Journal of Soil Sciences and Agricultural Engineering

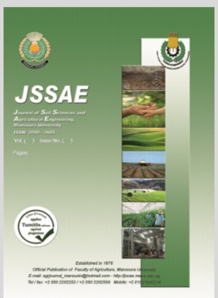
Journal homepage: www.jssae.mans.edu.eg
Available online at: www.jssae.journals.ekb.eg

Effectiveness of Gypsum Particle Size and Vermicompost in Reclaiming Salt Affected Soils and Faba Beans Productivity

Sahar H. Rashed[1]* and M. A. Ibrahim[2]

[1] Soils Improvement and Conservation Dept., Soils, Water and Environ. Res. Instit. (SWERI), Agric. Res. Center (ARC), Giza, Egypt
[2] Field Crops Research , institute , A.R.C. , Giza , Egypt

Cross Mark



ABSTRACT

Soil salinity is one of the environmental factors limiting the plant growth and soil productivity. Field experiment was conducted during 2018/2019 and 2019/2020 seasons in El Hamoul district, Kafr El-Sheikh Governorate, Egypt. This study aimed to investigate the effect of soil amendments *via.* VC and gypsum particle size on some soil physical and chemical properties and faba beans productivity in salt affected soil. The experiment was conducted in split plot design with three replicates. VC with four rates; VC_0, VC_1, VC_2 and VC_3 were placed in main plots, while gypsum particle size with three sizes; G_1, G_2 and G_3 was placed in sub-plots. The results revealed that the application of VC_3 combined with the G_3 recorded the highest decreases in soil ECe and BD (18.97% and 8.87%, respectively) compared to the initial soil values. While RSE, total porosity, OM, CEC and soil nutrient contents were increased with the same combination by (27.62, 9.78%, 48.94%, 22.42%, 18.00, 20.91 and 19.09%) respectively compared to the initial soil values. Also, the application of VC_3 combined with G_3 achieved the highest values of 100-seed weight (69.20 and 78.36 g), plant height (81.03 and 84.93 cm), pods yield (6.23 and 6.60 $Mg.ha^{-1}$) and seeds yield (4.02 and 4.39 $Mg.ha^{-1}$) of faba bean in the 1st and 2nd seasons, respectively as compared to G_1. Data also, revealed that the G_3 were more effective than G_1 on reclaiming the salt affected soil and faba beans yield.

Keywords: Soil salinity, Vermicompost, Gypsum, soil properties and Faba beans.

INTRODUCTION

Soil degradation, caused by salinity and sodicity, reduces the soil organic matter and can decline the soil productivity due to the unstable structure and low water holding capacity; also it disrupts the soil aggregates, thus affecting the soil water, nutrients, and plant development (Nan *et al.,* 2015). Soil salinity and sodicity affected crop production in the world because most of the crop plants are sensitive to salinity, and about 20% of cultivated land in the world and 33% of irrigated land are salt-affected and degraded (Shrivastava and Kumar, 2015). This process can be accentuated by climate change, excessive use of groundwater (mainly if close to the sea), increasing use of low-quality water in irrigation, and massive introduction of irrigation associated with intensive farming (Machado and Serralheiro, 2017).

Reclamation of saline-sodic soils as substantial percentage of the exchangeable sodium needs to be removed by calcium ions, this reaction can be quickly accomplished using chemically some soil amendments, such as gypsum. Gypsum ($CaSO_4$. $2H_2O$) is the most common amendment to reclaim sodic soils and to reduce sodium from the soil profile (Mahmood Abadi *et al.,* 2013). Gypsum is a source of sulfur and calcium to plants, is moderately soluble in water, and is affordable for farmers in developing countries (Yildiz e*t al.,* 2017). Some studies indicated that the gypsum in fine particles (<0.5 mm) is more effective than coarse grades on the reclamation of saline-sodic soil [Khosla and Abrol (1972); Abu-hashim and Abdel-Fattah (2013); Abdel-Fattah e*t al.,* (2015); Yildiz e*t al.,* (2017)].

The interests are shifted towards the organic amendments like vermicompost (VC), which is a bio-oxidative process that uses earthworms and microorganisms for the biochemical degradation of the organic waste e.g., food waste, horticultural waste, poultry droppings, and food industry sludge, whereas the earthworms are responsible for the fragmentation of the substrate, which increases the surface area. The produced VC, is a mature peat-like material with high porosity, aeration, drainage, water holding capacity (WHC) and microbial activity (Srivastava *et al.,* 2011; Yadav and Garg 2011; Arancon *et al.,* 2012; Mendoza-Hernández *et al.,* 2014; Huang *et al.,* 2014; Lalander *et al.,* 2015). Also, a large number of plant hormones are found in VC (*e.g.,* IAA, GA_3 and kinetin) as a result of jointing activity of earthworms and microorganisms (Ravindran *et al.,* 2016). VC have large particulate surface areas that provide many micro sites for microbial activity, strong retention of nutrients, high nutrients content and rich microbial populations (Atiyeh *et al.*, 2000c). It can be applied as soil amendment to improve soil fertility by increasing soil OM, CEC, and nutrients contents, and improve soil structure (Arancon

* **Corresponding author.**
E-mail address: Saharhassanrashed86@gmail.com
DOI: 10.21608/jssae.2020.114875

et al., 2006a; Azarmi *et al.,* 2008; Srivastava *et al.,* 2011; Makode, 2015, Mahmoud and Ibrahim, 2012; Mathivanan *et al.,* 2013; Wang *et al.,* 2017; Zhao *et al.,* 2017; Mahmud *et al.,* 2018, Aksakal *et al.,* 2016). Recently, VC has been widely used in the cultivation field to increase the dry mass and yield of greenhouse crops (Norman and Clive 2010; Warman and Anglopez 2010; Little *et al.,* 2011, Sakhavi *et al.,* 2016). Thus, the aim of this investigation was to study the effect of soil amendments *via.* VC and gypsum particle size as well as their combinations on some soil physicochemical properties and faba beans productivity in saline sodic soil.

MATERIALS AND METHODS

Experimental location and design:

Field experiment was conducted during two successive winter seasons (2018/2019 and 2019/2020) in El Hamoul district, Kafr El-Sheikh Governorate, Egypt. This study aimed to investigate the effect of soil amendments *via.* Vermicompost (VC) and gypsum particle size (G) as well as their combination on some soil physicochemical properties and productivity of faba beans (*Vicia faba*) in salt affected soil. The site lactation is at 31^0 05' 20.43" N latitude and 30^0 56' 9.29" E longitude with about 6 meters elevation above the sea level.

