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ORIGINAL ARTICLES

Improving Productivity of Zucchini Squash Grown Under Moderately Saline Soil Using Gypsum, Organo-Stimulants and AM-fungi

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ABSTRACT

A field experiment was conducted on a newly reclaimed moderate saline sandy clay loam soil at South-Tahrir Sector, Al-Behira Governorate, Egypt during the growing season of 2010, under sprinkler irrigation system, located between Latitude 30° 28′ 18″ N Longitude 30° 48′ 35″ E. This study was conducted to identify the effect of applied gypsum at the rates of 0, 0.75 and 1.50 ton fed^{-1} incombination with arbuscular mycorrhizal (AM) fungi and potassium fulvate soil application at the rates of 0, 0.50 and 1.0 kg fed^{-1} on improving some soil properties as well as the zucchini squash (*Cucurbita pepo* L. var Tempra) yield, some yield characters and nutrients. The obtained results of field work and physio-chemical characteristics revealed that the experimental soil could be classified as "Typic Torriorthents, fine loamy, mixed, hyperthermic" and a moderately suitable class (S2) for irrigated agriculture land in both current and potential conditions. Also, the resultant adaptations of soil suitability class in the current condition for cultivating zucchini squash plants could be considered as not suitable (N1S1n), with limiting factors of soil salinity/alkalinity, whether be becomes highly suitable (S2S1) in the potential condition. Data showed also a clearly response for ameliorating soil properties, *i.e.,* soil pH, ECe and ESP values as well as soil nutritional status as a result of the applied treatments, particularly those treated with the highest rates of gypsum and potassium fulvate as a combined treatment. In general, the data showed also that, application of gypsum and potassium fulvate led to improve some soil properties, *i.e.,* soil bulk density, total porosity, pH and ECe. It could be noticed that values of soil total porosity exhibited gradually pronounced increases with increasing the applied rates of gypsum in combination with arbuscular mycorrhizal (AM) and potassium fulvate, while the reverse was true for soil bulk density, pH, ESP and ECe, especially at the highest rate of gypsum and Potassium fulvate. Also, The data showed that a progressive significant increases in all the studied available macronutrients (N, P and K) and micronutrients (Fe, Mn and Zn) upon treating the soil with the gypsum in combination with arbuscular mycorrhizal (AM) and potassium fulvate particularly at the applied rate of (1.5 ton of gypsum fed^{-1} +1.0 kg of potassium fulvate fed^{-1}) as compared to the control after zucchini squash harvesting. In addition, the tested treatments recorded significant increases in biomass, yield, fruit characters measurements and leaf chlorophyll assay of zucchini squash plants as well as macro-& micro nutrients contents of N, P, K, Fe, Mn and Zn, while the reverse was true for Na as non-nutritive element with superiority to combined treatment of (AM fungi + gypsum + potassium fulvate). That was true, since such triple combined treatment resulted in a beneficial effect, which is more attributed to enrich in mineral and organic substances that are essential to plant growth, stimulating and activating the bio-chemical processes in plant (*i.e.* respiration, photosynthesis and chlorophyll content). The later processes are urgent to increase the yield and improve its quality under the severe conditions of the experimental soil. Therefore, under the condition of the studied newly reclaimed moderate saline sandy clay loam soil, the applied gypsum with AM fungi and organo-stimulants potassium fulvate plays an effective role for improving soil characters; increasing the available nutrient contents and raising the efficiency of gypsum application. This of course positively reflected on zucchini squash yield and improved its characters.

Key words: Newly reclaimed saline soil, AM-fungi, gypsum and potassium fulvate.

Introduction

Soil management of the newly reclaimed soils is usually carried out through the addition of natural or chemical soil amendments that have become one of the most important practices for improving soil hydro-physical, chemical and biological properties and in turn enhancing its productivity for different vegetable crops. Soil salinity is one of the most problems facing its productivity for most of the common crops, due to the high osmotic potential in solution within the crop root zone, which causes disturbances in nutrients balance, reduces either soil available nutrients or water uptake by roots of growing plants and consequently reduces the quality

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and yield of crops (Ayers and Westcot, 1985). The harmful effect of salinity stress is more attributed with the disturbances in plant growth through its negative influence on plant physiology and on the balance in water and ionic status in the cells. Thus, an ionic imbalance occurs in the cells due to the excessive accumulation of Na^+ and Cl^- and reduces uptake of other mineral nutrients, such as K^+, Ca^{2+} and Mn^{2+} (Tester and Davenport, 2003).

Exploiting saline soils in growing crops, can be sharing in solve the problem of shortage in food production, to face the demand of fast growing population. The most problem of exploiting saline soil in agricultural utilization is how to ensure sufficient requirements of necessary macro- and micro-nutrients for growing plants and correct their deficiencies. Nutrients availability, mobility and uptake are usually the most limiting factor for plant growth in saline soils. Many investigations on salinity-nutrients issue were focused on either nutrients influence on plant (*i.e.,* Svoboda and Haberle, 2006) or salinity as limiting plant growth factor (*i.e*., Supanjani and Lee, 2006). This goal can be achieved by using some inorganic (gypsum) and organic (Potassium fulvate) as soil amendments and fertilization manipulations for correcting the supplementary feed for growing vegetable crops with some certain formulations of balanced macro- and micro-nutrients as well as applying some liquid forms of organic fertilizers either to soil or by spraying grown plants. Fertilization plays an important role in promoting plants to tolerate salt stress and toxicity (Ghoulam *et al.* 2002). On the other hand, plant response to fertilizers depends on severity of salt stress in the root zone and application of fertilizers to saline soils may exacerbate soil salinization (Maas and Grattan, 1999).

The zucchini squash (*Cucurbita pepo* L.) is an important commercial crop in open-field and protected cultivation in the Mediterranean region. Zucchini is moderately tolerant to salinity (Rouphael *et al.* 2006) and is typically cultivated in newly reclaimed areas, where saline water is frequently used for irrigation. However, zucchini, as most crops, cannot survive under conditions of high salinity or can survive only with decreased yields. There are three main physiological mechanisms inducing stress under salinity conditions: (1) lower water potential of the root medium, (2) toxic effects of Na and Cl, (3) nutrient imbalance by depression in uptake and/or shoot transport (Marschner, 1995). Overcoming salt stress problems would have a positive impact on crop yields. Thus, developing proper cropping techniques to run sustainable horticulture in the presence of irrigation water of poor quality (*e.g.,* saline) becoming essential with limiting availability of fresh water for irrigation. Arbuscular mycorrhizal (AM) fungi have been shown to decrease yield losses of plants in saline soils (Abbaspour *et al.* 2006; Al-Karaki, 2000; 2006 and Sannazzaro *et al.* 2006). This may due to increased uptake of nutrients with low mobility, such as P, Fe, Cu and Zn (Al-Karaki, 2000) and to decrease the uptake of Na (Al-Karaki, 2006). In addition, AM fungi can improve physiological processes like water absorption capacity of plants by increasing root hydraulic conductivity and favorably adjusting the osmotic balance and composition of carbohydrates (Ruiz-Lozano an Azcon, 2003). This may lead to increased plant growth and subsequent dilution of toxic ion effects (Juniper and Abbott, 1993). Phosphorus availability can profoundly influence plant responses to AM (Chandrashekara *et al.* 1995). High P can inhibit AM colonization of plant roots, reduce formation of entry joints and vesicles (Amijee *et al*. 1989) and decrease the length of external hyphae associated with AM (Abbott *et al.* 1984), with a consequent reduction in nutrient uptake and host benefit from AM.

