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Cover Percentage Study of *Quercus libani* Oliv. In Relation to Elements Distribution in Soils Using Geostatistic Methods in Sardasht, West Azarbaijan, Iran

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Abstract: Relationship between the dispersion of *Quercus libani* Oliv. tree coverage and elements were studied in Sardasht forest, West Azarbaijan region. The study site was sampled by two-dimensional systematic with the random point starting. 152 square plots with 256 m^2 area by a grid (80m × 95m) were established. *Quercus libani* Oliv. tree coverage were measured in the plot and soil samples were taken in 4 main aspect from the depth of 0 to 20cm. The non-classical (geostatistics) method was used in order to study of *Quercus libani* Oliv. coverage and soil elements variability..On the basis of geostatistical method, P and Mn elements indicated strong spatial structure and wide range, Mg, Fe elements and *Q. libani* Oliv. coverage showed moderate spatial structure and wide range, Cu and K elements exhibited weak spatial structure and wide range. The results of contingency tables analysis expressed an adaptation between P,Cu,Ca,K and Mg and *Quercus libani* Oliv. coverage distribution ($P < 0.01$). Fe and Mn elemens showed disadaptation with *Quercus libani* Oliv. coverage ($P > 0.05$). In general, it has been approved that there is a direct relationship between oak tree coverage and elements of soil.

Key words: Forest sites · *Quercus libani* Oliv.species · Soil nutrients · Geostatistic methods · West Azarbaijan · Iran

INTRODUCTION

Heterogeneity in natural ecosystems exists at different scales [1, 2]. Non-uniformity and variance in environmental factors has had a significant influence on dispersion of plant species [3, 4]. As one of the significant ecological factors, soil has a crucial role in growth of forest plant canopy coverage [5]. Development of soil and plant coverage shall not be considered as a simple process. It has been one of complicated processes in which variances have strong effect on composition and pattern of distribution in plant species [6]. Soil nutrients have important role in any type of soil ecosystem and any type of variance in their composition and abundance have a great influence on performed processes in a natural system. Unfortunately, the range of this variability has not recognized yet [7]. Plant species on such soils usually make changes in chemical properties of soil and distribution of such variants will have significant influence on dispersion of tree species [8]. Being knowledgeable about soil chemistry and variability always looks important in the view of forest protectors to analyze fertility of soil [9]. Application of non-classical statistics (geostatistics) in methods of geostatistics has been put forth as a new subject to know about spatial variability of soil nutrients. Estimation methods of geostatistics search for variances based on location and provide maps of variances by means of variogram analysis, identifying suitable mathematical model and averaging in the method Kriging [10, 11, 12]. For structural analysis of variogram and interpolation in the method of Kriging, it is required to fit mathematical models in desired amounts. 2m × 2m blocks were used for interpolation in Kriging method, [4]. Common theoretical models [13] offered in 1978 are as follows:

Spherical model, Exponential model, Linear model, Gussian model. Spherical and exponential models are the most suitable and popular models for fitting data of soil [14].

The Objectives of this Study Includes: 1- Finding suitability of non-classical statistical methods to study soil and *Quercus libani* Oliv. tree coverage, 2- Finding suitable mathematical model for fitting data of soil

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nutrients and *Quercus libani* Oliv. -tree coverage, 3- Adaptability of variance in chemical elements and distribution of *Quercus libani* Oliv. tree coverage.

MATERIALS AND METHODS

Study Area: The study area is located in North West of Iran in West Azerbaijan; between 45° 16′ 52′′ and 45° 29′ 58′′ eastern longitude and 36° 9′ 45′′ and 36° 25′ 45′′ northern latitude. The considered study site covers an area of 242 hectares. The altitude of the study area is from 1400 to 1950 meters above sea level. Distribution of vegetation types can be divided into two major types in the entire area: *Quercus libani* Oliv. type in the northern side and *Quercus brantii* Lindl type in the southern side at Importance Value Index of: 146.3 and 160.3 accordingly [15].

Method of Sampling: The sample was taken from the study area in the systematic two-dimensional method by random starting point [16]. About 152 square samples with an area of 256 m^2 were placed on a topography map in 1/25000 scale by a grid (80*m* × 95*m*). The area of samples was calculated by drawing curve of area - species [17].

Quercus libani Oliv. coverage were measured in the plot of main sample. Species and abundance were considered as measuring standards for cover. Based on [16], estimation of cover was considered as abundance. Estimation of cover describes each of individual in the area of sampling unit in percentage [18].

