stems, and conversion in leaves), knowing the characteristics of this organ and the effective factors for increasing its biomass can be important references for choosing seed sources in nurseries. In this research, we studied the morphological characteristics of *A. velutinum* leaves from 11 seed sources (populations) in different geographical areas of the northern forests of Iran. In addition to the identifying superior genotypes, the possibility of increased biomass production in plantations is expected.

MATERIALS AND METHODS

In this research, seeds were collected from different geographical populations of *A. velutinum* in the Caspian Forests located in Mazandaran Province (northern Iran). The details of the geographical locations (collection sites) of various sources of *A. velutinum* are given in Table 1. In October 2003 at each sampling location (11 habitats), seeds were collected from the middle part of the crown (Merwin et al. 1995) in 10 phenotypically superior trees, depending upon the availability of the ideotypes (a healthy individual with a straight bole, lower branch numbers, and a smaller crown) (Cornelius et al. 1995). In December 2003 after cleaning the vegetation, the seeds were sown in a mountain nursery (Orimelk, 1550 m elevation) in 1-m^2 plots in a randomized complete-block design replicated 3 times. In each plot, 50 seeds were sown. The distance between plots was 50 cm, while blocks were separated by 100 cm. Following sowing of the seeds the trial plot was irrigated when required, and weeding was carried out 4 times during the period. Leaf samples from each seed origin were randomly taken in midsummer and placed in an oven. The heating and weighting were repeated for 2-h periods at 70℃ until a constant weight was obtained (Browning 1967). All leaves of 3 progenies (seedlings) from each seed source were measured by LI 3000 leaf portable area meter to record leaf area. The photosynthetic area (PA) was determined by the formula:

$PA = Sn \times Ln \times LA$;

where Sn is the number of the surviving seedlings originating from each region (seed source), Ln is the total leaf number of each seedling, and LA is thee average leaf area.

All data were subjected to statistical analysis to determine the mean values, analysis of variance (ANOVA), simple correlations, and significantly different treatments.

Table 1. Geographical description of seed collection sites

Region	Seed source	Elevation (m)	Latitude	Longitude
West	Park Noor	20	36º30’52”	52º3’11”
	Djourband	700	36º27’18”	52º8’2”
	Deeiz	1000	36º22’12”	52º3’35”
	Shahnazar	1200	36º22’26”	52º3’45”
Center	Ladjim	400	36º15’40”	53º8’21”
	Lamzer	1000	36º9’40”	53º6’11”
	Sangdeh	1600	36º3’36”	53º15’15”
	Ashak	2200	36º7’26”	53º20’35”
East	Pasand 1	400	36º11’17”	53º36’20”
	Pasand 2	800	36º11’27”	53º36’32”
	Pasand 3	1200	36º11’47”	53º36’33”

Duncan's multiple range test was used for grouping the parameter means (Steel and Torrie 1980). An ordinal ranking scheme was instituted to show the provenance score for each parameter to indicate the overall provenance performance. The analyses were conducted with SPSS software, vers. 12.5 (SPSS, Chicago, IL, USA). The average Linkage program was used to compute cluster groupings of *A. velutinum* seed sources, according to leaf morphology characteristics using the JMP program, vers. 3.1.2 (SAS, Cary, NC, USA). The average linkage distance is the average distance between pairs of points in each cluster (Oleksyn et al. 2001).

RESULTS

Results indicated that there was a significant negative correlation between the leaf number and geographical characteristics (latitude, longitude, and elevation) of the seed source. Likewise, a significant negative correlation was observed between the photosynthetic area and latitude of the seed source. A positive correlation was found between the LMA and the longitude of the seed source and between the photosynthetic area and the longitude of the seed source, but generally, these correlations were not significant (Table 2). A comparison of the means showed the significant effects of the seed source on the leaf area, leaf number, leaf mass, and photosynthetic area. In contrast, no significant effect was detected on LMA (Table 3). The Ladjim seed source had the largest leaf area, greatest leaf number, and largest photosynthetic area among the seed sources (Table 4). The Shahnazar seed source had the heaviest, while the Pasand 1 and 2 seed sources had the lightest leaf dry masses. Seed sources from higher elevations (Sangdeh and Ashak) had smaller photosynthetic areas and leaf numbers in comparison with other seed sources. The results of the average linkage clustering method used to determine the group provenances are summarized in a dendrogram (Fig. 1). The results obtained by this method revealed that populations of Park Noor, Pasand 1, Shahnazar and Pasand 3 were placed in group 1, populations of Ladjim, Djourband, Deeiz, and Lamzer in group 2, and populations of Pasand

