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Evaluation of Vermicompost and Zeolite Ability to Improve Water and Nutrients Retention in A Sandy Soil

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ABSTRACT

Improving water retention and nutrients in sandy soils is crucial for agricultural productivity under water shortage. Vermicompost (V) and Zeolite (Z) were applied to soil as alone or mixture to quantify their effect on sandy soil properties, physiological efficiency of nutrients and water use efficiency of cultivated wheat under three levels of moisture content (100, 80 and 60% from filed capacity) for 60 days in pot experiment. Treatments of vermicompost and zeolite were control-,1 and 2% as alone and 0.5%V+0.5%Z ,0.5%V+1%Z, 1%V+0.5%Z and1%Z+1%V as combined. The mixture of 1% Z+0.5% V had higher fresh and dry weights of wheat, macro nutrients content and uptake by wheat under all levels of moisture content as compared to other treatments. The WUE and Physiological efficiency of NP and K increased significantly by increasing the rates of zeolite and vermicompost either alone or mixture, especially at the lowest moisture content of field capacity. Soil porosity, bulk density, and the availability of soil macronutrients and water were associated by applications of zeolite and vermicompost. So, the synergistic effect of zeolite and vermicompost that carried out during the period of experiment on soil properties and nutrients uptake clearly occurred. Hence these results are enhancing plant growth under water shortage which can be used to improve, cultivate new areas and to enhance water use efficiency of wheat plant.

***Keywords**:* Water retention, sandy soil, zeolite, vermicompost, wheat growth.

INTRODUCTION

Water scarcity has become one of the main factors affecting land sustainability, especially in sandy soils. Water shortage is one of the main factors which effect on growth, yield of many crops in soil. Soil moisture is one of the most important factors affecting nutrient use efficiency in crop plants (Fageria 2013). Sandy soil had a lower organic matter content and nutrients. Plant growth and productivity depend on the availability of nutrients in soil. Also, plants often face major challenges in obtaining an adequate supply of these nutrients to meet the demands of essential processes under water shortage (Fahad *et al.*, 2017). Leaching of nutrients is a major threat to soil water pollution, particularly in sandy soils with low nutrient and water holding capacity (Tahir and Marschner 2017), that causes water pollution (Abbasi *et al.*, 2015). Generally, application of organic wastes to sandy soils is a common trend in the environment and agriculture to improve soil quality.

Zeolite can be used to improve soil properties under drought, boost the effects of chemical and organic fertilizers (Najafi-Ghiri 2014). The use of zeolite in sandy soils improved soil properties, and nutrients availability and consequently decreased the soil pollution (Khalifa *et al.*, 2019). Also, zeolites assure a permanent water reservoir, providing prolonged moisture during dry periods; they also promote a rapid re-wetting and improve the lateral spread of water into the root zone during irrigation. This results in a saving in the quantity of water needed for irrigation. Zeolites application improving the use efficiency of water and nutrients and thus reduce the risk of environmental pollution occurring due to nitrate leaching and emissions of nitrous oxides and NH_3 (Bernardi *et al.*, 2016). Vermicomposting is a process through which earthworms transform organic residues into compost that can be used as a substrate for plant growth (Blouin *et al.*, 2019). Vermicompost is a nutrient-rich, microbiologically active organic decomposition that results from interactions during the breakdown of organic matter between earthworms and micro-organisms. Bulk density, porosity available water capacity, and hydraulic conductivity, were positively influenced by addition of vermicompost (Demir 2019). The integrated supply of nutrients through organic and inorganic sources could be an effective practice of nutrient and water management by using organic materials. So, it is very important to manage both availability of water and nutrient to increase soil productivity. Amending sandy soil with vermicompost and zeolite can probably retain soil moisture, reducing nutrients losses and enhancing plant growth, which can lower water usage in agricultural activities. Hence, there is an imminent need to improve the water and nutrients retention, water productivity by improving the physical and chemical properties of sandy soil. This study mainly carried out to evaluate the effect of zeolite and vermicompost on some physical and chemical properties, water retention and fertility status of sandy soil under water shortage.

MATERIALS AND METHODS

In order to improve the retention of nutrients, water use efficiency, and improving wheat growth in sandy soil under water shortage, a pot experiment was conducted at

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the Faculty of Agriculture, Al- Azhar University, Nasr city, Cairo, Egypt, during the winter season of 2018.

Experimental design

The experiment was arranged in a randomized complete block design with 27 treatments with three replicates as follows: moisture contents, including three levels from field capacity (100, 80 and 60%), and application of zeolite (Z) and vermicompost (V) (1, 2 %) as alone. Also, mixture of 0.5 % Z +0.5% V, 0.5% Z+1% V, 1% Z+0.5% V, and 1% Z +1% V were added. The total amount of water applied during the period of the experiment were 6.2, 4.96 and 3.72 liter per pot, which versus 100, 80 and 60 %, from field capacity, respectively. Plastic pots of 25 cm, inside diameter and 30 cm, depth filled with 5 kg sandy soil; whole soil was mixed with the above mention treatments before planting. 20 seeds were cultivated in every pot. After germination the plants of each plot were thinned at 10 seeds of wheat *(Triticum aestivum*, sakha var. 93). Mineral fertilizers were applied according to the general recommendation dose of the Ministry of Agriculture**.** Nitrogen fertilizer rate was split into three doses as ammonium nitrate (33.5 % N) at rate of 358 $kg.fed^{-1}$., super phosphate 15% P_2O_5 (200 $kg.fed^{-1}$) was added during soil preparation and potassium sulfate 48% K_2O (50 $kg.fed^{-1}$).

