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Original Article

A Study of Large-Leaved Lime (*Tilia platyphyllos* Scop.) in Forests of Western Mazandaran

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Abstract

In order to study the effects of some environmental variables on the quantitative and qualitative characteristics of Large-leaved lime (*Tilia platyphyllos* Scop.) in the forests of western parts of Mazandaran province in the north of Iran, 9 experimental sites have been selected. **Approach:** Within each site, three elevations have been identified. Moreover, each selected site covers three plots with an area of 1 ha (100×100 m). In totally 27 plots have been chosen study. **Results:** The results of the study on the areas under investigation indicate that Large-leaved lime extends in a wide range of environmental conditions. This species is distributed from low elevation to high ones and in different slopes; especially northern, eastern and northeastern ones. The results also show that Large-leaved lime grows in semi-deep to shallow soils with a medium amount of nutrients contents. The soil texture of most sites is clay and clay-silt with pH varying between 5.9 and 7.6. **Conclusions:** The results demonstrate that because of being affected by environmental variables, the quantitative and qualitative characteristics played an important role on the site stratification. In this study, it has been observed that ecological factors such as soil, climate, altitude and slope sides have some effects on both quantitative characteristics of Large-leaved lime (diameter at breast height, diameter of crown, total height and height of first branch, as well as height of bi-branch) and qualitative characteristics (stem bending, convolution, as well as symmetry of crown).

Key-words: *Large-leaved lime, ecological characteristics, quantitative study, qualitative study, hyrcanian forests, Iran*

Introduction

The effects of environmental variables on plant communities have been the subject of many ecological studies in recent years, Bragazza *et al.*. (2005); Lyon and Gross, (2005); Pinto *et al.*. (2006); Ramirez *et al.*. (2007) and Naqinezhad *et al.*. (2008). Research focusing on the relationship between Basswood tree and environmental variables such as soils and physiographic factors has become increasingly important in understanding the ecology of forest species.

Hyrcanian forests are located at green strip extending over the northern slopes of Alborz range of mountains and the southern coast of the Caspian Sea. This area extends approximately 800 km long and 110 km wide and has a total area of 1.8 million ha. Hyrcanian forests encompass various forest types including 80 woody species (trees and shrubs). They are suitable habitats for a variety of hardwood species such as beech, hornbeam, oak, maple, alder and Large-leaved lime (Sagheb-Talebi *et al..*, 2003).

Comparative studies on the ecology of tree species in the Hyrcanian forests are scarce. Espahbodi *et al..*, (2007) studied the distribution of wild service tree based on some ecological factors in Sangdeh forests, north of Iran. Mattaji *et al..*, (2009) studied vegetation analysis based on plant associations and soil properties in natural forests.

Large-leaved lime is found in the central and southern Europe, Asia, Caucasian and north Iran (Browics, 1996).

In the North of Iran, large-leaved lime (*Tilia platyphyllos* Scop.) is one of the major species, accompanied with Beech, Horn Birch, Maple tree, Ash and Oak in the deciduous forest region.

Sadati *et al.*. (2007) studied on the influence of some topographic factors on the distribution of large-leaved lime (*Tilia platyphyllos* Scop.) and its natural regeneration characteristics in "Vaz" forest (northern Iran). After identification of site and preparation of topography map, selective sampling method was carried out for tree inventory in plots. The sample plots were circular in 1000 m^2 areas with at least 2-3 dominant lime trees in each. In the plots, altitude, slope gradient, direction, forest storey, tree type and natural regeneration were investigated. Results indicate that in this habitat the average diameter at breast height and height of *Tilia platyphyllos* is 36.9 cm and 23 m, respectively. *Tilia platyphyllos* prefers 1200-1400 m above sea level altitude, 75-100% slope gradient and northeastern to eastern directions and benefits from denser trees in these environments. It consists of some tree types together with *Fagus orientalis*, *Carpinus betulus* and *Parrotia persica*, whereas the dominant type is *Tilia platyphyllos*-*Fagus orientalis*. In most of the

tree types, lime occurs in the upperstorey. Natural regeneration of lime is often observed as sprout (coppiceshoot) (Sadati *et al*.., 2007).

