IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 8, Issue 9 Ver. II (Sep. 2015), PP 51-62
www.iosrjournals.org

Effect of Algae Extract and Zinc Sulfate Foliar Spray on Production and Fruit Quality of Orange Tree cv. Valencia

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Abstract: *A two – year trial was conducted during 2012 and 2013 seasons on 9 years old Valencia orange trees budded on Volkamer Lemon rootstock grown in sandy soil under drip irrigation system at El Tall El Kbeer region, Ismailia Governorate Egypt. The study was a factorial experiment with two factors i.e. the first factor consisted of 4 levels of algae extract foliar spray (0, 1, 1.5 and 2 %) and the second one involved 2 levels of zinc sulfate foliar spray (0.2 and 0.4%) arranged in a randomized complete block design with three replicates for each treatment and each replicate was represented by two trees.*

Obtained results showed that foliar spray of algae extract and/or combined with zinc sulfate enhanced leaf mineral content, total chlorophyll, number of fruits per tree, yield and fruit quality. Generally, 2.0% algae extract provided with 0.4%zinc sulfate proved to be the most efficient treatment in enhancing all studied leaf parameters, tree yield and fruit quality.

Key words*: Valencia orange; algae extract; zinc sulphate; yield; fruit quality.*

I. Introduction

Orange tree has a high economic value and considered one of the important fruit crops in Egypt. It is one of the major sources of vitamin "C" of human diet (Martí et al., 2007).

Most of the new reclaimed areas are cultivated with fruit trees especially citrus which considered the first fruit crop in Egypt. Valencia orange tree grown in new reclaimed soils such as sandy soil which is usually poor in their nutrients content, low organic matter and lower in catching water, with high nutrients leaching losses led to lower nutrient uptake by plant and has negative effect on vegetative growth, yield and fruit quality. Therefore, tree grown in this soil needs more attention in cultural practices such as fertilization, foliar spray with minerals and bio-fertilizers to enhance growth, yield and fruit quality.

One of cultural practices such as foliar spray of algae extract and zinc sulfate can improve yield and fruit quality of Valencia orange tree (Abd El-Motty and Orabi, 2014; Hanafy Ahmed et al., 2012 and Abd El-Motty and Shahin, 2010).

Algae extract as a new bio-fertilizer containing macronutrients as well as micronutrients, some growth regulators, polyamines, proteins and vitamins applied to improve nutritional status, vegetative growth, yield and fruit quality (Abd El-Migeed et al., 2004; Abd El-moniem and Abd-allah, 2008 and Spinelli et al., 2009). The mechanisms effect of algae on cell metabolism are mainly through the physiological action of major and minor nutrients, amino acids, vitamins, and also growth regulators affect cellular metabolism in treated plants leading to enhanced growth and crop yield (Stirk et al., 2003;Ördög et al., 2004 and Abd El-Motty et al., 2010). Hegab et al. (2005) reported that algae extract have a positive effect on fruit setting, yield and fruit quality of Balady orange trees. Abd El-Moniem and Abd-Allah (2008) mentioned that spraying algae extract at 50% improved yield, fruit quality of Williama banana plants. Also, Hassan (2008) showed that algae extract application was very effective in promoting growth and fruiting of Balady orange trees. Abd El-motty et al. (2010) showed that spraying "Keitte" mango trees once at full bloom with algae at 2% alone or in combination with yeast at 0.2% improved fruit set, fruit retention, number of fruits/ tree and yield. Besides, it also increased fruit length, fruit width, fruit weight, pulp/fruit percentage and total soluble solids and reduced fruit drop and weight of peel and seed comparing with the control. Moreover, this treatment improved leaf nitrogen, potassium and boron content.

On the other hand, zinc is an essential metal for normal plant growth and development (Cakmak, 2000). It plays a fundamental role in many essential cellular functions such as protein metabolism and IAA (Marschner, 1995). It is well known that zinc is an important component of many vital enzymes, including

ribulose-1, 5-bisphosphate carboxylase involved in photosynthesis (Brown et al., 1993). It stabilizes the structure of membrane proteins and DNA-binding proteins (Aravind and Prasad, 2004). Zinc plays a key role in nitrogen metabolism of plant and zinc deficient plants have reduced protein content (Mengel et al., 2001 and Hassan et al., 2010).

Zinc deficiency is very common in orange orchards (El-Fouly, 1985). Severe zinc deficiency symptoms appear on young leaf of orange tree and become progressively worse as leaf ages (Swietlik, 2002).

Dawood et al. (2000) on Washington navel orange trees and EL-Baz (2003) on Balady mandarin trees they reported that zinc sulfate application increased yield and improved physical and chemical fruit properties. Sajid et al. (2010) indicated that foliar application of zinc alone or in combination with born gave the maximum fruit yield/tree whereas, the combination of zinc and born as foliar spray significantly reduced the percentage of dieback, the percentage of chlorosis and the percentage of rosette/tree of sweet orange cv. Blood. Hanafy Ahmed et al. (2012) revealed that foliar spray with zinc improved yield and fruit quality as well as nutritional status (N, P, K, Mg, Zn, Cu, Fe and Mn concentrations) of leaves of Valencia orange trees. Abd El-Motty and Orabi (2014) demonstrated that foliar spray with zinc sulfate at 1000 mg/l improved yield and fruit quality of Navel orange tree.

This investigation aimed to study the effect of foliar spray of algae extract at (0, 1, 1.5 and 2 %) and zinc sulphate at (0.2 and 0.4%) as well as their combinations on leaf mineral content, yield and fruit quality of "Valencia" orange tree.