Many studies were carried out to investigate the beneficial effects of gypsum applied alone or in combination with other materials as a soil amendment and ameliorating soil nutrients status.
In addition, gypsum ($CaSO_4.2H_2O$) consider as a soil amendment refers to improvement of hydrophysical, chemical and biological properties of soil, particularly for agricultural purpose (Morsy *et al*. 1982). Gypsum can be ionized to Ca^{++} and SO_4^{--}, then Ca^{++} can be improved soil aggregation and permeability while, SO_4^{--} reduced soil pH and best source of S. The sulphur is one of the most macronutrients for plant, mainly due to it plays an important role in growth and development of plants being a constituent of three amino acids viz., methionine, cysteine and cystine. Sulphur is also needed for the synthesis of other metabolites like co-enzyme, biotin, thiamin (Vitamin B1) and glutathione, besides its role in the synthesis of chlorophyll. Ahmed, (2009) reported that sulphur fertilization significantly affected plant height, chlorophyll and number of green leaves/plant, which implies a better photosynthetic activity in comparison with plants grown without S. Also, sulphur application led to a significant reduction in soil ECe, pH and SAR values and increased the yield of wheat plants grown on calcareous soils (Wassif *et al.* 1995).

Because of the relatively small size of fulvic acids molecules they can readily enter plant roots, stems and leaves. As they enter these plant parts they carry trace minerals from plant surfaces into plant tissues. Fulvic acid is key ingredients in high quality soil fertilizers. Soil spray applications containing fulvic acid mineral chelates, at specific plant growth stages, can be used as a primary production technique for maximizing the plants productive capacity. Once applied to plant foliage fulvic acids transport trace minerals directly to metabolic sites in the plant cells. Fulvic acids are the most effective carbon containing chelating compounds known. They are plant compatible, thus nontoxic, when applied at relatively low concentrations.

Organic substances such as humic substances are made up of humin, humic and fulvic acids (Tan, 2003). These organic compounds have the capability of increasing N, P, K, Ca, Mg and Na availability in soils by producing soil organic carbon, forming organophosphate complexes, increasing cation exchange capacity, act as anion replacement of $H_2PO_4^-$ as well as coating materials for Fe/Al oxides (Tan, 2003 and Susilawati, *et al*, 2011). Therefore, it could be said that the application of fulvic acid salts such as Potassium fulvate could be improved plant growth under the conditions of soil salinity. The increase in CEC due to addition of fulvic acids may have increased N fertilizer use efficiency. Liquid organic-N did not affect dry matter production of corn. The concentration of other nutrients in the plant tissues and their uptake were also not affected much by the use of liquid organic-N fertilizer. However, in terms of N and K uptake and the use efficiency, a liquid urea-fulvic acid is recommended. According to Schnitzer, (1977), the total acidity of fulvic acids for tropical soil ranges from 820 to 1030 cmol kg^{-1}. This value is higher, when compared with humic acid (620 to 750 cmol kg^{-1}). Similar results have also been reported by Sim and Murtedza, (2007) for peat soils of Sarawak (584 and 1366 cmol kg^{-1}as averages for total acidity of humic acid and fulvic acid, respectively). This high total acidity may have enabled fulvic acid to fix N and made it more available to the plant. Fulvic acid is particularly preferred in that it allows surrounding stress to decrease, helps absorb other minerals and positively contributes to harvest and quality (Eyyüp and Unay, 2011).

Therefore, the present study was carried out to evaluate the gypsum application in combination with AM fungi and organo-stimulant (potassium fulvate soil application) on improving productivity of a newly reclaimed moderate saline sandy clay loam soil.

Materials and Methods

A field experiment was carried out on a newly reclaimed moderate saline sandy clay loam soil at South-Tahrir Sector, Al-Behira Governorate, Egypt during the growing season of 2010 under sprinkler irrigation system, located between Latitude 30° 28′ 18″ N Longitude 30° 48′ 35″ E. The current work was an attempt to identify the effect of applied gypsum at the rates of 0, 0.75 and 1.50 ton fed^{-1} in combination with arbuscular mycorrhizal (AM) fungi and potassium fulvate soil application at the rates of 0, 0.50 and 1.0 kg fed^{-1} on improving some soil properties as well as the yield and fruit quality of zucchini squash (*Cucurbita pepo* L. var Tempra).

Some physical and chemical properties of the experimental soil were determined according to the methods of Jackson, (1973) Chapman and Pratt (1961) and Page *et al.* (1982) and the obtained data are presented in Table (1).

Table 1: Some physical, chemical and fertility characteristics of the studied soil.

Soil characteristics	Value	Soil characteristics	Value
Particle size distribution%:		*Soluble cations (soil paste $mmole_cL^{-1}$):*	
Sand	52.7	Ca^{2+}	19.43
Silt	20.9	Mg^{2+}	8.62
Clay	26.4	Na^+	50.70
Textural class *Sandy clay loam*		K^+	0.75
Soil chemical properties:		*Soluble anions (soil paste $mmole_cL^{-1}$):*	
pH (1.25 soil water suspension)	8.36	CO_3^{2-}	0.00
$CaCO_3$ %	1.65	HCO_3^-	2.95
Organic matter %	1.18	Cl^-	36.40
ECe (dS m^{-1}, soil paste extract)	7.95	SO_4^{2-}	40.15
ESP	15.47		
Soil physical properties:			
Bulk density g cm^{-3}	1.34	Total porosity %	34.25
Gypsum ($CaSO_4.2H_2O$) %	0.93		

Available Nutrients mg kg^{-1}						
N	P	K	Fe	Mn	Zn	Cu
34.97	4.56	197.8	4.96	0.75	0.60	0.47

Critical levels of nutrients (mg kg^{-1}) after Lindsay and Norvell (1978) and Page *et al.* (1982).

Limits	N	P	K	Fe	Mn	Zn	Cu
Low	< 40.0	< 5.0	< 85.0	< 4.0	< 2.0	< 1.0	< 0.5
Medium	40.0-80.0	5.0-10.0	85.0-170.0	4.0-6.0	2.0-5.0	1.0-2.0	0.5-1.0
High	> 80.0	> 10.0	> 170	> 6.0	> 5.0	> 2.0	> 1.0

The IR (infra red) bands of the used K-fulvate were identified according to the standard method described by Kononova, (1966) to identify the active groups (Stevenson, 1994) with some specific components, as shown in Table (2).

Zucchini squash seeds (*Cucurbita pepo* L. var Tempra) were sown in the nursery on March 8, 2010 and the studied treatments were arranged in complete randomized blocks design with three replicates .The seedlings were transplanted 15 days (March 23) after sowing, at the two true-leaf stages into pots. Plant rows were 1.4 m apart and the space between plants within a row was 0.75 m. The distance between the centers of double rows was 2.0 m, resulting in a plant density of 1.33 plants m^{-2}.

Table 2: Some specific component of used potassium fulvate (% dry ash-free basis).