Soil sampling

Soil samples from each pot were taken after harvesting, air- dried, crushed and passed through a 2 mm sieve and kept for soil analysis. A part of the prepared soil was analyzed for some physicochemical properties as well as its moisture content were determined by a gravimetric method, available macronutrients according to the methods described by Cottenie *et al.,* (1982), Klute (1986), and Page *et al.,* (1982). Total porosity was calculated according to the formula: soil porosity = 1- (bulk density/particle density) x100 (Blake and Hartage 1986). Water use efficiency (WUE) of dry matter was calculated according to Stanhill (1987) from the following equation:

$$WUE\left(\frac{kg}{m^3}\right) = \frac{Total\ yield\ of\ dry\ matter\ (kg)}{Total\ water\ applied\ (m^3)}$$

The obtained data of soil chemical and physical properties are presented in Table 1. Also, chemical composition of the zeolite and vermicompost are presented in Table 2.

Plant sampling

After 60 days from planting, wheat shoots of each treatment were cut just one cm above the soil surface, washed several times by tap water followed by distilled water and their fresh weight were obtained. The shoots were oven dried at 70°C to a constant weight, then dry weights were recorded. The dried plant tissues were ground using a mill and kept for plant analysis. A half g of dry matter from each sample was digested by using a mixture of concentrated perchloric and sulphuric acids (1: 3) according to Chapman and Pratt (1961). Then, the plant digests were diluted with distilled water to a volume of 50 ml. Macronutrients content was analyzed according to Cottenie *et al.,* (1982). Physiological efficiency (PE) was calculated by Gerloff and Gabelman (1983).

$$PE(kg\,kg^{-1}) = \frac{(dry\ mater\ in\ treated\ state\ kg - dry\ mater\ in\ control\ kg)}{(ntrient\ uptake\ in\ treated\ state\ kg - nutrient\ uptake\ in\ control\ kg)}$$

Statistical analysis

The data obtained were statistically analyzed according to Snedecor and Cochran (1989). Significantly different was calculated at a 5% level of probability.

Table 1. Some chemical and physical properties of the investigated soil

Chemical properties											
pH	**EC** $dS\ m^{-1}$	**CEC** $cmol_c\ kg^{-1}$	**OM%**	**Soluble cations** $mmol_c\ l^{-1}$				**Soluble anions** $mmol_c\ l^{-1}$			
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
7.91	1.67	3.25	0.36	4.20	2.50	8.90	0.60	0.00	5.20	7.80	3.20
Available macronutrients $mg\ kg^{-1}$			Physical properties								
N	P	K	Bulk density $Mg.m^{-3}$	particle density $Mg.m^{-3}$		Porosity %	FC %	Sand	Silt	Clay	Texture class
38.00	8.00	66.50	1.60	2.65		39.62	9.00	87.50	8.80	3.70	Sand

Specification of zeolite and vermicompost

Zeolite is described as good permeability, relatively high density and high-water retention. (Central metallurgical Research and Development Institute (CMRDI). (Alix zeolite company- Giza). Vermicompost is the end-product of the breakdown of organic matter by earthworms, and contain a higher water-soluble nutrient.

Table 2. Physical and chemical characteristics of zeolite and vermicompost

Zeolite										
Physical properties										
Bulk density $Mg.m^{-3}$	**Particle density** $Mg.m^{-3}$	**Porosity %**	**Total pore area** $M^2\ g\ m^{-1}$	**Solubility %**	**Swelling index**	**Color**	**Humidity %**	**Hardness**	**Grain size**	**pH**
1.83	2.38	23.20	35.84	7.38	2.52	Greyish white	6.75	4	<6 mm	6.8
Chemical composition										
K_2O%	Ca O %	Na_2O%	SiO_2%	Al_2O_3%	Na_2O%	MgO%	Fe_2O_3%	TiO_2 %	Zr O_2 %	P_2O_5 %
3.27	3.58	0.78	62.22	11.10	0.03	0.60	4.03	0.34	0.11	0.03
Vermicompost										
pH	EC $dS\ m^{-1}$	OC %	OM %	C/N ratio	Total macronutrients %					
					N		P		K	
6.65	4.30	29.00	49.88	12.34	2.35		0.68		0.50	

RESULTS AND DISCUSSION

Wheat fresh and dry weight

Data presented in Table 3 show that there are significant increases in fresh (FW) and dry weight (DW) of wheat plant as a result of vermicompost and zeolite treatments addition under different levels of field capacity (FC). It noticed that, zeolite was more effective than vermicompost for improving fresh and dry weight under all levels of moisture content. Improvement of plant growth as a result of zeolite application may be due to improving soil conditions which, in turn, enhancing biological processes which led to an increase in various plant metabolites responsible for cell division and elongation because application of a natural zeolite is considered a slow plant-nutrient releaser (Na *et al.,* 2011).

