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Effect of Mining Diatoms and GA_3 Foliar Applications on Washington Navel Orange Tree Performance.

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THIS study was carried out during two successive seasons (2015/016 and 2016/017) on Washington Navel orange trees grown in sandy–loamy soil under flooding irrigation system with Nile water in a private orchard at Qalub district, El-Qalubia Governorate, Egypt. This experiment studied the effect of spraying trees with diatoms at 0.5, 0.75 and1.00 kg or GA_3 at 25 ppm during 25 %, 75 % or twice 25 & 75% of full-bloom on inflorescences types, fruit set %, leaf pigments, leaf minerals content and tree yield efficiency as fruit number & weight and fruit quality. Results showed that spraying of diatoms (0.5kg / 600L) on Navel orange trees at 75 % of full-bloom significantly increased leaf pigments contents. Spraying diatoms once at 25% or twice 25 & 75% % of full- bloom at 1.00 kg/600L improved with significant effect : fruit set % , leaf minerals content and tree yield efficiency as fruit number & weight and fruit quality (fruit size , fruit hardness) and (TSS %, TA % , TSS/ acid ratio and V. C content). Also, spraying of GA_3 at 25 ppm during 75% of full bloom statistically increased leaf iron, juice V. C and fruit hardness. Moreover, both diatoms and GA_3 reduced fruit drop and weight of peel when compared to the control. On the other hand, diatoms or GA_3 treatments had insignificant effect on leaf potassium, Chl. b, total carotenoids, zinc and number of both leafy and leafless inflorescences.

Keywords: Navel orange, Diatoms, GA_3, Leafy and Leafless Inflorescences.

Introduction

Navel orange (*Citrus sinensis* L) is one of the most important citrus fruits grown in the Mediterranean basin region. In Egypt, Navel orange ranks the first as its total area of fruitful orchards reached approximately 156514 Fed. Producing about 10.844 tons/Fed. (According to Ministry of Agric. And Land Reclamation/Annual Report 2015). However, low yield with poor quality is one of the main problems facing citrus growers in the old lands (Delta region). It may due to: I Navel orange is the most citrus varieties sensitive to the adverse changes of the climate especially during the period of flowering and fruit-set. This type of climatic volatility is now challenging the historical drivers for citrus crops improved crop management (Edgerton 2009), ii relative low of nutrients and essential elements. Meanwhile, various trials were done to raise the productivity and fruit quality of many fruit species by using some chemical substances fertilizers especially mineral ones for avoiding the use of these substances and chemical fertilizers and their harmful effect particularly on human health. Consequently, there is an urgent need to find new ways to increase agricultural resistance to stress and increasing productivity to supply the population's unprecedented demand for food. As a regular component of agricultural programs, diatoms or Algal extracts represent a major opportunity to significantly enhance crop gain and resistance to stress (Khan et al., 2009, Du Jardin, 2012, Craigie, 2011 and Calvo et al., 2014).

So, using of some natural bio-stimulants like plants extracts such as diatoms that are characterized by their richer contents with nutrient elements, growth regulators, antioxidants and vitamins. Nevertheless, diatoms or algal extracts are becoming more of the delivered to improve agricultural productivity, and a greater understanding of their biological modes of action will further enhance productivity in the future.

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Mining diatoms collected from mines near the seas and oceans have been exploited for centuries and are still used today, for their ability to improve soil nutritional and structural status through composting and their apparent and documented as plant growth stimulant-properties (Milton, 1952). Moreover, diatoms or algal extracts have been reported to assist plants in many ways such as enhancing crop yield, improving root structures, improving plant development like flowering and leaf development and fruit set, and enhancing ability to tolerate plant disease and climatic stresses such as cold or drought. There are also benefits that related to improve soil structure, soil water holding capacity and improve soil fertility (Khan et al., 2009, Craigie, 2011, Du Jardin, 2012 and Calvo et al., 2014). Many types of plant growth regulators have been identified in diatoms or algal extracts, such as: auxins, cytokinins, ethylene, gibberellins, abscisic acid (Tay et al., 1985, 1987, Crouch et al., 1992, Stirk and Van Staden, 1997, Khan et al., 2009 and Kurepin et al., 2014) and more: some macro and micro nutrients i.e. N, P, K, Ca, Mg, S, (Zn, Fe, Mn, Cu, Mo and Co as well as some growth regulators, polyamines and vitamins required to be applied for improving nutritional status, vegetative growth, yield and fruit quality in different fruit orchards, (Abd El-Migeed et al., 2004 and Spinelli et al., 2009). Bio-stimulants help plants help themselves. One of the roles of plant hormones is that of chemical messengers that tell plants when stressful environmental conditions exists. In response, plants may initiate or increase physiological processes that increase their tolerance to stress (Xunzhong and Schmidt, 2000). Gibberellins are a group of naturally occurring plant hormones (Janick, 1979) are used commercially to increase fruit size of "Thompson Seedless" grapes. They are applied at fruit set or shortly thereafter. They also promote male flower initiation in cucumbers when pollen is wanted for hybrid seed production and may overcome the cold requirement for flowering of some perennial plants (Hartman et al., 1981) Therefore, this study aimed to improve growth and productivity of Navel orange trees by spraying of mining diatoms with different rates and at different physiological tree growth development stages.

