Egyptian J. Desert Res., **68**, No. 1, 37-59 (2018)

IMPROVING PRODUCTIVITY AND QUALITY OF MANGO USING HUMIC ACID AND VERMICOMPOSTING LEACHATE IN NORTH SINAI

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This study was conducted during the two successive seasons 2016 and 2017 at Baloza district, North Sinai governorate, Egypt. This study is a trail to solve the problems of salinity that impede the sustainable development of horticultural economic activities (even all of the agriculture activities) by improving the productivity of such fruit orchard and the quality of the produced fruits. In this study, two bio-organic materials (humic acid and vermicomposting leachate) used to overcome the negative effects of salinity on mango trees (Keitt cultivar). Three concentrations of vermicomposting leachate (VCL): control (tap water), $(VCL)_1$: vermicomposting leachate at 10% and $(VCL)_2$: vermicomposting leachate at 15% were sprayed on the trees and three levels of humic acid [$(HA)_0$: control (without), $(HA)_1$: 20 ml/ tree/season and $(HA)_2$: 40 ml/ tree/season] added to soil were the main treatments applied to achieve the aim of the work. All treatments were added three times, the first added when growth started, the second was after full bloom and the last added three weeks later after setting. The obtained results revealed that all treatments were very effective in stimulating growth parameters, mineral contents, yield, physical and chemical characteristics of the fruits. In addition, $(VCL)_2$ with $(HA)_2$ increased leaf area, total chlorophyll content, leaf mineral contents (N, P and K), fruit set, fruit retention, fruit weight, pulp weight, pulp/fruit percentage, number of fruits/tree, yield/tree, total soluble solids, total sugar content, ascorbic acid and decreased peel weight and total acidity in the Keitt mangoes cv. Furthermore, increasing humic acid decreased EC, pH, Cl and Na and increased Fe, Zn, Cu and Mn in the soil.

Keywords: mango, Keitt, humic acid, vermicomposting leachate, yield, fruit quality

Mango (*Mangifera indica* L.) is an evergreen fruit tree belongs to the family Anacardiaceae and considered as one of the most important fruits of the tropical and subtropical countries in the world. It grows under a wide range of climatic and soil conditions. In Egypt, mango ranks the third after citrus and grapes. Keitt mango is cultivated widely in the newly reclaimed area, especially in Sinai governorate. The main problems in the soil of the newly reclaimed area are poor structure, low availability of water and nutrients, low fertility and salinity. Soil salinity is the major problem in these soils. In order to achieve salt-tolerance, the foremost task is either to prevent or alleviate the damage or to re-establish homeostatic conditions in the new stressful environment (Parida and Das, 2005). It is well known that salinity can impair the performance of production and growth of many horticultural plants, especially fruit trees, also high salinity causes plant deterioration (Abd El-Hady et al., 2003). The most harmful effect of salinity is the increase in osmotic stress due to high salt concentration in soil solution. Consequently, the decrease in the soil water potential and imbalance in overall concentrations of the ions is due to ion toxic effect on physiological processes, such as growth regulation, photosynthesis, respiration and enzyme activity (Mervat et al., 1996). The reclamation of these soils was mainly depended upon the addition of many natural amendments, such as organic material.

The organic matter is crucial for maintaining soil fertility, adjusting soil pH and increasing solubility of elements. Which have positive impact on encouraging proliferation of soil microorganisms, increasing microbial population and activity of microbial enzymes, i.e. dehydrogenize, urease and nitrogenase (Abou-Hussein et al., 2002). Humic acid and fulvic acid are essential in soil organic matter. In addition, the nature stability of these substances affects carbon and nitrogen cycles and carbon sequestration. Moreover, it can ameliorate the negative effect of salt that would inhibit the plant growth and the uptake of nutrient elements (Casierra-Posada et al., 2009).

Humic acid is a product contains many elements, which improve the soil fertility and increase the availability of nutrient elements and consequently, affect positively plant growth and yield (El-Sharkawy et al., 2010). Humic acid is the most significant component of organic substances in equates system. Humic substances function to buffer the hydrogen ion concentration (pH) of the soil (Mecan and Petrovic, 1995). Liu and Cooper (2002) showed that humic acid improved salinity tolerance in plant. Also, Davis and Ghabbour (1998) indicated that humic acid improved soil structure, organic matter, nutrient uptake, root development and microbial activity. Many investigators reported that, application of humic substances led to a remarkable increment in soil organic matter, which improved soil characteristics, plant growth and increase crop production (Mahmoud and Hafez, 2010). The role of these organic fertilizers is improving growth, chlorophyll content, enhancing photosynthesis and increasing tissue content of N (Hussein et al., 2005). In addition, El Kheshin (2016) stated that humic acid may enhance positively the transplants ability for nutrient uptake that led to produce healthy mango transplants, which reflect increasing in leaves as a natural result for healthy transplants and improving vegetative growth and yield. Ali et al. (2013) reported that application of humic acid on grapevine is more affecting in reducing salinity hazard of soil; it gave the lowest EC either horizontally or vertically at direction of vines. Hassan (2016) cleared that application of humic acid at 20 ml/tree profoundly alleviated salinity effect by enhancing available nutrients and microbial activity. In addition, it improved tree growth in terms of shoot length, leaves number/shoot, leaf area, and increased yield as kg/tree, number of fruits per tree, fruit quality as weight, volume, TSS and content of leaf N, P, K, Fe, Mn and Zn, in addition to noticed decrease in the acidity of the Egyptian lime trees under saline soil conditions. Tahira et al. (2013) mentioned that humic acid application to kinnow mandarin trees gave significant positive effect on total chlorophyll contents. Omima (2013) cleared that, applications of 60 g humic acid/ tree to the soil of Aggizy olive orchard gave the best effect on leaf area, total chlorophyll, leaf mineral content (N, P and K), yield, fruit quality and gave the lowest acidity percentage.

