Effect of Some Growth Regulators on Vegetative Growth, Fruit Set, Yield and Fruit Quality of "Anna" Apple Cultivar

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ABSTRACT: This investigation was conducted during 2015 and 2016 seasons on "Anna" apple trees (*Malus domestica,* L.). The trees were 10 years old at the start of experiment budded on Malus rootstock and grown in sandy clay loam soil in private orchard located at El-Nubaria region, El-Bahaira Governorate. The experiment involved the following treatments:1) control (spraying with tap water), 2) 5 mg/l Sitofex (CPPU), 3) 10 mg/l CPPU, 4) 15 mg/l CPPU, 5) 25mg/l Naphthalene acetic acid (NAA), 6) 50 mg/l NAA, 7) 75 mg/l NAA, 8) 25 mg/l Benzyladenine (BA), 9) 50 mg/l BA, 10) 75 mg/l BA. All applications were applied twice at full bloom (80% flowering) and after two weeks from setting. Results revealed that 75 mg/l NAA, as well as, 75 mg/l BA treatments gave the highest values of shoot length, shoot thickness and total chlorophyll compared to all others treatments during both experimental studied. On the contrary, the control treatment has the lowest values during two seasons. Also, it was noticed applications that CPPU treatments led increased fruit set and decreased fruit drop percentages. Furthermore, data showed that, 5, 10 and 15 mg/l CPPU significantly increased yield/tree and yield weight/feddan, as compared with control. Moreover, increasing rates of foliar application at all growth regulators treatments increased acidity and vitamin C content in fruits, while, all treatments did not affect total sugars and anthocyanin contents. Also, foliar application of CPPU, NAA and BA treatments increased the starch content.

Keywords: Apple, Anna, plant growth regulators, CPPU, NAA, BA, vegetative growth, yield, fruit quality.

INTRODUCTION

Apple (*Malus domesticsa*, L.) is belonging to deciduous trees and pomes fruit, family Rosaceae. It is one of the most important fruit trees in the world ,which at least as the apple yield of the world reached more than 55 million ton has been the yield of apple in the world, USA are the first in production, 7.5% of the world apple production. Turkey, France, Italia and Iran are the most important apple production exporter countries in the world (Marku *et al.,* 2014). In Egypt, the cultivated area reached about 79383 feddan, which produced about 623625 ton with an average of 10.2 ton per feddan (Anonymous, 2014).

Many investigators recorded that yield and quality of "Anna" apple fruits depended on several factors. One of the most vital factors which affects and plays an important role in this concern is spraying with some growth regulators which enhance fruit set, reduce fruit drop and consequently increase productively. Moreover, both concentration and application date are very important factors which in true reflect on increasing and improving fruit yield and fruit characteristics (Asaad 2014).

Sitofex (CPPU) (N-(2-chloro-1-pyridinyl)-Nphenylurea) at different concentrations enhanced cell division, increased cell size, increased fruit weight, size and fruit yield. Furthermore, application of the abovementioned

growth regulator improved the most fruit properties on apple (Fatma *et al*., 2009).

Chemical thinning response depends on many factors such as treated variety, the type and concentration of the chemical thinner used the environmental factors during and after application, tree factor, the timing of application, etc. Naphthalene acetic acid (NAA) and ethephon chemicals have been widely used chemicals for apple thinning for many years, although they both give variable results in thinning response. Part of this can be attributed to a weather/ temperature dependent thinning response and to cultivar sensitivity as well (Wertheim, 2000).

A disadvantage of NAA could also be its negative effect on fruit growth since NAA application may not increase the fruit size even though the thinning response occurred and crop load is substantially reduced (Ferree, 1996, Link, 2000, Stopar and Lokar, 2003). Some reports indicated that higher concentrations or late applications of NAA tended to depress the fruit size (Bound, 2001).

Cytokinin Benzyladenine (BA) was found to be more consistent and effective thinning compound for several apple cultivars, since it reduced the crop load, increased the fruit size and had a positive influence on the return bloom (Ferree, 1996). BA had shown to increase fruit size even in the absence of fruit thinning (Link, 2000). BA contributed to larger fruit size through an increased cell division rate in the fruit cortex (Wismer *et al*., 1995). It caused a greater increase in fruit size than an equal reduction in crop load caused by other thinning agents (Ferree, 1996). It was the most effective if applied when fruit diameter averaged about 10 mm (Greene, 1993).

Therefore, the present investigation was designed to study the possibility of producing high vegetative growth, fruit set and drop, yield and fruit quality of "Anna" apple tree by spraying with sitofex (CPPU), Naphthaline acetic acid (NAA) and Benzyladenine (BA).

MATERIALS AND METHODS

This study was carried out during two successive seasons 2015 and 2016 on ten years old "Anna" apple trees (*Malus domestica*, L.), budded on Malus rootstock. Trees were planted in sandy clay loam soil in a private orchard at El-Nubaria region, El-Bahaira governorate Egypt. The trees were spaced 5x5 m apart, irrigated by drip irrigation system and received similar cultural practices adapted in the orchard.