Materials and Methods

This study was carried out during two successive 2015/016 and 2016/017 experimental seasons on mature Washington Navel orange [*Citrus sinensis* (L.) Osbeck] trees budded on sour orange rootstock grown in a private orchard at the Delta region El-Qlubia governorate, Egypt. Thirty – nine of 40 years old Navel orange trees, planted at 5 × 5 m apart in sandy- loamy soil, under flooding irrigation system were carefully selected as being healthy, disease free and uniform as much as possible in their vigor and size to study the effect of foliar spray with mining diatoms that analysis is Table 1 or GA_3.

All devoted trees received regularly the same horticultural practices (fertilization, irrigation, pest control, pruning etc.,) adopted in Ministry of Agriculture and Land Reclamation. The randomized complete block design with three replications (each replicate was represented by a single tree) was used for arranging the following Thirty - nine spray treatments:

T1 - Control (spraying with water only).
T2 - Diatoms at 0.50kg /600 L during 25 % of full-bloom.
T3 - Diatoms at 0.50kg /600 L during 75 % of full-bloom.
T4 - Diatoms at 0.50kg /600 L twice during (25% and 75%) of full-bloom.
T5 - Diatoms at 0.75kg/600 L during 25 % of full-bloom.
T6 - Diatoms at 0.75kg/600 L during 75 % of full-bloom.
T7 - Diatoms at 0.75kg/600 L twice during (25% and 75%) of full-bloom.
T8 - Diatoms at 1.00 kg/600 L during 25 % of full-bloom.
T9 - Diatoms at 1.00 kg/600 L during 75 % of full-bloom.
T10- Diatoms at 1.00 kg/600 L twice during (25% and 75%) of full-bloom.
T11- GA_3 at 25 ppm during 25% of full-bloom.
T12- GA_3 at 25 ppm during 75% of full-bloom.
T13- GA_3 at 25 ppm twice during (25% and 75%) of full-bloom.

Mining diatoms extract: Preparing the desired rate by de-solving the fine powder in a suitable volume of tap-water water, then added to the tank of spraying machine.

GA_3 solution: To prepare the desired concentration by de-solving 1 g of a fine powder gibberline in 1L distilled water and kept at low temperature (4°C) till used. Triton B at 0.1% - as a wetting agent- was used with each treatment including that control. Taking into consideration,

TABLE 1. Diatoms analysis

Elements contents* %		Amino-acids* ppm		Organic acids* ppm		Hormones contents Ug/100g**	
SiO_2	46.56	L.Alanine	0797.77	Tartaric	000383.39	GAA	---
TiO_2	0.35	L.Glycine	0217.83	Citric	114390.25	IAA	---
Al_2O_2	8.67	L.Glutamine	5097.88	Maleic	000172.62	ABA	---
Fe_2O_3	1.13	L.Glutamine	1339.33	Oxalic	001251.37	Kinetine	---
MnO	0.10	L.Valine	0364.25	Succcinic	006941.25	Zeatin	489.88
MgO	1.64	L.Leucine	0645.35	Fumaric	485839.73		
CaO	16.45	L.Isolucine	0751.70				
Na_2O	0.87	L.Cysteine	0214.57				
K_2O	0.65	L.Proline	0289.54				
P_2O_3	0.26	L.Methionine	1496.87				
SO_3	1.65	L.Aspartic	0609.18				
Cl	0.55	L.Phenylalanine	0675.92				
l.O.i	20.78	L.Arginine	0156.71				
		L.Tyrosine	1599.89				
		L.Threonine	1213.20				
		L.Histidine	0430.24				
		L.Tryptophane	0025.57				
		L.Cysteyn	0008.34				

*Agr. Res. Cent. Soil & Water Unit . Analysis & Studies Component.

that treatments were sprayed at full- bloom stages i.e., just once at 25% or 75% of full - bloom or twice, at 25 and 75 % of full - bloom.

Measurements and analysis:

The effect of the different investigated spray treatments was evaluated through the response of the following measurements:

Growth parameters include: Tree height as well as tree size, expressed as canopy volume, was calculated by the formula: 0.5236 x height x diameter square (Turrell, 1946).

Blooming and fruit set parameters include: Number of leafy and leafless inflorescences and fruit set % four main branches of each tree (limbs/scaffolds) similar in their vigour and well distributed around its periphery (each towards one geographic direction) were carefully selected and labeled at flowers balloon stage "the 1st week of March" for determining the number of leafy and leafless inflorescences and the total number of flowers for each. At mid of June number of fruitlets were determined and fruit set % was calculated as :

$$\text{Fruit set \%} = \frac{\text{Total number of fruitlets}}{\text{Total number of flowers}} \times 100$$

Yield and tree efficiency: Fruit yield was recorded annually. Yield in relation to tree volume was used as a measure of tree efficiency (Tree efficiency as a number and weight of fruits /m^3 canopy of tree (Castle and Philips, 1980).

Fruit quality: Sample of 10 fruits per each replicate was harvested in the 1st week of January to determine the fruit quality as follows:

Fruit physical characteristics: Average of fruit size, the method of determination fruit hardness, fruit shape index and peel thickness.

Fruit chemical characteristics: Juice total soluble solids "TSS", Total acidity "TA.", TSS / Acid Ratio and V. C content as the method described in A.O.A.C. (1960).