Fulvic Acid %	Potassium (K_2O) %	Nitrogen (N) %	Phosphorus (P_2O_5) %	Free amino acids %	CEC cmol kg^{-1}
45	6 - 8	3 - 5	0.5 – 1	2 – 3	820 to 1030
pH (1%)	Water Soluble	Appearance	C %	H %	O %
5 -7	100%	Dark Brown Powder	44-49	3.5-5.0	44-49

The treatments were defined by a factorial combination of applied gypsum at the rates of 0, 0.75 and 1.50 ton fed^{-1}, two mycorrhizal treatments (with AM, +AM or without AM, −AM) and potassium fulvate soil application at the rates of 0, 0.50 and 1.0 kg fed^{-1}. Before transplantation, half of the plots received a commercial mycorrhizal inoculum carrying Glomus intraradices (Dpartment of Microbiology, SWERI, ARC, Egypt) by placing 10 ml per pot of inoculum containing bulking material composed of 95% clay minerals as granular carriers, plus root fragments and spores (100 spores/ml) below the zucchini plants. The commercial inoculum was originally cultured in leek roots (*Allium porrum* L.) as reported by Marleen *et al.* (2010).

Basic application of phosphorus fertilizer, as single superphosphate (12.5% P_2O_5) was added in two equal doses, *i.e.,* at planting and one month later at the rate of 25 kg P_2O_5 fed^{-1}. Potassium sulphate (48% K_2O) at the rate of 50 kg K_2O fed^{-1} was applied. However, nitrogen fertilizer was applied at a rate of 60 kg N fed^{-1} as ammonium sulphate (20.6% N). Both N- and K- fertilizers were applied in three equal doses, i.e., at planting, one month later and flowering stage. The normal cultural practices for zucchini squash plant were applied as recommended in the sector. Sprinkler irrigation was applied as plants needed. Taking into consideration K-amount of K-fulvate of the applied recommended K-rate.

Plant Parameters Recorded:
A.Yield, Biomass and *Fruit Quality Measurements:*

Fresh weight of marketable fruit and the number of fruit were recorded three times per week on six plants per plot from April 20 to May 29. Fruits were harvested when they reached marketable size (over 12 cm). At final harvest (May 30, 68 days after transplanting). All plant tissues were dried in a forced-air oven at 70°C for 72 h for biomass determination.

B. Leaf Chlorophyll Assay:

For the chlorophyll analyses, leaf discs were taken from the interveinal areas on the fully opened fourth or fifth leaf from the top of the six plants per replicate. Chlorophyll was extracted by grinding the tissue with a mortar and pestle using ammoniacal acetone. The resulting extracts were centrifuged at 3,000 rpm for 3 min. The total chlorophyll contents were determined by spectrophotometry. The absorbance of the solution was measured at 470 and 647 nm. Formulae used for the determination of chlorophyllous pigments (total chlorophyll) were described by Lichtenhaler and Wellburn, (1983). The content of the total chlorophyll was expressed in mg g^{-1} of fresh weight.

C. Leaf Mineral Analysis:

Dried leaf tissues were ground in a Wiley mill to pass through a 20-mesh screen and 0.2 g of the dried tissues was analyzed for the following macro- and micronutrients: N, P, K, Fe, Mn and Zn. The N concentration of leaf tissues was determined after mineralization with sulfuric acid by “Regular Kjeldahl method” (Bremner 1965), whereas P, K, Fe, Mn and Zn concentrations were determined by dry ashing at 400°C for 24 h, dissolving the ash in HNO_3 1:20 v/v and solution obtained assaying according to AOAC, (1990) by an inductively coupled plasma emission spectrophotometer (Karla, 1998).

Analytical Methods of Soil Properties:

The collected soil samples at the initial state were analyzed for particle size distribution (International pipette method after Piper, 1950), bulk density (Black and Hartge, 1986), organic matter content (Walkely and Black method after Hesse, 1971), $CaCO_3$ content, cation exchange capacity, exchangeable sodium %, pH and soil paste extract (Jackson, 1973). Available macronutrients of N, P and K in soil were extracted by 1% potassium sulphate, 0.5 M sodium bicarbonate and 1 N ammonium acetate, respectively (Soltanpour and Schwab, 1977) and their contents in soil were determined according to Jackson (1973). Available micronutrients of Fe, Mn, Zn and Cu in soil were extracted using ammonium bicarbonate-DTPA extract according to

Soltanpour and Schwab, (1977) and their contents in soil were measured by using the Atomic Absorption Spectrophotometer.

Statistical Analysis:

The results obtained were statistically analyzed by analysis of variance (ANOVA) using the SPSS software package (SPSS 10 for Windows 2001) according to Gomez and Gomez (1984).

Results and Discussion

General View on The Characteristics of The Experimental Soil:

The experimental sandy clay loam soil represents some newly reclaimed areas calcareous in nature of the South-Tahrir Sector, Al-Behira Governorate, Egypt. It is developed under climatic conditions of long hot rainless summer and short mild winter, with scarce amounts of rainfall. Data illustrated in Table 1 indicate that the ECe, pH and ESP values were averaged about 7.95 dS m^{-1}, 8.36 and 15.47 %,respectively, hence the studied soil was surveyed as a moderately saline-slightly sodic soil. Such results are emphasized by the progressive increments of soluble Na^{+}, which surpassed the soluble (Ca^{2+}+Mg^{2+}) contents that reflected the signs of unfavourable soil aggregation, with a massive structure type, which reflected the signs of imperfect soil aeration.

Also, the analytical data revealed that the studied sandy clay loam soil attains a relatively low $CaCO_3$ content (averaged about 12 %). In addition, the prevailing hot and arid climatic may be ascribed to the low accumulated plant residues (low organic matter content) and soil pH tended towards the alkaline side (averaged about 8.36). As for soil fertility status, the studied soil was mostly suffering from macro and micronutrients deficient, due to the virgin nature of such desert sandy clay loam soil and in turn it is poorer in available nutrient contents. According to the critical levels of the studied available nutrients undertaken by Lindsay and Norvell (1978) and Page *et al.* (1982), the experimental soil is suffering from plant nutrients deficiency, as shown from data illustrated in Table 1. Thus, supplying essential plant nutrients and soil amendments is undoubtedly of great importance for enhancing nutrients availability, mobility and uptake by the grown plants.

Soil Taxonomy and Evaluation In The Current and Potential Conditions:

Soil Taxonomy:

According to the obtained results of field work and physio-chemical characteristics as well as based on the outlines of classification system (USDA, 2010), the experimental soil could be classified at a family level of "Typic Torriorthents, fine loamy, mixed, hyperthermic.

Soil Evaluation For Irrigated Agriculture Land:

A parametric system of soil evaluation, undertaken by Sys and Verheye (1978), was applied to define the limitations for soil productivity, their intensity degrees and suitability classes for irrigated agriculture land, as shown in Table 3.

Table 3: Soil limitations and rating indices for evaluating the studied soil.

Suitability condition	Topography (t)	Wetness (w)	S				Soil salinity / Alkalinity (n)	Rating (Ci)	Suitability class	Suitability subclass
			Soil texture (s_1)	Soil depth (s_2)	$CaCO_3$ (s_3)	Gypsum (s_4)				
Current	100	100	90	100	100	100	85	61.96	S2	S2S1n
Potential	100	100	90	100	100	100	100	72.90	S2	S2S1n

The obtained data show that soil texture (s_1), $CaCO_3$ and salinity/alkalinity represent the main limitations for soil productivity, with an intensity degree of moderate (85 %), for soil salinity/alkalinity and (100 %) for the three other ones. Also, the suitability classes in the current and potential conditions of the studied soil could be categorized as a moderately suitable (S2) for irrigated agriculture land, with suitability index rating (Ci) ranged 61.96 and 72.90 %, respectively.

