https://doi.org/10.30799/jespr.122.18040104 J. Environ. Sci. Pollut. Res. - Volume 4 Issue 1 (2018) 250–252

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ISSN: 2455-0272

Effect of Foliar Application with Algae Extracts on Fruit Quality of Sour Orange, *Citrus aurantium, L.*

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ARTICLE DETAILS

Article history:
Received 10 March 2018
Accepted 29 March 2018
Available online 09 April 2018

Keywords:
Sour Orange Trees
Algae
Fucox
Ecklonia

ABSTRACT

This investigation was conducted during 2015 season on the local sour orange trees, *Citrus aurantium* L., grown in clay soil, under date palm trees and surface irrigation system of a private orchard located about 16 km to the north of Najaf city, Iraq. Twelve years old sour orange trees were sprayed twice, on 1st October and 1st November 2015, with two types of algae extracts, Fucox and Ecklonia, at 0, 1, 2, 3% of each to study their separate influences on some physical and chemical characteristics of fruit. Results showed that spraying trees twice, after fruit-set were effective in enhancing fruit length, fruit width, fruit size, fruit fresh weight, peel thickness , the percentages of, fruit moisture, fruit juice, fruit peel, peel moisture, ascorbic acid (C vitamin) and total soluble solid (T.S.S.). Moreover, they reduced each of the acidity and carotene content. Treatments had a significant effects in comparison with the control, especially with Fucox at 3% which gave the best results for the study.

1. Introduction

Citrus is a genus of flowering plants belonging to the Rutaceae family. A number of studies report that citrus originated from Southeast Asia, bordered by Northeast India, Burma, and Yunnan (China), but the most recent research indicates an origin in Australia, New Caledonia and New Guinea [1]. Citrus plants include sweet orange, mandarin, sour/bitter orange, lemon, lime, grapefruit, and pummelos [2] which are economically important for edible fruits, drugs, aromatic leaves with oil glands, essential oil and perfume. Citrus fruits contain compounds called flavonoids, which may have anticancer properties [3]. Also they are high in C vitamin, which is a powerful antioxidant and protects the body from damaging free radicals, and good sources of foliate and thiamin [4-6].

Sour orange, also known as Bitter orange, Seville orange, Bigarade orange, or Marmalade orange, refers to a tree *Citrus aurantium*, L. Most fruit trees are frequently exposed to various abiotic stresses during their lifetime that limit crop yield. To solve this problem, modern fruit tree physiology is currently focused, among others, on the agriculture bio-stimulants. The large number of publications cited for each category of bio-stimulants demonstrates that there is growing scientific evidence supporting the use of bio-stimulants as agricultural inputs on diverse plant species [7]. The European bio-stimulants industry council (EBIC) defined that "Agricultural bio-stimulants act on the physiology of the plant through different pathways to improve crop vigour, yields, quality and post-harvest shelf life/conservation [8]. A bio-stimulant is an organic material that, when applied in small quantities, enhances plant growth and development such that the response cannot be attributed to the application of traditional plant nutrients [9]. They include diverse formulations of compounds, substances and other products, such as microorganisms, trace elements, enzymes, plant growth regulators and macro-algal extracts. One of the main major categories of plant bio-stimulants is seaweed extracts and botanicals that applied to plants or soils to regulate and enhance the crops physiological processes, thus making them more efficient [10].

Seaweeds or algae extracts include green, brown and red marine macro-algae, and Brown seaweed extracts are widely used in horticulture crops. The composition of seaweed extracts strongly depend on the raw material ,geographical location of harvested algae and algal species, as well as on the extraction method, the biologically active compounds which are transferred from the biomass of algae to the liquid phase include polysaccharides, proteins, polyunsaturated fatty acids, pigments, polyphenols, minerals, plant growth hormones and other. They have beneficial effect on humans, animals and plants, mainly by protection of an organism from biotic and abiotic stress and have various commercially valuable products such as pharmaceutical and cosmaceutical compounds, plant growth promoters, Nitrogen fixers, bio-energy and functional foods [11-13]. Seaweeds have a high concentrations of essential vitamins, trace elements, proteins, lipids, polysaccharides, enzymes, and minerals as compared to terrestrial foodstuffs. These plants have been a source of food, fodder, medicine, cosmetics, energy, fertilizer and are used for industrial production of agar and alginate [14].

