

Effect of Foliar Application with Algae and Plant Extracts on Growth, Yield and Fruit Quality of Fruitful Mango Trees Cv. Fagri Kalan

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Abstract

An experiment was conducted during two successive seasons 2013 and 2014 on mango trees cv. Fagri Kalan to study the effect of foliar spray with some extracts (algae at 2%, roselle at 10% and garlic at 5%) applied four times along each season (at full bloom, fruit set, one and two months later from fruit set) either each extract was sprayed solely or in different combinations each other. The influence was evaluated through the response of leaf N, P, K content, vegetative growth, yield and some fruit physical and chemical characteristics of mango cv. Fagri Kalan.

The obtained results showed that, spraying algae extract at 2% either alone or combined with one of two plants extracts (10% roselle and 5% garlic) particularly both plant extracts together surpassed in most cases other investigated spray treatments for improving most measurements of fruiting (fruit set, retention, yield and fruit quality), vegetative growth, and nutritional status, (leaf N, P and K content). Besides, roselle and garlic extracts spray had also a noticeable positive effect particularly on some fruit physical and chemical characteristics. Therefore, algae and investigated two plants extracts could be safely recommended as a natural biostimulants application for improving most desirable measurements of mango trees cv. Fagri Kalan grown under the same experimental condition.

Keywords: Mango; Algae; Roselle; Garlic; Yield; Fruit quality; Vegetative growth

Introduction

Mango (*Mangifera indica* L.) belongs to the family Anacardiaceae considered as one of the most important fruits of the tropical and subtropical countries of the world. It grows under a wide range of climatic and soil conditions. In Egypt, mango ranks the third after citrus and grapes, whereas its total area of fruitful orchards reached approximately 101303 ha producing about 712537 tons annually [1]. However, lower yield with poor quality is one of the main problems facing mango growers in the new reclaimed lands particularly under sandy soil conditions. This may be attributed to the relative lower and/or the complete lacking of such nutrient and essential elements. Meanwhile, various trials were done to raise the productivity and fruit quality of much fruit species by the wasteful use of chemical fertilizers especially mineral ones. For avoiding the excessive use of the mineral chemical fertilizers and their harmful effect particularly on human health consequently using of some natural biostimulants such as plants and algae extracts that characterized by their richer contents with nutrient elements, growth regulators, antioxidants and vitamins were investigated for being applied as an effective nutritive application that could be replace partially or completely the aforesaid harmful ones.

Algae extract as a new biofertilizer containing some macro and micro nutrients i.e. (N, P, K, Ca, Mg and S) and (Zn, Fe, Mn, Cu, Mo and Co) as well as some growth regulators, polyamines and vitamins required to be applied for improve nutritional status, vegetative growth, yield and fruit quality in different fruits orchards [2-4].

Roselle (*Hibiscus sabdariffa* L.) belongs to the family Malvaceae. The edible portion is not flowers but calyces. Roselle main ingredients are vitamins C, A, D, B1 and B2, antioxidants, anthocyanins, Fe, Mg and omega3 beta-carotene (Bruneton, 2001). Furthermore, using extracts of roselle improve the nutritional status and yield as well as some physical and chemical characteristics of Valencia orange fruits. The beneficial effects of roselle extracts on building plant pigments and organic foods surely reflected on advancing maturity and improving fruit quality [5].

Garlic (*Allium sativum*) extract contains enzymes and more than 200 chemical compounds, some of its volatiles are more important i.e. Allicin that gives garlic its antibiotic properties. Its higher contents of volatile and sulphur compounds put both in the top due to their real and essential roles they play in fruiting process of various fruit crops [6-8]. Garlic also contains vitamins, minerals, flavonoids, ascorbic acid, sulphur and trace of iodine. Seventeen amino acids are found in garlic, including eight essential ones. Effect of garlic extract on plant characters has been interpreted by Sayeeda and Ahmed [9] and El-Shayeb [10]. They reported that garlic extract showed comparatively greater efficacy on promoting growth and nutrition status of groundnut. Abbas et al. [11] also indicated that spray of garlic extract on cucumber at (1:1) increased auxins and decreased gibberellins-like substances, whereas garlic extract at (0.5:1) decreased auxin contents.

