Plant Archives Vol. 19, Supplement 2, 2019 pp. 135- 139 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

EFFECT OF NATURAL ZEOLITE MINERAL AND GROUND ZEOLITE IN PHYSICAL PROPERTIES OF SOIL

Nisreen Aqeel Hussain and Abdul Mohsin Abdullah Radi
Agriculture College, University of Al-Muthanna, Iraq

Abstract

This study was conducted in the area of Basatin Mohamed Ali, located in the Muthanna Governorate for the winter season 2017-2018 to study the effect of zeolite metal on the physical properties of the soil of the experiment. The study investigated the effect of 4 levels of natural zeolite metal was 0, 1, 2, 3, 4% and 4 levels of ground zeolite 0, 1, 2, 3 and 4%. The experiment was carried out by designing the whole randomized sections with three replicates. The use of zeolite metal has improved the physical properties of the soil in general. The values of virtual density have been reduced from 1.243 to 1.013 Mg m^{-3}at the level of 4% natural zeolite and 0.887 Mg $m^{-3}$for the ground metal and reducing the real density values which increased porosity values but natural zeolite Pore values were increased to 47.33 and were mined to 43.46. The soil uptake was increased from 0.575 cm $min^{-1/2}$ in the comparison treatment to 0.70 cm $min^{-1/2}$ at 4% normal zeolite and 0.425 cm $min^{-1/2}$ zeolite, The natural zeolite increases the ratio of soil-filled water to a higher percentage than grounded by 13.09-20.26%, respectively They are natural zeolite to raise the values of the weighted average soil diameter to 0.94 mm beating ground 1.03 mm.

***Keywords*: Zeolite, Physical properties, Silty Loam Soils**

Introduction

The physical characteristics of the soil are of great importance in improving the productivity of soil soils and many studies have been testing some soil enhancers to develop these properties and Zeolite among these enhancers. Zeolite is a natural substance made up of crystalline aluminum silicate and is one of the most common minerals in sedimentary rocks (Ramesh and Reddy, 2011). It consists of fine particles with diameters (149-297 microns), large surface area and the ability to exchange ions (Moattar and Hayevipour, 2004). Zeolite has high porosity and low density (Ramesh *et al.*, 2015) and has the ability to absorb cations and anions (El-Tilib *et al.*, 2014) and has a high cathodic exchange capacity (Ramesh and Reddy, 2011) and has abundant cavities and channels capable of adsorbing water and nutrients (Cabanilla *et al.*, 2016) Molecular Sieving is a solid porous solid material M with a molecular size of 0.3-2.0 nm (Kulprathipanja, 2010) and selective adsorption (Kwakye-Awuad, 2008). Natural zeolite has been widely used as a poor clay soil enhancer (Noori *et al.*, 2006) as it improves its structure and soil permeability (Sabri, 2001) and improves zeolite water and nutrient management system (Tállai, 2011). Kazamian (2012) In agricultural activities, soil conditioners are considered to improve their physical and chemical properties such as water filtration, saturated water availability, soil conservation capacity, ion exchange capacity, which is 2-3 times greater than the rest of the minerals in the soil (Ramesh *et al.*, 2015) and 50% (Sangeeth and Baskar, 2016) (Durukan, 2014). Zeolite has contributed to the improvement of soil properties by increasing the values of cation exchange capacity, degree of reaction, reduction of electrical conductivity and salts in soil (Abdel Hassan, 2018). The study aimed at determining the effect of natural zeolite on the properties of physical soil and some chemical properties related to physical soil properties.

