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Improvements of Vegetative Growth, Leaf Mineral Content and Yield of "Aml" Apricot Cultivar Using Gibberellin, Sitofex, Stema (Amino Acids Plus Cytokinine) and Hand Fruit Thinning

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Abstract: This investigation was carried out during the 2017 and 2018 growing seasons on "Aml" apricot trees, grown in sandy loam soil conditions, at El-Regwa, km 76 of Cairo-Alexandria Desert Road, Giza Governorate, Egypt. The investigation aimed to study the effects of foliar sprays with GA_3, CPPU and Stema as well as hand fruit thinning on vegetative growth (leaf area, chlorophyll content, shoot length and number of leaves/shoots), yield and leaf mineral content. The obtained results revealed that generally, all treatments significantly increased the investigated parameters. Hand fruit thinning and stema spray treatments were the most effective for vegetative growth, especially hand thinning at 10 cm distance between the fruits on the branch. Furthermore, all treatments resulted in an increase in yield, especially treatment with GA_3 in combination with CPPU. Additionally, leaf mineral content (N, P, K, Ca, Cu, Zn and Mn) was improved by all treatments in comparison with the control. It could be concluded that hand thinning and stema treatments had significant positive effects on the majority of the investigated parameters.

Key words: "Aml" apricot cultivar · Gibberellin · Sitofex · Stema (Amino acid 10% plus Cytokinin 5%) · Fruit thinning · Vegetative growth · Yield

INTRODUCTION

Apricot (*Prunus armeniaca* L.) belonging to family Rosaceae and one of the members of stone fruits and grown in temperate regions of the world including Turkey, Uzbekistan, Iran, Algeria, Italy, Spain, Pakistan, France, Japan, Ukraine...etc. Apricot is the third most produced stone fruit after plums and peaches. There is an expansion in the apricot cultivated area in Egypt. According to the available statistics, the total cultivated area in Egypt is 6652 ha and the total production was estimated to be 99.841 tons [1]. Many of the commercially obtainable plant growth regulators are used in stone fruit production which enhance fruit size and quality and delay the storage disorder [2]. It is obvious that changes in the level of endogenous hormones due to biotic and abiotic stress alter the crop growth and any sort of manipulation including exogenous application of growth substances would help for yield enhancement. Plant growth regulators provide effective means for the improvement of productivity as a result of direct impact on the qualitative as well as quantitative facets of fruit growth [3]. Since, gibberellins are essential endogenous regulators of plant growth and development, including seed germination, trichome development, stem and leaf elongation, flower induction, anther development, developing pollen after anthesis, fruit and seed development [4]. Gibberellins primarily affect growth by controlling cell elongation and

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division, which is reflected on yield and its components and fruit quality of various grape cultivars [5]. Gibberellic acid is responsible for cell elongation, rather than cell division [6]. Forchlorfenuron, a synthetic cytokinin (CPPU) with strong growth regulation activities has been found very effective in enhancing fruit growth by stimulating cell division and cell elongation. It was being found that highly effective in increasing fruit size in some fruit crops [7]. Stema is an organic growth promoter which contains Amino acid 10% plus Cytokinin 5%. Amino acid helps to develop fruits to its optimum level of size, shape, quality and taste. It is also useful for fruit setting, enhancing quality, size, color as well as flavor and keeping quality of fruits. It also works as a stabilizer buffer to endure certain types of stresses more effectively [8]. In apricots, fruit size is one of the most important quality attributes, which mainly determine the price. In order to be more competitive in the market, the fresh fruit industry is continuously adopting newer or improved orchard management practices and postharvest techniques that increase productivity and fruit quality, including the use of growth regulators. Also, Hand-thinning is an expensive practice, but it is widely used to increase final fruit size due to the close correlation between crop load and fruit size. Therefore, this study intended to throw some light of the prospective on the use of CPPU and GA_3 singly or in combinations and Stema to promote the yield quantitatively and qualitatively in Aml Apricot cv. in comparison with hand thinning and untreated trees.