II. Material and Methods

This investigation was carried out during two successive seasons of 2012 and 2013 at private orchard at El Tall El Kbeer region, Ismailia Governorate Egypt. Nine years old Valencia orange trees (*Citrus sinensis* L.) budded on Volkamer lemon (*Citrus volkameriana* L.) rootstock, grown in sandy soil and spaced 5 x 5 m apart subjected to drip irrigation system. Physical and chemical analysis of the experimental soil shown in Table, 1. Forty eight trees healthy, nearly uniform in shape and size and productivity and received the same horticulture practices.

The present study was a factorial experiment with two factors i.e. the first factor consisted of 4 levels of algae extract foliar spray (0, 1, 1.5 and 2 %) and the second one involved 2 levels of zinc sulfate foliar spray (0.2 and 0.4%).

Algae extract obtained from Union for Agricultural Development Company and chemical constituents are shown in Table, 2.

The experiment was designed as a factorial experiment with two factors arranged in randomized complete block design with three replicates for each treatment and each replicate was represented by two trees.

However, foliar sprays of algae extract or zinc sulfate as well as their combinations were carried out at three times during each season i.e. just after fruit setting (2^{nd} week of April) and at two month intervals (2^{nd} week June and August). Meanwhile, the control trees were sprayed with tap water. Tween-20 was added at 0.1% as a surfactant to spray solution including the control "tap water". Spraying was carried out using compression sprayers (5L solution/tree) at the previously mentioned times.

Response of Valencia orange trees to the tested treatments was evaluated through the following determinations

2.1. Leaf mineral content

To determine leaf mineral content (N, P and K) and micronutrient (Fe, Zn and Mn), leaf samples were taken at the end of September in each season. Thirty leaf samples were taken from the previous spring cycle. Leaf samples were washed with tap water then with distilled water to remove the dust. After washing, they were dried in an electric oven at 70ºc for 72 hours. The dried leaves were ground, digested and prepared for analysis using the method described by Parkinson and Allen (1975). Total nitrogen was determined by the semi-micro Kjeldahl methods Bremner (1965). Phosphorus was estimated by the method Chapman and Pratt (1961). Potassium was determined by the flame-photometer according to Jackson (1958). Iron, zinc and Manganese were determined by using the Atomic Absorption Spectrophotometer "GBC 932 AA".

2.2. Leaf total chlorophyll content

Leaf total chlorophyll content was measured by Minolta chlorophyll meter SPAD-502.

2.3. No. of fruits/tree and Yield (kg/tree)

At harvest time (1st week of May) the number of fruits per each treated tree was counted and reported then yield (kg) per tree was weighed and recorded.

2.4. Fruit physical and chemical properties

Twenty five fruits were taken at harvest from each treated tree for determination of the following physical and chemical properties i. e. fruit weight (g), fruit volume (cm^3), fruit length (cm), fruit diameter (cm), peel thickness (cm), fruit juice percentage, total soluble solids (T.S.S.) was determined by Hand refractometer. Percentage of total acidity as g citric acid / 100 g F.wt., T.S.S./Acid ratio and ascorbic acid (mg ascorbic acid/100 ml juice) according to A.O.A.C. (1995).

Table 1. Analysis of orchard experimental soil at Ismailia Governorate, Egypt.

Soil Depth (cm)	Texture class	Organic matter (%)	$CaCO_3$	PH Soil past	E.Ce (dSm^{-1})	Soluble cations (mequiv./l)				soluble anions (mequiv./l)			
						Ca^{2+}	K^+	Na^+	Mg^{2+}	Cl^-	So_4^{2-}	Hco_3^-	Co_3^{2-}
0-30	Sand	0.22	5.90	7.7	0.70	3.12	0.11	2.63	1.12	4.08	1.54	1.36	--
30-60	Sand	0.21	3.82	7.7	0.80	3.08	0.20	3.35	1.33	3.78	3.34	0.84	--
60-90	Sand	0.19	4.36	7.4	1.10	4.46	0.03	4.36	2.18	8.46	1.59	1.00	--

Table 2. Chemical constituents of algae extract.

N %	P_2O_5 %	K_2O %	Fe %	Mn %	Zn %	IAA %	Cytokinins %	Betanin %	Oligosaccharide %	Alginic acid %	Zatin %	Mannitol %
1	0.5	12	0.2	0.1	0.3	0.0002	0.001	0.02	3.0	5.0	0.003	0.001

Statistical analysis

The obtained data in 2012 and 2013 seasons were subjected to analysis of variance according to Clarke and Kempson (1997). Means were differentiated using Rang test at the 0.05 level (Duncan, 1955).

III. Results And Discussion

3.1. Leaf mineral content

3.1.1 Nitrogen (%)

Table, 3 indicates that algae extract foliar sprays gave high positive effect on leaf nitrogen content as compared with control treatment in both seasons. Generally, 2% algae extract treatment proved to be the superior treatment in this respect.

Moreover, zinc sulfate foliar sprays showed no significant effect on leaf nitrogen content of Valencia orange tree.

However, the interaction between two factors showed that algae extract combined with zinc sulfate foliar sprays succeeded in increasing leaf nitrogen content as compared with control treatment in 2012 and 2013 seasons. Generally, 2% algae extract combined with 0.4% zinc sulfate foliar spray surpassed other combinations in both seasons.

3.1.2. Phosphorus (%)

Table, 3 illustrates that algae extract treatments exerted high leaf phosphorus content as compared with control in 2013 season. While, 2% and 1.5% algae extract treatments gave similar and high positive effect on leaf phosphorus content but 1% algae extract foliar spray failed in inducing any positive effect in 2012 seasons.

Leaf phosphorus content did not show significant to zinc sulfate foliar sprays in 2012 and 2013 seasons.

