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Influence of Slope Aspects and Depth on Soil Properties in a Cultivated Ecosystem

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ABSTRACT

In order to find out how topographical factors effect on soil properties, as a pivotal indicator in terms of soil degradation and sustainable land management in natural ecosystem, the investigation of soil physical and chemical parameters are indispensable. The research aimed to assess slope aspects on soil quality. Soil samples were gathered by completely randomized factorial design in four geographical directions and flat by three replications in two depths of 0-30 and 30-60 cm; therefore equals 30 soil samples from the dry and irrigation farming of Khorasan Razavi. The investigated variables were Total Nitrogen, Phosphorus, Potassium, pH, Saturated Percentage, Calcium Carbonate Equivalent, Fe and Soil Texture. Results showed that there was a significant relationship in N, P and F, whereas there was no significant relationship in K, pH, SP and TNV in different aspects. Turning to depths, none of parameters showed statistically significant, except for P. Totally, the results suggest that West and Flat aspect are the appropriate area for agriculture. The differences may be attributed to topographic aspect, which causing differences in the some soil component, affect soil fertility.

KEYWORDS: Slope aspect, Soil fertility, Khorasan Razavi

INTRODUCTION

Spatial variability of soil properties is somewhat inherent in nature because of variations in soil parent materials and microclimate (Zhao et al., 2007). Efficiency in agriculture requires application of principles of farming according to the field variability, which creates new requirements for estimating and mapping spatial variability of soil properties. In the last few years, considerable contributions have been made to understand the soil distribution within the landscape using geo-statistic approach. Knowing the soil distribution is required for effective land management. Adhikari et al. (2009) employed geostatistics to determine the spatial behavior of soil texture contents and produced useful maps for farmers and government organizations to design land management projects. According to Krasilnikov et al. (2008) geostatistics can be used for studying and predicting the spatial structure of georeferenced variables, generating soil properties map and understanding the distribution of these . Soil nutrients, which result from the effect of various anthropogenic activities and factors such as climate and topography, demonstrate certain spatial pattern with different structure and stochastic attributes. It is believed that soil variability in the field can be defined with classic statistical methods and is assumed to have a random variability (Cemek et al., 2007). According to Webster (1985) soil characteristics generally show spatial dependence which means samples close to each other have similar properties than those far away from each other.

The spatial variation of soil properties is significantly influenced by some environmental factors such as climate, landscape features, including landscape position, topography, slope gradient and evolution, parent material, and vegetation (Ollinger et al., 2002). It is common knowledge that topography influences local microclimates by changing the pattern of precipitation, temperature and relative humidity (Yimer et al., 2006) and significantly affects some soil parameters. Non-technical cultivation methods can seriously effect on soil fertility in a short time due to conversing subsurface soil to surface layers. Therefore, depth of soil is an important factor in agriculture and land evaluation. Studies on topographic characteristics, on slope aspect in particular, have produced contrasting results; foresters have traditionally viewed south aspects as less productive than north aspects, yet there is substantial evidence that the assumption of lower site productivity on south aspects may be incorrect (Coble et al., 2001). Several research have been conducted assess the effect of terrain characteristics on soil properties. Ata Rezaei and Gilkes (2005) shown that landscape attributes including slope, aspect, and elevation affected plant growth through indirect influences involving soil properties. Some other research focused on the effect of slope and aspect in grassland (Gong et al., 2008) rangeland (Ata Rezaei and Gilkes, 2005), conventional tillage system (Some'e et al., 2011) and northern forest of Iran (Khaledian et al., 2012).

The purposes of this study were to evaluate the influence of four aspect plus flat to assess soil quality in semi-arid agricultural field. This would enable the identification of areas where equipping and modernization of land is needed to improve crop growth.

STUDY AREA

The study area in Razavi Khorasan Province, in eastern Iran, is located between 57°55'52"-60°30'56"E and 35°12'39"- 37°05'46"N (Figure 1). The land uses of this ecosystem are cultivated. The average annual temperature and amount of precipitation are 12.5 °C and 202.8 mm (Razavi Khorasan Province Regional Water Co).

