

## Effect of Magnetite and Some Biofertilizer Application on Growth and Yield of Valencia Orange Trees Under El – Bustan Condition

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**Abstracts:** The response of Valencia orange trees (*Citrus Sinensis*) budded on Volkamer lemon rootstock (*Citrus Volkameriana*) to Magnetite, Diatoms and biofertilizer (mixture of Cyanobacteria and Azolla) were studied during (2011 & 2012) seasons. Trees were four years old, planted at 4x6m apart (175 trees/ feddan), under drip irrigation system and growing in soil influenced by salinity, (where EC was 3.64 ds/m), in a private orchard, located at El Bustan County, El Behera Governorate, Egypt. The experiment involved 14 treatments. The obtained results indicated that, the application of biofertilizer plus 750 gm. Magnetite treatment was the best combination for achieving the highest total yield (51.44, 38.22 % over control) during two seasons, respectively. Diatoms either singly or in combination with Magnetite treatments improved fruit peel quality, where, (the peel thickness and firmness has increased, fruit peel was more lightness and had high good color quality), so it seems more attractive. Diatom treatments could earlier the harvest date by increasing fruit TSS/ Acid ratio and Vitamin C contents and to decrease fruit acidity especially Diatoms at 5 ppm plus 750 gm. Magnetite. All treatments slightly reduced soil EC and pH, increased leaf K<sup>+</sup> and reduced Na<sup>+</sup> uptake especially biofertilizer plus 750 gm. Magnetite treatment. Treatments also enhanced of the soil biological activity in terms of increasing the total (bacterial, cyanobacterial) counts and CO<sub>2</sub> evolution. Based on the economic study, it could be recommended to use biofertilizer plus 750 gm. Magnetite for achieving the best total yield and produced the highest net profit / fed., (4541.75 L.E), or use Diatoms at 5 ppm plus 750 gm. Magnetite for giving the high fruit peel quality which very important characteristics especially when fruits tended to be exported and earlier maturation of fruit as well as increased net profit / fed. (3426.75 L.E). While, it could not be recommended to use biofertilizer alone because it caused loss of money (-742 L.E).

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**Key words:** Magnetite, Diatoms, cyanobacteria, Azolla, yield, fruit quality and Valencia orange trees.

### 1. Introduction

It will known that most of the new reclaimed areas in Egypt are planted with fruit trees especially citrus which considered the first fruit crop in Egypt. The area of citrus has increased rapidly through the last few years and reached about 462772 feddans (According to the yearly Bull. Agric. Economic and Statistics, Ministry of Agriculture and Land Reclamation of Egypt, 2010). Efforts are insistently devoted to raise the productivity of such a crop. Unfortunately, many factors are contributing to reduce crop yield. One of these factors is the salinity soil which is a biotic stress factors. Egypt has an area of about one million square kilometers or 238 million feddans (one feddan = 0.42 ha). The total agricultural land in Egypt amounts to nearly 8.4 million feddans (3.5 million ha) and accounts for around 3.5 percent of the total area. One million ha in the irrigated areas suffer from salinization problems, water logging and sodicity (FAO, 2005). The majority of salt-affected soils in Egypt are located in the Northern central part

of the Nile Delta and on its Eastern and Western sides. About 900 000 ha suffer from salinization problems in cultivated irrigated areas, 6 % of Northern Delta region are salt-affected, 20 % of the Southern Delta and Middle Egyptian region and 25 % of the Upper Egypt region (FAO, 2003). Million hectares of arable land too saline for agriculture and hundreds of thousands hectares of agriculture productive land are lost annually for food production due to salinization (FAO, 2008). Salinity stress depresses plant growth and development at different physiological levels. The mechanism by which salt stress damage plants are still a discussing matter due to very complex nature of the salt stress in plants (zhu, 2001). Plants growing in saline soil come across generally with major drawbacks; the first is the increase in the osmotic stress due to high salt concentration of soil; the second is the increase in concentration in Na<sup>+</sup> and Cl<sup>-</sup>, exhibition tissue accumulation of Na<sup>+</sup> and Cl<sup>-</sup>, and inhibition of mineral nutrient uptake, Mesut *et al.* (2010).

Magnetite (Magnetite iron ore), Diatoms as a source of Silicon and some biofertilizer like (Azolla and Cyanobacteria) are the most important factors affecting plant growth, especially under salt conditions. Magnetite is a natural rock that has very high iron content, Magnetite has a black or brownish-red, and it has hardness about 6 on the Mohs hardness scale, it is one of two natural rocks in the world that is naturally magnetic (Mansour, 2007). Application of magnetic iron increased vegetative growth, yield and on pepper plant grow under saline irrigation conditions, Taha *et al.* (2011). Also, magnetic iron increased plant growth and leaf mineral content on cauliflower (Mansour, 2007) and on Roselle plants (*Hibiscus Sabdariffa*), Yasser *et al.* (2011). Moreover, some studies reported that, magnetic field had a positive effect on the number of flowers and total yield, Matsudo *et al.* (1993) on strawberry; Podlesny *et al.* (2005) on pea. In addition, application of a magnetic field to irrigation water was shown to increase plant nutrient content, Moon and Chung (2000).

Diatoms are the world's largest contributors to bio silicification and are one of the predominant contributors to global carbon fixation. Silicon is a major limiting nutrient for diatom growth and hence is a controlling factor in primary productivity, Veronique *et al.* (2000). The function of Si as a protective agent is one of the most important for plants. Improved Si nutrition has been shown to increase plant tolerance to a biotic stresses such as Al, Mn, heavy metal toxicities, salinity, frost and drought (Epstein, 1999). In this respect, grove studies conducted in Russia on citrus responses to Si fertilizers showed 30 to 80 % accelerated growth, 2-4 week earlier maturation of fruits, and increased fruit yield (Taranovskaia, 1939). Moreover, (Wutscher, 1989) reported that, citrus trees treated with Si absorbed more nutrients than the untreated trees. In plants growing under salt- stress conditions, added silicon helps in maintain an adequate supply of essential nutrient and reduce sodium uptake and its transport to shoots Tuna *et al.* (2008). Also, in experiments with salt- stressed barley, (Liang, 1999) indicated that, silicon ( $1 \text{ mmol dm}^{-3} \text{ K}_2\text{SiO}_3$ ) decreases sodium but increases potassium concentrations both in roots and shoots. In addition, Romero- Aranda *et al.* (2006) stated that, silicon evidently improves water status in tomato growing under salt- stress ( $80 \text{ mmol dm}^{-3} \text{ NaCl}$ ).

On the other hand, Cyanobacteria are a diverse group of prokaryotes possessing oxygen evolving photosynthetic system Prabina *et al.* (2004). Azolla is a free floating water fern that floats in the water and fixes atmospheric nitrogen because of its association with the nitrogen fixing cyanobacterium

Anabaena, Waseem *et al.* (2012). Several studies have indicated that, Azolla and cyanobacteria as biofertilizer could improve plant growth and yield under salinity conditions Sikander *et al.* (1995) and Aziz and Hashem, (2004). Also, the positive effect of Azolla on rice grain yield has also been reported from different countries, Kumarasinghe and Eskew, (1993). Moreover, inoculation of the cyanobacteria inoculums on rice in the saline soil resulted 80.48 % increase in yield over control.

The present study was therefore, undertaken to study the effects of application of Magnetite, Diatoms, and some bio fertilizer (Azolla and Cyanobacteria) on growth, yield and fruit quality of Valencia orange grown under saline soil conditions located at El Bustan County, Egypt.

## 2. Materials and Methods

Four years old trees of Olinda Valencia orange (*Citrus Sinensis*) budded on Volkamer lemon rootstock (*Citrus Volkameriana*) planted at 4x6m apart (175 trees/ feddan), (feddan = 4200 m<sup>2</sup>) and growing in soil influenced by salinity in a private orchard, belong to Mr. Ashraf hegazi located at El Bustan County, El Behera Governorate, Egypt were selected for two seasons (2010, 2011 and 2011, 2012). The experiment area was irrigated by drip irrigation system. Fifty six of 'Olinda Valencia orange' trees were used according to vigor and number of flowers for data collection. Different materials were used in the experiment as follow: 1) Magnetite (Magnetic iron ore), contained 48.8% Fe<sub>3</sub>O<sub>4</sub>, 17.3% Fe O, 26.7% Fe<sub>2</sub> O<sub>3</sub>, 2.6% MgO, 4.3% SiO<sub>2</sub> and 0.3% CaO, obtained from "El- Ahram company for mining and natural fertilizers" (ECMNF), Giza. Egypt. 2) Diatoms (the major constituent of diatom is amorphous silicon dioxide 93% SiO<sub>2</sub> and was obtained from "World Foundation Stimuli Trading", Cairo, Egypt. 3) biofertilizer consists of mixture of Azolla and cyanobacteria were obtained from the microbiology Department, Soil Water and Environment, Res. Inst., Agric Res., Center. Cyanobacteria strain (*Spirulina platensis*) was cultured in Zarrouk medium (Zarrouk, 1966) and incubated in a growth chamber under continuous illumination (2000 lux) and temperature of 32±2°C. (*Azolla pinnata*) was grown on modified Yoshida medium, Yoshida *et al.* (1976). After 30 days of incubation, the cultures were homogenized and blended with a mixer to have a homogenized suspension (Fig.1). Fresh *Azolla pinnata* was harvested from the culture medium and mixed well with distilled water (1:2 w/v) using an electric mixer till obtaining a homogeneous suspension.(Fig.2). However, the obtained suspensions for both Azolla and cyanobacteria were also mixed together and kept at 4°C till field applications as foliar spray.