The experiment followed the completely randomized design on fifty trees as 10 treatments were applied and each treatment comprised of five trees. Each tree was considered a replicate; five replicate trees per each treatment were used. Treatments were sprayed with the specified solutions till run off on trees at full bloom stage at which 80% of flower buds reached the

stage of full open and two weeks after fruit setting. A fine mist ensured complete coverage of fruits before run off.

Treatments

The experiment involved the following treatments:

1. Control (Spraying with tap water)
2. 5 mg/l CPPU (Sitofex)
3. 10 mg/l CPPU (Sitofex)
4. 15 mg/l CPPU (Sitofex)
5. 25 mg/l NAA (Naphthalene Acetic Acid)
6. 50 mg/l NAA (Naphthalene Acetic Acid)
7. 75 mg/l NAA (Naphthalene Acetic Acid)
8. 25mg/l BA (Benzyladenine)
9. 50 mg/l BA (Benzyladenine)
10. 75mg/l BA (Benzyladenine)

The effect of the previous treatments was studied by evaluating their influence on the following parameters:

Vegetative growth

Shoot length (cm):

In the spring of each season, 20 non –fruiting shoots of spring cycle were tagged at constant height and at all direction of each tree. In June, the average length of tagged shoots was measured.

Shoot thickness (cm): At late June in both seasons, shoot thickness for twenty shoots was measured by hand caliber.

Leaf area (cm^2):

Leaf area was measured during the second half of May on fully developed mature leaves by portable area meter LI-COR model LI-3000A No. PAM 1671 (Bioletti, 1938).

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Fruit set and drop (%):

Both number of flowers and set fruitlets on the tagged branches were counted and recorded for all treatments. Then percentages of fruit set were calculated by the following equation according to the Westwood (1978).

$$\text{Fruit set (\%)} = \frac{No\ of\ \ fruitlets}{No\ of\ \ opened\ \ flowers} \text{X}\ 100$$

Fruit drop (%):

Furthermore, number of dropping fruits was recorded till harvesting time, then estimated as percentage on the basis of initial number of fruitlets according to this equation:

$$\text{Fruit drop (\%)} = \frac{No\ of\ \ dropped\ \ fruits}{No\ of\ \ set\ \ fruitlets} \text{X}\ 100$$

Yield (kg/tree):

At harvest time, yield of each treatment was recorded as yield weight/tree by the multiplying number of fruits × average weight of fruit. Also, yield produced

as ton/feddan was expressed by multiply the weight of fruits/tree x number of trees/feddan.

Physical fruit characteristics:

Sample of 10 fruits per tree from each replicate was collected randomly, when the fruits were yellow colored (20 June) in both seasons, then transported quickly to the laboratory to determine physical and chemical fruit characteristics. Regarding the physical fruit characteristics, samples of 10 fruits from each replicate tree i.e. 30 fruits for each of the applied treatment was picked randomly at harvest to determine: Average fruit weight (g/ fruit):

Average fruit length (L) and diameter (D) in cm:

were measured by using hand caliper.

Fruit firmness:

Was expressed as (pound / $Inch^2$) according to (Magness and Taylor, 1925). Flesh firmness was measured in two opposite sides of the fruit using Magness Taylor pressure tester.

Chemical fruit characteristics:

Regarding the chemical fruit characteristics, at harvest to determine the following parameters were determined at harvest:

Total soluble solids of fruit juice (TSS %):

Was used to determine the percentage of TSS by hand refractometer according to Chen and Mellenthin (1981).

The percentage of total acidity:

Was determined in fruit juice measured according to Chen and Mellenthin (1981). Five milliliters from the obtained juice were used to determine the titratable acidity. The titratable acidity was expressed as grams of malic acid/100 milliliters fruit juice.

TSS/acid ratio:

Were calculated for each replicate of the applied treatments.

Vitamin C (Ascorbic acid):

The ascorbic acid content of the juice was determined by titration with 2, 6 dichloro phenol-indo-phenol (AOAC, 1985) and calculated as milli-grams per 100 ml of juice.

Total sugars:

were determined in fresh fruit samples according to Malik and Singh (1980). Sugars were extracted from 5 gram fresh weight and determined by phenol sulfuric and Nelson arsenate –molybadate colorimetric methods.

Starch contents:

were determined in 0.1 g of the residue by hydrolysis with concentrated HCL for 3hr under reflux condenser (AOAC 1985). The total reducing power

was determined according to the method of Malik and Singh (1980) and the factor 0.9 was used to calculate the starch (Woodman, 1941).

Leaf chlorophyll index (SPAD):

It was determined by chlorophyll meter apparatus in ten leaves from each plot at 60 and 75 DAS, according to the method that described by Moran (1982).

