Productivity and Fruit Quality of Lime (*Citrus aurantifolia* L.) as Affected by GA_3 and NAA Foliar Spray

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Abstract: A field trial was achieved during 2018 and 2019 seasons on 9-years old Balady lime trees, to study the effect of spraying gibberellic acid (GA3) and naphthalene acetic acid (NAA) at 10, 20 and 30 ppm three times each year on yield and fruit physical and chemical properties of the fruit, grown in sandy reclamation soil located at Cairo-Alexandria desert road (60 Km from Cairo city), Egypt. A gradual yield increment was observed, physical and chemical properties of Balady lime fruits were improved the two growth regulators concentration from 0.0 to 30 ppm. Meaningless stimulation was detected among the two higher concentrations of GA_3 and NAA namely 20 and 30 ppm. The best results with regard to yield, fruit physical and chemical properties of Balady lime obtained when the trees were sprayed with GA_3 combined with NAA each at 20 ppm.

Keywords: *Citrus aurantifolia*, GA_3, NAA, sandy soil, fruit quality

INTRODUCTION

Citrus is one of the most important fruit crops in tropical and subtropical regions (Ranganna *et al.,* 2017). Lime tree (*Citrus aurantifolia* L.) is widely grown in tropical and subtropical zones. It is known that lime trees are the most important member of citrus group. However, lime juice is a popular fresh healthy drink and it has a good effect on the protection from many diseases for the human. Lime fruit contain a different healthy components *i.e.* citric acid which is valuable in processing, pectin, and in pharmaceuticals, as well as gelatinization in jelly and confectionery. Also, volatile oil can be extracted from lime fruit peel (Yassen, 2006; Ranganna *et al.,* 2017; Arunadevi *et al.,* 2019; Abd El-Sabor, 2020).

Plant growth regulators have become an important tool in the production of various fruit crops. Growth regulators as a mean for enhancing flowering, fruit set, control of fruit drop, fruit size, yield and fruit quality have become important in horticulture (Sharma *et al.,* 2003; Yassen, 2006; Guirguis *et al.,* 2010; Arunadevi *et al.,* 2019). Gibberellins (GAs) are a large family of tetracyclic diterpenoid plant hormones. It can regulate many different aspects of plant growth and development through the entire life cycle of the plant, including the promotion of cell division and elongation, seed germination, stem and hypocotyl elongation, root growth and flowering induction (Guariola *et al.,* 1981; Lei *et al.,* 1992; Arunadevi *et al.,* 2019). According to Guardiola *et al.* (1988) the role of NAA in enhancing yield and fruit quality is the result of at least three independent effects on fruit development, namely: (a) stimulation of fruitlet abscission linked to the synthesis of ethylene; (b) a transient reduction in fruitlet growth rate which reduces the final fruit size; (c) a direct stimulation of late fruit growth rate.

The present study was undertaken to investigate the response of productivity and fruit quality of Balady lime trees grown under sandy newly reclamation land to foliar spraying of gibberellic acid (GA_3) and Naphthalene acetic acid (NAA) at different concentrations.

MATERIALS AND METHODS

The present investigation conducted during two successive seasons 2018 and 2019 on 48 own rooted uniforms in vigor Balady lime trees (*Citrus aurantifolia* L), grown in private orchard located at Cairo-Alexandria desert rood (50 km from Cairo city), where the soil texture was sandy and well drained since water table depth is more than two meters. The chosen lime trees are 9 years old planted at 6 × 6 meters apart. Drip irrigation system was adopted using water supply from underground well with pressure and volume controllers. Winter pruning was done at the last week of December, in both the experimental seasons. The chosen trees were subjected to regular horticulture practices that were commonly applied in the orchard including fertilization, irrigation, hoeing and pest management.

Soil and irrigation water characters:

Samples of soil and irrigation water were collected and subjected to physical and chemical analysis according to the procedures of Wilde *et al.* (1985), Walsh and Beaton (1986) and the data are shown in Table (1).

