

## Effect of Gypsum and Compost on Growth and Yield of Washington Navel Orange under Saline-Sodic Soils

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**I**NCREASING saline-sodic soils area as a result of climatic change, wrong agriculture practices and unsuitable of nutrition sources were lead to malnutrition and caused low productivity and quality of citrus. The study focused on gypsum and compost application in the proper rates for coping with such variable parameters. The trial carried out during 2017 and 2018 seasons on Washington navel orange trees (*Citrus sinensis* L., Osbek) grafted on sour orange (*Citrus aurantium* L.). Six application treatments were examined for the purpose of the study, *i.e.*, T1: control, T2: compost at 10 tons/ fed, T3: compost at 15 tons/ fed, T4: gypsum at 10 tons/ fed, T5: T4+T2 and T6: T4+T3. Field capacity (FC), Permanent wilting point (PWP), available water (AW), soil moisture and soil total content of NPK as indicators of soil parameter for application treatments were looked up. Growth parameters such shoot length, number of shoots/branch, number of leaves/shoot and leaf area, yield attributes such fruit set, fruit cracking, peel thickness, total tree yield (Kg), fruit juice volume, TSS, acidity, total sugars and vitamin C and leaf nutritional content of N, P, K, Ca and Mg were also determined. Results showed that T6 gave the highest results followed by T5, T4, T3 and T2 whereas T1 was the lowest ones for all parameters under investigations. The study aimed and recommends gypsum at 10 tons/ fed + compost at 15 tons/ fed for ameliorating saline-sodic soil and improving growth, yield and quality of Washington navel orange under such conditions.

**Keywords:** Saline soil, Moisture, Gypsum, Compost, Vegetative growth, Yield, Fruit quality, Washington navel orange.

### Introduction

Citrus is the first Egyptian fruit crops for exporting worldwide. The citrus cultivated area is occupies around 485940 fed with a total area including (418415) feddans as a fruitful area with a total annual production about (427886) tons of fruits with an average of 10.21 tons/ fed as reported by Ministry of Agriculture and Land Reclamation (2016). Citrus in Delta Nile of Egypt suffer low productivity due to several reasons, *i.e.*, increasing salinity and sodicity are the main reasons which related to malnutrition due to climate changing, wrong practices and unsuitable fertilizers. Therefore it was necessary developing agriculture practices that deal with those problems together and improve citrus production in that region. Gypsum as fascinating soil reclamation is totally neglected in the meantime. Gypsum considers the main source of

calcium ( $\text{Ca}^{2+}$ ) that exchange with  $\text{Na}^+$  which can be leached or uptake by crops (Qadir and Oster, 2002). The sulfate in gypsum is not a problem for crops but improve dissolves calcium-rich at high pH (Horneck et al, 2007). Gypsum application followed by irrigation improves the efficiency than application on dry soil surface (Choudhary et al., 2008). Gypsum at higher rates to saline-sodic soils following by irrigation results an increase in sodium, chloride, potassium, manganese and zinc in leached water but decrease pH, exchangeable sodium (Alva et al., 1991, Sahin et al., 2003 and Makoi & Ndakidemi, 2007). Furthermore, gypsum lead to aggregation which happened due to similarly charged ions accumulate at the same site and connect to each other in stable aggregates such  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  (Fisher, 2011). Therefore, improving soil aggregation resulting salt leaching as a result of gypsum application and this lead to enhancing infiltration rate (IR) (Ahmad et al., 2006

and Zia et al., 2007). Increasing soil aggregation leads to increasing soil porosity, subsequently increasing bulk density (BD) (Chaudhry, 2001). Increasing IR and BD combined with deep tillage are breaking the compacted soil subsequently increasing water storage in deeper rooting area which means enhancing water use efficiency, *i.e.*, increasing tolerance to drought stress (Shainberg et al., 1989). Furthermore, sulphur in gypsum increases the availability of plant nutrient in root area such as P, Mn, Ca and  $\text{SO}_4$  via decreasing pH (Lindemann et al., 1991, Neilsen et al., 1993 and Chien et al., 2011). The following model (Fig. 1) explains the previous described gypsum effect on chemical and physical properties:

However, limited literature were found in the effect of gypsum on fruit trees, some of them stated that gypsum had direct relation in increasing growth and leaf mineral content of some fruit trees such as persimmon, grapevine and orange trees (Abdel- Nasser and El-Shazly, 2000). Other studies found that gypsum improve the quality of horticultural crops in general (Shear, 1979, Scott et al., 1993 and Sumner 2007). Moreover, it was

found that gypsum controlling many symptoms coming from soil desieses such citrus glue, avocado root rot, apples bitter pit and blossom-end rot of watermelon and tomatoes (Scott et al., 1993 and Shear, 1979). Xu (2006) found that 1, 5 and 10 tons/fed as low, medium and high, respectively were suggested as gypsum rate for sodic or sodium affected soil. On the other hand, the application of compost to sodic soils was found to reduce pH and ESP values (Rao and Pathak, 1996). Also, soil aggregates was enhanced via organic matter of compost (Six et al., 2004 and Abbas et al., 2012) and soil structure showed higher stability with improving plant growth under application of compost (Avnimelech et al., 1994 and Puget et al., 2000). Furthermore, compost was found to be a crucial organic mulching material that showed positive effects on soil physical properties by decreasing soil evaporation and increasing soil water moisture (García-Moreno, 2013, López et al., 2014 and Zribi et al., 2015). The study aimed to figure out the effect of optimal gypsum rate combined with compost on growth, leaf mineral content, yield and quality of Washington navel orange under saline-sodic soil condition.

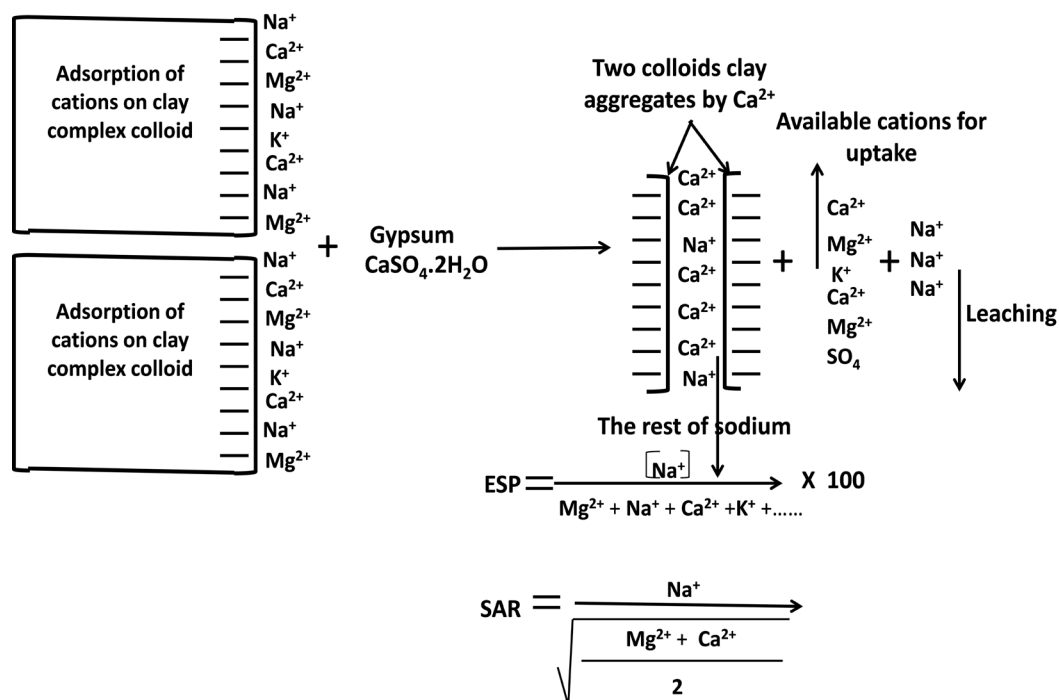


Fig. 1. Model explains gypsum effect on soil chemical and physical properties.

## Materials and Methods

### Experimental design

The experiment was carried out during 2017 and 2018 seasons on eight years old Washington navel orange trees (*Citrus sinensis* L., Osbek) budded on sour orange (*Citrus aurantium* L.) with planting space of 5 x 5 meters resulting density 168 trees/ fed. The trees grown on saline-sodic soil in a private orchard located at Akwa El Hessa village, Kafr El-Zayat, El- Gharbyia Governorate, Egypt.

The amount of gypsum needed to reclaim a sodic soil was according to Schoonover (1952) where a weighed quantity of sodic soil (5 g) is shaken with 100 ml of a saturated gypsum solution of known calcium concentration,  $Ca^{2+}$  and  $Mg^{2+}$  were calculated to determine gypsum requirements as follow:

$$\text{The Gypsum requirement} = \frac{(C_1 - C_2) \times 100 \times 100}{1000 \times 5}$$

The Gypsum requirement =  $(C_1 - C_2) \times 2$  meq  $L^{-1}$  of  $Ca^{2+}$  per 100 g soil.