In the center, each main sample was considered at distance of 2 meters to the center and 4 soil samples were taken in 4 main aspects from the depth of 0 to 20cm and after blending them, a compound sample was obtained. Some of the nutrients in soil such as phosphorus (mg/kg), potassium (mg/kg), calcium (mmol/kg), magnesium (mmol/kg), iron (mg/kg), manganese (mg/kg), copper (mg/kg) were measured. Logarithmic transformation was done for elements such as magnesium and copper [19]. After transporting soil samples to laboratory, first they were dried in air and after taking roots, stones and other impurities off, they were ground and passed through a sieve with diameter of 2mm. Soil nutrients were measured based on standard methods [20, 21].

Method of Data Analysis: Normality of all data was checked by Kolmogrov - Smirnov test. The method of logarithmic transformation was performed for copper and manganese variants. One of geostatistics methods was used to identify adaptation between *Quercus libani* Oliv. tree coverage and soil elements in non-classical system. In non-classical method, first by considering method of isotropy, primary analysis of variogram was performed on each of the variants and suitable mathematical models with model components was obtained for all variants. Then ordinary kriging method was used for interpolation and providing maps of variants. Finally, by means of contingency tables and identifying Kappa statistic, significance of adaptation degree of classifications was recognized [22], specified adaptation degree of classifications by means of Kappa standard.

Results of Non-Classical Method

Quantitative Sampling Results: Variants of percentage of oak cover, P, K, Mg, Ca, Mn, Cu and Fe were spatially analyzed. The results of descriptive statistics for 152 samples are shown in Table (1). The high variability in data were observed in oak cover, Mg and P variants while, Ca, Mn, Fe, Cu and K variants showned low variability.

Variography: The calculated variogram for data of variants are shown in Figure 1. On the base of Figure 1, the real nugget indicated little random variability however, structural variance or spatial association degree indicated well spatial dependence in all of variants. Spherical mathematical model indicated the best fitness between the points for the major of variants.

Table 1: The descriptive statistical results of variants

Variants	Sd±Mean	CV%	Minimum	Maximum
Oak cover	26±31.6	82	0.80	99.80
P	12.4±20.2	61	0.05	47.80
K	55.9±174.9	32	42.50	300.00
Mg	1.6±3.3	67	1.00	6.50
Ca	0.8±5.0	16	3.50	9.50
Mn	95±492.2	19	362.50	837.50
Cu	5.1±17.1	30	10.00	30.00
Fe	5690±24683	23	14450.00	40000.00