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Soil Suitability For Zucchini Squash Plants:

Firstly, land suitability for agricultural irrigated soils is the appraisal of specific areas of land from a general point of view without mentioning the specific kind of use. So, some soils may be suitable for a specific crop and unsuitable for another. The ideal approach for land evaluation is based on evaluating the land for utilization types which used as guides for the most beneficial use for a specific productivity by replacing a less adapted land utilization type by another promising one and was applied in this study. Also, the evaluation indices of land characteristics are done by rating them and specifying their limitations for certain crops by matching the calculated rating with the crop requirements in different suitability levels as proposed by Sys *et al.* (1993). In the studied area, without major land improvements, the crop requirements were matched with the present land qualities for processing the current and potential land suitability of the different land units. This approach enables management of different alternatives for specific utilizations that are adapted to the existing limitations to give maximum output. The suitability classes of the experimental soil either in the current or potential condition for the cultivation of Zucchini squash plants are shown in Table 4.

As for this purpose, the land utilization is applicable for the main characteristics of the studied area, which are considered regarding land qualities of drainage, salinity and sodicity.

Moreover, the resultant adaptations of soil suitability class for cultivating zucchini squash plants could be considered as not suitable ($N1s_1n$) and highly suitable ($S1s_1$) adaptation in the current and potential conditions, with a rating index of 17.21 and 81.00 %, respectively. Also, soil texture (s_1), salinity (ECe) and alkalinity (ESP) represent the main limitations for soil productivity in the current condition, with an intensity degree of severe (25 %) for ECe and slight (90 %) for the other three ones. As for the potential condition soil salinity and alkalinity should be corrected, but both soil texture (s_1) and will be remained as permanent soil limitations and then the resultant adaptations of soil suitability class for cultivating pea plants could be considered as highly suitable ($S1s_1$), with a rating index of 81.0 %.

Table 4: Soil suitability for cultivation of zucchini squash plants.

Condition	Topography (t)	Wetness (w)*	Soil characteristics						Rating (Ci)	Suitability class	Suitability subclass
			Soil texture (s_1)	Soil depth (s_2)	$CaCO_3$ (s_3)	Gypsum (s_4)	ECe	ESP			
Current	100	100	90	100	100	100	25	85	17.21	N1	S2S1n
Potential	100	100	90	100	100	100	100	100	81.00	S1	S2S1

I. Effect of and Gypsum Application With Bio-Inoculation And Organo-Stimulants On Some Soil Properties:
Soil Chemical Properties:

Data in Table (5) showed a clearly response of some soil chemical properties, *i.e.,* pH, ESP and ECe to the applied treatments, particularly those treated with the highest rates of gypsum in combination with arbuscular mycorrhizal (AM) fungi and potassium fulvatd. That was true, since gypsum can be ionized to Ca^2 and SO_4^{2-} which reduce soil pH, besides the acidity reacts of potassium fulvate, consequently such acidity media led to lowering soil pH value. These results are in agreement with those obtained by Awadalla *et al.* (2003).

On the other hand, the released soluble ions of Ca^{2+} can be improved soil aggregation, due to a Ca^{2+} partial substitution by exchangeable Na^+ that enhancing the coagulation of Na-separated clay particles and leading to reduce ESP value which encouraging the formation of small clay domains. Such clay domains are coated with the released active organic acids that are resealed from organo-stimulants (potassium fulvate) and then forming coarse sizes of water stable aggregates isolated or separated by conductive coarse pores that are increased soil permeability and accelerating leaching of a pronounced content of excess soluble salts and then reducing the ECe value.

The effective role of microbial activity for reducing soil salinity stress, particularly in a combination with either applied gypsum or organo-stimulants as a source of active organic acids, could be interpreted according to many opinions outlined by Bacilio *et al.* (2003) and Ashmaye *et al.* (2008) who reported that many strains produce several phytohormones (*i.e.,* indole acetic acid and cytokinins) and organic acids. Such products reduce the deleterious effect of Na-salts and then simultaneously improving soil structure, *i.e.,* increasing aggregate stability and drainable pores. Consequently, these created conductive pores enhancing the leaching process of soluble salts through irrigation fractions.

Soil Physical Properties:

Data in Table (5) showed that concerning the variations in soil bulk density among the different used amended treatments, data show that a gradually decrease in its values was occurred with increasing the applied potassium fulvate rates, where the greatest rate (1.0 kg fed^{-1}) gave the lowest soil bulk density value. This positive effect might attribute to the pronounced content of organic colloidal particles, which plays an important role for modifying distribution pattern of pore spaces in soil. These findings are in agreement with those obtained by Batey (1990) who reported that soil bulk density was closely related to solid phase properties and pore spaces. Since the applied potassium fulvate possesses a positive effect for soil bulk density (*i.e.,* reduced its value), hence it leads to increase total porosity of the soil. However, the amended moderate saline soil with potassium fulvate encouraged the creation of medium and micro pores (*i.e.,* water holding and useful pores) between simple packing sand particles and in turn increasing capillary potential. On the other hand, application of gypsum can be improved soil aggregation, due to a Ca^{2+} partial substitution by exchangeable Na^{+} and decreased the soil bulk density. The decrease in bulk density may be attributed to the effect of both applied gypsum and microbial activity on the redistribution of soil particles which tended to decrease soil bulk density and consequently the total porosity increasing. The best improved effect was subjected with highest rates of gypsum. These finding are in harmony with those outlined by Massoud (2006) who found that, the soil bulk density tended to decrease due to increasing gypsum addition.

Table 5: Influence of gypsum and potassium fulvate in combination with AM-fungi on some properties of the tested soil.

Bio-inoculation	Gypsum rate (ton/fed)	ECe (dSm^{-1})			pH (1:2.5)			ESP%			Bulk density (g cm^{-3})			Total porosity %		
		Organo-stimulants potassium fulvate (kg fed^{-1})														
		0.0	0.5	1.0	0.0	0.5	1.0	0.0	0.5	1.0	0.0	0.5	1.0	0.0	0.5	1.0
- AM	0.0	8.05	7.60	7.17	8.35	8.17	8.05	15.45	14.70	13.95	1.36	1.33	1.30	36.25	37.95	40.10
	0.75	7.67	7.20	6.86	8.26	8.04	7.93	14.87	14.05	13.32	1.34	1.31	1.29	37.76	39.20	42.80
	1.50	6.70	6.52	6.28	7.98	7.86	7.72	13.74	12.90	11.97	1.31	1.28	1.26	38.81	40.85	43.65
	Mean	7.26	7.11	6.77	--	--	--	14.69	13.88	13.08	1.34	1.31	1.28	34.27	39.33	42.18
+ AM	0.0	7.90	7.20	6.50	8.35	8.05	7.78	15.05	13.95	12.46	1.34	1.31	1.30	37.90	40.25	43.45
	0.75	7.15	6.60	6.14	8.12	7.84	7.60	14.35	12.69	11.06	1.31	1.29	1.26	40.65	42.65	45.30
	1.50	6.37	5.99	5.80	7.91	7.65	7.45	13.15	11.45	9.71	1.29	1.26	1.23	43.20	45.50	48.13
	Mean	7.14	6.59	6.15	--	--	--	14.18	12.69	11.08	1.31	1.29	1.26	40.58	42.80	45.63

- AM = soil without inoculate arbuscular mycorrhizal fungi and + AM= soil with inoculate arbuscular mycorrhizal fungi

II. Effect of Gypsum Application With Bio-Inoculation and Organo-Stimulant on Soil Available Nutrient Contents:

Data illustrated in Tables (6 and 7) indicated that the available contents of the studied macro- (N, P and K) and micronutrients (Fe, Mn and Zn) after harvesting of zucchini squash plants gradually increased with increasing the applied gypsum rates in combination with arbuscular mycorrhizal (AM) compare with the soil without inoculate arbuscular mycorrhizal fungi. Also, the available contents of the studied macro- (N, P and K) and micronutrients (Fe, Mn and Zn) gradually increased with increasing the applied potassium fulvate rates. These results are in harmony with those obtained by Massoud (2006).