This may be due to naturally occurring groups of minerals may promote plant growth by enhancing nutrient availability and water availability. These data are in agreement with those obtained by Demir (2019). The highest values of FW and DW were recorded 64 and 11.80 g.pot^{-1}, respectively at 2% zeolite under 100 %FC, as compared to control (100% FC) which were 57.80 and 10.50 g.pot^{-1}, respectively. This may be due to water and nutrition availability improvement by zeolite. Zeolite improved plant growth, water holding capacity, nutrient retention and availability (Bernardi *et al.,* 2016).

Generally, fresh and dry weights were increased significantly with increasing the addition rates of mixture vermicompost and zeolite. The increasing in fresh and dry weight of wheat plants could be attributed to the improving root environment caused by mixture of zeolite and vermicompost application. Mixture of 1% zeolite + 0.5% vermicompost gave the highest values of FW an DW under all levels of moisture content. The highest values of FW and DW were 69.0 and 15.13 g.pot^{-1}, respectively as compared to other treatments.

NPK content and uptake of wheat plant

Data presented in Table 4 show that amended sandy soil with vermicompost and zeolite as alone or mixture clearly stimulated the content of macronutrients of wheat plant under all levels of moisture content. Generally, the decreasing in water availability limited the concentrations of total nutrient in wheat plants. Decreasing in macronutrients during drought are correlated with decreases in levels of nutrient-uptake by plants (Deepesh *et al.,* 2018). NPK content of wheat plant was increased significantly by increasing the addition rates of vermicompost and zeolite alone or mixture under all levels of moisture content. Use of zeolite in arid and semi-arid areas reduced the water stress conditions, it considers a highly absorbent of water (Islam *et al.,* 2011). The highest values of N and P content were 1.57%,0.58 %, respectively at 1% Z+0.5 V under 100% FC. While, the highest value of K content was 1.57 % at 1% Z+1% V, as compared to other treatments.

It is a known fact that ionic uptake by plants is controlled by the external and internal ionic concentration, selectivity and plant energy levels as well as water absorption. The data indicated that increasing rates of mixture zeolite and vermicompost were increased N, P and K uptake (mg.pot^{-1}) significantly, compared to other treatments. Zeolites are effective controlled nutrient release materials that are highly useful to improve plant uptake of nutrients especially NPK (Ramesh *et al.*, 2015). The highest values of N P and K were 257.21,87.75 and 234.52 mg.pot^{-1}, respectively at 1% Z+0.5%V under 100 % FC. The reason for this increasing behavior could be attributed to the effect of vermicompost and zeolite on raising organic matter levels, consequently availability of N, P and K or availability of water content in the sandy soil. While, the lowest values of N, P and K uptake were recorded at 60 % FC under all treatments. The use of fertilizers mixed with zeolite remarkably increased N, P and K uptake, and their use efficiency shoot plants, the use of zeolite could be beneficial with respect to nutrient retention in soil and their use efficiency (Ahmed *et al.*, 2010).

Table 3. Effect of vermicompost and zeolite on fresh and dry weights (g.pot^{-1}) of wheat plant

Treatments	Moisture content %	Fresh weight (g.pot^{-1})		Dry weight (g.pot^{-1})	
		Value	% increase	Value	% increase
Control	100	57.8^{h}	-	10.50^{f}	-
	80	49.2^{j}	-	9.30^{gh}	-
	60	43.5^{k}	-	8.10^{i}	-
1% Vermicompost	100	60.5^{ef}	4.70	11.30^{e}	7.60
	80	58.9^{g}	19.70	9.70^{gh}	4.30
	60	56.3^{i}	29.40	8.90^{h}	9.90
2% Vermicompost	100	63.5^{de}	9.90	11.50^{de}	9.50
	80	60.2^{ef}	22.40	11.00^{ef}	18.30
	60	60.0^{ef}	37.90	10.70^{ef}	32.10
1% Zeolite	100	63.0^{de}	9.00	11.50^{de}	9.50
	80	60.5^{ef}	23.00	11.20^{ef}	20.40
	60	58.5^{gh}	34.50	9.80^{g}	21.00
2% Zeolite	100	64.0^{d}	10.70	11.80^{de}	12.40
	80	64.0^{d}	30.10	11.70^{de}	25.80
	60	60.5^{ef}	39.10	11.00^{ef}	21.00
0.5% Z + 0.5%V	100	65.5^{c}	13.32	13.32^{c}	26.86
	80	63.5^{de}	29.06	11.54^{de}	24.09
	60	59.6^{f}	37.01	11.00^{ef}	35.80
0.5% Z + 1%V	100	66.7^{bc}	15.40	14.50^{ab}	38.10
	80	63.2^{de}	28.46	13.52^{bc}	45.38
	60	61.0^{e}	40.23	12.00^{d}	48.15
1%Z + 0.5% V	100	69.0^{a}	19.38	15.13^{a}	44.10
	80	67.5^{b}	37.20	14.50^{ab}	55.91
	60	60.5^{ef}	39.08	11.93^{de}	47.28
1%Z + 1%V	100	67.0^{bc}	15.92	15.00^{ab}	42.86
	80	65.5^{c}	33.13	14.03^{b}	50.86
	60	60.4^{ef}	38.85	13.32^{c}	64.44

% increase = 100 x [1 - (treated parameter / control)]
There was no significant difference between means have the same alphabetical superscript letter in the same column (p≤0.05)