MATERIALS AND METHODS

The present investigation was carried out during two successive seasons in 2017 and 2018 on Aml apricot trees budded on seedling rootstocks, at a private orchard located in Regwa, km 76 of Cairo-Alexandria Desert Road, Giza Governorate, Egypt. The trees were about 6 years old and planted at 6×3 m apart in sandy loamy soil. The orchard was under a drip irrigation system and the trees received their normal cultural practices, in line with those usually applied in commercial orchards. The experimental soil and irrigation water analyses illustrated in (Tables 1, 2, 3):

The trees used in this experiment were healthy and as uniform in growth behavior and yield as possible. The trees were trained and pruned uniformly to an open center shape. The selected trees were subjected to the following treatments:

- T1: Foliar spray with GA_3 at 25 ppm.
- T2: Foliar spray with GA_3 at 50 ppm.
- T3: Foliar spray with CPPU at 10 ppm.
- T4: Foliar spray with CPPU at 15 ppm.
- T5: Foliar spray with GA_3 at 25 ppm + CPPU at 10 ppm.
- T6: Foliar spray with GA_3 at 25 ppm + CPPU at 15 ppm.
- T7: Foliar spray with GA_3 at 50 ppm + CPPU at 10 ppm.
- T8: Foliar spray with GA_3 at 50 ppm + CPPU at 15 ppm.
- T9: Foliar spray with Stema (20 ppm amino acids plus 10 ppm cytokinin) at 200 ppm.
- T10: Foliar spray with Stema (40 ppm amino acids plus 20 ppm cytokinin) at 400 ppm.
- T11: Hand fruit thinning at 5 cm.
- T12: Hand fruit thinning at 10 cm.
- T13: Control (foliar spray with water).

Trees were sprayed at the full-bloom stage, when 100% of the flowers have been already opened, in accordance with the work of Pérez-Pastor *et al*. [9]. Hand fruit thinning treatment was carried out 15 days after full bloom at fruit set.

Thirteen treatments with three replicates were established with a randomized complete design. For the spray treatments, 10 liters of spray solution was made. To decrease the surface tension of the droplets and facilitate absorption, a few drops of Teepol were added to the solution prior to spraying. The spray solutions of the different plant growth regulators were applied on the trees with the help of a foot sprayer to wet the developing buds and achieve complete flowering without causing run off in the morning. The effects of the investigated treatments were studied by evaluating their influence on the following parameters.

Vegetative Growth Parameters

Shoot Length (cm) and Number of Leaves per Shoot: Four main and uniform branches were chosen and tagged at four cardinal points of each treated tree and the average of their shoot length in cm and No. of leaves/shoot were determined in October, in the two studied seasons.

Leaf Area (cm^2) and Leaf Chlorophyll Content: Samples of 20 leaves from the middle part of the shoots were randomly selected from each replicate to determine leaf area (cm^2), which was measured with a CI-203 laser area meter (CID Inc., Camas, WA, USA). A leaf portion from each sample was kept fresh for chlorophyll determination; total chlorophyll (mg/g) was determined in accordance with the method of Arnon [10].

Table 1: Analysis of soil chemical characteristics of Aml apricot trees just before starting the experiment

Cations (mEq /L)				Anions (mEq /L)						
K^+	Na^+	Mg^{2+}	Ca^{2+}	SO_4^{2-}	Cl^-	HCO^{3-}	CO_3^{2-}	SP	EC (ds/m)	pH 1:2.5
1.0	5.6	5.0	5.4	4.0	12.0	1.0	---	22.0	1.89	7.83

Table 2: Mechanical analysis, soil texture, wilting point and field capacity of the experimental soil

			Volumetric classification of soil grains %			
WP %	FC %	Texture	Clay	Celt	Soft sand	Rough sand
7.5	10.3	Loam sand	4.5	14.8	42.2	38.5