(Fig. 1) Cyanobacteria (*Spirulina platensis*)



(Fig. 2) Azolla (*Azolla pinnata*)

A complete randomized block design with four replicates for each treatment was done. The experiment involved 14 treatments as follow:

- 1- Control (untreated)
- 2- Magnetite at 500gm.
- 3- Magnetite at 750gm.
- 4- Magnetite at 1000gm.
- 5- Diatoms at 5 ppm
- 6- Diatoms at 5 ppm + Magnetite at 500gm.
- 7- Diatoms at 5 ppm + Magnetite at 750gm.
- 8- Diatoms at 5 ppm + Magnetite at 1000gm.
- 9- Bio fertilizer at 300cm<sup>3</sup>
- 10- Biofertilizer at 300cm<sup>3</sup>+Magnetite at 500gm.
- 11- Biofertilizer at 300cm<sup>3</sup>+Magnetite at 750gm.
- 12- Biofertilizer at 300cm<sup>3</sup>+ Magnetite at 1000gm.
- 13- Diatoms at 3 ppm
- 14- Diatoms at 10 ppm

In mid- December of each season Magnetite rates were individually added in the soil at two trenches (100cm length x 20 cm width x 20cm depth) in the both side of the tree which was done at the end of the tree shadow and in the direction of irrigation furrows then immediately followed by drip irrigation. Biofertilizer (mixture of Azolla and cyanobacteria) was used at 300cm<sup>3</sup>/ tree and diluted with 3litres of tap water (50L/fed.plus550L tap water).Both Diatoms and bio fertilizer treatments were added in the soil and foliar sprayed at two times (full bloom stage and two weeks after full bloom). The following parameters of the studied treatments were carried out.

#### Tree canopy volume (m<sup>3</sup>).

Tree volume was calculated according to the following equation reported by Morse and Robertson, (1987).  $TV = 0.5236 \times HD^2$ , Where H = tree height, D = tree diameter.

#### Leaf area (cm<sup>2</sup>).

Forty mature leaves at different four sides of each tree were collected and average leaf area at the end of spring growth cycle (September) was calculated using the equation of (Chou, 1966). Leaf area =  $\frac{2}{3}$  length  $\times$  width.

#### Yield.

The number of fruits per tree was counted at the harvesting time (mid February). The yield per tree (kg) was determined and the theoretical yield (ton/ fed.) was calculated.

#### Fruit quality.

Ten fruits of Olinda Valencia orange were randomly taken from the yield in two seasons for each replicate and the following determinations were carried out:

Average of fruit weight (gm.) was determined. Fruit size (ml) was determined from the volume of water displaced by immersing the fruit sample in graduated jar filled with water and average volume was calculated. Fruit length, diameter and peel thickness (mm) in each individual fruit were measured by using a digital vernier caliper. Juice weight percentage was calculated and recorded. Fruit firmness was measured with Effegl, Pentrometer (11.1 mm diameter prop, Effegl, Alfonsing, Italy and expressed as Lb/inch<sup>2</sup>). Total soluble solids (T.S.S %) was determined by using Zeiss hand refractometer. Total acidity (%) was determined in fruit juice as percentage of anhydrous citric acid according to (A.O.A.C, 1995). Total soluble solids/acid ratio was calculated from the values of total soluble solids divided by values of total acids. Ascorbic acid (Vitamin C) was calculated as mg/100 ml juice according to (Horwitz, 1972).

#### Leaf mineral content.

Leaf samples were collected from the third or fourth leaf and were taken from the up side of shoot of each tree replicate representing spring cycle after cessation of the shoot growth in length. Forty leaves of five to seven-month-old from non-fruiting and non flushing shoots, were collected according to Jones and Embleton, (1960) to determine leaf content of N,P,K, Fe, Zn and Mn on leaf dry weight basis. Total nitrogen (%) was determined in 0.2 g of dried substance of the leaves using microkjeldahl method according to (Pregl, 1945). Phosphorus (%) was

determined calorimetrically using stannous chloride-sulfuric acid method according to Troug and Meyer, (1939). Potassium (%) was determined using the flame photometric method according to Brown and Lilliland, (1966). Iron, Manganese and Zinc were determined as ppm using atomic absorption according to (Carter, 1993).

#### Soil analysis.

Soil samples were taken three times (before starting the experiment in October 2010, at the end of the first season in December 2011 and at the end of the second season in December 2012. Soil biological activities, soil physical and chemical properties were measured. The CO<sub>2</sub> evolution was determined according to Gaur *et al.* (1971), total bacterial count was performed on nutrient agar using the spread plate

method (APHA, 1992) and total cyanobacterial counts were conducted by plating ten-fold serial soil suspension-dilutions in triplicate on to agarized BG11 medium, Allen and Stanier, (1968). Available nitrogen was determined according to (Black, 1982). Available phosphorus was determined spectrophotometrically as mentioned by Watanabe and Olsen, (1965). Available potassium was determined using flame-photometric method (APHA, 1992). Soil reaction (pH) was measured in 1: 2.5 soil water extract using glass electrode pH meter Model (955), and electric conductivity (EC) was measured in 1:5 soil water extract using glass electrode conductivity meter Model Jenway 4310. Table (1) shows Physical, chemical and biological analyses of the Soil.

**Table (1). Physical, chemical and biological analyses of the Soil before starting the experiment.**

Physical properties of soil (%)										
Corse sand	Fine sand	silt	Clay	Texture		OM	CaCO <sub>3</sub>			
73.85	4	6.50	15.65	Sandy loam		0.28	1.8			
Chemical properties of soil										
Cations meq / L						Anions meq / L				
pH 1:2.5	ECds/m	Ca <sup>++</sup>	Na <sup>+</sup>	Mg <sup>++</sup>	K <sup>+</sup>	CO <sub>3</sub> <sup>=</sup>	HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>=</sup>	SP (%)
8.82	3.64	10.6	9.50	15.69	0.61	-	7.40	23.00	6.00	28%
Available macro and micro nutrients (mg / kg) of soil										
N		P		K		Fe		zn		Mn
17.5		12.00		58.50		3.51		0.45		2.00
Biological analysis of soil										
Total count Bacteria cfu (10 <sup>6</sup> g soil <sup>-1</sup> )				Total count Cyano. cfu (10 <sup>3</sup> g soil <sup>-1</sup> )				CO <sub>2</sub> evolution (mg /100g soil <sup>-1</sup> day <sup>-1</sup> )		
3.00				6.00				10.00		

Where SP = Saturation percentage

#### Statistical analysis.

The experiment was designed in completely randomized block design with four replicates for each treatment and each replicate was represented by one tree. The obtained data of both seasons were subjected to analysis of variance according to Clark and Kempson, (1997) and the means were differentiated using Duncan multiple range test at 5% level (Duncan, 1955).

### 3. Results and Discussions

**Growth Criteria.** Results concerning the tree canopy volume (m<sup>3</sup>) and average leaf area (cm<sup>2</sup>) of Olinda Valencia orange trees as affected by Magnetite, Diatoms as a source of silicon (Si) and biofertilizer (mixture of cyanobacteria and Azolla) treatments are presented in Table (2). The obtained data showed that, all treatments increased tree canopy volume and leaf area in the second season in comparison with the first season. In more details and regarding the tree canopy volume, data indicated that, trees treated by Diatoms

at 5 ppm recorded the highest values (26.25 and 28.28 m<sup>3</sup>) followed by Diatoms at 5 ppm plus 1000 gm. Magnetite treatment (23.67 and 25.58 m<sup>3</sup>) and Diatoms at 10 ppm (23.60 and 25.55m<sup>3</sup>). While, the lowest significant values was in control treatment (19.31 and 21.64 m<sup>3</sup>) in the first and second seasons (2011 & 2012), respectively. On the other hand, the other treatments gave the intermediate values in this regard. As for leaf area, data in Table (2) showed that, all treatments increased leaf area as compared to control treatment. Also the changes of leaf area slightly fluctuated in both seasons, and no obvious trend could be detected.

Magnetic treatments may affect phytohormone production leading to improve cell activity and plant growth (Maheshwari, 2009). The present results were conforming to those of, Taha *et al.* (2011) they reported that, the application of Magnetic improved growth of pepper plant under salt condition.