Experimental work and statistical analysis:

In order to justify the effect and the suitable concentrations of GA_3 and NAA on Balady lime trees, four doses of each material, namely: 0.0 ppm, 10 ppm, 20 ppm and 30 ppm as well as their combinations were tested on Balady acid lime trees. The experiment involved sixteen treatments from GA3 (factor A) and NAA (factor B) concentrations as well as their interactions (A × B). The two examined growth regulators (GA_3 and NAA) were sprayed three times yearly; the first one at the end of February, the second one just after fruit setting, and the third one was one month later. The experiment was performed using a randomized complete block design (RCBD) in split plot design. Statistical analyses (Sendecor and Cochran, 1980) were performed with SPSS program (SPSS Inc., Chicago, USA). Each treatment was replicated three times. The data were analyzed by one-way ANOVA. Means of the treatments were compared using New LSD test, ($P<0.05$).

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Table (1): Physical and chemical analysis of experiment orchard soil and the water used in irrigation

Soil analysis		Water analysis	
Constituents	**Values**	**Constituents**	**Values**
Sand %	81.5	**E.C (mmhos/cm/25C)**	1.1
Silt %	9.8	**Hardness**	14.5
Clay %	8.7	**pH**	7.49
Texture	Sandy	**Ca (mg/L)**	33.4
EC (1:2.5Ext.) mmhos/cm/ 25 C	1.2	**Mg (mg/L)**	29.3
Organic matter %	0.46	**K (mg/L)**	8.12
pH (1 : 2.5 extract)	8.71	**Na (mg/L)**	62.9
Active lime %	6.6% ($CaCO_3$)	**Sum of Cations (mg/L)**	9.16
N (mg/kg)	248	**Alkalinity (mg/L)**	145
Phosphorus (ppm)	9.55	**Chlorides (mg/L)**	98
Available Ca (meq/100g)	20.6	**Nitrate (mg/L)**	10.9
Available Mg (meq/100g)	4.66	**Sulphates (mg/L)**	35.9
Available K (meq/100g)	0.89	**Sum of anions (mg/L)**	7.72

Measurement of yield as well as fruit physical and chemical properties:

During the flowering period, four shoots/tree were selected (one/each geographic direction), the number of total flowers/shoot, the number of leafy inflorescences/shoot and the number woody inflorescences/shoot were counted. After fruit setting, the numbers of fruit per tree were counted. Then, the % of fruit setting was calculated.

The fruits were harvested when the fruit color start to turn on yellow and the juice % arrive to 30% from fruit weight "on check treatment trees" during the two experimental seasons. The yield/tree was recorded in terms of fruit weights (kg), as a result of multiply the number of fruits/tree × the average fruit weight (g). From each tree, twenty mature fruits were randomly picked for achieving fruit physical and chemical analysis.

The following physical characteristics of fruit were studied:

Average fruit height and diameter (cm), using vernier caliper with 0.01 cm accuracy. Then, the shape index was mathematically calculated, using the following equation.

Shape Index = Fruit height (cm)/Fruit diameter (cm)

Average fruit peel diameter (cm) and average fruit pulp diameter (cm) using vernier caliper with 0.01cm accuracy.

Chemical Characteristics of juice:

10 fruits from each replicate were randomly chosen from homogenized sample, pressed by Electric Extractor for extracting the juice, the following chemical characteristics were determined:

- Percentage of total soluble solids (T.S.S %) were determined in juice obtained from each replicate, using a hand refractometer at 20°C, and expressed as a percentage (Brix), according to Ranganna (1985).
- Percentage of total acidity (TA), expressed in grams citric acid per 100 grams of juice, by titration with 0.1 N NaOH, using 1 ml diluted juice in 10 ml distilled H_2O, and the results expressed as gram citric acid/100 g of fresh juice (%) According to AOAC (2000). And TSS/acidity ratio was calculated.
- Vitamin C was determined by volumetric titration method using 2,6-Dichlorophynol Endophynol Pigment, according to Ranganna (1985).

RESULTS AND DISCUSSION

Effect of GA_3 and NAA on fruit setting %

Data concerning the effect of different concentrations of GA_3 and NAA on fruit setting % of Balady lime trees, during 2018 and 2019 seasons are presented in Table (2). It is clearly show that spraying Balady lime trees with GA_3 and NAA both material at 10 to 30 ppm significantly was accompanied with gradual improvement in fruit compared with the control trees. However, NAA was superior to GA_3 in stimulating fruit, in both experimental seasons.