Therefore, this study aimed to improve growth and productivity of "Fagri Kalan" mango trees by applying some natural extracts i.e. algae, roselle and garlic sprayed either solely or combined each other.

Materials and Methods

This study was carried out during two successive 2013 and 2014 experimental seasons on fruitful mango trees cv. Fagri Kalan grown in Research and production Station orchard at El-Nobaria region, Behera Governorate, Egypt. Twenty four Fagri Kalan mango trees of ten years old, planted at 3 × 5 m apart in a sandy soil under drip irrigation system were carefully selected as being healthy, disease free and uniform as possible in their vigour and size to study the effect of foliar spray with some plants and algae extracts. All devoted trees received regularly the same horticultural practices (fertilization, irrigation, pest control, pruning etc.) adopted in mango orchards of the region. The complete randomized block design with three replications (each replicate was represented by a single tree) was used for arranging the following eight spray treatments:

Control (spraying with water only)

Algae extract at 2%

Roselle (*Hibiscus sabdariffa* L.) extract at 10% (dried hibiscus leaves brought from the local market, then grinded and taking soft powder to prepare the desired concentration by dissolving 250 g of fine powder in 250 ml of distilled water in an electric mixer and mixing the mixture for 15 m, then let the mixture for 30 m and filtering several times and kept at low temperature (4°C) till used.

Garlic (*Allium sativum*) extract at 5% (250 g of garlic cloves were mixed with 250 ml tap water and thawed three times. Water was added to a final volume of 1 liter before filtering. Where the filtrate was adjusted to 1:1 by volume before being used).

Roselle extract at 10%+garlic extract at 5%

Roselle extract at 10%+algae extract at 2%

Garlic extract at 5%+algae extract at 2%

Roselle extract at 10%+garlic extract at 5%+algae extract at 2%

Triton B at 0.1% as a wetting agent was used with each treatment even control.

Taking into consideration that all investigated spray treatments were applied four times along each growing season i.e., just at full bloom, fruit set, one and two months after fruit set had been taken place prior to harvesting.

Measurements and Analysis

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

Vegetative growth parameters: On each tree four main branches (limbs/scaffolds) similar in their vigour and well distributed around its periphery (each towards one geographic direction) were carefully selected and labeled. Then, twelve spring cycle shoots (three per every labeled limb were randomly selected) for determining the following growth measurements:

Number of new shoots

Shoot length (cm)

Shoot diameter (cm)

Numbers of leaves/shoot

Leaf area in (cm²) according to Ahmed and Morsy [12] using the following equation: Leaf area (cm²)=0.70 (leaf length x leaf width)-1.06.

Leaf N, P and K contents as percentages in dry matter of leaves samples at 2nd week of July during both seasons were determined as follows:

Nitrogen, after Pregel [13] (using Micro-Kjeldahl).

Phosphorus, according to method described by Champman and Pratt [14].

Potassium, according to Brown and Lilleland [15].

Average number of fruit set/panicle was recorded.

Fruit retention percentage was recorded at mature stage (a week before harvest).

Tree yield was estimated as weight of harvested fruits (Kg) per tree on the last week of July in each season.

Fruit quality:

Five mature fruits were randomly sampled from those harvested ones per each tree for determining the following fruit physical and chemical properties:

Fruit physical characteristics: such as average fresh weights of the whole fruit, pulp, peel and stone (seed) in grams were determined. Besides, pulp/peel ratio was also estimated.

Fruit chemical characteristics: samples of fruit juice were used to determine the total soluble solids percentage (TSS%) using hand refractometer and total sugars as (g/100 g fresh weight) after method described by Dubois et al. [16]. Moreover, total acidity as percentage of citric and malic acids was determined according to A.O.A.C [17]. Fruit ascorbic acid (V.C) content as milligrams ascorbic acid /100 ml juice, was determined according to A.O.A.C [17].

Statistical Analysis

The obtained data was subjected to analysis of variances (ANOVA) according to Snedecor and Cochran [18]. Mstat-C program was used to calculate least significant differences LSD letters were used for comparing between means of different treatments according to Wallar and Duncan [19] at probability of 0.05 level [20].

