

[Nutrient Composition in the Ecosystem of *Olea europaea* cv. *aspani* in Derna, Libya]

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Abstract:

Olea europaea L. constitutes a source of many bioactive compounds, which have recognized benefits for both human health and technological purposes. Orchards varied much greatly in their nutrient concentrations. The aim of the present study was to assess the mineral nutrient composition of twelve olive agroecosystems under the environmental factors of Derna (Libya). Application of principal components analysis (PCA) for use with nutrient analysis and edaphic factors data was performed to test the distribution and similarity between orchards. Application of step-wise multiple regression model revealed that electric conductivity, soil texture, pH, CaCO_3 concentration and organic matter were the most important edaphic factors affecting nutrient concentration levels in leaves of *Olea europaea* (olive). The yield (Kg/ tree) was strongly affected besides these factors by tree age. Application of PCA proved that, the distribution of orchards in the three-dimensional plane varies along two gradients, (a) nutrient gradients in leaves and roots and (b) edaphic gradients of soil salinity, CaCO_3 , pH and organic matter (O.M).

Keywords: Olive; Aspani variety; PCA; Edaphic factors; Yield; Libya (Derna).



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1. Introduction

Olive (*Olea europaea* L., Oleaceae) is one of the oldest known cultivated plant tree species. The wild olive tree is an evergreen, prolonged species, extensive as a native plant in the Mediterranean province. This sanctified tree is an affluent source of important nutrients and bioactive of remedial and therapeutic interest. Olive fruit contains substantial concentration of fresh pulp weight of hydrophilic, lipophilic and phenolic compounds that are known to possess multiple biological activities such as antioxidant, anticarcinogenic, anti-inflammatory, antimicrobial, antihypertensive, laxative and antiplatelet (Parvaiz et al., 2013).

Olea europaea L. constitutes a source of many bioactive compounds, which have recognized benefits for both human health and technological purposes (Rashed et al., 2022). *O. europaea* trees are considered as one of the oldest recognized cultivated plants in the world, as they have been planted for approximately 6000 years. The current cultivation covers about 9 million hectares worldwide (Espeso et al. 2021). It is one of the most globally important long-lived Mediterranean fruit trees and its habitat is determined by the Mediterranean climate (Kabbash et al., 2019).

The Al Jabal Al Akhdar region contains 90% of the Libyan flora because it is the only area with reasonable amounts of rain. It is a regional hotspot of Mediterranean biodiversity. The major plant communities of the Al Jabal Al Akhdar region are dominated by dense Mediterranean maquis scrub, with cover reaching 70-80%. The plant communities resemble those of Crete and the western Mediterranean, rather than those of the eastern Mediterranean (Boulos, 1972).

The main objectives of this study were to evaluate the mineral nutrient composition of olive agroecosystems under the environmental factors of Derna (Libya) and application of principal components analysis (PCA) for use with nutrient analysis and edaphic factors data to test the distribution and similarity between orchards.

2. The Study Area

The present work was conducted at Derna (Libya). It is a coastal city in north-east Libya (Ahwide et al., 2013), is situated in the Jabal al-Akhdar mountain range. Derna experiences hot, dry summers and mild, wet winters thanks to its Mediterranean climate with cool sea breezes moderating the summer heat. It also experiences relatively mild winters in comparison to other regions of Libya, with average temperatures between 10°C and 18°C. Summers can be sweltering, with average highs of over 30°C. It is one of the wettest regions in Libya with 265 millimeters (11 inches) of annual rainfall on average.



Figure 1. A map to show the study area of Derna location

3. Materials and Methods

Twelve orchards were selected for this study. Eight representative trees were selected in each orchard for sampling of plant material and soil. The tillage practices in all orchards were carried out in the period; December- February. These practices include plowing between trees, weed control, insect control, plant disease control, pruning and application of manure and chemical fertilizers. The manure (15% moisture) was applied once at a rate of about 40-50 Kg / tree during the growth period in January by spreading. Superphosphate and ammonium nitrate applied also once at a rate of about 2-3 and 4-6 Kg / tree, respectively, at the end of February. The orchards received irrigation water from wells 2 times / month during winter and one time / month during summer.

