

Assessment of Spatial Distribution Patterns of Soil Properties in the EAARI-Experimental Station (Erzurum)

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ABSTRACT

Defining spatial distribution patterns of soil properties within a field or watershed is important for site-specific soil and plant management. The objective of this study was to determine spatial distribution patterns of particle size distribution, organic matter, lime content, pH and plant-available P contents of soils in the Experimental Station of the Eastern Anatolia Agricultural Research Institution (EAARI). The research area, about 100 ha, was gridded with 100 m intervals in the north to south and east to west directions, and 68 soils samples were collected from 0-20 cm dept at each intersection. Exponential semivariogram models were fitted for clay, silt and sand contents and soil pH, Gaussion models for lime content and plant-available P, and spherical model for organic matter content. Block kriging analysis was performed to prepare distribution maps. Distribution patterns of soil properties studied showed great similarities with each other, as the patterns of yield.

Key Words: spatial variability, soil properties, EAARI

INTRODUCTION

Although soil properties show continuous changes on earth, the sample mean values for measured soil properties are commonly used to represent soil populations. There is no way to measure a property at every location within a study area. But, many soil properties produce great variations among sample values measured at several points. Therefore, classic statistical methods may not be used safely for characterizing variations in soil properties. It is assumed that samples are independent from each other and the mean value is the best representative of population mean in classical statistics. However it is well known that samples taken close together may produce more related values than those far apart. That means is that sample pairs produce values as a function of distance between them (Oztas, 1995).

Geostatistical methods are commonly used to define spatial variability and estimations in many properties in different fields. Autocorrelation and kriging analyses are applied to soil science for defining spatial and temporal variability as a function of time and location (Warrick et al., 1986, Kutilek and Nielsen 1994, Reese and Moorhead 1996, Bourgault et al., 1997, Goovaerts 1999, Bocchi et al., 2000, Webster and Oliver 2001).

Geostatistical methods are applied in two steps. In the first step, the degree of autocorrelation among the measured values of a soil property is defined and in the second step values of the property at unsampled points or areas are estimated using an advanced interpolation technique. Semivariograms and Kriging methods are commonly used for these purposes (Isaaks and Srivastava, 1989).

Within the last decade, geostatistical methods are intensively used to modeling spatial variability and mapping distribution patterns of soil properties within an area (Yost et al, 1982; Trangmar et al., 1987; Miller et al., 1988; Lark 2002). Oztas and Ardahanlioglu (1998) defined spatial variability of soil texture in a deposited alluvial plain. The researchers reported that spherical model was the best-fit model for characterizing clay, silt and sand contents within the study area and the ranges of influence were 27, 16 and 18 m for the textural fractions, respectively. Mahinakbarzadeh et al. (1991) analyzed spatial variation patterns of soil organic matter throughout transects and indicated that organic matter had small variations as compared to other soil properties. On the other hand Huang et al. (2001) reported that soil total C periodically changes depending on topography other than land use type.

Degree of variation in soil properties are caused by many factors including soil forming factors and processes, land use type and soil management. Alluvial materials are recognized with higher heterogeneity because of origin of sediments deposited by water at different times and amounts (Die et al., 1989). Therefore, characterizing spatial patterns of soil properties formed on alluvial parent material are complex and always gets special interest.

The objective of this study was to determine spatial distribution patterns of particle size distribution, organic matter, lime content, pH and plant-available P contents of soils in the Experimental Station of the Eastern Anatolia Agricultural Research Institution (EAARI), which formed on alluvial parent material.

MATERIAL and METHODS

The study area, the EAARI Experimental Station is located in Pasinler-Erzurum (39°58'723" N - 41°37'500" E). The altitude is 1680 m and average slope gradient of the experimental field is less than 1 %. Soils of the study site were formed on alluvial parent material (Anonymous 1998), having slightly alkaline soil reaction, low organic matter, moderate level of plant-available P and clay or clay-loam texture.