Results and Discussions

In this regard foliar spray with some algae and plant extracts were investigated regarding their effects on some measurements of vegetative, growth, nutritional status, productivity and fruit quality of fruitful mango trees cultivar Fagri Kalan during 2013 & 2014 seasons.

Effect on vegetative growth parameters

Data obtained during both seasons as shown in Table 1 displayed that all/most spray treatments with algae and plant extracts resulted in an increase over control for the differential investigated growth parameters (No. of new developed shoots, shoot length, shoot thickness, No. of leaves/shoot and average leaf area). The increase in all evaluated growth parameters exhibited by the differential investigated spray application with algae and plant extracts over control (tap water spray) varied not only from one spray treatment to another but also, each evaluated growth easements reflect its own rate of response.

Anyhow, it could be obviously concluded that the response was more pronounced and increases over control were significant as the three spray treatments (roselle 10%+algae extract 2%, garlic 5%+algae extract 2% and roselle 10%+garlic 5% +algae extract 2%). Such trend

was true during both seasons with few exceptions particularly in 2nd season for the number of new developed shoots, when differences were completely absent.

Treatments	No. New shoots		Shoot length (cm)		Shoot thickness (mm)		No. Leaves/ shoot		Leaf area (cm ²)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
T1: Control	3.00 b	3.50 a	18.00 d	16.00 b	6.00 b	7.50 c	12.00 c	15.00 b	28.46 d	47.07 b
T2: Algae Extract 2%	3.50 ab	3.50 a	26.00 bcd	23.00 b	7.50 ab	9.50 a	17.50 b	19.50 a	59.67 ab	50.65 b
T3: Roselle Extract 10%	3.00 b	3.00 a	20.50 d	19.50 b	6.00 b	7.50 c	14.50 bc	16.00 b	41.62 c	49.59 b
T4: Garlic Extract 5%	3.50 ab	3.00 a	21.00 d	20.50 b	7.00 ab	7.50 c	15.50 bc	17.00 b	47.44 bc	45.32 b
T5: Roselle 10% + Garlic Extract 5%	3.50 ab	3.00 a	24.50 cd	22.00 b	7.50 ab	8.00 bc	16.35 bc	17.00 b	56.00 ab	50.65 b
T6: Roselle 10% + Algae Extract 2%	3.67 ab	3.50 a	32.00 abc	31.50 a	8.00 a	9.50 a	18.50 b	25.00 a	61.50 a	51.51 b
T7: Garlic 5% + Algae Extract 2%	4.00 ab	4.00 a	35.00 ab	33.00 a	9.00 a	9.50 a	22.50 a	25.00 a	61.94 a	62.35 a
T8: Roselle 10% + Garlic 5% + Algae Extract 2%	5.00 a	4.00 a	41.00 a	34.00 a	9.50 a	10.00 a	24.50 a	26.00 a	65.56 a	64.94 a

Table 1: Effect of foliar application with algae and plant extracts on some vegetative growth parameters of mango trees cv. Fagri kalan during 2013 and 2014 seasons. Means within each column followed by different letter/s are statistically different at 5% level.

On the other hand, the least increase over control in all evaluated growth measurements was always in concomitant to the Fagri Kalan mango trees sprayed with roselle extract at 10% and garlic extract at 5% either each was applied solely or both combined each other i.e. roselle extract 10%, garlic extract 5% and roselle 10% +garlic extract 5%, where the increase was not significant and it could be safely neglected from the statistic point during both seasons. In addition, the effect of spray treatment with algae extract at 2% solely was in between aforesaid two extremes.

Effect on nutritional status (leaf N, P, K contents)

Table 2 reveals that the response of leaf N, P, and K contents of Fagri Kalan mango trees to the investigated foliar spray with some extracts of algae, garlic and roselle was to some extent similar to that previously detected with growth measurements, pertaining the relative (slight/clear) increase over control.