The studied interaction between GA_3 and NAA concentrations had significant effect on fruit setting %, during the two experimental seasons. The maximum percentages were recorded for trees sprayed with GA_3 and NAA at 30 ppm (51.9% and 52.3%), on the other side, untreated trees gave the minimum fruit setting (31.5% and 30.9%), during the two experimental seasons.

The positive effect of GA3 and NAA on enhancing citrus fruit set % were observed by other authors such as: Greenberg *et al.* (2000) stated that fruit set % and fruit weight of Washington Navel orange was positively affected by spraying the trees with NAA at 10 to 50 ppm. Eman *et al.* (2007) confirmed that spraying Washington Navel orange with GA_3 at 10 or 20 ppm increased final fruit set percentage compared to untreated trees. Hikal *et al.* (2013) found that spraying Washington navel oranges with GA_3 improved fruit set and fruit retention as a comparison with control.

Effect of GA_3 and NAA on Yield and its components

Data in Tables (2 and 3) reveal that the number of fruits/tree, average fruit weight, and yield (kg/tree) of Balady lime trees were improved significantly as a result of spraying both GA_3 and NAA at 10 to 30 ppm compared with untreated trees, during the two experimental seasons. A gradual promotion was observed in fruit numbers/tree, fruit weight (g), and yield with increasing the concentrations of the two growth regulators from 0 to 30 ppm. Significant differences were observed for the yield and its components (average fruit weight and fruit number/tree) with varying the concentrations except among the 20 and 30 ppm concentrations. Therefore, the recommended concentration was 20 ppm from the economical point of view.

The interaction between GA_3 and NAA concentrations was significant for yield and its component (number of fruits/tree and fruit weight) in both experimental seasons (Tables 2 and 3). The highest yield, fruit numbers/tree and average fruit weight were produced due to supplying Balady lime trees with GA_3 and NAA at high level (30 ppm) in combination, during both seasons. However, untreated trees produced the lowest yield, fruit numbers/tree and average fruit weight, in both seasons.

The stimulating effect of GA_3 and NAA on yield might be attributed to the positive action of the two growth regulators on translocation and biosynthesis of carbohydrates which was reflected on increasing fruit numbers and average fruit weight. These results are in accordance with those obtained by Southwick *et al.* (1995), Greenberg *et al.* (2000), Saraswathi *et al.* (2003), Singh and Sharma (2005), Cline and Trought (2007), Eman *et al.* (2007), Ghosh *et al.* (2009), Patel *et al.* (2010), Hikal *et al.* (2013), Bons *et al.* (2015) and Dilip *et al.* (2017). Whereas, their results proved that application of GA_3 and NAA improved yield/tree, fruit weight and fruit volume.

Table (2): Effect of GA_3 and NAA on fruit setting % and number of fruits/tree of Balady lime grown in calcareous soil conditions, during 2018 and 2019 seasons

Fruit setting %										
Treatments	First season 2018					Second season 2019				
	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B
(b1) 0.0 ppm NAA	31.5	33.1	35.1	35.4	**33.8**	30.9	35.4	36.2	36.8	**34.8**
(b2) 10 ppm NAA	37.7	41.4	46.9	47.8	**43.2**	37.1	39.7	40.9	42.1	**39.9**
(b3) 20 ppm NAA	49.9	46.6	49.9	50.2	**47.9**	47.3	49.8	51.3	51.7	**50.0**
(b4) 30 ppm NAA	45.1	46.8	51.8	51.9	**48.9**	48.1	50.2	51.9	52.3	**50.6**
Mean A	**39.6**	**41.98**	**45.9**	**46.3**		**40.9**	**43.8**	**45.1**	**45.7**	
New LSD 5%	**A=1.08 ; B= 2.1 ; AB= 3.06**					**A= 1.2 ; B= 2.3 ; AB= 3.21**				