The EAARI-Pasinler Experimental Field was gridded with 100 m intervals in the north-south and east-west directions, and soil samples from 0-20 cm top layer were collected at 68 intersection points. Plant pattern of the experimental field is given in Figure 1.

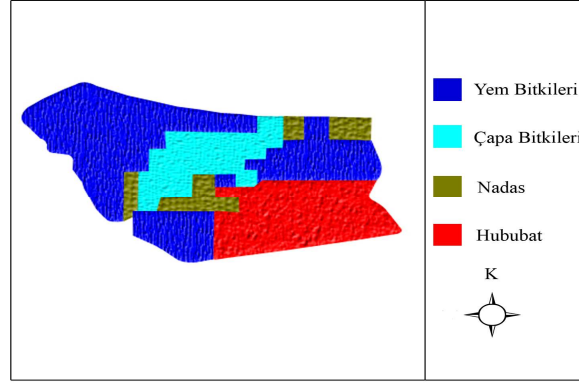


Figure 1. Plant patterns of the experimental field

Texture, pH, organic matter, lime content and plant available P contents of soil samples were determined (Klute, 1986; Page, 1982). Descriptive statistics (mean, standard deviation, minimum and maximum values, coefficient of variation, skewness and kurtosis) were calculated for each measured soil property.

Semivariogram analysis was performed to describe spatial variation among the measured points. The best fit model was chosen based upon the maximum r^2 and minimum residual sum of squares. Each soil property was estimated for 100 m² cells at unsampled locations .

RESULTS and DISCUSSIONS

Descriptive statistics for the measured soil properties were given in Table 1. The highest coefficient of variation (CV = 87 %) was obtained for plant-available P, followed by organic matter and lime content, but the lowest (1.7 %) for soil pH. That means the most confident soil property for the study area is soil pH. Higher CV values may be due to land use-type and soil management strategies within the experimental field.

Table 1. Descriptive statistics of soil properties studied.

Property	Mean	sd	Min.	Max.	Skew.	Kurt.	cv %
Clay, %	40.2	11.2	10.5	59.3	-0.7	2.9	28.0
Silt, %	29.2	5.0	9.8	37.7	-1.0	5.4	17.0
Sand, %	30.6	10.8	7.8	64.4	1.1	4.4	35.5
OM. %	1.8	0.8	0.1	3.9	0.4	3.4	46.1
CaCO ₃ , %	6.3	2.5	1.6	13.8	0.1	2.8	40.4
pH, 1:2.5	7.8	0.1	7.5	8.1	-0.6	2.9	1.7
Ava.-P, ppm	29.1	25.5	0.7	93.1	0.9	2.6	87.3

In order to determine isotropy/anisotropy variation, four different directional semivariograms (N-S, NE-SW, E-W, NE-NW) were performed and they were compared for the best-fit model and model parameters (sill, nugget and range). All soil properties showed isotropic variation, therefore a single isotropic semivariogram was defined (Table 2).

Table 2. Best-fitted isotropic semivariogram models and parameters.

Soil property	Model	Co	Co+C	A ₀	r ²
Clay	Exponential	0,1	201,1	326	0,99
Silt	Exponential	2,06	20,6	58	0,79
Sand	Exponential	39,1	216,8	618	0,97
Organic matter	Spherical	0,45	0,9	1258	0,98
CaCO ₃	Gaussian	0.01	8,8	153	0,99
pH	Exponential	0.01	0.02	80	0,91
Available P	Gaussian	318	776	263	0,99

Exponential semivariogram models were fitted for clay, silt and sand contents and soil pH, Gaussian model for lime content and plant-available P, and spherical model for organic matter content (Fig. 2).