Anthocyanin content (mg/100g):

Anthocyanin content was determined at the stage of coloration (mg/100g fresh weight) according to Rabino *et al*. (1977).

Statistical analysis:

Results of the measured parameters were subjected to computerized statistical analysis using MSTAT package for analysis of variance (ANOVA) and means of treatments were compared using LSD at 0.05 according to Snedecor and Cochran (1990).

RESULTS AND DISCUSSION

Vegetative growth and total chlorophyll

The data for both experimental seasons, regarding the effect of applying different rates of Sitofex (CPPU), naphthalene acetic acid (NAA) and benzyladenine (BA) on shoot length of "Anna" apple trees are shown Table (1). As for the effects of applying CPPU, data indicated that increasing CPPU concentrations was in concomitance with increasing shoot length as compared with control during both experimental seasons. Furthermore, data showed that for both experimental seasons increasing NAA concentrations from 25 to 75 mg/l increased shoot length as compared with control. Concerning the effect of applying different rates of BA, results revealed that increasing BA concentrations from 25 to 75 mg/l increased shoot length as compared with control during both experimental seasons. The same results were reported by several authors, Aly *et al.* (2012) on "Le Conte" Pear and Asaad (2014) on "Anna" apple. They all concluded that shoot length was increased with all growth regulators treatments.

Results of the effects of different concentration of growth regulators (CPPU, NAA and BA) on shoot thickness of "Anna" apple trees clearly indicated that foliar application of different growth regulators under the study increased the shoot thickness of "Anna" apple trees during 2015 and 2016 seasons as compared with control. On "Le Conte" pear trees, Aly *et al.* (2012) found that foliar CPPU spray increased shoot thickness.

With regard to leaf area, data indicated that increasing (CPPU, NAA and BA) concentrations increased leaf area as compared with control during both experimental seasons.

The same results were reported by several authors, Negi and Sharma (2005) on Flemish beauty pear, Aly *et al.* (2012) on "Le Conte" Pear. They

showed that all applied (CPPU, NAA and BA) concentration increased leaf area of trees.

As for total chlorophyll in "Anna" apple leaves, data revealed that the 75 mg/l BA treatment gave the highest value of total chlorophyll compared by all treatments in both seasons. It was, also, found that increasing NAA concentrations as foliar applications caused an increasing in total chlorophyll in "Anna" apple trees in both seasons.

Table (1). Effect of foliar application with growth regulators on some morphological parameters of apple in 2015 and 2016 seasons.

Treatment	Shoot length (cm)		Shoot thickness (cm)		Leaf area (cm^2)		Total chlorophyll (reading)	
	2015	2016	2015	2016	2015	2016	2015	2016
Control	26.71	27.04	0.61	0.63	19.42	19.74	48.98	48.22
5mg/l CPPU	28.35	29.16	0.71	0.73	22.04	22.85	49.39	50.86
10 mg/l CPPU	31.35	32.85	0.79	0.83	24.07	25.27	51.4	52.84
15 mg/l CPPU	37.65	38.17	0.84	0.87	26.52	27.84	52.20	54.35
25 mg/l NAA	27.85	28.46	0.68	0.71	19.72	20.61	50.70	51.81
50 mg/l NAA	32.46	33.51	0.77	0.80	21.14	22.19	52.93	53.17
75 mg/l NAA	39.21	40.09	0.88	0.90	23.08	24.14	53.79	54.64
25 mg/l BA	27.61	28.73	0.65	0.68	20.50	21.32	51.72	52.31
50 mg/l BA	33.14	34.65	0.76	0.80	22.19	23.30	52.25	53.90
75 mg/l BA	40.53	41.64	0.81	0.85	24.03	25.22	54.13	55.73
LSD (0.05)	**1.57**	**1.66**	**0.07**	**0.08**	**1.07**	**1.14**	**2.74**	**2.96**

B. Fruit set and drop (%)

The data concerning the effect of foliar application of (CPPU, NAA and BA) on the percentage of initial fruit set of "Anna" apple trees during 2015 and 2016 seasons are presented in Table (2). The data revealed that spraying the trees with 5 to 15 mg/l CPPU treatments increased initial fruit set percentages significantly as compared with control treatment. On the other hand, NAA and BA foliar applications decreased initial fruit set significantly as compared with control treatment. The same trend for the effect of spraying NAA was reported by Sourour *et al.* (2009) on Manzanillo olives who showed that NAA spraying significantly decreased the percentage of fruit set.

Concerning final fruit set, 5, 10 and 15 mg/l CPPU treatments increased final fruit set percentage significantly as compared with control treatment during both experimental seasons. On the other hand, NAA foliar applications at 50 and 75 mg/l significantly decreased the final fruit set percentage as compared with control in both seasons.

Moreover, the results regarding the influence of applying BA on the final fruit set percentage, data showed that 75 mg/l of BA decreased significantly the final fruit set percentage as compared with control treatment, while no significant difference was noticed between each of 25 and 50 mg/l BA and control. In addition, the data revealed that foliar application of 5, 10 and 15 mg/l CPPU treatments gave less values of fruit drop percentage, while NAA at 75

mg/l treatment gave the highest values of the given parameter in both experimental seasons.