Leaf pigments content : Leaf chlorophylls a and b and total carotenoides : Disks (2.5 cm.²/ area) from the third leaf at the top of spring shoot were extracted with dimethyl formamide (D.M.F.) solution [HCON(CH3)2] and placed overnight at cool temperature (5°C).Chlorophyll a and b as well as carotenoids were measured by Spectrophotometer Beckman Du 7400 at wavelengths 663,647 and 470 *MU,* respectively, according to the equation described by Nornai (1982) and calculated as (mg/100g FW) as follows :

Chl. a=12.70 A_{663} – 2.79 A_{647}.

Chl. b = 20.76 A_{647} – 4.62 $A_{663.}$

Total carotenoids = 1000 x A470 -3.72Chl.a -104 Chl. b /229.

Leaf mineral contents: Mature leaves from non-fruiting spring flushes were collected in September 2015 and 2016 , oven dried at 70°C and the wet digestion using sulfuric acid and H_2O_2 was employed due to Chapman and Pratt, (1961) to determine the following mineral elements (macro–elements: N , P , K , Ca and Mg % and micro – elements (ppm):

Total nitrogen by semi-micro kjeldahl method as described by Pregel (1945).

Phosphorus using "Specol" spectrophotometer at 882U.V. according to the method described by Murphy and Riely (1962).

Potassium was determined using Flame photometer according to Brown and Lilleland (1946).

Calcium, magnesium, iron, zinc and manganese were determined using Atomic Absorption Spectrophotometer "Perkin Elmer-3300" alter Chapman and Pratt (1961).

Statistical analysis: Data obtained during each season were subjected to statistical analysis of variance according to Snedecor and Cochran (1980). Means values represented the various investigated treatments were compared at 5% level of significance.

Finally, Economic studies were made at the end of this study to help the procedures for selecting the suitable treatment.

Results

Tree blooming

Number of leafy and leafless inflorescences

In this regard, results presented in Table 2 clear that diatoms or GA_3 foliar applications have insignificant effect on Navel orange inflorescences types when sprayed at tree blooming stage during both studied seasons.

Fruit – setting (%)

Results in Table 2 indicate that spraying diatoms or GA_3 improved Navel orange fruit-set percentage. Moreover, diatoms at 1.00 kg/600L twice during 25&75 % of full-bloom (T10) significantly increased fruit set % compared with the other applications in both seasons while the control treatment recorded the lowest value.

Tree yield:

Referring to data tabulated in Table (2) cleared that diatoms at 1.00 kg/600L during 25&75% of full-bloom (T10) significantly increased both number and weight of fruits / m^3 canopy in compared to other investigated treatments for both studied seasons. Whereas, the control treatment gave the lowest values.

Fruit quality

Physical fruit properties

Fruit shape index

With this respect, results in Table 3) show that Navel orange fruit shape trend for the experimental treatments was "ellipsoid" shape expected diatoms foliar spraying (1.00kg/600L) at 25% of full-bloom (T8) which had "Globose" shape for the two seasons.

Fruit size:

Results in Table 3 clear that diatoms foliar spraying (0.5 kg/600L) at 25% of full-bloom stage (T2) significantly increased fruit size, Whereas, spraying 25ppm GA_3 at 25 % of full-bloom (T11) gave the smallest fruit with insignificant differences with the other GA_3 or diatoms spraying treatments during 75% of full-bloom in both seasons.

Fruit hardness

Results presented in Table 3 reveal that most of experimental foliar applications improved fruit hardness. Moreover, diatoms foliar sprays at 0.75kg/600L during 25 &75 % of full-bloom (T7) significantly increased fruit hardness, while spraying GA_3 at 25 ppm of 75% full-bloom (T12) reduced fruit hardness in both seasons.

Fruit peel thickness

As for the effect of diatoms or GA_3 on Navel orange peel thickness results presented in Table 3 cleared that diatoms foliar spray at 1.00 kg/600L during 25 &75 % of full-bloom (T10) significantly increased fruit peel thickness in both studied seasons. While, GA_3 at 25 ppm applications during 75 % (T12) or twice during 25 & 75 % of full-bloom (T13) and the control treatment had a thinner peel thickness with insignificant differences.

Fruit chemical character :

Juice total soluble solids (TSS) %:

Results in Table 4 illustrate that diatoms foliar spray (1.00kg/600L) at 25% of full-bloom (T8) statistically increase juice TSS% in the two

TABLE 2. Effect of mining diatoms foliar applications on: tree yield efficiency, blooming and fruit- set % of Navel orange trees during the two seasons.