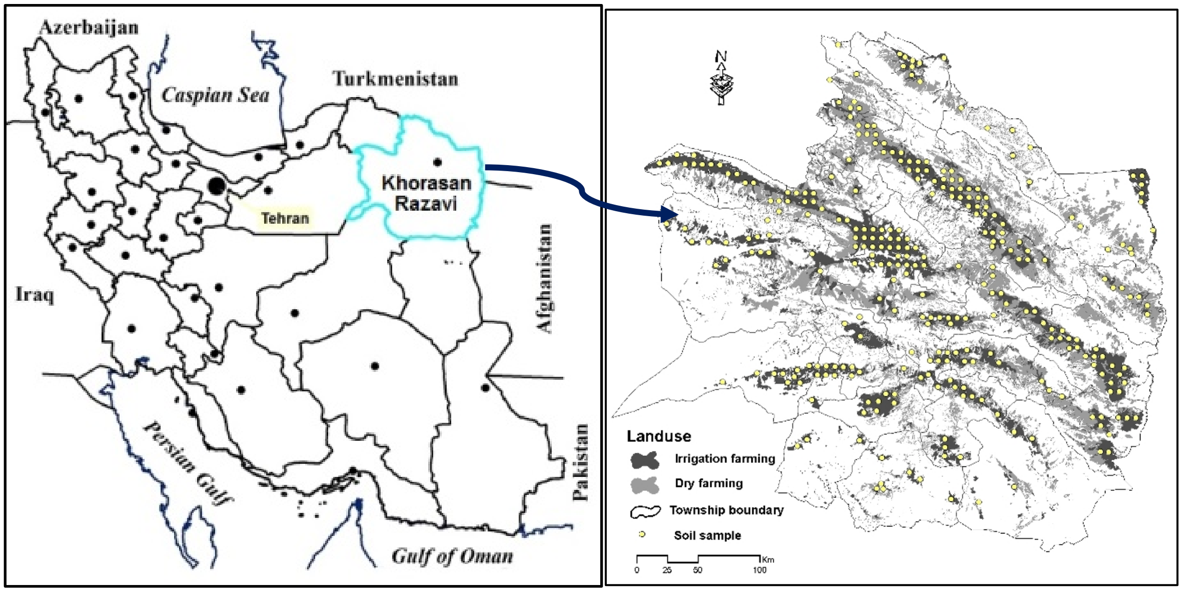


Figure 1: Layout of the Study area, a) Location of Khorasan Razavi in Iran map, b) Overly of landuse and soil sampling map on districts of Khorasan Razavi.

MATERIALS AND METHODS

Soil sampling

A research study was conducted to identify the soil fertility map of Khorasan Razavi. The study was funded by Soil and Water Management of Khorasan Razavi's Agricultural Organization in 2013. In this research around 325 soil samples were collected in two depths from the irrigation and dry farming landuse. All the samples were collected based on soil taxonomy standards and all chemical and physical characteristics of soils were measured in soil laboratory according to the standard guidelines. The main objective of this study was to assess changes in soil properties in different slope aspects and depths. For this purpose 30 soil samples were selected. The sampling design involved selection of a site in four geographical aspects and flat with cultivated lands in two depths (0-30 cm and 30-60 cm).

Laboratory analysis

In this research, particle size distribution was determined by the Bouyoucos hydrometer method (Klute, 1986). The soil pH was measured in saturated paste using pH electrode (McLean, 1982). TN was determined by Kjeldahl method (Bremner, 1996). Calcium carbonate was measured by titration method (Page, 1982). Also K+ (Sparks et al., 1996), Phosphorus and Fe (Wada, 1977) were measured.

Statistical analysis

For statistical analysis of the data, a factorial experiment (Factor 1: slope aspect in five levels and Factor 2: depth in two levels with three replications) based on the completely randomized was designed. Descriptive statistical analyses including mean, standard deviation, and coefficient of variation (CV) measures and one way analysis of variance (ANOVA) and mean comparison using LSD's test were conducted using SAS software (Page, 1982).

RESULTS AND DISCUSSIONS

Particle size distribution

Percentage of particle size distribution in four aspect and flat and in surface and subsurface depth had no a significant difference in soil texture (see table 1). The soil textural class in all aspects and depths are Loam. Marzaioli et al. (2010) showed similar soil texture in different land uses; therefore it was assumed that different aspect cannot create remarkable differences in soil quality.

Table 1: ANOVA result of chemical, physical and biological soil quality indicators in different land uses for the two study aspect positions

Indicators	Aspect	Depth	Aspect*Depth	Error	CV(%)
Df	4	1	4	20	-
pH	0.043^{ns}	0.9^{ns}	0.99^{ns}	0.024	1.95
SP	157.36^{ns}	5.41^{ns}	17.06^{ns}	80.9	24.24
CCE	16.26^{ns}	0.07^{ns}	1.033^{ns}	19.17	25.24
TN	$0.0.002^{**}$	0.001^{*}	0.0005^{ns}	0.0005	36.34
P	21.2^{**}	32.44^{**}	13.83^{*}	4.48	33.4
K	1530^{ns}	5917.15^{ns}	1127.5^{ns}	6688.43	33.58
Fe	6.95^{**}	0.164^{ns}	0.171^{ns}	1.52	32.82