Table 2. Correlation coefficients among investigated parameters with geographical characteristics

Geographical characteristic	Leaf mass	Leaf number	Leaf area	leaf mass/leaf area (LMA)	Photosynthetic area
Latitude	-0.09	-0.65[1)]	-0.33	-0.47	-0.63[1)]
Longitude	-0.035	-0.64[1)]	-0.17	0.24	0.25
Elevation (m)	-0.11	-0.82[1)]	-0.11	-0.42	-0.53

[1)] $p < 0.05$.

Table 3. *F* value and its probability for the investigated parameters

Parameters	Leaf area	Leaf number	LMA	Leaf mass	Photosynthetic area
F	2.56[1)]	4.6[2)]	0.79[ns]	5.3[2)]	8.52[2)]
Pr.	0.03	< 0.001	0.63	< 0.001	< 0.001

[1)] $p < 0.05$.

[2)] $p < 0.001$. LMA = leaf mass/leaf area.

Table 4. Mean±SE for leaf characteristics of *Acer velutinum* (Boiss.) seedlings from 11 seed sources

Seed source	Elevation (m)	Leaf mass (mg)	Leaf area (cm^2)	LMA (mg/cm^2)	Leaf number	Photosynthetic area (cm^2)
Park noor	20	1/6±0/1[c]	62/3±12/3[c]	27±4[a]	21/7±5/4[ab]	1173±440[ab]
Pasand 1	400	1/4±0/2[c]	63/6±22/6[c]	23±9[a]	19/3±1/2[abcd]	320±54[bcd]
Ladjim	400	2/7±0/6[ab]	100/4±13[a]	27±3[a]	22/5±6/1[a]	1252±358[a]
Djourband	700	1/9±0/2[ab]	85/3±17[abc]	20±2[a]	21/3±5/4[abc]	1146±333[ab]
Pasand 2	800	1/4±0/2[c]	76/6±34/6[abc]	24±7[a]	16/3±1/2[de]	725±242[d]
Deeiz	900	2/4±0/3[ab]	98/7±26/1[ab]	23±2[a]	17/1±2/3[cde]	793±233[cd]
Lamzer	1000	2/3±0/4[ab]	96/8±17/8[ab]	24±8[a]	18/3±1/4[abcd]	940±176[abcd]
Shahnazar	1100	3/1±0/5[a]	66/8±16/9[bc]	26±4[a]	17/7±3/8[bcde]	819±223[bcd]
Pasand 3	1200	2/7±1/0[ab]	62/7±10[c]	22±4[a]	19/6±1/26[abcd]	1062±314[abc]
Sangdeh	1600	2/3±0/6[ab]	88/5±26/4[abc]	28±9[a]	13/8±1/6[e]	519±109[e]
Ashak	2200	2/0±0/2[ab]	61/6±5/9[c]	29±5[a]	14±2/9[e]	436±154[e]

Different letters in the same column indicate a statistical difference at the α = 5% significance level.
LMA = leaf mass/leaf area.