The taxonomy of the North American basswoods is problematical. Recently, the choice has been to recognize either four poorly defined species (one in Mexico and three in the United States), based mainly on vestiture, or alternatively, two species (one in Mexico and only one in the U.S.) based mainly on geography. It usually occurs in mixed stands and is often associated with red maple, *Acer ubrum* L., sugar maple, *A. saccharum* Marsh., northern red oak, *Quercus rubra* L., eastern hemlock, *Tsuga canadensis* (L.) Carr. and yellow birch *Betula alleghaniensis* Britton (Hardin,1990). American basswood grows up to 43 m and thrives in sunny, rich, moderately moist areas with non-acidic soil (Elias, 1980). Seedling survival is strongly related to light availability, which can be affected by competing ground vegetation (Küßner, 2003). *T. americana* is ecologically important as habitat for wildlife, a pollen source and maintenance of soil quality. It is economically important, with uses for veneer, furniture and pulpwood (Burns and Honkala, 1990).

This study evaluates the influence of some environmental variables on the Large-leaved lime and discusses which variables have the main role in establishing different Large-leaved lime. These ecological data can form the basis for future management strategies on the restoration of these ecosystems. The objective of the present research is to study the forest sites of Large-leaved lime in the western Mazandaran forests in Hyrcanian vegetation zone and to study the effects of some environmental variables on the quantitative and qualitative characteristics of large-leaved lime of the western parts of the Mazandaran province.

Material and Methods

In order to study the effects of some environmental variables on the quantitative and qualitative characteristics of Large-leaved lime (*Tilia platyphyllos* Scop.) in the forests of western parts of Mazandaran province in the north of Iran, 9 experimental sites have been selected (Fig. 1). Within each site, three elevations have been identified. Moreover, each selected site covers three plots of land with an area of 1 ha (100×100 m). In total 27 plots have been chosen study (Table 1).

Ramsar, Noshahr and Royan forests are located in the western parts of Mazandaran province in north of Iran.

Average annual precipitation varies between 1100 and 1311 mm, with an average annual mean temperature varying between 8.1-15.2°C, recorded at the nearest meteorological stations in Ramsar (1980-2000), Noshahr (1961-2000) and Royan (1986-1996) (Table 2).

In each plot altitude, slope gradient and aspect have been recorded. To determine

the quantitative characteristics-diameters at breast height (cm), diameter of crown (m), trunk height and total height (m)-trees with more than 12.5 cm DBH were assessed. Stem bending, branch bearing and crown symmetry were observed to define the qualitative characteristics. Moreover, in each site 9 soil profiles were studied in the Large-leaved lime stands of the research area. For all soil samples, pH, texture, percent organic carbon, N, P and K were determined.

Data were analyzed by descriptive statistical methods in order to characterize the selected plots and the forest stands in the study area. One way Analysis Of Variance (ANOVA) was used to compare the trees quantitative characteristics of different sites. A Chi-square test was used to test the significance of expected values from observed qualitative ones at each site.

Results and Discussion

The study plots characteristics were shown in Table 1. Totally, 27 plots were measured in the study areas. Within each area, three sites were identified. Also in each site, three plots were established. From the total of plots, 17 plots were located in the northern slopes (63%), 3 plots in the eastern slopes (11%), 2 plots in the northeastern slopes (7.4%) and 5 plots in the other sites (18.5%). In the study, plots 6, 11 and 10 were found in the slope gradient <35%, 35-70% and >70% respectively (Table 1).

The results of the study of physical and chemical characteristics of soil in the sites under investigation are shown in Table 3. The soils were Alfisols, Inceptisols, Molisols and Entisols, clay, loam, clay loam and loam sandy in texture and dark grey to brown dark grey in color, as well as being moderate in nutrients. Soil pH values varied from 5.2 to 7.7. The soil was rich in nitrogen and calcium, poor in potassium and phosphorous. C/N ratio varied 10-12.4 (Table 3).

The assessed mean of the density of Larged-lime tree numbers was 20 numbers in hectare. Total number of trees on different sites varied from 78 (Royan3) to 7 (Noshahr1 and Noshahr2). The highest numbers of trees observed in three significant situations: altitude up to 1000 m above sea level, eastern slopes and slope gradient less than 35% (Table 4).