Where :  $C_1$  is the concentration (meq  $L^{-1}$ ) of  $Ca^{2+}$  in gypsum solution.

$C_2$  is the concentration of  $Ca^{2+}$  and  $Mg^{2+}$  in filtrate.

Since it was found that 1.70 ton of gypsum reduce one meq  $L^{-1}$  of Na per ha (USDA, 1954). The dose of gypsum needed for the experimental

soil to reduce ESP from 35.2% to 20.0%, i.e., 6 meq  $L^{-1}$  was found 10 tons/fed. Compost was used at normal agriculture practices at two rates which were 10 and 15 tons/fed as alternative material for mulching benefits plus its advantages as organic matter. The experiment was arranged in spilt-plot based on randomized complete blocks design with six treatments (control and gypsum) placed in two main plots while compost was placed in four sub-plots (with rates of 10 and 15 tons/ fed) as follows: T1: untreated soil (control), T2: compost at 10 tons/ fed, T3: compost at 15 tons/ fed, T4: gypsum at 10 tons/ fed, T5: gypsum at 10 tons/ fed + compost at 10 tons/ fed, T6: gypsum at 10 tons/ fed + compost at 15 tons/ fed. The application of the treatments starts in first of January each season. Prior gypsum application, soil samples were analyzed for background characteristics as shown in (Table 1).

The result analysis of compost used for the experimental treatments was shown Table 2 as well:

### Soil characteristics analysis

Soil samples from depths 0-30, 30-60 and 60-90 cm and at harvest from 0-30 cm were collected and divided into two subsamples, the first was for physical and chemical soil properties, while second was for chemical soil composition. Soil characteristics analysis was done according to Bouyoucos (1962). Bulk density (BD,  $g\ cm^{-3}$ ) was measured using the core method (Grossman and Reinsch, 2002). A portable EC and pH meters were used for electrical conductivity (EC, 1:5) and  $pH_{1:5}$ . Flame photometer (Chintala et al.,

TABLE 1. Soil characteristics of Washington navel orange orchard at the start of the treatments

parameter	Physical properties				Chemical properties										
	Depth	Clay	Silt	Sand	pH	EC	$Ca^{2+}$	$Mg^{2+}$	$Na^+$	$Cl^-$	ESP	SAR	OM%	P%	K%
	0-30	47.2	24.1	28.6	8.21	9.51	7.53	12.6	77.2	59.2	36.51	23.15	1.35	3.94	201.06
	30-60	45.1	22.1	32.7	8.01	8.15	5.11	11.7	66.3	45.3	32.33	21.01	1.16	3.75	194.13
	60-90	43.1	21.7	35.0	8.26	8.33	4.63	10.8	63.5	41.0	31.91	22.12	0.85	3.59	198.45

Note: Acidity ( $pH_{1:5}$ ), Electrical conductivity ( $EC_{1:5}$  dS  $m^{-1}$ ), SAR = Sodium Adsorption ratio, ESP= Exchangeable sodium%, OM refer to organic matter, Meq  $L^{-1}$  is the concentration of  $Ca^{2+}$ ,  $Mg^{2+}$ ,  $Na^+$  and  $Cl^-$

TABLE 2. compost characteristics used for the experimental treatments

Prosperities	EC	pH	BD	OM	C:N	Total N	Total P	Total K
Unit	dS $m^{-1}$	(1:10)	Mg $m^{-3}$	g $kg^{-1}$	ratio	%	%	%
Value	4.44	7.85	0.59	330.12	15.15	1.88	0.79	1.83

2014 and USDA 1954) was used for Na<sup>+</sup> and K<sup>+</sup> determination. Calcium was measured using atomic absorption spectrophotometer Perkin Elmer-3300 according Chapman and Pratt (1961). Magnesium (Mg) was determined according to Wilde et al., (1985). Chloride was analyzed using silver nitrate (0.025 M) with potassium chloride (0.1 M) according to Mohr's titration method (Rhoades, 1982). Organic matter of compost was calculated using the method of (AFNOR, 1991).

Infiltration rate (IR) was measured using double ring with applying 15 cm depth of water. Infiltration time was recorded for each plot then, average of these values was calculated using the equation of Kostiakov (1932):  $IR = KT^n$ , Where, IR is the cumulative infiltration after time T, T= Time after infiltration starts, K and n are constants that depend on the soil and initial conditions (evaluated from measured infiltration data. K and n values range between zeros to one. Soil organic carbon was determined according (Nelson and Sommers, 1982) and used for calculation of organic matter (%) = organic carbon (%) × 1.72.