Materials and Methods

A field experiment was carried out during the agricultural season (2017-2018) in the orchards of Mohamed Ali, located in Muthana Governorate, along the length line 45.278777 and the width of 31.327489, in order to study the effect of addition of natural zeolite metal on the properties of physical soil and the growth and yield of soft wheat *Triticum aestivum* L. In an experiment whose coefficients included two forms of zeolite, natural and symbolized by the symbol (N) and the mill and symbolized (Z) with five levels of zeolite (0-1% -2% -3% -4%) and three replicates for both natural and flat forms. After preparing the soil of the experiment of plowing, softening and settling, The soil samples were taken from depth of 0-30 cm from different locations of the field, mixed well for homogenization, air-dried and softened using a polyethylene hammer, and passed from a 2 mm diameter sieve, from which a compound sample was taken for the purpose of estimating some chemical and physical soil characteristics of the soil (Table 1). And then the field was divided into squares of area (2 * 3 = 6M) according to the design used Each panel included 12 lines with a length of 2 m and 20 cm between the lines using a hand made to adjust the distance between the lines and left a stand between the experimental units with a distance of 0.5 m and replicates distance of 3 m In addition to the drains, To the boards allocated to agriculture and according to the above levels mixed with soil at a depth of 20 cm, one week before planting. Then the plates were planted with seeds of the class used on 15 November at a rate of 120 kg. Hectar[1], phosphate fertilizer was added at once in agriculture with 30 kg. Superphosphate fertilizer (P_2O_5). Nitrogen fertilizer was added to the quantity of 50 kg per Acres, by two payments at the end of the plantation phase and before the expulsion of the spice and in the form of urea fertilizer (46% N) (1993). Potassium fertilizer was added 20% kg per Acres, Iron and zinc components at a rate of 50 ppm organic fertilizer has been added to all experimental units at a rate of 2%. The crop service operations were carried out from the preparation of the land to the agriculture till the harvest. Each experimental unit was irrigated from the date of planting till the date of maturity and as needed. The control was carried out using the(Refugil) herb, and the bushes were cultivated as needed and harvested on 21/4/2018. The experiment was carried out by designing two-way randomized whole sectors for both natural and ground metal using (R.C.B.D) and three replicates. The physical properties of the soil after the harvest and for all the treatments were estimated. The density was calculated in the Core Sample method (Black and 1965) and porosity was estimated from the values of the virtual density and the real density according to Vomocil method (Black and others 1965)

From the relationship: Total porosity% = 100 * (real density / virtual density -1)

According to the content of the water prepared Aw) by the difference between the volumetric content of the water at 22 kPa of the soil, which represents the field capacity and the soil moisture content of the soil at 1500 kPa, which represents the permanent wilt point according to the following equation :

$$A_w=\theta_{fc} - \theta_{WP}$$

The absorbability of the soil was measured by water from the speed of moisturization of the aggregates according to the method proposed by Al-Ani and Dudas (1988) and developed by Al-Khatib (2000) by taking total soil aggregates (3 g) and the time record for absorption was 0.2 cm 3. The following relationship: $S=0.1211t^{-½}\rho_b^{2/3}$

S / Absorption cm.s$^{-1/2}$, t / time, min, ρb / virtual density microgram.

A method for measuring water conductivity saturated with soil, using a fixed water column as the soil surface is subjected to constant water pressure, the water is stable and the Darcy law is used to calculate the value of ks.

$$K = \frac{v \times L}{A \times H \times T}$$

K / Water Desalination (cm.min^{-1}), V/ Water Size (cm ^{3}), L / Soil column length (cm)

A / soil section area (cm^2), T / Time (s), H / Water compressor (cm).

The weighted mean was estimated by taking soil samples, sifting with an 8 mm sieve and collecting on a 4 mm sieve and taking 15 g of them and placing it on a set of sieves of 4.75, 2.36, 1.0, 0.6, 0.3, 0.125, 0.075 and 0.053 mm after moistening with the poetic properties The process of sieving in a device rotates at a speed of 30 min, 1 min for 6 minutes, the contents of each sieve were transferred to a moisture tray, dried in the oven at 105°C and the soil weight was recorded on each sieve,) According to the formula proposed by Black and others (1965) and as follows:

$$M.W.D = \sum_{i=1}^{n} X_i W_i$$

As: M.W.D / Weighted diameter (mm), Wi / mass clusters as a ratio to the total weight of the model (without units), Xi / The rate of those clusters (mm).