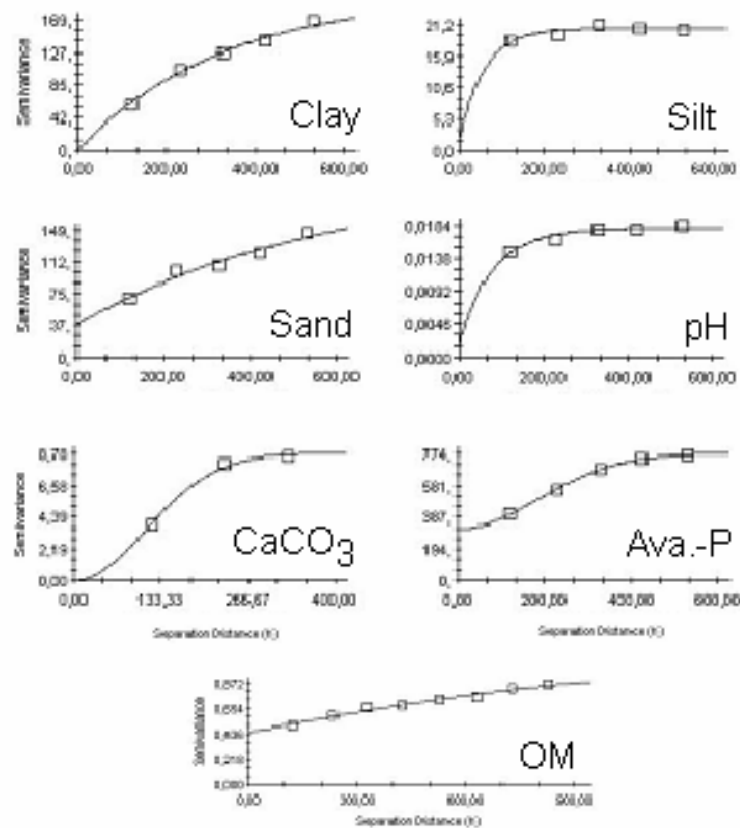


Figure 2. The best-fitted experimental semivariogram models for soil properties studied.

The range of influence, which indicates the maximum distance of spatial dependence between sample pairs, was 326, 58, 618, 1258, 153, 80 and 263 m for clay, silt, sand, organic matter and lime contents, and pH and plant-available P, respectively.

Based upon the best-fit model for each soil property, values were estimated for unsampled locations gridding the experimental field with 10x10 m sub-cells using block kriging analysis.

The distribution map of soil clay content indicated that clay content was the lowest at the northern part of the experimental field in where a creek lies through causing partial leaching of clay to deeper soil layers (Fig. 3). The most complex distribution was obtained for silt content (Fig. 4). This situation was thought to be related to silt content of sediment carried in different times and flow characteristics. On the other hand, sand content was highest in the northern part of the study site as expected because of leaching of clay (Fig. 5). Sand content gradually decreased from north to south direction as a function of deposition, flow carry capacity and load.

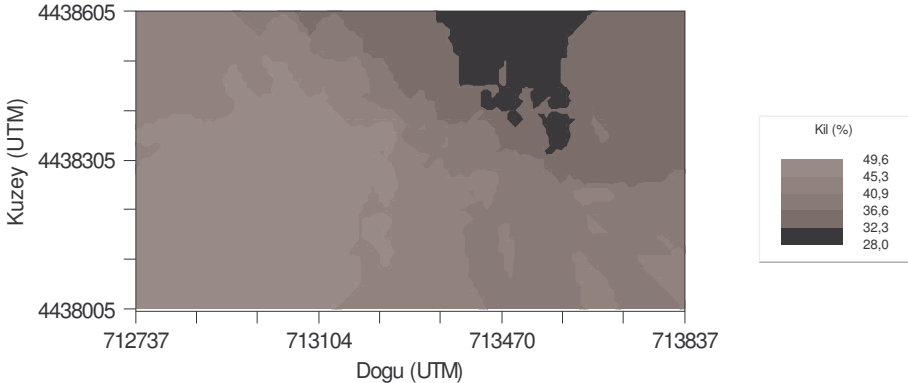


Figure 3. Spatial distribution pattern of clay within the syudy area.