**Table (2) Effect of Magnetite, Diatoms and bio fertilizer applications on tree volume and leaf area of Olinda Valencia orange trees.**

Treatments	Tree canopy volume(m <sup>3</sup> )		Leaf area(cm <sup>2</sup> )	
	2011	2012	2011	2012
Control	19.31 i	21.64 f	17.71 h	19.25 e
Magnetite at 500 gm.	21.79 ef	25.62 b	18.24 gh	21.84 d
Magnetite at 750 gm.	23.60 b	25.11 bc	20.24 bc	19.83 e
Magnetite at 1000 gm.	20.64 gh	22.51de	19.21 ef	21.71 d
Diatoms at 5ppm	26.25 a	28.28 a	22.57 a	21.70 d
Diatoms at 5ppm + 500 gm. Magnetite	22.00 e	23.62 bc	20.55 b	21.47 d
Diatoms at 5ppm + 750 gm. Magnetite	23.31 c	25.00 bc	17.94 h	23.01 c
Diatoms at 5ppm + 1000 gm. Magnetite	23.67 b	25.58 b	18.16 h	22.79 c
Bio fertilizer at 300cm <sup>3</sup>	20.48 h	21.87 ef	19.59 de	24.81 ab
Bio fertilizer + 500 gm. Magnetite	20.50 h	22.38 de	19.72 cd	24.14 b
Bio fertilizer + 750 gm. Magnetite	21.62 f	24.07 bc	19.26 ef	22.84 c
Bio fertilizer + 1000 gm. Magnetite	20.78 g	23.05 cd	19.17 ef	25.43 a
Diatoms at 3 ppm	22.93 d	24.55 bc	18.94 fg	24.80 ab
Diatoms at 10 ppm	23.60 b	25.55 b	20.36 bc	22.81 c

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

Where Bio fertilizer refer to mixture of: *Azolla pinnata* and cyanobacteria (*Spirulina platensis*).

Also, (De souza, 2005) indicated that, Magnetic treatments led to a remarkable increase in plant root and stem length as well as fresh dry weight during the nursery period of tomato plant. On the other hand, our results are in harmony with the results obtained by Vladimir *et al.* (2001) who found that, the application of pro- Silsilica slag as a source of Si to young Valencia orange trees significantly increased both the total tree height and the length of tree branches. Also, (Wutscher,1989) demonstrated in a laboratory experiment that optimization of Si nutrition for 1 year old and 2 year old orange trees increased fresh weight of shoots by 30, 40 % during a 6 months period. Moreover, Anser *et al.* (2012) stated that, silicon improves growth and dry matter production under salt stress conditions, its application also enhances the crop performance against a biotic stress.

On the other hand, Azolla and cyanobacteria as biofertilizer could improve plant growth under salinity conditions Aziz and Hashem (2004). In this context, (Adam, 1999) in Egypt studied the effect of cyanobacteria on seed germination and related processes of wheat, sorghum, maize and lentil. It was observed that growth parameters were significantly increased compared with control. These increases could be attributed to the amino acids and peptides produced in the algal filtrate and/or other compounds that stimulate growth of crop plants. Also, Nanjappan-Karthikeyanl *et al.* (2007) stated that, cyanobacteria have growth promoting activity as inoculants of wheat. This stimulation effect of blue green algal (BGA) on plant growth may be attributed to their influence on increasing the biological activity

(Table 10) and chemical properties of the tested soil (Tables 8 & 9).

**Yield.** Data in Table (3) showed that, all treatments increased fruit yield as compared with control treatment during two seasons. Also, it is noticed that, the application of biofertilizer plus 750 gm. Magnetite treatment was the best combination and was superior for achieving the highest total yield followed by Diatoms at 5 ppm plus 750 gm. Magnetite and 750gm. Magnetite alone, This increase of yield was about (51.44, 38.22 %), (39.93, 26.57 %) and (32.69, 23.51 %) during two seasons, respectively. Meanwhile, the other treatments gave the intermediate values in the first and second seasons.

These results are in the same line with the obtained by Taha *et al.* (2011) on *Capsicum Annuum* L. grown under saline irrigation conditions and they indicated that, the highest significant increase in yield appeared under the highest dose of Magnetite treatments (4g/pot). Moreover, (Mansour, 2007) revealed that, there were gradual increments in curd characters and yield of cauliflower plants with increasing the Magnetite levels, this increase might be attributed to stimulating effect of Magnetite on plant growth and the absorption of N, P, K, and Ca. Also, our results were in harmony with finding by Arab *et al.* (2011) who found that, in Iran the application of 600 kg Si ha<sup>-1</sup> and 4 liter cycocel ha<sup>-1</sup> increased total yield of rice. Moreover, (Bokhtiar, 2011) reported that, Si amendment increased yield in dry matter (26 to 70%) and in yield (30 to 66%) on sugarcane, the higher yields due to Si application were correlated with higher leaf Si concentrations (Epstein, 1994). On the other hand, Aziz and hashem,

(2004) reported that, inoculation, of the cyanobacterial inoculums in the saline soil resulted 80.48 % increase in yield over control. Also, Sikander *et al.* (1995) revealed that the application of Azolla in rice grown under Saline Soil increased crop yield.

### **Fruit quality.**

#### **1. Fruit physical properties.**

Data in Tables (4 & 5) showed that Diatoms spray at (3 or 10 ppm) treatments and biofertilizer plus Magnetite at different rates increased fruit dimensions (diameter and length) with low significant differences between them during two seasons. On the other hand, trees sprayed with Diatoms at (3 or 10 ppm) alone increased fruit size, while, the other treatments were in between in the first and second seasons.

As for Fruit peel quality represented by peel thickness, firmness, lightness and Peel hue angle which are very important characteristics especially when fruits tended to be exported. In general data in Tables (4 & 5) indicated that, all treatments increased peel fruit quality especially trees were treated by Diatoms (as a source of Si) either singly or in combination with Magnetite treatments, which increased peel thickness and firmness, also its fruits were more lightness and had good rind color, so it seems more attractive than the other fruits which treated by other treatments. Concerning juice volume, results showed that, Diatoms at (3 or 10 ppm) increased juice volume in the first season, while, the differences between all treatments were low to be significant with no obvious trend with them in the second season. As for Juice weight percentage, it is clear from Tables (4 & 5) that, the best results were obtained by the use of 3 or 10 ppm Diatoms (54.99 & 56.44 %), (56.59 & 55.67 %) and bio fertilizer plus 750 gm. Magnetite (51.19 & 58.11 %) treatments, While, the lower value resulted by using 1000 gm. Magnetite (40.68 & 50.66 %) in the first and second seasons, respectively. On the other hand, the changes of Juice weight percentage were slightly fluctuated during two seasons.

#### **2. Fruit chemical properties.**

It is noticed from Table (6) that, all treatments tended to increase fruit TSS/ Acid ratio and Vitamin C contents and to decrease fruit acidity as compared to control treatment. In more details and regarding fruit TSS percentage, the highest values were obtained by the use of 10 ppm Diatoms in the first season (10.17%) and trees treated by 10 ppm Diatom or 1000gm. Magnetite treatments (10.17 and 11.00%) in the second season. While, the minimum values were obtained by 5 ppm Diatoms (7.83%) in first season and 5 ppm Diatoms plus 500gm. Magnetite (9.33%) in the second season. Meanwhile, the

differences between the other treatments were in between during two seasons.

As for acidity % data in Table (6) revealed that, all treatments reduced acidity, whereas, the lowest values were obtained by 5ppm Diatoms plus 750 gm. Magnetite treatment (0.67 and 0.71 %) comparing control treatment which recorded the highest values (1.76 and 1.76%) in the first and second seasons, respectively. while the differences between other treatments didn't show any obvious trend during two seasons.

TSS/Acid ratio is an important characteristic for fruits exportation. The results indicated that, 5 ppm Diatoms plus 750 gm. Magnetite or 10 ppm Diatoms were the best treatments (14.26 & 13.15) and (14.36 & 14.36) followed by 5 ppm Diatoms plus 500gm. Magnetite (11.99 & 12.91). While, the minimum values were in control treatment (5.48 & 5.99) in the first and second seasons, respectively. Concerning the Vitamin C, it is clear that, all treatments increased V.C as compared with control treatment especially trees treated by Diatoms either singly or in combination with Magnetite treatments. Also, Diatoms at 5ppm plus 750gm. Magnetite was the best combination, and the changes of V.C were slightly fluctuated during two seasons.