Recently, researches have shed light on the possible molecular mechanisms activated by seaweed extracts [15]. The beneficial effect of seaweed extract application is as a result of many components that may work synergistically at different concentrations, although the mode of action still remains unknown [16]. They act as bio-stimulants mostly due to the presence of plant hormones, and the main phyto-hormones identified in seaweed extracts are: auxins, cytokinins, gibberelins, abscisic acid and ethylene [17, 18]. In general, seaweed extracts are capable of inducing an array of physiological plant responses, such as promotion of plant growth, improvement of flowering and yield, enhance quality of products, and improve nutritional content of edible product as well as shelf life. Brown seaweeds, phaeophyta, are some of the most commonly used for the commercial manufacture of extracts for applications in agriculture and horticulture. Amongst the brown seaweeds, *Ascophyllum nodosum*, *Ecklonia maxima*, *Macrocystis pyrifera* and *Durvillea potatorum* are the most frequently commercially used by the extract industries [19].

Many researchers studied the possibility of using algae extracts for improving growth and productivity of citrus fruits. Hegab et al. reported that algae extract has a positive effect on fruit setting, yield and fruit quality of balady orange trees [20]. Hassan et al. showed that algae extract application was very effective in promoting growth and fruiting of balady orange trees [21]. Ahmed et al. mentioned that treating valencia orange trees four times with roselle, turmeric and seaweed extracts either alone or in double and triple applications was significantly favourable in improving fruit quality in terms of increasing fruit weight, T.S.S%, total and reducing sugars% and vitamin C content and reducing total acidity% in relative to the check treatment [22]. Salama found that foliar spray of algae extract and/or combined with zinc sulfate enhanced yield and fruit quality of orange tree cv. valencia [23]. Moreover, previous studies emphasized the beneficial effects of using algae extracts on growth and fruiting of other fruit crops such as mango [24-26], apple [27], pear [28,

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https://doi.org/10.30799/jespr.122.18040104

29], date palm [30], banana [31], olive [32], peach [33], fig [34], grapevines [35-37], strawberry [38, 39] and all gave positive effect in connection with the enhancing fruits quality.

The aim of this study is to evaluate the influence of foliar application of two algae, Ecklonia and Fucox, extracts on physical and chemical characteristics of sour orange fruit under clay soil conditions of Abbasiyah district.

2. Experimental Methods

This study was carried out during the season 2015 on twelve years old trees of local sour orange, *Citrus aurantium,* L., grown in clay soil, under date palm trees and surface irrigation system of a private orchard located about 16 km to the north of Najaf city, Iraq. Twenty-one selected trees were uniform in vigor as possible, fertilization program and other agricultural practices were the same for all trees. Randomized complete block design (RCBD) was used for arranged the treatments, and the results were statistically analyzed according to LSD test at the probability level of 5% [40]. While each of the following treatment was replicated three times using one tree/plot. Therefore the experiment included the following seven treatments:

1. Control, spraying with water only.
2. Ecklonia extract spraying at 1%
3. Ecklonia extract spraying at 2%
4. Ecklonia extract spraying at 3%
5. Fucox extract spraying at 1%.
6. Fucox extract spraying at 2%
7. Fucox extract spraying at 3%.

Tween 20 as a wetting agent was added at 0.1% for all spraying treatments. All trees were sprayed twice with treatments, until the run off point, on 1st September and 1st November 2015, after set of fruit. Algae, Ecklonia and Fucox, extracts produced by Green River company, India and their composition illustrated in Table 1 and 2.