Table 4. Effect of vermicompost and zeolite on NPK content (%) and uptake (mg.pot^{-1}) of wheat plant

Treatments	Moisture content %	N		P		K		Uptake (mg.pot^{-1})		
		Value	% increase	Value	% increase	Value	% increase	N	P	K
Control	100	1.17 ^{cd}	-	0.31 ^{j}	-	1.29 ^{ab}	-	122.85 ^{mn}	32.55^{ik}	135.45^{no}
	80	0.95 ^{de}	-	0.31 ^{j}	-	1.29 ^{ab}	-	88.35 ^{o}	28.83^{k}	119.97^{q}
	60	0.95 ^{de}	-	0.26 ^{k}	-	1.24 ^{ab}	-	76.95 ^{p}	21.06^{l}	100.44^{s}
1% Vermicompost	100	1.40 ^{bc}	19.66	0.39 ^{gh}	25.81	1.35 ^{ab}	4.65	158.20 ^{kl}	44.07^{hi}	152.55^{k}
	80	1.23 ^{cd}	29.47	0.35 ^{i}	12.90	1.31 ^{ab}	1.55	119.31 ^{mn}	33.95^{jk}	127.07^{p}
	60	1.11 ^{d}	16.84	0.30 ^{jk}	15.38	1.25 ^{ab}	0.81	98.79 ^{n}	26.70^{kl}	111.25^{r}
2% Vermicompost	100	1.53 ^{ab}	30.77	0.42 ^{f}	35.48	1.47 ^{ab}	8.89	175.95 ^{i}	48.30^{h}	169.05^{i}
	80	1.33 ^{bc}	40.00	0.37 ^{h}	19.35	1.41 ^{ab}	13.71	146.3 ^{lm}	40.70^{i}	155.10^{jk}
	60	1.16 ^{cd}	22.11	0.37 ^{h}	42.31	1.27 ^{ab}	2.42	124.12 ^{m}	39.59^{ij}	135.89^{n}
1% Zeolite	100	1.31 ^{c}	11.97	0.44 ^{e}	41.94	1.39 ^{ab}	7.75	150.65 ^{l}	50.60^{gh}	159.85^{h}
	80	1.28 ^{cd}	34.74	0.41 ^{fg}	32.26	1.40 ^{ab}	8.53	143.36 ^{lm}	45.92^{hi}	156.80^{j}
	60	1.25 ^{cd}	31.58	0.36 ^{hi}	38.46	1.34 ^{ab}	8.10	122.50 ^{mn}	35.28^{j}	131.32^{o}
2% Zeolite	100	1.35 ^{bc}	15.38	0.49 ^{cd}	58.10	1.47 ^{ab}	13.95	159.30 ^{k}	57.82^{e}	173.46^{h}
	80	1.35 ^{bc}	42.11	0.44 ^{e}	41.94	1.42 ^{ab}	10.10	157.95 ^{kl}	51.48g	166.14^{j}
	60	1.30 ^{cd}	36.84	0.37 ^{h}	42.31	1.33 ^{ab}	7.26	143.00 ^{lm}	40.70^{i}	146.30^{l}
0.5% Z + 0.5%V	100	1.57 ^{ab}	34.19	0.43 ^{ef}	38.71	1.40 ^{ab}	8.53	209.12 ^{e}	57.28^{ef}	186.48^{g}
	80	1.43 ^{bc}	50.53	0.40 ^{g}	29.03	1.34 ^{ab}	3.86	165.02 ^{j}	46.16^{hi}	154.64^{jk}
	60	1.35 ^{bc}	42.10	0.35 ^{i}	34.62	1.30 $^{a b}$	4.84	148.50 ^{lm}	38.50^{ij}	143.00^{m}
0.5% Z + 1%V	100	1.60 ^{ab}	36.75	0.51 ^{b}	64.52	1.54 ^{ab}	19.38	232.00 ^{c}	73.95^{bc}	223.30^{b}
	80	1.60 ^{ab}	68.42	0.50 ^{c}	61.29	1.44 ^{ab}	11.63	216.32 ^{de}	67.60^{c}	194.69^{e}
	60	1.51 ^{b}	58.95	0.37 ^{h}	42.31	1.37 ^{ab}	10.48	181.20 ^{h}	44.40^{hi}	164.40^{jh}
1%Z + 0.5% V	100	1.70 ^{a}	45.30	0.58 ^{a}	87.10	1.55 ^{ab}	20.15	257.21 ^{a}	87.75^{a}	234.52^{ab}
	80	1.50 ^{bc}	57.89	0.51 ^{b}	64.52	1.37 ^{ab}	6.21	217.50 ^{d}	73.95^{bc}	198.65^{d}
	60	1.38 ^{bc}	45.26	0.40 ^{g}	53.85	1.34 ^{ab}	8.06	164.63 ^{jk}	47.72^{hi}	159.86^{h}
1%Z + 1%V	100	1.58 ^{ab}	35.04	0.51 ^{b}	64.52	1.57 ^{a}	21.71	237.00 ^{b}	76.50^{b}	235.50^{a}
	80	1.42 ^{bc}	49.47	0.46 ^{d}	48.39	1.52 ^{ab}	17.83	199.23 ^{f}	64.54^{d}	213.26^{c}
	60	1.40 ^{bc}	47.37	0.40 ^{g}	53.85	1.43 ^{ab}	15.32	186.48 ^{g}	53.28^{f}	190.48^{f}

% increase = 100 x [1 - (treated parameter / control)]
There was no significant difference between means have the same alphabetical superscript letter in the same column ($p \leq 0.05$).