The assessed mean of DBH was 43.2 cm. However, the mean of DBH on different sites varied from 101.2 (Noshahr1) to 27.3 (Ramsar1). The highest of DBH mean were in altitude 500-1000 m above sea level, northwestern slopes and slope gradient from less than 35% (Table 4).

Although the mean of crown diameter on different sites varied from 12.3 (Ramsar2) to 5.2 (Noshahr3), the assessed mean of crown diameter was 7.1 m. The highest mean of crown diameter were in an altitude of 500-1000 m above sea level, northwestern

slopes and slope gradient less than 35% (Table 4).

The assessed mean of total height was 34.2 m. The mean of total height on different sites varied from 30.8 (Royan1) to 16.1 (Ramsar1). The highest mean of total height were in an altitude of 500-1000 m above sea level, northwestern slopes and slope gradient from 0-35% (Table 4).

The assessed mean of trunk height was 15.1 m. The mean of trunk height on different sites varied from 19.8 (Noshahr3) to 10.2 (Ramsar1). The highest of trunk height mean were in an altitude of 500-1000 m above sea level, northwestern slopes and slope gradient from 35- 70% (Table 4).

ANOVA revealed that environmental variables such as site, altitude, slope gradient and aspect, caused significant differences in the mean of DBH, crown diameter, total height, trunk height and density. There are no significant differences between the mean of density of tress in hectare in different slope gradients. However, there are significant differences between quantitative characteristics of trees under investigation in the sites. Results showed that there is no significant difference in the mean of density in sites (ANOVA, values of p-value in Table 5).

In this study, the qualitative characteristics of the trunks and crowns of the observed Large-leaved lime tress showed that only 27% of trunks were without branches. 23% of tree's trunks were non-cylindrical, 12% convoluted, 54% of them were bi-branch and 16% of crowns were non-symmetric. The results of χ^2 test shows that there is a significant difference between environmental variables and some qualitative characteristics such as trunk bending, branch bearing and crown symmetry for all Large-leaved lime trees. However, there is no significant relation between stem convolution and altitude, bi-branch trunks and slope aspect. Moreover, there is no significant relation between stem convolution, bi-branch trunks and crown symmetry in different slope gradients (Table 6: Likelihood ratio χ^2 test, $p<0.05$).

Large-leaved lime grows in mixture with other species; hence, it has formed large leaved lime- Beech, Beech-Large-leaved forest types in observed study plot. Large-leaved lime trees grow in study sites with *Fagus orientalis* Lipsky, *Carpinus betulus* L., *Alnus subcordata* C.A.M., *Quercus castanefolia* C.A.M., *Acer velutinum* Boiss and *Diospyrus lotus* L., *Celtis australis* L, *Cerasus avium* L., *Fraxinus excelsior* Scheele., *Gleditschia caspica* Desf., *Ilex spinigera* Loesn., *Juglans regia* L., *Parotia persica* (DC.) C.A. Meyer., *Sorbus torminalis* L., *Tilia platyphyllos* Stev., *Ulmus glabra* Huds. and *Vaccinium arctostaphylus* L.

The results of TWINSPAN and cluster analysis allow for an ecologically sound scheme of four main sites groups of studied areas with specific ecological composition

(Fig. 2). The first division of the clustering dendrogram generated a group of Royan2, Noshahr2, Ramsar3, Ramsar2, Royan3 and Noshahr3 (Group I). The second division generated a group with Royan1 (Group II). The two sites, Ramsar1 and Noshahr1 cluster in the lowland area (Group III) were generated by the third division in the dendrogram (Fig. 2).

Large-leaved lime is a semi shade tolerant demanding tree of Hyrcanian forests. The results have indicated that Large-leaved lime grows up in a wide range of environmental conditions. This species has distributed from low elevations to high elevations and in different slopes, especially northern, eastern and northeastern slopes.

The results indicate that Large-leaved lime was generally confined to, loam, clay loam and loam sandy in texture. Most soils were classified as Alfisols, Inceptisols, Molisols and Entisols. Climatic conditions associated with the species range are generally mild winters, moderate summers and a very humid moisture regime. The genus *Tilia* (L.) linden or basswood consists of about 40 species of large or medium-sized, deciduous trees that are indigenous to the temperate of Northern Hemisphere. *Tilia* is the only genus of its family, the *Tiliaceae*. Species reach their maximum size in loamy, moist, fertile soil, but they tolerate poor soils, pollution, windy conditions and transplanting and can grow in full sun or partial shade (Dirr, 1998; Kunneman and Albers, 1991). American basswood grows up to 43 m and thrives in sunny, rich, moderately moist areas with non-acidic soil (Elias, 1980).