Table 6: Influence of gypsum and potassium fulvate in combination with AM-fungi on availability of soil macro-nutrient contents.

Bio-inoculation, B	Gypsum rate (ton/fed) G	Soil macronutrients content (mg kg^{-1} soil)											
		N				P				K			
		Organo-stimulants potassium fulvate (kg fed^{-1}), O											
		0.0	0.5	1.0	Mean	0.0	0.5	1.0	Mean	0.0	0.5	1.0	Mean
-AM	0.0	36.4	40.1	43.5	40.0	4.32	5.45	6.10	5.29	20.0	20.8	21.7	20.8
	0.75	39.5	43.7	47.1	43.4	5.35	5.90	6.54	5.93	20.7	21.5	22.5	21.6
	1.50	43.0	47.1	50.3	46.8	5.84	6.42	6.95	6.40	21.5	22.3	23.2	22.3
	Mean	39.6	43.6	46.9	43.4	5.71	5.92	6.53	6.05	20.7	21.5	22.5	21.6
+AM	0.0	42.2	47.8	50.3	46.8	6.57	7.64	8.07	7.43	22.3	22.6.	23.5	22.8
	0.75	46.4	50.4	54.0	50.3	7.00	8.07	9.06	8.04	23.1	23.3	24.2	23.5
	1.50	50.7	54.0	57.6	54.1	7.48	8.50	9.75	8.88	24.0	24.1	24.8	24.4
	Mean	46.4	50.7	53.9	50.3	7.02	8.07	8.98	8.02	23.1	23.4	24.2	23.6
LSD at 0.05	B	0.84				0.06				0.20			
	G	1.07				0.10				0.21			
	O	0.54				0.04				0.10			
	BxG	1.51				0.13				0.34			
	BxO	0.74				0.05				0.17			
	GxO	1.00				0.05				0.15			
	BxGxO	1.14				0.09				0.22			

- AM = soil without inoculate arbuscular mycorrhizal fungi and + AM= soil with inoculate arbuscular mycorrhizal fungi

Accordingly, the greatest values of the studied macro- and micro nutrients in soil were produced by applying gypsum and potassium fulvate at a rate of (1.5 ton fed^{-1} + 1.0 kg fed^{-1}) in combination with arbuscular mycorrhizal (AM). The effectiveness of applied gypsum and organo-stimulants in combination with arbuscular mycorrhizal (AM) may be due to decrease the soil pH as a result of ionized gypsum to SO_4^{--}. Further, the resultant favourable conditions enhanced the availability of soil nutrients. Similar results were obtained by El-Shahawy (2003), Abbas *et al*. (2004) and Massoud (2006).

On the other hand, potassium fulvate have many carboxyl (-COOH) and hydroxyl (-COH) groups, thus fulvic acids are much more chemically reactive. The exchange capacity of fulvic acids is more than double that of humic acids. This high exchange capacity is due to the total number of carboxyl (-COOH) groups present. The number of carboxyl groups present in fulvic acids ranges from 520 to 1120 cmol (H^+)/kg.(Kasim 2009).

Table 7: Influence of gypsum and potassium fulvate in combination with AM-fungi on availability of soil micro-nutrient contents.

Bio-inoculation, B	Gypsum rate (ton/fed), G	Soil micronutrients content (mg kg $^{-1}$soil)											
		Fe				Mn				Zn			
		Organo-stimulants potassium fulvate (kg fed^{-1}), O											
		0.0	0.5	1.0	Mean	0.0	0.5	1.0	Mean	0.0	0.5	1.0	Mean
-AM	0.0	5.09	5.64	6.20	5.64	0.82	1.08	1.21	1.04	0.71	0.85	1.04	0.87
	0.75	5.30	5.90	6.52	5.91	0.95	1.19	1.30	1.15	0.85	0.97	1.15	0.99
	1.50	5.54	6.17	6.84	6.18	1.07	1.30	1.38	1.25	0.99	1.08	1.24	1.10
	Mean	5.31	5.90	6.52	5.90	0.91	1.19	1.30	1.13	0.85	0.97	1.15	0.99
+AM	0.0	5.87	6.70	7.14	6.57	1.15	1.35	1.41	1.30	0.98	1.14	1.23	1.17
	0.75	6.15	7.10	7.45	6.90	1.31	1.42	1.62	1.45	1.20	1.27	1.38	1.28
	1.50	6.45	7.38	7.86	7.23	1.40	1.55	1.73	1.56	1.32	1.47	1.59	1.46
	Mean	6.16	7.06	7.49	6.90	1.29	1.44	1.59	1.44	1.17	1.29	1.40	1.29
LSD at 0.05	B	0.22				0.05				0.06			
	G	0.38				0.14				0.09			
	O	0.14				0.03				0.10			
	BxG	0.29				0.10				0.12			
	BxO	0.15				0.11				0.11			
	GxO	0.11				0.06				0.17			
	BxGxO	0.24				0.09				0.15			

- AM = soil without inoculate arbuscular mycorrhizal fungi and + AM= soil with inoculate arbuscular mycorrhizal fungi

Effect of and Gypsum Application With Bio-Inoculation And Organo-Stimulant On Plant: Vegetative Growth and Chlorophyll Content:

Vegetative growth of zucchini squash plants and the chlorophyll a & b contents were drastically affected by excess salts in case of grown on moderate saline soil (Table 8). These findings are in harmony with those reported by Gupta and Gupta (1984) who found that salinity stress negatively affected plant growth through the influence of several factors on physiological processes, *i.e.,* photosynthesis, osmotic potential, specific ion effect and ion uptake. The previously behaviour could be primarily due to an adjustment of subcelluler ion distribution to maintain osmotic potentials and favourable water relations (Treeby and Van-Steveninck 1988). Also, these results are in agreement with those reported by El Masry and Hassan (2001).

Data of the studied dry weight of zucchini squash plants amended with different rates of gypsum and potassium fulvate in combination with AM fungi showed significantly increases with increasing the applied levels of gypsum and potassium fulvate. It is evidently that impact of the applied treatments of potassium fulvate on the dry matter productions was more attributed to the leaves area and number. This is due to the obtained increases in the total dry matter accumulations can be interpreted on the fact that higher leaves area and number contributed to more photosynthesis and better carbohydrates yield. These findings are in harmony with those obtained by Duncan (1971) who obviously cleared the importance of canopy structure in light interception, vegetative growth and yield.