Table 3: Analysis of irrigation water used in the study

Total dissolved soil (TDS)	
EC (deciSiemens/meter)	1.1
EC (ppm)	704.0
pH	7.50
Dissolved anions (mEq/L)	
Carbonate (CO_3^{2-})	-
Bicarbonate (HCO^{3-})	0.3
Chloride (Cl^-)	10.1
Sulfate (SO_4^{2-})	0.6
Dissolved cations (mEq/L)	
Calcium (Ca^{2+})	2.0
Magnesium (Mg^{2+})	1.4
Sodium (Na^+)	7.3
Potassium (K^+)	0.3
Residual sodium carbonate (RSC)	-
Sodium adsorption ratio (SAR)	5.61

Yield: Fruit yield under the different treatments was recorded at harvesting time by weighing the total fruits of each replicated on a top pan balance. The yield was expressed as kg/tree.

Growing Degree Hours (GDH): The influence of temperature on the duration of each phenological stage was studied using the growing degree hours (GDH), calculated by subtracting 6°C (base temperature according to Tabuenca and Herrero [11], from the average temperature of each day.

Leaf Mineral Composition: Leaf mineral content was measured in June of both seasons. Samples of 30 leaves/tree were taken at random from the previously tagged shoots of each tree. Leaf samples were washed with tap water and distilled water twice, dried at 70°C to a constant weight and finally were grounded. Those grounded samples were digested with sulfuric acid and hydrogen peroxide. Total nitrogen was determined by Kjeldahl procedure. Phosphorus was estimated by colorimetric method. Atomic Emission Spectrometry for K. Atomic absorption spectrophotometry for Ca, Cu, Zn and Mn. The concentrations of macroelements were expressed as (mg/100g fw) while microelements were expressed as parts per million (ppm) on a dry weight basis.

Statistical Analysis: All data obtained in both studied seasons were subjected to analysis of variance according to the procedures reported by Sednecor and Cochran [12] Treatment means were compared by new LSD at $p < 0.05$ using M-Stat-C (ver. 2.10).

RESULTS AND DISCUSSION

Vegetative Growth Parameters

Shoot Length (cm) and Number of Leaves per Shoot: The data pertaining to the effects of GA_3, CPPU, stema and hand fruit thinning on shoot length and No. of leaves/shoot of apricot cv. Aml are presented in Table (4). The data showed significantly greater shoot length upon T_{12} (hand fruit thinning at 10 cm a part) treatment (47.91 & 49.31 cm), followed by T_{10} [stema (400 ppm)] (46.81 & 48.09 cm), T_9 [stema (200 ppm)] (46.25 & 47.33 cm) and then T_5 [GA_3 (25 ppm) + CPPU (10 ppm)] (43.27 & 44.10 cm) during both seasons. The shortest shoot length was observed in the control during the first season and with T_1 [GA_3 (25 ppm)] treatment during the second season.

Concerning the No. of leaves/shoot as affected by the different treatments under study, the data in Table 2 clearly show that the greatest No. of leaves/shoot resulted from T12 (hand fruit thinning at 10 cm a part), although this was not significantly different from those for T_{11} (hand fruit thinning at 5 cm a part), T_{10} [stema (20 ppm)], T_9 [stema (200 ppm)], T_6 [GA_3 (25 ppm) + CPPU (15 ppm)] and T_5 [GA_3 (25 ppm) + CPPU (10 ppm)]. The opposite trend was detected with water-sprayed trees (control), exhibiting the lowest No. of leaves/shoots. Other treatments showed values in-between those mentioned above. Such trends were the same during the two experimental seasons.

The increase in different tree growth attributes with thinning treatment might attribute to the reduction of the initial crop load, which favored the accumulation of starch and soluble sugars in leaves. As a result, thinning treatment had a significant positive effect on the current year's shoot elongation [13].