Data were analyzed after data was collected and tabulated statistically using the Genestat program. The mean of the coefficients was compared according to the L.S.D Least Significant Difference at the probability level (0.05) and Steel (1997).

Table 1 : Some physical and chemical properties of pre-planting soil.

Adjective		**the value**	**Unit**
Chemical properties	Soil reaction (PH)	7.22	——
	Electrical conductivity (ECE)	4.90	dsm^{-1}
	Nitrogen ready	11.2	mg kg^{-1}
	Phosphorus Ready	14.1	mg kg^{-1}
	Potassium ready	165.4	mg kg^{-1}
	Cation Exchange Capacity (CEC)	8.98	C .Mol kg-1
Physical properties	sand	14	gm kg^{-1} soil
	Green	60	gm kg^{-1} soil
	Clay	26	gm kg^{-1} soil
	Soil tissue	Silty Loam	

Table 2 : Some physical and chemical properties of zeolite metal.

Adjective	Value	Unit
PH reaction rate	7.3	____
Electrical conductivity EC	0.01	dsm^{-1}
Bulk density	0.09	Mg m^{-3}
Partial density	1.0	Mg m^{-3}
Porosity%	91	%
Cation exchange capacity CEC	Natural 75.43, Grounded 83.79	C .Mol kg-1

Results and Discussion

The results of the statistical analysis (Table 3) showed the moral effect and the apparent role of zeolite on the values of the apparent density when treated with soil. The table shows that the average mean density of natural zeolite at 4% normal zeolite was 1.013 Mg m^{-3} and 1.177 Mg m^{-3} at 3% of the metal while (0.887), (0.937) Mg m^{-3} for the 2% and 4% respectively of the molten cellulite, respectively. This is the difference in the nominal density values of natural cellulite and millonite compared to the non-treated cellulite (1.670) Mg m^{-3} may be due mainly to the properties of the metal that have improved soil construction and increased porosity Thereby reducing bulk density. In general, the soil density showed a significant gradual decrease in the value of natural zeolite (1.243 to 1.013.1.177.1.260) Mg m^{-3} at the rate of zeolite (1 to 4.3.2%) and 0.937 to 0.887, 977, 1.080) Mg m^{-3} for the same levels of crushed cellulite. This decrease may be due to the increase in metal to porosity of zeolite, which is permeated by many gaps and channels and its effect on physical soil properties, especially the apparent density

(Hassan and Mohmoud, 2013). The natural zeolite recorded higher values of 1.013 Mg m^{-3} compared to the recorded zeolite which recorded lower values of the apparent density of (0.877) Mg m^{-3}. This may be due to the difference in the nature of the minute form of the metal itself and any increase in the softness of metal minutes The surface quality of the soil and the improvement of its structure and the proportion of pores total, which increases the reduction of the apparent density of the mineral ground compared to the natural metal.