Recently, more focus has been given to vermicomposting technique. This technology used the assistance of earthworms to stabilize the organic waste material and produces microorganism rich medium that enhances the process of composting (Ismail, 2005). The principle of the vermicomposting leachate collecting unit is designed to allow the percolation of water through these passages and hence collecting the nutrient and microorganisms along with it. Vermicompost leachate (VCL) as a bio-fertilizer is a liquid phase that comes from vermicompost and it has a very positive impact on soil improvement and plant growth (Chinsamy et al., 2013). Bio-fertilizers are the most importance for plant production and soil as they play an important role in increasing vegetative growth, yield and fruit quality (Hasan et al., 2013). Several epithets such as vermiwash, vermicomposting leachate, vermi-leachate, worm bed leachate and worm tea have been used to describe the liquid derived from the vermicomposting process (Quaik and Ibrahim 2013). Use of VCL as a liquid fertilizer provides the advantage of homogeneity, when applied to growth media as compared to application of solid fertilizer (Quaik et al., 2012 and Shlrene et al., 2012). Vermicomposting leachate acts as plant tonic, because it contains humic acid, fulvic acid, amino acids, vitamins, enzymes, microorganisms, actinomycetes, nutrients like nitrogen, potassium, magnesium, zinc, calcium, iron, and copper and some growth hormones like auxins and cytokines (Suthar, 2010). These characteristics increased vegetative growth and productivity of fruit trees by about 15%. Vermicomposting leachate increased disease resistance capacity in many agricultural crop plants against various bacterial, vital and fungal diseases. VCL considers as a biotic aqua fertilizer, which is applied as pesticide that also contains plant essential nutrients. VCL had anti-spawning effects on insects and increased disease resistance capacity in many agricultural crop plants against various bacterial, vital and fungal diseases (Zhu et al., 2001). Vermicomposting leachate is very good foliar spray, which prevents detachment of flowers and helps in fruit setting (Tejada et al., 2008). In addition, Sathe and Patil (2014) recorded that VCL is a good bio-fertilizer and tonic to mango (*Mangifera indica*), which increased the fruit production of mango and fruit quality. It was very interesting that, during the experimental period there were no insect pests and bacterial or fungal diseases attacked mango indicating the controlling capacity of VCL against pests and diseases. Furthermore, foliar spray of VCL increase salt tolerance by reducing the accumulation of Na^+ in pomegranate tree, increased leaf area and total Chlorophyll (Siamak et al., 2017).

This study is a trial aiming to solve the problems of salinity that impede the sustainable development of horticultural economic activities by improving the productivity of such fruit orchard and the quality of the produced fruits. In this study two bio-organic materials (vermicomposting leachate and humic acid) were used to overcome the negative effects of salinity on mango trees (Kiett cultivar).

MATERIALS AND METHODS

This study was conducted during 2016 and 2017 seasons on 54 Keitt mango trees (*Mangifera indica*) of 10-year old, budded on mango Succary seedlings as rootstocks, grown in sandy soil (Table 1), spaced 5x5 m apart and subjected to drip irrigation system at Baloza district, North Sinai Governorate, Egypt. The selected trees were uniform in vigor as possible. Fertilization and other agricultural practices were the same for all trees. Three concentrations of vermicomposting leachate; $(VCL)_0$: control (tap water), $(VCL)_1$: vermicomposting leachate at 10% and $(VCL)_2$: vermicomposting leachate at 15% sprayed on the trees, and three level of humic acid [$(HA)_0$: control (without), $(HA)_1$: 20 ml/ tree/ season and $(HA)_2$: 40 ml/ tree/ season] added to the soil. These treatments applied to achieve the aim of the work and to evaluate the improvement of that highly economic value fruit orchard. All treatments were added three times, the first added when growth started, the second was after full bloom and the last added three weeks later after setting. Triton B at 0.1% was used as a diffuser with all treatments to spray solution including the control "tap water".

Table (1). Some physical and chemical properties of the experimental soil.

Particle size distribution (%)			Soil texture	Ec (ds/m[1])	pH	Soluble cations (meq/l)				Soluble anions (meq/l)			
Sand	Silt	Clay				K^+	Na^+	Ca^{+2}	Mg^{+2}	CO_3^{-2}	HCO_3^-	Cl^-	SO_4^{-2}
95	5	-	Sandy	2.67	7.9	1.0	16.65	5.3	3.8	-	3.85	14.3	8.6

Table (2). Characteristics of vermicompost leachate obtained from cattle manure.

Characteristic	pH	OM	EC (dS/m)	C/N	N (%)	P (mg/kg)	K (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	Purity (%)	
												Humic	Fulvic
VCL	7.08	20.06	2.78	5.38	2.42	1865	2487	11.08	0.08	24.57	0.49	18	15

This study was designed as split plot design arranged in factorial design with three replicates for each treatment and each replicate was represented by two trees.

The following parameters were measured for both seasons:

1. Leaf area

Leaf area (cm^2) was determined by using the leaf area meter CL203.

2. Total chlorophyll content

Leaves were tested for total chlorophyll content in field using Minolta meter SPAD.

3. Leaf mineral content

The collected leave samples were dried and ground and then digested for nitrogen, phosphorus and potassium analyses. Nitrogen was determined by micro-Kjeldahl method. Phosphorus was estimated calorimetrically using ascorbic acid and ammonium molybdate using spectrophotometer and potassium was measured using flame photometer according to Page et al. (1982).

4. Fruit Set and Fruit Retention

Number of fruitlets per panicle was counted after 15 days of full bloom to determine the initial number of set fruitlets per panicle. The initial fruit set was calculated as a percentage. After recording the initial fruit set, number of fruits per panicle was recorded at mature stage (a week before harvest). The percentage of retained fruits at harvest time was calculated.

5. Yield and Number of Fruits

In each season, at harvest time (October), number of fruits per each treated tree was counted and reported then yield (kg/tree) was weighed and recorded.

6. Fruit Quality

Five ripen fruits were taken at harvest from each treated tree for determination of the following physical and chemical properties, i.e. fruit weight (g), peel weight (g), pulp weight (g) and pulp/fruit percentage. Total soluble solids (T.S.S.) were determined by hand refractometer. Percentage of total acidity as g citric acid/ 100 g F.wt, total sugars %, and ascorbic acid (mg ascorbic acid/100 ml juice) were determined according to A.O.A.C. (1995).

7. Soil Nutrient Contents

Before applying the treatments and at the end of experiment, soil samples were taken from each treatment at major root zone (0 – 60 cm depth). Soil samples were prepared for analysis according to Jackson (1967). These soil samples were dried, sieved through a 2 mm and analyzed for soluble cations, soluble anions and available micronutrients in soil according to Page et al. (1982).

8. Statistical Analysis

The obtained data in 2016 and 2017 seasons were subjected to analysis of variance according to Clarke and Kempson (1997). Means were differentiated using Range test at the 0.05 level (Duncan, 1955).

