

# **Contribution of clay, Organic matter and PH to the cation Exchange in Taworgha Agricultural project soils**

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## **1-ABSTRACT**

Forty soil samples were collected from Taworgha Agricultural project in the spring season. Some physical and chemical properties of soils, including cation exchange capacity (CEC), PH, organic matter (OM) and particle size composition (sand%, silt%, clay%) were measured. The correlations among these physical and chemical properties were examined and a correlation analysis based on the Pearson correlation coefficient established. The results shown that most of the soils were sandy loam texture. The PH values of soils range from 7.3 to 8.3. The OM percentage range from 0.08 to 1.04 %, clay % range from 0.60 to 29.70 % and CEC of soils range from 3.80 to 12.50 meq /100g dry soil. Pearson correlation analysis showed insignificant positive correlation between CEC of soils and both OM, clay % ( $r = 0.17, 0.25$ ) respectively. However, the correlation coefficient between soil CEC and soil PH was insignificant negative correlation ( $r = - 0.27$ ).

## **2-INTRODUCTION**

Soil cation exchange capacity (CEC) is an important chemical property of agricultural soils, which reflects the retention and supply capacity of soil fertilizer. CEC is an important indicator for evaluating soil fertility, crop growth, Cation exchange capacity (CEC) and usually expressed in mill equivalents per 100-gram dry

soil. It is a measure of the quantity of readily exchangeable cations neutralizing negative charge in the soil. Due to the mutual influence of soil physical and chemical properties, there are significant differences in CEC among different soils. Many studies showed that physical and chemical properties of soil, such as OM, PH and particle size composition have significant effects on CEC. Another important factor influencing the CEC was the presence of organic materials Martel *et al.* (1978). Soil organic matter has an important effect on the physicochemical status of highly weathered soils in the tropics, it was responsible for 75- 85 % of the CEC of these soils Oorts *et al.* (2003). Highly significant multiple correlation coefficient of 0.97, 0.96 and 0.91 respectively were calculated for the relationships of CEC (me/100g soil) and clay content with water content at -33kpa, -1500 kpa and with  $\Delta W$  Astrid and Lambooy (1984). Manrique *et al.* (1991) found poor predictions of CEC resulted from clay for Aridisols and Vertisol, indicating that factors other than clay interfered with accurate predictions of CEC.

Another important factor influencing the CEC to percent clay ratio was the presence of organic materials in the samples. Wright and Foss (1972) found that the correlation coefficients of clay and organic matter with CEC in the Coastal Plain Ap horizons were 0.90 and 0.76 respectively, and 88% of the variation in CEC could be attributed to these components. Martel *et al.* (1978) found that the variations in the mineralogical composition, although small, were sufficient to explain nearly 50 % of the variation in the CEC. The clay mineralogy is important to predict the CEC of clay-rich soils where the contribution of clay is 3.5 to 5 times greater than that of organic matter. Parfitt *et al.* (1995 )found a significant

effect of interaction between organic matter and some clay minerals on the CEC. Other sources of CEC or variability in the clay mineralogy, organic matter composition, or both in these classes of data were obtained by Drake *et al.* (1982). Charles *et al.* (1964) found that the mean relative contribution of organic matter to total CEC of 60 Wisconsin soils were varied from 19% at PH 2.5 to 45% at PH 8.0, the mean organic matter and clay contents of the soils studied were 3.28% and 13.3% respectively. Matschonat and Vogt (1997) reported that the decreasing acid deposition will not inevitably increase CEC because in some soil PH effects may be balanced by simulations decrease in ionic strength.

Cotrufo *et al* (2019) reported that more than half of soil organic carbon is chemically or physically associated with soil minerals. These interactions limit microbial access to otherwise decomposable substrates Cotrufo *et al* (2013). Climate- and land-use-induced changes to soil may alter soil organic carbon cycling and the human land-use and land-cover change have resulted in a significant net loss of soil carbon over the past two centuries Sander man *et al* (2018).

### **3 -TEST AND ANALYSIS METHODS**

#### **3.1 – Soil samples**

Forty soil samples were randomly collected from Taworgha Agricultural Project, located about 300 km east of Tripoli on the Mediterranean coast. 20 soil samples from 0-50 cm depth and other 20 samples from 50-100 cm depth were collected in the spring season. The weight of each soil sample was 2 kg, soil samples were sieved using a 2mm sieve after air-dried.