Table 1 Chemical composition of algae, Ecklonia, extract

Substance	Concentration	Substance	Concentration
Auxin (IAA)	11 mg/L	Potassium (K)	2%
Cytokinins (CKs)	31 mg/L	Magnesium (Mg)	2%
Amino acids	3%	Iron (Fe)	2%
Organic nitrogen	2%	Zinc (Zn)	2%
Phosphors (P)	3%	Organic acids	50%
Organic matters	12%	-	--

Table 2 Chemical composition of algae, Fucox, extract

Substance	Concentration	Substance	Concentration
Fucoxanthin pigment	70 mg/L	Vitamin C	9 mg/L
Riboflavin	30 mg/L	Organic Matter	35 mg/L
Fucoidan	23 mg/L	Amino Acids	6%
Methyl puntosan	20 mg/L	Organic N	3%
Auxin , IAA	20 mg/L	Potassium (K)	3%
Mannitol	15 mg/L	Iron (Fe)	2% mg/L
Alginic acid	2%	Magnesium	2%
Cytokinins	35 mg/L	Copper(Cu)	2%
Oligosacchrides (CKs)	90 mg/L	Phosphor(P)	2%

At harvest, on 1 December 2015, twenty fruits were taken from each treated tree for determination of the following physical and chemical characteristics.

2.1 Physical Properties

Comprise of average of fruit fresh weight (g) fruit size (cm_3), fruit length(cm), fruit width (cm), peel thickness (mm), were measured by a Varner caliper, fruit juice percentage, and peel percentage.

2.2 Chemical Properties

Include fruit moisture (%), fruit peel moisture (%), (TSS) total soluble solids (%) which determined by Hand refractometer, acidity (%) as g. citric acid/100 g, C vitamin or ascorbic acid (mg ascorbic acid/100 mL juice) and carotene pigment in fruit peel (mg/ 100 g) according to AOAC [41].

3. Results and Discussion

3.1 Fruit Length, Width, Size, and Fresh Weight

It is clear from the data in Table 3 that spraying Sour orange trees twice after fruit- set with the Ecklonia and Fucox extracts each at 1%, 2%, and 3% concentration caused a significant promotion on fruit quality in terms of increasing fruit length and width, fruit size, and fruit fresh weight, compared with the control treatment. However, 3% Fucox extract treatment produced the highest values of fruit length 78.78 mm, width 80.79 mm, size 95.33, and weight 99.61, against 66.60, 68.85, 78.33 and 90.30 for the control treatment at the harvest, respectively.

Table 3 effect of Eklonia, and Fucox extracts application on some physical characteristics of sour orange fruit

Parameters	Fruit length (mm)	Fruit width (mm)	Fruit size (cm^3)	Fruit fresh weight (g)	Fruit Juice (%)	Fruit Peel (%)	Fruit Peel thickness (mm)
Control	66.60	68.85	78.33	90.30	42.51	28.75	3.39
Ecklonia extract (1%)	69.79	70.61	80.22	91.45	43.64	30.71	3.57
Ecklonia extract (2%)	74.18	75.50	86.67	92.67	44.80	31.16	3.71
Ecklonia extract (3%)	75.08	76.85	89.90	92.15	46.84	33.42	3.86
Fucox extract (1%)	73.70	72.63	82.49	91.76	44.26	31.03	3.75
Fucox extract (2%)	76.42	78.75	90.33	94.90	46.66	33.25	3.97
Fucox extract (3%)	78.78	80.79	95.33	99.61	48.95	36.83	4.11
L.S.D. = 0.05	2.09	1.87	1.60	0.99	1.01	1.01	0.09

3.2 Percentages of Fruit Juice, Fruit Peel, and Peel Thickness

The findings in Table 3 illustrate that, Eklonia and Fucox, extracts treatments gave high values of fruit juice percentage, fruit peel percentage, and peel thickness as compared with the control treatment. While, 3% Fucox extract treatment gave the high significant values run to 48.95% fruit juice, 36.83% fruit peel, and 4.11mm peel thickness, against 42.51%, 28.75%, and 3.39 mm for the control treatments at the harvest, respectively.

3.3 Percentages of Peel Moisture, Total Soluble Solids, and Fruit Moisture

It is evident from Table 4 that the percentages of fruit moisture, peel moisture, and total soluble solids (TSS) were significantly affected by all treatments. Spraying Sour orange trees with Eklonia or Fucox extracts enhanced fruit moisture (%), total soluble solids (%), peel moisture (%) as compared with the control treatment. Furthermore, Fucox extract treatment at 3% gave the highest percentages mark 53.12% peel moisture, 11.96% total soluble solids, and 80.64% fruit moisture against 47.30%, 10.14%, and 73.15% for control at the harvest, respectively.