The available water (AW) was calculated according Klute (1986) by subtracting permanent wilting point (-1500 kpa) from field capacity (-33kpa):  $AW = FC - PWP$ , Where, FC is the water content at field capacity, WP is the water content at permanent wilting point. Then soil moisture % as a percent of field capacity were calculated. Exchangeable cations capacity (CEC) was estimated according (Bower *et al.*, 1952) and use to calculate exchangeable Na<sup>+</sup> percentage (ESP) according Richards (1954). Sodium adsorption ratio (SAR) as described in USDA (1954) as follow:

#### *Vegetative Growth parameters*

Developed twigs from spring bud sprouting at end of May were used to calculate shoot length (cm), number of shoots/branch, number of leaves/shoot and leaf area (cm<sup>2</sup>) using model CL-203 area meter CID, Inc. USA.

#### *Yield and Fruit quality attributes*

Fruit set % a month after full bloom and Fruit cracking% at harvest time was calculated according to the following equations:

In December average fruit weight multiplied by numbers of fruit /tree was used to calculated yield (Kg/tree). Peel thickness, fruit juice volume and total soluble solids (TSS) as Brix Harvest using Hand refractometer were measured. Total sugars %, acidity % and vitamin c (mg/100 juice) were determined according A.O.A.C., (2000).  
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#### *Leaf nutritional status*

The fourth leaves from the top of the spring twigs were labeled in April and collected in September for analysis. Nitrogen was determined using Micro-kjeldehl as described by (page, 1982). Cotteine et al. (1982) method was followed for Phosphorus determination. Flame photometer was used for Potassium (K) determination according Jackson (1958). Calcium was measured using atomic absorption spectrophotometer Perkin Elmer-3300 according Chapman and Pratt (1961). Magnesium (Mg) was measured according to Wilde et al., (1985).

#### *Statistical analysis*

Data were analyzed by Statistical Graphics Corporation, STATGRAPHICS Plus (St. Louis, MO, USA) for one way analysis of variance and employing Duncan's multiple range tests (Duncan, 1955) at the 0.05 confidence level and for principle component analysis (PCA).

### **Results and Discussions**

#### *Effect of gypsum and compost on soil attributes*

The mean results of soil moisture as a percentage of field capacity are shown in (Fig. 2) which illustrated that gypsum application alone or combined with compost significantly improved soil moisture % especially after long distance of water irrigation. T6 that introduce gypsum with higher compost rate showed the best results followed by T5, T4, T3 and T2, respectively, compared to control treatment. It is clear that both of gypsum and compost play together an important role in amelioration saline-sodic soils which reflect in decreasing surface soil evaporation and increasing the ability of soil holding water, subsequently increasing soil moisture percentage.

In the same trend where results of field capacity (FC), permanent wilt point (PWP) and available water (AW) showed similar results to that obtained in soil moisture % after gypsum and compost applications (Table 3). In that concern T6 revealed the highest results followed by T5, T4, T3 and T2, respectively, compared to control treatment. Increasing water content at the higher rates of gypsum and compost refer to increasing soil potential in holding capacity subsequently, increasing available water to plants. These results come in the same line with other findings (Shainberg et al., 1989) who found that increasing soil aggregates due to gypsum application lead to increasing water storage in deeper rooting area.