### **3.2. Test methods of soil physical and chemical properties**

After air-drying, four kinds of physical and chemical properties were determined respectively. The soil particle size ratio was carried out using a standard hydrometer method as described by Black *et al.* (1995). The P<sup>H</sup> value was measured in a 1:2.5 suspension of soil in distilled water using a combination P<sup>H</sup> glass electrode. OM was determined by potassium dichromate volumetric method-external heating method (Rowell, 1994). The CEC was determined by the replacement of adsorbed sodium from the soil sample by extraction with neutral 1 M ammonium acetate solution (Bower *et al.*, (1952).

### **3.3-Data analysis method**

For experimental data analysis, Excel program was used as the data processing tool. SPSS17 program was used for correlation analysis of data.

## **4- RESULTS AND DISCUSSION**

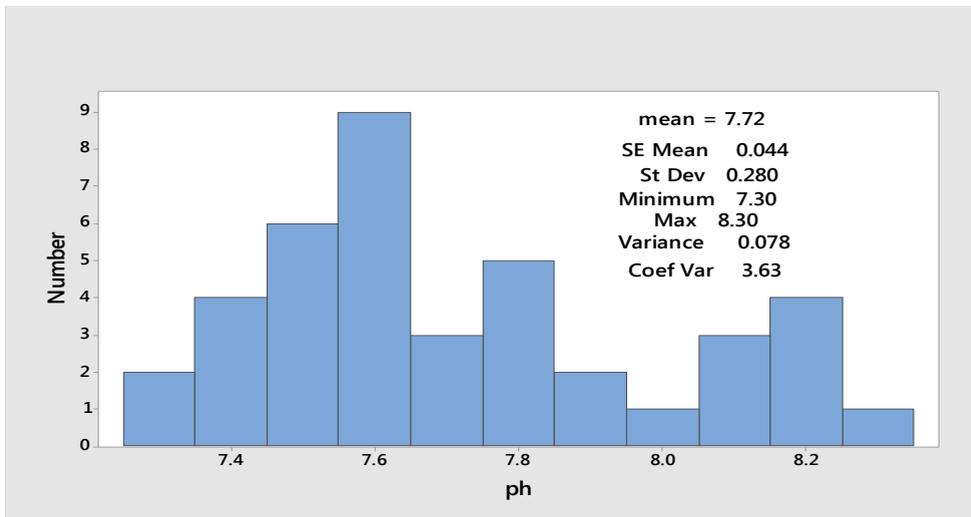
### **4.1 Distribution of main physical and chemical properties of soils**

Figures 1-4 list the statistical distribution of four basic physical and chemical properties of the measured soils. In this study, soils were classified by soil texture according to the international classification method. The classification results showed that most soil textures are sandy soils. The P<sup>H</sup> values range from 7.3 to 8.3 (Fig 1). The range of OM is 0.08 – 1.04 % (Fig 2). The CEC of soil samples range from 3.8 to 12.5 meq/100g dry soil (Fig 3) and the clay percentage range from 0.60 to 29.70 (Fig 4). The

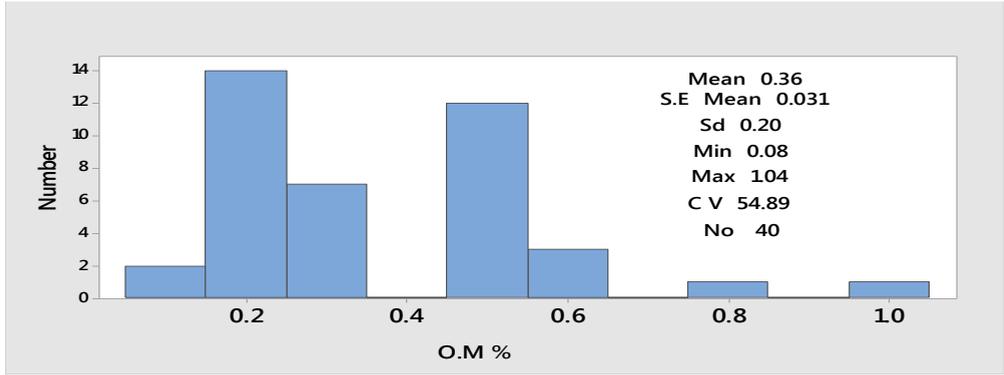
coefficient of variation (CV) for  $P^H$ , OM, clay and CEC of soils were 3.63 %, 54.89 %, 69.92% and 36.29 respectively. The variation of soil properties might be related to parent material, forming environment, tillage and utilization.