Similar results were obtained by Ismail *et al.* (2010) who found that, the application of 71.5 gm. Magnetite/ tree on grapevine grown in a newly reclaimed area was more effective in achieving the best values of both length and diameter berry, gave low total acidity in juice and high ratio of TSS / acid ratio. Also, Taha *et al.* (2011) revealed that, treated pepper plants with Magnetite at (4 g/pot) progressive increases in V.C and capsaicin contents. On the other hand, from the previous results it could be noticed that, Diatoms could improved fruit peel thickness and firmness, whereas, Si is absorbed by plants as monosilicic acids or its anion forms (Youshida, 1975). Si is accumulated primarily in epidermal tissue both in roots and leaves as polymerized silica-gel and is associated with pectin and calcium ions Waterkeyn *et al.* (1982).The thickening epidermal silicon-cellulose layer supports mechanical stability of plants and can increase plant resistance against insects, diseases, salt and drought stresses (Epstein, 1999). Also, Diatoms could earlier the harvest date by increasing fruit TSS/ Acid ratio and Vitamin C contents and to decrease fruit acidity. These results were in the same line with finding by (Taranovskaia, 1939) who found that, Si fertilizers showed 30 to 80% accelerated growth, 2-4 week earlier maturation of fruit, and increased fruit yield. On the other hand, Amal *et al.* (2010) revealed that, the quality of seeds produced from common bean plants inoculated with

cyanobacteria is greatly enhanced significantly than control treatment.

#### Leaf mineral content.

As for leaf N content (%) results in Table (7) showed that, the differences between different treatments were low to be significant and the lowest value were obtained by control treatment for the two seasons. On the other hand, the results did not show any significant between all treatments for leaf P content (%). Concerning leaf K<sup>+</sup> concentration (%) it is clear from Table (7) that, salt stress (control treatment) considerably reduced the leaf K<sup>+</sup> concentration in both seasons in comparison with other treatments. The application of biofertilizer plus 750 gm. Magnetite was the best combination (1.06 and 1.05 %) compared to control treatment (0.84 and 0.99) for two seasons, respectively, followed by Diatoms treatments. On the other hand, the differences between the other treatments were slightly signification.

Concerning leaf Fe content (ppm) data showed that, all Magnetite treatments either singly or in combination with bio fertilizer or Diatoms increased leaf Fe (ppm), also the concentration of leaf Fe content increased in the second season as a result of application of Magnetite compared to the first season. However the differences between different treatments were high to be significant in both the experimental seasons (2011 and 2012). Regarding the concentration of leaf Zn content (ppm) it is clear that bio fertilizer treatment had the highest concentration (56.00, 47.00 ppm) compared to control treatment (19.00, 21.40 ppm) in the first and second season, respectively. While the other treatments gave the intermediate values during two seasons. Data also in Table (7) shows all treatments increased leaf Mn content (ppm) and didn't show any obvious trend between them. As for leaf silicon content (ppm) the results revealed that, leaves of Olinda Valencia orange trees treated by Diatoms treatments either singly or in combination with Magnetite treatments had higher concentration of Si especially trees treated by 10ppm Diatoms which recorded the highest significant values (1250 & 1316 ppm) as compared to control treatment (817.20 & 916 ppm) in the first and second seasons, respectively. Also, it could be noticed that, the second season was higher leaf Si content than the first season, this increase due to application of Diatoms as a source of Si, the obtained results are in general agreed with the finding of Weber and Batchelor (1948) they found that, in citrus leaves the content of Si ranged from 400 – 2000 ppm of the dry weight. As for leaves Na<sup>+</sup> content it is clear that, the uptake of Na<sup>+</sup> by control treatment was more pronounced (0.280 & 0.274%) as compared to other treatments, however, application of all treatments

significantly reduced uptake of Na<sup>+</sup> in leaves, and minimum concentration was observed in trees treated by biofertilizer plus 750 gm. Magnetite (0.162 & 0.158%) in the first and second season, respectively.

This result may be due to that Magnetic assisting to reduce the Na<sup>+</sup> toxicity at cell level by detoxification of Na<sup>+</sup>, either by restricting the entry of Na<sup>+</sup> at membrane level or by reduced absorption of Na<sup>+</sup> by plant roots (Maheshwari, 2009). Also, Diatoms as a source of silicon inhibited the Na<sup>+</sup> transportation to aerial parts of plants by its effect on transpiration movement, Yeo *et al.* (1999) or by making a complex with Na<sup>+</sup>, Ahmad *et al.* (1992). Moreover, Ma *et al.* (2001) stated that the alleviation of Na<sup>+</sup> toxicity in corn plant was due to the formation of Na<sup>+</sup> and Si complexes in the solution as compared to any other physiological impact of Si on the plant. Lower Na<sup>+</sup> is a good indicator of salt tolerance in plants. Increased K<sup>+</sup> concentration also shows the ability of trees to combat the salinity stress that will strongly depend upon Na<sup>+</sup> and Si content. The added diatoms increased the K<sup>+</sup> concentration than the trees under other treatments. Si uptake is positively correlated with K<sup>+</sup> and negatively with Na<sup>+</sup> uptake. Possibly, the K<sup>+</sup> transport was improved by Si application by its effect on the flux through K<sup>+</sup> ion transporters, Ali *et al.* (2009). In this respect (Wutscher, 1989) reported that, trees treated with Si absorbed more nutrients than the untreated trees. However he concluded that citrus is apparently not a Si accumulating plant and that the results indicated only limited role of this element in citrus nutrition. These results also were in the same line with those obtained by (Mansour, 2007) who reported that there were gradual increments in N,P,K and Fe concentrations in cauliflower leaves with increasing Magnetite levels. Similar results were obtained by Ismail *et al.* (2010) who found that, the highest concentrations of Fe in the leaves of Thompson Seedless were associated with trees grown in soil treated with Magnetite. On the other hand, (Grobbelaar, 1983) reported that, cyanobacteria can excrete other compounds and change the pH of their surroundings, which in turn can render adsorbed P available. In addition, cyanobacteria can store resources like P in excess of their immediate needs. In addition, (Waseem, *et al.*, 2012) indicated that, *Azolla* has great ability than rice to accumulate potassium in its tissues in low potassium environment; thus, after decomposition, it makes this nutrient available to rice, also, *Azolla* fixes nitrogen at substantial rates, optimize fertilizers use, especially nitrogen, and increase tolerance to soil salinity.

#### Soil analysis.

Soil analysis was shown from Tables (8&9) and it is evident from Table (8) that all treatments

increased soil N availability and Diatoms at 5ppm plus 750 gm. Magnetite was the best combination in the first season (25.20 ppm) while Magnetite at 750 gm. alone was the best treatment (25.20 ppm) in the second season, meanwhile, the lowest values were obtained by control treatment (10.08 and 10.90 ppm) during two seasons, respectively. The changes of available P were slightly fluctuated in the soil in both seasons and no obvious trend could be detected. Concerning K availability it is clear from Table (8)

that, the all treatments increased the soil K content. The use of 750gm. Magnetite plus 5 ppm Diatoms in the first season and plus biofertilizer in the second season gave the highest values (197.50 and 256.20 ppm) as compared to control treatment (119.70 and 207.32 ppm) during two seasons, respectively. Anyhow, the differences between the other treatments were high to be significant and no evident trend was observed through them.

**Table (3) Effect of Magnetite, Diatoms and bio fertilizer applications on yield (ton/fed.) of Olinda Valencia orange trees during 2011&2012 seasons.**

Treatments	Fruit weight(gm.)		Fruit NO./ tree		Yield kg/tree		Yield ton/fed.		Yield over control (%)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Control	211 bc	192 ab	367 d	700 g	77.4 i	134.4 h	13.55 h	23.52 g	-----	-----
Magnetite at 500 gm.	199 de	207 a	500 ab	717 fg	99.5 cd	148.4fg	17.41cd	25.97 ef	28.49	10.42
Magnetite at 750 gm.	195 e	181 c	527 a	917 b	102.8 bc	166 bc	17.98bc	29.05 bc	32.69	23.51
Magnetite at 1000 gm.	209 bc	185 bc	440 c	867 bc	92.0 ef	160.4 cd	16.09ef	28.07 c	18.75	19.35
Diatoms at 5ppm	208 cd	191 bc	450 bc	850 cd	93.6 ef	162.4 cd	16.38 ef	28.41 c	20.89	20.79
Diatoms at 5ppm + 500 gm. Magnetite	208 cd	187 bc	500 ab	767 ef	104.0 bc	143.4gh	18.20 bc	25.10 fg	34.32	6.72
Diatoms at 5ppm + 750 gm. Magnetite	197 de	189 bc	550 a	900 bc	108.4 ab	170.1 b	18.96 ab	29.77 b	39.93	26.57
Diatoms at 5ppm + 1000 gm. Magnetite	200 de	185 bc	417 cd	850 cd	83.4 hi	157.3cd	14.60gh	27.52 cd	7.75	17.01
Bio fertilizer at 300cm <sup>3</sup>	212 bc	187 bc	423 cd	750 ef	89.7 fg	140.3 h	15.69fg	24.54 fg	15.79	4.34
Bio fertilizer + 500 gm. Magnetite	223 ab	200ab	420 cd	783 e	93.7 ef	156.7de	16.39de	27.58cd	20.96	17.26
Bio fertilizer + 750 gm. Magnetite	220 ab	189 bc	533 a	983 a	117.3 a	185.8 a	20.52 a	32.51 a	51.44	38.22
Bio fertilizer +1000 gm. Magnetite	224 ab	188 bc	450 bc	850 cd	100.8bc	159.8cd	17.64 bc	27.97 cd	30.18	18.92
Diatoms at 3 ppm	231 a	192 ab	413 cd	857 c	95.4 cd	164.5bc	16.70 cd	28.80 bc	23.25	22.45
Diatoms at10 ppm	217ab	191 bc	400 cd	800 de	86.8gh	152.8 ef	15.19 fg	26.74 de	12.10	13.69

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different Where Bio fertilizer refer to ixture of: *Azolla pinnata* and cyanobacteria (*Spirulina platensis*).