Number of fruits/tree %										
Treatments	First season 2018					Second season 2019				
	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B
(b1) 0.0 ppm NAA	996	1069	1099	1109	**1068**	988	1111	1177	1183	**1114**
(b2) 10 ppm NAA	1092	1105	1129	1145	**1117**	1119	1152	1199	1209	**1169**
(b3) 20 ppm NAA	1122	1179	1199	1217	**1179**	1181	1189	1208	1234	**1203**
(b4) 30 ppm NAA	1131	1190	1205	1227	**1188**	1196	1197	1220	1240	**1213**
Mean A	**1085**	**1135**	**1158**	**1174**		**1122**	**1162**	**1200**	**1216**	
New LSD 5%	**A= 29.2 ; B= 28.5 ; AB= 41.4**					**A= 23.1 ; B= 19.2 ; AB= 28.03**				

Table (3): Effect of GA_3 and NAA on average fruit weight (g) and yield/tree (kg) of Balady lime grown in calcareous soil conditions, during 2018 and 2019 seasons

Fruit weight (g)

Treatments	First season 2018					Second season 2019				
	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B
(b1) 0.0 ppm NAA	30.5	34.5	36.8	37.9	**34.9**	30.3	35.2	38.0	39.2	**35.7**
(b2) 10 ppm NAA	32.3	35.7	38.1	38.9	**36.3**	32.5	35.9	39.2	40.8	**37.1**
(b3) 20 ppm NAA	35.9	37.3	39.6	40.1	**38.2**	33.9	36.9	41.1	42.1	**38.5**
(b4) 30 ppm NAA	36.7	38.2	40.1	40.6	**38.9**	36.7	38.5	40.8	42.3	**39.6**
Mean A	**33.8**	**36.4**	**38.7**	**39.4**		**33.3**	**36.7**	**39.9**	**41.1**	
New LSD 5%	**A= 0.92 ; B= 1.11 ; AB= 1.62**					**A= 1.2 ; B= 1.3 ; AB= 1.9**				

Yield (kg)/tree

Treatments	First season 2018					Second season 2019				
	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B
(b1) 0.0 ppm NAA	30.38	36.98	41.44	41.93	**38.41**	29.94	39.11	44.73	46.37	**40.04**
(b2) 10 ppm NAA	35.27	39.45	43.02	43.54	**40.32**	36.37	41.36	47.00	49.33	**43.52**
(b3) 20 ppm NAA	40.28	43.98	47.48	48.80	**45.14**	40.04	43.87	49.65	51.95	**46.38**
(b4) 30 ppm NAA	41.51	45.46	48.32	49.82	**45.10**	43.89	46.08	49.78	52.45	**48.05**
Mean A	**36.86**	**41.44**	**44.89**	**46.02**		**37.56**	**42.61**	**47.79**	**50.03**	
New LSD 5%	**A= 2.1 ; B= 2.2 ; AB= 3.19**					**A= 2.5 ; B= 2.1 ; AB= 3.06**				

Effect of GA_3 and NAA on Fruit physical properties:

Data concerning the effect of different concentrations of GA_3 and NAA on physical properties of Balady lime fruit during 2018 and 2019 seasons are presented in Tables (4 & 5). Spraying GA_3 and NAA was significantly improved all fruit physical properties. However, a gradual promotion was observed in fruit height, fruit diameter, peel diameter, and fruit juice % with increasing the concentration used from 10 to 30 ppm. Significant differences were observed on these parameters with varying the concentrations used, except between the two high concentrations (20 and 30 ppm).

The interactions between the two examined growth regulators (GA_3 and NAA) had significant enhancement effect on all fruit physical properties. However, the trees sprayed with high concentration of the two growth regulators (30 ppm) produced the highest values of fruit dimension and peel diameter as well as highest juice %, during the two experimental seasons. On the other side, untreated trees produced the lowest values of fruit dimension, lowest peel diameter and lowest juice % of, during the two experimental seasons.

It is well known that, GA_3 and NAA had a many functions in plant nutrition and growth that influence physical properties of fruits. These included enhancing of metabolic processes such as photosynthesis; activation of carbohydrate metabolized for synthesis of amino acids and proteins; main role of cell division and fruit growth. The aforementioned roles of the two growth regulators could be explanted its effect on improving fruit physical properties (Chacko *et al.,* 1972; Bons *et al.,* 2015; Arunadevi *et al.,* 2019; Abd El-Sabor, 2020) on lime trees, Guardiola *et al.* (1988) on Satsuma mandarin and Moss and Bevington (1977) on valance Orange.