The table shows a significant effect of zeolite in the real density profile. The real density values of both treatments are decreased from natural zeolite and ground zeolite with the addition of the metal additive level. The results showed a difference in the values of the real density of the transactions. The treatment gave 4% ground zeolite (1.570) Mg m^{-3} less than the normal zeolite treatment (2.130) Mg m^{-3} for the same level and the comparison of these values with the comparison treatment 0% zeolite (2.583). In the reduction of the quality of both treatments as the real density in the treatment of the zeolite ground from 1.580 to 1.880, 1.637, 1.570 Mg m^{-3} when the metal level increased from (1 to 2, 3, 4%) zeolite respectively, The table also indicates an increase in the decrease in the real density values with the increase of the percentage of metal added in the natural zeolite treatment (2,203 to 2.173, 1.947, 2.130) mg m^{-3} at the same levels of metal addition and respectively. These differences may be attributed to the role of the metal in improving the properties of the physical soil and to the low value of the actual density of the metal itself. The results showed an increase in the values of soil porosity with increased soil zeolite ratios. At the level of 4% of the natural zeolite treatment, the porosity values increased to 47.33% and 43.46% at the same level of the zeolite ground. When comparing these values with the comparison treatment, 0% zeolite 35.34 showed high morale differences, The treatment of natural zeolite from 43.34 to 43.73, 39.25, 47.33 % when the metal was upgraded from 1 to 2,3,4 % respectively. This may be due to the effect of zeolite on the improvement of (Al-Busaidi et al,2007) Zeolite works to improve the soil structure and reduce soil density, thus improving soil porosity due to its construction of the spacers (Al khalaf, 2010). This result is in line with the findings of the study (Abdel-Hassan, 2018). It showed that the high porosity effect of the zeolite mineral, which in turn affects the pores of the soil, thus improving the soil porosity system, reducing the density of both treatments and increasing the total porosity values of the soil.