Physiological efficiency of macronutrients

Physiological efficiency (PE) is referred to the increasing of the yield of dry matter in relation to the increase in plant uptake of the nutrient in above-ground parts of the plant. Physiological efficiency of NP and K as affected by zeolite and vermicompost and illustrated in Fig. 1,2 and 3, respectively. Physiological efficiency on NP and K increased by increasing the addition rates of vermicompost and zeolite alone or mixture under all levels of moisture content. Application of zeolite to low quality soil is emerging as the promising technique to improve the use efficiency of nutrients and gave environment favorably effects by preventing the leakage of mineral nutrients into the groundwater (Vilcek *et al.*, 2013). The highest values of PE observed at 0.5% Z+1%V treatment compared with other treatments. Zeolite can hold nutrients in the root zone of plants until required (Khodaei-Joghan and Asilan 2012), this leads to more efficient use of N and K fertilizers.

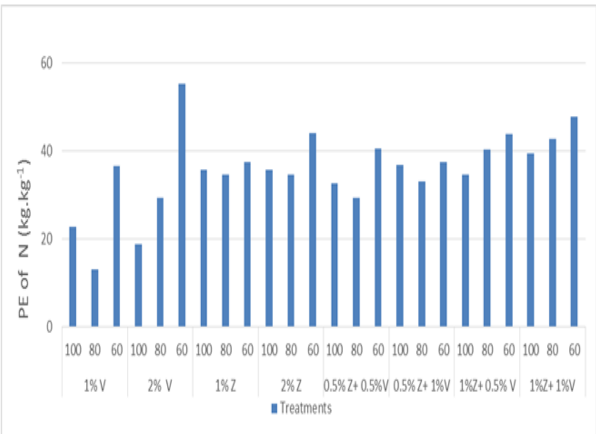

Fig. 1. Effect of vermicompost and zeolite on Physiological efficiency of nitrogen (kg.kg^{-1})

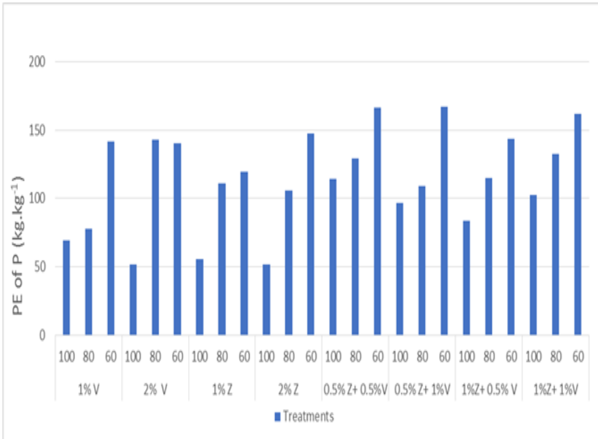

Fig. 2. Effect of vermicompost and zeolite on Physiological efficiency of phosphorus(kg.kg^{-1})

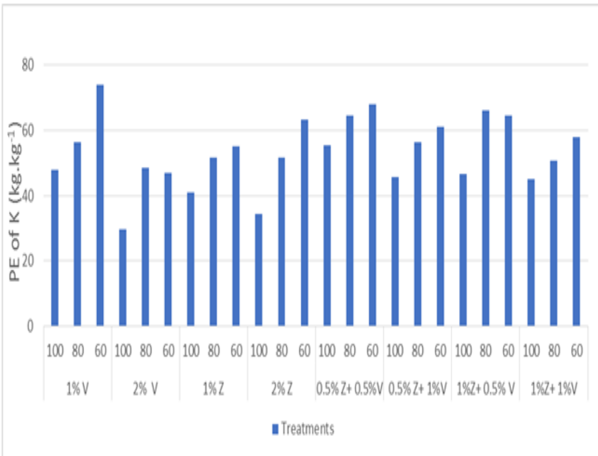

Fig. 3. Effect of vermicompost and zeolite on Physiological efficiency of potassium (kg.kg^{-1}).

Water use efficiency (WUE)

Illustrated data in Fig. 4 show that, WUE (kg.m^{-3}) was clearly affected by both of zeolite and vermicompost as alone or mixture under all levels of moisture content. WUE increased significantly with increasing the addition rates of zeolite and vermicompost either alone or mixture. It noticed that lower level of moisture content, the higher water use efficiency. Similar results were found by Abou Hussien *et al.*, (2020) who showed that the lower amount of water use, gave the higher water use efficiency. The highest values were observed under the highest rates of the studied materials. It noticed that the highest value was recorded 3.58 at 1%Z+1%V under 60% FC. The percent increase of WUE reached 64.22 % at 1% Z+1%V under 60% FC, as compared to untreated one. Application of zeolite can increase WUE through increasing soil WHC (Bernardi *et al.*, 2016). These may be referred to the increase in fine particles content as resulted of vermicompost and zeolite which act as water moderators. Zeolite can be used to improve soil properties and enhance water retention (Hassan and Abdel Wahab 2013).