Table (4): Effect of GA_3 and NAA on average fruit height (cm) and fruit width (cm) of Balady lime grown in calcareous soil conditions, during 2018 and 2019 seasons

Fruit length (cm)

Treatments	First season 2018					Second season 2019				
	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B
(b1) 0.0 ppm NAA	3.8	4.1	4.5	4.6	**4.3**	3.7	3.9	4.7	4.7	**4.3**
(b2) 10 ppm NAA	4.1	4.4	4.6	4.8	**4.5**	4.3	4.5	4.8	4.9	**4.6**
(b3) 20 ppm NAA	4.4	4.7	5.0	5.1	**4.8**	4.5	4.6	4.9	5.0	**4.8**
(b4) 30 ppm NAA	4.5	4.8	5.1	5.2	**4.9**	4.6	4.9	5.2	5.1	**4.9**
Mean A	**4.2**	**4.5**	**4.8**	**4.9**		**4.3**	**4.5**	**4.9**	**5.0**	
New LSD 5%	**A= 0.18 ; B= 0.20 ; AB= 0.29**					**A= 0.19 ; B= 0.17 ; AB= 0.25**				

Fruit diameter (cm)

Treatments	First season 2018					Second season 2019				
	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B
(b1) 0.0 ppm NAA	3.3	3.6	3.9	4.1	**3.7**	3.2	3.4	3.9	4.0	**3.6**
(b2) 10 ppm NAA	3.7	3.9	4.1	4.5	**4.1**	3.6	3.8	4.2	4.3	**4.0**
(b3) 20 ppm NAA	3.9	4.3	4.6	4.8	**4.4**	3.8	4.1	4.5	4.5	**4.2**
(b4) 30 ppm NAA	4.0	4.4	4.8	4.9	**4.5**	3.9	4.3	4.7	4.8	**4.4**
Mean A	**3.7**	**4.1**	**4.4**	**4.6**		**3.6**	**3.9**	**4.3**	**4.4**	
New LSD 5%	**A= 0.18 ; B= 0.19 ; AB= 0.28**					**A= 0.19 B= 0.21 AB= 0.31**				

Table (5): Effect of GA_3 and NAA on shape index and peel thickness (cm) of Balady lime grown in calcareous soil conditions, during 2018 and 2019 seasons

Shape index

Treatments	First season 2018					Second season 2019				
	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B
(b1) 0.0 ppm NAA	1.15	1.14	1.15	1.12	**1.14**	1.00	1.15	1.21	1.18	**1.14**
(b2) 10 ppm NAA	1.11	1.13	1.12	1.07	**1.11**	1.19	1.18	1.14	1.14	**1.16**
(b3) 20 ppm NAA	1.13	1.09	1.09	1.06	**1.09**	1.18	1.12	1.09	1.11	**1.13**
(b4) 30 ppm NAA	1.13	1.09	1.06	1.06	**1.09**	1.18	1.14	1.11	1.06	**1.12**
Mean A	**1.13**	**1.11**	**1.11**	**1.08**		**1.14**	**1.15**	**1.14**	**1.12**	
New LSD 5%	**A= NS ; B= NS ; AB= NS**					**A= NS ; B= 0.03 ; AB= 0.05**				

Peel thickness (cm)

Treatments	First season 2018					Second season 2019				
	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B
(b1) 0.0 ppm NAA	0.24	0.25	0.32	0.35	**0.29**	0.23	0.31	0.35	0.37	**0.32**
(b2) 10 ppm NAA	0.23	0.27	0.33	0.35	**0.29**	0.24	0.31	0.35	0.38	**0.32**
(b3) 20 ppm NAA	0.24	0.26	0.35	0.36	**0.30**	0.25	0.33	0.37	0.37	**0.33**
(b4) 30 ppm NAA	0.24	0.28	0.34	0.36	**0.31**	0.25	0.33	0.38	0.39	**0.34**
Mean A	**0.24**	**0.27**	**0.34**	**0.36**		**0.24**	**0.32**	**0.36**	**0.38**	
New LSD 5%	**A= 0.019 ; B= 0.021 ; AB= 0.029**					**A= 0.07 ; B= 0.041 ; AB= 0.059**				

Effect of GA_3 and NAA on Fruit physical properties:

Data concerning the effect of GA_3 and NAA on fruit chemical properties of Balady lime trees, during 2018 and 2019 seasons are illustrated in Tables (6 and 7).