The treatments were arranged in 36 plots (3x3.5 m) with total area of 387 m^2. The experiment was conducted in a split plot design with three replicates. VC with four rates (0.0, 1.2, 2.4 and 3.6 Mg ha-1 ie VC_0, VC_1, VC_2 and VC_3) were placed in main plots, while gypsum particle size with three sizes (1-2, 0.5-1 and < 0.5 mm ie G_1, G_2 and G_3) was placed in sub-plots. Gypsum was applied to the soil according its requirement (16.82 Mg ha^{-1}). Gypsum requirements (GR) were determined according to FAO and IIASA (2000) to reduce the initial ESP for the soil matrix to 10% in the surface layer (0-30 cm) according to the following equation:

$$\mathbf{GR = (ESP_i - ESP_f) \times CEC \times 1.72 \times (100/purity)}$$

Where: **GR: gypsum requirement (Mg ha^{-1}) for upper 30 cm soil, ESP_i: initial soil ESP, ESP_f: The desired soil ESP and CEC: cation exchange capacity (cmolc kg^{-1}).**

Gypsum characterizes were: pH of 7.0, EC of 2.2 dS m^{-1}, purity of 85.0% and solubility of 2.90, 4.54 and 7.85 g L^{-1} for coarse, medium and fine particles, respectively. While the VC was made from rice straw and animal wastes with earthworm species *Eisenia fetida* and *Dendrobaena veneta* (Joshi *et al.,* 2014).

Gypsum and VC were thoroughly mixed with the surface soil layer (0-30 cm) before cultivation, and then it was ploughed twice in two ways using chisel plough. The chemical composition of VC was listed in Table (1).

Table 1. Some chemical composition of Vermicompost (VC).

pH (1: 2.5)	ECe (dS m^{-1})	Organic matter (%)	Organic Carbon (%)	C/N Ratio	CEC (cmolc kg^{-1})	Total nutrients (%) N	P	K
7.62	4.59	31.92	18.56	11.46	272	1.62	1.26	1.01

The seeds of Faba beans (*Sakha 1* variety) were inoculated just before sowing with rhizobium and sown at rate of 144 kg grains ha^{-1} on Nov. 14^{th}, 2018 and Nov. 18^{th}, 2019. Nitrogen fertilizer as urea (46% N) was applied at rate of 36 kg N ha^{-1} in two doses with first irrigation and the 2^{nd} irrigation. Phosphorus fertilizer (15.5 % P_2O_5) at rate of 107.14 kg P_2O_5 ha^{-1} was applied with soil preparation. Also 50 kg K_2O ha^{-1} as potassium sulfate (48% K_2O) was applied at flowering stage. Other agricultural practices were performed according to the Ministry of Agric. recommendation for Faba beans in North Delta.

Soil analysis: Soil samples from 0-30 cm layer were collected from each experimental plot before and after harvesting. Soil chemical properties were analyzed according to the standard methods outlined by Page *et al.,* (1982) and Klute (1986).

Soil texture, bulk density and total porosity were determined as described by Briggs (1977). Available N and K were determined according to Jackson (1973), while available P was determined according to Olsen (1954). Soil moisture characters were determined by pressure membrane according to Black (1975). Data of physical, chemical and moisture characteristics of the tested soils are shown in Table 2.

Table 2. Soil chemical and physical characteristics of the experimental site before cultivation.

Chemical characteristics	Value	Physical characteristics	Value
Soluble ions, EC and pH		Particle size distribution (%)	
pH (Soil suspension 1:2.5)	8.53	Sand	16.82
ECe (dS m^{-1})	7.59	Silt	26.29
Soluble ions (mmol. L^{-1})		Clay	56.89
Na^+	55.79	Texture class	Clayey
K^+	0.65	Soil type	Saline - Sodic
Ca^{++}	12.07	O.M % [a]	0.84
Mg^{++}	7.44	CEC (cmolc kg^{-1}) [b]	31.72
HCO_3^-	4.50	Bulk density (g cm^{-3})	1.39
Cl^-	39.06	Total porosity (%)	47.55
$SO_4^=$	32.38	Soil moisture characters %	
SAR	17.86	F.C	39.50
ESP	20.35	W.P	21.47
Available macronutrients (mg. Kg^{-1})		A.W	18.03
N 26.15	P 6.38	K 239.66	

O.M [a] (soil organic matter) was analyzed as described by Walkley and Black (1934), CEC [b] (cation exchange capacity) was determined according to Bower *et al.*, (1952).

Sodium adsorption ratio (SAR) was calculated according to Richards, (1954) where the concentrations of cations are expressed in meq L^{-1} as the follows:

$$\mathbf{SAR = Na \sqrt{(ca^{2+} + Mg^{2+})/2}}$$

While, Exchangeable sodium percentage (ESP) was calculated according to the equation of Rashidi and Seilsepour (2008):

$$ESP = 1.95 + 1.03\ SAR$$

Removal sodium efficiency (RSE %) was calculated according to the equation of Amer (2017) :

$$RSE = ((ESP_i - ESP_f)/ESP_i)*100$$

Plant sampling: Plants were taken from 1 m^2 for each plot at maturity stage (135 days after sowing). Plant height (cm), 100-seed weight (g), pod yield (Mg ha^{-1}) and seed yield (Mg ha^{-1}) were measured.

Statistical analyses: The obtained results were subjected to analyses of variance and LSD test at 0.05 level of probability according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Soil physical and chemical characteristics:

Results shown in Table 3 indicated that soil addition of vermicompost (VC), gypsum (G) and their combinations showed a pronounced enhancement in chemical and physical characteristics of saline sodic soil.

Electrical conductivity (*ECe*)

The soil amendments decreased soil salinity at the end of the experiment. Application of 3.6 Mg VC ha^{-1}(VC_3) recorded the lowest ECe value (6.26 dS m^{-1}) as compared to untreated soil (6.83 dS m^{-1}). These results agree with Demir (2019) who demonstrated that the soil EC was significantly decreased with application of VC.

The fine gypsum particles were more prominent on decreasing soil salinity as compared to the other two gypsum particle sizes. The EC values were 6.46, 6.49 and 6.56 dS m^{-1} with fine, medium and coarse gypsum particles, respectively. These results were confirmed by Abdel-Fattah e*t al.,* (2015) who found that the soil salinity was decreased with gypsum especially with finer particles.

Moreover, the application of 3.6 Mg VC ha^{-1} combined with finer gypsum particles recorded the lowest ECe value (6.15 dS m^{-1}) compared to coarse gypsum particles without VC which recorded the highest ECe value (6.96 dS m^{-1}).