RESULTS AND DISCUSSION

1. Leaf Area and Total Chlorophyll Content

Data in table (3) clear that leaf area and chlorophyll content were affected significantly by spraying all treatments with vermicomposting leachate (VCL) in both seasons. Whoever, $(VCL)_2$ produced the highest leaf area and total chlorophyll content in both seasons. In addition, control $(VCL)_0$ was the lowest in leaf area and total chlorophyll content in both seasons.

In addition, leaf area and total chlorophyll content was significantly affected by all treatments in both seasons. However, adding 40 ml/tree humic acid $(HA)_2$ to the soil gave the best leaf area (82.58 in the 1st and 84.95 cm^2 in the 2nd season) and leaf chlorophyll (47.21 in the 1st and 47.74 in the 2nd season) and adding 20 ml/ tree humic acid came the second in both seasons.

The obtained data from the interaction between spraying tree with vermicomposting leachate (VCL) and adding humic acid (HA) to soil cleared that, $(VCL)_2$ and $(VCL)_1$ with $(HA)_2$ recorded the highest leaf area and leaf chlorophyll in the first season. While $(VCL)_2$ with $(HA)_2$ recorded the highest leaf area and leaf chlorophyll content in the second season. In addition, $(VCL)_0$ with $(HA)_0$ recorded the lowest leaf area and leaf chlorophyll content in both seasons.

Table (3). Effect of vermicomposting leachate spray (VCL) and humic acid soli addition (HA) on leaf area and total chlorophyll of mango at 2016 and 2017 seasons.

Parameters / Treatments	Leaf area (cm^2) Season 2016	Leaf area (cm^2) Season 2017	Total chlorophyll Season 2016	Total chlorophyll Season 2017
Effect of spraying vermicomposting leachate (VCL)				
$(VCL)_0$	76.35c	78.14c	44.74c	45.24c
$(VCL)_1$	79.40b	81.16b	46.05b	46.54b
$(VCL)_2$	81.55a	83.77a	46.73a	47.38a
Effect of application humic acid (HA)				
$(HA)_0$	75.33c	76.48c	44.34c	44.84c
$(HA)_1$	79.38b	81.65b	45.97b	46.58b
$(HA)_2$	82.58a	84.95a	47.21a	47.74a

The interaction between vermicomposting leachate (VCL) and humic acid (HA)

(VCL)	(HA)	Leaf area (cm^2) Season 2016	Leaf area (cm^2) Season 2017	Total chlorophyll Season 2016	Total chlorophyll Season 2017
$(VCL)_0$	**$(HA)_0$**	74.00g	74.87i	43.70f	44.00g
	$(HA)_1$	76.06ef	75.14h	44.51e	44.51fg
	$(HA)_2$	79.00cd	79.44f	46.00c	46.01e
$(VCL)_1$	**$(HA)_0$**	74.54fg	78.24g	44.11ef	45.00f
	$(HA)_1$	80.11c	82.14d	46.41c	47.11cd
	$(HA)_2$	83.54ab	84.56c	47.64a	47.64bc
$(VCL)_2$	**$(HA)_0$**	77.46de	81.32e	45.21d	46.74d
	$(HA)_1$	81.98b	86.21b	47.00b	48.00ab
	$(HA)_2$	85.21a	87.32a	48.00a	48.50a

Means having the same letter(s) in each column of first factor, second factor or interaction are not significantly different at 5% level. *$(VCL)_0$= 0 of vermicomposting leachate, $(VCL)_1$= 10% vermicomposting leachate and $(VCL)_2$= 15% of vermicomposting leachate, While, $(HA)_0$= 0 humic (control), $(HA)_1$= 20 ml/ tree/season humic acid and $(HA)_2$= 40 ml/ tree/season humic acid.

These results may be due to that vermicomposting leachate acts as plant tonic, because it contains humic acid, fulvic acid microorganisms, actinomycetes, enzymes, hormones and multi nutrients. These characteristics increased the vegetative growth and productivity of fruit trees. Furthermore, foliar spray of VCL induced salt tolerance by reducing the accumulation of Na^+ in the tree (Siamak et al., 2017). In addition, humic acid considered nonconventional sources of organic matter suitable for soil amendments, different humic acid – derived materials have improved soil characteristics and plant growth (Obreza and Biggs, 1989). The role of these organic fertilizers is improving growth, chlorophyll content enhanced photosynthesis and increased tissue content of N (Hussein et al., 2005). In addition, El Kheshin (2016) stated that humic acid may enhance positively the transplants ability for nutrient uptake, which led to produce healthy mango transplants and improving vegetative growth.

Generally, those obtained results are in agreement with Naeini et al. (2005), Siamak et al. (2017) on pomegranate, Chinsamy et al. (2013), who reported that tomato leaf area and total chlorophyll increased by spraying with VCL under saline conditions. In addition, Omima (2013) and Tahira et al. (2013) mentioned that, humic acid application to mandarin and olive trees gave a significant positive effect on leaf area and total chlorophyll.

2. Leaf Mineral Content

Nitrogen, phosphorus and potassium (%)

Data presented in table (4), show that all treatments were significantly effective on mango (Kiett cultivar) leaf mineral content (nitrogen, phosphorus and potassium) in both seasons. However, $(VCL)_2$ produced the highest leaf nitrogen, phosphorus and potassium content in both seasons. While, control $(VCL)_0$ gave the lowest leaf nitrogen, phosphorus and potassium content in both seasons.

In addition, leaf nitrogen, phosphorus and potassium contents were affected significantly by all treatments of adding humic acid to the soil in both seasons. Whoever, adding 40 ml/ tree humic acid $(HA)_2$ to the soil gave a higher significant leaf nitrogen, phosphorus and potassium content in both seasons comparing with other treatments.

The interaction between vermicomposting leachate (VCL) and humic acid (HA) cleared that, $(VCL)_2$ with $(HA)_2$ recorded the highest leaf nitrogen, phosphorus and potassium content in both seasons. In addition, $(VCL)_0$ with $(HA)_0$ recorded the lowest leaf nitrogen, phosphorus and potassium content in both seasons.

These results may be due to that foliar spray of VCL increase salt tolerance by reducing the accumulation of Na^+ in the tree (Siamak et al., 2017). Use of VCL as a liquid fertilizer provides the advantage of homogeneity when applied to growth media as compared to application of solid fertilizer (Quaik et al., 2012). A significant increase in the growth occurred on VCL treated plants could be due to the proper ratio of macro and micronutrients in the VCL (Hatti et al., 2010). Arthur et al. (2012) reported that VCL could serve as a potential substitute for phosphorus and potassium deficiency. Furthermore, humic acid is a product contains many elements, which improve the soil fertility and increase the availability of nutrient elements and consequently improve plant growth (El-Sharkawy et al., 2010). In addition, El Kheshin (2016) found that humic acid may enhance positively the ability of nutrient uptake, which led to produce healthy mango transplants and improve vegetative growth.