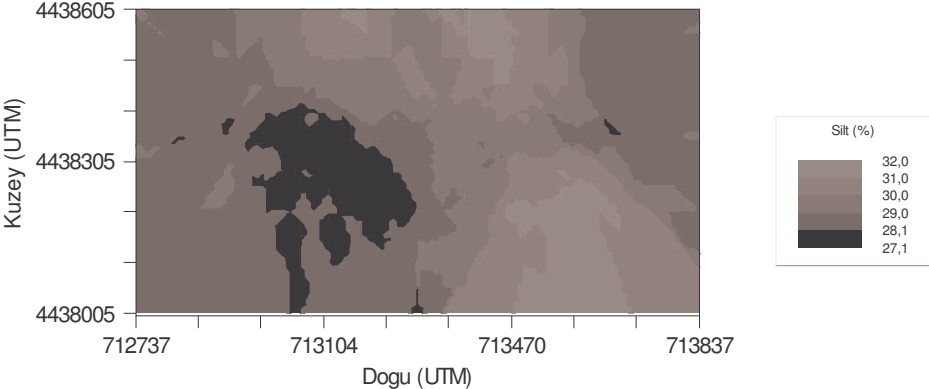


Figure 4. Spatial distribution pattern of silt within the syudy area.

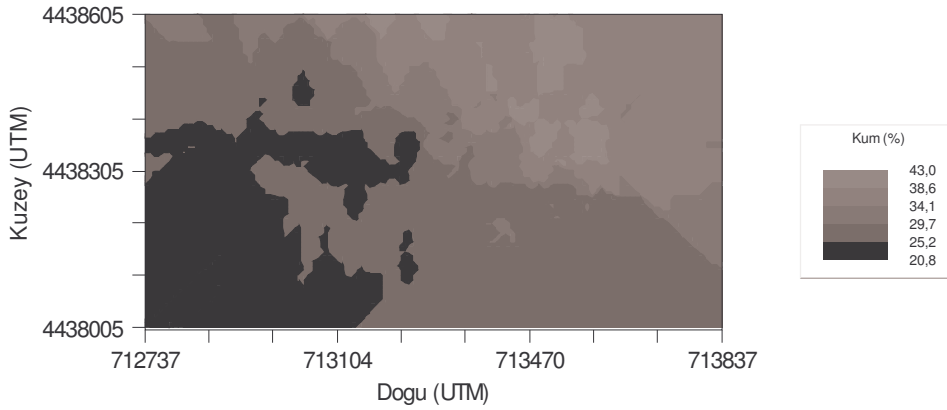


Figure 5. Spatial distribution pattern of sand within the study area.

As seen in Figure 6, organic matter content was highest at the southern part of the study area in where cereals was planted for long years, however, it was lowest amount in row-crop planted areas and in the northern part. High organic matter amounts were also obtained in alfa alfo and tall fescue planted areas. Organic matter content decreased in artificial rangeland areas, in where row-crops were planted in previous years. All these results were related to biomass input to soil because of plant type, and higher mineralization rate of organic matter in relatively coarse-textured areas.

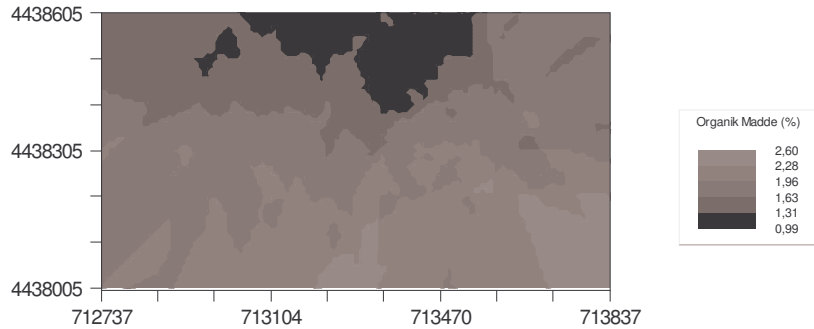


Figure 6. Spatial distribution pattern of organic matter content within the study area.

Lime content of soils was the highest in the center part of the experimental field in where row-crops take place (Fig. 7). But, lime content was relatively in lower amounts in cereal and hay production areas and in the lowest amount in the northern part in where a creek lies through.