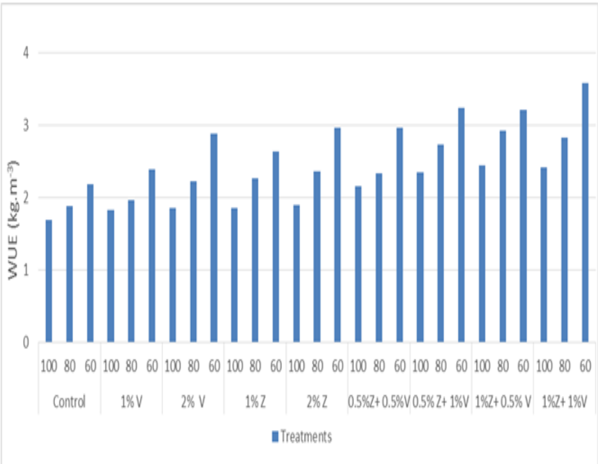

Fig. 4. Effect of vermicompost and zeolite on water use efficiency (kg.m^{-3}).

LSD between treatments at 0.05 = 0.28. Water use efficiency = Total dry matter kg.fed^{-1} / Total water applied m^{3}.fed^{-1}.

Soil chemical properties after wheat harvest

Data represented in Table 5 clear that soil pH affected by addition of vermicompost and zeolite. The addition of zeolite increased soil pH values. The highest and lowest pH values were observed at the rate of 2% Z and 2% V, respectively. Amended soil with highly rates of vermicompost and zeolite had higher EC than the untreated soils. This may be due to the high exchange capacity of zeolites contributes to the electrical conductivity because the zeolites can introduce cations to the water being used to measure the EC (Fansuri *et al.*, 2008).

Organic matter content was increased by increasing the rates of vermicompost and zeolite alone or mixture. The values ranged between 0.40 to 0.75 %. The increasing was significantly at the mixture of zeolite and vermicompost. The highest value was observed at 1% V+1% Z under 100% FC as compared to other treatments. Zeolite can be used to improve the soil properties under drought conditions, boost the effects of chemical and organic fertilizers (Najafi-Ghiri 2014). Vermicompost has ahigh content of organic matter, it has been emerged as an alternative to conventional organic fertilizers due to its additional benefits. (Ersahin *et al.*, 2009).

Macronutrients

The obtained data of available NP and K as affected by the addition of zeolite and vermicompost are presented in Table 5. Values of N, P and K in sandy soil were highly trended at the highly rates of vermicompost or zeolite. This superiority may be due to the beneficial effect of vermicompost and zeolite in improving soil characteristics. The marked increase in available macronutrients content in soil treated by vermicompost due to it contains large amounts of organic matter and nutrients. Application of zeolite gets a positive effect with at nitrogen loss due to leaching from the soils (Ippolito *et al.*, 2011). The highest values of NP and K were 85.0, 17.7 and110 mg.kg^{-1} at 1% V+1% Z under 100% FC, respectively. This is may be due to zeolite and vermicompost roles in improving the soil fertility and increasing the availability of nutrient elements and consequently affected plant growth and yield. These results are in line with those obtained by (Tohidi-Moghadam *et al.*, 2009).

Table 5. Some soil chemical properties and macronutrients as affected by vermicompost and zeolite after wheat harvest