Gradual promotion on TSS %, total acidity % and vitamin C (mg/100g F.W.) was associated with increasing GA_3 and NAA concentrations compared to untreated trees. However, non-significant differences were observed between the 20 and 30 ppm concentrations neither for GA_3 nor for NAA. The date took the similar trend during the two seasons (Table 6 and 7).

Concerning the interactions between GA_3 and NAA it was significant in both experimental seasons. The highest TSS %, total acidity % and vitamin C (mg/100g F.W.) were obtained due to spraying the two growth regulators at high concentration (30 ppm). On the other hand, the lowest TSS %, total acidity % and vitamin C (mg/100g F.W.) were obtained from the untreated trees. The data had similar trend during the two experimental seasons.

There is a wide variety of reports confirmed the beneficial effects of GA_3 and NAA each one alone or in combination, on the fruit chemical properties of different citrus specious and cultivars, like increasing TSS and Vitamine C, under Spain environmental conditions (Garmendia *et al.,* 2019); enhancing vitamin C and other antioxidant as well as TSS % of lime trees grown and on chemical properties of lime fruit under Indian environmental conditions (Bhatt *et al.,* 2016); (Guardiola *et al.,* 1988; Ortola *et al.,* 1991); Improving all chemical properties of Satsuma mandarin under Spain environmental conditions (Ortola *et al.,* 1991); Under Egyptian environmental conditions, Hifny *et al.* (2017) on chemical properties of Washington Navel Orange at El-Behera Governorate and Abd El-Sabor (2020) on Balady lime trees at El-Minia Governorate conditions.

Table (6): Effect of GA_3 and NAA on fruit juice (%) and TSS (%) of Balady lime grown in calcareous soil conditions, during 2018 and 2019 seasons

Juice %

Treatments	First season 2018					Second season 2019				
	(a1) 0.0 ppm GA3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B
(b1) 0.0 ppm NAA	31.1	34.3	35.2	36.4	**34.3**	32.2	35.2	37.4	38.2	**35.8**
(b2) 10 ppm NAA	34.6	37.7	39.3	39.9	**37.9**	35.5	38.4	40.3	41.5	**38.9**
(b3) 20 ppm NAA	39.3	41.5	44.7	43.7	**42.3**	38.6	40.8	43.3	44.6	**41.8**
(b4) 30 ppm NAA	41.2	42.7	44.6	44.8	**43.3**	40.1	42.3	44.6	45.7	**43.2**
Mean A	**36.6**	**39.1**	**40.9**	**41.2**		**36.6**	**39.2**	**41.4**	**42.5**	
New LSD 5%	**A= 1.25 ; B= 2.17 ; AB= 3.15**					**A= 1.54 ; B= 1.99 ; AB= 2.89**				

TSS (%)

Treatments	First season 2018					Second season 2019				
	(a1) 0.0 ppm GA3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B
(b1) 0.0 ppm NAA	8.21	8.99	9.32	9.39	**8.97**	8.11	9.13	9.81	9.99	**9.26**
(b2) 10 ppm NAA	9.12	9.76	10.82	10.62	**9,93**	9.12	10.12	10.39	10.76	**10.09**
(b3) 20 ppm NAA	10.84	10.88	11.08	11.02	**10.96**	10.98	11.03	11.51	11.57	**11.28**
(b4) 30 ppm NAA	11.09	11.21	11.16	11.34	**11.16**	11.16	11.59	11.61	11.89	**11.56**
Mean A	**9.82**	**10.26**	**10.45**	**10.65**		**9.84**	**10.47**	**10.97**	**11.05**	
New LSD 5%	**A= 0.45 ; B= 0.62 ; AB= 0.91**					**A= 0.49 ; B= 0.38 ; AB= 0.56**				

Table (7): Effect of GA_3 and NAA on fruit total acidity (%) and vitamin C (mg/100g F.W.) of Balady lime grown in calcareous soil conditions, during 2018 and 2019 seasons

Total acidity (%)