Eight composites' samples; each consists of leaves and roots, were taken from each orchard. After washing and drying at 65° C, the samples were ground and digested with triple acid reagents (HNO₃: H₂SO₄: HClO₄) (10: 1: 1). The elements K, Ca, Mg, Cu, Fe, Mn and Zn were determined using

an atomic adsorption spectrophotometer. Micro-kjeldahl and stannous chloride methods were used for determination of N and P respectively. At each orchard, four soil samples were taken from beneath each tree at the zone of active roots (30- 60 cm). Samples were analyzed for deciding some of their physical and chemical properties. Procedures of all analysis were outlined by **Allen, (1989)**. Samples of plant material and soil were collected during the period June- July (2023) and the leaves were sampled from the fruitless spring shoot.

4. Statistical Treatments of the Results

A step-wise multiple regression models were used to select the most important edaphic factors influencing the nutrient concentration levels and yield of *O. europaea*.

Principal components analysis (PCA) was used for representing the similarity between orchards depending on the nutrient concentration levels in leaves and soils and the edaphic factors. Procedures of analysis are according to **Kwanchai and Arturo (1984)**.

5. Results and Discussion

5.1 General features of the orchards

The studied orchards were nearly homogenous in their size and growth. The major differences lie only in age, distance between trees (planting density) and yield (Table 2). Orchards 1, 2, 3, 4 and 5 were cultivated mixed with date palms and some organs while the remaining orchards were in pure cultures. Figure 2 showed the average mean of some morphological characters with its confidence intervals in *O. europaea*. It is clear that the confidence limits exhibited a narrow range of variability between orchards which confirmed the morphological similarity between the different orchards of the present study.

5.2 Mineral concentration

The average mean of different nutrient concentration in soils under *O. europaea* as well as its confidence intervals was illustrated in Figure 3.

Table 1. Different forms of land use and its area (ha) in Derna during 2020

Description	Area (ha)	%
Deep drainage water	4738.950	1.13
Sallow drainage water	2094.660	0.50
Flat sandsheet	21936.061	5.21
Sand dunes	109844.555	26.08
Calcareous soil and rock	236339.734	56.11
Pure salt crust	1321.380	0.31
Dense bankreed vegetation	3039.570	0.72
Moist sabkha + salt crust + tamarix	10799.190	2.56
Moist sabkha + sparse date palms + reed	2921.310	0.69
Moist sabkha without vegetation	14524.561	3.45
Dry and light sabkha	8219.790	1.95
Bersim garden + young olives	352.440	0.08
Pure date palms	175.770	0.04
Sparse date palms	2429.550	0.58
Dense mixed date palms and olives	639.360	0.15

Pure olives	173.970	0.04
Sparse rangeland	1649.160	0.39

Table 2. Age (year), planting density (number of trees / hectare) and yield (Kg / tree) of olive trees in the present study.

Features	Orchards											
	1	2	3	4	5	6	7	8	9	10	11	12
Age	100	50	100	100	50	50	15	10	60	60	35	70
Planting density	156	156	177	156	177	204	204	204	190	204	190	204
Yield	70	130	90	80	130	120	50	40	140	150	100	130

It is notable that N is the element with the highest mean concentration compared to all other elements and it has a wide range of variability in different orchards (0.39 ± 0.23 mg /g). Although the mean concentration of P and Mn was less than that of K, their upper limits in some orchards reached comparable levels of mean K concentrations. The average mean concentration (mg / g.d.w) of different nutrients in leaves and roots of *O. europaea* in all orchards and the deviation of each one from the mean was calculated. In general, leaves exhibited the highest concentrations of all elements if compared to roots. The highest concentrations of Fe and Zn; CA, P and K; Mn; Na and Cu; and Mg were attained by leaves in orchards 1; 3; 5; 8 and 12 respectively. On the other hand, orchards 3, 4, 7, 8, 9, 10 and 11 achieved the lowest concentrations of Zn, P, Mn, Ca, Fe and Cu, N, and Mg and K respectively. With respect to roots, elements N, Mg and P, K, Zn, Mn, and Fe, and Ca and Cu attained their lowest concentrations in orchards 2, 4, 7, 8 and 12 respectively. On the other hand, the orchards 1, 6, 8, 10 and 11 achieved the highest concentrations for N, Fe, Cu and Zn, for Mg, for P, for Ca and Mn and for K respectively. To go through with this, the highest concentrations of Fe and Zn were attained in orchards 1 for both leaves and roots. The lowest concentrations of P and Mn in leaves and of K and Zn in roots were attained in orchards 4 and 7 respectively.