The results of the statistical analysis shown in Table (4) showed the effect of zeolite soil additive in raising the soil hydraulic conductivity values in the zeolite treatment these values increased from (0.9400) m day^{-1} in the comparison treatment to (1.4667) m^{-1} day in the zeolite treatment Ground at 4%. The results showed that the increase was significant with the increase in the metal level. The hydraulic conductivity gradually increased with the increase of the added ground zeolite mineral. The results showed an increase in the saturated water conductivity values from 1.0200 to 1.1267, 1.3467, 1.4667 m day^{-1} in the level zeolite ground (1% to 2, 3, 4%) Overall, the treatment showed 4% Zeolite crushed with a significant effect on both treatments. The natural zeolite treatment also behaved differently in this capacity if the water delivery values decreased with the increase in addition Metal from (0.8833 to 0.8167, 0.7633, 0.7133) m day^{-1} for the same levels respectively. It is clear that the treated zeolite treatment showed an increase in this characteristic, unlike the natural zeolite treatment, which showed a decrease. This may be due to the clogging of soil pores with natural zeolite minutes. Zeolite helps improve the horizontal distribution of water after irrigation (Polat *et al.*, 2004). This is due to the fact that the pores were smaller and more numerous in this treatment and the loss of zeolite has many properties that help to spread horizontally when grinding. This is consistent with (Yasuda *et al.*, 1998). It was found that the ground zeolite had a high cation exchange capacity that helped raise hydraulic conductivity values. This corresponds to what (Ahmed *et al.*, 2006) mentioned in the contribution of zeolite in improving the physical and hydrological properties of the soil surface layer as an increase in the filtration of soil water by increasing porosity, thus reducing the rotting of the plant roots and improving the chemical properties of the soil, (Sangeetha and Baskar, 2016) The possibility of zeolite retention of water more than half its weight due to high porosity. The results showed (Table 4) that there was a significant effect on the treatment of natural zeolite in the absorption properties. The table shows the values of absorbance indicators in the natural zeolite treatment (0.7020) cm $min^{-1.2}$ and 0.6897 cm $min^{-1.2}$ at the addition level of (4%) and (3%) respectively. The comparison of these values with the treatment of 0% zeolite (0.5753) cm $min^{-1.2}$ shows the role of the metal in increasing this characteristic and significantly different from the other zeolite levels. In the natural zeolite treatment, the absorption values increased from (0.5753) cm $min^{-1.2}$ to (0.6897) (0.7020) cm $min^{-1.2}$ at the level of the added metal from 0% to (3) (4)% respectively. These differences may be due to the fact that the mineral is able to increase the amount of water stored in the soil compared to the soil without the addition of Zeolite (Torres, 2016) Natural increase in the soil as well as the role of metal in the absorption of water, as demonstrated by (Sulakhudin and Sunarminto, 2011) Detaining the added water and improving its soil management. In the treatment of molten zeolite, the elevation of the added metal showed different behavior did not significantly affect the absorption values, if these values decreased from (0.5753) cm $min^{-1/2}$ to (0.3907) (0.4440) (0.4470) (0.4250) respectively. When the metal is added from 0% to (1) (2) (3) (4%) respectively in the soil, this may be due to the grinding of the metal making the soil texture semi-clay and the soil granules These differences in the absorption values of natural zeolite and mill are due to the fact that the natural zeolite mineral improves the physico-chemical properties of the soil And high capacity for absorption and slow release of micronutrients and micro-nutrients depending on the chemical soil environment because it is highly absorbent. It contains large water-filled cavities capable of supplying ready-made water for a longer period of time compared to non-treated soil (Jakkula, 2005) Less cavities than natural metal have less water absorption. These results are consistent with his findings (Abdel-Hasan, 2018). The results showed (Table4) that there was a significant effect of zeolite in the Water available content. The soil capacity for water retention increased with the addition of natural zeolite mineral. The highest average for natural zeolite treatment was 20.26% at 4%. When comparing this value with the comparison treatment, 0% zeolite with an average of 14.62%. The role of the metal in increasing the ratio of ready water in this soil is attributed to zeolite susceptibility to increasing water retention due to The connection between water and negative charges carried by zeolite and thus increase the moisture content of the soil. The remaining levels of natural zeolite treatment (1, 2, 3) showed an average of 16.78, 18.86 and 19.41%, while the treated zeolite showed a significant decrease in the mean water averages (10.04, 10.21, 10.48 and 13.09) The levels (1, 2, 3, and 4) were zeolite, respectively, when compared with the 0% Zeolite treatment, which gave an average of 14.62%. The results of Table (4) showed that the natural zeolite treatment was significantly higher than that of zeolite ground, with the highest value of both treatments at 4%, where natural zeolite had a value of 0.7020%, and the zeolite ground treatment was 0.4250% These results are in line with (Ramesh *et al*., 2015) The use of zeolite in modifying the properties of sandy soils resulted in an increase of 50% (Xiubin and Zhanbin, 2001) that structural structure The dilution of cellulite helps soil ventilation and improves its ability to retain water and nutrients through ionic absorption and exchange. It stores water for a long time and improves the horizontal distribution of water in the root zone and loss of water from the mineral does not affect its crystalline structure. The results showed that the effect of different treatments on some physical properties, including the apparent density of soil, was the reason for this increase. The improvement of the structure and stability of assemblies and the volume distribution of pores all increase the moisture content of the soil and thus increase the ready water as a result of improved building. Dry areas to provide water and reduce the number of irrigation. Zeolite promotes rapid soil re-hydration of high absorption capacity and is a source of negative charges that attract positively charged aggregates such as water and ammonia, improve water and nutrient efficiency, reduce runoff and sediment by increasing soil capacity in water storage (Jakkula and Wani, 2018). The results of the statistical analysis (Table 4) showed significant differences in the effect of the added metal levels in the weighted mean ratio of Soil aggregate stability. The treatment exceeded 4% natural zeolite with a value of (1,947) mm compared with 0% zeolite which recorded a value less (0.198) mm. In the values of the stability of the soil complexes with the increase in the level of addition of the metal if the values rose from (0.545) to (0.818) mm, (1.179) mm and (1,947) mm when lifting the metal from (1) to (2), (3), (4) % respectively and increased in the treatment of ground zeolite from (0.283) mm to (0.412) mm (0.771) mm (1.034) mm respectively for the same levels. This is due to the fact that zeolite has an important role in improving the physical properties of the soil and improving the soil structure by increasing the construction standards represented by the weighted diameter. Zeolite has a large surface area and a high exchange capacity that enables it to increase the absorption of minutes to the cations, Fixed it. (Moritani *et al*., 2010) showed that the addition of 10% zeolite to the soil improved the weighted average water (MWD) and saturated water solubility of decreasing the sodium exchange rate, resulting in a decrease in soil dispersion.