**Table (4). Effect of Magnetite, Diatoms and bio fertilizer applications on fruit physical characteristics of Olinda Valencia orange trees in the first season.**

Treatments	Season, 2011								
	Fruit diameter (mm)	Fruit length (mm)	Fruit Size (cm <sup>3</sup> )	Peel thickness (mm)	Peel firmness	Peel lightness	Peel hue angle	Juice volume (mL <sup>3</sup> )	Juice weight (%)
Control	73.75bc	75.42 bc	252 e	3.72 e	14.61 f	65.76 e	67.67 d	96.7 fg	47.51 cd
Magnetite at 500 gm.	73.61bc	73.33cd	260 de	4.49 bc	17.52 cd	66.16 de	67.84 d	86.7 hi	43.33 ef
Magnetite at 750 gm.	72.21de	71.80 e	259 de	4.52 bc	16.92 de	66.81 bc	68.63 cd	100.0 ef	43.38 ef
Magnetite at 1000 gm.	73.02cd	74.86bc	279 bc	4.52 bc	16.35 e	66.52 cd	68.77 cd	102.7de	40.68 g
Diatoms at 5ppm	74.60 bc	72.70de	282 bc	4.66 b	18.85 ab	68.58 ab	70.32 ab	87.3 hi	42.28 fg
Diatoms at 5ppm + 500 gm. Magnetite	73.53bc	75.08bc	286 bc	4.71 b	19.10 ab	68.00 ab	70.80 ab	91.3 gh	45.05 de
Diatoms at 5ppm + 750 gm. Magnetite	71.79 ef	72.84de	289 b	5.13 a	19.33 ab	67.40 ab	70.90 ab	80.70 i	48.41 cd
Diatoms at 5ppm + 1000 gm. Magnetite	71.39 f	73.33cd	287 bc	5.31 a	20.16 a	67.28 ab	70.99 ab	80.70 i	48.61 cd
Bio fertilizer at 300cm <sup>3</sup>	74.26bc	76.70ab	255 e	4.65 b	17.23 de	68.96 ab	69.82 bc	101 ef	48.85 cd
Bio fertilizer + 500 gm. Magnetite	75.25 ab	78.30 a	261 de	4.20 cd	17.13de	68.08 ab	69.03 cd	107 cd	48.56 cd
Bio fertilitze + 750 gm. Magnetite	75.34ab	76.20ab	264 cd	4.57 bc	16.57 de	67.19 ab	69.05 cd	110 cd	51.19 ab
Bio fertilizer + 1000 gm. Magnetite	75.71 ab	77.94 a	285 bc	3.96 de	16.84 de	68.78 ab	69.59 bc	112 bc	51.11 bc
Diatoms at 3 ppm	76.96 a	77.94 a	317 a	5.24 a	17.95 bc	68.22 ab	69.59 bc	123 a	54.99 ab
Diatoms at10 ppm	74.79ab	78.22 a	323 a	5.12 a	17.89 bc	69.18 a	71.95 a	120 ab	56.44 a

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different. Where Biofertilizer refer to mixture of: *Azolla pinnata* and cyanobacteria (*Spirulina platensis*).



**Table (5). Effect of Magnetite, Diatoms and bio fertilizer applications on fruit physical characteristics of Olinda Valencia orange trees in the second season.**

Season, 2012									
Treatments	Fruit diameter (mm)	Fruit length (mm)	Fruit Size (cm <sup>3</sup> )	Peel thickness (mm)	Peel firmness	Peel lightness	Peel hue angle	Juice volume (mL <sup>3</sup> )	Juice weight (%)
Control	70.06 bc	70.08 b	257 b	3.91 b	17.83 c	63.61 f	65.40 g	94.7 b	52.75 cd
Magnetite at 500 gm.	69.99 bc	70.92 b	257 bc	4.17 ab	18.45 ab	64.59 de	67.54 bc	104.0 a	56.13 ab
Magnetite at 750 gm.	68.19 c	70.80 b	243 d	3.96 ab	20.58 ab	64.36 ef	65.50 g	98.7 ab	51.57 de
Magnetite at 1000 gm.	69.82 bc	71.10 b	251 bc	4.16 ab	20.06 ab	64.23 ef	66.12 fg	93.3 b	50.66 e
Diatoms at 5ppm	70.13 bc	71.13 b	257 bc	4.20 ab	18.65 ab	67.09 ab	68.99 ab	96.7 ab	51.97 de
Diatoms at 5ppm + 500 gm. Magnetite	69.70 bc	69.51 b	253 bc	4.49 a	20.90 a	66.00 ab	68.13 ab	95.3 ab	51.42 de
Diatoms at 5ppm + 750 gm. Magnetite	69.37 bc	71.05 b	257 bc	4.36 ab	19.06 ab	66.58 ab	68.31 ab	97.3 ab	53.52 bc
Diatoms at 5ppm + 1000 gm. Magnetite	69.52 bc	70.85 b	247 cd	4.08 ab	18.41 ab	65.99 ab	68.47 ab	94.0 b	54.14 bc
Bio fertilizer at 300cm	70.24 bc	71.87 ab	255 bc	3.92 b	18.14 bc	65.14 bc	66.56 ef	96.0 ab	53.51 bc
Bio fertilizer + 500 gm. Magnetite	71.28 ab	71.26 ab	260 ab	4.09 ab	19.22 ab	65.16 bc	66.68 de	104.0 a	53.00 cd
Bio fertilizer + 750 gm. Magnetite	70.45 ab	71.57 ab	253 bc	4.14 ab	18.40 ab	64.96 cd	66.94 cd	94.0 b	58.11 a
Bio fertilizer + 1000 gm. Magnetite	70.41 ab	71.36 ab	258 b	3.95 ab	18.85 ab	67.14 ab	68.24 ab	97.3 ab	54.61 bc
Diatoms at 3 ppm	71.06 ab	72.15 ab	261 ab	4.50 a	19.49 ab	66.70 ab	66.35 fg	96.7 ab	56.59 ab
Diatoms at 10 ppm	73.14 a	73.99 a	268 a	4.10 ab	19.40 ab	67.25 a	69.35 a	100.0 ab	55.67 ab

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different. Where Biofertilizer refer to mixture of: *Azolla pinnata* and cyanobacteria (*Spirulina platensis*).

**Table (6) Effect of Magnetite, Diatoms and bio fertilizer applications on fruit chemical characteristics of Olinda Valencia orange trees during two seasons.**

Treatments	T.S.S. (%)		Acidity (%)		T.S.S./Acid Ratio		V.C (mg./100juice)	
	2011	2012	2011	2012	2011	2012	2011	2012
Control	9.58 ab	10.50 ab	1.76 a	1.76 a	5.48 i	5.99 i	35.83 f	40.17 e
Magnetite at 500 gm.	8.67 ef	9.67 de	1.31 b	1.08 bc	6.93 hi	7.91 h	36.83 ef	40.67 e
Magnetite at 750 gm.	8.83 de	10.67ab	1.18 bc	1.14 b	8.10 gh	10.01 fg	37.50 ef	45.33 bc
Magnetite at 1000 gm.	9.00 cd	11.00 a	1.07 bc	1.08 bc	9.40 ef	10.83 ef	40.50 bc	45.67 bc
Diatoms at 5ppm	7.83 g	10.33ab	0.74 fg	0.84 de	10.78 cd	12.46 bc	42.33 ab	45.50 bc
Diatoms at 5ppm + 500 gm. Magnetite	8.67 ef	9.33 e	0.77 ef	0.76 ef	11.99 bc	12.91 b	41.50 b	45.17 bc
Diatoms at 5ppm + 750 gm. Magnetite	9.42 ab	10.00 bc	0.67 g	0.71 f	14.26 a	14.36 a	44.50 a	50.50 a
Diatoms at 5ppm + 1000 gm. Magnetite	8.58 fg	9.83 cd	0.84 de	0.94 bc	10.80 cd	11.03 de	42.00 b	45.50 bc
Bio fertilizer at 300cm <sup>3</sup>	9.58 ab	10.50 ab	1.07 bc	1.10 b	9.01 fg	9.56 g	40.17 bc	43.33 cd
Bio fertilizer + 500 gm. Magnetite	9.67 ab	10.33 ab	0.85 de	0.87cd	11.37 cd	12.02 bc	38.17 de	42.17 de
Bio fertilizer + 750 gm. Magnetite	10.0 ab	10.07 bc	0.96 cd	0.98bc	11.45 cd	10.88 ef	41.17 b	45.33 bc
Bio fertilizer + 1000 gm. Magnetite	9.50 ab	10.67 ab	0.99 cd	1.02 bc	10.14 de	10.54 ef	38.67 cd	44.17 cd
Diatoms at 3 ppm	9.25 bc	10.00 bc	0.89 de	0.87 cd	10.41 cd	11.49 cd	41.50 b	44.50 bc
Diatoms at 10 ppm	10.17 a	10.83 a	0.84 de	0.80 de	13.15 ab	14.36 a	41.67 b	47.67 ab

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different. Where Biofertilizer refer to mixture of: *Azolla pinnata* and cyanobacteria (*Spirulina platensis*).