Table (4). Effect of vermicomposting leachate spray (VCL) and humic acid soli addition (HA) on leaf N, P, K content of mango at 2016 and 2017 seasons.

Parameters / Treatments		N (%)		P (%)		K (%)	
		Season 2016	Season 2017	Season 2016	Season 2017	Season 2016	Season 2017
Effect of spraying vermicomposting leachate (VCL)							
$(VCL)_0$		1.86 c	1.83c	0.30c	0.30 c	1.55c	1.60c
$(VCL)_1$		2.08b	2.07b	0.36b	0.37b	1.69 b	1.75b
$(VCL)_2$		2.20a	2.19a	0.39a	0.40a	1.78 a	1.83a
Effect of application of humic acid (HA)							
$(HA)_0$		1.85 c	1.77c	0.28c	0.29 c	1.51 c	1.56c
$(HA)_1$		2.08b	2.04b	0.36b	0.36b	1.70 b	1.75b
$(HA)_2$		2.22a	2.28 a	0.41a	0.42a	1.82a	1.87a
The interaction between vermicomposting leachate (VCL) and humic acid (HA)							
(VCL)	**(HA)**	**N (%)**		**P (%)**		**K (%)**	
		Season 2016	**Season 2017**	**Season 2016**	**Season 2017**	**Season 2016**	**Season 2017**
$(VCL)_0$	**$(HA)_0$**	1.77i	1.71 h	0.24i	0.25 i	1.41i	1.47i
	$(HA)_1$	1.81g	1.80g	0.30g	0.30g	1.55g	1.60g
	$(HA)_2$	2.01 e	1.98e	0.35e	0.35e	1.70e	1.72e
$(VCL)_1$	**$(HA)_0$**	1.80h	1.74h	0.27h	0.28 h	1.47h	1.54h
	$(HA)_1$	2.14d	2.10d	0.37d	0.38d	1.75d	1.80d
	$(HA)_2$	2.32 b	2.36b	0.43b	0.43b	1.85b	1.90b
$(VCL)_2$	**$(HA)_0$**	1.97f	1.85f	0.32f	0.34f	1.64f	1.68f
	$(HA)_1$	2.30c	2.21c	0.40c	0.41c	1.80c	1.84c
	$(HA)_2$	2.33 a	2.50a	0.44 a	0.46a	1.91a	1.97a

Means having the same letter(s) in each column of first factor, second factor or interaction are not significantly different at 5% level. *$(VCL)_{0}$= 0 of vermicomposting leachate, $(VCL)_{1}$= 10% vermicomposting leachate and $(VCL)_{2}$= 15% of vermicomposting leachate. While, $(HA)_{0}$= 0 humic (control), $(HA)_{1}$= 20 ml/ tree/season humic acid and $(HA)_{2}$= 40 ml/ tree/ season humic acid.

The obtained results are in agreement with Chinsamy et al. (2013) on tomato, Sathe and Patil (2014) on mango and Siamak et al. (2017) on pomegranate, who reported that spraying VCL enhanced the available nutrients under saline concentration. In addition, Davis and Ghabbour (1998), Liu and Cooper (2002), Omima (2013) and Hassan (2016) showed that humic acid improves salinity tolerance and improves nutrient uptake.

3. Fruit Set and Fruit Retention (%)

It is evident from the data in table (5), that fruit set and fruit retention were affected significantly by all spraying treatments with vermicomposting leachate (VCL) in both seasons. However, $(VCL)_2$ produced the highest fruit set and fruit retention in both seasons. While, control $(VCL)_0$ gave the lowest fruit set and fruit retention in both seasons.

Table (5). Effect of vermicomposting leachate spray (VCL) and humic acid soli addition (HA) on fruit set and fruit retention of mango at 2016 and 2017 seasons.

Treatments \ Parameters	Fruit set (%)		Fruit retention (%)	
	Season 2016	Season 2017	Season 2016	Season 2017
Effect of spraying vermicomposting leachate (VCL)				
$(VCL)_0$	9.29c	9.99b	1.39c	1.50c
$(VCL)_1$	10.49b	11.06a	1.72b	1.85b
$(VCL)_2$	11.14a	11.47a	2.99a	2.14a
Effect of application of humic acid (HA)				
$(HA)_0$	9.00c	9.70c	1.34c	1.47c
$(HA)_1$	10.39b	10.95b	1.67b	1.83b
$(HA)_2$	11.53a	11.87a	2.02a	2.19a

The interaction between vermicomposting leachate (VCL) and humic acid (HA)

(VCL)	(HA)	Fruit set (%)		Fruit retention (%)	
		Season 2016	Season 2017	Season 2016	Season 2017
$(VCL)_0$	**$(HA)_0$**	8.03g	9.11f	1.25i	1.34i
	$(HA)_1$	9.52e	9.77e	1.35g	1.42h
	$(HA)_2$	10.32cd	10.22e	1.56e	1.67f
$(VCL)_1$	**$(HA)_0$**	8.95f	10.00e	1.32h	1.45g
	$(HA)_1$	10.65bc	11.21cd	1.72d	1.88d
	$(HA)_2$	11.87a	12.20ab	2.11b	2.26b
$(VCL)_2$	**$(HA)_0$**	10.03de	10.87d	1.47f	1.70e
	$(HA)_1$	11.01b	11.65bc	1.94c	2.15c
	$(HA)_2$	12.39a	12.54a	2.39a	2.59a

Means having the same letter(s) in each column of first factor, second factor or interaction are not significantly different at 5% level. $(VCL)_{0=}$ 0 of vermicomposting leachate, $(VCL)_{1=}$ 10% vermicomposting leachate and $(VCL)_{2=}$ 15% of vermicomposting leachate. While, *$(HA)_{0=}$ 0 humic (control), $(HA)_{1=}$ 20 ml/ tree/season humic acid and $(HA)_{2=}$ 40 ml/ tree/season humic acid.

Fruit set and fruit retention were significantly affected by all treatments in both seasons. However, application of 40 ml/ tree humic acid $(HA)_2$ gave a higher significant fruit set (11.53% in the 1^{st} and 11.87% in the

2[nd] season) and fruit retention (2.02% in the 1[st] and 2.19% in the 2[nd] season) comparing with other treatments.