Algae extract combined with zinc sulfate foliar sprays produced significant effect on leaf phosphorus content as compared with control in both seasons. Generally, 2 %algae extract combined with 0.4 % zinc sulfate foliar spray proved to be the superior treatment in this respect.

Table 3. Effect of algae extract, zinc sulfate foliar spray and their combination on leaf nitrogen and phosphorus content of Valencia orange trees (2012 and 2013 seasons).

	N (%)						P (%)					
	2012			2013			2012			2013		
	Zn_2SO_4		Mean	Zn_2SO_4		Mean	Zn_2SO_4		Mean	Zn_2SO_4		Mean
Treatments	0.2 %	0.4%		0.2 %	0.4%		0.2 %	0.4%		0.2 %	0.4%	
Control	2.40 d	2.40 d	**2.40 D**	2.41 f	2.41 f	**2.41 D**	0.13 de	0.11 e	**0.12 B**	0.09 e	0.10 e	**0.09 D**
Algae extract at 1%	2.45 c	2.46 c	**2.45 C**	2.44 e	2.47 d	**2.46 C**	0.12 e	0.14 cd	**0.13 B**	0.11 de	0.12 cd	**0.11 C**
Algae extract at 1.5%	2.48 b	2.49 b	**2.49 B**	2.49 c	2.51 b	**2.50 B**	0.15 bc	0.16 ab	**0.16 A**	0.12 cd	0.14 bc	**0.13 B**
Algae extract at 2%	2.50 b	2.55 a	**2.52 A**	2.53 b	2.55 a	**2.54 A**	0.16 ab	0.17 a	**0.17 A**	0.15 ab	0.16 a	**0.15 A**
Mean	**2.46 A**	**2.47 A**		**2.47 A**	**2.48 A**		**0.14 A**	**0.15 A**		**0.12A**	**0.13 A**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

3.1.3. Potassium (%)

Table, 4 demonstrates that algae extract treatments gave similar and high enhanced effect on leaf potassium content as compared with control treatment in both seasons. However, in 2012 season 2% and 1.5% algae extract foliar sprays and in 2013 season 2% algae extract surpassed other treatment in enhancing leaf potassium content in both seasons

Moreover, 0.4 % zinc sulfate foliar spray induced high leaf potassium content than 0.2 % zinc sulfate foliar spray in 2013 seasons.

Furthermore, the interaction between two studied factors produced higher leaf potassium content as compared with control in both seasons. However, 2% algae extract combined with 0.4 % zinc sulfate foliar spray proved to be the superior treatment in this concern.

Table 4. Effect of algae extract, zinc sulfate foliar spray and their combination on leaf potassium and iron content of Valencia orange trees (2012 and 2013 seasons).

	K (%)						Fe (ppm)					
	2012			2013			2012			2013		
	Zn_2SO_4		Mean	Zn_2SO_4		Mean	Zn_2SO_4		Mean	Zn_2SO_4		Mean
Treatments	0.2 %	0.4%		0.2 %	0.4%		0.2 %	0.4%		0.2 %	0.4%	
Control	1.02 e	1.05 de	**1.03 C**	1.02 f	1.01 f	**1.02 D**	63.43 h	64.40 g	**63.92 D**	64.77 g	63.89 h	**64.33 C**
Algae extract at 1%	1.24 bc	1.16 cd	**1.20 B**	1.20 e	1.26 d	**1.23 C**	65.37 f	67.44 e	**66.40 C**	65.89 f	66.89 e	**66.39 C**
Algae extract at 1.5%	1.33 ab	1.26 abc	**1.29 A**	1.33 c	1.39 b	**1.36 B**	70.33 d	74.52 c	**72.42 B**	68.77 d	70.66 c	**69.72 B**
Algae extract at 2%	1.36 ab	1.38 a	**1.37 A**	1.40 b	1.51 a	**1.46 A**	75.04 b	77.38 a	**76.21 A**	71.89 b	73.89 a	**72.89 A**

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

3.1.4. Iron (ppm)

Table, 4 shows that algae extract produced a pronounced effect on leaf iron content as compared with control in both seasons. However, 2 % algae extract foliar spray shows superiority in this respect.

Moreover, 0.4% zinc sulfate treatment succeeded in increasing leaf iron content than 0.2 % zinc sulfate treatment in both seasons.

On the other hand, the interaction between two factors produced a pronounced effect on leaf iron content as compared with control in both seasons. Generally, 2% algae extract combined with 0.4% zinc sulfate surpassed other tested combinations in this concern.

3.1.5. Zinc (ppm)

Table, 5 indicates that algae extract treatments significantly increased leaf zinc content as compared with control in both seasons. However, 2% algae extract treatment showed to be the superior treatment in this respect.

Moreover, 0.4% zinc sulfate treatment significantly increased leaf zinc content than 0.2 % zinc sulfate foliar spray in both seasons.

Furthermore, the interaction between algae extract and zinc sulfate gave a positive effect on leaf zinc content as compared with control in 2012 and 2013 seasons. Generally, 2% algae extract treatment combined 0.4 % zinc sulfate foliar spray surpassed other tested combinations in enhancing leaf zinc content in both seasons.

3.1.6. Manganese (ppm)

Table, 5 shows that algae extract treatments gave a high positive effect on leaf manganese content as compared with control in both seasons. However, 2% algae extract treatment proved to be the superior treatment in this concern

Moreover, 0.4% zinc sulfate foliar spray increased leaf manganese content than 0.2% zinc sulfate treatment in 2012 season. Whereas, zinc sulfate treatments failed in induce any positive effect in 2013 season.

The interaction between algae extract and zinc sulfate gave a high positive effect on leaf manganese content as compared with control in both seasons. However, 2% algae extract combined with 0.4 % zinc sulfate treatment proved to be the superior treatment in this concern.