As for soil Fe availability it could be noticed that, most of Magnetite treatments either singly or in combination with either Diatoms or biofertilizer increased the soil Fe availability content, while, the lowest results were obtained by control treatment in the first season, biofertilizer and control treatments in the second season. Also, it is noticed that, Soil Fe availability content in the second season scored higher values than the first season as a result of application of Magnetite. Regarding Zn and Mn availability in the soil data in Table (8) indicated that, trees treated by combination with 750 gm. Magnetite plus bio fertilizer recorded the highest averages followed by 750 gm. Magnetite plus Diatoms while the other treatments gave the intermediate values,

data also revealed that, the differences between the other treatments were high to be significant during two seasons.

Concerning soil electric conductivity (EC) data in Table (9) showed a slight reduction of soil EC in the first and second seasons. The least values resulted from the use of 1000 gm. Magnetite (3.19 and 3.18) where the highest values were recorded from control treatment (3.62 and 3.60) during two seasons, respectively. As for soil pH it is noticed that, all treatments slight reduction of soil pH and no obvious trend was observed during two seasons. Also, the Magnetite, Diatoms and biofertilizer applications increased K<sup>+</sup> and reduced Na<sup>+</sup>, Cl<sup>-</sup> in the root rhizosphere as compared with control treatment (salt

stress) and the use of biofertilizer plus 750gm. Magnetite was the best combination. The obtained results are in general agreed with the finding of (Maheshwari, 2009) who reported that, Magnetic application assisting to reduce the Na<sup>+</sup> toxicity at cell level by detoxification of Na<sup>+</sup>, either by restricting the entry of Na<sup>+</sup> at membrane level or by reduced absorption of Na<sup>+</sup> by plant roots.

Also, these results are supported by Liang *et al.* (2005) who reported that, the Silicon amended stimulation of H<sup>+</sup>-ATPase activity on root plasma membrane and H<sup>+</sup>-PPase activity in tonoplast of barley roots under salt stress enhanced the compartmentation of Na<sup>+</sup> into the vacuole through Na<sup>+</sup>/H<sup>+</sup> antiport movement. The stimulated H<sup>+</sup>-ATPase enhanced the uptake and upward transport of K<sup>+</sup> and retarded the movement of Na<sup>+</sup> thus, improved the K<sup>+</sup>: Na selectivity ratio in the shoots of salt-stressed barley. As Na<sup>+</sup>/H<sup>+</sup> antiport is operated with input of energy, thus, both the H<sup>+</sup>-ATPase and H<sup>+</sup>-PPase are the chief sources of H<sup>+</sup> electrochemical potential gradient, which acts as an Electromotive

Force (EMF) for such energy dependent antiports (Blumwald, 2000). In this respect, Si soil amendments influence plant growth by soil treatment with biogeochemical active Si substances optimizes soil fertility through improved water, physical and chemical soil properties while maintaining nutrients in plant available form, Matichenkov *et al.* (1995). In addition, the extracellular polysaccharide production by offers some temporary relief by chelating exchangeable cations in soil and thereby decreases the soil EC, Most of Na<sup>+</sup> removed by CB remains extracellularly trapped in their mucopolusaccharide sheaths, Apte and Thomas,(1997).

Moreover, Azolla cultivation in saline environment for a period of two consecutive years decreased salt content from 0.35-0.15 and desalinate rate (71.4%) was 1.8 times faster than through water leaching and 2.1 times faster than *Sesbania* and also reduced the electrical conductivity, pH of acidic soil and increased calcium content of soil, Anjuli *et al.* (2004).

**Table (7). Effect of Magnetite, Diatoms and bio fertilizer applications on Leaf mineral content of Olinda Valencia orange trees in the first and second seasons.**

Treatments	(%)				Ppm			
	N	P	K	Na	Fe	Zn	Mn	Si
	<b>Season, 2011</b>							
Control	2.21 c	0.10 a	0.84 d	0.280 a	72.0 i	19.00g	26.40i	871.20g
Fe at 500 gm.	2.39 ab	0.12 a	1.03 ab	0.213bc	80 gh	32.80f	38.80b	893.0ef
Fe at 750 gm.	2.41 ab	0.13 a	1.01 ab	0.184de	83.0 f	48.20b	40.53a	897.00e
Fe at 1000 gm.	2.40 ab	0.12 a	1.03 ab	0.235ab	100 b	49.20b	38.2bc	900.60e
Diatoms at 5ppm	2.40 ab	0.12 a	1.05 a	0.230ab	79.0 h	38.94d	36.8cd	1081.0b
Diatoms at5ppm + 500 gm. Magnetite	2.42 ab	0.12 a	1.03 ab	0.193de	83.0 f	35.40e	38.4bc	1083.0b
Diatoms at5ppm + 750 gm. Magnetite	2.44 a	0.14 a	1.04 a	0.176ef	98.0 b	34.6ef	36.2de	1087.8b
Diatoms at5ppm + 1000 gm. Magnetite	2.43 ab	0.12 a	1.03 ab	0.260ab	105 a	34.0ef	28.50h	1090.0b
Bio fertilizer at 300cm <sup>3</sup>	2.44 a	0.12 a	0.93 c	0.252ab	87.0e	56.00a	33.8fg	876.9fg
Bio fertilizer + 500 gm. Magnetite	2.41 ab	0.12 a	0.93 c	0.234ab	90.0d	32.80f	38.80b	883.5ef
Bio fertilizer + 750 gm. Magnetite	2.44 a	0.14 a	1.06 a	0.162f	94.0 c	48.20b	34.40f	874.95g
Bio fertilizer + 1000 gm. Magnetite	2.39 ab	0.13 a	0.98 bc	0.204cd	103 a	49.00b	32.20g	919.00d
Diatoms at 3 ppm	2.39 ab	0.12 a	1.02 ab	0.221bc	82 fg	35.40e	27.1hi	1014.6c
Diatoms at10 ppm	2.38 b	0.12 a	1.02 ab	0.261ab	89 de	44.60c	34.8ef	1250.0a
	<b>Season, 2012</b>							
Control	2.28 e	0.11 a	0.99 b	0.274a	69.0 i	21.40g	26.70h	916.00h
Fe at 500 gm.	2.29 e	0.12 a	1.02 ab	0.203bc	87.0 f	23.60f	46.20a	940.0fg
Fe at 750 gm.	2.40 bc	0.13 a	1.02 ab	0.173de	90.0 e	40.01b	40.40c	945.0fg
Fe at 1000 gm.	2.41 ab	0.14 a	1.01 ab	0.221ab	103 c	41.66b	32.20e	948.0ef
Diatoms at 5ppm	2.39 cd	0.16 a	1.03 ab	0.234ab	75.0 h	40.89b	30.20f	1138.0b
Diatoms at5ppm + 500 gm. Magnetite	2.44 ab	0.14 a	1.04 ab	0.184cd	90.0 e	37.17c	35.40d	1140.0b
Diatoms at5ppm + 750 gm. Magnetite	2.46 a	0.16 a	1.01 ab	0.163ef	102 c	36.3cd	33.40e	1145.0b
Diatoms at5ppm + 1000 gm. Magnetite	2.39 cd	0.13 a	1.01 ab	0.253ab	109 b	35.0de	27.6gh	1148.0b
Bio fertilizer at 300cm <sup>3</sup>	2.41 ab	0.12 a	1.03 ab	0.242ab	85.0 f	47.00a	35.80d	923.0gh
Bio fertilizer + 500 gm. Magnetite	2.43 ab	0.13 a	1.02 ab	0.223ab	96.0 d	33.6ef	44.20b	930.0fg
Bio fertilizer + 750 gm. Magnetite	2.45 ab	0.15 a	1.05 a	0.158f	111 b	41.51b	35.40d	921.00d
Bio fertilizer + 1000 gm. Magnetite	2.38 d	0.14 a	1.02 ab	0.202bc	119 a	41.20b	29.0fg	1000.0e
Diatoms at 3 ppm	2.40bc	0.14 a	1.01 ab	0.214bc	79.0 g	37.17c	28.3fg	1068.0c
Diatoms at10 ppm	2.39cd	0.13 a	1.03 ab	0.252ab	85.0 f	46.83a	36.20d	1316.0a

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

Where Biofertilizer refer to mixture of: *Azolla pinnata* and cyanobacteria (*Spirulina platensis*).