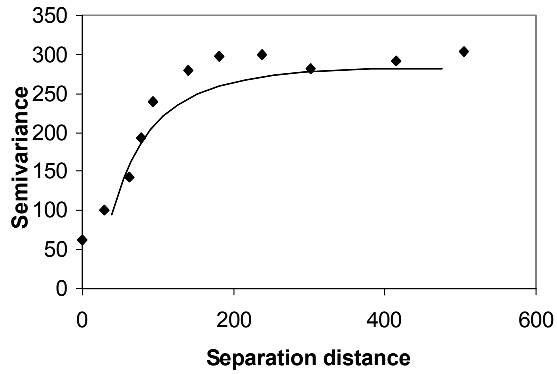

Fig. 1a: Variogram of oak cover percentage

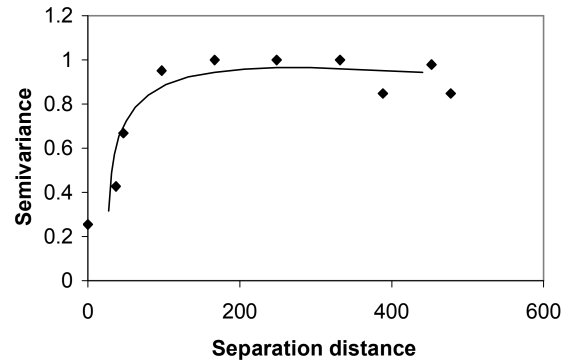

Fig. 1e: Variogram of Ca variant

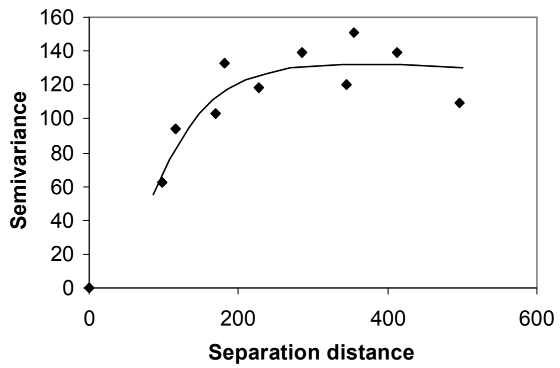

Fig. 1b: Variogram of P variant

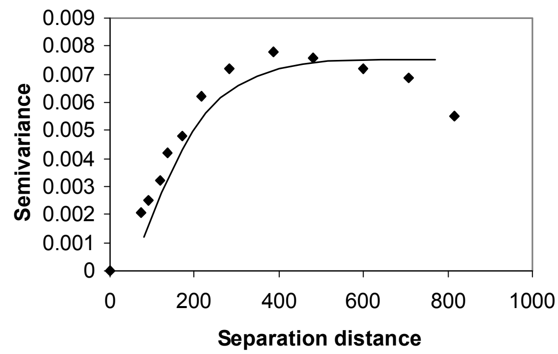

Fig. 1f: Variogram of Mn variant

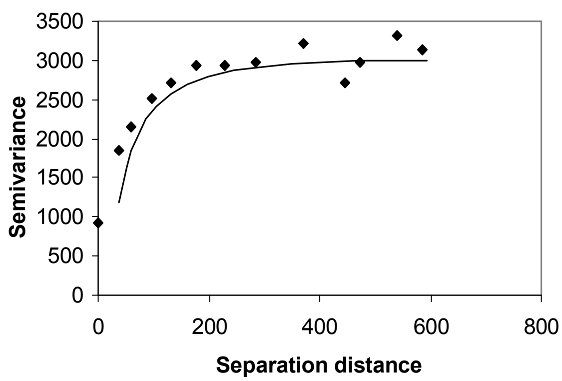

Fig. 1c: Variogram of K variant

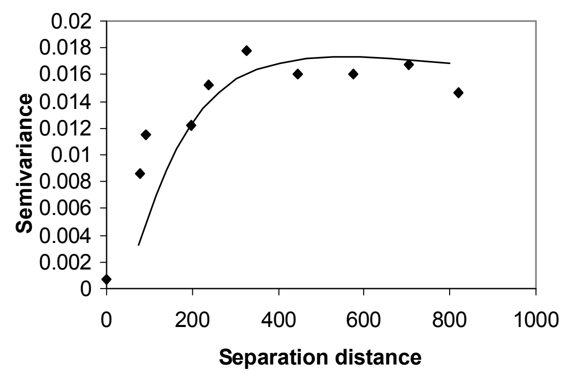

Fig. 1g: Variogram of Cu variant

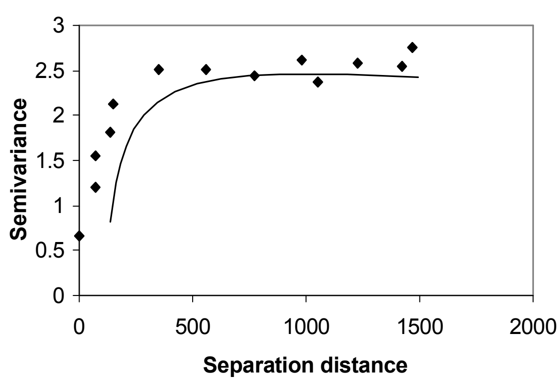

Fig. 1d: Variogram of Mg variant

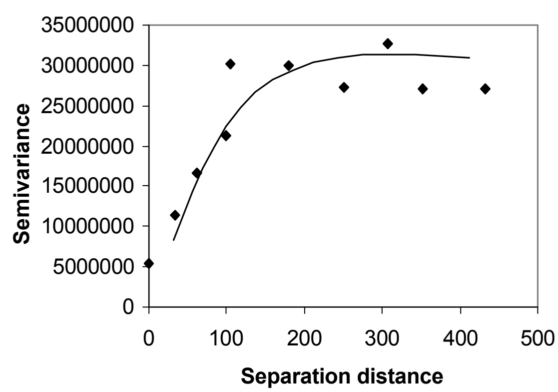

Fig. 1h: Variogram of Fe variant

Table 2: Variogram model parameters for spatial variants

Spatial variants	Model	Nugget effect Real	Relative (%)	Sill ($C + C_0$)	Structural variance (%)	Range (m)	RSS	(%) r^2%
P	Spherical	0.1	0.08	134.2	99.90	257	1120	78
Mn	Spherical	0.00001	0.10	0.007	99.90	342	<0.005	81
Oak cover	Spherical	68.5	23.00	293.9	77.00	177	150.7	94
Mg	Spherical	0.66	24.00	0.025	76.00	275	<0.003	94
Fe	Spherical	5380000	18.00	30190000	82.00	207	>2000	79
Ca	Spherical	0.252	31.00	0.0065	76.00	129	<0.003	81
Cu	Spherical	0.007	44.00	0.016	56.00	366	<0.003	71
K	Exponential	920	29.00	3132	71.00	77	22187	93