Table 5. Effect of algae extract, zinc sulfate foliar spray and their combination on leaf zinc and manganese content of Valencia orange trees (2012 and 2013 seasons).

	Zn (ppm)						Mn (ppm)					
	2012			2013			2012			2013		
	Zn_2SO_4		Mean	Zn_2SO_4		Mean	Zn_2SO_4		Mean	Zn_2SO_4		Mean
Treatments	0.2 %	0.4%		0.2 %	0.4%		0.2 %	0.4%		0.2 %	0.4%	
Control	45.55 g	44.55 h	**45.05 D**	45.77 g	47.22 f	**46.50 D**	55.06 h	55.76 g	**55.41 D**	55.88 d	59.77 cd	**57.83 C**
Algae extract at 1%	47.33 f	51.46 e	**49.39 C**	49.66 e	55.11 d	**52.38 C**	57.20 f	59.15 e	**58.17 C**	58.70 cd	59.55 cd	**59.13 C**
Algae extract at 1.5%	53.44 d	56.46 c	**54.95 B**	55.76 c	57.48 b	**56.62 B**	60.87 d	62.23 c	**61.55 B**	61.85 bc	64.33 ab	**63.09 B**
Algae extract at 2%	57.37 b	59.33 a	**58.35 A**	57.89 b	59.44 a	**58.66 A**	65.11 b	67.76 a	**66.43 A**	65.59 ab	67.37 a	**66.48 A**
Mean	**50.92 B**	**52.95 A**		**52.27 B**	**54.81 A**		**59.56 B**	**61.22 A**		**60.50 A**	**62.76 A**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

The enhanced effect of algae extract on leaf mineral content are mainly through the physiological action of nutrients, vitamins, and growth regulators (Abd El-Migeed et al., 2004; Abd el Moniem et al., 2008 and Abd El-Moniem and Abd-Allah 2008) which reflected on improved nutritional status of tree.

The obtained results of algae extract on leaf mineral content are in harmony with the findings of Abd El-Motty et al. (2010) showed that spraying "Keitte" mango trees once at full bloom with algae at 2% alone or in combination with yeast at 0.2% improved nitrogen and potassium contents in the leaves.

The enhanced effect of zinc sprays on leaf mineral content may be due to zinc is an essential metal for normal plant growth and development (Cakmak, 2000). Zinc plays a fundamental role in many essential cellular functions such as protein metabolism and IAA (Marschner, 1995). It is well known that zinc is an important component of many vital enzymes, including ribulose-1, 5-bisphosphate carboxylase involved in photosynthesis (Brown et al., 1993). It stabilizes the structure of membrane proteins and DNA-binding proteins (Aravind and Prasad, 2004). Zinc plays a key role in N metabolism of plant and zinc deficient plants have reduced protein content (Mengel et al., 2001 and Hassan et al., 2010).Thus, it reflected on improved nutritional status of tree.

The obtained results of zinc sprays treatments regarding leaf mineral content are in agreement with the findings of Hanafy Ahmed et al. (2012) who mentioned that zinc foliar spray improved leaf nutritional status (N, P, K, Mg, Zn, Cu, Fe and Mn concentrations) of Valencia orange trees.

3.2. Leaf total chlorophyll content

Table, 6 indicates that algae extract treatments gave high positive effect on leaf chlorophyll content as compared with control treatment in both seasons. Generally, 2% algae extract treatment showed to be the superior treatment in this respect

Moreover, 0.4% zinc sulfate treatment increased leaf chlorophyll content of Valencia orange than 0.2% zinc sulfate treatment tree in 2012 and 2013 seasons.

However, the interaction between two tested factors showed that algae extract treatment combined with zinc sulfate treatments succeeded in increasing leaf chlorophyll content as compared with control treatment in 2012 and 2013 seasons. Generally, 2% algae extract treatment combined with 0.4% zinc sulfate surpassed other combinations in both seasons.

The enhanced effect of algae extract on nutritional status of tree reflected on better development of chlorophyll and photosynthesis processes.

The obtained results of algae extract treatments concerning leaf chlorophyll content are in harmony with the findings of Ismail et al. (2011) who showed that algae application enhanced leaf chlorophyll content of Bitter orange.

The obtained results of zinc treatments regarding leaf chlorophyll content are in agreement with the findings of Desai et al. (1991) on sweet orange, Supriya and Bhattacharyya (1993) on Citrus Limon. They found that zinc foliar sprays enhanced leaf total chlorophyll content of sweet orange and lemon trees.

Table 6. Effect of algae extract, zinc sulfate foliar spray and their combination on leaf total chlorophyll content of Valencia orange trees (2012 and 2013 seasons).

	Total chlorophyll					
	2012			2013		
	Zn_2SO_4		**Mean**	Zn_2SO_4		**Mean**
Treatments	0.2 %	0.4%		0.2 %	0.4%	
Control	61.71 h	62.60 g	**62.15 D**	60.90 h	61.82 g	**61.36 D**
Algae extract at 1%	65.63 f	66.58 e	**66.11C**	63.91 f	64.68 e	**64.29 C**
Algae extract at 1.5%	66.66 d	67.74 c	**67.20 B**	66.77 d	67.78 c	**67.27 B**
Algae extract at 2%	68.79 b	69.74 a	**69.24 A**	68.87 b	69.08 a	**68.97 A**
Mean	**65.70 B**	**66.65 A**		**65.11B**	**65.84 A**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

3.3. No. of fruit / tree

Table, 7 shows that algae extract treatments increased number of fruits per tree as compared with control treatment in both seasons. However, 2% algae extract treatment scored 323 and 330 fruits/tree against 298 and 307 fruits /tree for control treatment in both seasons, respectively.