Parameters / Treatments	Tree yield efficiency No./m³		Tree yield efficiency Kg /m³		No. of leafy inflorescences		No. of leafless inflorescences		Fruit set %	
	SI	SII	SI	SII	SI	SII	SI	SII	SI	SII
Control (water)	3.52	3.88	0.65	0.93	31.95	31.95	66.60	64.26	1.00	1.10
0.50 kg Dtm /600L – 25% FB	9.58	10.54	2.49	2.74	32.16	33.38	64.16	67.58	1.50	1.60
0.50 kg Dtm /600L – 75% FB	7.88	8.66	1.89	2.08	34.56	34.56	66.88	61.56	1.70	1.90
0.50 kg Dtm /600L – 25&75 % FB	13.23	14.56	3.17	3.49	39.60	39.60	68.00	62.80	1.70	1.90
0.75 kg Dtm /600L – 25% FB	12.20	13.43	2.44	2.68	32.38	32.38	66.38	63.02	1.70	1.90
0.75 kg Dtm /600L – 75% FB	8.19	9.02	2.05	2.26	33.30	33.30	66.00	60.60	2.00	2.20
0.75 kg Dtm /600L – 25 &75 % FB	15.15	16.67	3.64	4.03	33.21	33.21	63.54	68.90	1.50	1.20
1.00 kg Dtm /600L – 25% FB	9.33	1026	2.05	2.26	37.33	37.33	64.33	69.76	1.40	1.60
1.00 kg Dtm /600L – 75% FB	13.74	15.12	3.02	3.33	34.33	34.33	67.06	62.77	1.40	1.50
1.00 kg Dtm /600L – 25 &75 % FB	20.07	22.08	4.22	4.63	35.21	35.20	66.91	63.60	2.10	2.30
25 ppm GA3 – 25% FB	11.61	12.77	2.56	2.81	39.14	39.14	60.00	64.00	1.60	1.80
25 ppm GA3 – 75% FB	9.11	10.02	2.19	2.4d	31.89	31.89	63.20	60.52	1.60	1.80
25 ppm GA3 – 25 & 75 % FB	12.24	13.47	3.06	3.37	31.11	31.11	67.71	62.48	1.80	2.00
LSD 0.05	1.88	2.06	0.42	0.46	8.22	8.22	8.62	8.48	0.43	0.44

TABLE 3. Effect of mining diatoms foliar applications on fruit shape index, size, hardness & peel thickness of Navel orange trees during the two seasons.

Parameters / Treatments	Fruit shape index		Fruit size (ml.)		Fruit hardness (Lb /F²)		Fruit peel thickness (mm)	
	SI	SII	SI	SII	SI	SII	SI	SII
Control (water)	1.19	1.21	272.22	277.07	10.51	10.72	4.03	4.11
0.50 kg Dtm/ 600L – 25% FB	1.13	1.16	316.67	323.00	12.44	12.69	5.08	5.18
0.50 kg Dtm/ 600L – 75% FB	1.07	1.09	277.22	282.77	12.29	12.54	5.20	5.30
0.50 kg Dtm/ 600L – 25&75 % FB	1.09	1.11	293.89	299.77	12.88	13.14	4.88	4.97
0.75 kg Dtm/ 600L – 25% FB	1.12	1.14	263.89	269.17	13.41	13.67	5.37	5.48
0.75 kg Dtm/ 600L – 75% FB	1.11	1.13	314.44	320.73	13.16	13.43	4.58	4.67
0.75 kg Dtm/ 600L – 25&75 % FB	1.11	1.14	302.22	308.27	10.06	10.26	5.15	5.25
1.00 kg Dtm/600L – 25% FB	0.97	0.99	278.89	284.47	14.10	14.38	4.90	4.99
1.00 kg Dtm/ 600L – 75% FB	1.14	1.16	281.11	286.73	12.67	12.93	4.71	4.79
1.00 kg Dtm/600L – 25&75 % FB	1.11	1.13	285.56	291.27	13.21	13.48	5.48	5.59
25 ppm GA3 – 25% FB	1.11	1.14	258.89	264.07	13.81	14.09	4.99	5.09
25 ppm GA3 – 75% FB	1.06	1.07	278.89	284.47	14.70	15.00	4.11	4.19
25 ppm GA3 – 25&75 % FB	1.09	1.11	283.33	289.00	14.42	14.71	4.53	4.62
L.S.D 0.05	0.14	0.15	29.30	29.89	2.20	2.25	0.63	0.64

seasons. Whereas, spraying GA_3 at 25 ppm during 25&75 % full- bloom gave the lowest percentage.

Juice total acidity (TA)%

Diatoms foliar spraying (1.00kg/600L) at 25% of full-bloom (T8) statistically increased juice TA% in the two seasons Table 4. Diatoms foliar spray 0.5kg/600L at 25% (T2) of full-bloom gave the lowest percentage.

Juice TSS / acid ratio:

In this respect, data presented in Table 4 reveal that diatoms foliar spray 0.75kg/600L at 25% of full- bloom (T5) statistically increased juice TSS/ acid ratio in both seasons in compared to the control which gave the lowest.

Juice V. C content (mg/100g fresh juice):

Results in Table 4 cleared that V. C content gave the same trend of TSS/acid ratio during the two experimental seasons, whereas, diatoms foliar spray 0.75kg/600L at 25% of full-bloom (T5) statistically increase juice V. C for both seasons in compared to the control which was the lowest value.

Leaf pigments content

Leaf total carotenoids:

In spite of, diatoms foliar spray 0.5kg/600L at 25% or 75% (T2 & T3) full-bloom gave the highest leaf total carotenoids content .Nerveless, results presented in Table 5 clear that all experimental treatments have insignificant effect on Navel orange leaves carotene contents in both seasons.

Leaf Chlorophyll a

With regards to Navel orange leaf Chl. a contents, tabulated results in Table 5 indicate that diatoms foliar spray 0.5kg/600L at 75% (T3) full-bloom significantly increased leaf Chl. a contents when compared to the other treatments in this

TABLE 4. Effect of mining diatoms foliar applications on fruit juice "TSS, TA, TSS/acid ratio & V. C" contents of Navel orange trees during the two seasons.