It was obvious that there are great variations in the concentration of most nutrients among different orchards. These variations may be ascribed mainly by the variations in the soil factors, planting density and tree ages. **Sultanbawa and Sultanbawa (2023)** stated that mineral composition of plants is influenced by the growing environment, plant genetics and management practices. This affects claims about nutritional value of food plants. Environmental factors such as temperature, seasonality, and CO₂ levels as well as plant factors such as genetics, variety, root architecture, stage of growth etc. affect absorption of mineral nutrients. Performance of fruit trees is a product of several tree and non-tree characters. Each in turn is affected by habitat factors. The association of these with each other can provide useful information about how the habitat factors influence tree response as growth, yield, accumulation of nutrient elements and other useful metabolites (**Kwanchai and Arturo, 1984**). Fruit production tends to be highly unequal among trees of the same species, which may be due to environmental factors (**Minor and Kobe, 2019**). A step-wise multiple regression models was used to predict the most important edaphic, climatic and tree factors that influence nutrients concentration levels and yield of *O. europaea*. The X-variables (independent) introduced to the model were: soil texture, pH, organic matter (O.M), CaCO₃ concentration, electric conductivity (EC), water holding capacity (W.H.C) and hygroscopic moisture (H.M) as edaphic factors, air temperature as a climatic factor and age of trees as a tree factor. The Y- variables (dependent variables) were the concentrations of different nutrient elements in leaves and yield. The run of the model revealed that EC of soil solution significantly affected the concentrations of Fe, Mn and Zn. In addition, Fe and Mn were affected by O.M and Fe by CaCO₃

concentration in soil. The yield (Kg / tree) was strongly affected by texture, CaCO_3 concentration, O.M and pH of soil solution as well as by the age of tree on one hand, and by the concentration of N, P, K, Fe and Zn in soil on the other hand. The results confirmed those obtained by **Marschner (1986)** on crop plants and natural vegetation.

It of interest to compare the results of *O. europaea* presented here with those of other species of fruit trees. **El-Darier (1992)** reviewed that in *Citrus reticulata* and *C. aurantium*; pH and CaCO_3 concentration of soil solution were the most effective factors on the concentrations of more than 50% of the total elements, respectively. He also proved that Fe in *pisidium guauava* was highly affected by soil texture and EC of soil solution while K and Mg were affected by soil texture and CaCO_3 concentration in soil whereas P and Ca were affected by pH and conductivity of soil solution. Moreover, **Mengel and Kirkby (1987)** reported that pH influences the rate of nutrient uptake and accumulation in plant organs. PH directly affects nutrient availability in the rhizosphere and nutrient uptake by plants (**Ferrarezi et al., 2022**). Macronutrients such as nitrogen, potassium, calcium, magnesium, and sulfur are highly available at pH 6.0–6.5, while micronutrients become less available at higher, alkaline pH (pH > 7.0). Recent research has indicated that low PHS can enhance nutrient uptake and improve sweet orange (*Citrus sinensis*) tree health. The results also revealed that the elements N, P and K decreased with age, while Ca and Mg increased (**Ferrarezi et al., 2022**). The same results were obtained by **Mengel and Kirkby (1987)** on apple, citrus, fig, peach and pine trees and vegetables.