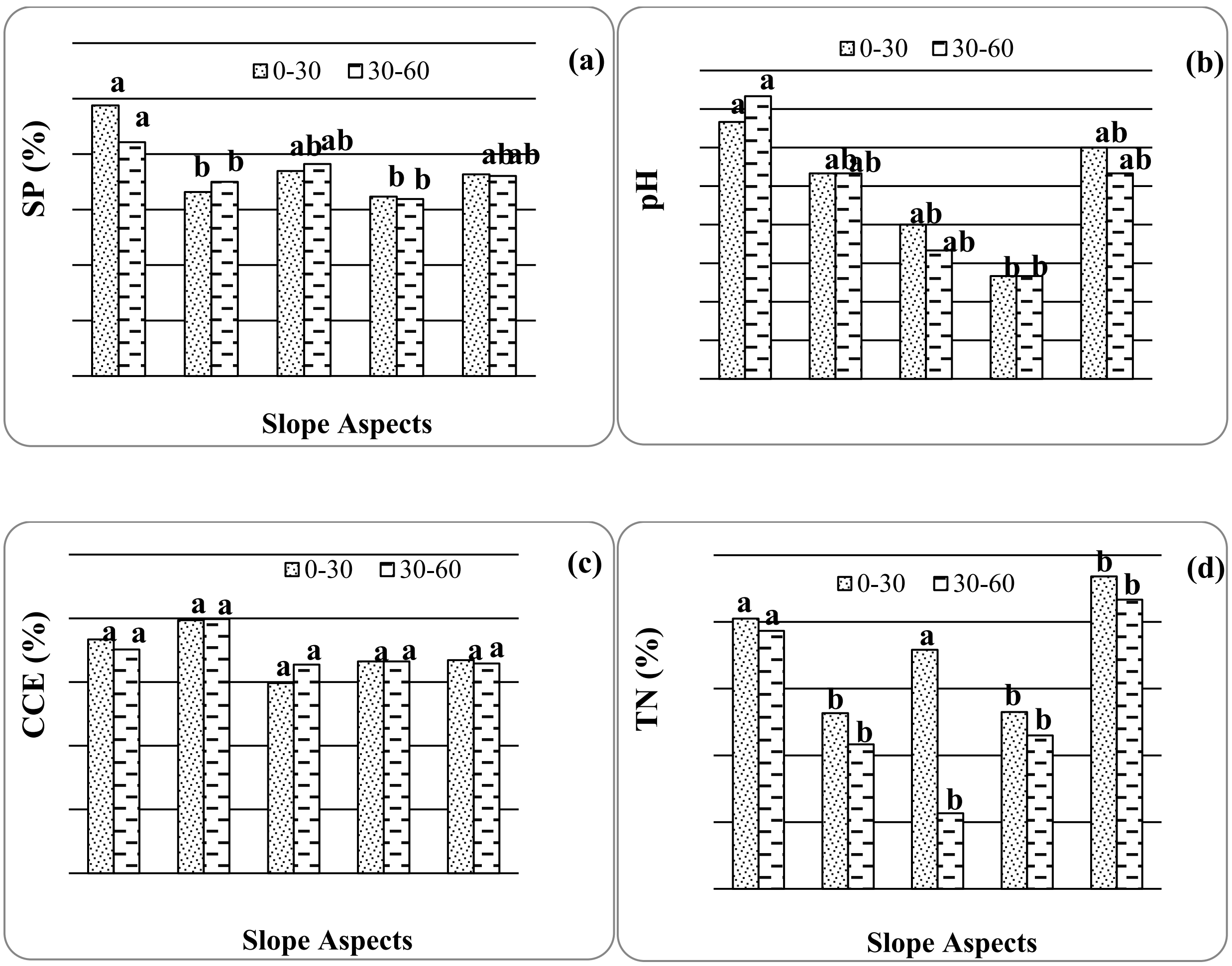
Numbers with the similar letters are not significantly ($P < 0.05$) different in four aspects in each depths.

SP, pH and CCE

Table 1 shows ANOVA result of saturated percentage in different slops for the two study depths. Although the amount of SP in flat and pH in flat and north received the highest percentage, there is no a statistically difference among all treatments in SP and pH (Figure 2(a)(b)) respectively. CCE in flat and east had a remarkable amount rather than the other aspects (Figure 2(b)), also we can see a significant difference among different aspects and between depths, it would mainly be due to having the same situation in terms of soil moisture and temperature regimes.