Parameters / Treatments	Juice TSS %		Juice Tot. Ac. %		TSS/acid ratio		V. C. (mg/100g juice)	
	SI	SII	SI	SII	SI	SII	SI	SII
Control (water)	13.00	13.26	1.08	1.10	12.04	12.28	42.75	43.61
0.50 kg Dtm /600L – 25% FB	13.00	13.26	0.91	0.92	14.38	14.67	44.1	44.98
0.50 kg Dtm /600L – 75% FB	14.00	14.28	1.02	1.04	13.73	14.00	48.15	49.11
0.50 kg Dtm /600L – 25&75 % FB	12.50	12.75	0.94	0.96	13.36	13.63	44.55	45.44
0.75 kg Dtm /600L – 25% FB	15.00	15.3	0.99	1.01	15.13	15.43	51.75	52.79
0.75 kg Dtm /600L – 75% FB	13.50	13.77	1.05	1.07	12.85	13.11	51.75	52.79
0.75 kg Dtm /600L – 25&75 % FB	13.50	13.77	1.02	1.04	13.24	13.50	54.00	55.08
1.00 kg Dtm /600L – 25% FB	15.50	15.81	1.14	1.16	13.70	13.98	51.75	52.79
1.00 kg Dtm /600L – 75% FB	15.00	15.3	1.05	1.07	14.29	14.58	51.75	52.79
1.00 kg Dtm /600L – 25&75 % FB	13.50	13.77	1.11	1.13	12.20	12.44	52.2	53.24
25 ppm GA3 – 25% FB	14.00	14.28	0.99	1.01	14.11	14.39	48.6	49.57
25 ppm GA3 – 75% FB	13.00	13.26	0.94	0.96	13.89	14.17	50.85	51.87
25 ppm GA3 – 25&75 % FB	12.00	12.24	0.99	1.01	12.09	12.33	42.75	43.61
L.S.D 0.05	1.310	1.33	0.06	0.06	1.65	1.68	6.13	6.26

study. On the other hand, spraying 25ppm GA_3 at 25% of full- bloom (T11) resulted in the lowest contents, during the two seasons.

Leaf Chlorophyll b

With respect, leaf chl. b results presented in Table 5 reveal that all spraying diatoms or GA_3 treatments under this study have insignificant effect on leaf Chl. b contents. Generally, diatoms foliar spray 0.5kg/600L at 75% of full-bloom (T3) gave the highest values in both seasons, and diatoms foliar spraying (1.00 kg/600L) at 25 &75 % of full-bloom (T10) in the 1st season and the control treatment (T1) in the 2nd season, were the lowest.

Leaf minerals content

Macro nutrients : N:

Concerning leaf N, results in Table 6 disclose that diatoms foliar spray 1.00kg/600L at 25% of full-bloom (T8) statistically increased leaf N % in comparison with the other experimental treatments in this study. Whereas, diatoms foliar spray 0.5kg/600L at 75% full-bloom (T3) gave the lowest values, in both studied seasons.

P:

Results presented in Table 6 show that diatoms foliar spraying (1.00kg/600L) at 25% full-bloom (T8) significantly increased Navel orange leaf P %. Moreover, spraying either 25ppm GA_3 at 25% full-bloom (T11) in the 1st season or diatoms foliar spray 1.00 kg/600L at 75 % full-bloom (T9) in both seasons gave the lowest leaf P %.

K:

Results in Table 6 indicate an insignificant effect of both diatoms and GA_3 experimental treatments in this study on leaf K% in the two seasons. Moreover, diatoms foliar spray 0.50kg/600L at 25 &75 % full-bloom (T4) showed the highest values, while diatoms 0.75kg/600L at 75% full-bloom (T6) induced the lowest in the two seasons.

Ca:

Results presented in Table 6 reveal that the control treatment significantly increased Ca contents in the leaves when compared to diatoms at 0.50kg/600L during 25 &75 % of full- bloom (T4) for both seasons. Whereas, both diatoms foliar spray at 1.00kg/600L during 25% of full-bloom (T8) in the 1st season or at (0.50kg/600L) during 25 &75 % of full-bloom (T4) in the 2nd season gave the lowest values.

Mg:

Results presented in Table 6 indicate that diatoms foliar spray 0.75kg/600L at 25 &75% of full-bloom (T7) significantly increased leaf Mg % during the two successive seasons. Whereas, 0.50kg / 600L at 75% of full-bloom (T3) in the 1st season or diatoms foliar spray 1.00 kg/600L at 25 &75 % of full-bloom (T10) in the 2nd season were the lowest of leaf Mg %.

Leaf micro-nutrient (ppm)

Iron "Fe ":

In this regard results in Table 7 clear that GA_3 at 25 ppm foliar spray during 75% (T12) or at 25&75 (T13) and diatoms "1.00 kg / 600L during 75% (T9) of full-bloom significantly increased Navel orange leaf iron contents when compared to other treatments in this study. Moreover, diatoms "0.50 kg / 600L at 25 & 75% of full-bloom (T4) gave the lowest values.

Zinc " Zn "

With this respect, results in Table 7 showed that insignificant differences in leaf Zn contents under this study during the two seasons.