Accordingly, the greatest dry weight of zucchini squash plants and chlorophyll content were produced by plants supplied by (1.5ton of gypsum/fed + 1.0 kg of potassium fulvate/fed) in combination with AM fungi. The effectiveness of applied gypsum and organo-stimulants in combination with arbuscular mycorrhizal (AM) may be due to the role of AM fungi mechanisms that improve salt tolerance may include maintaining membrane integrity (Rinaldelli and Mancuso 1996) that would facilitate compartmentalization within vacuoles and selective ion uptake. Induction of osmotica could lead to osmotic adjustment (Duke *et al.* 1986) and improved and balanced nutrition in plants could also increase salt tolerance (Marschner 1995).

Also, It could noticed that the studied vegetative growth parameters tended to gradual increase with increasing the applied rates of both gypsum and potassium fulvate from 0 to 1.5 ton/fed and 0 to 1.0 kg fed^{-1}, respectively. Also, it is noteworthy to mention that the applied combined treatments of both two at the highest rates were achieved the greatest values of the dry weight of zucchini squash plants with significant differences. That was true, since treated soil with gypsum during preparing process for zucchini squash cultivation in combination enhancing and sustaining the increase in the values of germination rate, shoot and radical lengths.

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Moreover, such combination is more attributed to enrich in both organic and mineral substances that are essential to plant growth, stimulating and activating the bio-chemical processes in plant organs, i.e., respiration, photosynthesis, chlorophyll content, vital enzymes and hormonal stimulating, which increasing photosynthetic activity. Such favourable conditions of soil fertility was reflected on vegetative growth characters of the grown zucchini squash plants, owing to such applied inorganic and organic soil amendments are not only improving soil fertility status but also assisting zucchini squash plants to tolerant soil salinity. In addition, combining gypsum with potassium fulvate led to a markedly increase in the dry weight, this is due to their outcomes are essentially for creation of protoplasm and hence producing new cells and new leaves of zucchini squash plants that lead to a larger leaf area available for photosynthesis and increase dry matter accumulation (Osman and Ewees 2008; Rady and Migawer 2010 and Rady 2011).

Table 8: Influence of gypsum and potassium fulvate in combination with AM-fungi on plant dry weight and Chlorophyll content.

Bio-inoculation B	Gypsum rate (ton/fed) G	Plant dry weight (g plant^{-1})				Chlorophyll a & b (mg g^{-1}fresh weight)			
		Organo-stimulant potassium fulvate (kg fed^{-1}), O							
		0.0	0.5	1.0	Mean	0.0	0.5	1.0	Mean
-AM	0.0	137.8	140.3	142.7	140.3	0.82	0.87	1.02	0.90
	0.75	149.6	157.6	175.4	160.9	0.94	0.99	1.16	1.03
	1.50	155.6	161.8	184.4	167.3	1.07	1.12	1.30	1.16
	Mean	147.7	153.2	167.5	156.2	0.94	0.99	1.16	1.14
+AM	0.0	140.5	142.8	150.4	144.6	1.02	1.19	1.39	1.20
	0.75	160.5	179.8	199.7	180.0	1.15	1.34	1.55	1.34
	1.50	167.6	194.5	222.3	194.8	1.42	1.66	1.94	1.67
	Mean	156.2	172.4	190.8	173.1	1.19	1.39	1.63	1.40
L.S.D. at 0.05	B	2.15				0.11			
	G	1.15				0.07			
	O	0.90				0.18			
	BxG	2.12				0.05			
	BxO	1.14				0.06			
	GxO	1.11				0.14			
	BxGxO	2.04				0.11			

- AM = soil without inoculate arbuscular mycorrhizal fungi and + AM= soil with inoculate arbuscular mycorrhizal fungi

On the other hand, application of potassium fulvate to zucchini squash increased the availability and uptake of nutrients and decreases the ECe values when added 1.0 kg fed^{-1}, all that reflected the best result on plant growth. The mechanism of fulvic acid on stimulating growth may be similar to that of plant growth regulators as fulvic substances include auxins or function as auxins and thus affect plant metabolism in a positive manner. In addition, fulvic acid is readily complexes with minerals and metals making them available to plant roots and easily absorbable through cell walls. It makes minerals such as iron that are not usually very mobile, easily transported through plant structures.

The chlorophyll content of recently expanded leaves was influenced by gypsum application and AM fungi, with potassium fulvate interaction (Table 8). The data showed that chlorophyll a and b contents were significantly higher in zucchini squash plants grown in moderate saline soil amended with gypsum and organo-stimulants in combination with arbuscular mycorrhizal (AM), where potassium fulvate levels were applied through to match the nutrients uptake by crop. This enhanced the current photosynthesis for developing vegetative growth parameters that leading to the development of dry matter production per plant in the case of amended moderate saline soil. These findings are in harmony with results obtained by (Hebbar *et al.* 2004). Also, chlorophyll content of recently expanded leaves was influenced by gypsum application and AM fungi, with potassium fulvate interaction (Table 8). Chlorophyll content was higher in +AM (mean value 1.54 mg g^{-1} fresh weight) than −AM (mean values 1.34 mg g^{-1} fresh weight) but with potassium fulvate (mean value 1.37 and 1.72 mg g^{-1} fresh weight) at 0.5 and 1.0 kg fed^{-1}, respectively, compared to gypsum application treatments (mean value 1.46 and 1.55 mg g^{-1} fresh weight) at 0.75 and 1.5 ton fed^{-1}, respectively. Al-Khaliel, (2010) stated that chlorophyll content and leaf water content were increased significantly under salinity condition by the inoculation with mycorrhizal fungi.

N, P and K as Macronutrients, Fe, Mn and Zn as Micronutrients and Na as Non-Nutritive Element Content by Zucchini Squash Plants:

Irrespective of gypsum and potassium fulvate in combination with AM fungi treatments, data of N, P and K as macronutrients, (Fe, Mn and Zn) as micronutrients and Na as non-nutritive uptake by zucchini squash plants at maximum vegetative growth stage, which are presented in Tables (9 and 10), exhibited pronounced increases for at studied macronutrients and micronutrients vs a noticeable decrease for the non-nutritive one of Na as a result of applied gypsum and potassium fulvate as solely or combined treatments as compared to the control treatment. The elements content in zucchini squash plants are more related to the released available nutrients and their easily mobility towards the plant roots. Such surpassed effect of the applied treatments, especially at the combined ones, is more associated with ameliorated soil pH due to the added gypsum as well as to the relatively high contents released active organic substances that enhancing more released nutrients or their solubilization from both native and added sources, besides the favourable biological conditions that are keeping them in available forms for extended period and their mobility for uptake by plant roots.

Table 9: Influence of gypsum and potassium fulvate in combination with AM-fungi on some macronutrient and non-nutritive zucchini squash leaf element contents under reclaimed soil conditions.