Moreover, 0.4 % zinc sulfate treatment induced high positive effect on number of fruits per tree than 0.2 % zinc sulfate treatment in 2012 season. However, number of fruits per tree did not response to zinc sulfate concentration in 2013 season.

The interaction between two factors shows that combination of 2% algae extract plus 0.4 % zinc sulfate in 2012 season and 2 % algae extract plus (0.2 and/or 0.4 %) Zinc sulfate in 2014 season, were significantly superior in enhancing of fruits/tree as compared to all other tested combinations.

Table 7. Effect of algae extract, zinc sulfate foliar spray and their combination on number of fruits/tree and yield of Valencia orange trees (2012 and 2013 seasons).

	No. of fruit /tree						Yield (kg)/tree					
	2012			2013			2012			2013		
	Zn_2SO_4		**Mean**	Zn_2SO_4		**Mean**	Zn_2SO_4		**Mean**	Zn_2SO_4		**Mean**
Treatments	0.2 %	0.4%		0.2 %	0.4%		0.2 %	0.4%		0.2 %	0.4%	
Control	298.5 e	298.4 e	**298.4 D**	307.3 e	306.5 e	**306.9 D**	61.07 d	61.28 d	**61.18 C**	62.12 g	62.41 g	**62.26 D**
Algae extract at 1%	299.1 e	304.8 d	**301.9 C**	311.3 d	313.4 c	**312.3 C**	62.26 d	64.87 cd	**63.57 C**	65.48 f	68.50 e	**66.99 C**
Algae extract at 1.5%	312.9 c	313.5 c	**313.2 B**	320.3 b	319.2 b	**319.7 B**	67.08 c	72.66 b	**69.87 B**	70.06 d	72.63 c	**71.34 B**
Algae extract at 2%	320.0 b	326.3 a	**323.2 A**	329.3 a	330.3 a	**329.8 A**	70.90 b	77.15 a	**74.03 A**	75.91 b	78.15 a	**77.03 A**
Mean	**307.6 B**	**310.8 A**		**317.1 A**	**317.3 A**		**65.33 B**	**68.99 A**		**68.39 B**	**70.42 A**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

3.4. Yield (kg) / tree

Table, 7 indicates that algae extract treatments significantly improved tree yield as compared with control in 2012 and 2013 seasons. However, 2% algae extract treatment record 74.03 and 77.03 kg/tree against 61.18 and 62.26 kg/tree for control treatment in 2012 and 2013 seasons, respectively.

Moreover, 0.4 % zinc sulfate treatment significantly increased tree yield than 0.2 %zinc sulfate treatment in both seasons.

The interaction between algae extract and zinc sulfate showed the highest tree yield as compared with control in both seasons. Generally, combination of 2% algae extract plus 0.4 % zinc sulfate foliar spray scored (77.15 and 78.15 kg/tree) against (61.28 and 62.41 kg/tree) for control in 2012 and 2013 seasons, respectively.

The enhanced effect of algae extract treatment on tree yield may be to algae extract contents of minerals, vitamins and growth regulators especially, IAA and cytokinins which induced a positive effect on reducing fruit drop and increase number of fruits per tree and yield kg/tree (Stirck et al., 2003; Abd El-Motty et al., 2010 and Abd El-Wahab, 2007). Also, the increment of chlorophyll production and photosynthesis processes lead to increased in number of fruits per tree and yield.

The obtained results of algae extract go with line with the findings of Hegab et al. (2005) who reported that algae extract have a positive effect on yield of Balady orange trees. Abd El-Moniem and Abd-Allah (2008) mentioned that spraying algae extract at 50% improved yield of Williams banana plants. Hassan (2008) showed that algae extract application was very effective in promoting fruiting of Balady orange trees. Abd El-Motty et al. (2010) showed that spraying "Keitte" mango trees once at full bloom with algae at 2% alone or in combination with yeast at 0.2% improved number of fruits/ tree and yield.

On the other hand, the increase in number of fruits per tree and yield (kg) per tree of Valencia orange tree could be attributed to fact that zinc may enhance photosynthetic activity and protein synthesis in leaves. Also, zinc plays an important role in biosynthesis of IAA and it is required for preventing the abscission layer formation which led to reduce fruit drop and increase fruit retention subsequently, increased number of fruits per tree and improved yield per tree (Marchner, 1995; Sajida et al., 2000; El-Baz, 2003 and Aravind and Prasad, 2004).

The obtained results of zinc are in agreement with the findings of Dawood et al. (2000) on Washington navel orange trees and EL-Baz (2003) on Balady mandarin trees. They reported that zinc sulfate application increased yield. Sajid et al. (2010) indicated that foliar application of Zn alone or in combination with B gave the maximum fruit yield/tree. Hanafy Ahmed et al. (2012) revealed that foliar spray with zinc improved yield of Valencia orange trees. Abd El-Motty and Orabi (2014) demonstrated that foliar spray with zinc sulfate at 1000 mg/l improved yield of Navel orange tree.

3.5. Fruit properties

3.5.1. Fruit physical properties

3.5.1.1. Fruit weight (g)

Table, 8 indicates that algae extract treatments significantly increased fruit weight as compared with control in 2012 and 2013 seasons. However, 2% algae extract treatment produced the heaviest fruits weight (229.5 and 234.8 g) against (205.8 and 203.4 g) for control treatment in 2012 and 2013 seasons, respectively.

Moreover, 0.4 % zinc sulfate treatment surpassed the corresponding ones of 0.2 % zinc sulfate treatment in enhancing fruit weight of Valencia orange in both seasons of study.

The interaction between algae extract and zinc sulfate significantly increased fruit weight as compared with control in both seasons. Generally, 2% algae extract combined with 0.4 % zinc sulfate foliar spray recorded the higher values of fruit weight (237.6 and 238.3 g) against (206.2 and 203.6 g) for control in the first and second season, respectively.