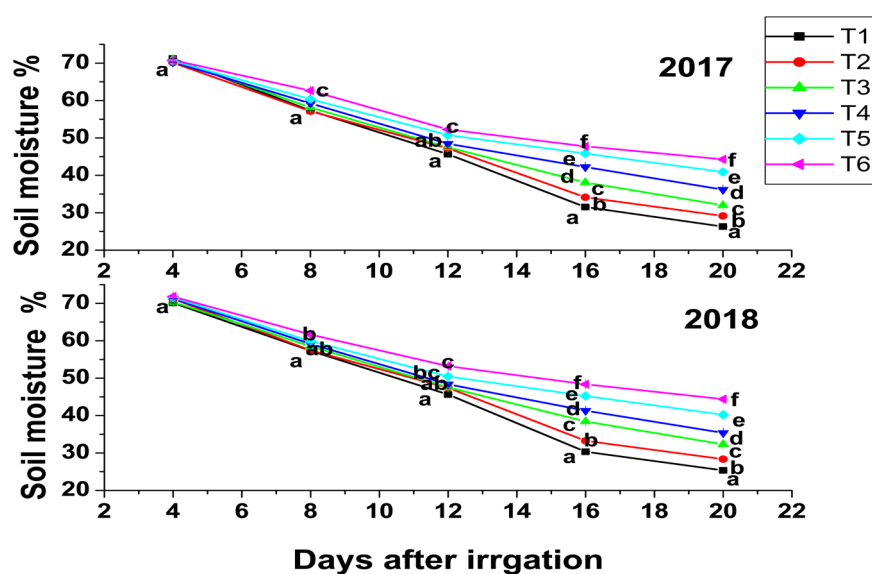


Fig. 2. Is (control), T2: compost at 10 tons/ fed., T3: compost at 15 tons/ fed., T4: gypsum at 10 tons/ fed., T5: gypsum at 10 tons/ fed. + compost at 10 tons/ fed., T6: gypsum at 10 tons/ fed. + compost at 15 tons/ fed., on soil moisture % for the orchard of Washington navel orange trees under saline –sodic soil during 2017 and 2018 seasons. Data indicated means ( $n=5 \pm SE$ ). Different letters indicated significant differences at  $p < 0.05$ .

TABLE 3. The effect of gypsum and compost on field capacity (FC), permanent wilt point (PWP), available water (AW) and soil total content of NPK in the trail field of Washington navel orange trees under saline –sodic soil during 2017 and 2018 seasons.

Parameters	FC		PWP		AW		N mg Kg <sup>-1</sup>		P mg Kg <sup>-1</sup>		K mg Kg <sup>-1</sup>	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
T1	37.62e	37.58e	19.48b	19.35b	18.14d	18.23d	44.35d	44.23d	4.41c	4.42c	201.32d	201.33d
T2	39.18d	39.09d	19.51a	19.44a	19.67cd	19.65cd	44.43d	44.68d	4.50c	4.51c	202.42d	202.44d
T3	39.98c	39.86c	19.77a	19.64a	20.21c	20.22c	45.65c	45.61c	4.60c	4.61c	207.71c	207.74c
T4	39.82c	39.82c	19.61a	19.60a	20.21c	20.22c	47.75b	47.77b	4.79b	4.78b	210.07b	210.04b
T5	42.08b	42.18b	19.57a	19.65a	22.51b	20.53b	49.12a	49.15a	5.25a	5.29a	211.11b	211.17b
T6	45.21a	45.31a	21.24a	21.37a	23.97a	23.94a	49.29a	49.28a	5.33 a	5.37a	215.24 a	215.36 a

T1: untreated soil (control), T2: compost at 10 tons/ fed., T3: compost at 15 tons/ fed., T4: gypsum at 10 tons/ fed., T5: gypsum at 10 tons/ fed. + compost at 10 tons/ fed., T6: gypsum at 10 tons/ fed. + compost at 15 tons/ fed., on soil moisture % for the orchard of Washington navel orange under saline –sodic soil during 2017 and 2018 seasons. Means followed by the same letter are not statistically different by Duncan at 0.05 levels.

Other supporting results on compost as mulching material were found by (Mubarak et al., 2009, García-Moreno, 2013, López et al., 2014 and Zribi et al., 2015) which stated that increasing water moisture as a correlation of improving soil physical properties was markedly noted after compost application. Soil total content of NPK showed the same direction as well as the previous

introduced soil parameters. These findings are in harmony with the previous results of (Alva et al., 1991, Sahin et al., 2003, Makoi and Ndakidemi, 2007) who found that gypsum and compost applications were lead to the increase of nutrient release, subsequently increasing soil content of total NPK.

#### *Effect of gypsum and compost on vegetative growth parameters*

Results in Table 4 showed that all vegetative growth parameters, *i.e.*, shoot length, number of shoots/branch, number of leaves/shoot and leaf area were slightly increased after gypsum and compost application compared to control treatment. The first rate of compost (T2) not significantly differed with control (T1), but showed significant differences with other treatments (T3, T4, T5 and T6). Moreover, there were no significant differences between T3 compared to T4 and T5 compared to T6, whereas T5 and T6 showed significantly higher results compared to T3 and T4. These results are in the same line with (Abdel- Nasser and El-Shazly, 2000) who found that gypsum application showed growth increasing of some fruit trees such as persimmon, grapevine and orange tree. Other studies were found that improving growth parameter was related to improving soil structure under application of compost (Avnimelech et al., 1994 and Puget et al., 2000).