Quantitative studies showed that the best conditions of frequency and density has been observed in Royan3 site. In the northern slopes, Large-leaved lime condition is better than other slopes. The best qualitative condition has been seen in northeastern, eastern and western slopes. The quantitative and qualitative characteristics played an important role on the site stratification because of being affected by environmental variables. There is a relationship between ecological characteristics (soil, climate, altitude and slope sides) and quantitative characteristics (diameter at breast height, diameter of crown, total height and height of first branch, as well as height of bi-branch) and qualitative characteristics (stem bending, convolution, as well as symmetry of crown). Whereas results of Sadati *et al.*. (2007) indicated that in this habitat the average diameter at breast height and height of *Tilia platyphyllos* is 36.9 cm and 23 m, respectively, *Tilia platyphyllos* prefers 1200-1400 m above sea level altitude, 75-100% slope gradient and northeastern to eastern directions and benefits from denser trees in these environments. Seedling survival is strongly related to light availability, which

can be affected by competing ground vegetation (Küßner, 2003).

Large-leaved lime grows in mixture with other species and only rarely forms pure stands. This species has formed two main forest types with Beech in the high elevation in Royan3 site. Whereas results of Sadati *et al*.. (2007) indicated that the study site consists of some tree types together with *Fagus orientalis*, *Carpinus betulus* and *Parrotia persica*, the dominant type is *Tilia platyphyllos*-*Fagus orientalis*. In most of tree types, lime occurs in the upperstorey. Natural regeneration of lime is often observed as sprout (coppiceshoot).

Conclusion

Large-leaved lime is a semi shade tolerant demanding tree of Hyrcanian forests in the north of Iran. Large-leaved lime grows up in a wide range of environmental conditions. This species has distributed from low elevations to high elevations and in different slopes, especially northern, eastern and northeastern slopes. The results demonstrate that because of being affected by environmental variables, the quantitative and qualitative characteristics played an important role on the site stratification. In this study, it has been observed that ecological factors such as soil, climate, altitude and slope sides have some effects on both quantitative characteristics of Large-leaved lime and qualitative characteristics.

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Table 1: Characteristics of the study plots of large-leaved lime

Plot	Forest	Parcel no.	Site name	Aspect	Slope (%)	Canopy (%)	Total of trees	Total of lime tree
1	Tarkin	1	Royan1	N	<35	50-75	111	10
2	Seri13	2		E	<35	50-75	167	10
3	Watershed No.48	2		N	<35	50-75	132	9
4	Tarkin	13	Royan2	N	35-70	>75	182	8
5	Seri13	13		NE	35-70	>75	170	18
6	Watershed No.48	13		N	35-70	>75	219	22
7	Tarkin	30	Royan3	E	35-70	>75	334	121
8	Seri13	30		N	<35	>75	247	43
9	Watershed No.48	30		N	<35	>75	263	69
10	Lirasara	311	Noshahr1	N	35-70	>75	178	4
11	Seri 3	321		W	<35	>75	332	9
12	Watershed No.45	321		N	35-70	50-75	132	7
13	Larochal	107	Noshahr2	N	>70	>75	176	11
14	Seri 1	106		N	>70	>75	182	7
15	Watershed No.45	106		N	<35	50-75	92	2
16	Jamand	202	Noshahr3	S	35-70	>75	184	8
17	Seri 2	202		N	>70	>75	256	4
18	Watershed No.45	202		N	>70	>75	266	23
19	Sangposhteh	207	Ramsar1	SE	>70	>75	251	39
20	Seri 2	207		NE	>70	>75	332	33
21	Watershed No.30	207		E	>70	>75	235	14
22	Tejemir	506	Ramsar2	N	35-70	>75	125	6
23	Seri 6	506		N	35-70	>75	178	9
24	Watershed No.30	506		N	35-70	>75	167	13
25	Barbiran	606	Ramsar3	SW	>70	>75	101	6
26	Seri 5	606		N	>70	>75	118	15
27	Watershed No.30	606		NW	35-70	>75	94	5