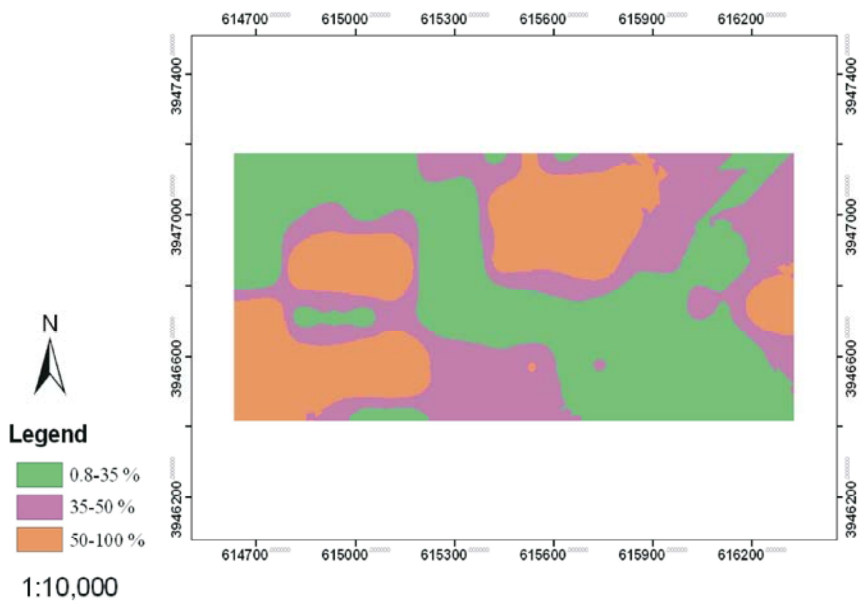

Fig. 2a: Distribution map of oak cover at its site

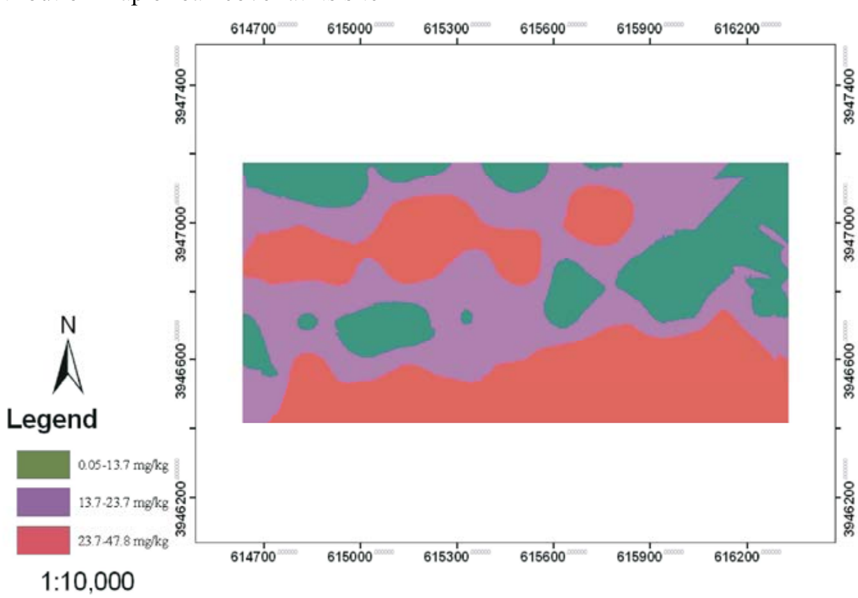

Fig. 2b: Distribution map of P at oak site

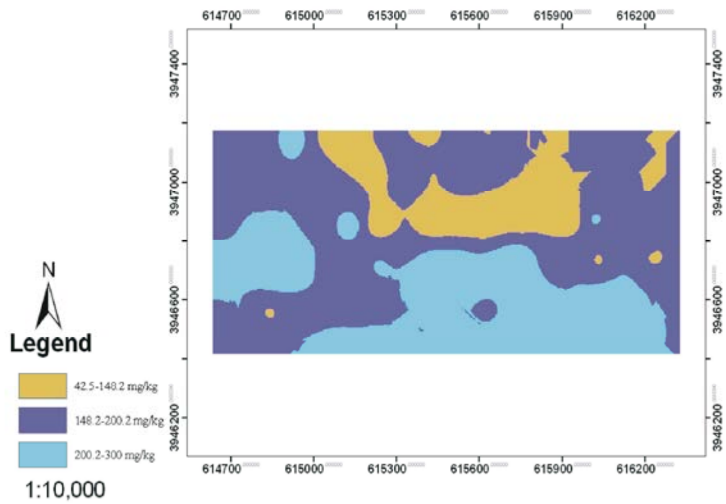

Fig. 2c: Distribution map of K at oak site

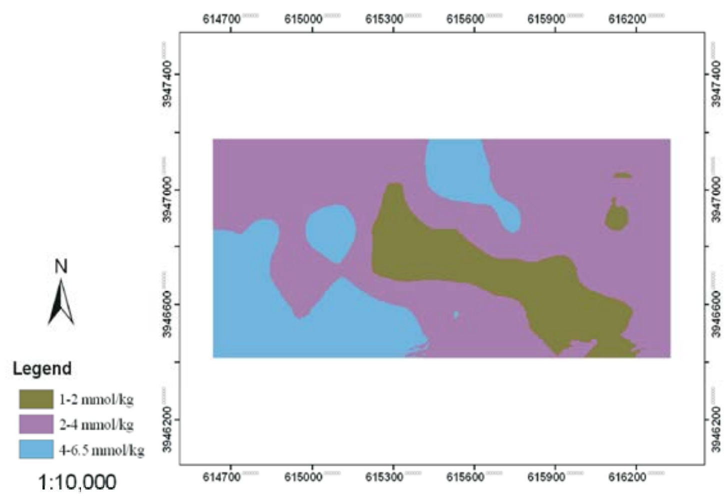

Fig. 2d: Distribution map of Mg at oak site

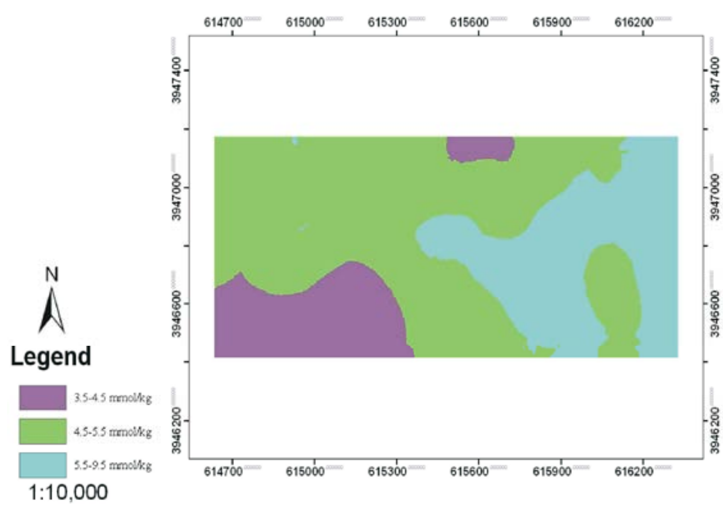

Fig. 2e: Distribution map of at oak site

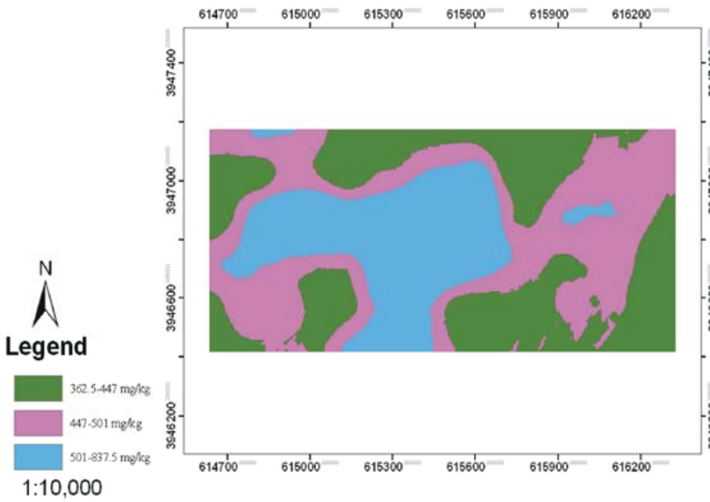

Fig. 2f: Distribution map of Mn at oak site

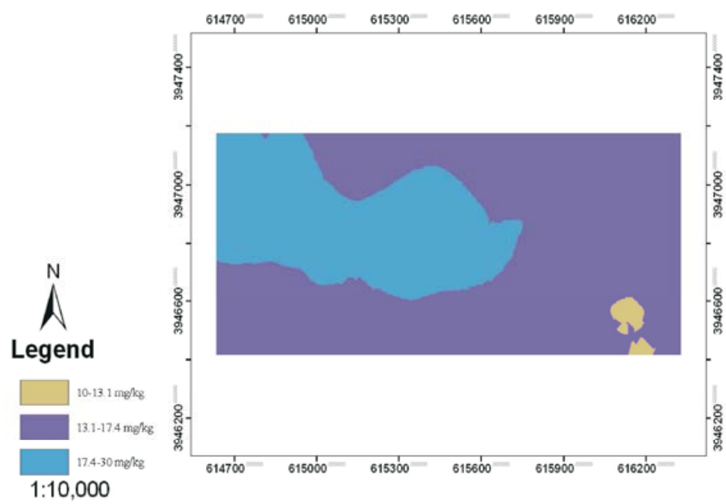

Fig. 2g: Distribution map of Cu at oak site

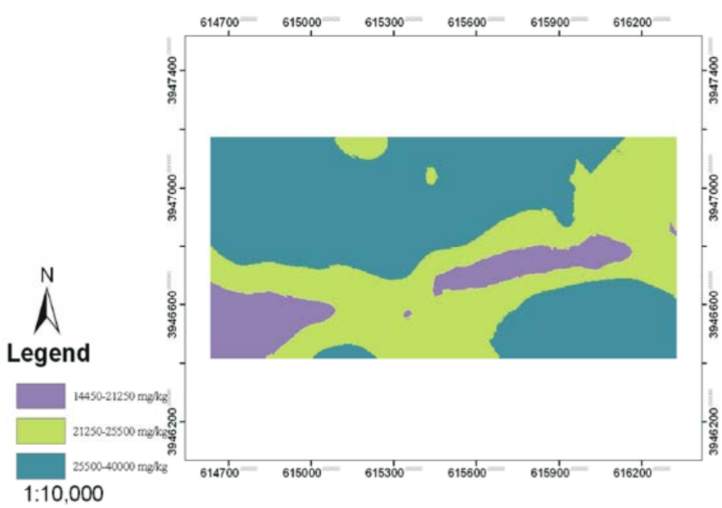

Fig. 2h: Distribution map of Fe at oak site

Parameters of the model of variants are described in Table (2). Concerning some variants such as P and Mn, the calculated relative nugget indicated very low random variability. For Cu variant, the nugget effect showed relatively high random variability and for the rest variants, the nugget effect indicated relatively low random variability. Structural variance or spatial association degree of P and Mn indicated strong spatial dependence but Cu variant indicated relatively low spatial dependence. The other variants showed relatively suitable spatial dependence, (Table 2).

Ordinary Kriging: Ordinary block kriging was used to produce maps of variants at a grid dimension of 2m × 2m. The result of ordinary kriging estimation was as follow:

Oak Cover: The estimation map of this element indicated that 72.5% of the interpolated area is in the range of 35% to 50% and 12% of the region is less than 35%, (Figure 2a). This is because the values so strongly skewed.

P: The map of this element indicated that 48.3% of the interpolated area was in the range of 13.7-23.7 mg/kg and 16.5% of the region was in the range of less than 13.7mg/kg, (Figure 2b).

K: The map of the estimated quantity of K showed that 72.5% of the interpolated area was in the range of 148.2-200.2 mg/kg and 9.9% of the region was less than 148.2 mg/kg, (Figure 2c).

Mg: The map of the estimated quantity of this element showed that 68.1% of the interpolated area was in the range of 2-4 mmol/kg and 14.3% of the region was less than 2 mmol/kg, (Figure 2d).
Ca: The map of the estimated quantity of Ca showed that 85.6% of the interpolated area was in the range of 4.5-5.5 mmol/kg and 6.6% of the region was less than 4.5 mmol/kg, (Figure 2e).

Mn: The map of the estimated quantity of this element showed that 49.4% of the interpolated area was less than 447 mg/kg and 13.2% of the region was more than 501 mg/kg, (Figure 2f).

Cu: The map of the estimated quantity of Cu showed that 64.8% of the interpolated area was in the range of less than 13.1-17.4 mg/kg and 7.7% of the region was in the range of less than 13.1mg/kg, (Figure 2g).