Treatments	First season 2018					Second season 2019				
	(a1) 0.0 ppm GA3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B
(b1) 0.0 ppm NAA	6.61	7.61	8.12	8.23	**7.64**	6.48	7.99	8.58	8.99	**8.01**
(b2) 10 ppm NAA	7.72	8.15	8.79	9.13	**8.45**	7.81	8.69	9.25	9.71	**9.04**
(b3) 20 ppm NAA	8.84	9.07	9.89	10.09	**9.55**	9.09	9.82	10.14	10.39	**9.86**
(b4) 30 ppm NAA	9.09	9.38	10.21	10.62	**9.83**	10.15	10.05	10.41	10.76	**10.34**
Mean A	**8.05**	**8.55**	**9.25**	**9.51**		**8.38**	**9.14**	**9.60**	**9.96**	
New LSD 5%	**A= 0.50 ; B= 0.47 ; AB= 0.68**					**A= 0.44 ; B= 0.52 ; AB= 0.76**				

Vitamin C (mg/100g F.W.)

Treatments	First season 2018					Second season 2019				
	(a1) 0.0 ppm GA3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B	(a1) 0.0 ppm GA_3	(a2) 10 ppm GA_3	(a3) 20 ppm GA_3	(a4) 30 ppm GA_3	Mean B
(b1) 0.0 ppm NAA	28.2	31.4	32.3	33.6	**31.4**	27.1	33.5	34.2	35.5	**32.6**
(b2) 10 ppm NAA	33.4	37.2	38.8	38.8	**37.1**	33.9	38.8	39.3	40.1	**38.0**
(b3) 20 ppm NAA	39.3	42.5	42.9	44.9	**42.4**	40.9	44.1	45.7	47.8	**44.6**
(b4) 30 ppm NAA	40.5	43.2	44.6	45.9	**43.6**	41.5	44.8	47.9	48.6	**45.7**
Mean A	**35.4**	**38.6**	**39.7**	**40.8**		**35.9**	**40.3**	**41.8**	**42.8**	
New LSD 5%	**A= 2.1 ; B= 2.2 ; AB= 3.2**					**A= 2.6 ; B= 2. 4 ; AB= 3.5**				

CONCLUSION

In conclusion, for improving productivity, fruit physical and chemical properties of Balady lime grown under new reclamation sandy soil in Egypt; it is necessary to spray the trees with GA3 and NAA in combination at 20 ppm three times; one month before flowering, just after fruit sett and one month later.

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الإنتاجية وجودة الثمار في الليمون البلدي المالح ومدى تأثرها برش حامض الجبرليك و نفثالين حامض الخليك

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من أجل دراسة تأثير الرش بحامض الجبرليك ونفثالين حامض الخليك بتركيزات ١٠ و ٢٠ و ٣٠ جزء في المليون ثلاث مرات في العام على كمية المحصول والمواصفات الفيزيائية والكيميائية لأشجار الليمون البلدي المالح النامية في الأراضي الرملية حديثة الاستصلاح بطريق القاهرة الإسكندرية الصحراوي (على بعد ٦٠ كيلومتر من مدينة القاهرة) بجمهورية مصر العربية، أجريت هذه التجربة الحقلية خلال عامي ٢٠١٨ و ٢٠١٩ على أشجار ليمون بلدي مالح عمرها ٩ سنوات عند بداية التجربة. لقد كان هناك تحسن معنوي وتدريجي في كمية المحصول (كجم/الشجرة) ومكوناته (عدد الثمار/الشجرة ومتوسط وزن الثمرة بالجرام) وكذلك على المواصفات الفيزيائية والكيميائية للثمار نتيجة لزيادة التركيز المستخدم من كلا المركبين من ١٠ إلى ٣٠ جزء في المليون. رش كلا المركبين، في حين أن الفروق لم تكن معنوية بين التركيزين المرتفعين من حامض الجبرليك ونفثالين حامض الخليك (٢٠ و ٣٠ جزء في المليون) . وتم الحصول على أفضل النتائج من حيث كمية المحصول وجودة الثمار كنتيجة لرش حامض الجبرليك ونفثالين حامض الخليك معا كلاً بتركيز ٢٠ جزء في المليون ثلاث مرات خلال العام.