Consequently, the changes in ECe values with different treatments compared to the initial ECe as shown in Fig. (1) indicated that application of 3.6 Mg VC ha^{-1} combined with finer gypsum particles has the highest decreasing in ECe (18.97%) followed by application of 2.4 Mg VC ha^{-1} combined with fine gypsum particles (17.48%) while, the lowest change in ECe (8.37%) was recorded with coarse gypsum alone. These results are in the same line with those obtained by Adane *et al.,* (2019); Filho *et al.,* (2020) who revealed that the gypsum addition combined with organic amendments is better than gypsum alone in reducing soil salinity.

Table 3. Effect of Vermicompost (VC) and gypsum particle size and their combination on soil salinity (ECe).

Parameters / Treatments		1st	2nd	R.C (± %) EC_i : EC_f
Vermicompost (VC) Mg ha^{-1}	0	6.94±0.09 d	6.71±0.13 d	10.08
	1.2	6.64±0.05 c	6.41±0.07 c	14.03
	2.4	6.53±0.09 b	6.28±0.05b	15.61
	3.6	6.38±0.08 a	6.14±0.08 a	17.52
	$LSD_{0.05}$	0.09	0.05	
Gypsum particles sizes (G)	Coarse	6.67±0.06 b	6.45±0.07 c	13.57
	Medium	6.61±0.07 ab	6.37±0.11 b	14.49
	Fine	6.58±0.10 a	6.34±0.10 a	14.89
	$LSD_{0.05}$	0.06	0.002	
Significant				
VC		**	**	
G		*	**	
VC x G		**	**	

** EC_i is the initial value and EC_f is mean value of the final EC.

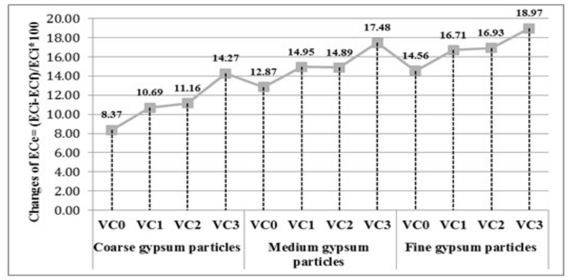


Fig. 1. Changes of ECe (%) as affected by VC and gypsum particle size and their combination.

** VC_0, VC_1, VC_2 and VC_3: 0, 1.2, 2.4 and 3.6 Mg VC ha^{-1}, respectively.

Soil sodicity (*ESP and RSE %*)

The results related to exchangeable sodium percentage (ESP) after two growing seasons are given in Table (4). Data revealed that the VC application with gypsum particle size and their combination significantly alleviated soil sodicity.

Application of vermicompost alone at rate of 3.6 Mg ha^{-1} decreased significantly the ESP value by 27.37 % less than the initial values (Table 2). The reduction of sodicity with vermicompost may be due to vermicompost which allow continuous supply of Ca^{++}, Mg^{++} and other cations. These cations lead to replace the exchangeable Na^+ from soil matrix and to form new stable aggregates. These results are in agreement with those of Shaaban et al., (2013) who explained that organic matter decomposition, increases CO_2, organic acids and large amounts of H^+ are released which enhance the dissolution of $CaCO_3$ and unleash more Ca^{+2} that exchange with Na+ on soil colloids. The application of organic matter such as VC to salt-affected soil promotes flocculation of clay particles, which is an essential for aggregation process and leads to an increase in the pores spaces, increase of Na^+ leaching and decreases ESP and ECe (Lakhdar *et al*., 2010). Also, Demir (2019) demonstrated that the soil EC, SAR, Cl^- and Na^+ were significantly decreased, while the organic matter, CEC and nutrients available (N, P and K) were increased as the rate of the VC increased.

Moreover, the application of gypsum at finer particles was more effective than different particles size on decreasing ESP value, which decreased from 20.35 to 15.61. Increased gypsum particle fineness implies a greater solubility and therefore greater liberation of Ca^{+2} to soil solution and adsorption on the soil exchangeable complex. All such consequences would reduce the dominance of Na^+ ions in the soil-water system, and consequently lead to lower soil sodicity (Abdel-Fattah e*t al.,* 2015).

An overall change ($p \leq 0.05$) in removal sodium efficiency (RSE%) after two growing seasons compared to that of the initial soil value as affected by different treatments was observed from Table (4) and Fig. (2). The RSE% was significantly increased with the application of 3.6 Mg VC ha^{-1} combined with fine gypsum particles (27.62%) over the initial values. The decrease of RSE% with the combination of gypsum and VC may be related to the improvement of soil porosity due to decreasing Na^+ and increasing Ca^{+2}. These findings are in agreement with the early findings of Adane *et al.,* 2019 and Filho *et al.,* 2020 they found that gypsum combined with organic amendments is better to reduce soil sodicity and increase water infiltration than gypsum alone.

Table 4. Effect of Vermicompost (VC) and gypsum particle size as well as their combination on soil sodicity.

Parameters				
Treatments		1st season	2nd season	RSE
Vermicompost (VC) Mg ha^{-1}	0	17.47±0.13 d	16.53±0.10 d	16.46
	1.2	16.45±0.06 c	15.86±0.06 c	20.61
	2.4	15.55±0.09 b	15.40±0.07 b	23.96
	3.6	14.63±0.09 a	14.93±0.09 a	27.37
	$LSD_{0.05}$	0.10	0.09	
Gypsum particles sizes (G)	Coarse	16.35±0.06 c	15.85±0.06 c	20.88
	Medium	16.04±0.11 b	15.67±0.08 b	22.09
	Fine	15.69±0.10 a	15.53±0.11 a	23.29
	$LSD_{0.05}$	0.06	0.04	
Significant				
VC		**	**	
G		**	**	
VC x G		**	*	

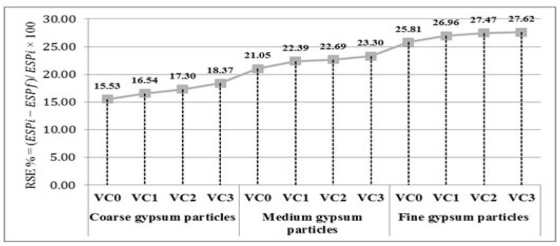


Fig. 2. Removal sodium efficiency (RSE %) as affected by Vermicompost (VC) and gypsum particle size and their combination.

Soil organic matter (*O.M.*):

Data illustrated in Fig. 3 showed that soil OM was significantly ($p \leq 0.05$) affected by VC alone or with different gypsum particle sizes. The highest O.M value (1.27%) was observed with the application of 3.6 Mg VC ha^{-1} combined with fine gypsum particles, which increased by 48.94% compared to that of the initial soil value followed by application of 2.4 Mg VC ha^{-1} combined with fine gypsum particles 1.22% (increased O.M by 43.57%) while the lowest O.M value 0.85% was recorded with coarse gypsum alone.