Fe: The map of the estimated quantity of this element showed that 47.2% of the interpolated area was in the range of 21250-25500 mg/kg and 13.2% of the region was less than 21250 mg/kg (Figure 2h).

Analysis of Contingency Tables

Results of Adaptability of Site Variant of Phosphorus and *Quercus libani* Oliv. Tree Coverage: There was a significant relationship between phosphorus distribution and dispersion of *Quercus libani* Oliv. tree coverage ($\chi^2_{0.05,4}$ = 14.5, P=0.006) and significant linear association between phosphorus classes and *Quercus libani* Oliv.tree coverage classification (r=0.41, p<0.001). Significance of adaptation between distribution of phosphorus and dispersion of *Quercus libani* Oliv. tree coverage was observed (Kappa=0.23, p=0.006). Table (3) shows the results of contingency table analysis related to phosphorus and *Quercus libani* Oliv. tree coverage.

Results of Adaptability of Site Variant of Potassium and *Quercus libani* Oliv. Tree Coverage: There was a significant relationship between potassium distribution and dispersion of *Quercus libani* Oliv. tree coverage ($\chi^2_{0.05,4}$ = 10.1, P=0.039) and significant linear association between potassium classes and *Quercus libani* Oliv. tree coverage classification (r=0.4, p=0.006). Significance of adaptation between distribution of potassium and dispersion of *Quercus libani* Oliv. tree coverage was observed (Kappa=0.3, p=0.004). Table (4) shows results of contingency table analysis related to potassium and *Quercus libani* Oliv. tree coverage.