Manganese " Mn"

Diatoms foliar spray at 1.00kg/600L during 25% of full-bloom (T8) significantly increased Navel orange leaf Mn as ppm (Table 7) when compared to other experimental treatments. On the other hand, spraying GA_3 25 ppm at 25 % of full-bloom statistically reduced it, in both seasons.

Economic studies

In economic studies of yield production, the main economic criteria was cost of each substance (mining diatoms and GA_3) that used under the study (L.E / fed.), cost of such materials that used in control treatment (L.E / fed.). Results are given in Table 8. Other expenses such as the costs of supervision and royalties were not taken into consideration in this study. In more details unit price of mining diatoms was 50.00 L.E / kg, unit price of GA_3 was 10.00 L.E/gm. In consideration, all orchard practical managements were constant during both studied seasons. Moreover, the cost over control for each treatment/Fed. was calculated. As for the yield, net return by L.E. was calculated as the average of 3500 LE./ ton . From this economic study it could be noticed that, increasing the final cost of mining diatoms and GA_3 as comparison with the conventional production (control treatment).

TABLE 5. Effect of mining diatoms or GA_3 foliar applications on leaf total Carotenoids, Chl. a. and Chl. b. contents of Navel orange trees during the two seasons.

Parameters / Treatments	Tot. carotenoids (mg/100gf.wei.)		Chl. a (mg/100gf.wei.)		Chl. b (mg/100gf.wei.)	
	SI	SII	SI	SII	SI	SII
Control (water)	1.87	1.90	0.40	0.41	1.06	1.08
0.50 kg Dtm /600L – 25% FB	2.05	2.10	0.52	0.53	1.28	1.31
0.50 kg Dtm /600L – 75% FB	2.11	2.15	0.60	0.61	1.40	1.42
0.50 kg Dtm /600L – 25&75 % FB	1.98	2.02	0.47	0.48	1.18	1.20
0.75 kg Dtm /600L – 25% FB	1.98	2.02	0.47	0.47	1.18	1.21
0.75 kg Dtm /600L – 75% FB	1.89	1.93	0.41	0.42	1.09	1.11
0.75 kg Dtm /600L – 25&75 % FB	1.94	1.97	0.45	0.45	1.15	1.17
1.00 kg Dtm /600L – 25% FB	1.94	1.98	0.44	0.45	1.15	1.17
1.00 kg Dtm /600L – 75% FB	1.88	1.92	0.43	0.43	1.10	1.21
1.00 kg Dtm /600L – 25&75 % FB	1.78	1.81	0.39	0.39	1.01	1.03
25 ppm GA3 – 25% FB	1.79	1.82	0.38	0.39	0.10	1.02
25 ppm GA3 – 75% FB	2.02	2.06	0.49	0.50	1.24	1.27
25 ppm GA3 – 25&75 % FB	1.97	2.01	0.46	0.47	1.19	1.21
L.S.D 0.05	0.65	0.66	0.09	0.09	0.53	0.54

TABLE 6. Effect of mining diatoms foliar applications on leaf (N,P,K,Ca& Mg) % of Navel orange trees during the two seasons.

Parameters / Treatments	N %		P %		K%		Ca %		Mg%	
	SI	SII	SI	SII	SI	SII	SI	SII	SI	SII
Control (water)	1.80	1.98	0.02	0.03	1.80	1.98	3.51	3.86	1.77	1.95
0.50 kg Dtm /600L – 25% FB	2.00	2.20	0.03	0.03	2.00	2.20	3.02	3.33	1.61	1.77
0.50 kg Dtm /600L – 75% FB	1.20	1.32	0.04	0.04	1.80	1.98	3.32	3.65	1.04	1.14
0.50 kg Dtm /600L – 25&75 % FB	1.60	1.76	0.05	0.05	2.10	2.31	2.72	2.10	1.65	1.81
0.75 kg Dtm /600L – 25% FB	1.80	1.98	0.03	0.03	1.70	1.87	3.57	3.92	1.40	1.54
0.75 kg Dtm /600L – 75% FB	1.80	1.98	0.03	0.03	1.60	1.76	3.28	3.61	1.66	1.82
0.75 kg Dtm /600L – 25&75 % FB	1.80	1.98	0.04	0.05	2.00	2.20	3.22	3.54	1.79	1.96
1.00 kg Dtm /600L – 25% FB	2.20	2.42	0.05	0.05	2.00	2.20	2.68	2.95	1.21	1.33
1.00 kg Dtm /600L – 75% FB	1.40	1.54	0.02	0.02	1.80	1.98	3.25	3.57	1.75	1.92
1.00 kg Dtm /600L – 25&75 % FB	2.00	2.20	0.03 abcxd	0.03	1.70	1.87	3.49	3.83	1.02	1.12
25 ppm GA3 – 25% FB	2.00	2.20	0.01	0.01	2.00	2.20	3.52	3.87	1.04	1.14
25 ppm GA3 – 75% FB	2.00	2.20	0.03	0.03	1.80	1.98	3.25	3.58	1.08	1.19
25 ppm GA3 – 25&75 % FB	1.40	1.54	0.03	0.03	1.90	2.09	3.18	3.49	1.60	1.76
L.S.D 0.05	0.30	0.34	0.03	0.027	0.69	0.76	0.71	0.78	0.21	0.23

TABLE 7. Effect of mining diatoms foliar applications on leaf "Fe , Zn & Mn " ppm of Navel orange trees during the two seasons .