Treatments	N (%)		P (%)		K (%)	
	2013	2014	2013	2014	2013	2014
T1: Control	1.07 c	1.12 b	0.21b	0.22 c	0.88 b	0.89 d
T2: Algae Extract 2%	1.15 ab	1.18 ab	0.25 ab	0.27 ab	0.95 ab	0.97 abc
T3: Roselle Extract 10%	1.09 bc	1.12 b	0.29 a	0.29 a	0.89 ab	0.91 cd
T4: Garlic Extract 5%	1.13 abc	1.14 b	0.25 ab	0.28 ab	0.91 ab	0.91 cd
T5: Roselle 10% + Garlic Extract 5%	1.14 abc	1.17 ab	0.25 ab	0.30 a	0.91 ab	0.94 bcd
T6: Roselle 10% + Algae Extract 2%	1.17 ab	1.24 a	0.22 ab	0.25 bc	0.95 ab	0.99 ab
T7: Garlic 5% + Algae Extract 2%	1.18 a	1.24 a	0.24 ab	0.25 bc	0.96 ab	1.01 ab
T8: Roselle 10% + Garlic 5% + Algae Extract 2%	1.19 a	1.25 a	0.25 ab	0.30 a	0.98 a	1.02 a

Table 2: Effect of foliar application with algae and plant extracts on leaf mineral content (NPK) percentages of mango trees cv. Fagri kalan during 2013 and 2014 seasons. Means within each column followed by different letter/s are statistically different at 5% level.

On the other hand, the trend of response for both leaf nitrogen and potassium contents followed typically the same one resulted in growth parameters particularly the superiority of (roselle 10% +algae extract 2%, garlic 5% +algae extract 2% and roselle 10% +garlic 5% +algae extract 2%) discerningly followed by (algae at 2%), (garlic at 5% solely and/or garlic 5% +roselle 10%) and (roselle 10% solely). However, leaf phosphorus content, the trend of response was slightly modified. Herein, the differences were in most cases not significant and foliar spray with roselle extract at 10% either solely or combined to (garlic 5%) and (garlic 5% +algae 2%) induced generally the riche of Fagri Kalan mango leaves in their phosphorus contents.

Effect on some productivity measurements

In this respect fruit set, fruit retention and yield/tree in Kg were the investigated measurements of mango trees productivity.

It's quite evident as shown from tabulated data in Table 3 that, three measurements followed to great extent the same trend pertaining their response to the differential investigated spray treatments with some

algae and plant extracts. Herein, the seven spray treatments with algae, garlic and roselle extracts (either each was applied solely or in combination each other/s) resulted significantly in increasing three productivity parameters over control (water spray), during two seasons of study. Meanwhile, (roselle 10% +algae extract 2%, garlic 5% +algae extract 2% and roselle 10% +garlic 5% +algae extract 2%) spray treatments were statistically the superior with comparison to four other extracts sprayed treatments regarding their increasing effect over control during two seasons of study. However, foliar spray with three extracts of algae, garlic and roselle together i.e., roselle 10% +garlic 5% +algae extract 2% treatment surpassed in most cases two other effective ones (roselle 10% + algae extract 2% and garlic 5% +algae extract 2% treatments) particularly roselle 10% +algae extract 2% ones during both 2013 and 2014 seasons. Such trend of the beneficial effect of different spray treatments with investigated three extracts of algae, garlic and roselle on three productivity measurements of Fagri Kalan mango trees may be logically explained as a real reflection of the enhancement resulted by such extracts in both growth and nutritional status measurements.

Treatments	Fruit set/panicle		Fruit retention (%)		No. of fruits/tree		Yield (kg/tree)	
	2013	2014	2013	2014	2013	2014	2013	2014
T1: Control	5.92 e	6.08 d	0.60 f	0.65f	24.00 f	28.67 g	11.59 d	12.27 ef
T2: Algae Extract 2%	7.98 cd	8.07 bc	1.12 d	1.24 c	38.67 c	43.33 cd	16.65 c	19.00 cd
T3: Roselle Extract 10%	6.23 e	6.39 d	0.75 e	0.94 e	31.33 e	37.00 ef	12.74 d	14.95 e
T4: Garlic Extract 5%	7.17 de	7.34 cd	0.85 e	1.02 de	31.00 e	35.67 f	12.75 d	15.57 e
T5: Roselle 10% + Garlic Extract 5%	7.69 cd	7.74 c	1.04 d	1.20 cd	35.67 d	40.33 de	15.28 c	17.94 de
T6: Roselle 10% + Algae Extract 2%	9.01 bc	9.20 ab	1.28 c	1.64 b	44.00 b	47.33 b	19.93 b	21.54 bc
T7: Garlic 5% + Algae Extract 2%	9.69 ab	9.76 a	1.46 b	1.70 ab	46.00 ab	51.67 b	21.71 ab	24.77 ab
T8: Roselle 10% + Garlic 5% + Algae Extract 2%	10.75 a	10.43 a	1.71 a	1.86 a	47.67 a	57.00 a	23.33 a	28.33 a