## 4.2 Correlation analysis

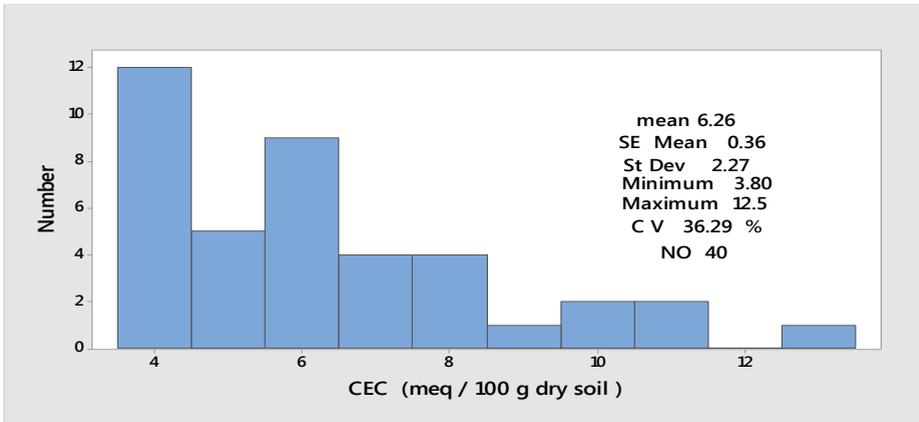
Based on the Pearson correlation coefficient data analysis, the observed soil CEC showed insignificant positive correlation with clay and OM, and the correlation coefficients are 0.257 in turn ( $P>0.05$ ) and 0.170 and in turn ( $P>0.05$ ) but it showed obvious insignificant negative correlation with  $P^H$ , and the correlation coefficient is  $-0.271$  in turn ( $P>0.05$ ). In this study, it was found that the relationship between CEC and PH value different from the conclusion that there is a significant negative correlation between CEC and  $P^H$  in the study of Zhang *et al.* (2011) which could be related to the regional distribution and variability of studied soil samples.



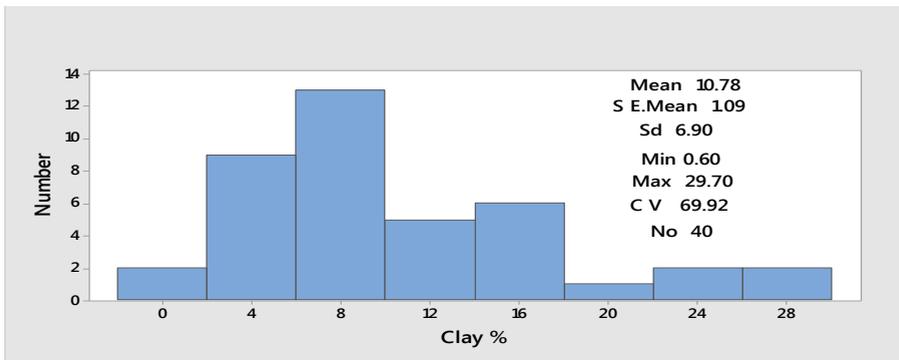
**Fig 1 – Distribution of soil  $P^H$**



**Fig 2 – Distribution of soil OM%**



**Fig 3 – Distribution of soil CEC (meq / 100 g dry soil)**



**Fig 4 – Distribution of soil clay%**

## 5- CONCLUSION

The results from this study shown that there were differences in Soil PH, OM, particle size composition and CEC levels of the soil samples under study. The PH values of soils range from 7.30 8.30. The OM contents range from 0.08 to 1.04 %. The CEC values of soils range from 3.80 to 12.50 meq/100g dry soil and the clay content was varied from 0.6 to 29.70%. Correlation analysis showed that the contents of clay and OM in soils are insignificantly positively correlated with CEC, while the soil PH is insignificantly negatively correlated with CEC.