#### *Effect of gypsum and compost on yield indicators and Fruit quality attributes*

Fruit set as the most important yield parameter which reflects the stability of flowers and fruitlets against abscission zone that occurs between branch and peduncle during blooming stage and June drop. Table 5 showed that gypsum and compost application at all rates increased the fruit set percentage compared to untreated soils (control, T1). The increasing of fruit set was probably due to the improving nutritional status

and this come in agreements with many previous studies such (Goldschmidt & Koch, 1996, Iglesias et al., 2003 & 2006 and Syvertsen et al., 2003) who was found a link between creating the abscission zone and nutritional status. Fruit cracking and peel thickness were found related to each other and affected by gypsum and compost treatments. All gypsum and compost rates may increase the availability and the uptake of  $Ca^{2+}$  subsequently reduced the fruit cracking % and increased peel thickness compared to T1. these results was found in agreements with the previous studies who stated that increasing available water leads to increasing absorption of  $Ca^{2+}$ , subsequently reduce the fruit cracking rate (Fan et al., 2012). This can be happen via increasing cell-wall  $Ca^{2+}$  content and inhibit the degradation of pectin, cellulose and hemicellulose in the peel cell wall (Alvaro et al., 2010). Wen and Shi (2012) also found the lower leaves  $Ca^{2+}$  content was in the cracking peel and pulp in 'Jincheng' sweet orange compared to normal fruit. Results of yield, *i.e.*, fruit weight and number of fruits/tree showed that gypsum and compost treatments were better than control (Table 5). T6 gave the greatest yield value followed by T5, T4, T3 and T2.

Table 6 showed that fruit quality, *i.e.*, fruit juice volume, TSS, acidity, total sugars and vitamin C had significantly higher values compared to control (T1) due to gypsum and compost applications. It was logically to note the improved fruit quality attributes due to gypsum and compost applications as a reflection of improvement of soil physical and chemical properties subsequently their relates such increasing availability of water

**TABLE 4. The effect of gypsum and compost on shoot length (cm), number of shoots/ branch, number of leaves/ shoot and leaf area (cm<sup>2</sup>) in the trail field of Washington navel orange trees under saline –sodic soil during 2017 and 2018 seasons.**

Parameters	Shoot length(cm)		No. shoots/ branch		No. leaves/shoot		Leaf area (cm <sup>2</sup> )	
	2017	2018	2017	2018	2017	2018	2017	2018
T1	24.24c	24.53c	18.12c	18.23c	5.15c	5.13c	14.12c	14.17c
T2	24.32c	24.55c	18.24c	18.51c	5.24c	5.25c	14.22c	14.21c
T3	26.19b	26.15b	20.74b	20.70b	5.87b	5.77b	16.14b	16.17b
T4	26.98b	26.78b	21.41b	21.31b	6.07b	6.09b	16.23b	16.26b
T5	28.17a	28.15a	22.95a	22.91a	6.95a	6.89a	17.91a	17.85a
T6	29.06a	29.07a	23.21a	23.24a	7.11a	7.13a	18.11a	18.14a

T1: untreated soil (control), T2: compost at 10 tons/ fed., T3: compost at 15 tons/ fed., T4: gypsum at 10 tons/ fed., T5: gypsum at 10 tons/ fed. + compost at 10 tons/ fed., T6: gypsum at 10 tons/ fed. + compost at 15 tons/ fed., on soil moisture % for the orchard of Washington navel orange under saline –sodic soil during 2017 and 2018 seasons. Means followed by the same letter are not statistically different by Duncan at 0.05 levels.

**TABLE 5.** The effect of gypsum and compost on fruit set %, fruit cracking %, Peel thickness (mm), fruit weight (g), number of fruits /tree and tree yield (kg) in the trail field of Washington navel orange trees under saline –sodic soil during 2017 and 2018 seasons.