Table 2: Climatic characteristics of the study plots of large-leaved lime

Site	Altitude (m a.s.l.)	Meteorological station	Average annual precipitation (mm)	Average annual temperature (°C)	Average min annual temperature (°C)	Average max annual temperature (°C)
Royan1	450	Royan	1100.0	13.3	4.10	22.50
Royan2	800	Royan	1100.0	11.6	2.40	20.80
Royan3	1400	Royan	1100.0	8.1	1.10	17.30
Noshahr1	150	Noshahr	1311.2	15.2	6.60	23.90
Noshahr2	780	Noshahr	1311.2	12.0	3.30	20.80
Noshahr3	1500	Noshahr	1311.2	9.2	0.40	17.80
Ramsar1	250	Ramsar	1148.5	14.5	5.55	23.95
Ramsar2	830	Ramsar	1148.5	11.6	2.65	21.05
Ramsar3	1050	Ramsar	1148.5	10.5	1.55	19.95

Table 3: Physico-chemical properties of soil in large-leaved lime study sites

Profile	Horizon	Depth (cm)	Clay (%)	Silit (%)	Sand (%)	BSP	EC (DS m^{-1})	pH	$CaCo^3$ (%)	Organic carbon (%)	Total nitrogen (%)	Phosphor (ppm)	Potassium (ppm)	C/N
Royan1	A	0-20	54	32	14	71.7	0.48	5.51	5.85	1.06	0.100	14.0	8.0	10.6
	Bw	20-48	66	22	12	92.7	0.50	6.85	5.00	0.51	0.050	5.0	2.0	10.2
	Ck	40-88	44	42	14	57.6	0.30	7.65	46.35	0.00	0.000	6.5	3.0	-
Royan2	A	0-40	44	36	20	60.2	0.23	5.91	1.35	0.47	0.040	6.0	14.0	11.8
	Bw	40-88	60	24	16	77.0	0.28	6.13	3.60	0.39	0.030	4.5	9.0	13.0
Royan3	O	3-0												
	A	0-40	56	30	14	77.5	0.56	5.19	4.74	1.25	0.120	12.0	6.5	10.4
	C	>40	41	41	19	62.0	0.76	6.83	6.50	0.73	0.070	11.0	7.5	10.4
Noshahr1	A	0-34	37	31	36	59.0	0.89	6.18	4.60	1.89	0.180	13.0	9.0	10.5
	B	34-59	45	32	23	64.0	0.78	6.33	5.19	0.90	0.090	15.0	8.0	10.0
	C	59-125	63	25	12	83.0	0.59	6.34	1.49	0.63	0.060	7.0	3.0	10.5
Noshahr2	A	0-35	44	35	21	66.9	0.83	6.35	5.71	0.77	0.070	6.5	12.0	11.0
	C	35-100	35	29	36	41.5	0.73	6.36	39.00	1.27	0.120	10.5	6.0	10.6
Noshahr3	O	7-0												-
	A	0-15	12	49	39	41.0	0.93	6.13	41.00	1.48	0.140	10.5	5.0	10.6
	C	15-60	42	38	20	62.3	0.56	5.73	1.46	0.58	0.050	7.5	13.0	11.6
Ramsar1	O	3-0												-
	A	0-60	26	46	28	74.4	0.62	7.59	28.35	1.78	0.170	7.0	20.0	10.5
Ramsar2	O	1-0												-
	A	0-15	14	18	68	67.3	1.09	7.19	22.50	3.07	0.300	8.0	5.5	10.2
	C	15-90	8	48	44	37.5	0.88	6.65	45.00	1.34	0.130	11.0	4.0	10.3
Ramsar3	A	0-30	28	36	36	73.9	0.58	6.27	2.70	1.42	0.140	17.0	7.5	10.1
	Bt	30-90	34	32	34	62.9	0.18	6.26	2.25	0.52	0.050	11.0	6.0	10.4
	E	90-129	48	24	28	63.0	0.23	6.18	1.35	0.05	0.045	5.0	7.0	1.1
	C	>129	36	28	36	64.6	0.31	5.89	2.70	1.21	0.120	2.0	9.0	10.1