Table (2). Effect of foliar application with growth regulators on initial fruit set %, final fruit set %, fruit drop % of apple in 2015 and 2016 seasons.

Treatment	Initial fruit set (%)		Final fruit set (%)		Fruit drop (%)	
	2015	2016	2015	2016	2015	2016
Control	45.06	47.26	12.32	12.84	42.39	43.01
5mg/l CPPU	55.08	57.83	15.29	16.05	36.70	38.28
10 mg/l CPPU	68.85	71.53	19.08	20.07	35.21	36.91
15 mg/l CPPU	72.89	73.46	21.13	23.19	31.14	32.10
25 mg/l NAA	43.80	45.61	11.80	12.36	49.68	50.66
50 mg/l NAA	41.42	42.15	10.25	11.81	64.31	69.62
75 mg/l NAA	38.72	39.85	9.14	10.56	73.67	74.36
25 mg/l BA	41.91	43.31	11.79	12.38	43.51	45.67
50 mg/l BA	39.95	40.87	10.24	11.80	48.33	50.14
75 mg/l BA	37.65	39.24	9.37	10.54	53.71	56.31
LSD (0.05)	**2.27**	**2.35**	**1.97**	**1.86**	**2.21**	**2.64**

Average fruit weight (g/fruit)

Concerning the effect of applying CPPU on the average fruit weight (g/fruit) of "Anna" apple trees in 2015 and 2016 seasons, results revealed that 5, 10 and 15 mg/l CPPU treatments increased fruit weight as compared with control treatment during both seasons of the study.

As for the effects of spraying NAA and BA concentrations, data showed that, increasing rates of NAA and BA applied caused a gradual increase in average fruit weight in both seasons**,** Table (3). These resulted were in line with many investigators who reported that, average fruit weight increased due to using some growth regulators, such as Sourour *et al.* (2009) on Manzanillo olives, Aly *et al.* (2012) on "Le Conte" Pear and Taha and El-Ghany (2016).

Number of fruits/ tree

Data in Table (3) showed that spraying the "Anna" apple trees with CPPU gradually increased the number of fruits per tree compared to both NAA and BA treatments. As for the effects of foliar application of CPPU, data showed that 15 mg/l CPPU significantly increased the number of fruits per tree in both seasons as compared with control treatments. These results are in line with Fatma *et al.* (2009) on "Anna" apple and Aly *et al.* (2012) on "Le Conte" pear. They studied the efficiency of a CPPU and found that all treatments with CPPU significantly increased fruiting.

Yield weight

Concerning the influence of applying different rates of growth regulators on yield/ tree (kg) of "Anna" apple trees in 2015 and 2016 seasons, results generally revealed that all applied treatments generally, increased weight of fruits/trees (kg) as compared with control treatments in both seasons.

Furthermore, data showed that 5, 10 and 15 mg/l CPPU treatments significantly increased fruit weight/feddan (ton) in both seasons, while control, 25 mg/l NAA and 25 mg/l BA treatments gave the lowest values with other control Table (3). Guirguis *et al.* (2003), Fatma *et al.* (2009) and Aly *et al.* (2012) found that all treatments with CPPU significantly increased fruiting especially at high concentration. Also, Faissal and Abdellal (2007) found that CPPU significantly increased fruit weight.

Table (3). Effect of foliar application with growth regulators on yield and some physical fruit characteristics of apple in 2015 and 2016 seasons.

Treatment	Average fruit weight (g)		Number of fruits/tree		Fruit weight/tree (kg)		Fruit yield (ton/fed)	
	2015	2016	2015	2016	2015	2016	2015	2016
Control	98.88	101.92	186.32	195.32	18.42	19.91	3.09	3.34
5mg/l CPPU	108.14	113.68	206.21	216.48	22.30	24.61	3.75	4.13
10 mg/l CPPU	115.65	116.18	227.81	235.18	26.35	27.32	4.43	4.59
15 mg/l CPPU	126.72	128.75	264.42	273.60	33.51	35.23	5.63	5.92
25 mg/l NAA	100.33	103.34	184.06	193.24	18.47	19.97	3.10	3.35
50 mg/l NAA	117.28	120.14	177.38	185.74	20.80	22.31	3.49	3.75
75 mg/l NAA	137.49	141.89	161.68	169.72	22.23	24.08	3.73	4.05
25 mg/l BA	101.51	105.08	180.46	190.32	18.32	20.00	3.08	3.36
50 mg/l BA	139.47	147.94	169.20	178.16	23.60	26.36	3.96	4.43
75 mg/l BA	153.21	161.11	151.32	167.64	23.18	27.01	3.89	4.54
LSD (0.05)	**2.41**	**2.87**	**5.60**	**5.73**	**1.85**	**1.91**	**0.36**	**0.41**

Physical fruit quality

Data of the two seasons concerning fruit dimensions in response to different CPPU, NAA and BA concentrations of "Anna" apple fruits are presented in Table (4). The obtained data cleared that all concentrations of different chemicals increased fruit length, diameter and average fruit volume of apple fruits significantly in 2015 and 2016 seasons. Similar results were found by Aly *et al.* (2012) who showed that foliar application of trees with different concentration of CPPU significantly increased fruit diameter of "Le Conte" pear fruit as compared with control treatments.