Parameters	Fruit set %		No. fruits /tree		Tree Yield (Kg)		Fruit weight (g)		Fruit cracking %		Peel thickness (mm)	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
T1	14.25c	14.21c	65.53e	65.74e	65.75e	75.65e	235.23e	235.78e	5.64a	5.61a	3.11a	3.15a
T2	14.25bc	14.22bc	66.75de	66.41de	66.68de	66.78de	236.35de	236.74de	5.32a	5.31a	3.12ab	3.14ab
T3	16.18b	16.17b	67.71cd	67.54cd	68.68cd	68.89cd	237.43cd	237.54cd	4.11b	4.12b	2.97bc	2.9bc
T4	17.18b	17.18b	68.45c	68.87c	70.74c	70.85c	238.87c	238.89c	3.81b	3.85b	2.74c	2.71c
T5	18.85a	18.81a	70.51b	70.87b	72.36b	72.74b	240.31b	240.29b	2.51cd	2.53cd	2.75d	2.71d
T6	19.03a	19.06a	72.13a	72.11a	74.05a	74.03a	241.17a	241.11a	2.10d	2.11d	2.51e	2.49e

T1: untreated soil (control), T2: compost at 10 tons/ fed., T3: compost at 15 tons/ fed., T4: gypsum at 10 tons/ fed., T5: gypsum at 10 tons/ fed. + compost at 10 tons/ fed., T6: gypsum at 10 tons/ fed. + compost at 15 tons/ fed., on soil moisture % for the orchard of Washington navel orange under saline –sodic soil during 2017 and 2018 seasons. Means followed by the same letter are not statistically different by Duncan at 0.05 levels.

**TABLE 6.** The effect of gypsum and compost on fruit juice volume (ml), TSS, acidity %, total sugars % and vitamin C (mg/100 juice) in the trail field of Washington navel orange trees under saline –sodic soil during 2017 and 2018 seasons.

Parameters	Fruit juice volume (ml)		TSS%		Acidity %		Total sugars%		Vitamin C (mg/100 juice)	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
T1	68.34e	68.54e	10.11c	10.12c	0.97d	0.97d	6.11d	6.13d	53.55e	53.51e
T2	68.53de	68.51de	10.35c	10.33c	1.03cd	1.05cd	6.36d	6.35d	53.61de	53.65de
T3	69.63cd	69.74cd	11.15b	11.17b	1.09bc	1.07bc	7.36c	7.37c	54.22d	54.19d
T4	70.89c	70.83c	11.74b	11.81b	1.15b	1.13b	7.78c	7.79c	56.65c	56.68c
T5	72.47b	72.41b	12.52a	12.54a	1.24a	1.22a	8.15b	8.12b	58.24b	58.21b
T6	73.13a	73.11a	12.98a	12.97a	1.30a	1.31a	9.22a	9.23a	59.69a	59.67a

T1: untreated soil (control), T2: compost at 10 tons/ fed., T3: compost at 15 tons/ fed., T4: gypsum at 10 tons/ fed., T5: gypsum at 10 tons/ fed. + compost at 10 tons/ fed., T6: gypsum at 10 tons/ fed. + compost at 15 tons/ fed., on soil moisture % for the orchard of Washington navel orange under saline –sodic soil during 2017 and 2018 seasons. Means followed by the same letter are not statistically different by Duncan at 0.05 levels.

and nutrients to plants which showed the direct effect on fruit quality as stated in previous studies (Shainberg et al., 1989, Sahin et al., 2003, Makoi & Ndakidemi, 2007, Sumner 2007, López et al., 2014 and Zribi et al., 2015).

#### *Effect of gypsum and compost on leaf mineral content*

As expected gypsum with the higher rate of compost showed the highest value of all measured nutrients compared to other treatments (Table 7). There were no significant differences between T1 compared to T2 and T3 compared to T2 for measured leaf mineral. Whereas, T5 showed higher significant differences compared to T4. These results come in harmony with the previous studies (Lindemann et al., 1991, Abdel- Nasser

and El-Shazly, 2000, Neilsen et al., 1993 and Chien et al., 2011) who stated that application of gypsum or compost resulted to the increase of plant nutrient in root area, subsequently increasing the uptake of it.

#### **Conclusion**

Gypsum 10 tons/ fed and compost at 15 tons/ fed (T6) showed the best results followed by T5, T4, T3 and T2 whereas T1 was the lowest ones for all parameters under investigations. Gypsum combined compost at T6 treatment was found to be promising agriculture practices for ameliorating saline-sodic soil and improving growth parameter, yield level and enhancing quality of Washington navel orange.

**TABLE 7.** The effect of gypsum and compost on the uptake of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) in the trail field of Washington navel orange trees under saline –sodic soil during 2017 and 2018 seasons.