Table 4: Quantitative characteristics of Large-leaved lime in study area

Variable		Frequency of trees	Numbers tree (ha^{-1})	DBH (cm)	Crown diameter (m)	Total height (m)	Trunk height (m)
Site	Royan1	29	10	83.2	11.7	30.8	17.3
	Royan2	48	16	52.7	8.4	28.1	18.6
	Royan3	233	78	28.9	5.3	24.9	15.6
	Noshahr1	20	7	101.2	11.9	26.2	15.2
	Noshahr2	20	7	52.8	6.8	23.7	14.8
	Noshahr3	35	12	42.0	5.2	28.9	19.8
	Ramsar1	86	29	27.3	6.3	16.1	10.2
	Ramsar2	28	10	73.3	12.3	23.0	12.6
	Ramsar3	26	9	75.8	11.9	25.6	14.0
Altitude	<500	135	15	50.2	8.3	20.7	12.4
(m a.s.l.)	500-1000	96	11	59.3	9.4	25.8	16.2
	>1000	294	34	34.9	5.8	25.3	15.9
Aspect	N	262	16	50.9	8.0	26.6	16.0
	NE	51	26	53.2	6.7	19.3	13.0
	E	145	48	27.3	4.8	23.2	15.6
	SE	39	39	27.1	6.2	16.3	10.2
	S	8	8	47.1	7.3	26.0	15.5
	SW	6	6	71.6	8.9	18.7	8.4
	W	9	9	118.7	13.0	27.0	15.0
	NW	5	5	128.7	19.1	36.9	18.7
Slope	<35%	152	22	50.5	8.0	27.9	15.5
	35-70%	497	20	41.8	7.0	24.3	16.3
	>70%	180	18	38.1	6.0	20.3	13.0
Total		525	20	43.2	7.1	34.2	15.1

Table 5: ANOVA Test for quantitative characteristics of large-leaved lime in study area

Variable		Numbers tree (ha^{-1})	DBH (cm)	Crown diameter (m)	Total height (m)	Trunk height (m)
Site	F	6.7000	38.8000	28.7000	24.8000	29.7000
	p-value	0.0001	0.0001	0.0001	0.0001	0.0001
Altitude	F	193.7000	23.3000	30.5000	2.0000	29.4000
	p-value	0.0001	0.0001	0.0001	0.0001	0.0001
Aspect	F	110.5000	24.6000	16.2000	18.9000	11.8000
	p-value	0.0001	0.0001	0.0001	0.0001	0.0001
Slope	F	0.0410	5.3000	5.7000	39.6000	25.1000
	p-value	0.9610	0.0050	0.0040	0.0001	0.0001

Table 6: ANOVA Test for quantitative characteristics of Large-leaved lime in study area

Variable		Numbers tree per hectare	DBH (cm)	Crown diameter (m)	Total height (m)	Trunk height (m)
Site	F	6.7	38.8	28.7	24.8	29.7
	P-value	0.0001	0.0001	0.0001	0.0001	0.0001
Altitude	F	193.7	23.3	30.5	20	29.4
	P-value	0.0001	0.0001	0.0001	0.0001	0.0001
Aspect	F	110.5	24.6	16.2	18.9	11.8
	P-value	0.0001	0.0001	0.0001	0.0001	0.0001
Slope	F	0.041	5.3	5.7	39.6	25.1
	P-value	0.961	0.005	0.004	0.0001	0.0001