Table 8. Effect of algae extract, zinc sulfate foliar spray and their combination on fruit weight and fruit volume of Valencia orange trees (2012 and 2013 seasons).

	Fruit weight (g)						Fruit volume (cm^3)					
	2012			2013			2012			2013		
	Zn_2SO_4		Mean	Zn_2SO_4		Mean	Zn_2SO_4		Mean	Zn_2SO_4		Mean
Treatments	0.2 %	0.4%		0.2 %	0.4%		0.2 %	0.4%		0.2 %	0.4%	
Control	205.4 g	206.2 g	**205.8 D**	203.3 g	203.6 g	**203.4 D**	224.5 f	224.3 f	**224.4 D**	228.3 h	230.3 g	**229.3 D**
Algae extract at 1%	210.3 f	213.4 e	**211.8 C**	210.4 f	219.4 e	**214.9 C**	228.3 e	234.3 d	**231.3 C**	234.3 f	235.3 e	**234.8 C**
Algae extract at 1.5%	215.3 d	232.5 b	**223.9 B**	220.5 d	227.5 c	**224.0 B**	236.4 c	239.5 b	**238.0 B**	240.6 c	239.6 d	**240.1 B**
Algae extract at 2%	221.5 c	237.6 a	**229.5 A**	231.3 b	238.3 a	**234.8 A**	240.5 b	244.4 a	**242.5 A**	244.3 b	255.3 a	**249.8 A**
Mean	**213.1 B**	**222.4 A**		**216.4 B**	**222.2 A**		**232.4 B**	**235.6 A**		**236.9 B**	**240.1 A**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

3.5.1.2. Fruit volume (cm^3)

Table, 8 demonstrates that algae extract treatments enhanced fruit volume of Valencia orange as compared with control in both seasons. However, 2% algae extract foliar spray surpassed other tested treatments in both seasons.

In additions, 0.4 % zinc sulfate treatment produced a pronounced positive effect on fruit volume than 0.2 % zinc sulfate treatment in both seasons.

The interaction between algae extract and zinc sulfate gave a high value of fruit volume as compared with control in both seasons. Generally, 2 % algae extract combined with 0.4 % zinc sulfate surpassed other in enhancing fruit volume in both seasons.

3.5.1.3. Fruit length (cm)

Table, 9 indicates that algae extract significantly increased fruit length as compared with control in 2012 and 2013 seasons. However, 2% algae extract treatment produced the longest fruits in both seasons.

Moreover, 0.4 % zinc sulfate treatment surpassed the corresponding one of 0.2 % zinc sulfate treatment in enhancing fruit weight of Valencia orange in 2012 season.

The interactions between algae extract treatment and zinc sulfate treatment increased fruit length as compared with control in both seasons. Generally, 2% algae extract combined with 0.4 % zinc sulfate foliar spray record the higher values of fruit length.

Table 9. Effect of algae extract, zinc sulfate foliar spray and their combination on fruit length and fruit diameter of Valencia orange trees (2012 and 2013 seasons).

	Fruit length (cm)						Fruit diameter (cm)					
	2012			2013			2012			2013		
	Zn_2SO_4		Mean	Zn_2SO_4		Mean	Zn_2SO_4		Mean	Zn_2SO_4		Mean
Treatments	0.2 %	0.4%		0.2 %	0.4%		0.2 %	0.4%		0.2 %	0.4%	
Control	7.26 g	7.19 h	**7.22 D**	7.44 h	7.46 g	**7.45 D**	6.98 d	7.02 c	**6.99 D**	7.17 f	7.18 ef	**7.18 D**
Algae extract at 1%	7.43 f	7.53 e	**7.48 C**	7.54 e	7.48 f	**7.51 C**	7.18 b	7.20 b	**7.19 C**	7.19 e	7.24 d	**7.21 C**
Algae extract at 1.5%	7.55 d	7.57 c	**7.56 B**	7.70 b	7.58 d	**7.64 B**	7.23 b	7.24 b	**7.23 B**	7.30 c	7.30 c	**7.30 B**
Algae extract at 2%	7.67 b	7.73 a	**7.70 A**	7.67 c	8.020 a	**7.84 A**	7.31 a	7.34 a	**7.32 A**	7.32 b	7.58 a	**7.45 A**
Mean	**7.48 B**	**7.50 A**		**7.59 A**	**7.63 A**		**7.17 B**	**7.20 A**		**7.25 B**	**7.32 A**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

3.5.1.4. Fruit diameter (cm)

Table, 9 shows that algae extract treatments increased fruit diameter as compared with control treatment in both seasons. However, 2 % algae extract treatment produced the widest fruits in both seasons.

Moreover, 0.4 % zinc sulfate treatment induced high positive effect on fruit diameter than 0.2 % zinc sulfate treatment in 2012 and 2013 seasons.

The interaction between two factors showed that combination of 2% algae extract with (0.2 and/or0.4 %) zinc sulfate in 2012 season and 2 % algae extract plus 0.4% Zinc sulfate in 2013 season, were significantly superior to all other tested combinations.

3.5.1.5. Peel thickness (cm)

Table, 10 illustrates that algae extract treatments gave similar and high values of peel thickness as compared with control treatment in 2012 season while, 2% algae extract treatment gave similar and high positive effect on peel thickness and surpassed other tested treatments in both seasons.

Peel thickness did not response to zinc sulfate concentration in both seasons.

The interaction between algae extract and zinc sulfate gave similar and high positive effect on peel thickness as compared with control in both seasons. Generally, 2 and 1.5% algae extract treatment combined with 0.2 and/or 0.4 % zinc sulfate treatments gave similar and high values in this combination in both seasons.