Table 4: Effect of GA_3, CPPU, stema and hand fruit thinning on shoot length (cm) and No. of leaves/shoot of apricot cv. "Aml" during 2017 and 2018 seasons

	Shoot length (cm)		No.of leaves/shoot	
Treatment	2017	2018	2017	2018
T1:GA_3 (25 ppm)	38.38 f	40.03 g	30.67 d	32.07 d
T2:GA_3 (50 ppm)	40.33 ef	41.04 fg	32.67 c	33.00 cd
T3:CPPU (10 ppm)	41.08 de	41.77 efg	33.36 c	33.82 bc
T4:CPPU (15 ppm)	42.11 de	42.52 def	33.91 bc	34.06 abc
T5:GA_3 (25 ppm) + CPPU (10 ppm)	43.27 cd	44.10 d	34.35 abc	34.33 abc
T6:GA_3 (25 ppm) + CPPU (15 ppm)	42.81 d	43.36 de	34.29 abc	34.41 abc
T7:GA_3 (50 ppm) + (CPPU 10 ppm)	42.39 de	43.18 de	33.89 bc	34.12 abc
T8:GA_3 (50 ppm) + (CPPU 15 ppm)	42.19 de	43. 16 de	33.18 c	33.14 cd
T9:Stema (200 ppm)	46.25 ab	47.33 bc	35.17 ab	35.11 ab
T10:Stema (400 ppm)	46.81 ab	48.09 ab	35.13 ab	35.22 ab
T11:Hand thinning at 5 cm	45.36 bc	46.10 c	35.11 ab	35.32 ab
T12:Hand thinning at 10 cm	47.91 a	49.31 a	35.87 a	35.73 a
T13:Control	31.53 g	42.69 def	29.06 d	30.21 e
New LSD 0.5	2.32	1.759	1.715	1.738

*Values within a column with the same letter are not significantly different, according to the least significant difference (LSD) test at $p < 0.05$

In addition, the obtained results may have been due to the role of amino acids. Amino acids can directly or indirectly impact the physiological activities of plant growth and development. The effects of amino acids on protecting plant cells from oxidation and stresses, as well as enhancing the biosynthesis of proteins, plant pigments, natural hormones such as IAA, gibberellin and cytokinin, as well as cell division, are reflected in the stimulation of vegetative growth, improved chemical composition and greater productivity [14].

These findings resemble those of Hota *et al*. [15] who stated that foliar spray of CPPU at 10 ppm improved vegetative characters such as tree height (17.40%), tree spread (22.17%) and tree volume (27.82%) compared with the control. Moreover, the increases in different tree growth attributes with CPPU treatment might have been due to the cytokinin-like action, leading to rapid cell division and cell elongation [16]. CPPU is a strong cytokinin that plays roles in retarding apical dominance, thereby causing lateral shoot growth.

Leaf Area (cm^2) and Leaf Chlorophyll Content

Leaf Area: The data in Table (5) clearly show that both bio-regulators and hand-thinning treatments significantly influenced leaf area. The greatest leaf area in the first season was obtained with T_{12} (hand thinning at 10 cm), although this was not significantly different from those with T_{11} (hand thinning at 5 cm), followed by T_9 [stema (200 ppm)], T_{10} [stema (400 ppm)], T_5 [GA_3 (25 ppm) + CPPU (10 ppm)], T_6 [GA_3 (25 ppm) + CPPU (15 ppm)] and then T_4 [CPPU (15 ppm)]. On the other hand, the lowest leaf area was observed in the control during both seasons (28.37 & 28.41), whereas T_{11} (hand thinning at 5 cm) gave the highest value of leaf area in the second season, although this was not significantly different from the remaining treatments.

Generally, all treatments improved the leaf area of Aml apricot trees in comparison with the control. These results are in agreement with those Shahin *et al*., [17], found that spraying GA_3 at 20 ppm caused a significant increase in leaf area of "Anna" apple trees compared with that in the control.

The obtained results also agree with the findings of Hota *et al*. [15] they found that CPPU treatments increased the vegetative growth and leaf area. The results are also in agreement with those of El-badawy [18] who showed that the largest leaf area was obtained from the combination of amino acids at a high rate (3 ml/l) sprayed with micronutrients at a high rate (150 ppm).

Moreover, In another study, El-Boray [19] showed that hand blossom thinning (HBT) had a great effect on the leaf area of Florida Prince peach trees. With increasing hand blossom thinning (HBT) distance, the leaf area increased, so HBT at 20 cm presented a higher value in this respect than that at 10 cm and 15 cm. Chemical blossom thinning also improved the leaf area, which may have been due to the thinning effect of these treatments, which decreased the number of fruits per tree.