Parameters / Treatments	Fe ppm		Zn ppm		Mn ppm	
	SI	SII	SI	SII	SI	SII
Control (water)	90.00	99.00	146.00	160.60	123.00	135.30
0.50 kg Dtm /600L – 25% FB	81.00	89.10	143.00	157.30	136.00	149.60
0.50 kg Dtm /600L – 75% FB	81.00	89.10	152.00	167.20	117.00	128.70
0.50 kg Dtm /600L – 25&75 % FB	51.00	56.10	152.00	167.20	113.00	124.30
0.75 kg Dtm /600L – 25% FB	81.00	89.10	146.00	160.60	120.00	132.00
0.75 kg Dtm /600L – 75% FB	64.00	70.40	143.00	157.30	118.00	129.80
0.75 kg Dtm /600L – 25&75 % FB	94.00	103.40	147.00	161.70	129.00	141.90
1.00 kg Dtm /600L – 25% FB	89.00	97.90	144.00	158.40	179.00	196.90
1.00 kg Dtm /600L – 75% FB	107.00	117.70	152.00	167.20	140.00	154.00
1.00 kg Dtm /600L – 25&75 % FB	88.00	96.80	144.00	158.40	131.00	144.10
25 ppm GA3 – 25% FB	71.00	78.10	141.00	155.10	97.00	106.70
25 ppm GA3 – 75% FB	127.00	139.70	143.00	157.30	111.00	122.10
25 ppm GA3 – 25&75 % FB	119.00	130.90	145.00	159.50	107.00	117.70
L.S.D 0.05	30.90	33.99	25.67	28.24	19.25	21.17

TABLE 8. Economic study for using mining diatoms and GA_3 in compared to the control treatment application on yield of Navel orange trees (average of the two seasons).

Parameter / Treatments	Treat. average cost (L.E/Fed)	Average yield for two seasons. Ton/fed.	Yield over control Ton/fed.	Yield over control price L.E	Net Profit / Fed. L.E
Control (water)	0.00	7.74	0.00	0.00	27090.00
0.50 kg Dtm /600L – 25% FB	50	10.48	2.74	9590.00	36630.00
0.50 kg Dtm /600L – 75% FB	50	9.15	1.41	4539.00	31975.00
0.50 kg Dtm /600L – 25&75 % FB	100	14.04	6.30	22050.00	49040.00
0.75 kg Dtm /600L – 25% FB	75	11.60	3.86	12880.00	40525.00
0.75 kg Dtm /600L – 75% FB	75	10.43	2.69	9415.00	36430.00
0.75 kg Dtm /600L – 25&75 % FB	150	16.19	8.45	29575.00	56515.00
1.00 kg Dtm /600L – 25% FB	100	9.11	1.39	4865.00	31785.00
1.00 kg Dtm /600L – 75% FB	100	13.42	5.68	19880.00	46870.00
1.00 kg Dtm /600L – 25&75 % FB	200	18.30	10.56	36960.00	63850.00
25 ppm GA3 – 25% FB	300	11.28	3.54	12390.00	39180.00
25 ppm GA3 – 75% FB	300	10.40	2.66	9310.00	36100.00
25 ppm GA3 – 25&75 % FB	600	14.69	6.95	24325.00	50815.00

Finally, the price of mining diatoms is usually lower than the price of GA_3 and more net profit return for producers , safe food and gave a high fruit quality.

Discussions

It well known, that algal extract (SWE) and PGR's have been used for several decades to enhance plant growth and productivity, through the development of non- pollution organic bio-stimulants which increase plant growth, vigor, crop yield and quality through increasing efficiency of nutrients and water uptake.

Therefore these results are in line with those obtained by Abd El-Motty et al. (2010) who stated that "spraying Keitte mango trees once at full bloom with algae at 2% combined with yeast at 0.2% was very effective in improving :fruit set, fruit retention and yield as number of fruits or weight (kg) / tree, increased fruit-length (cm), fruit width (cm), fruit weight (g), enhanced total soluble solids (T.S.S.), reduced fruit drop and fruit peel weight, improved nitrogen , potassium and boron contents in the leaves and had no effect on leaf phosphorus percentage".

Jaswant et al. (1994) demonstrated that algae extract has a positive effect on fruit setting, yield and fruit quality.

Abd El- Migeed et al. (2004) and Spinelli et al. (2009) illustrated that algae extract as a new bio fertilizer containing N, P,K, Ca, Mg, and S as well as Zn, Fe, Mn, Cu, Mo, and Co, some growth regulators, polyamines and vitamins was applied to improve nutritional status, vegetative growth, yield and fruit quality in different orchard as well as vineyards.

Jensen (2004) stated that "application of seaweed extract which is rich in macro and micro elements, important plant hormones like auxins, gibberellins and cytokinin, which induce cell division, increase cell enlargement and lead to balance of physiological and biological processes, increase photosynthesis processes and improve growth characters".

Shoeib and El-Sayed (2003) and El-Shewy (1999) who observed that 50 mg NAA and 50 mg GA_3 per litre at full bloom and three months after the first spray were most effective treatments in reducing pre harvest fruit drop as well as fruit seed contents in guava.