Table 10. Effect of algae extract, zinc sulfate foliar spray and their combination on peel thickness and fruit juice percentage of Valencia orange trees (2012 and 2013 seasons).

	Peel thickness (cm)						Fruit juice (%)					
	2012			2013			2012			2013		
	Zn_2SO_4		Mean	Zn_2SO_4		Mean	Zn_2SO_4		Mean	Zn_2SO_4		Mean
Treatments	0.2 %	0.4%		0.2 %	0.4%		0.2 %	0.4%		0.2 %	0.4%	
Control	0.41 c	0.42 c	**0.42 C**	0.44 b	0.44 b	**0.44 B**	48.63 d	49.40 d	**49.01 D**	49.64 e	50.33 d	**49.98 D**
Algae extract at 1%	0.44 b	0.44 b	**0.44 B**	0.44 b	0.46 a	**0.45 B**	49.64 cd	50.63 bc	**50.13 C**	50.63 d	50.63 d	**50.63 C**
Algae extract at 1.5%	0.46 a	0.47 a	**0.47 A**	0.46 a	0.47 a	**0.47 A**	51.39 ab	51.73 ab	**51.56 B**	52.36 b	51.40 c	**51.88 B**
Algae extract at 2%	0.46 a	0.46 a	**0.46 A**	0.47 a	0.47 a	**0.47 A**	52.34 a	52.50 a	**52.42 A**	52.60 b	53.50 a	**53.05 A**
Mean	**0.44 A**	**0.45 A**		**0.45 A**	**0.46 A**		**50.50 A**	**51.06 A**		**51.31 A**	**51.46 A**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

3.5.1.6. Fruit juice percentage

Table, 10 indicates that algae extract treatment significant increased fruit juice percentage as compared with control in both seasons. However, 2% algae extract foliar spray proved to be the superior treatment in this respect.

Moreover, zinc sulfate treatments induced similar effect on fruit juice percentage of Valencia orange tree in both seasons from the statistical standpoint.

Furthermore, the interaction between algae extract treatment and zinc sulfate treatment gave a positive effect on fruit juice percentage as compared with control in both 2012 and 2013 seasons. Generally, in 2012 season 2% algae extract treatment combined 0.2 % and/or 0.4 % zinc sulfate foliar spray and in 2013 season 2% algae extract combined 0.4 % zinc sulfate foliar spray surpassed other tested combination in enhancing fruit juice percentage.

3.5.2. Fruit chemical properties

3.5.2.1. T.S.S. (%)

Table, 11 indicates that algae extract treatment gave high positive effect on TSS as compared with control treatment in both seasons. Generally, 2% algae extract treatment proved to be the superior treatment in this respect

Moreover, 0.4 % zinc sulfate treatment induced high positive effect on TSS than 0.2 % zinc sulfate treatment in 2013 season. While, zinc sulfate foliar spray had no significant effect on TSS of Valencia orange fruit in 2012 season.

However, the interaction between the two tested factors showed that algae extract treatment combined with zinc sulfate foliar sprays succeeded in increasing TSS as compared with control treatment in 2012 and 2013 seasons. Generally, 2% algae extract combined with 0.4% zinc sulfate foliar spray surpassed other combinations in both seasons.

Table 11. Effect of algae extract, zinc sulfate foliar spray and their combination on T.S.S. and acidity of Valencia orange trees (2012 and 2013 seasons).

	T.S.S. (%)						Acidity (%)					
	2012			2013			2012			2013		
	Zn_2SO_4		Mean	Zn_2SO_4		Mean	Zn_2SO_4		Mean	Zn_2SO_4		Mean
Treatments	0.2 %	0.4%		0.2 %	0.4%		0.2 %	0.4%		0.2 %	0.4%	
Control	9.62 c	9.83 bc	**9.72 C**	10.13 g	10.12 g	**10.12 D**	0.94 b	1.07 a	**1.01 A**	0.95 b	1.00 a	**0.98 A**
Algae extract at 1%	10.12 abc	10.27 abc	**10.19 BC**	10.26 f	10.40 e	**10.33 C**	0.90 c	0.86 d	**0.88 B**	0.86 c	0.81 d	**0.83 B**
Algae extract at 1.5%	10.73 abc	10.87 abc	**10.80 AB**	10.87 d	11.03 c	**10.95 B**	0.75 e	0.73 f	**0.74 C**	0.73 ef	0.74 d	**0.73 C**
Algae extract at 2%	11.17 ab	11.33 a	**11.25 A**	11.18 b	11.48 a	**11.33 A**	0.72 fg	0.71 g	**0.72 D**	0.72 fg	0.71 g	**0.71 D**
Mean	**10.41 A**	**10.57 A**		**10.61 B**	**10.76 A**		**0.83 A**	**0.84 A**		**0.81 A**	**0.81 A**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

3.5.2.2. Acidity (%)

Table, 11 illustrates that algae extract treatments exerted high reduction effect on acidity of Valencia orange fruit as compared with control in 2012 and 2013 seasons. However, 2% algae extract treatment surpassed other tested treatments in reducing acidity in both seasons.

Moreover, zinc sulfate concentration had no significant effect on acidity of Valencia orange fruit in both seasons.

However, the interaction between two factors showed that algae extract treatment combined with zinc sulfate foliar sprays induced high reduction in acidity of Valencia orange fruit as compared with control in both seasons. Generally, 2% algae extract combined with 0.4% zinc sulfate foliar spray surpassed other combinations reduced acidity of Valencia orange fruit in both seasons.

3.5.2.3. T.S.S./acid ratio

Table, 12 shows that algae extract produced a pronounced positive effect on TSS/acidity of Valencia orange fruit as compared with control in both seasons. However, 2 % algae extract treatment showed superiority in this respect.