5.3 Principal components analysis (PCA)

Ordination revealed a summarization of a matrix whose elements define the spatial relationships between ecological entities. These entities (species, stands, environmental factors or habitats) are visualized as points in space with their attribute scores as coordinates. In the present study, principal components analysis was applied to achieve three-dimensional ordination of olive orchards based on nutrient concentration levels in leaves (a) and roots (b) and edaphic factors (c). The correlation coefficients were calculated between each element in leaves and roots and each soil variable on one hand and orchard position on each axis of the ordination on the other hand. The three axes were responsible for the separation and position of each orchard within the ordination space. In Table 3 (a) the X-axis showed a strong positive correlation with P, while its correlation with K, Mg, Cu and Fe was strongly negative. The Y- axis showed a strong positive correlation also with P and a strong negative correlation with N, K, Ca, Cu and Mn. The distribution of orchards on the basis of Fe, Zn, Mg and Mn was achieved through the Z-axis which showed a strong positive correlation with Fe and Zn and a strong negative correlation Mg and Mn. A strong positive correlation was notable between X-axis and N, Cu and Fe (Table 3 (b)). The negative correlation was noticed with K, Ca and Mn. Y- axis demonstrated strong positive and negative correlation with P and Mn respectively. With respect to Z- axis, positive correlation was clear with N, Ca and Mn while the correlation was negative with P and Zn. The results in Table 4 and Figure 5 indicated that X-axis revealed a strong positive correlation with CaCO_3 and EC, while the correlation was negative with pH and H.M. the distribution of orchards on the basis of O.M; H.M and W.H.C. was obtained through Y-axis. Negative correlation with CaCO_3 and EC was achieved through Z-axis. The multidimensional analysis permits the projection of different orchards within the space of a multidimensional ordination diagram. The relative position of each orchard is a function of its nutrient concentrations and soil factors.

The elements N, P, Ca and Mn exhibited a clear relationship with the coordinate values of the three axes. The relationship with the coordinates of axes X and Y was achieved by elements K and Cu,

while Mg and Fe was related to X and Z axes. Zn was related to Z-axis only. With respect to the edaphic factors; conductivity (EC) and CaCO_3 concentration of soil solution were the most important factors affecting the orchard distribution along X and Z axes. PH and O.M were related to X and Y axes respectively. It is therefore; clear that, the distribution of orchards in the study area varied along two gradients, (a) nutrient gradients and (b) complex edaphic gradients of soil salinity, CaCO_3 concentration, pH and O.M. these findings are in agreement with those proved by **Ayyad and El-Ghonemy (1976)** on the distribution of the natural vegetation in the western desert of Egypt.

Conclusion

The most significant finding of this research is the dependence of the nutrient concentrations of leaves and roots on the edaphic conditions represented by salinity, pH, CaCO_3 concentrations, soil texture and O.M. which was confirmed by the application of step-wise multiple regression. The distribution of olive orchards within the space of a multidimensional ordination diagram on the basis of nutrient concentration in leaves and roots and edaphic factors was highly significant. The primary effect on the distribution may be ascribed mainly to the edaphic factors rather than to nutrients which depend also on the edaphic factors.

Table 3. Simple correlation coefficient (r) between ordination axes and nutrient concentration levels in (a) leaves and (b) roots of *Olea europaea*. Asterisks denote a significant coefficient (at the 0.05 probability level).

Elements	Ordination axis					
	(a) Leaves			(b) Roots		
	X	Y	Z	X	Y	Z
N	0.070	-0.320**	0.220	0.324**	-0.226	0.478**
P	0.499**	0.397**	-0.164	-0.008	0.489**	-0.425**
K	-0.462**	-0.072	-0.037	-0.380**	0.073	-0.078
Ca	-0.033	-0.423**	-0.178	-0.357**	0.015	0.414**
Mg	0.360**	0.166	-0.315**	-0.030	0.142	-0.240
Cu	-0.304**	-0.393**	0.118	0.353**	0.049	0.208
Fe	-0.306**	-0.106	0.510**	0.498**	0.106	-0.151
Mn	0.161	-0.406**	-0.358**	-0.273**	-0.477**	0.472**
Zn	0.152	-0.073	0.291**	0.210	0.091	-0.312**

Table 4. Simple correlation coefficient (r) between ordination axes and edaphic factors. Asterisks denote a significant coefficient (at the 0.05 probability level).

Edaphic factor	Ordination axis		
	X	Y	Z
Texture	-0.005	-0.149	0.117
CaCO_3 concentration	0.233**	-0.112	-0.244**
Organic matter (O.M)	-0.090	0.398**	-0.057
pH	-0.262**	0.219	-0.165
Electric conductivity (E.C)	0.317**	0.191	-0.570**
Hygroscopic moisture (H.M)	-0.590**	0.391**	0.073