Bio-inoculation, B	Gypsum rate (ton/fed), G	Plant micro nutrient content %												Na			
		N				P				K							
		Organo-stimulants potassium fulvate (kg fed^{-1}), O															
		0.0	0.5	1.0	Mean	0.0	0.5	1.0	Mean	0.0	0.5	1.0	Mean	0.0	0.5	1.0	Mean
-AM	0.0	2.12	2.17	2.32	2.20	0.257	0.283	0.315	0.285	1.58	1.66	1.79	1.68	1.09	1.04	0.98	1.04
	0.75	2.22	2.28	2.44	2.31	0.270	0.297	0.329	0.299	1.65	1.74	1.88	1.76	1.03	0.99	0.93	0.98
	1.50	2.38	2.44	2.61	2.48	0.290	0.317	0.353	0.320	1.77	1.87	2.01	1.88	0.96	0.92	0.87	0.92
	Mean	2.24	2.29	2.46	2.32	0.272	0.299	0.332	0.301	1.67	1.76	1.89	1.77	1.02	0.98	0.93	0.98
+AM	0.0	2.44	2.51	2.68	2.54	0.297	0.326	0.362	0.328	1.82	1.92	2.07	1.94	0.96	0.92	0.87	0.92
	0.75	2.72	2.81	3.00	2.84	0.331	0.365	0.405	0.367	2.03	2.15	2.31	2.16	0.85	0.81	0.77	0.81
	1.50	2.77	2.86	3.06	2.89	0.338	0.373	0.412	0.374	2.07	2.19	2.36	2.21	0.83	0.80	0.75	0.79
	Mean	2.69	2.73	2.91	2.78	0.322	0.355	0.393	0.357	1.79	2.09	2.25	2.10	0.88	0.84	0.79	0.84
LSD at 0.05	B	0.14				0.061				0.20				0.02			
	G	0.17				0.111				0.23				0.05			
	O	0.15				0.045				0.10				0.07			
	BxG	0.11				0.164				0.33				0.02			
	BxO	0.13				0.090				1.15				0.11			
	GxO	0.15				0.065				0.18				0.12			
	BxGxO	0.09				0.097				0.11				0.10			

- AM = soil without inoculate arbuscular mycorrhizal fungi and + AM= soil with inoculate arbuscular mycorrhizal fungi

So, the combined treatments at the highest rates of gypsum and potassium fulvate exhibited a superior effect due to improving soil physico-chemical properties that positively affect the nutrients availability as well as maintaining a suitable soil moisture regime, which showed a pronounced positive effect on the biological activity in soil. Also, such favourable effect extends to reduce soil pH, mainly due to the integrated action of the released active organic acids and SO_4^{--} transformation to H_2SO_4, respectively, besides the possible released phosphate ions by sulfate ions (El-Tapey and Hassan, 2002). It is noteworthy to mention that the nutrient contents in plant tissues were, in general, extending parallel close to the corresponding available nutrient contents in the studied soil, as shown in Tables (6 and 7). Also, such favourable effect of both applied gypsum and potassium fulvate as combined treatments may attributed to the reduction in soil pH (Table 5) which improved the solubility and availability of nutrients for plant roots which was positively reflected on the nutrient contents in plant tissues (Rady, 2011).

In addition, the results in Tables (9 and 10) showed that AM fungi treatment significantly increased N, P, K, Fe, Mn and Zn contents of zucchini leaves as compared with un-inoculated one. The positive effects of AM fungi inoculation may be due to the AM fungi mitigate growth reduction caused by salinity (Tsang and Maum, 1999). Poss *et al.* (1985) concluded that the salt tolerance mechanism in onion is primarily related to P nutrition. Duke *et al.* (1986) concluded that improved P uptake by AM vs. non-AM citrus plants did not totally account for the improved salt tolerance of AM plants. In addition, the positive effect of AM fungi inoculation on the other nutrients of P, K, Fe, Mn and Zn may be due to the pronounced increase in nitrogen and phosphorus, which enhances the vegetative growth of plant and consequently increased the contents of these nutrients. Also, the contents of Fe, Mn and Zn were significantly increased in cases of applied potassium fulvate as well as AM + potassium fulvate. On the other hand, there was an increase for each of the studied micronutrients in case of treated soil with AM fungi; such increases were significant as compared to the control treatment. In this concerning, Habashy and Abo-Zaide, (2005) and Turky *et al.* (2007) showed that the availability of micronutrients (Fe, Mn and Zn) were positively affected by inoculation AM fungi when compared to the uninoculated treatments.

On the other hand, the relative decrease in Na contents in plants may be due to the positive plant response to the applied gypsum and potassium fulvate which combating the negative effect of salt stress in the root zone as well as exacerbate soil salinity conditions (Maas and Grattan, 1999). In this concern, Kulikova *et al.* (2005) pointed out that organic substances might show anti-stress effects under a biotic condition stress (unfavorable temperature, pH, salinity, *etc.*) either added as soil application or as spraying on plants. However, organic substances may enhance the contents of nutrients and reduce the uptake of some toxic elements. Also, Abdallah et *al.* (2010) showed that S deficiency for field-grown oilseed rape can reduce nitrogen use efficiency (NUE: ratio of harvested N to N fertilization) and that N deficiency can also reduce sulphur use efficiency (SUE). Also, it had a great extent favourable effect on the mobilization of the released nutrients that could be explained by many aspects, *i.e.,* increasing the released macro-nutrient and micro-nutrient contents through the decomposition of the native sources, reduction of nutrient fixation and forming the stable complexes with fulvic substances supplied and keeping them in available forms for extended period and mineralization processes as well as minimizing their possible lose by leaching process through such a relatively coarse textured soil (Shanmugam and Veeraputhran, 2001).

Table 10: Influence of gypsum and potassium fulvate in combination with AM-fungi on some micronutrient zucchini squash leaf element contents under reclaimed soil conditions.

Bio-inoculation, B	Gypsum rate (ton/fed) G	Plant micro nutrient content %											
		Fe				Mn				Zn			
		Organo-stimulants potassium fulvate (kg fed^{-1}), O											
		0.0	0.5	1.0	Mean	0.0	0.5	1.0	Mean	0.0	0.5	1.0	Mean
-AM	0.0	102.6	109.2	116.8	109.5	42.0	48.4	55.7	48.7	32.7	36.2	40.9	37.6
	0.75	107.3	119.5	128.9	118.6	46.5	51.2	60.2	52.6	35.8	41.1	46.5	41.1
	1.50	116.2	127.4	140.3	127.9	52.4	57.1	68.7	59.4	40.0	45.1	50.5	45.2
	Mean	108.7	118.7	128.6	118.7	46.9	52.2	61.5	53.5	36.2	40.8	45.9	40.9
+AM	0.0	120.0	132.1	145.0	132.4	47.4	57.8	62.7	55.9	37.4	41.9	52.1	43.8
	0.75	133.3	149.4	160.9	147.9	53.4	61.7	68.9	61.3	45.2	52.1	61.8	35.0
	1.50	140.0	160.5	177.3	159.3	62.7	74.5	85.1	74.1	60.7	61.0	69.1	63.6
	Mean	131.1	147.3	131.1	146.5	54.5	64.7	72.2	63.8	47.8	51.7	61.0	53.5
LSD at 0.05	B	1.14				1.06				0.20			
	G	2.07				1.11				1.19			
	O	1.60				1.04				0.11			
	BxG	1.80				1.16				0.29			
	BxO	1.08				1.15				1.13			
	GxO	1.10				1.06				1.19			
	BxGxO	1.16				1.29				1.12			

- AM = soil without inoculate arbuscular mycorrhizal fungi and + AM= soil with inoculate arbuscular mycorrhizal fungi

Total Fruit Yield, Marketable Fruit Mean Weight and Number of Fruit Per Plant:

The aforementioned best vegetative growth characters were positively reflected on increasing zucchini squash yields as well as their quality as shown in Tables 11 and 12. In general, the optimums zucchini squash yields of as well as their qualities were extending parallel close to the corresponding soil available nutrient contents and some vegetative growth characters, as shown in Tables 6 and 7. Also, it was noticed that significant gradual increments were observed in all studied yields and their quality with increasing gypsum and potassium fulvate levels starting from 0 to 1.5 ton fed^{-1} and 0 to 1.0 kg fed^{-1} respectively, in combination with arbuscular mycorrhizal fungi (AM).