Parameters	N %		P %		K %		Ca %		Mg%	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
T1	2.14d	2.15d	0.121d	0.124d	1.33e	1.35e	4.01e	4.03e	0.31d	0.32d
T2	2.21cd	2.19cd	0.129cd	0.128cd	1.43de	1.44de	4.14de	4.17de	0.41cd	0.43cd
T3	2.38bc	2.37bc	0.136bc	0.137bc	1.55cd	1.54cd	4.29d	4.28d	0.46c	0.47c
T4	2.48b	2.47b	0.156b	0.158b	1.59bc	1.57bc	4.89c	4.86c	0.56b	0.57b
T5	2.69a	2.68a	0.177a	0.178a	1.68ab	1.65ab	5.23b	5.26b	0.63ab	0.65ab
T6	2.88a	2.87a	0.191a	0.192a	1.89a	1.87a	5.87a	5.88a	0.69a	0.68a

T1: untreated soil (control), T2: compost at 10 tons/ fed., T3: compost at 15 tons/ fed., T4: gypsum at 10 tons/ fed., T5: gypsum at 10 tons/ fed. + compost at 10 tons/ fed., T6: gypsum at 10 tons/ fed. + compost at 15 tons/ fed., on soil moisture % for the orchard of Washington navel orange under saline –sodic soil during 2017 and 2018 seasons. Means followed by the same letter are not statistically different by Duncan at 0.05 levels.

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#### Conflicts of interest

The authors declare that there are no conflicts of interest related to the publication of this work.

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## تأثير الجبس مع الكمبوست على النمو والمحصول للبرتقال بسرة تحت ظروف الأراضي الملحية السوديّة

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زادت مساحة الأراضي الملحية السوديّة كنتيجة لتغيرات المناخ والممارسات الزراعيّة الخاطئة والأسمدة الغير مناسبة مما أدى إلى خلل في تغذية أشجار الموالح والذي إنعكس بدوره على إنخفاض الإنتاج والجوده. ولذلك تهدف الدراسة على التركيز على إضافة الجبس والكمبوست بالمعدلات المناسبة والتي تغطي سلبيات هذه المتغيرات. أجريت الدراسة خلال عامي ٢٠١٧ و ٢٠١٨ بمزرعة خاصة بقرية أكوة الحصّة - مركز كفر الزيات - محافظة الغربية- مصر وذلك على أشجار برتقال بسرة مطعومة على النارج البلدي عمره ثمانية سنوات منزرعة على مسافات ٥ X ٥ بكتافة زراعية ١٦٨ شجرة للفدان. إشتملت الدراسة على ٦ معاملات هي ١- الكنترول , ٢- الكمبوست بمعدل ١٠ طن/فدان , ٣- الكمبوست بمعدل ١٥ طن/فدان , ٤- الجبس بمعدل ١٠ طن/فدان , ٥- الجبس بمعدل ١٠ طن/فدان+ الكمبوست بمعدل ١٠ طن/فدان , 6- الجبس بمعدل ١٠ طن/فدان+ الكمبوست بمعدل ١٥ طن/فدان. لمعرفة تأثير تلك المعاملات على التربة حيث تم تقدير نسبة الرطوبة عند السعة الحقلية ونقطة الذبول المستديم ثم قدرت الرطوبة كنسبة مئوية من السعة الحقلية بالإضافة إلى تقدير محتوى التربة من النتروجين والفوسفور والبوتاسيوم. كما تم إختبار تأثير تلك المعاملات على قياسات النمو مثل طول أفرخ نموات الربيع وعددها ومساحة الأوراق , دلائل المحصول مثل نسبة الثمار العاقدة وأوزان الثمار و المحصول للشجرة الواحدة. أما بالنسبة لصفات الجودة فقد تم تقدير نسبة الثمار المشقوفة ونسبة سمك القشرة , كمية العصير في الثمرة ونسبة المواد الذائبة الكلية والحموضة والسكر وفيتامين ج. كما تم قياس نسبة العناصر المعدنية في الأوراق مثل النتروجين والفوسفور والبوتاسيوم والكالسيوم والماغنسيوم. وقد أظهرت المعاملة رقم ٦ الخاصة بالجبس والكمبوست بمعدل ١٥ طن/فدان اعلى النتائج لكل الصفات تحت الدراسة تلتها المعاملة رقم ٥ ثم رقم ٤ ثم ٣ ثم ٢ بينما أظهرت المعاملة رقم ١ ( الكنترول ) أقل القيم للصفات المدروسة. ولذلك يمكن التوصية بإضافة الجبس مع الكمبوست بمعدل ١٥ طن/فدان لمزارع البرتقال بسرة لمعالجة ظروف الأراضي الملحية السوديّة والتي أعطت أفضل نتائج للنمو والمحصول والجودة تحت نفس ظروف التجربة.