Verkleij, (1992) mentioned that seaweed extract (SWE) contains essential nutrients, several organic compounds, enzymes, vitamins and natural hormones.

However, Berlyn and Russo, (1990) cleared that seaweed extract (SWE) promoting yield, uptake of nutrients, and resistance of plants to most stresses and the incidence of fungal and insect attack.

In addition, Kullk, (1995), Dahama, (1999), Norric et al. (2002) and Chouliaras et al. (2005) indicated that seaweed extract was responsible for enhancing growth, uptake of nutrients, resistance of plants to un-favourable stresses, soil fertility and microbial activity. It acts as chelated compound and soil conditioners.

Also, Aziz et al. (2003), Ebeid-Sanaa, (2007) and El-Sayed - Esraa, (2010) reported that spraying seaweed extract was very effective in promoting growth and fruiting of different evergreen fruit crops.

Conclusion

Generally, it can be concluded that spraying algal extracts or GA_3 consider as one of the factors that helps the plant to withstand environmental stress. Thus, spraying of diatoms or GA_3 on Navel orange trees during different full- blooming levels improved: fruit setting, leaf minerals content, tree yield efficiency and fruit quality. Thus, diatoms foliar spray at 1kg/600L during both 25 & 75 % of full-bloom was more effectiveness on tree yield efficiency and fruit quality parameters in this study.

In additions, the price of mining diatoms is usually lower than the price of GA_3 and more net profit return for producers, safe food and gave a high fruit quality.

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تأثير اضافة الدياتومات المنجمية والجبرالين على آداء أشجار البرتقال بسرة .

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أجريت هذه الدراسة خلال موسمين متعاقبين (٢٠١٦/٢٠١٥ و ٢٠١٧/٢٠١٦) علي أشجار البرتقال بسرة النامية في تربة رملية / طينية وتروي بماء النيل "ري غمر" في حديقة خاصة بمركز قليوب التابع لمحافظة القليوبية – مصر. تهدف هذه الدراسة الي معرفة مدي تأثير رش الأشجار بالدياتومات المنجمية بمعدل ٠,٥ كجم او ١ كجم/٦٠٠ لتر ماء او بالجبرالين بتركيز ٢٥ جزء/مليون، تمت الاضافة رشا علي الأشجار عند ٢٥ او ٧٥٪ من تمام تفتح الازهار أو في كلا المرحلتين علي: نوع النورات الزهرية، نسبة العقد، محتوي الاوراق من (الصبغات النباتية والعناصر الغذائية الكبري والصغري)، كفاءة الاثمار (عددا أو وزنا) وبعض صفات الجودة المتعلقة بمثل هذه المعاملات.

وجاءت نتائج الدراسة كالتالي:
رش الاشجار بالدياتومات المنجمية بمعدل ١ كجم/٦٠٠ لتر ماء مرة واحدة أو مرتين عند ٢٥٪ و٧٥٪ من تفتح الازهار كان اكثر المعاملات تأثيرا حيث ادي الي زيادة في: نسبة العقد، محتوي الأوراق من العناصر المعدنية، والمحصول عددا ووزنا وصفات الجودة تحت الدراسة (صلابة الثمرة وزيادة حجمها ومحتوي العصير من المواد الصلبة الذائبة الكلية مع تقليل نسبة الحموضة وزيادة في النسبة بينهما مما يعني التبكير في الحصاد مع تقليل وزن القشرة) .

رش الأشجار بالدياتومات المنجمية بمعدل ٠,٥ كجم/٦٠٠ لتر عند ٧٥٪ تفتح أزهار ادي الي زيادة معنوية في الصبغات المرتبطة بعملية التمثيل الضوئي .

كذلك كان للرش بالجبرالين بتركيز ٢٥ جزء/مليون عند ٧٥٪ تفتح ازهار اثره الجيد في تحسن مستوي الحديد بالأوراق وزيادة محتوي العصير من فيتامين ج وزيادة صلابة الثمار التي قد ترجع الي تأخر النضج .
من ناحية أخري لم يكن هناك تأثيرا واضحا لهذه المعاملات علي محتوي الأوراق من البوتاسيوم والزنك بالاضافة الي عدد كلا النوعين من النورات الزهرية .

التوصية : في ضوء ما تم التوصل اليه من نتائج مؤكدة معنويا يوصي : - بالرش بالدياتومات المنجمية بمعدل ٠,٥ كجم/٦٠٠ لتر ماء عند ٧٥٪ تفتح أزهار او ١ كجم/٦٠٠ لتر ماء مرتين الأولي عند ٢٥٪ والثانية عند ٧٥٪ تفتح ازهار وهذه المعاملة هي الأفضل .
كذلك بالرش بالجبرالين بتركيز ٢٥ جزء/ مليون عند ٧٥٪ تفتح ازهار لما حققه من نتائج جيدة لنسبة العقد وبعض صفات الثمار تحت الدراسة.
وبناءا علي ما تم التوصل اليه من تحليل اقتصادي لنتائج هذه الدراسة اتضح ان استعمال مستخلص الدياتومات المنجمية بتركيز ١ كجم/٦٠٠ لتر مرتين عند ٢٥ و ٧٥٪ من التفتح الكامل لازهار البرتقال ابو سرة كان الانسب والافضل من حيث انخفاض التكلفة وتحقيق افضل عائد مادي للمنتج .