Fruit firmness

Regarding the influence of spraying different growth regulators on "Anna" apple trees in fruit firmness (pound/inch^2) during both seasons, data in Table (4) showed that CPPU at 15 and NAA at 75 mg/l treatments significantly increased the firmness of fruit a compared control treatment in the first season. These results are partially in agreement with the fact that, at maturity, fruit firmness easily tolerates post-harvest treatments. Moreover, previous reports of Khurshid *et al*. (1997), Guirguis *et al*. (2003), Fatma *et al.* (2009) and Aly *et al.* (2012) on apple and pear trees have supported this trend.

Table (4). Effect of foliar application with growth regulators on some physical fruit characteristics of apple in 2015 and 2016 seasons.

Treatment	Average fruit length (cm)		Average fruit diameter (cm)		Average fruit volume (cm^3)		Fruit firmness ($lb/inch^2$)	
	2015	2016	2015	2016	2015	2016	2015	2016
Control	5.67	5.95	5.15	5.40	101.97	107.06	9.50	9.96
5mg/l CPPU	6.22	6.52	5.75	6.00	109.96	115.46	10.96	10.42
10 mg/l CPPU	6.35	6.66	5.88	6.17	124.93	131.17	11.26	10.65
15 mg/l CPPU	6.64	6.97	6.34	6.65	139.37	146.34	12.59	11.27
25 mg/l NAA	6.36	6.68	5.99	6.28	122.00	128.07	9.64	10.82
50 mg/l NAA	6.66	6.99	6.06	6.36	140.00	147.63	10.65	11.17
75 mg/l NAA	7.28	7.64	6.36	6.67	150.70	158.23	11.46	11.05
25 mg/l BA	7.01	7.35	7.00	7.15	143.78	150.96	10.12	9.92
50 mg/l BA	7.35	7.71	7.49	7.26	161.16	169.22	11.56	10.70
75 mg/l BA	7.54	7.91	7.73	7.61	185.32	194.58	12.70	11.10
LSD (0.05)	**0.16**	**0.13**	**0.18**	**0.1**	**2.67**	**3.17**	**1.58**	**1.74**

Chemical fruit quality

Total soluble solids (TSS %), Total acidity (%) and TSS/acid ratio

The data concerning the effect of foliar applicationof CPPU, NAA and BA on the percentage of TSS, acidity and TSS/acidity ratio of "Anna" apple trees during 2015 and 2016 seasons are presented in Table (5).

The data revealed that increasing rates of foliar application of all growth regulators gradually increased the fruits content of TSS % in both seasons except spraying CPPU at 5 mg/l, NAA at 25 mg/l and BA 25 mg/l. Generally, 75 mg/l BA treatment gave the best results for TSS as compared with all treatments. These results were in agreement with those obtained by Fatma *et al.* (2009) on "Anna" apple, Sourour *et al.* (2009) on Manzanillo olives, and Aly *et al.* (2012) on "Le Conte" Pear. Furthermore, data showed that all CPPU, NAA and BA concentrations, increased acidity % as compared with the control treatment. The 50 mg/l NAA and 75 mg/l BA treatment showed a significant increase in acidity % in fruits as compared with control treatment in both seasons. These results are in agreement with those reported by Kabeel and Fawaaz (2005) and Sourour *et al.* (2009). They all concluded that these growth regulators increased fruit acidity.

Data presented in Table (5) showed that 50 mg/l NAA and 50 and 75 mg/l BA foliar application treatments gave the lowest values of TSS/acid ratio of "Anna" apple fruits during both seasons followed by 5 and 10 mg/l CPPU treatments as compared with control treatment in both seasons. Similar trend was reported by Mansour *et al*. (2008) and Fatma *et al.* (2009) who studied the efficiency of synthetic cytokinin CPPU on fruit quality of "Anna" apple trees and found that all treatments with CPPU tended to significantly increase acidity and decrease TSS/acid ratio.

Vitamin C

The data as for the effects of CPPU, NAA and BA on VC content in "Anna" apple fruits during 2015 and 2016 seasons showed that increasing rates of CPPU, NAA and BA as foliar application, gradually, led to increase VC content as compared with control treatment. Similar results, in generals were noticed about VC content when applied the different concentrations of CPPU on "Anna" apple trees in both seasons Table (5). The obtained results are in parallel with those obtained by Raphael and Faleishman (2003) who showed that VC content in fruit gave no differences among the treatments and the control when CPPU applied at 5mg/l.