## Recommendations

Through the results obtained from this study, it was shown that weak positive correlation coefficient exists between the cation exchange capacity and the percentages of both clay and organic matter, in addition to the presence of a negative correlation coefficient between the cation exchange capacity and soil P<sup>H</sup>. Therefore, we recommend studying this research topic on a large scale at other different depths and studying the effect of other factors effects the on the cation exchange capacity of the soil under study such as the effect of the calcium carbonate percentage.

## 6- REFERENCES

- 1-Astrid & Lambooy. 1984. Relationship between cation exchange capacity, clay content and water retention of Highveld soils. South African Journal of Plant and Soil 1, 33-38.
- 2-Black, C.A., Evans, D.D. & White, J.L. 1965. Methods of Soil Analysis. American Society of Agronomy. Inc. Wisconsin USA.

- 3-Bower, C.A., Reitemeier, R.F. & Fireman, M. 1952. Exchangeable cation analysis of saline and alkali soils. *Soil Science* 73, 251 -261.
- 4- Charles.S., Helling,G. V., Chesters, R.B., Corey. 1964. Contribution of Organic Matter and Clay to Soil Cation-Exchange Capacity as Affected by the pH of the Saturating Solution. *Soil Science Society of America Journal* 28, 517-520
5. Cotrufo, M. F., Wallenstein, M. D., Boot, C. M., Deneff, K. & Paul, E. 2013. The Microbial Efficiency-Matrix Stabilization (MEMS) framework integrates plant litter decomposition with soil organic matter stabilization: do labile plant inputs form stable soil organic matter? *Glob. Chang. Biol.* 19, 988–995
- 6- Cotrufo, M. F., Ranalli, M. G., Haddix, M. L., Six, J. & Lugato, E. 2019. Soil carbon storage informed by particulate and mineral-associated organic matter. *Nat. Geosci* 12, 989–994.
- 7- Drake, Elissa.H., Motto,Harry, L. 1982. An analysis of the effect of clay and organic matter content on the cation exchange capacity. *Soil Science* 133, 281-288.
- 8- Manrique, L.A., Jones, C.A., Dyke, P. T. 1991. Predicting Cation-Exchange Capacity from Soil Physical and Chemical Properties. *Soil Science Society of America Journal* 55. 787-794
- 9- Martel, Y.A., De Kimpe, C.R., Laverdiere, M.R. 1978. Cation-exchange Capacity of Clay-rich Soils in Relation to Organic Matter, Mineral Composition, and Surface Area. *Soil Science Society of America Journal* 42, 764-767.
- 10- Matschonat, G., Vogt, R. 1997. Effects of changes in pH, ionic strength, and sulphate concentration on the CEC of temperate acid forest soils. *European J of Soil Science* 48, 163-171.

- 11- Oorts, K., Vanlauwe, B., Merckx, R. 2003. Cation exchange capacities of soil organic matter fractions in a Feeric Lixisol with different organic matter inputs. *Agriculture Ecosystems and Environment* 100, 161–171.
- 12- Parfitt, R.L, Giltrap,D.J., Whitton, J.S. 1995. Contribution of organic matter and clay minerals to the cation exchange capacity of soils. *Communications in Soil Science and Plant Analysis* 26: 1343-1355.
- 13-Rowell, D.L. 1994. *Soil Science. Methods and Applications.* John Wiley and Sons Inc. New York.
- 14- Sander man, J., Hengl, T. & Fiske, G. J. 2018. Soil carbon debt of 12,000 years of human land use. *Proc. Natl Acad. Sci. USA* 115, 1–6.
- 15-`Wright, W.R & Foss, J. E. 1972. Contributions of Clay and Organic Matter to the Cation Exchange Capacity of Maryland Soils. *Soil Science Society of America Journal* 36, 115-118.
- 16-Zhang, S., Huang, S., Guo, D. 2011. Correlation and prediction models of Cation Exchange Capacity in three soils in Henan. *J of Soil Science* 42, 627-.