Table 3 : Zeolite effect in the values of both Bulk density, Partial and porosity.

Attributes studied			Added levels	Added levels
Porosity (%)	**Partial Density(Mg m^{-3})**	**Bulk Density(Mg m^{-3})**		
35.34 b	2.583 e	1.670 f	0	Control
43.34 a	2.203 d	1.243e	1	Natural Zeolite
43.73 a	2.173 d	1.260 e	2	
39.25 ab	1.947 cb	1.177 de	3	
47.33 a	2.130 cb	1.013 bc	4	
40.73 ab	1.580 a	0.937 ab	1	Ground zeolite
42.40 ab	1.880 b	1.080 cd	2	
40.28 ab	1.637 a	0.977 ab	3	
43.46 a	1.570 a	0.887 a	4	
N.S	0.2188	0.1051	$L.S.D_{0.05}$	

Table 4 : Effect of zeolite in Hydraulic conductivity (m.day^{-1}), Sorptivity (cm min$^{-1.2}$), Available water (%) and Soil aggregate stability (mm).

Attributes studied				Added levels %
Soil aggregate stability	**Available Water %**	**Sorptivity**	**Hydraulic conductivity**	
0.198 e c	14.62 c	0.5753 b	0.9400 e	0
0.545 d	16.78 b	0.5113 c	0.8833 f	1
0.818 c	18.86 a	0.5453 b	0.8167 g	2
1.179 b	19.41 a	0.6897 a	0.7633 h	3
1.947 a	20.26 a	0.7020 a	0.7133 i	4
0.283 c	10.04 d	0.3907 e	1.0200 d	1
0.412 c	10.21 d	0.4440 d	1.1267 c	2
0.771 b	10.48 d	0.4470 c	1.3467 b	3
1.034 a	13.09 c	0.4250 d e	1.4667 a	4
0.283 c	1.966	0.05717	0.04367	$L.S.D_{0.05}$

References

Abdel-Hassan, S.N. (2018). Using Zeolite Metal in Improving the Physical Properties of Different Tissue and Growth of Wheat Plant, Al-Muthanna University, Faculty of Agriculture.

Ahmed, O.H.; Aminuddin, H. and Husni, M.H.A. (2006). Reducing ammonia loss from urea and improving soil exchangeable ammonium retention through mixing triple superphosphate, humic acid and zeolite.

Al-khalaf, I.A. (2010). Study the effect of adding different levels of zeolite ore on the fertility and moisture properties of irrigated land in the Euphrates basin area. Master degree in Soil and Land Reclamation Department, Faculty of Agricultural Engineering, Euphrates University.

Al-Busaidi, A.; Yamamoto, T. and Irshad, M. (2007). The ameliorative effect of artificial zeolite on barley under saline conditions. Journal of Applied Sciences, 7: 2272-2276.

Black, C.A. (1965) Methods of soils analysis. Amer. Soc. of Agro. Inc. USA.

Cabanilla, C.C.; Canillas, N.C.; Molinos, J.A. and Palmes, L.J.K.S. (2016). Effects of pH initial concentration and zeolite loading on the removal of nitrates from synthetic wastewater using rice hush-derived zeolite.

Durukan, S.; Pulat, H.F. and Yukselen-Aksoy, Y. (2014). Suction characteristics of compacted zeolite-bentonite and sand–bentonite mixtures. Waste Management; Research, 32(2): 149-156.

El-Tilib (2014). Disposal in Soil of Waste Zeolite Produced by Khartoum Petroleum Oil Refinery and its Potential Use as a Soil Amendment Emirates Journal of Food and Agriculture. 25(9): 713–22.