**Table (8). Effect of Magnetite, Diatoms and bio fertilizer applications on available of macro and micro elements at the end of the first and second seasons.**

Treatments	Available (ppm)					
	N	P	K	Fe	Zn	Mn
<b>Season, 2011</b>						
Control	10.08 f	22.0 d	119.70 h	3.76 f	1.04 h	1.19 i
Fe at 500 gm.	18.90 c	26.0 b	148.00 g	5.41 de	1.28 f	1.79 d
Fe at 750 gm.	18.90 c	28.0 a	179.7 cd	7.77 ab	1.88 bc	1.96 c
Fe at 1000 gm.	12.60 e	28.0 a	151.15 f	7.58 ab	1.85 cd	1.45 g
Diatoms at 5ppm	19.65 b	22.0 d	158.50 e	5.83 de	1.84 cd	1.96 c
Diatoms at 5ppm + 500 gm. Magnetite	18.90 c	24.0 c	178.00 d	5.48 de	1.20 g	1.61 f
Diatoms at 5ppm + 750 gm. Magnetite	25.20 a	28.0 a	197.50 a	7.48 ab	1.93 b	2.06 b
Diatoms at 5ppm + 1000 gm. Magnetite	18.90 c	26.0 b	181.15 c	7.90 a	1.23 fg	1.77 de
Bio fertilizer at 300cm <sup>3</sup>	18.90 c	24.0 c	120.43 h	5.72 de	1.78 de	1.30 h
Bio fertilizer + 500 gm. Magnetite	12.60 e	26.0 b	151.15 f	6.91 bc	1.72 e	1.98 c
Bio fertilizer + 750 gm. Magnetite	18.90 c	28.0 a	188.00 b	8.32 a	2.10 a	2.40 a
Bio fertilizer + 1000 gm. Magnetite	16.75 d	22.0 d	161.15 e	7.60 ab	1.26 fg	1.99 bc
Diatoms at 3 ppm	18.90 c	22.0 d	178.00 d	5.28 e	1.24 fg	1.84 d
Diatoms at 10 ppm	18.90 c	28.0 a	177.50 d	6.16 cd	1.29 f	1.71 e
<b>Season, 2012</b>						
Control	10.90 e	22.0 d	207.32 j	5.78 g	1.64 bc	1.58 f
Fe at 500 gm.	18.90 c	28.0 a	220.25 g	7.20 e	1.36 fg	2.24 cd
Fe at 750 gm.	25.20 a	26.0 b	240.76 c	8.92 b	1.64 bc	2.62 b
Fe at 1000 gm.	12.60 d	22.0 d	230.25 e	10.36 a	1.40 ef	2.56 b
Diatoms at 5ppm	22.05 b	22.0 d	217.32 h	8.04 cd	1.24 fg	1.99 e
Diatoms at 5ppm + 500 gm. Magnetite	22.05 b	24.0 c	238.43 c	8.48 bc	1.26 fg	2.10 de
Diatoms at 5ppm + 750 gm. Magnetite	18.90 c	26.0 b	246.65 b	9.92 a	1.82 b	2.70 ab
Diatoms at 5ppm + 1000 gm. Magnetite	18.57 c	24.0 c	210.25 i	9.92 a	1.22 g	2.30 c
Bio fertilizer at 300cm <sup>3</sup>	18.57 c	22.0 d	212.50 i	5.56 g	1.22 g	2.60 b
Bio fertilizer + 500 gm. Magnetite	22.05 b	24.0 c	233.87 d	6.52 f	1.42 de	2.32 c
Bio fertilizer + 750 gm. Magnetite	22.05 b	26.0 b	256.20 a	9.76 a	2.08 a	2.82 a
Bio fertilizer + 1000 gm. Magnetite	18.90 c	24.0 c	233.0 de	8.80 b	1.68 bc	2.24 cd
Diatoms at 3 ppm	12.60 d	20.0 e	226.20 f	8.32 bc	1.58 cd	2.30 c
Diatoms at 10 ppm	12.60 d	22.0 d	212.00 i	7.84 d	1.60 cd	2.00 e

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different. Where Biofertilizer refer to mixture of: *Azolla pinnata* and cyanobacteria (*Spirulina platensis*).

### Biological activity of the soil.

Changes in root rhizosphere could give an approximate vision to the ability of different applications to enhance crop production, especially under salt conditions. However, all treatments affected significantly biological activity of the soil, Table (10) in terms of increasing the total bacterial counts, total cyanobacterial counts and CO<sub>2</sub> evolution compared to control treatment in the two seasons. The maximum microbial activity was achieved by the combined effect of biofertilizer with 750 gm. Magnetite application followed by Diatoms at 5ppm with 750 gm. Magnetite. While, the changes of biological activity in root rhizosphere were greatly fluctuated among the other treatments, with no obvious trend could be observed during two seasons (2011&2012). Also, it could be noticed that, the high doses of Magnetite (1000gm.) applications either singly or in combination with Diatoms or biofertilizer decreased the growth and yield and therefore decreased microbial activity. This results are in

harmony with those obtained by Josep *et al.* (2004) who reported that, root growth inhibition by the high forces of magnetic field on (*Lens culinaris*), (*Glycine soja*) and (*Triticum aestivum*) and therefore a significant effect on the microbial activity. Moreover, the application of both *Azolla* and cyanobacteria enhanced the soil microbial activity. The obtained results are in line with those found by Waseem *et al.* (2012) they observed that. The biological health of the soil due to application of *Azolla* has resulted in improving mineralization and consequent increase microbial status of the soil. Also, cyanobacteria promoted establishment of microbial population, increased organic matter and nutrient content and also soil stability Acea *et al.* (2003). The enhancement influence of blue green algal (BGA) on the biological activity and chemical properties of the soil positively affected plant characteristics which led to improve in yield and fruit quality of Olinda Valencia orange trees.

**Table (9). Effect of Magnetite, Diatoms and bio fertilizer applications on soil chemical analysis at the end of the first and second seasons.**

Treatments	pH	EC	Cations meq / L				Anions meq / L			
	1: 2.5	ds/m	Ca <sup>++</sup>	Mg <sup>++</sup>	Na <sup>+</sup>	K <sup>+</sup>	Co <sub>3</sub> <sup>-</sup>	Hco <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	So <sub>4</sub> <sup>-</sup>
	Season, 2011									
Control	8.81	3.62	10.61	15.01	9.95	0.63	-	7.27	23.07	5.86
Fe at 500 gm.	8.79	3.33	11.24	13.23	7.85	0.98	-	3.86	20.95	8.49
Fe at 750 gm.	8.80	3.36	21.37	3.31	7.31	1.61	-	5.63	17.58	10.39
Fe at 1000 gm.	8.82	3.19	14.93	7.76	7.69	1.52	-	4.36	21.25	6.29
Diatoms at 5ppm	8.79	3.48	7.58	19.31	6.34	1.57	-	5.15	19.49	10.16
Diatoms at 5ppm + 500 gm. Magnetite	8.78	3.41	18.18	7.89	6.69	1.34	-	6.21	20.20	7.69
Diatoms at 5ppm + 750 gm. Magnetite	8.79	3.46	9.64	16.89	6.30	1.77	-	6.34	16.68	11.58
Diatoms at 5ppm + 1000 gm. Magnetite	8.80	3.63	10.29	17.64	6.91	1.46	-	4.56	20.47	11.27
Bio fertilizer at 300cm <sup>3</sup>	8.82	3.40	21.23	3.32	7.78	1.67	-	7.44	20.11	6.45
Bio fertilizer + 500 gm. Magnetite	8.81	3.60	17.10	10.11	7.26	1.53	-	7.47	19.26	9.27
Bio fertilizer + 750 gm. Magnetite	8.80	3.30	11.20	14.16	5.66	1.98	-	4.47	15.80	12.73
Bio fertilizer + 1000 gm. Magnetite	8.78	3.26	10.97	12.87	7.64	1.12	-	3.48	18.81	10.31
Diatoms at 3 ppm	8.80	3.56	14.50	12.79	7.28	1.03	-	5.73	18.86	11.01
Diatoms at 10 ppm	8.79	3.41	9.13	16.26	7.21	1.50	-	6.97	20.32	6.81
	Season, 2012									
Control	8.83	3.60	9.37	16.11	9.77	0.75	-	5.27	26.87	3.86
Fe at 500 gm.	8.82	3.45	11.66	13.78	7.50	1.56	-	4.86	20.00	9.64
Fe at 750 gm.	8.80	3.40	10.90	14.37	7.07	1.66	-	5.60	18.39	10.01
Fe at 1000 gm.	8.76	3.18	12.56	10.23	7.51	1.50	-	4.62	22.00	5.18
Diatoms at 5ppm	8.80	3.45	7.55	18.31	7.07	1.57	-	5.05	12.45	17.0
Diatoms at 5ppm + 500 gm. Magnetite	8.79	3.50	18.48	7.59	7.19	1.74	-	6.96	15.14	12.90
Diatoms at 5ppm + 750 gm. Magnetite	8.81	3.52	10.29	16.75	6.39	1.77	-	6.40	17.50	11.30
Diatoms at 5ppm + 1000 gm. Magnetite	8.84	3.25	10.90	13.04	7.10	1.46	-	3.06	18.87	10.57
Bio fertilizer at 300cm <sup>3</sup>	8.80	3.34	11.43	12.52	7.75	1.70	-	7.24	20.91	5.25
Bio fertilizer + 500 gm. Magnetite	8.84	3.48	18.60	7.15	7.52	1.53	-	8.17	16.29	10.34
Bio fertilizer + 750 gm. Magnetite	8.83	3.46	12.00	15.76	5.26	1.58	-	8.77	15.20	10.63
Bio fertilizer + 1000 gm. Magnetite	8.82	3.52	15.67	10.57	7.34	1.62	-	4.38	11.71	19.11
Diatoms at 3 ppm	8.81	3.56	11.70	14.59	7.78	1.53	-	6.93	18.56	10.11
Diatoms at 10 ppm	8.83	3.47	12.40	13.47	7.33	1.50	-	8.54	19.13	7.03