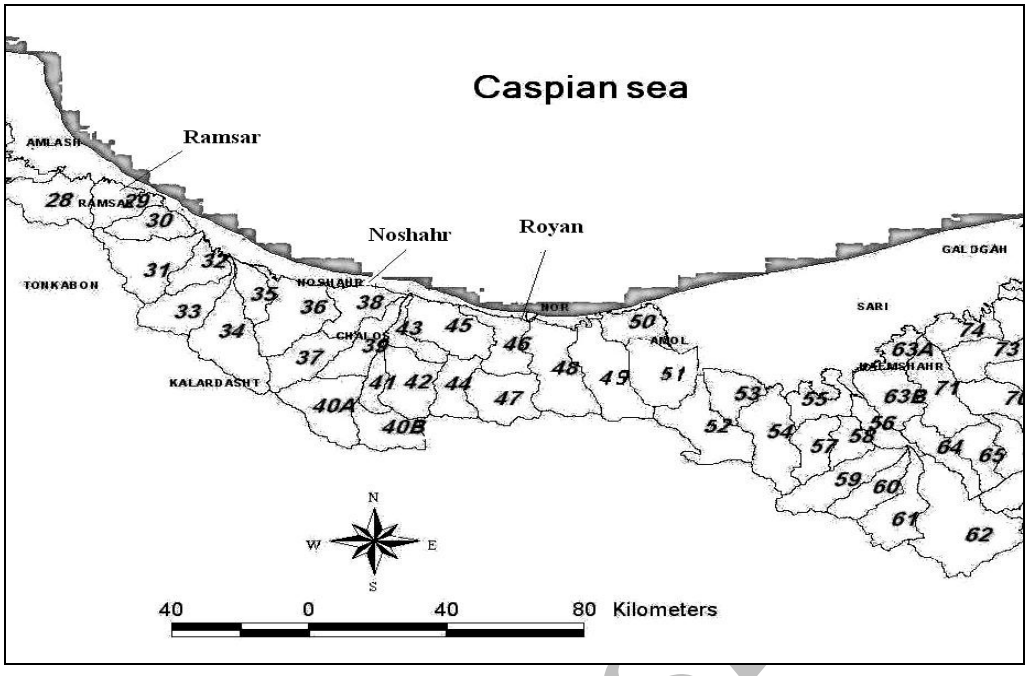

Fig. 1: Location of the study sites in the north of Iran

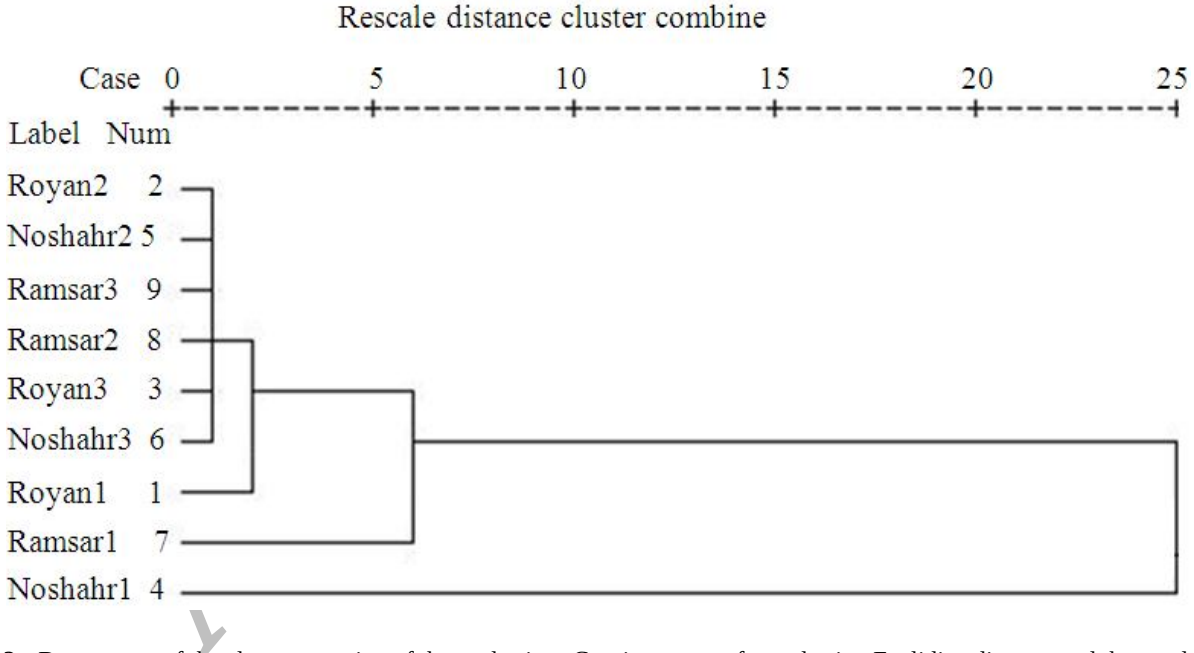

Fig. 2: Dentrogram of the cluster grouping of the study sites. Groping was performed using Euclidian distance and the ward method