Treatments	Moisture content %	pH	EC dS.m^{-1}	OM %	N mg.kg^{-1}	P mg.kg^{-1}	K mg.kg^{-1}
Control	100	7.70 ^{ab}	1.73 ^{cd}	0.45 ^{bc}	44.50 ^{kl}	10.0 ^{fg}	78.5 ^{m}
	80	7.72 ^{ab}	1.78 ^{cd}	0.45 ^{bc}	45.00 ^{k}	11.0 ^{ef}	78.0 ^{mn}
	60	7.75 ^{ab}	1.80 ^{cd}	0.40 ^{bc}	45.00 ^{k}	11.5 ^{ef}	78.0 ^{mn}
1% Vermicompost	100	7.40 ^{bc}	1.78 ^{cd}	0.55 ^{b}	58.50 ^{h}	11.8 ^{de}	83.6 ^{l}
	80	7.40 ^{bc}	1.85 ^{cd}	0.50 ^{bc}	55.50 ^{cd}	12.0 ^{de}	90.5 ^{i}
	60	7.60 ^{b}	2.00 ^{bc}	0.50 ^{bc}	52.80 ^{j}	11.5 ^{ef}	85.0 ^{k}
2% Vermicompost	100	7.20 ^{cd}	1.90 ^{c}	0.65 ^{ab}	64.50 ^{gh}	12.5 ^{de}	88.4 ^{ij}
	80	7.35 ^{c}	1.90 ^{c}	0.65 ^{ab}	60.80 ^{gh}	12.0 ^{de}	88.0 ^{j}
	60	7.50 ^{bc}	2.20 ^{ab}	0.60 ^{ab}	60.00 ^{gh}	11.6 ^{ef}	88.3 ^{ij}
1% Zeolite	100	7.72 ^{ab}	1.76 ^{cd}	0.48 ^{bc}	60.00 ^{gh}	11.7 ^{e}	94.6 ^{gh}
	80	7.72 ^{ab}	1.83 ^{cd}	0.45 ^{bc}	61.50 ^{gh}	11.0 ^{ef}	90.0 ^{ij}
	60	7.77 ^{ab}	1.90 ^{c}	0.45 ^{bc}	60.50 ^{gh}	10.5 ^{f}	88.5 ^{ij}
2% Zeolite	100	7.75 ^{ab}	1.85 ^{cd}	0.40 ^{bc}	62.50 ^{gh}	13.7 ^{cd}	98.0 ^{e}
	80	7.76 ^{ab}	1.90 ^{c}	0.40 ^{bc}	60.00 ^{gh}	12.0 ^{de}	96.5 ^{f}
	60	7.80 ^{a}	1.92 ^{bc}	0.40 ^{bc}	60.00 ^{gh}	11.4 ^{ef}	95.0 ^{g}
0.5% Z + 0.5%V	100	7.45 ^{bc}	1.85 ^{cd}	0.60 ^{ab}	73.50 ^{d}	14.5 ^{c}	95.5 ^{fg}
	80	7.45 ^{bc}	2.00 ^{bc}	0.60 ^{ab}	70.60 ^{ef}	14.8 ^{bc}	92.0 ^{h}
	60	7.65 ^{ab}	2.00 ^{bc}	0.55 ^{b}	63.50 ^{gh}	13.0 ^{d}	90.0 ^{ij}
0.5% Z + 1%V	100	7.25 ^{cd}	2.00 ^{bc}	0.70 ^{ab}	80.70 ^{b}	14.8 ^{bc}	105.0 ^{b}
	80	7.30 ^{cd}	2.10 ^{bc}	0.70 ^{ab}	73.40 ^{de}	13.0 ^{d}	103.0 ^{c}
	60	7.40 ^{bc}	2.20 ^{b}	0.68 ^{ab}	66.50 ^{fg}	12.4 ^{de}	96.5 ^{f}
1%Z + 0.5% V	100	7.68 ^{ab}	1.70 ^{cd}	0.66 ^{ab}	75.50 ^{cd}	15.0 ^{bc}	95.0 ^{g}
	80	7.70 ^{ab}	1.80 ^{cd}	0.60 ^{ab}	70.80 ^{e}	14.0 ^{cd}	93.6 ^{gh}
	60	7.70 ^{ab}	1.90 ^{c}	0.60 ^{ab}	67.80 ^{f}	14.5 ^{c}	98.0 ^{e}
1%Z+ 1%V	100	7.60 ^{b}	2.35 ^{ab}	0.75 ^{a}	85.00 ^{a}	17.5 ^{a}	110.0 ^{a}
	80	7.65 ^{ab}	2.45 ^{ab}	0.70 ^{ab}	76.00 ^{c}	16.0 ^{b}	99.5 ^{d}
	60	7.67 ^{ab}	2.50 ^{a}	0.60 ^{ab}	65.50 ^{g}	14.0 ^{cd}	99.0 ^{de}

There was no significant difference between means have the same alphabetical superscript letter in the same column ($p \leq 0.05$)

Soil physical properties

Data presented in Table 6 show that soil bulk density and total porosity were improved due to the increase in the zeolite and vermicompost. The highly porosity in the soil treated with vermicompost was due to an increase in the amount of rounded prose. This attitude can be attributed to the redistribution of soil particles, the increase in bulk soil volume and the binding action of vermicompost and zeolite which assess to improve soil aggregates formation. These findings are very close to that obtained by Demir (2019).

Available water is the major component of the soil characteristic playing a critical role in plant growth. Soil water content is limited factor for plant growth, microbial activity, regulating soil temperature, (Bittelli *et al.,* 2015). From the outstanding impacts of zeolite and vermicompost are decreasing soil bulk density and increasing soil porosity, therefore effectively boost the capacity water retention. Application of 1% Z+1%V, significantly increased available water content. The higher rates of zeolite and vermicompost had more available water than the lower rates due to the higher water holding capacity (WHC), therefore its ability to improve water content of the treated soils. These findings are in line with those obtained by Wu *et al.,* (2019).

Table 6. Soil physical properties as affected by vermicompost and zeolite after wheat harvest