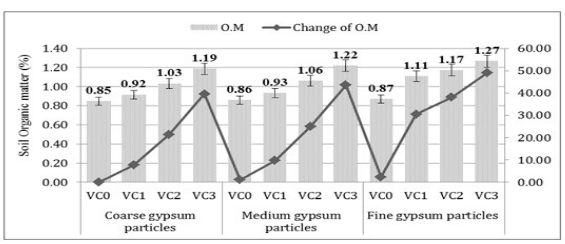


Fig. 3. Soil organic matter and its Change as affected by VC and gypsum particle size and their combination.

These increases may be attributed to high OM content in VC, which enhances soil microbial biomass growth and consequently increases soil organic carbon (Tejada and Gonzalez, 2003). These results are in the same line with findings of Arancon *et al.,* (2006a); Azarmi *et al.,* (2008); Srivastava *et al.,* (2011); Makode (2015), Mahmoud and Ibrahim (2012); Mathivanan *et al.,* (2013); Wang *et al.,* (2017); Zhao *et al.,* (2017); Mahmud *et al.,* (2018) and Aksakal *et al.,* (2016).

Cationic exchange capacity (*CEC*):

Data in Fig. 4 indicated that CEC was significantly increased ($p \leq 0.05$) as affected by different VC application rates and gypsum particle size as well as their combination compared to the initial CEC as shown in Fig. (4). The highest change in CEC (22.42%) exists in case of application of 3.6 Mg VC ha^{-1} with fine gypsum particles followed by application of 2.4 Mg VC ha^{-1} combined with fine gypsum particles (19.38%) while the lowest change in CEC (4.33%) was recorded with coarse gypsum alone. These increases may attribute to high OM and CEC in VC. Similar results were obtained by Arancon *et al.,* (2006a); Azarmi *et al.,* (2008); Srivastava *et al.,* (2011); Makode (2015). Mahmoud and Ibrahim (2012); Mathivanan *et al.,* (2013); Wang *et al.,* (2017); Zhao *et al.,* (2017); Mahmud *et al.,* (2018). Aksakal *et al.,* (2016).

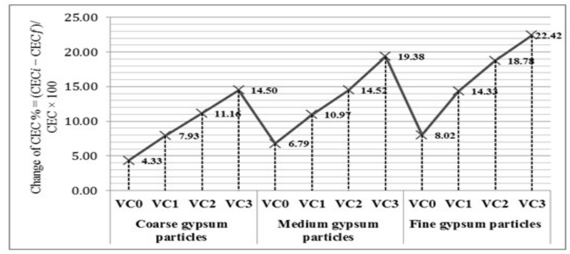


Fig. 4. Change of cation exchange capacity as affected by Vermicompost (VC) and gypsum particle size and their combination

Bulk density (BD) and total porosity (TP):

The results in Table 5 and fig 5 showed that soil bulk density and total porosity are slightly affected by different treatments. In soil treated by 3.6 Mg VC ha^{-1}, BD value was increased by 7.91%, while TP value was decreased by 8.63% compared to that in untreated soil. This trend may attribute to that VC enhanced microorganism population and activity which produced polysaccharides that resulted in the formation of soil aggregates and increased its porosity. Also, according to Singh *et al.,* (2017), bulk density and solid space were decreased and pore space was increased with increasing application of VC.

Also, soil BD and TP values were slightly affected by different gypsum particle size. The BD values were 1.32, 1.31 and 1.29 g cm^{-3}, while TP values were 49.91, 50.29 and 50.92% in soil treated by the coarse, medium and fine particles, respectively. This may be related to that gypsum increases soil aggregation and porosity, while decreases its BD value.

Table 5. Effect of VC and gypsum particle size on Bulk density and total porosity

Parameters		BD (gcm^{-3})			T.P (%)		
Treatments		1st	2nd	Mean	1st	2nd	Mean
Vermicompost (VC) Mg ha^{-1}	0	1.37± 0.01 c	1.36± 0.03 c	1.37	48.39± 0.44 d	48.64± 1.02 d	48.52
	1.2	1.32± 0.02 ab	1.31± 0.02 ab	1.32	50.15± 0.58 c	50.40± 0.91 c	50.28
	2.4	1.30± 0.02 a	1.29± 0.02 a	1.30	50.90± 0.32 b	51.15± 0.91 b	51.03
	3.6	1.28± 0.01 a	1.28± 0.01 a	1.28	51.53± 0.15 a	51.78± 0.44 a	51.66
	$LSD_{0.05}$	0.04	0.02		0.39	0.37	
Gypsum particles sizes (G)	Coarse	1.33± 0.01 c	1.31± 0.02 c	1.32	49.78± 0.44 c	50.03± 0.77 c	49.91
	Medium	1.32±0. 02 ab	1.29± 0.02 b	1.31	50.16± 0.28 b	50.41± 0.77 b	50.29
	Fine	1.30± 0.01 a	1.28± 0.01 a	1.29	50.79± 0.43 a	51.04± 0.93 a	50.92
	$LSD_{0.05}$	0.002	0.004		0.07	0.09	
Significant							
VC		*	*		**	**	
G		**	**		**	**	
VC x G		**	**		**	**	

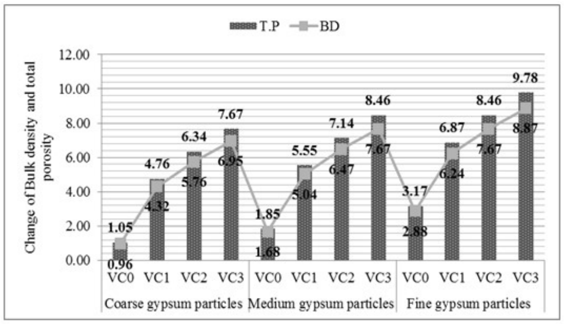


Fig. 5. Change of soil bulk density and total porosity as affected by VC and gypsum particle size and their combination

Moreover, both BD and TP parameters were slightly affected by the interaction between VC application and gypsum particle size. The application of 3.6 Mg VC ha^{-1} in combination with fine gypsum particles decreased BD by 8.87% and increased TP by 9.78% over the initial values (Table 2), while the minimum changes of BD (0.96%) and TP (1.05%) were recorded with the application of coarse gypsum particles alone. These results may be related to that the application of VC along with gypsum caused significant reduction in bulk density. Improvement of soil bulk density and porosity is mainly due to the action of gum, polysaccharides and humical compounds produced from VC on the soil structure (Raut *et al.,* 2000).