Total, reducing and non-reducing sugar (%)

Results in Table (6) illustrated that the application of CPPU, NAA and BA did not exert regulator effect on total, reducing and non-reducing sugar (%) in "Anna" apple fruits as compared with control treatment in both experimental seasons. The same results were reported by Kacha *et al*. (2014), Anawal *et al*. (2015) and Safaei-Najad *et al*. (2015).

Starch (%)

The data as for the effects of different rates of growth regulators concentration on starch (%) content in "Anna" apple fruits during 2015 and 2016 seasons showed that increasing rates of CPPU, NAA and BA as foliar application, gradually, led to increase content of starch (%) significantly in "Anna" apple fruits as compared with control treatment in both seasons. These results are in parallel with those obtained by Aly *et al.* (2012) on pear and Asaad (2014) on apple.

Anthocyanin (mg/100g)

Data in Table (6) illustrated the effects of different concentrations of growth regulators on anthocyanin (mg/100g) content in "Anna" apple fruits during 2015 and 2016 seasons and showed that increasing rates of NAA and BA as foliar application generally had no effect on the| content of anthocyanin (mg/100g) in "Anna" apple fruits as compared with control treatment in both seasons. Meanwhile, foliar application of different rates of CPPU did not affect significantly on anthocyanin (mg/100g) content in both seasons as compared with control. The data are in line with Fatma *et al.* (2009) on "Anna" apple.

Table (5). Effect of foliar application with growth regulators on some chemical fruit characteristics of apple in 2015 and 2016 seasons.

Treatment	TSS (%)		Acidity (%)		TSS/Acidity (%)		VC (mg/100ml)	
	2015	2016	2015	2016	2015	2016	2015	2016
Control								
5mg/l CPPU	11.46	11.01	0.45	0.48	25.47	22.94	18.70	19.63
10 mg/l	10.69	10.23	0.47	0.49	22.74	20.88	19.46	20.43
CPPU	11.36	10.92	0.48	0.50	23.67	21.84	19.84	20.82
15 mg/l	12.49	11.11	0.50	0.52	24.98	21.37	21.23	22.08
CPPU	11.18	10.80	0.51	0.54	21.92	20.00	18.83	19.77
25 mg/l NAA	11.53	11.11	0.59	0.61	19.54	18.21	19.57	20.54
50 mg/l NAA	12.42	11.04	0.49	0.65	25.35	16.98	20.09	21.08
75 mg/l NAA	10.80	10.33	0.49	0.51	22.04	20.25	18.81	19.74
25 mg/l BA	11.63	10.21	0.55	0.58	21.15	17.60	19.19	20.14
50 mg/l BA	12.83	11.46	0.58	0.61	22.12	18.79	19.91	20.90
75 mg/l BA								
LSD (0.05)	**0.74**	**0.81**	**0.05**	**0.04**	**2.84**	**3.11**	**1.08**	**1.17**

Table (6). Effect of foliar application with growth regulators on some chemical fruit characteristics of apple in 2015 and 2016 seasons.

Treatment	Total sugars (%)		Reducing sugars (%)		Non-reducing sugars (%)		Starch (%)		Anthocyanin content (mg/100g)	
	2015	2016	2015	2016	2015	2015	2015	2016	2015	2016
Control	7.68	7.56	4.63	4.46	3.05	3.10	2.36	2.42	19.51	19.43
5mg/l CPPU	7.34	7.70	4.18	4.44	3.16	3.26	2.49	2.61	19.68	19.66
10 mg/l CPPU	7.53	7.72	4.34	4.60	3.19	3.12	2.70	2.83	20.33	20.17
15 mg/l CPPU	7.71	7.69	4.44	4.71	3.27	2.98	2.94	3.08	20.15	19.84
25 mg/l NAA	6.94	7.10	4.80	4.50	2.14	2.60	2.58	2.71	19.84	19.04
50 mg/l NAA	7.10	7.14	4.89	4.62	2.21	2.52	2.60	2.73	20.45	20.32
75 mg/l NAA	7.63	7.21	4.37	4.48	3.26	2.73	2.64	2.77	20.64	19.66
25 mg/l BA	7.13	7.26	4.92	4.56	2.21	2.70	2.74	2.87	18.83	19.77
50 mg/l BA	7.21	7.56	4.90	4.26	2.31	3.30	2.66	2.79	19.67	19.47
75 mg/l BA	7.47	7.48	4.20	4.48	3.27	3.00	2.54	2.66	20.17	19.81
LSD (0.05)	**0.54**	**0.48**	**0.27**	**0.31**	**0.14**	**0.17**	**0.05**	**0.07**	**1.74**	**1.68**

CONCLUSIONS

Results of the presented study on the effect of CPPU, NAA and BA on "Anna" apple trees indicated positive effects on vegetative growth. Also, CPPU increased yield and decrease fruit drop percentage and improved fruit quality either physical (weight, length, diameter and volume) or chemical (acidity and VC).