Treatments	Moisture content %	Bulk density Mg.m^{-3}	Porosity %	FC %	WP %	AW %
Control	100	1.60 ^{a}	39.62 ^{dc}	9.22	3.20	6.02 ^{hj}
	80	1.58 ^{ab}	40.38 ^{d}	9.15	3.00	6.15 ^{ef}
	60	1.58 ^{ab}	40.38 ^{d}	9.00	3.00	6.00 ^{ij}
1% Vermicompost	100	1.53 ^{ab}	42.26 ^{c}	10.00	3.80	6.20 ^{c}
	80	1.53 ^{ab}	42.26 ^{c}	10.00	3.50	6.50 ^{cd}
	60	1.58 ^{ab}	40.38 ^{d}	9.75	3.80	5.95 ^{jk}
2% Vermicompost	100	1.51 ^{ab}	43.02 ^{bc}	10.55	4.00	6.55 ^{b}
	80	1.53 ^{ab}	42.26 ^{c}	10.50	4.40	6.10 ^{fg}
	60	1.56 ^{ab}	41.13 ^{cd}	10.00	4.25	5.75 ^{kl}
1% Zeolite	100	1.53 ^{ab}	42.26 ^{c}	10.25	4.00	6.25 ^{e}
	80	1.58 ^{ab}	40.38 ^{d}	10.40	4.25	6.15 ^{ef}
	60	1.56 ^{ab}	41.13 ^{d}	10.40	4.25	6.15 ^{ef}
2% Zeolite	100	1.51 ^{ab}	43.02 ^{bc}	10.60	4.50	6.10 ^{fg}
	80	1.53 ^{ab}	42.26 ^{c}	10.40	4.40	6.00 ^{ij}
	60	1.53 ^{ab}	42.26 ^{c}	10.55	4.45	6.10 ^{fg}
0.5% Z + 0.5%V	100	1.48 ^{ab}	44.15 ^{b}	10.85	4.65	6.20 ^{c}
	80	1.48 ^{ab}	44.15 ^{b}	10.55	4.55	6.00 ^{ij}
	60	1.50 ^{ab}	43.40 ^{bc}	10.50	4.35	6.15 ^{ef}
0.5% Z + 1%V	100	1.43 ^{ab}	46.04 ^{a}	11.00	4.85	6.15 ^{ef}
	80	1.48 ^{ab}	44.15 ^{b}	10.55	4.65	5.90 ^{jk}
	60	1.51 ^{ab}	43.02 ^{bc}	10.50	4.50	6.00 ^{ij}
1%Z + 0.5% V	100	1.48 ^{ab}	44.15 ^{b}	11.25	5.20	6.05 ^{gh}
	80	1.48 ^{ab}	44.15 ^{b}	11.00	5.00	6.00 ^{ij}
	60	1.53 ^{ab}	42.26 ^{c}	11.00	5.10	5.90 ^{jk}
1%Z+ 1%V	100	1.43 ^{ab}	46.04 ^{a}	12.85	5.80	7.05 ^{a}
	80	1.48 ^{ab}	44.15 ^{b}	12.50	5.80	6.70 ^{b}
	60	1.51 ^{ab}	42.02 ^{bc}	12.20	5.65	6.55 ^{cd}

There was no significant difference between means have the same alphabetical superscript letter in the same column ($p \leq 0.05$)

CONCLUSION

It was concluded that favorable modifications in sandy soil properties were clearly obtained by applying the natural zeolite and vermicompost either alone or combined. But, the combined effect of zeolite and vermicompost was mor effective. Consequently, fresh and dry weight, NPK content and uptake, physiological efficiency of macronutrients and water use efficiency were improved significantly. Generally, it noticed that the combination of zeolite and vermicompost were more effective in improving soil characteristics, Available water, water use efficiency and fertility status in sandy soil. Therefore, applying certain additives such as zeolite and vermicompost would be one of the reasonable approaches to retaining water and meanwhile maintaining adequate nutrient levels in sandy soil.

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تقييم قدرة الفيرميكومبوست والزيوليت على تحسين الاحتفاظ بالمياه والمغذيات فى أرض رملية

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أجريت هذه الدراسة بهدف تحسين كفاءة المياه والمغذيات فى الارض الرملية تحت النقص المائي. لتحقيق هذا الهدف تم تصميم تجربة اصص في مزرعة كلية الزراعة، جامعة الأزهر، مدينة نصر، القاهرة – مصر خلال فصل الشتاء لعام 2018 بإضافة الزيوليت والفيرميكومبوست بصورة منفردة اومختلطة مع بعضهم بمعدلات : 0، 1، 2% من الصورة المنفردة ، 0.50 % زيوليت+0.50 % فيرميكومبوست ،0.50 % فيرميكومبوست +1 % زيوليت ،0.50 % زيوليت +1% فيرميكومبوست ، 1% زيوليت +1% فيرميكومبوست بصورة مختلطة تحت مستويات رطوبة مختلفة (100 ،80 و60% من السعة الحقية) تم إضافة هذه المعاملات أثناء إعداد الارض للزراعة. أوضحت النتائج التي تم الحصول عليها أن المعدلات المرتفعة من المواد المضافة (زيوليت وفيرميكومبوست) بصورة مختلطة كان لها تاثير معنوى فى زيادة الوزن الجاف والرطب لنبات القمح ،وكذلك المحتوى الكلى من المغذيات تحت جميع مستويات الرطوبة المختلفة مقارنة بالكنترول. بالاضافة الى ذلك زادت كفاءة استعمال المياه معنويا، والكفاءة الفسيولوجية للعناصر الغذائية لنبات القمح مع زيادة معدلات إضافة الزيوليت والفيرميكومبوست إما بصورة منفردة او بنسب مختلطة ، وكان للمعاملات المضافة الاثر الكبر تحت المستويات المنخفضة من الرطوبة مقارنة بالمعاملات الاخرى. كما لوحظ ايضا انخفاض فى قيم الكثافة الظاهرية مع زيادة معدلات الاضافة وبالتالى تحسن معنوى فى المسامية الكلية والمحتوى الكلى من المادة العضوية ، خصوصاً عند المعدلات المختلطة بنسب 1% زيوليت+ 1% فيرميكومبوست ، 1% زيوليت + 0.50% فيرميكومبوست ، بما تؤكد النتائج اهمية اضافة هذه المواد الى الاراضى الرملية بالصورة المختلطة لتحسين خواص التربة والاحتفاظ بالمياه والعناصر الغذائية لتخفيف اثر الاجهاد المائي على نمو نبات القمح.