Soil Nutrient content:

Data in fig (6) revealed that the contents of available nitrogen (N), phosphorus (P) and potassium (K) were increased with additions of VC with different gypsum particle size as well as their combinations compared to their initial contents. The soil treated with 3.6 Mg VC ha^{-1} combined with finer gypsum particles significantly increased the available N, P and K values by 18.00, 20.91 and19.09 %, respectively over than that in the initial soil (Table 2). These increases were more pronounced in the plots treated by VC associated with VC. VC is a nutritive 'organic fertilizer' rich in NKP, micronutrients, and provides the soil by microbes like 'N-fixing bacteria' and 'mycorrhizal fungi' as growth promoters (Sinha *et al.,* 2009). Also, application of compost and VC can increase soil organic carbon, nitrates, phosphates, exchangeable calcium and some other nutrients for plants (Jindo *et al.,* (2016).

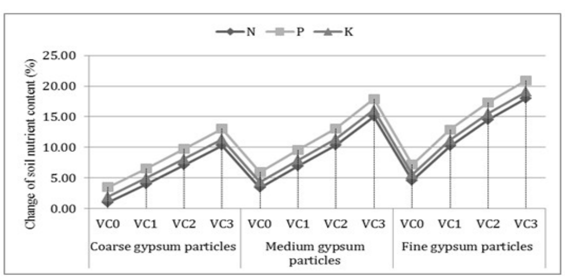


Fig. 6. Change of soil nutrient content as affected by VC and gypsum particle size and their combination

Effect of VC and gypsum on faba bean growth and yield:

Faba bean growth parameters:

Figs 7 and 8 exhibited the effect of VC application rate and gypsum particle size as well as their combination on faba beans growth yield. The magnitude of the enhancement of plant biomass was observed with plots received VC in combination with gypsum particle size. The VC_3 combined with finer gypsum particles recorded the highest increases in plant growth such as 100 grain weight (69.20 and 78.36 g) and plant height (81.03 and 84.93 cm) for the 1st and 2nd seasons, respectively. This stimulation of growth may result from water soluble bioactive molecules like phytohormones, humic, and fulvic acids, minerals, amino acids, or microbial metabolites present in VC (Arancon *et al.,* 2012; Baldotto and Baldotto 2014).

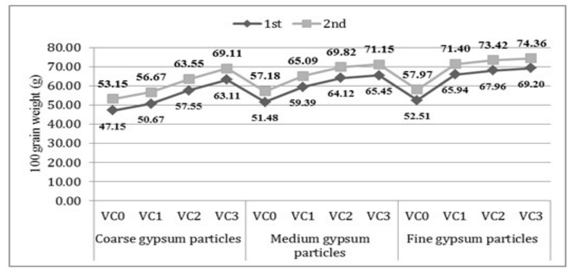


Fig. 7. Effect of VC and gypsum particle size and their combination on 100-seed weight.

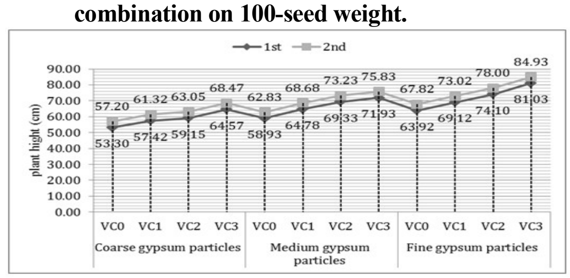


Fig. 8. Effect of VC and gypsum particle size and their combination on plant height

Pods and Seeds yield:

Data in table 6 and fig 9 showed that the pods and seeds yield of faba bean with higher vermicompost application rate (3.6 Mg ha^{-1}) were more than that without addition by 31.88 and 29.66%, for the 1st and 2nd season, respectively, while seed yield was increased by 46.33 and 40.54, in the 1st and 2nd season, respectively. These trends may be related to that the vermicompost contains most nutrients in plant-available forms such as nitrates, phosphates, and exchangeable calcium and soluble potassium (Orozco *et al.,* 1996). Also, Day *et al.,* (2019) hypothesized that the combination between organic and chemical conditioners would improve the performance of chemical amendments by mobilizing surface sodium which in turn cause enhancement of soil physical and chemical properties and it will reflect on plant production, beside the nutrition availability regarding to the decomposition of compost materials. Argaw and Mnalku (2017); Mohammadii and Rezaei-Chiyaneh (2019) revealed that the yield and yield traits of faba bean (Vicia faba L.) were increased with increasing vermicompost application rates. Mohamed e*t al.,* (1999); Smith *et al.,* (2009); Gendy (2011) revealed that the gypsum application was increased the yield and yield traits of faba bean (*Vicia faba L.*).

In addition, the pods and seeds yield of faba bean were significantly affected by different gypsum particles sizes. The lowest pods yield were recorded with coarse gypsum particles (4.93 and 5.30 Mg ha^{-1} for the 1st and 2nd seasons, respectively), while the highest pods yields were achieved with fine gypsum particles (5.17 and 5.54 Mg ha^{-1} for the 1st and 2nd seasons, respectively). No significant differences in the seeds yield were found as affected by fine and medium gypsum particles sizes in first season. Also, the lowest mean values are 3.11 and 3.47 Mg ha^{-1} were recorded with coarse gypsum particles in the 1st and 2nd seasons, respectively, without significant difference as compared with medium gypsum particles in the 1st and 2nd seasons.

Table 6. Effect of vermicompost and different gypsum particle size on Faba beans yield

Parameters		Pods Yield ($Mg.ha^{-1}$)			Seeds Yield ($Mg.ha^{-1}$)		
Treatments		1st	2nd	Mean	1st	2nd	Mean
Vermicompost (VC) Mg ha^{-1}	0	4.36± 0.15 ^{d}	4.72± 0.19 ^{d}	4.54	2.59± 0.16 ^{d}	2.96± 0.31 ^{d}	2.78
	1.2	4.83± 0.08 ^{c}	5.19± 0.19 ^{c}	5.01	3.00± 0.18 ^{c}	3.36± 0.34 ^{c}	3.18
	2.4	5.26± 0.16 ^{b}	5.63± 0.28 ^{b}	5.45	3.24± 0.14 ^{b}	3.60± 0.26 ^{b}	3.42
	3.6	5.75± 0.11 ^{a}	6.12± 0.19 ^{a}	5.94	3.79± 0.09 ^{a}	4.16± 0.19 ^{a}	3.98
	$LSD_{0.05}$	0.15	0.28		0.11	0.17	
Gypsum particles sizes (G)	Coarse	4.93± 0.08 ^{c}	5.30± 0.20 ^{c}	5.12	3.11± 0.12 ^{b}	3.47± 0.27 ^{b}	3.29
	Medium	5.05± 0.15 ^{b}	5.41± 0.22 ^{b}	5.23	3.13± 0.15 ^{ab}	3.49± 0.30 ^{b}	3.31
	Fine	5.17± 0.14 ^{a}	5.54± 0.22 ^{a}	5.36	3.24± 0.16 ^{a}	3.65± 0.25 ^{a}	3.45
	$LSD_{0.05}$	0.10	0.09		0.11	0.10	
Significant							
VC		**	**		**	**	
G		**	**		*	*	
VC x G		**	**		**	**	