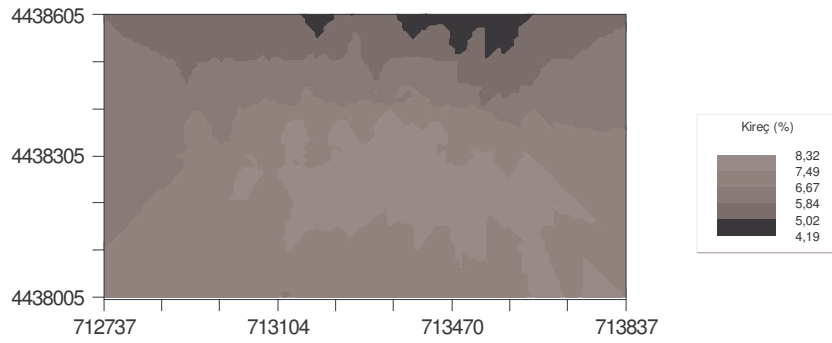


Figure 7. Spatial distribution pattern of lime content within the study area.

Although soil reaction has the minimum variation within the study area, small differences were still existed. Soil pH was relatively higher in hay crop production areas as compared with cereal and row-crop planted areas (Fig. 8).

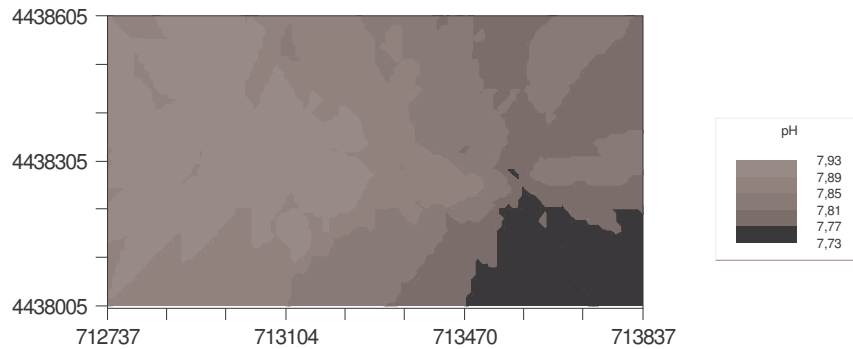


Figure 8. Spatial distribution pattern of pH within the study area.

The highest variation was obtained for plant-available P. It was higher in the northern site cereal-planted areas and decreased from north to south, and get the lowest values in creek sites (Fig. 9). This result may be due to P fertilizer application and cattle manure because of grazing animals.

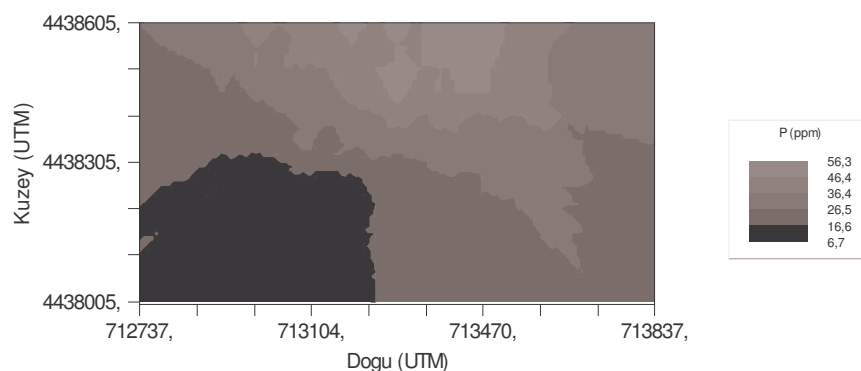


Figure 9. Spatial distribution pattern of plant-available P within the study area.

In conclusion, the results of this study clearly indicated that spatial distribution patterns of soil properties are closely related to each other in addition to land use type and plant patterns, even in soils formed on alluvial material.

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