Table 3: Effect of foliar application with algae and plant extracts on fruit setting, fruit drop, fruit retention and yield of mango trees cv. Fagri klan during 2013 and 2014 seasons. Means within each column followed by different letter/s are statistically different at 5% level.

Effect on fruit quality

Fruit physical characteristics: In this concern, average weight in g. of the (whole fruit, fruit pulp, peel, stone and the pulp/fruit ratio) were the investigated of the fruit physical characteristics of Fagri Kalan mango cv.

Data obtained during both 2013 and 2014 seasons are presented in Table 4 displayed that all/most spray treatments with algae and plant extracts resulted in an increase over control for the differential investigated fruit physical characteristics (average weight of whole fruit, fruit pulp, peel, stone and the pulp/fruit ratio). Anyhow, it could be obviously concluded that the response was more pronounced and increases over control were significant as the three spray treatments (roselle 10% +algae extract 2%, garlic 5% +algae extract 2% and roselle 10% +garlic 5% +algae extract 2%). Such trend was true during both seasons 2013 & 2014.

On the other hand, the least increase over control in all evaluated fruit physical characteristics was always in concomitant to the Fagri Kalan mango sprayed with roselle extract at 10% and garlic extract at 5% either each was applied solely or both combined each other i.e. roselle extract 10%, garlic extract 5% and roselle 10% +garlic extract 5%.

Fruit chemical properties: Total soluble solids (TSS%), total sugar%, total acidity and vitamin C (ascorbic acid) were the investigated chemical properties in response to foliar spray treatments with algae, garlic and roselle extracts. Data obtained during two seasons are presented in Table 5 illustrated the effect of algae and plant extracts as foliar spray on fruit chemical properties.

Treatments	Fruit weight (g)		Pulp weight (g)		Pell weight (g)		Seed weight (g)		Pulp/Fruit ratio	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
T1: Control	399.67 e	393.33 d	301.99 e	292.97 f	58.48 h	59.97f	39.20 g	40.39 g	75.56 a	74.48 a
T2: Algae Extract 2%	430.67 d	445.00 c	322.46 d	333.72 cd	64.65d	65.65 d	43.59 d	45.63 d	74.87 a	74.99 a
T3: Roselle Extract 10%	406.33 e	404.33 d	304.58 e	299.58 e	60.78 g	63.17 e	40.97 f	41.58 f	74.96 a	74.09 a
T4: Garlic Extract 5%	411.33 e	437.67 c	307.83 e	329.56 d	61.60 f	63.49 e	41.90 ef	44.62 e	74.84 a	75.30 a
T5: Roselle 10% + Garlic Extract 5%	428.33 d	438.00 c	322.66 d	327.70 d	62.92 e	65.03 d	42.75 de	45.27 de	75.33 a	74.82 a
T6: Roselle 10% + Algae Extract 2%	452.67 c	455.00 bc	338.29 c	336.34 c	68.12 c	70.15 c	46.26 c	48.51 c	74.73 a	73.92 a
T7: Garlic 5% + Algae Extract 2%	472.00 b	479.33 ab	353.95 b	357.86 b	70.01 b	71.49 b	48.04 b	49.98 b	74.99 a	74.66 a
T8: Roselle 10% + Garlic 5% + Algae Extract 2%	489.33 a	497.00 a	364.23 a	367.60 a	74.77a	76.37 a	50.33 a	53.03 a	74.43 a	73.96 a

Table 4: Effect of foliar application with algae and plant extracts on some fruit physical properties of mango cv. Fagri kalan during 2013 and 2014 seasons. Means within each column followed by different letter/s are statistically different at 5% level.