The interaction between vermicomposting leachate (VCL) and humic acid (HA) cleared that, $(VCL)_2$ and $(VCL)_1$ with $(HA)_2$ recorded the highest fruit set in both seasons, while $(VCL)_2$ $(HA)_2$ recorded the highest fruit retention in both seasons. In addition, $(VCL)_0$ with $(HA)_0$ recorded the lowest fruit set and fruit retention in both seasons.

The obtained results are in agreement with Tejada et al. (2008) and Sathe and Patil (2014) on mango, who stated that vermicomposting leachate was very good foliar spray to prevent detachment of flowers and consequently helps to increase fruit setting. In the same trend, Liu and Cooper (2002), Abbas et al. (2006) on grape, Ismail et al. (2007) on Le-Conte pear, Magda et al. (2012) on pomegranate and Shaddad et al. (2005) clearly showed that humic acid improves salinity tolerance and also, increasing amount of humic acid makes an increase in fruit set percentage and increases retained fruit.

4. Number of Fruits and Total Yield

It is evident from the data in table (6), that the number of fruits and total yield were affected significantly by all spraying treatments with vermicomposting leachate (VCL) in both seasons. Whoever, $(VCL)_2$ produced the highest number of fruits (30.33 in the 1[st] and 31.33 in the 2[nd] season) and total yield (17.71 kg in the 1[st] and 21.65 kg in the 2[nd] season). While, control $(VCL)_0$ gave the lowest number of fruits (23.11 in the 1[st] and 24.66 in the 2[nd] season) and total yield (10.63 kg in the 1[st] and 13.40 kg in the 2[nd] season).

Number of fruits and total yield was significantly affected by all treatments in both seasons. However, application 40 ml/ tree humic acid $(HA)_2$ gave the highest significant number of fruits and total yield in both seasons comparing other treatments.

The interaction between vermicomposting leachate (VCL) and humic acid (HA) cleared that, $(VCL)_2$ with $(HA)_2$ recorded the highest number of fruits and total yield in both seasons. In addition, $(VCL)_0$ with $(HA)_0$ gave the lowest number of fruits and total yield in both seasons.

These results may be due to that vermicomposting leachate acts as plant tonic, because it contains humic acid, fulvic acid microorganisms, actinomycetes, enzymes, hormones and multi nutrients. These characteristics increase 40 to 80% yield of the crops (Tejada et al., 2008). Moreover, humic acids (HAs) are the main fraction of humic substances (HS) and the most active components in the soil and compost organic matter. In addition, HAs stimulate plant growth and consequently yield by acting on mechanisms involved in: cell respiration, photosynthesis, protein synthesis, water and nutrient uptake, and enzyme activities (Chen et al., 2004).

These mentioned results are in agreement with those of Sathe and Patil (2014), who recorded that VCL is a good biofertilizer and tonic for mango (*M. indica)* to increase fruit yield. In addition, Fathi et al. (2002) on peach, Eissa et al. (2003) and Shaddad et al. (2005) on apricot, Omar and Abdelall (2005), Abbas et al. (2006) on grape, Ismail et al. (2007) on Le-Conte pear, Magda et al. (2012) on pomegranate and Omima (2013) on aggizy olive stated that there is a gradual increase in yield parallel to the increase of humic acid.

Table (6). Effect of vermicomposting leachate spray (VCL) and humic acid soli addition (HA) on number of fruits and total yield of mango at 2016 and 2017 seasons.

Parameters / Treatments		Number of fruits		Total yield (kg)	
		Season 2016	Season 2017	Season 2016	Season 2017
Effect of spraying vermicomposting leachate (VCL)					
$(VCL)_0$		23.11c	24.66c	10.63c	13.401c
$(VCL)_1$		27.44b	29.11b	15.22b	18.87b
$(VCL)_2$		30.33a	31.33a	17.71a	21.65a
Effect of application of humic acid (HA)					
$(HA)_0$		21.77c	23.33c	9.49c	12.25c
$(HA)_1$		27.33b	29.00b	14.81b	18.43b
$(HA)_2$		31.77a	32.77a	19.25a	23.55a
The interaction between vermicomposting leachate (VCL) and humic acid (HA)					
(VCL)	**(HA)**	**Number of fruits**		**Total yield (kg)**	
		Season 2016	**Season 2017**	**Season 2016**	**Season 2017**
$(VCL)_0$	**$(HA)_0$**	19.00i	20.33i	7.570i	9.561i
	$(HA)_1$	23.33g	25.00g	10.54g	13.43g
	$(HA)_2$	27.00e	28.66e	13.78e	17.20e
$(VCL)_1$	**$(HA)_0$**	21.00h	23.33h	8.83h	11.68h
	$(HA)_1$	28.33d	30.33d	16.04d	19.73d
	$(HA)_2$	33.00b	33.66b	20.79b	25.21b
$(VCL)_2$	**$(HA)_0$**	25.33f	26.33f	12.08f	15.50f
	$(HA)_1$	30.33c	31.66c	17.86c	22.14c
	$(HA)_2$	35.33a	36.00a	23.19a	28.23a

Means having the same letter (s) in each column of first factor, second factor or interaction are not significantly different at 5% level. *$(VCL)_{0=}$ 0 of vermicomposting leachate, $(VCL)_{1=}$ 10% vermicomposting leachate and $(VCL)_{2=}$15% of vermicomposting leachate. While, $(HA)_{0=}$ 0 humic (control), $(HA)_{1=}$ 20 ml/ tree/season humic acid and $(HA)_{2=}$ 40 ml/ tree/season humic acid.

5. Fruit, Peel, Pulp Weight and Pulp/Fruit (%)

Concerning the results in table (7) fruit weight, peel, pulp weight and pulp/fruit were affected significantly by all spraying treatments with vermicomposting leachate (VCL) in both seasons. Whoever, $(VCL)_2$ produced the highest fruit weight (574.17 g in the 1st and 690.74 g in the 2nd season), pulp weight (444.84 g in the 1st and 560.29 g in the 2nd season) and pulp/fruit (77.08% in the 1st and 80.85% in the 2nd season) and gave the lowest peel weight (74.33 g in the 1st and 73.34 g in the 2nd season). While, control $(VCL)_0$ gave the lowest significant fruit weight, pulp weight and pulp/fruit % and gave the highest peel weight in both seasons.

Table (7). Effect of vermicomposting leachate spray (VCL) and humic acid soli addition (HA) on fruits weight, peel, pulp weight and pulp/fruit of mango at 2016 and 2017 seasons.