Moreover, zinc sulfate concentration had no significant effect on TSS/acidity of Valencia orange fruit in both seasons.

On the other hand, the interaction between two factors produced pronounced positive effect on TSS/acidity as compared with control in both seasons. Generally, 2% algae extract combined with 0.4% zinc sulfate surpassed other tested treatment in this respect in both seasons.

Table 12. Effect of algae extract, zinc sulfate foliar spray and their combination on total T. S .S. / acid ratio and ascorbic acid of Valencia orange trees (2012 and 2013 seasons).

	T. S .S. / acid ratio						Ascorbic acid(mg /100 ml juice)					
	2012			2013			2012			2013		
	Zn_2SO_4		Mean	Zn_2SO_4		Mean	Zn_2SO_4		Mean	Zn_2SO_4		Mean
Treatments	0.2 %	0.4%		0.2 %	0.4%		0.2 %	0.4%		0.2 %	0.4%	
Control	10.20 f	9.13 g	**9.66 D**	10.63 f	9.99 g	**10.31 D**	50.13 g	50.22 g	**50.17 D**	53.42 d	53.34 d	**53.38 D**
Algae extract at 1%	11.16 e	11.85 d	**11.51 C**	11.88 e	12.83 d	**12.36 C**	53.25 f	55.25 e	**54.25 C**	55.23 c	55.62 c	**55.42 C**
Algae extract at 1.5%	14.18 c	14.75 b	**14.47 B**	14.83 c	14.84 c	**14.83 B**	56.59 d	57.60 c	**57.09 B**	57.53 b	58.51 ab	**58.02 B**
Algae extract at 2%	15.51 ab	15.95 a	**15.73 A**	15.45 b	16.17 a	**15.81 A**	58.64 b	59.28 a	**58.96 A**	59.58 a	59.24 a	**59.41 A**
Mean	**12.76 A**	**12.92 A**		**13.19 A**	**13.46 A**		**54.65 B**	**55.59 A**		**56.35 B**	**56.76 A**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

3.5.2.4. Ascorbic acid (mg/100 ml juice)

Table, 12 indicates that algae extract treatment significantly increased fruit ascorbic acid content as compared with control in both seasons. However, 2% algae extract treatment showed to be the superior treatment in this respect.

Moreover, 0.4% zinc sulfate treatment significantly increased fruit ascorbic acid content than 0.2 % zinc sulfate foliar spray in both seasons.

Furthermore, the interaction between algae extract and zinc sulfate gave a positive effect on fruit ascorbic acid content as compared with control in both 2012 and 2013 seasons. Generally, 2% algae extract treatment combined 0.4 % zinc sulfate treatment in 2012 season and 2% algae extract combined 0.2 % and/or 0.4 % zinc sulfate foliar spray in 2013 season surpassed other tested combination in enhancing ascorbic acid in both seasons.

The enhancement effect of algae extract on fruit quality properties are mainly through the physiological action of nutrients, vitamins, and growth regulators (Abd El-Migeed et al., 2004; Abd el Moniem et al., 2008 and Abd El-Moniem and Abd-Allah 2008) which reflected on fruit quality. Also, the increase in leaf total chlorophyll content was reflected in increasing rate of photosynthesis rate and accumulation of carbohydrates reserves which lead to positive effect on fruit quality.

The obtained results of algae extract are in harmony with the findings of Hegab et al. (2005) who reported that algae extract have a positive effect on fruit quality of Balady orange trees. Abd El-Moniem and Abd-allah (2008) mentioned that spraying algae extract at 50% improved fruit quality of Williama banana plants. Abd El-Motty et al. (2010) showed that spraying "Keitte" mango trees once at full bloom with algae at 2% alone or in combination with yeast at 0.2% increased fruit length, fruit width, fruit weight, pulp/fruit percentage and total soluble solids and reduced fruit drop and weight of peel and seed comparing with the control.

The improved effect of zinc on fruit quality of Valencia orange might be due to the fact that zinc play an active role in production of auxin in plant (Bose and Tripathi, 1996 and Alloway, 2008), and its affect on starch metabolism (Marchner, 1995 and Hafez et al., 2007), biological processes such as photosynthesis reaction and carbohydrate biosynthesis (Yamdagni et al., 1979), nucleic acid metabolism and cell division as well as protein which led to more accumulation of metabolites in fruit (Badu and singh, 2001 and Dickinson et al., 2003). Also, zinc play an important role in the activities various enzymes involved in this biochemical reaction,

which facilitates and increases buildup of organic compounds (Brown et al., 1993 and Alloway, 2008) subsequently, improved fruit quality of Valencia orange.

The obtained results of zinc are in agreement with the findings of Dawood et al. (2000) on Washington navel orange trees and EL-Baz (2003) on Balady mandarin trees they reported that zinc sulfate application improved physical and chemical fruit properties. Hanafy Ahmed et al. (2012) showed that foliar spray with zinc improved fruit quality of Valencia orange trees. Abd El-Motty and Orabi (2014) stated that foliar spray with zinc sulfate at 1000 mg/l improved fruit quality of Navel orange tree.

IV. Conclusion

The results of this study demonstrated that algae extract (1.0 and 2.0 %), zinc sulfate (0.2 and 0.4%) alone or in combination enhanced leaf minerals content, total chlorophyll, number of fruits per tree, yield and fruit quality. Consequently, it is preferable to foliar spray Valencia orange trees with 2.0% algae extract combined with 0.4%zinc sulfate foliar spray at three times a year i.e., just after fruit setting (2^{nd} week of April) and at two month intervals (2^{nd} week June and August) to enhance tree yield and fruit quality.

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