Hassan, A.Z.A. and Mahmoud, A.W.M. (2013). The combined effect of bentonite and natural zeolite on sandy soil properties and productivity of some crops. Top class Journal of Agricultural Research. 1: 22-28.

Jakkula, S.V. (2005). Synthesis of zeolites and their application as soil amendments to increase crop yield and potentially act as controlled release fertilizers thesis presented for the degree of Doctor, University of Wolver Hampton.

Jakkula, V.S. and Wani, S.P. (2018). Zeolites: Potential soil amendments for improving nutrient and water use efficiency and agriculture productivity. Scientific Reviews; Chemical Communications. 8(1): 1-15.

Klute, A. (1965) Laboratory measurement of hydraulic conductivity of saturated soil. in Black, C.A. et al., (ed). Methods of soil analysis. Agron, Madison Wisconsin.

Kulprathipanja, S. (2010). Zeolites in industrial separation and catalysis. John Wiley; Sons.

Kwakye-Awuah, B. (2008). Production of silver-loaded zeolites and investigation of their antimicrobial activity. Ph.D. thesis, University of Wolver Hampton.

Moattar, F. and Hayeripour, S. (2004). Application of chitin and zeolite adsorbents for treatment of low level radioactive liquid wastes. International Journal of Environmental Science; Technology. 1(1): 45-50.

Moritani, S.; Yamamoto, T.; Andry, H.; Inoue, M.; Yuya, A. and Kaneuchi, T. (2010). Effectiveness of artificisal zeolite amendment in improving the physicochemical properties of saline-sodic soils characterized by different clay mineralogies. Australian journal of soil Research Report 9JAPA.

Noori, M.M.; Zendehdel, B. and Ahmadi, A. (2006). Using natural Zeolite for the improvement of soil salinity and cro yield A Department of Biology. Faculty of Science. University of Arak, Arak-Iran. Pages: 77-84.

Polat, E.; Karaca, H. Demir and Onus, A.N. (2004). Use of natural zeolite (clinoptilolite) in agriculture. Journal of fruit and ornamental plant research, 12(1): 183-189.

Ramesh, K. and Reddy, D.D. (2011). Zeolites and their potential uses in agriculture. In *Advances in agronomy* 113: 219-241.

Ramesh, K., Biswas, A.K. and Patra, A.K. (2015). Zeolitic farming. Indian Journal of Agronomy. 60(2): 50-56.

Sangeetha, C. and Baskar, P. (2016). Zeolite and its potential uses in agriculture: A critical review. Agricultural Reviews, 37(2): 101-108.

Steel, R.G.D.; Torrie, J.H. and Dickey, D.A. (1997). Principles and Procedures of Statistics: A Biometrical Approach, 3rd Ed. McGraw Hill Book Co. Inc., New York, USA.

Sulakhudin, A.S. and Sunarminto, B.H. (2011). Zeolite and its potential uses in agriculture : A critical review. Agricultural Reviews, 37(2): 101-108.

Tállai, M. (2011). Effect of Bentonite and zeolite on characteristics and change of microbial activity of acidic humic sandy soil (Doctoral dissertation, Ph.D. thesis submitted to University of Debrecen, JenoHankoczy Doctoral school of plant production, Horticultural and food sciences).

Torres, M. (2016) Moisture retention and salinity control using zeolites in soil, The University of Texas at El Paso.

Xiubin, H. and Zhanbin, H. (2001). Zeolite application for enhancing water infiltration and retention in loess soil. Resources, Conservation and Recycling, 34(1): 45-52.

Yasuda, H.; Takuma, K.; Fukuda, T.; Araki, Y.; Suzuka, J. and Fukushima, Y. (1998). Effect of zeolite on water and salt control in soil. Bulletin of the Faculty of Agriculture, Tottori University 51: 35–42.

Younis, A.H.A. (1993). Product and Improvement of Agriculture CVrops. The Ministry of Higher Education and Scientific Research, University of Baghdad.