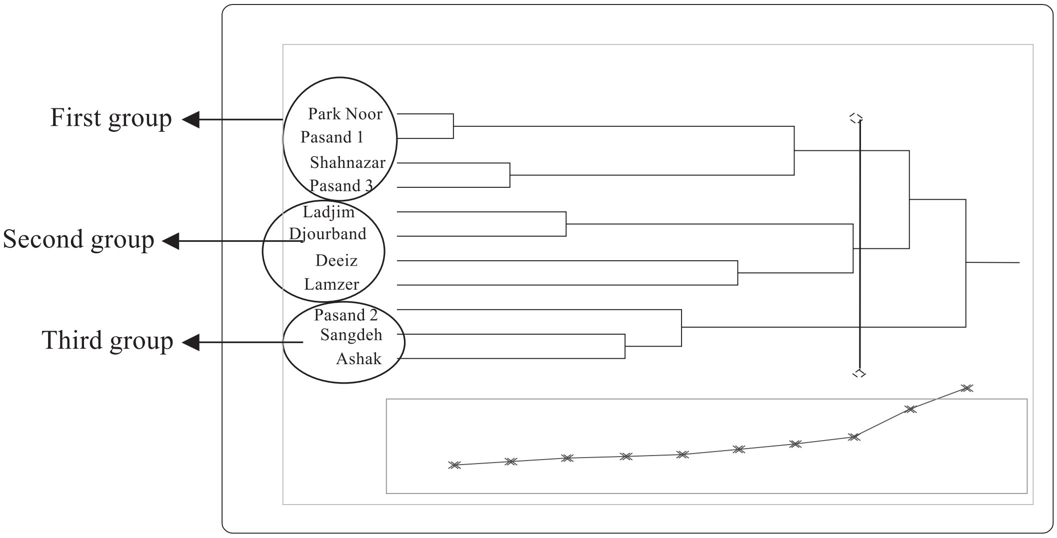

Fig. 1. Dendrogram of cluster groupings of seed sources of *Acer velutinum* based on the characteristics studied (average linkage clustering method).
-An asterisk indicates a difference of variances among groups, and the vertical line (cut off level) separates the groups.

2, Sangedeh, and Ashak in group 3. It should be noted that in reality, there were similarities in characteristics measured among populations of each group. Other clustering methods (Ward's minimum variance method, single linkage, and centroid) showed similar results.

DISCUSSION

The results of this research revealed that the progenies of eastern origins had greater leaf areas than those of western origins. This implies that warmer origins compared to cooler origins benefit from higher leaf water contents and consequently lower leaf dry masses. Generally, high values of LMA are related to a high intensity of light (Osunkoya and Ash 1991, Mulkey et al. 1993, Kitajima, 1994, Muraoka et al. 1997) which induces an increased thickness of the leaf tissue (Hanson 1917), especially the palisade parenchyma (Fretz and Dunham 1972). LMA increased linearly with an increase in the relative irradiance. Therefore, this may be considered a species-specific estimate of long-term light conditions (Niinemets 1997). A diminished water supply can contribute to a reduction in the LMA in some cases (Groom and Lamont 1997), while in others no difference was observed (Mulkey et al. 1993).

In this study, leaf area and photosynthetic area differed among populations. Differences in photosynthetic area, environmental conditions of the site, and interactions between environmental characteristics and genotypes were the reasons for differences in leaf area among the different populations (Orlovic 1993, Orlovic et al. 1994). Leaves are an important interface with environmental factors. Some morphological characters of leaf, e.g., area and thickness, are strongly modified by ecological conditions (Coelho et al. 2002). Changes in the features of leaves can be a part of the adaptive responses in the face of these factors, for example, light intensity and water supply (Groom and Lamont 1997).

Among the 11 populations studied in this paper, the large area and high photosynthetic area of leaves from Ladjim could be the results of particular climatic conditions. In addition, the Ladjim population due to a higher photosynthetic area can exchange a higher quantity of gas during the photosynthesis process and subsequently obtain greater plant growth and biomass. It is important to highlight the population differences observed here for *A. velutinum*, considering the high intrapopulational diversity of this species. Generally, it was deduced that populations of Ladjim, Djourband, Deeiz, and Lamzer could be placed within the same group, due to the closer values of measured characteristics compared to other populations. However, due to the main role of leaf morphological characteristics in producing wood, the seed source at Ladjim is an important choice for this purpose. According to this study, *A. velutinum* is well adapted to different environmental conditions and its wood is valuable, so we can use this species in afforestation projects with low risk.

ACKNOWLEDGEMENTS

The authors are grateful to Moslem Akbarinia, Mohsen Hosseini, Mohammad Reza Hedayati, Mohammad Mahdi Hoshyari and Moein Ghomeishian for scientific and logistical assistance. Thanks are also due to Hossein Akbarian, Saeed Ghasemi, Taghavi and Sadegh Bour for their assistance with data collection. The special thanks go to two anonymous referees and also to who edited the language of manuscript.