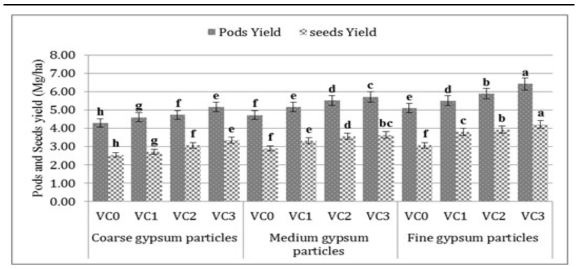


Fig. 9. Effect of VC and gypsum particle size and their combination on pods and seeds yield.

****The bars sharing the same letters are statistical similar according to Duncan Multiple Range Test (DMRT) at P <0.05**

Concerning the effect of soil amendments on the yield, VC and gypsum as well as their combinations increased faba bean yield as shown in Fig. (8). The highest mean values of pods yield (6.42 $Mg.ha^{-1}$) and seeds (4.21 $Mg.ha^{-1}$) were obtained when 3.6 Mg VC ha^{-1} was applied in combination with finer gypsum particles. While the lowest values of these parameters (4.28 and 2.54 $Mg.ha^{-1}$, respectively) were recorded with coarse gypsum particles alone. This increase was attributed to ameliorative role of these amendments on salt affected soils may due to the increase of plant tolerance to salinity hazard at physiological growth stages and improving some soil proprieties.

CONCLUSION

It could be concluded that the application of VC is a new strategy for alleviating abiotic stress like saline-sodic conditions of soil, besides improving of faba beans growth. Also, it could be concluded that the finer gypsum particles were more effective than coarse particles on the improving physical and chemical properties of salt affected soil as well as improving productivity of faba beans especially with VC application in proper rate.

ACKNOWLEDGEMENT

The author wish to express his sincere gratitude and appreciation to the staff of “Soils Improvement & Conservation Res. Dept.; Agric. Res. Center (ARC); Soil, Water and Environ. Res. Institute (SWERI), Giza, Egypt, for their supports needed to accomplish this study.

REFERENCES

Abdel-Fattah M.K.; S. Fouda and U. Schmidhalter (2015). Effects of Gypsum Particle Size on Reclaiming Saline-Sodic Soils in Egypt. Communications in Soil Science and Plant Analysis 00:1–11.

Abuhashim M. and M.K. Abdel-Fattah (2013). Impact of Gypsum Particle Size on Soil Physical Properties of a Saline-Sodic Soil from North Sinai, Egypt. Egypt. J. Soil Sci., 53 (1): 89-103.

Adane A.; H. Gebrekidan and K. Kibret (2019) Effects of treatment application rates (fym and gypsum) on selected chemical properties of saline sodic soils under water limited condition in eastern lowlands Ethiopia. Forest Res Eng Int J.; 3 (3):106-113.

Aksakal E.L.; S. Sari and I. Angin (2016). Effects of vermicompost application on soil aggregation and certain physical properties. Land degradation & development. 27: 983–995.

Amer, A.Kh. (2017). Role of soil amendments, plant growth regulators, and amino acids in improvement salt-affected soil properties and wheat productivity. J.Soil Sci. and Agric. Eng., Mansoura Univ., 8 (3):123-131.

Arancon, N.Q., C.A. Edwards, and P. Bierman. (2006a). Influences of vermicomposts on field strawberries: Part 2. Effects on soil microbiological and chemical properties. Bioresource Technol. 97:831–840.

Arancon, N.Q.; A. Pant; T. Radovich; N.V. Hue; J.K. Potter and C.E. Converse (2012). Seed germination and seedling growth of tomato and lettuce as affected by vermicompost water extracts (teas). Horti science, 47:1722-8.

Argaw A. and A. Mnalku (2017). Vermicompost Application as Affected by Rhizobium Inoculation on Nodulation and Yield of Faba Bean (Vicia Faba L.). Ethiop. J. Agric. Sci. 27(2) 17-29.

Atiyeh, R.M.; J. Dominguez; S. Subler and C.A. Edwards (2000c). Biochemical changes in cow manure processed by earthworms (Eisenia Andrei) and their effects on plant growth. Pedobiologia 44, 709-724.

Azarmi R.; M.T. Giglou and R.D. Taleshmikail (2008). Influence of vermicompost on soil chemical and physical properties in tomato (Lycopersicum esculentum) field. African Journal of Biotechnology, 7 (14): 2397-2401.

Baldotto, L. R. B., and M. A. Baldotto (2014). Adventitious rooting on the Brazilian red cloak and Sanchezia after application of indole butyric and humic acids. Horticultura Brasileira 32 (4):4349.

Black CA. (1975) Methods of Soil Analysis. Amer. Soc. Agron. Inc., Madison, Wisconsin, U.S.A.Carter, D.L.. Problems of salinity in agriculture; 1965.

Bower, C.A.; R.F. Reitemeier and M. Fireman, (1952). Exchangeable cation analysis of saline and alkali soils. Soil Sci. 73: 251–262.

Briggs, D.J. (1977). Soils, Sources, and Methods in Geography. Butterworths, London.

Day, S.J.; J.B. Norton; C.F. Strom; T.J. Kelleners and E.F. Aboukila (2019). Gypsum, langbeinite, sulfur, and compost for reclamation of drastically disturbed calcareous saline-sodic soils. International journal of environmental science and technology, 16 (1): 295-304.

Demir Z. (2019). Effects of Vermicompost on Soil Physicochemical Properties and Lettuce (Lactucasativa Var. Crispa) Yield in Greenhouse under Different Soil Water Regimes, Communications in Soil Science and Plant Analysis, 50 (17): 1-17.

FAO and IIASA (2000). Diagnosis and Improvement of Saline and Alkali Soils, USDA Handbook No 60, U.S. Salinity Lab. Staff (1954), Washington.