Results of Adaptability of Site Variant of Magnesium and *Quercus libani* Oliv. Tree Coverage: There was a significant relationship between magnesium distribution and dispersion of *Quercus libani* Oliv. tree coverage ($\chi^2_{0.05,4}$ = 13.6, P=0.009) and significant linear association between magnesium clases and *Quercus libani* Oliv. tree coverage classification (r=0.4, p<0.001).

Table 3: Contingency table of phosphorous and *Quercus libani* Oliv. coverage (The numbers inside table is in terms of total percentage)

	Phosphorous classes (ppm)		
Coverage classes of *Quercus libani* (%)	0-13.7	13.8-23.8	23.9-100
0-35	18.1	15.3	5.6
36-50	11.1	11.1	8.3
51-100	4.2	6.9	19.4

Table 4: Contingency table of potassium and *Quercus libani* Oliv. coverage (The numbers inside table is in terms of total percentage)

	Potassium classes (ppm)		
Coverage classes of *Quercus libani* (%)	0-148.2	148.3-200.0	200.1-1000.0
0-35	19.0	12.1	3.4
36-50	6.9	22.4	6.9
51-100	5.2	13.8	10.3

Table 5: Contingency table of magnesium and *Quercus libani* Oliv. coverage (The numbers inside table is in terms of total percentage)

	Magnesium classes (meq/lit)		
Coverage classes of *Quercus libani* (%)	0-0.2	0.3-0.4	0.5-1.0
0-35	22.2	15.3	1.4
36-50	9.7	15.3	5.6
51-100	6.9	11.1	12.5

Table 6: Contingency table of calcium and *Quercus libani* Oliv. coverage (The numbers inside table is in terms of total percentage)

	Calcium classes (meq/lit)		
Coverage classes of *Quercus libani* (%)	0-0.45	0.46-0.55	0.56-1.00
0-35	6.9	18.1	13.9
36-50	9.7	16.7	4.2
51-100	22.2	4.2	4.2

Table 7: Contingency table of copper and *Quercus libani* Oliv. coverage (The numbers inside table is in terms of total percentage)

	Copper classes (ppm)		
Coverage classes of *Quercus libani* (%)	0-12.9	13.0-17.4	17.5-100
0-35	17.7	14.5	3.2
36-50	1.6	8.1	14.5
51-100	11.3	17.7	11.3

Table 8: Contingency table of iron and *Quercus libani* Oliv. coverage (The numbers inside table is in terms of total percentage)

	Iron classes (ppm)		
Coverage classes of *Quercus libani* (%)	0-21250	21251-25500	25501-100000
0-35	16.7	15.3	6.9
36-50	12.5	8.3	9.7
51-100	11.1	5.6	13.9

Table 9: Contingency table of manganese and *Quercus libani* Oliv. coverage (The numbers inside table is in terms of total percentage)

	Manganese classes (ppm)		
Coverage classes of *Quercus libani* (%)	0-447	448-501	502-1000
0-35	15.3	12.5	11.1
36-50	15.3	5.6	9.7
51-100	15.3	5.6	9.7

Significance of adaptation between distribution of magnesium and dispersion of *Quercus libani* Oliv. tree coverage was observed (Kappa=0.3, p=0.003). Table (5) shows results of contingency table analysis related to magnesium and *Quercus libani* Oliv. tree coverage.

Results of Adaptability of Site Variant of Calcium and *Quercus libani* Oliv. Tree Coverage: There was a significant relationship between calcium distribution and dispersion of *Quercus libani* Oliv. tree coverage ($\chi^2_{0.05,4}$ = 19.1, P=0.001) and significant linear association between calcium classes and *Quercus libani* Oliv. tree coverage classification (r=-0.42, p<0.001). Significance of adaptation between distribution of calcium and dispersion of *Quercus libani* Oliv. tree coverage was not observed (Kappa=-0.09, p=0.27). Table (6) shows results of contingency table analysis related to calcium and *Quercus libani* Oliv. tree coverage.

Results of Adaptability of Site Variant of Copper and *Quercus libani* Oliv. Tree Coverage: There was a significant of relationship between copper distribution and dispersion of *Quercus libani* Oliv. tree coverage ($\chi^2_{0.05,4}$ = 13.8, P=0.008) but no significant linear association between copper classes and *Quercus libani* Oliv. tree coverage classification (r=0.22, p=0.09). Significance of adaptation between distribution of copper and dispersion of *Quercus libani* Oliv. tree coverage was not observed (Kappa=0.07, p=0.4). Table (7) shows results of contingency table analysis related to copper and *Quercus libani* Oliv. tree coverage.