Treatments	Total soluble solids TSS (%)		Total Sugar (g/100 g FW)		Acidity (%)		Ascorbic acid (mg/100 ml juice)	
	2013	2014	2013	2014	2013	2014	2013	2014
T1: Control	15.00 b	12.77 c	10.53 a	9.94 c	0.50 a	0.61 a	32.57 a	31.33 cd
T2: Algae Extract 2%	18.20 ab	16.13 ab	12.74 a	11.34 ab	0.36 a	0.51 a	37.72 a	32.77 bc
T3: Roselle Extract 10%	15.93 ab	14.53 bc	11.17 a	10.16 bc	0.47 a	0.61 a	32.85 a	31.88 bc
T4: Garlic Extract 5%	16.07 ab	15.20 abc	11.31 a	10.64 abc	0.47 a	0.58 a	34.33 a	32.28 bc
T5: Roselle 10% + Garlic Extract 5%	16.40 ab	15.47 abc	11.61 a	10.80 ab	0.44 a	0.53 a	37.47 a	32.50 bc
T6: Roselle 10% + Algae Extract 2%	18.47 ab	16.40 ab	12.96 a	11.50 ab	0.45 a	0.54 a	37.89 a	34.59 ab
T7: Garlic 5% + Algae Extract 2%	19.47 a	17.27 ab	13.70 a	12.06 a	0.43 a	0.57 a	39.85 a	37.07 a
T8: Roselle 10% + Garlic 5% + Algae Extract 2%	19.87 a	17.73 a	13.97 a	12.45 a	0.44 a	0.54 a	40.52 a	37.15 a

Table 5: Effect of foliar application with algae and plant extracts on some fruit chemical properties of mango cv. Fagri kalan during 2013 and 2014 seasons. Means within each column followed by different letter/s are statistically different at 5% level.

It is quite clear that, spraying algae and plants extracts had an obvious effect on enhance the fruit chemical properties. Whereas, 10% roselle+5% garlic+2% algae extracts showed to be the most effective treatment for inducing the highest values of total soluble solids percentage, total sugars and ascorbic acid content followed in a descending order by 5% garlic+2% algae extracts and 10% roselle+2% algae extracts in both seasons when compared with control which recorded the lowest values of these concerns in both seasons. However, other treatments came in between in both seasons of the study. While, there were no significant effects of different treatments on fruit content of total acidity in both seasons.

Discussions

The outstanding effects of algae and plant extracts on vegetative growth, leaves content of N, P and k, fruit set, fruit retention, yield as well as fruit quality of mango cv. Fagri Kalan might be due to the content of these extracts on nutrients such as (N, P, K, Ca, Mg, and S), vitamins, some growth regulators and polyamines as algae extract. Also, may be due to these extracts contents of antioxidants, vitamins C, anthocyanins and carotene as roselle extract or may be due to these extracts contain of enzymes, volatile compounds and sulphur compounds as garlic extract. The use of such materials on the plant in general and especially on mango trees will improve the physiological

and nutritional status of the trees and increase the yield and fruit quality.

These results are in harmony with those obtained by Chawdhury et al. [21], Karim and Rahim [22], Abd El-Motty et al. [23], Ahmed et al. [24] and Adel Abed El Hamied [25] on mango. They reported that, spraying mango trees with algae extracts alone or combined with natural or plant extracts was very effective in improving fruit set, fruit retention, yield and enhanced fruit quality. Also, Ahmed et al. [5] and Hegab et al. [26] on citrus, Hafez et al. [27] on olive and Hanafy et al. [28] on plant extract.

Conclusion

From the above results it could be concluded that, using algae extract at 2% alone or in combination with 10% roselle or 5% garlic extracts had a clear effects on vegetative growth, leaves contents of N, P and K, fruit set, fruit retention, yield and fruit quality of mango cv. Fagri Kalan. It was also noted that spraying extracts of roselle at 10 % and garlic at 5% had a good effect on some fruit quality characteristics. Therefore algae and two plants extracts (10% roselle and 5% garlic) could be safety recommended as a natural biostimulants application for improving most desirable measurements of mango cv. Fagri Kalan grown under the same experimental condition.

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