Filho F. G.; N. S. Dias; S. R. P. Suddarth; J. F. S. Ferreira; R. G. Anderson; C. S. Fernandes; R. B. de Lira; M. F. Neto and C. R. Cosme (2020). Reclaiming Tropical Saline-Sodic Soils with Gypsum and Cow Manure. Water, 12, 57; 1-13.

Gendy, A. A. S. (2011). Response of Some Field Crops to Proper Tillage under Salt Affected Soils in North Nile Delta. J. Soil Sci. and Agric. Eng., Mansoura Univ., 2 (5): 441 – 453.

Gomez, K.A., and A.A. Gomez (1984). Statistical Procedures for Agric. Res., 2nd edition. John Wiley and Sons, New York, 680.

Huang K.; F. Li; Y. Wei; X. Fu and X. Chen (2014). Effects of earthworms on physicochemical properties and microbial profiles during vermicomposting of fresh fruit and vegetable wastes. Bioresour Technol 170:45–52.

Jackson ML. (1973)"Soil Chemical Analysis." 2nd Ed. Prentice-Hall of India Private and L. T. D., New Delhi, India.

Jindo K.; C. Chocano; J.M. De Aguilar; D. Gonzalez; T. Hernandez and C. Garcia (2016). Impact of compost application during 5 years on crop production, soil microbial activity, carbon fraction, and humification process. Commun. Soil Sci. Plant Anal. 47, 1907–1919.

Joshi, R.; J. Singh and A.P. Vig (2014). Vermicompost as an effective organic fertilizer and biocontrol agent: effect on growth, yield, and quality of plants. Rev Environ Sci Biotechnol. DOI 10.1007/s11157-014-9347-1.

Khosla, B. K., and I. P. Abrol (1972). Effect of gypsum fineness on the composition of saturation extract of a saline-sodic soil. Soil Science 113: 204–06.

Klute, A. Ed. (1986). "Methods of Soil Analysis". No. 9 Part 1, Amer. Soc. Agron., Inc. Madison, Wisconsin, USA.

Lakhdar A.; R. Scelza; M. Scotti; N. Rao; L. Jedidi; and C. Gianfreda (2010). The effect of compost and sewage sludge on soil biologic activities in salt-affected soil. R.C. Suelo Nutr. Veg. 10 (1) 40 – 47.

Lalander C.H.; A.J. Komakech and B. Vinnerås (2015). Vermicomposting as manure management strategy for urban small-holder animal farms Kampala case study. Waste Manag 39:96–103.

Little A.G.; C. Arellano; G.G. Kennedy and Y.J. Cardoza (2011). Bottom-up effects mediated by an organic soil amendment on the cabbage aphid pests Myzus persicae and Brevicoryne brassicae. EntomolExpAppl 139:111–119.

Machado R. M. A. and R. P. Serralheiro (2017). Soil Salinity: Effect on Vegetable Crop Growth. Management Practices to Prevent and Mitigate Soil Salinization. Horticulturae, 3, 30: 1-13.

Mahmoodabadi M.; N. Yazdanpanah; L.R. Sinobas; E. Pazira and A. Neshat (2013). Reclamation of calcareous saline-sodic soil with different amendments (I): Redistribution of soluble cations within the soil profile. Agric. Water Manag., 120, 30–38.

Mahmoud E.K. and M.M. Ibrahim (2012). Effect of vermicompost and its mixtures with water treatment residuals on soil chemical properties and barley growth. Journal of Soil Science and Plant Nutrition, 2012, 12 (3), 431-440.

Mahmud M.; R. Abdullah and J. S. Yaacob (2018). Effect of Vermicompost Amendment on Nutritional Status of Sandy Loam Soil, Growth Performance, and Yield of Pineapple (Ananas comosus var. MD2) under Field Conditions. Agronomy, 8, 183: 1-17.

Makode P.M. (2015). Effect of vermicompost on the growth of Indian orange, Citrus reticulatus with reference to its quality and quantity. Biosci Biotech res Comm 8:217–220.

Mathivanan S.; R. Kalaikandhan; AL. A. Chidambaram, and P. Sundramoorthy (2013). Effect of vermicompost on the growth and nutrient status in groundnut (Arachis hypogaea. L). Asian J. Plant Sci. Res., 3(2):15-22.

Mendoza-Hernández D.; F. Fornes and R.M. Belda (2014). Compost and vermicompost of horticultural waste as substrates for cutting rooting and growth of rosemary. Sci Hortic 178:192–202.

Mohamed, A.A., E.N. Gendy and S.R. Saleeb, (1999). The combined effect of irrigation and number and gypsum application on faba beann (Vicia faba L.) yield and its main components. Annals of Agric. Sci., Moshtohor, 37(4): 2805-2812.

Mohammadii H. and S. Rezaei-Chiyaneh (2019). Effect of vermicompost application on seed yield and quality in faba bean (Vicia faba L.) and fennel (Foeniculum vulgare L.) intercropping. Iranian Journal of Crop Sciences 21 (2): 139-154.

Nan, J.; X. Chen; C. Chen; M.S. Lashari; J. Deng and Z. Du (2016). Impact of flue gas desulfurization gypsum and lignite humic acid application on soil organic matter and physical properties of a saline-sodic farmland soil in Eastern China. J. Soils Sediments, 16, 2175–2185. [CrossRef]

Norman A. and E. Clive (2010). The use of vermicomposts as soil amendments for production of field crops vermiculture technology. CRC Press, Boca Raton, pp 129–151.

Olsen S.R.; C.V. Cale; F.S. Watenable and L.A. Dean. (1954) Estimation of available phosphorus in soil by extraction with sodium bicarbonate U.S. Dept., Agric. Circ.

Orozco, S.H.; J. Cegarra; L.M. Trujillo and A. Roig,(1996). Vermicomposting of coffee pulp using the earthworm Eisenia fetida: Effects on C and N contents and the availability of nutrients. Biol. Fertil.Soils. 22: 162-166.

Page, A.L.; R. H. Miller and D.R. Keeney (1982). Methods of Soil Analysis. Part 2: Chemical and microbiological properties. second edition, Amer Soc. Of Agron. Madison, Wisconsin, USA.

Rashidi M. and M. Seilsepour, (2008). Modeling of soil exchangeable sodium percentage based on soil sodium adsorption ratio. Arpn Journal of Agricultural and Biological Science. 3 (4) July Issn 1990-6145.

Raut, R.S. (2000).In: International Conference on Managing Natural Resources, New Delhi. Extended Summary, 2: 375-376.

Ravindran B.; J.W.C. Wong; A. Selvam and G. Sekaran (2016). Influence of microbial diversity and plant growth hormones in compost and vermicompost from fermented tannery waste. Bioresour Technol 217:200–204.