Parameters / Treatments		Fruit weight (g)		Peel weight (g)		Pulp weight (g)		Pulp/fruit (%)	
		Season 2016	Season 2017	Season 2016	Season 2017	Season 2016	Season 2017	Season 2016	Season 2017
Effect of spraying vermicomposting leachate (VCL)									
$(VCL)_0$		453.69c	535.93c	75.84a	74.89a	324.79c	405.98c	71.29c	75.51c
$(VCL)_1$		539.12b	633.44b	74.62b	73.92b	410.02b	503.04b	75.35b	78.85b
$(VCL)_2$		574.17a	690.74a	74.33c	73.34c	444.84 a	560.29a	77.08a	80.85a
Effect of application humic acid (HA)									
$(HA)_0$		432.20c	519.92c	75.99a	75.11a	303.35c	390.04c	70.01c	74.80c
$(HA)_1$		535.77b	629.01b	75.06b	74.00b	406.41b	498.58b	75.53b	79.00b
$(HA)_2$		599.01a	711.18a	73.75c	73.03c	469.89a	580.69a	78.18a	81.40a
The interaction between vermicomposting leachate (VCL) and humic acid (HA)									
(VCL)	**(HA)**	**Fruit weight (g)**		**Peel weight (g)**		**Pulp weight (g)**		**Pulp/fruit (%)**	
		Season 2016	**Season 2017**	**Season 2016**	**Season 2017**	**Season 2016**	**Season 2017**	**Season 2016**	**Season 2017**
$(VCL)_0$	**$(HA)_0$**	398.50i	470.21i	76.77a	75.66a	269.70i	340.57i	67.67 i	72.42i
	$(HA)_1$	452.11g	537.37g	75.76b	74.99c	323.22g	407.27g	71.49g	75.78g
	$(HA)_2$	510.45e	600.22e	75.01cd	74.01e	381.44e	470.09e	74.72e	78.32e
$(VCL)_1$	**$(HA)_0$**	420.88h	500.77h	75.98b	75.11b	292.02h	371.11h	69.38h	74.10h
	$(HA)_1$	566.24d	650.44d	74.87d	73.77f	436.70d	519.79d	77.12d	79.91d
	$(HA)_2$	630.24b	749.10b	73.01f	72.88h	501.35b	618.23b	79.54b	82.53b
$(VCL)_2$	**$(HA)_0$**	477.22f	588.77f	75.21c	74.55d	348.34f	458.45f	72.99f	77.86f
	$(HA)_1$	588.96c	699.22c	74.54e	73.25g	459.31c	568.67c	77.98c	81.33c
	$(HA)_2$	656.33a	784.22a	73.24f	72.21i	526.87a	653.75a	80.27a	83.36a

Means having the same letter(s) in each column of first factor, second factor or interaction are not significantly different at 5% level. $(VCL)_{0=}$ 0 of vermicomposting leachate, $(VCL)_{1=}$ 10% vermicomposting leachate and $(VCL)_{2=}$ 15% of vermicomposting leachate. While, *$(HA)_{0=}$ 0 humic (control), $(HA)_{1=}$ 20 ml/ tree/season humic acid and $(HA)_{2=}$ 40 ml/ tree/season humic acid.

On the other hand, fruit, peel, pulp weight and pulp/fruit were significantly affected by all treatments in both seasons. However, application of 40 ml/ tree humic acid $(HA)_2$ gave a highest significant fruit weight, pulp weight and pulp/fruit and gave the lowest peel weight in both seasons. On the other side, control $(HA)_0$ gave the lowest significant fruit weight, pulp weight and pulp/fruit and gave the highest peel weight in both seasons.

The obtained data from the interaction between vermicomposting leachate (VCL) and humic acid (HA) cleared that, $(VCL)_2$ with $(HA)_2$ recorded the highest fruit weight, pulp weight and pulp/fruit and gave the lowest peel weight in both seasons. In addition, $(VCL)_0$ with $(HA)_0$ gave the lowest fruit weight, pulp weight and pulp/fruit and gave the highest peel weight in both seasons.

6. Total Soluble Solids, Total Sugar, Total Acidity Content and Ascorbic Acid

Data presented in table (8) show that total soluble solids, total sugar, total acidity content and ascorbic acid were significantly affected by all spraying treatments with vermicomposting leachate (VCL) in both seasons. However, $(VCL)_2$ produced the highest total soluble solids (22.03% in the 1st and 23.00% in the 2nd season), total sugar (19.95% in the 1st and 20.99% in the 2nd season) and ascorbic acid [35.96 in the 1st and 36.37 (mg/100 ml juice) in the 2nd season] in fruits and gave the lowest total acidity content (0.21% in the 1st and 0.19% in the 2nd season). The control of $(VCL)_0$ treatment gave the lowest significant total soluble solids, total sugar and ascorbic acid and gave the highest fruits total acidity percentage in both seasons.

Furthermore, total soluble solids, total sugar, total acidity content and ascorbic acid in fruits were significantly affected by all treatments in both seasons. However, application of 40 ml/ tree humic acid $(HA)_2$ gave higher significant total soluble solids, total sugar and ascorbic acid in fruits and gave the lowest fruits total acidity content in both seasons. On the other side, control $(HA)_0$ gave the lowest significant total soluble solids, total sugar, total acidity content and ascorbic acid and gave the highest fruits total acidity content in both seasons.

The obtained data from the interaction between vermicomposting leachate (VCL) and humic acid (HA) cleared that, $(VCL)_2$ with $(HA)_2$ recorded the highest total soluble solids, total sugar and ascorbic acid in fruits, while it gave the lowest total acidity content in both seasons. Furthermore, $(VCL)_0$ with $(HA)_0$ gave the lowest total soluble solids, total sugar, total acidity content and ascorbic acid in fruits and gave the highest total acidity content in both seasons.

Table (8). Effect of vermicomposting leachate spray (VCL) and humic acid soli addition (HA) on total soluble solids, total sugar, total acidity content and ascorbic acid of mango at 2016 and 2017 seasons.