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different. Where Biofertilizer refer to mixture of: *Azolla pinnata* and cyanobacteria (*Spirulina platensis*).

**Table (10). Effect of Magnetite, Diatoms and bio fertilizer applications on soil biological activity at the end of the first and second seasons (2011&2012).**

Treatments	Total count Bacteria cfu (10 <sup>6</sup> g soil <sup>-1</sup> )		Total count Cyano. cfu (10 <sup>3</sup> g soil <sup>-1</sup> )		CO <sub>2</sub> evolution (mg /100g soil <sup>-1</sup> day <sup>-1</sup> )	
	2011	2012	2011	2012	2011	2012
	Control	3.73 j	13.0 L	8.33 j	7.00 j	13.00 i
Fe at 500 gm.	11.0 h	22.7 k	8.33 j	7.70 j	21.3 g	37 cd
Fe at 750 gm.	39.0 c	115 h	25.0 c	15.7 g	35.0 c	36.7 e
Fe at 1000 gm.	16.0 f	111 h	12.0 h	11.7 h	25.0 f	38.3bc
Diatoms at 5ppm	7.33 i	52.0 i	7.67 j	9.70 i	18.0 h	38.0 bc
Diatoms at 5ppm + 500 gm. Magnetite	23.0 d	203 d	14.7 g	36.5 c	33.0 d	37.0 de
Diatoms at 5ppm + 750 gm. Magnetite	49.7 b	260 b	31.0 b	38.7 b	36.7 b	39.0 b
Diatoms at 5ppm + 1000 gm. Magnetite	14.0 g	34.0 j	10.7 i	13.0 h	26.0 f	37.0 de
Bio fertilizer at 300cm <sup>3</sup>	19.0 e	185ef	21.7 d	25.7 d	34.0 cd	33.7 f
Bio fertilizer + 500 gm. Magnetite	23.0 d	225 c	20.0 e	23.7 e	18.0 h	26.3 h
Bio fertilizer + 750 gm. Magnetite	54.0 a	285 a	59.0 a	62.7 a	38.0a	41.8 a
Bio fertilizer + 1000 gm. Magnetite	20.0 e	188 e	19.7 e	20.0 f	21.0 g	25.7 h
Diatoms at 3 ppm	20.0 e	181 f	20.0 e	23.0 e	30.3 e	32.7 f
Diatoms at 10 ppm	13.7 g	137 g	18.0 f	20.0 f	26.0 f	30.7 g

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different. Where Biofertilizer refer to mixture of: *Azolla pinnata* and cyanobacteria (*Spirulina platensis*).

**Table (11). Economic study for using Magnetite, Diatoms and bio fertilizer applications on yield of Olinda Valencia orange trees.**

Treatments	Total Q.of eachTrea./ fed.	Unit Price (L.E)	Cost of each Trea./fed. (L.E)	NO. Labor/ year	Labor & S.M. fees (L.E)	Labor & S.M. Cost (L.E)	Total cost trea./fed. (L.E)	Average yield for Two seas. Ton/fed.	yield over control Ton/fed.	yield over control Price (L.E)	Net Profit/ Fed. (L.E)
control	.....	.....	.....	.....	.....	.....	.....	18.54	.....	.....	.....
Magnetite at 500 gm.	87.5 kg	5	437.5	2	50	100	537.5	21.69	3.15	3150	2612.5
Magnetite at 750 gm.	131.25kg	5	656.25	2	50	100	756.25	23.52	4.98	4098	3341.75
Magnetite at 1000 gm.	175 kg	5	875	2	50	100	975	22.08	3.54	3054	2079
Diatoms at 5ppm	3 kg	100 x 2time	600	(2+S.M.) x 2time	50,50	300	900	22.40	3.86	3086	2186
Diatoms at 5ppm + 500 gm. Magnetite	3 kg 87.5 kg	100 x 2time 5	1037.5	(2+S.M.) x 2time 2	50,50 50	400	1437.5	21.65	3.11	3011	1573.5
Diatoms at 5ppm + 750 gm. Magnetite	3 kg 131.25kg	100 x 2time 5	1256.25	(2+S.M.) x 2time 2	50,50 50	400	1656.25	24.37	5.83	5083	3426.75
Diatoms at 5ppm + 1000 gm. Magnetite	3 kg 175 kg	100 x 2time 5	1475	(2+S.M.) x 2time 2	50,50 50	400	1875	21.06	2.52	2052	177
Bio fertilizer at 300cm <sup>3</sup>	50 Liter	15 x 2time	1500	(2+S.M.) x 2time	50,50	300	1800	20.12	1.58	1058	-742
Bio fertilizer + 500 gm. Magnetite	50 Liter 87.5 kg	15x 2time 5	1937.5	(2+S.M.) x 2time 2	50,50 50	400	2337.5	21.99	3.45	3045	707.5
Bio fertilizer + 750 gm. Magnetite	50 Liter 131.25kg	15x 2time 5	2156.25	(2+S.M.) x 2time 2	50,50 50	400	2556.25	26.52	7.98	7098	4541.75
Bio fertilizer + 1000 gm. Magnetite	50 Liter 175 kg	15x 2time 5	2375	(2+S.M.) x 2time 2	50,50 50	400	2775	22.81	4.27	4027	1252
Diatoms at 3 ppm	1800 gm..	100 x2time	360	(2+S.M.) x 2time	50,50	300	660	22.75	4.21	4021	3361
Diatoms at10 ppm	6 kg	100x2time	1200	(2+S.M.) x 2time	50,50	300	1500	20.97	2.43	2043	543

Where: (S.M.) refers to Spraying Motor., two times refer to (full bloom stage and two weeks after full bloom)

### Economic study.

In economic study of yield production the main economic criteria were cost of each substance (Magnetite, Diatoms and biofertilizer) that used under study(L.E / fed.), cost of labor and spraying motor (L.E / fed.), averages yield (ton / fed) for two seasons (2011 & 2012), price of yield over control (L.E) and net profit (L.E / fed.) for each treatment. Results are given in Table (11). Other expenses such as the costs of supervision and royalties were not taken into consideration in this study.

In more details unite price of Magnetite was (5 L.E / k.gm.), Diatoms was (100 L.E / k.gm.) and unite price of biofertilizer was (15 L.E / Liter) taking into account of both Diatoms and biofertilizer were sprayed at two times under study. The study also revealed that the cost of labor that were used per treatment as well as the spraying motor and thus the total costs were calculated. Also averages yield (ton / fed.) for the first and second seasons and yield over control were calculated and finally the net profit (L.E / fed.) for yield over control was determine.

From this economic study it could be noticed that, application of bio fertilizer plus 750 gm. Magnetite was the best combination for giving the highest net profit / fed. (4541.75 L.E) followed in descending order by using of Diatoms at 5 ppm plus 750 gm. Magnetite (3426.75 L.E), Diatoms at 3 ppm, (3361 L.E),750 gm. Magnetite (3341.75 L.E), 500 gm. Magnetite (2168 L.E), 1000gm. Magnetite (2079 L.E) and so on as shown in Table (11),while the lowest net profit was obtained by using combination of Diatoms at 5ppm plus 1000gm. Magnetite (177 L.E). On the other hand using of biofertilizer treatment only achieved loss of money (-742 L.E) although the increasing of yield.

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