Water holding capacity (W.H.C)	-0.038	0.324**	0.079
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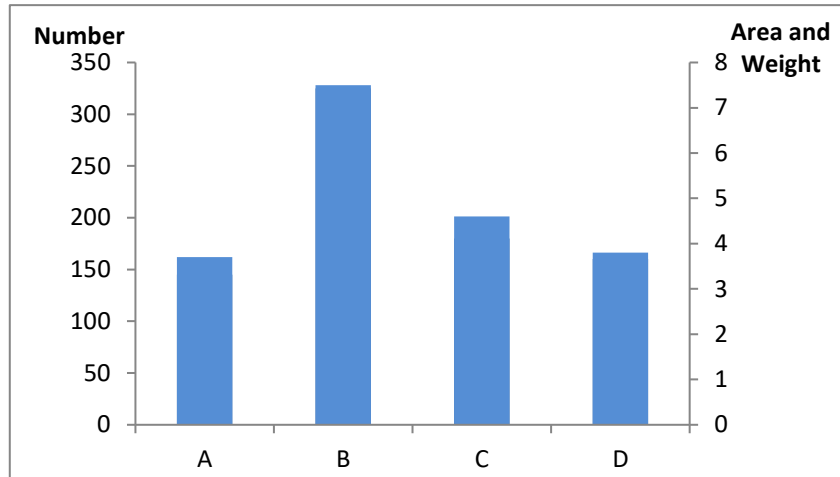


Figure 2. Average of twelve orchards and its confidence interval for some morphological characters in *Olea europaea*.

- A: average na of branches per tree
B: average na of leaves per branches
C: average area of a single leaf (cm)²
D: average dry weight of leaves (kg/ tree)

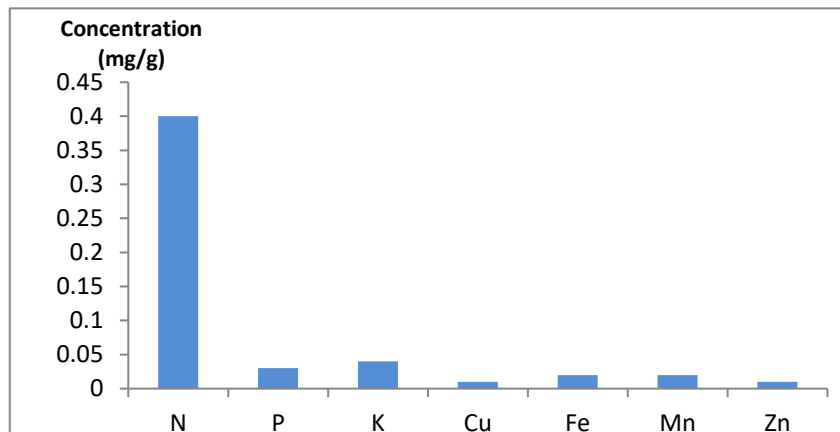
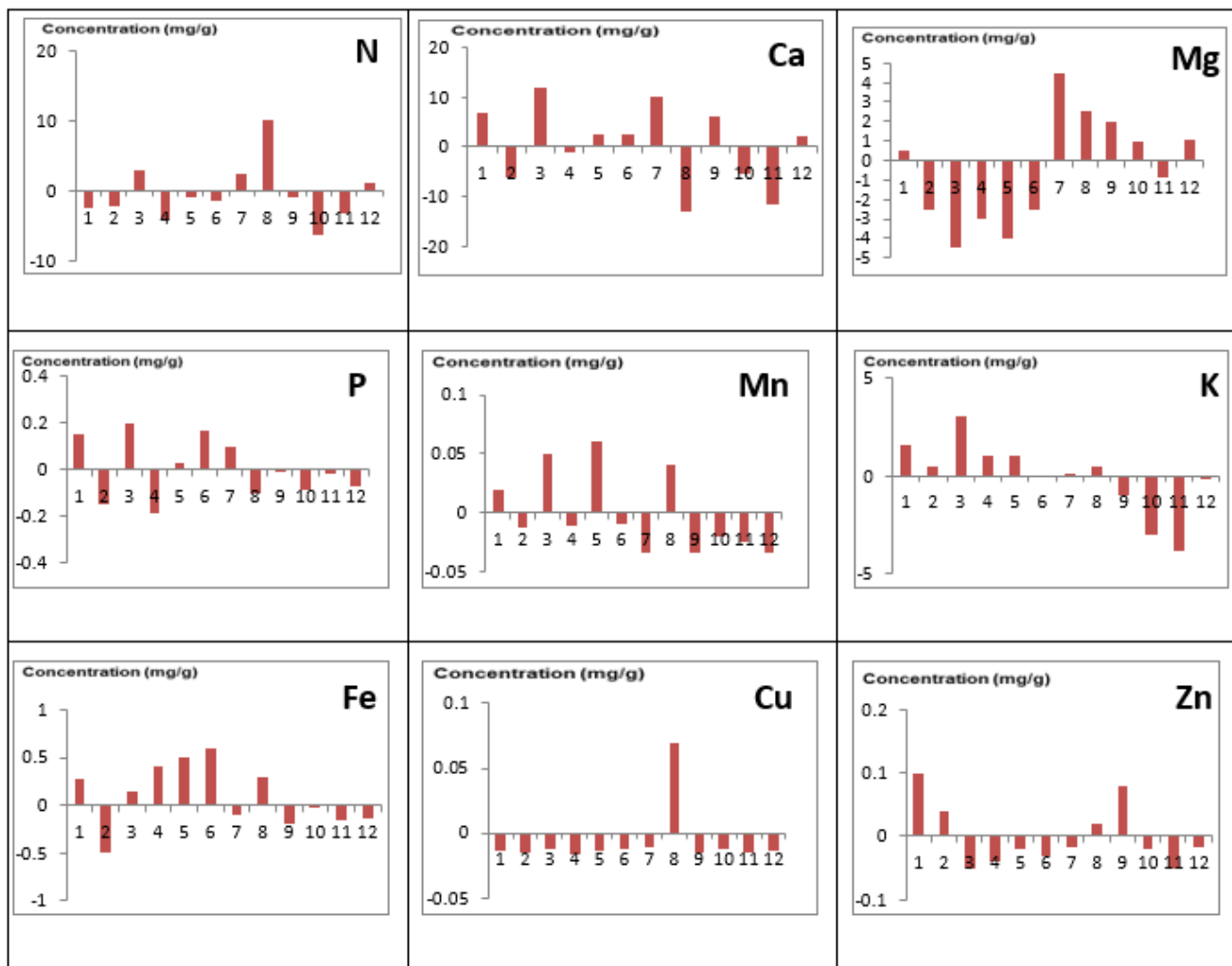