Results of Adaptability of Site Variant of Iron and *Quercus libani* Oliv. Tree Coverage: Significant relationship between iron distribution and dispersion of *Quercus libani* Oliv. tree coverage was not observed ($\chi^2_{0.05,4}$ = 5.1, P=0.3) but no significant linear association between iron classes and *Quercus libani* Oliv. tree coverage classification (r=0.17, p=0.2). Significance of adaptation between distribution of iron and dispersion of *Quercus libani* Oliv. tree coverage was not observed (Kappa= 0.08, p=0.4). Table (8) shows results of contingency table analysis related to iron and *Quercus libani* Oliv. tree coverage.

Results of Adaptability of Site Variant of Manganese and *Quercus libani* Oliv. Tree Coverage: There was no significant relationship between manganese distribution and dispersion of *Quercus libani* Oliv. tree coverage ($\chi^2_{0.05,4}$ = 1.9, P=0.8) and no significant linear association between manganese classes and *Quercus libani* Oliv. tree coverage classification (r=-0.04, p=0.8). Significance of adaptation between distribution of manganese and dispersion of *Quercus libani* Oliv. tree coverage was not observed (Kappa=-0.06, p=0.5). Table (9) shows results of contingency table analysis related to manganese and *Quercus libani* Oliv. tree coverage.

DISCUSSION AND CONCLUSION

In the non-classical method, most of elements such as phosphorus, potassium, magnesium, calcium and copper indicated significance of relationship (p<0.05). High quantity of structural variance of these elements indicated their significance of spatial association (Table 1). Most of studies had approved spatial variability of soil chemicals [5, 23-27]. The results of variogram analysis indicated that spherical model was suitable for structural display of most of variants (r^2 >0.7) which matches with those of other researchers [28] who stated that spherical and exponential models fitted soil data the most. In this research, magnesium showed the fittest spherical model (r^2 = 0.94). RSS indicated uniformity of data of regional variants [12]. The results of this research showed that variants such as: copper, calcium, magnesium and manganese have the highest uniformity and variants such as: potassium, iron, phosphorus and *Quercus libani* Oliv. species had the least uniformity [11]. Attributed sill of variogram to variance in data. Variance means diversity and uniformity in frequency of data. In this research, variants such as iron, potassium, phosphorus and *Quercus libani* Oliv. species had the highest degree of diversity but manganese, magnesium, calcium and copper had the least degree of diversity [10]. Considered the compound of diversity and uniformity as a homogenous factor. In this research, homogenous variants encompassed manganese, magnesium, calcium, phosphorus and copper and heterogeneous variants included iron, potassium and *Quercus libani* Oliv. species. In general, by considering features of variogram, regional variants in *Quercus libani* Oliv. site can be classified in four groups:

Group One: Variants with strong structural variance and high homogeneity such as phosphorus and manganese.

Group Two: Variants with moderate structural variance and high homogeneity such as calcium and magnesium.

Group Three: Variants with moderate structural variance and low homogeneity such as potassium and iron.

Group Four: Variants with weak structural variance and high homogeneity such as copper.

In *Quercus libani* Oliv. site, the lowest range belonged to potassium variant (77 m) and the highest range belonged to copper (366 m). [10], considered 2/3 range as distance between sampling. Therefore, the distance between samples in the following ecological studies in this region or similar regions should be 50 meters based on the current lowest amplitude (77 m). About the third objective of this research which refers to the adaptability of *Quercus libani* Oliv. tree coverage and regional variants, the results of contingency tables can be classified in three groups:

Group One: Included variants which both had significant relationship with *Quercus libani* Oliv. tree coverage ($p < 0.05$) and significant adaptability degree of classes on each other such as: phosphorus, potassium and magnesium.

Group Two: Included variants which had significant relationship with *Quercus libani* Oliv. tree coverage ($p < 0.05$) but adaptability degree of classes on each other was not significant ($p > 0.05$) such as: copper and calcium.

Group Three: Included variants which did not have significant relationship with *Quercus libani* Oliv. tree coverage ($p < 0.05$) such as: iron and manganese.

The variants in group one created direct significant association on *Quercus libani* Oliv. tree coverage ($p < 0.05$); which means that the more *Quercus libani* Oliv. tree coverage was developed, the more of these elements increased. In general, it has been approved that there is a direct relationship between oak tree coverage and fertility of soil [29]. The elements in this group were all required and mostly consumed from soil and soil fertility highly depended on them. In some of studies, copper and calcium had not played any roles in division of plant groups [30]. Iron and manganese in non-classical and classical methods did not show significant of relationship with *Quercus libani* Oliv. tree coverage.

Suggestions: This study had been performed to acquire primary and basic information for next precise researches and therefore, the following conclusion can be considered:

- Determining distance between samples and the number of samples has been important in geostatistical studies and therefore, it seems more efficient to consider a few site variants, a lot of samples and a little distance between samples.
- Geostatistical studies in ecology shall be repeated in various sites and types of soil to achieve a standard and identical conclusion.
- The results of this study can be strongly used as an introduction to studies on spatial analysis in the western side of Iran.

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