Generally, CPPU 15 mg/l, NAA 75 mg/l and BA 50, 75 mg/l were the best concentrations in increase on fruit weight and volume.Results revealed that the best treatments were spraying CPPU 15 mg/l, NAA 75 mg/l and BA 75 mg/l at full bloom and after two weeks from full bloom.

EFERENCES

Aly, M. A., Thanaa, M. Ezz, Nagwa, A. Abd El-Megeed and Fatma, A. Naseb (2012). Improving "le-Conte" pear trees productivity by foliar application with plant bioregulators and boric acid. J. Adv. Agric. Res., Fac. Agric., Saba Basha, Alex. Univ., 17 (3): 622- 643.

Anawal, **V. V., P. Narayanaswamy and S. D. Ekabote (2015).** Effects of plant growth regulators on fruit set and yield of pomegranate Cv. Bhagwa. Int. J. Sci. Res., 4(9):220-222.

Anonymous (2014). Annaual report of Agric. Statistical Dept. Egyptian Min. of Agric., A.R.E

AOAC (1985). Official Methods of Analysis. Association of Official Analytical Chemists Washington, D.C. pp 490-510

Asaad, S. A. (2014). The influence of spraying sitofex, iron, manganese and zinc on "Anna" apple trees planted on new reclaimed calcareous land. Life Sci. J., 11(1s):1-8.

Bioletti, F.T. (1938). Outline of ampelography for the vinifera grapes in california. Hilgardia, 227: 93.

Bound, S.A. (2001). Managing crop load. in: Dris R., Niskanen R., Jain S.M. (Eds.), Crop management and postharvest handling of horticultural products. Volume I. Inc. Plymouth UK. Sci. Publisher. pp. 89-109.

Chen, B.M. and W.M. Mellenthin (1981). Effect of harvest date on ripening capacity and post-harvest life of Anjou pears. J. Amer. Soc. Hort. Sci., 106: 38-42.

Faissal, F. A. and A. M. K. Abdella (2007). Effect of concentrations and date of spraying Sitofex (CPUU) on yield and quality of Le-Conte pear fruits. Afri. Crop Sci. Conf. Proc., 8: 523-527.

Fatma I.A.A., A. Nagwa and E. H. Hanaa (2009). Effect of sitofex (CPPU) on fruit set and fruit quality of Anna apple trees. Fayoum J. Agric. Res. & Dev., 23 (1-B). 54-65.

Ferree, D.C. (1996). Performance of benzyladenine as a chemical thinner on eight apple cultivars. J. of Tree Fruit Production, 1 (2): 33-50.

Greene, D.W. (1993). A review of the use of benzyladenine (BA) as a chemical thinner for apples. Acta Hort., 329: 231-236.

Guirguis, N. S., E. S. Attala and M. M. Ali (2003). Effect of Sitofex (CPPU) on fruit set, fruit quality of Le Conte pear cultivar. Annals Agric. Sci., Moshtohor, 41(1): 271-282.

Kabeel, H. and S. A. A. Fawaaz (2005). Effect of spraying some growth regulators on "Le-Conte" pear trees on I- productivity, fruit quality and leaf mineral content. Minofiya J. Agric. Res., 3(3): 173-193.

Kacha, H. L., G. Jat and S. K. Patel (2014). Performance of various plant growth regulators on yield and quality of phalsa (*Grewia asiatica* L.) Hort. Flora Res. Spectrum, 3(3): 292-294.

Khurshid, T., D. J. MC. Neiland and M. C. Trought (1997). Effect of foliar applied gibberellins and soil applied paclobutrazol, on reproductive and vegetative of "Braebun" apple trees growing under a high density planting system. New Zealand J. Crop and Hort. Sci., Lincoh Univ. (C. F. Hort. Abt. 67-6637.

Link, H. (2000). Significance of flower and fruit thinning on fruit quality. Plant Growth Regulation 31: 17-26.

Magness, J. R. and G. F. Taylor (1925). An improved type of pressure tester for the determination of fruit maturity. U. S. Depy. Agric. Circ. 50, 8 PP.

Malik, C.P. and M.B. Singh (1980). Plant Enzymology and Histoenzymology. A text manual, Kalyani publishers, New Delhi**.**

Mansour, A.E.M., F.F. Ahmed, E.A. Shaaban and A. A. Fouad (2008). The Beneficial of using citric acid with some nutrients for improving productivity of Le- Conte pear trees. Res. J. Agric. Biol. Sci., 4(3): 245-250.

Marku, L., H. Vrapi and M. Hasani (2014). Effect of potassium bicarbonate (Armicarb) on the control of apple scab (*Venturia inequalis*) in the region of Puka in Albania. Int. Ref. J. of Eng. and Sci. (IRJES), 3(6): 80-86.