Figure 3. Average of twelve orchards and its confidence interval for different nutrient elements in the soil under *Olea europaea*.

Figure 4. Variation in nutrient concentration levels in leaves of *Olea europaea* for each orchard in relation to the means of all orchards.



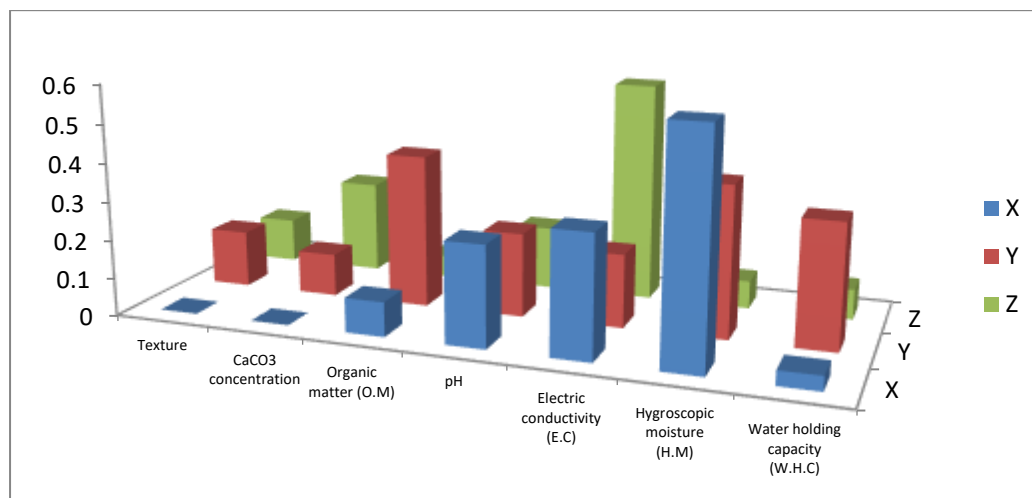


Figure 5. Simple correlation coefficient (r) between ordination axes and edaphic factors.

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