Parameters / Treatments		TSS (%)		Total sugar (%)		Total acidity (%)		Ascorbic acid (mg/100 ml juice)	
		Season 2016	Season 2017	Season 2016	Season 2017	Season 2016	Season 2017	Season 2016	Season 2017
Effect of spraying vermicomposting leachate (VCL)									
$(VCL)_0$		20.00c	20.87c	18.06c	18.88c	0.26a	0.24a	34.58c	34.99c
$(VCL)_1$		21.28b	22.26b	19.39b	20.22b	0.23b	0.21b	35.47b	35.92b
$(VCL)_2$		22.03a	23.00a	19.95a	20.99a	0.21c	0.19c	35.96a	36.37a
Effect of application humic acid (HA)									
$(HA)_0$		19.91c	20.52c	17.80c	18.51c	0.26a	0.25a	34.29c	34.72c
$(HA)_1$		21.15b	22.27b	19.29b	20.22b	0.24b	0.21b	35.51b	35.85b
$(HA)_2$		22.25a	23.34a	20.32a	21.36a	0.20c	0.19c	36.21a	36.72a
The interaction between vermicomposting leachate (VCL) and humic acid (HA)									
(VCL)	**HA**	**TSS (%)**		**Total sugar (%)**		**Total acidity (%)**		**Ascorbic acid (mg/100 ml juice)**	
		Season 2016	**Season 2017**	**Season 2016**	**Season 2017**	**Season 2016**	**Season 2017**	**Season 2016**	**Season 2017**
$(VCL)_0$	**$(HA)_0$**	19.00i	19.54i	17.00i	17.65i	0.28a	0.27a	33.66i	34.14i
	$(HA)_1$	20.01g	21.05g	18.00g	19.00g	0.26c	0.24c	34.77g	35.00g
	$(HA)_2$	21.00e	22.02e	19.20e	20.00e	0.24e	0.22e	35.32e	35.84e
$(VCL)_1$	**$(HA)_0$**	19.87h	20.45h	17.65h	18.23h	0.27b	0.26b	34.21h	34.76h
	$(HA)_1$	21.45d	22.77d	19.87d	20.55d	0.23f	0.20f	35.76d	36.00d
	$(HA)_2$	22.54b	23.56b	20.65b	21.87b	0.20 h	0.18h	36.44b	37.01b
$(VCL)_2$	**$(HA)_0$**	20.87f	21.57f	18.76f	19.65f	0.25d	0.23d	35.00f	35.26f
	$(HA)_1$	22.01c	23.00c	20.00c	21.11c	0.22g	0.19g	36.01c	36.54c
	$(HA)_2$	23.21a	24.44a	21.11a	22.21a	0.18i	0.17i	36.87a	37.32a

Means having the same letter(s) in each column of first factor, second factor or interaction are not significantly different at 5% level. $(VCL)_0$ = 0 of vermicomposting leachate, $(VCL)_1$= 10% vermicomposting leachate and $(VCL)_2$= 15% of vermicomposting leachate. *While, $(HA)_0$= 0 humic (control), $(HA)_1$= 20 ml/ tree/ season humic acid and $(HA)_2$= 40 ml/ tree/season humic acid.

The positive effect of the applied treatment on fruits characteristics in tables (7 and 8) may be due to that positive effects of vermicomposting leachate acts as plant tonic, because it contains humic acid, fulvic acid, amino acids, vitamins, enzymes, microorganisms, actinomycetes, nutrients like nitrogen, potassium, magnesium, zinc, calcium, iron, and copper and some growth hormones; like auxins and cytokines (Suthar, 2010). Also, vermicomposting leachate improved plant growth and yield and also increased plant resistance against different diseases (Nath and Singh, 2009). In addition, humic substances on plant metabolism may depend on the uptake of some macro- and micronutrients (Pinton et al., 2007). Furthermore, several studies have hypothesized those physiological mechanisms through which humic substances exert that their effects may depend on hormones and, in particular, on the presence of auxin or auxin-like components in their structure (Nardi et al., 2002).

So, it can be concluded that humic acid and vermicomposting leachate enhance, growth, the uptake of some nutrients, reduce the uptake of toxic elements and could improve plant response to salinity and improve productivity and quality of fruits

Data in table (8) are generally in agreement with those of Sathe and Patil (2014), who recorded that VCL is a good biofertilizer, tonic that provide mango trees with most of the essential inputs for metabolism and growth which resulted in the increase of fruiting improvement either qualitatively or quantitatively. In addition, Fathi et al. (2002) on peach, Eissa et al. (2003) and Shaddad et al. (2005) on apricot, Omar and Abdelall (2005) and Abbas et al. (2006) on grape, Ismail et al. (2007) on Le-Conte pear, Magda et al. (2012) on pomegranate and Omima (2013) on aggizy olive, showed a gradual increase in quality of fruits to increasing humic acid.

7. Effect of Different Humic Acid Levels on Soil Chemical Properties

Data presented in Fig. (1a, b, c, d, e, f, g and h) clearly indicated that, there was a significant correlation between humic concentrations and all of soil chemical properties (EC, pH, Na, Cl, Fe, Mn, Zn and Cu). As shown in fig. 1a, 1b, 1c, and 1d a gradual decrease occurred in EC, pH, Cl, and Na in soil paste extract with the increase of humic acid concentration. These results could approve the idea saying that using humic acid leads to the intensive reduction of soluble Na salts and Cl and consequently the decrease of EC, and pH, On the other hand, it appears from fig. 1e, 1f, 1g, and 1h the high correlation between humic acid concentration and availability of soil minerals, indicating that there is an ascending increase in the available soluble Fe, Mn, Zn, and Cu in the soil as the humic acid concentration increased.

Humic acid has an important role in improving the soil aggregation and water movement that leaching the excessive soluble salts (Fahramand, et al., 2014). In this respect, Mohamed (2012) found that the electric conductivity (EC) of the soil treated with humic acid application was lower as compared to the non-treated. Moreover, in salt affected soil, the sodium concentration in water generally increases, in this situation humus complex is considered to be the effective amelioration methods to removal exchange of soluble sodium and changing the ionic composition of soils, at the same time, leaching the sodium salts out of the soil profile (Ouni et al., 2014).