Richards L.A. (1954). Diagnosis and Improvement of Saline and Alkali Soils. USDA Agricultural Handbook No. 60, US Department of Agriculture, Washington DC. 160 p.

Sakhavi, Sh.; R. Amini; M. R. Shakiba and A. D. M. Nasab (2016). Advantage of faba bean (Vicia faba L.) and cumin (Cuminum cyminum L.) intercropping under organic, biological, and chemical fertilizer treatments. J. Sustain. Agric. Prod. Sci. (4)26: 17-32.

Shaaban, M.; M. Abid, and R.A.I. Abou-Shanab (2013). Amelioration of salt-affected soils in rice paddy system by application of organic and inorganic amendments. Plant, Soil, and Environment, 59(5): 227-233.

Shrivastava P. and R. Kumar (2015). Soil salinity: A serious environmental issue and plant growth-promoting bacteria as one of the tools for its alleviation. Saudi J Biol Sci. 22(2): 123–131.

Singh, TH. D.; N. Swaroop; T. Thomas and A. A. David (2017). Effect of Different Levels of Vermicompost on Soil Physical Properties of Two Cultivars of Cabbage (Brassica oleracea L.) under Eastern UP (India) Conditions. Int.J.Curr.Microbiol.App.Sci. 6(6): 2908-2911.

Sinha, R. K.; S. Herat; G. Bharambe; S.l. Patil; P.D. Bapat; K. Chauhan and D. Valani (2009). Vermiculture Biotechnology: The Emerging Cost-effective and Sustainable Technology of the 21st Century for Multiple Uses from Waste and Land Management to Safe and Sustained Food Production, Environmental Research Journal, NOVA Science Publishers, NY, USA, Invited Paper, Vol: 3 (2/3).

Smith A. P.; D. Chen and P. M. Chalk (2009). N2 fixation by faba bean (Vicia faba L.) in a gypsum-amended sodic soil. Biol Fertil Soils 45:329–333.

Srivastava, P.K.; P.C. Singh; M. Gupta; A. Sinha; A. Vaish; A. Shukla; N. Singh and S.K. Tewari (2011). Influence of earthworm culture on fertilization potential and biological activities of vermicomposts prepared from different plant wastes. J. Plant Nutr. Soil Sci. 174:420–429.

Tejada, M., and J.L.Gonzalez, (2003). Effects of the application of a compost originating from crushed cotton gin residues on wheat yield under dryland conditions. European Journal of Agronomy 19, 357–368.

Walkley, A., and I.A. Black (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Sci. 37: 29–38.

Wang X.X.; F. Zhao; G. Zhang; Y. Zhang and L. Yang (2017). Vermicompost Improves Tomato Yield and Quality and the Biochemical Properties of Soils with Different Tomato Planting History in a Greenhouse Study. Front. Plant Sci. 8:1978.

Warman P.R. and M.J. Anglopez (2010). Vermicompost derived from different feedstocks as a plant growth medium. Bioresour Technol 101:4479– 4483.

Yadav A. and V.K. Garg (2011) Recycling of organic wastes by employing Eisenia fetida. Bioresour Technol 102:2874–2880.

Yildiz O.; E. Altundağ; B. Çetin; Ş.T. Güner; M. Sarginci and B. Toprak (2017). Afforestation res-toration of saline-sodic soil in the Central Anatolian Region of Turkey using gypsum and sulfur. Silva Fennica 51 (1B) article ID 1579: 1-17.

Zhao H.; T. Li; Y. Zhang; J. Hu; Y. Bai; Y. Shan and F. Ke (2017). Effects of vermicompost amendment as a basal fertilizer on soil properties and cucumber yield and quality under continuous cropping conditions in a greenhouse. J Soils Sediments 17:2718–2730.

فاعلية استخدام احجام مختلفة من الجبس،والفيرم كمبوست فى استصلاح الاراضى المتأثرة بالاملاح وانتاجية محصول الفول البلدي

سحرحسن راشد[1] و محمد عباس ابراهيم[2]

[1]قسم بحوث تحسين وصيانة الراضي ـ معهد بحوث الاراضى والمياه والبيئة – مركز البحوث الزراعية

[2] قسم بحوث المحاصيل البقولية – معهد بحوث المحاصيل الحقلية ، مركز البحوث الزراعية – جيزة ، مصر

تعد ملوحة التربة من اهم العوامل البيئية المحددة لنمو النبات وانتاجية التربة،لذا تم دراسة تجربة حقلية خلال الموسمين الشتويين(2019/2018،2020/2019) فى مركز الحامول، محافظة كفرالشيخ، مصر.تهدف الدراسة الى دراسة تاثير محسنات التربة:الفيرم كمبوست بمعدلات (3.6, 2.4, 1.2, 0ميجاجرام/هكتار)،وحجم حبيبات الجبس(اقل من 0.5مم،0.5-1،1-2مم) والتفاعل بينهم على بعض الخصائص الفيزيوكيمائية للتربة وانتاجية الفول فى الاراضى المتأثرة بالاملاح.تبين من النتائج ان هناك تناقص معنوي في ملوحة التربة والكثافة الظاهرية للتربة بمعدل (18.97،8.87%) بالمقارنة بما قبل المعاملات،نتيجة اضافة3.6ميجاجرام/هكتار من الفيرم كمبوست مع اضافة الجبس ذات الحجم الاقل من0.5مم. بينما تزايدت معنويا قيم كل من كفائة الصوديوم المزال،المسامية الكلية،المادة العضوية،السعة التبادلية الكاتيونية ،ومحتوى التربة من العناصر بمعدل (27.62،9.78،48.94،22.425،18.00،20.91،19.09%) على الترتيب بالمقارنة بما قبل المعاملة . تبين ان اضافة 3.57ميجاجرام فيرم كمبوست / هكتار مع الجبس الناعم أدت الى الحصول على أعلى القيم لكل من وزن 100حبة (69.20،78.36جم)،طول النبات (81.03،84.93سم)،محصول القرون (6.6، 6.23ميجاجرام/هكتار)،محصول البذور(4.02،4.39ميجا /هكتار) لنبات الفول البلدي للموسم الاول والثانى على الترتيب،بالمقارنةباحجام حبيبات الجبس الخشن،تشير البيانات الى ان حبيبات الجبس الناعم اكثر فاعلية فى استصلاح الاراضى المتأثرة بالاملاح ،وانتاجية محصول الفول البلدي

الكلمات الدالة: الملوحة،الفيرم كمبوست،الجبس،خواص التربة،الفول البلدي