Table 4 effect of Eklonia and Fucox extracts application on some chemical characteristics of sour orange fruit

Parameters	Peel Moisture (%)	Total soluble solids (%)	Acidity (%)	Ascorbic acid (mg/100 cm^3)	Fruit Moisture (%)	Peel carotene (mg/100 g)
Control	47.30	10.14	2.50	45.19	73.15	195.78
Ecklonia extract (1%)	48.75	10.30	2.019	47.26	74.45	193.45
Ecklonia extract (2%)	49.69	10.81	1.92	48.64	74.67	192.89
Ecklonia extract (3%)	51.83	10.98	1.58	49. 09	76.15	190.42
Fucox extrac (1%)	49.22	10.43	1.81	46.71	75.76	191.90
Fucox extract (2%)	51.98	10.85	1.67	48.50	78.90	190.17
Fucox extract (3%)	53.12	11.96	1.40	50.47	80.64	188.23
L.S.D = 0.05	1.15	0.12	0.17	0.89	0.62	1.24

3.4 Acidity Percentage, Ascorbic Acid and Peel Carotene Contents

Data in Table 4 indicates that Eklonia and Fucox extracts treatments significantly reduced the values of acidity percentage and carotene

https://doi.org/10.30799/jespr.122.18040104

content. However, they significantly increased the ascorbic acid content as compared with control. These reductions of acidity and carotene contents or increase of ascorbic acid content were extremely correspond with increases of algae extracts concentrations. Therefore, 3% fucox extract treatment was the lowest values in acidity or carotene content, and the highest value in ascorbic acid content, run to 1.40% acidity 188.23 mg peel carotene, and 50.47 mg ascorbic acid against 2.50%, 195.78 mg and 45.19 mg for control at the harvest, respectively.

The positive influences of algae extracts on the fruit quality may be as a result of their contents of nutrients, vitamins, and growth regulators etc. which are acting to enhance growth and nutritional status of the trees, and ultimately reflected on improving the quality of fruit and their physical-chemical properties [20-39]. Algae extracts are the most popular growth regulators which contain high levels of plant hormones, in particular cytokinins, polysaccharides, amino acids and macro- and micro-elements necessary for plants to grow and develop [42].

The obtained results of spraying sour orange trees with algae extracts are in agreement with the findings of other published workers on citrus. Various researchers reported that algae extract have a positive effect on fruit quality of Balady orange trees [20, 21]. Ahmed et al. mentioned that treating valencia orange trees with roselle at 0.2%, turmeric at 0.1% and seaweed extracts at 0.2 either alone or in double and triple applications was significantly favourable in improving fruit quality in terms of increasing fruit weight, T.S.S%, and reducing sugars% and vitamin C content and reducing total acidity% in relative to the check treatment [22]. Salama found that spraying Valencia orange trees with algae extracts treatments, especially at 2% increased fruit weight, fruit size, fruit length and diameter, peel thickness, percentage of juice, ascorbic acid content, percentage of total soluble solid, high reduction of acidity [23].

Moreover, the obtained results of this study in respect of spraying sour orange with algae extracts also, in harmony with the findings of other fruits species applied on mango [24-26], apple [27], Pear [28, 29], date palm [30], banana [31], olive [32], peach [33], fig [34], grapevine [35-37], and strawberry [38, 39].

4. Conclusion

From the results, it could be concluded that spraying sour orange trees, (grown under clay soil, and surface irrigation system conditions) with Eklonia and Fucox extracts twice at 1, 2, 3% after fruit-set were improved fruit quality due to enhancing fruit-length, width, fresh weight, size, the percentages of fruit moisture, fruit-juice, peel moisture, fruit-peel, total soluble solids , ascorbic acid content in juice, peel thickness, While they reduced fruit acidity percentage, and carotene content of the peel comparing with the control, especially with Fucox treatment at 3% which gave the best results for the study.

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https://doi.org/10.30799/jespr.122.18040104

Cite this Article as: Md. A.H.M. Al-Musawi, Effect of foliar application with algae extracts on fruit quality of sour orange, *Citrus aurantium, L.*, J. Env. Sci. Pollut. Res. 4(1) (2018) 250–252.