Table 11: Influence of gypsum and potassium fulvate in combination with AM-fungi on fruit dry weight and fruit yield of zucchini grown under reclaimed soil conditions.

Bio-Inoculation, B	Gypsum rate (ton fed^{-1}), G	Fruit dry weight (kg plant^{-1})				Total yield (ton fed^{-1})			
		Organo-stimulant potassium fulvate (kg fed^{-1}), O							
		0.0	0.5	1.0	Mean	0.0	0.5	1.0	Mean
-AM	0.0	1.70	1.79	1.97	1.82	3.78	4.00	4.21	4.00
	0.75	1.80	2.00	2.50	2.10	4.15	4.58	5.78	4.84
	1.50	1.95	2.30	3.00	2.42	4.72	5.61	6.40	5.58
	Mean	1.82	2.03	2.49	2.11	4.22	4.73	5.46	4.80
+AM	0.0	1.90	2.25	2.74	2.30	4.26	4.29	4.59	4.38
	0.75	2.00	2.55	3.10	2.55	4.50	5.00	6.89	5.79
	1.50	2.45	3.00	3.58	3.01	5.08	6.10	7.58	6.25
	Mean	2.12	2.60	3.14	2.62	4.61	5.13	6.35	5.36
L.S.D. at 0.05	B	0.23				2.08			
	G	0.27				1.24			
	O	0.19				3.45			
	BxG	0.38				1.17			
	BxO	0.84				1.87			
	GxO	1.03				0.96			
	BxGxO	1.46				1.43			

- AM = soil without inoculate arbuscular mycorrhizal fungi and + AM= soil with inoculate arbuscular mycorrhizal fungi

As for the interaction effect of gypsum and potassium fulvate, data shown in Tables (11and 12) represent that it was significant. Maximum finding of all tested yields and their characters was obtained from the treatment of 1.0 kg potassium fulvate fed^{-1} and 1.5 ton gypsum fed^{-1} in combination with arbuscular mycorrhizal fungi (AM). That was true, since the applied treatments led to an enrichment soil media in both organic and mineral substances essential to plant growth and activating the bio-chemical processes in plants, *i.e.*, respiration, photosynthesis and chlorophyll content, which increased the plant yield (Hegazi, 2004).

Also, arbuscular mycorrhizal (AM) fungi significantly increased total marketable yield as compared without AM fungi treatments. The positive effect of AM fungi in yield was achieved due to the improved nutritional status (higher N, P and K contents) and relative soil contents caused by AM fungi colonization would have alleviated soil poverty impacts and promoted zucchini fruit production and enhanced fruit marketable under sandy soil with slightly saline conditions. Amijee, *et al*, (1989) found that AM fungi colonization by *Glomus* intraradices improved growth, yield, water status, nutrient content and quality of zucchini fruits when exposed to salinity stress supports our first hypothesis that inoculate AM plants grow better than non-AM plants under saline conditions.

On the other hand, concerning the combined effect between AM fungi and applied potassium fulvate rates on zucchini squash marketable fruit weight g plant^{-1} and number of fruit per plant indicated that AM fungi treatment was more effective than - AM fungi treatment one. Moreover, it could be noticed that the highest potassium fulvate rate of 1.0 kg fed^{-1} in combination with mycorrhizal treatment gave the greatest values for all studied parameters zucchini marketable fruit weight g plant^{-1} and number of fruit per plant as compared with low potassium fulvate rate (0.5 kg fed^{-1}) and the control. Fulvic acid substances are effective in stimulating even more vigorous and healthy growth, producing certain bacteria, fungi and actinomycetes in decomposing vegetation in the soil.

Table 12: Influence of gypsum and potassium fulvate in combination with AM-fungi on weight and number of zucchini fruit per plant under reclaimed soil conditions.

Bio-Inoculation, B	Gypsum rate (ton fed^{-1}), G	Marketable fruit							
		Mean weight (g plant^{-1})				Number of fruit (No. plant^{-1})			
		Organo-stimulant potassium fulvate (kg fed^{-1}), O							
		0.0	0.5	1.0	Mean	0.0	0.5	1.0	Mean
-AM	0.0	152.2	154.9	158.6	155.2	12.5	14.2	16.9	14.5
	0.75	155.2	159.6	163.3	159.4	14.6	15.8	16.7	15.7
	1.50	158.6	163.1	169.3	163.7	15.8	16.7	17.4	16.6
	Mean	155.3	159.2	163.7	159.4	14.3	15.6	17.0	15.6
+AM	0.0	155.2	158.3	161.1	158.2	13.5	15.7	17.9	15.7
	0.75	158.6	162.4	170.1	163.7	15.9	17.4	19.5	17.6
	1.50	162.0	170.3	179.5	170.5	16.7	18.1	21.9	18.9
	Mean	158.6	163.7	170.3	164.1	15.4	17.1	19.8	17.4
L.S.D. at 0.05	B	19.80				0.58			
	G	11.54				0.68			
	O	2.87				0.45			
	BxG	11.20				1.06			
	BxO	3.45				0.97			
	GxO	3.67				0.54			
	BxGxO	2.36				0.64			

- AM = soil without inoculate arbuscular mycorrhizal fungi and + AM= soil with inoculate arbuscular mycorrhizal fungi

The presence of the AM fungi in the roots may have modified the osmotic potential of the leaves, as they have been shown to influence the composition of carbohydrates (Augé *et al.* 1987) and the level of proline (Ruiz- Lozano and Azcon, 1995). Moreover, the +AM plants under saline conditions had greener leaves than −AM, suggesting that salt interfered in chlorophyll synthesis or turnover more in −AM than in +AM plants. Cantrell and Linderman, (2001) reported a similar response in (AM) fungi lettuce and onion plants. Ezz and Nawar, (1994) also reported that AM inoculation ameliorated the decrease in chlorophyll for sour orange seedlings watered with saline water.

Conclusions:

Finally, under the current experimental conditions, it has been concluded that this work gave evidence to the effective role of gypsum as soil application, especially at the rate of 1.5 ton fed^{-1} and the application of potassium fulvate as soil application with a rate of 1.0 kg fed^{-1}, on soil pH and ECe reduced. Also, we can conclude that arbuscular mycorrhizal (AM) fungi alleviate the detrimental effect of gypsum on soil properties and nutrients content. Improved nutritional status (N, P, K, Fe, Mn and Zn concentration in leaf tissue), may have assisted the plants to translocated minerals and assimilates to the sink and alleviated the impacts of poverty soil on fruit production. Furthermore, zucchini fruit content was improved by (AM) fungi and organo-stimulant potassium fulvate. However, even at moderate saline sandy clay loam soil, the yield, plant growth and nutritional status of +AM zucchini plants grown under organo-stimulant potassium fulvate as soil application with gypsum were higher than those grown at without AM fungi and organo-stimulant.

Consequently, such soil favourable conditions allowing for more solubility and availability of nutrients for the absorption by plant roots which in turn positively reflected on zucchini squash (*Cucurbita pepo* L. var Tempra) yield and some characters under unfavourabale conditions of soil salinity and/or sodicity stress.

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