TN, P, Fe, K

Analyses of the variance of total nitrogen, phosphorus, potassium and Fe in the different slope positions are shown in Table 1. The results revealed that slope position had significant effects on properties such as total nitrogen (Figure 2 (d)), phosphorus (Figure 2 (e)) and Fe (Figure 2 (g)) at 5% level of confidence, whereas there was no significant relationship in potassium (Figure 2 (f)) in different slope aspects. These results are according to Khormali et al. (2007). The slope aspect indirectly affects the surface runoff and erosion. Slopes of the same gradient but with different aspects are not under the same risk of soil erosion. The main effect of the slope aspect on the surface runoff and erosion is through differences in the microclimate. The solar radiation received by a sloping landform is highly related to the aspect. The role of slope aspect is highly visible in the dryer regions than the humid areas (Zaidenberg et al., 1982).



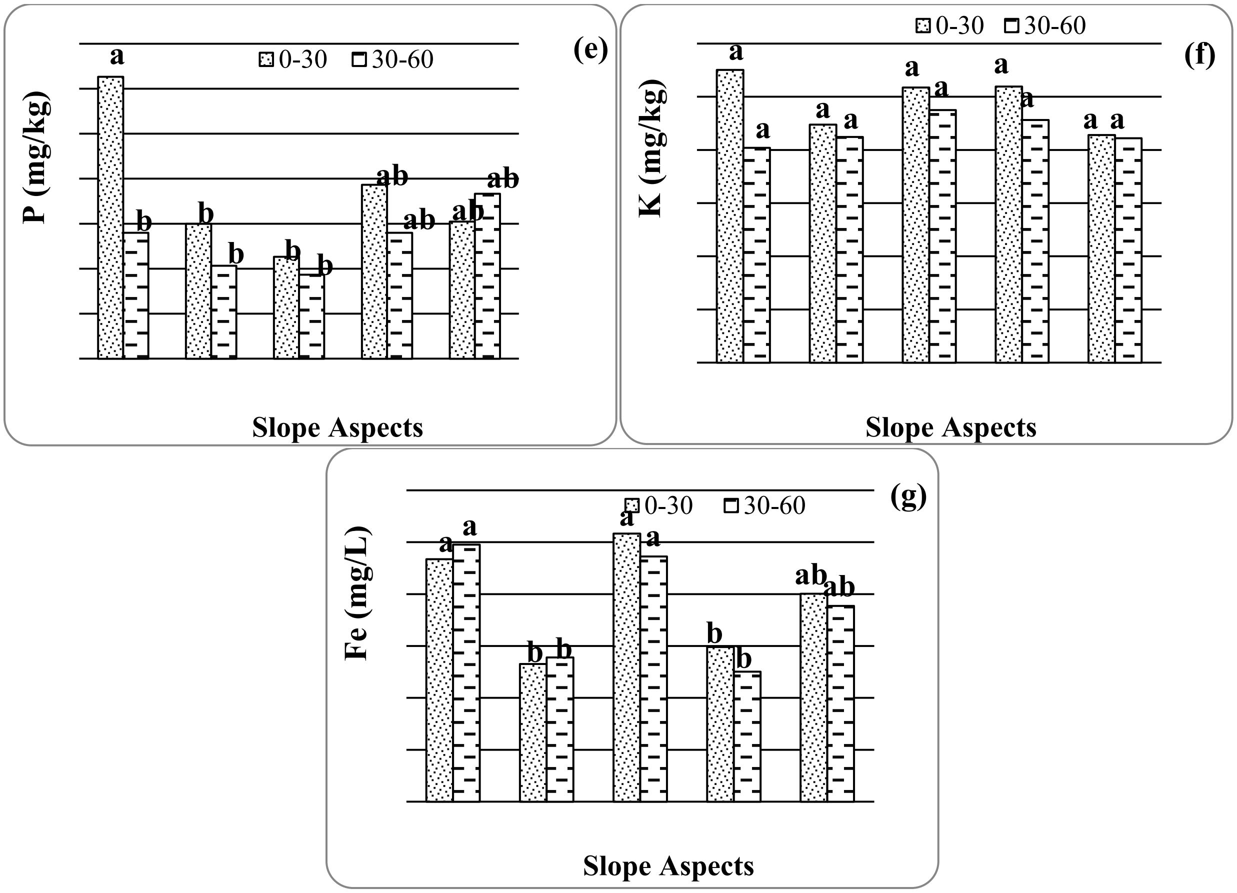


Figure 2: The chemical and physical parameters of soil quality including: SP (a), pH(b), CCE(c), TN(d), P(e), K(f) and Fe(g) on both depths of surface (0-30) and subsurface (30-60); Columns with similar letters in each land use are not statistically significant.

CONCLUSION

The results of this investigation indicated that total nitrogen, phosphorus and total nitrogen in surface layer (0-30) and iron in both surface (0-30) and subsurface (30-60) varied significantly on different slope positions. Potassium, pH, saturated percentage, calcium carbonate equivalent and soil texture were not significantly different. Totally, the slope aspect and depth did not significantly affect the soil properties mainly due to the almost uniform precipitation and climate condition in the area.

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