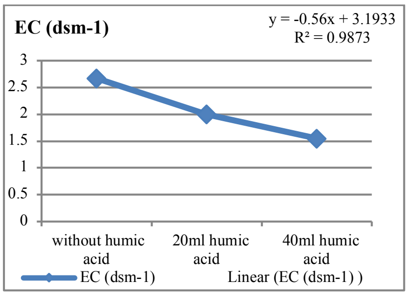

Fig. (1a)

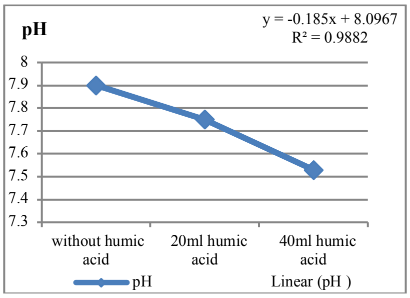

Fig. (1b)

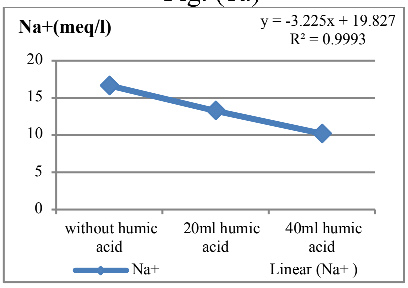

Fig. (1c)

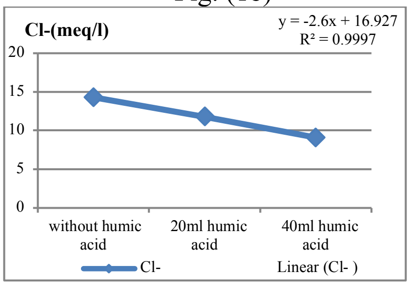

Fig. (1d)

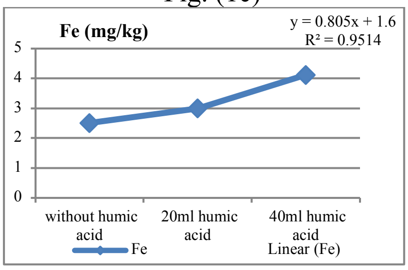

Fig. (1e)

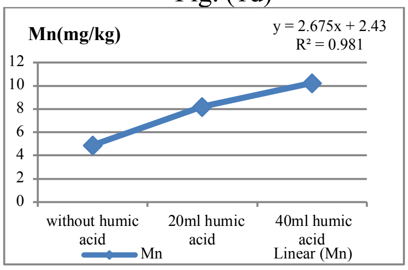

Fig. (1f)

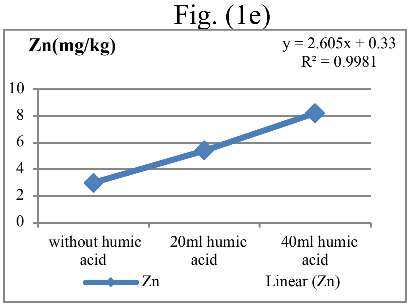

Fig. (1g)

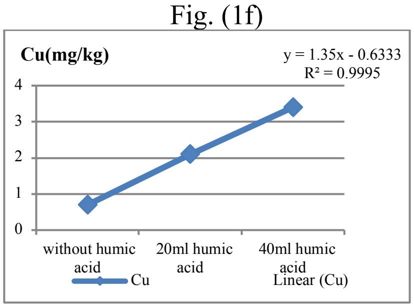

Fig. (1h)

Fig. (1). Effect of different humic acid levels on soil chemical properties.

Similar results were reported by El-Galad et al. (2013), who found that application of humic acid in saline soil gave the highest soil available Fe, Mn and Zn values after harvesting In addition, Cavalcante et al. (2013) reported that, humic acid improve soil structure and change physical properties, promote the chelation of many elements and make these available to plants.

CONCLUSION

Regarding mentioned results, it can be concluded that vermicomposting leachate and humic acid treatments could be one of the valuable technologies that assist in improving plant growth, fruit quality, productivity and soil chemical properties under saline stress by ameliorate soil conditions around plant roots and induced salt tolerance by reducing the accumulation of Na^+ in the tree. Moreover, spraying vermicomposting leachate $(VCL)_2$ at 15% to the trees with adding humic acid $(HA)_2$ at 40 ml/tree/season to the soil could be recommended to achieve the goal of improving such fruit orchard productivity.

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تحسين إنتاجية وجودة المانجو بإستخدام حمض الهيومك وراشح سماد دودة الأرض في شمال سيناء

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أجريت هذه الدراسة خلال الموسمين المتعاقبين ٢٠١٦ و٢٠١٧ في منطقة بالوظة بمحافظة شمال سيناء بمصر. تهدف هذه الدراسة إلى حل مشاكل الملوحة التي تعرقل التنمية المستدامة للأنشطة الاقتصادية البستانية من خلال تحسين إنتاجية بستان الفاكهة وجودة الثمار. تم استخدام اثنين من المواد العضوية (حمض الهيوميك والراشح السائل الناتج من سماد كمبوست دودة الأرض) للتغلب على الآثار السلبية للملوحة على أشجار المانجو (صنف الكيت). كانت المعاملات كالتالي: المعاملة الأولى: المقارنة الرش بماء (الصنبور)، المعاملة الثانية: الرش بالراشح السائل الناتج من سماد كمبوست دودة الأرض بتركيز ١٠٪ والمعاملة الثالثة: الرش بالراشح السائل الناتج من سماد كمبوست دودة الأرض بتركيز ١٥٪ مع إضافة ثلاثة مستويات من حمض الهيوميك أرضيًا كالتالي: المقارنة (بدون)، إضافة ٢٠ مل/شجرة/الموسم وإضافة ٤٠ مل/شجرة/الموسم. وأضيفت جميع المعاملات ثلاث مرات (عند بدء النمو، والثانية بعد تمام التزهير والثالثة بعد ثلاثة أسابيع من العقد). وأظهرت النتائج أن جميع المعاملات كانت فعالة جدًا في تحفيز النمو ومحتوى الأورق من العناصر المعدنية والمحصول والخصائص الفيزيائية والكيميائية للثمار وكذلك خصائص التربة. كما أنه الرش بتركيز ١٥٪ من الراشح السائل الناتج من سماد كمبوست دودة الأرض مع إضافة ٤٠ مل/شجرة/الموسم من حامض الهيوميك أدى إلى زيادة مساحة الورقة ومحتوى الكلوروفيل الكلي ومحتوى الأوراق من العناصر المعدنية (النيتروجين، الفوسفور، البوتاسيوم)، نسبة العقد، نسبة بقاء الثمرة، وزن الثمرة، وزن اللحم، ونسبة اللحم (٪)، وعدد الثمار، الإنتاجية وحمض الأسكوربك، بالإضافة إلى إنخفاض في وزن القشرة ونسبة الحموضة بالثمرة وعلاوة على ذلك، في نهاية الدراسة وجد انخفاض في ملوحة التربة، ودرجة الحموضة وزاد محتوى التربة من الحديد، والزنك، والنحاس والمنجنيز.