Moran, M.J. (1982). Availability Analysis: A Guide to Efficient Energy Use, Prentice Hall NJ USA.

Negi, N.D. and N. Sharma (2005). Growth, flowering and cropping response of Flemish beauty pear to bloom spray of gibberellic acid and benzyleadenine. Acta Hort. (ISHS), 696:295-298.

Rabino, L., L. Alberto and M.K. Monrad (1977). Photocontrol of anthocyanin synthesis. J. Plant Physiol. 59: 569-573.

Raphael, A. S. and M. A. Flaishman (2003). Benzyladenine effects on fruit size, fruit thinning and return yield of 'Spadona' and 'Coscia' pear. Scientia Horticulturae 98 499–504.

Safaei-Nejad, G., A. Shahsavar and A. Mirsoleimani (2015). Effects of naphthalene acetic acid and carbaryl on fruit thinning in 'Kinnow' Mandarin Trees., 5(2):212-215

Snedecor, G.W. and W.G. Cochran (1990). Statistical Methods. Oxford and J.B.H. Bub. Com. 6th Edition.pp:507.

Sourour, M. S. M., Eman, E. K. Abd-Ella and M. M. El-Tanany (2009). Effect of some growth regulators on yield and fruit quality of Manzanillo olives. J. Adv. Agric. Res., 14(2):349-362.

Stopar, M. and V. Lokar (2003). The effect of ethephon, NAA, BA and their combinations on thinning intensity of 'Summered' apples. Journal of Central European Agric., 4: 399-403.

Taha, N.M. and K.M. El-Ghany (2016). Some horticultural and pathological studies to reduce fruit decay of "Anna" apple and increase fruit set, yield and improve fruit quality and storability. J. Am. Sci., 12(1): 104-122.

Wertheim, S. J. (2000). Developments in the chemical thinning of apple and pear. Plant Growth Regulation 31: 85-100.

Westwood, M.N. (1978). Temperate Zone Pomology. W.H. Freeman and Company. San Francisco.

Wismer, P.T., J.T.A. Proctor and D. C. Elfving (1995). Benzyladenine affect cell division and cell size during apple fruit thinning. J. Amer. Soc. Hort. Sci., 120 (5): 802-807.

Woodman, A. G. (1941). Food Analysis. McGraw-Hill Book Company, Inc. New York.

الملخص العربي

تأثير بعض منظمات النمو علي النمو الخضري وعقد الثمار والمحصول وجودة ثمار التفاح صنف انا

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أجريت هذه الدراسة خلال موسمي ٢٠١٥، ٢٠١٦علي أشجار التفاح صنف آنا عمرها ١٠ سنوات المطعمة علي أصل المالص ومنزرعة في أرض رملية طينية لومية في إحدي المزارع الخاصة في منطقة النوبارية بمحافظة البحيرة . وقد أشتملت التجربة علي عدد من المعاملات هي: ١) المقارنة (الرش بماء الصنبور)، ٢) ٥ مجم/لتر من السيتوفكس،٣) ١٠ جزء في الملون من السيتوفكس، ٤) ١٥مجم/لتر من السيتوفكس، ٥) ٢٥ مجم/لتر من النفتالين استيك اسد، ٦) ٥٠ مجم/لتر من النفتالين استيك اسد، ٧) ٧٥ مجم/لتر من النفتالين استيك اسد ، ٨) ٢٥ مجم/لتر من البنزيل ادنينين، ٩) ٥٠ مجم/لتر من البنزيل ادنينين، ١٠) ٧٥ مجم/لتر من البنزيل ادنينين. وقد تم الرش في كل المعاملات مرتين الأولي عند تمام التزهير (٨٠ % ازهار)، والثانية بعد أسبوعين من العقد وقد بينت النتائج أن المعاملات ٧٥ مجم/لتر لكل من النفتالين استيك اسد والبنزيل ادنينين أعطت أعلي القيم لكل من طول الفرع ، سمك الفرع ، ومحتوي الأوراق من الكلورفيل وذلك مقارنة بباقي المعاملات خلال موسمي الدراسة. كذلك لوحظ أن معاملة المقارنة أعطت أقل القيم خلال موسمي الدراسة. أيضاً لوحظ أن المعاملات السيتوفكس أدت الي زيادة عقد الثمار وقللت من نسبة التساقط. أيضاً أتضح أن معاملات ٥، ١٠، ١٥ مجم/لترمن السيتوفكس أدت الي زيادة في المحصول للشجرة وكذلك للفدان مقارنة بمعاملة الكنترول. أيضاً لوحظ أن زيادة معدلات الرش بمنظمات النمو أدت الي زيادة في محتوي الثمار من الحموضة وفتيامين C، بينما لم تؤثر كل المعاملات علي محتوي السكريات والأنثوسيانين. إن إضافة السيتوفكس و النفتالين استيك اسد و البنزيل ادنينين أدت الي زيادة محتوي الثمار من النشا.