LITERATURE CITED

Anonymous. 2003. Forest management plane of Lirehsar. Chalous, Iran: Forestry Technical Bureau, Forest and Range Organization. 350 p.

Barigah TS, Saugier B, Mousseau M, Guittet J, Ceulemans R. 1994. Photosynthesizes, leaf area and productivity of five poplar clones during their establishment year. Ann Sci For 51:613-25.

Browning BL. 1967. Determination of water. In: Methods of wood chemistry. Vol. 1: 59-71. J Wiley Press.

Ceulemans R, Impens I, Steenackers V. 1984. Stometal and anatomical leaf characteristics of ten *Populus* clones. Can J Bot 62:513-8.

Coelho GC, Mariath JEA, Schenkel EP. 2002. Populational diversity on leaf morphology of Mate. Brazil Arch Biol Technol 45:47-51.

Cornelius J, Apedaile L, Mesen F. 1995. Provenance and family variation in height and diameter growth of *Cupressus iustianica* Mill. at 28 months in Costa Rica. Silvae Genet 45:2-3.

Fretz TA, Dunham CW. 1972. Influence of three levels of light-intensity on leaf structure, area and color difference in American holly, *Ilex opaca* AIT. cv Miss Helen. Python- Int Exp Bota 30:135-9.

Groom PK, Lamont BB. 1997. Xerophytes implications of increased sclerophlly: interactions with water and light in *Hakea psilorrhyncha* seedlings. New Phytol 136:231-7.

Guzina V, Orlovic S, Ivanisevic P. 1995. Black poplar clone variability of stoma numbers and sizes on the leaves of two-year-old seedlings depending on soil properties. Soil Plant 44(1):39-48.

Hanson HC. 1917. Leaf structure as related to environment. Am J Bot 4:533-60.

Isebarands JG, Ceulemans R, Wiard B. 1988. Genetic variation in photosynthetic traits among *Populus* clones in relation to yield. Plant Physiol Biochem 26(4):427-37.

Kitajima K. 1994. Relative importance of photosynthetic traits and allocation patterns as correlates of seedling shade tolerance of 13 tropical trees. Oecologia 98:419-28.

Merwin ML, Martin JA, Westfall RD. 1995. Provenance and progeny variation in growth and frost tolerance of *Casuarina cunninghamiana* in California, USA. For Ecol Manage 79:61-71.

Mulkey SS, Wright SJ, Smith AP. 1993. Comparative physiology and demography of three neo-tropical forest shrubs: alternative shade-adaptive character syndromes. Oecologia 96:526-36.

Muraoka H, Tang Y, Koizumi H, Washitani I. 1997. Combined effects of light and water availability on photosynthesis and growth of *Arisamea heterophylum* in forest under story and an open site. Oecologia 112:26-34.

Niinemets U. 1997. Role of foliar nitrogen in light harvesting and shade tolerance of four temperate deciduous woody species. Funct Ecol 11: 518-31.

Oleksyn J, Reich PB, Tojoelker MG, Chalupka W. 2001. Biogeographic differences in shoot elongation pattern among European Scots pine populations. For Ecol Manage 148:207-20.

Orlovic S. 1993. An investigation of stomata variability. [M. Sc. thesis]. Forestry Faculty of Belgrade, Belgrade, p 118. [in Serbian with English summary].

Orlovic S, Merkulove LJ, Guzina V. 1994. Variability of elements of poplar leaf anatomic structure. Matica Srpska- Proc Nat Sci 87:65-72.

Osunkoya OO, Ash JE. 1991. Acclimation to a change in light regime in seedlings of 6 Australian rainforest tree species. Aust J Bot 39:591-605.

Sabeti H. 1984. Forests, trees and shrubs of Iran. Yazd, Iran: Yazd Univ Publishers. 875 p.

Steel RCD, Torrie JH. 1980. Principles and procedures of statistics: a biotic Approach. Toronto, Canada: McGraw Hill Inc. 633 p.