Leaf Chlorophyll Content: The data presented in Table (5) show that chlorophyll content significantly increased due to most studied treatments compared with both the stema at 200 ppm and control treatments. The same table reveals that thinning significantly affected the leaf chlorophyll content of apricot trees, where the maximum chlorophyll content was recorded upon thinning

Table 5: Effect of GA_3, CPPU, stema and hand fruit thinning on leaf area (cm^2) and leaf chlorophyll content of apricot cv. Aml during 2017 and 2018 seasons

	Leaf area (cm^2)		Leaf chlorophyll (mg/g)	
Treatment	2017	2018	2017	2018
T1:GA_3 (25 ppm)	30.13 b	30.11ab	36.99de	37.97d
T2:GA_3 (50 ppm)	30.25 b	30.35 ab	38.22cde	38.61d
T3:CPPU (10 ppm)	30.19 b	30.45 ab	38.23cde	38.58d
T4:CPPU (15 ppm)	30.72 ab	30.67 ab	38.04cde	38.14d
T5:GA_3 (25 ppm) + CPPU (10 ppm)	30.89 ab	31.13 a	38.02cde	38.11d
T6:GA_3 (25 ppm) + CPPU (15 ppm)	30.85 ab	30.98 a	39.87bc	41.69b
T7:GA_3 (50 ppm) + (CPPU 10 ppm)	30.33 b	30.76 ab	34.05f	34.41ef
T8:GA_3 (50 ppm) + (CPPU 15 ppm)	30.45 b	30.43 ab	38.98cd	39.2 cd
T9:Stema (200 ppm)	31.26 ab	31.36 a	34.11f	34.36f
T10:Stema (400 ppm)	31.11 ab	31.29 a	36.66e	36.87de
T11:Hand thinning at 5 cm	31.83 a	31.93 a	41.22b	41.44 bc
T12:Hand thinning at 10 cm	32.05 a	31.89 a	44.53a	44.7 a
T13:Control	28.37 c	28.41 b	37.13de	37.50d
New LSD 0.5	1.349	2.488	2.151	2.504

*Values within a column with the same letter are not significantly different according to the least significant difference (LSD) test at $p < 0.05$ Yield/tree (kg)

at 10 cm, followed by thinning at 5 cm, in both seasons (44.53 & 44.7 vs. 41.22 & 41.44, respectively). On the other hand, minimum chlorophyll content was recorded upon treatment with stema at 200 ppm, while the other treatments showed intermediate values. Shahin *et al*. [17] found that the spraying of GA_3 at 20 ppm caused a slight increase in leaf chlorophyll content of "Anna" apple trees, which was not significantly different from that of the control.

Yield Kg/tree: Concerning the yield as affected by the different treatments under study, the data in (Fig. 1) show that yield estimated as kg/tree significantly responded to the studied treatments compared with the control during the two experimental seasons. Moreover, the greatest yield was achieved for apricot trees sprayed with GA_3 at 50 ppm and CPPU at 15 ppm (T8) and then GA_3 at 50 ppm and CPPU at 10 ppm (T7), followed by CPPU at 15 ppm (T4) and finally GA_3 at 50 ppm (T2), compared with either the control or any other tested treatments in both seasons of study. The opposite trend was detected with water-sprayed trees (control), representing the lowest values of tree yield. Other investigated treatments gave intermediate values during both seasons of study.

The experimental results indicated that the foliar application of GA_3 significantly improved the yield and significantly decreased the fruit drop percentage. These results agree with the findings of Kabbel and Fawazz [20] who found that the spraying of gibberellic acid on "Le Conte" pear trees greatly enhanced the fruit set percentage and thereby the yield percentage.

With respect to the effects of the application of CPPU alone, stema alone and their use in combination, these may be related to the accumulation of higher rates of auxin and cytokinin after pollination and fertilization, which act as accelerators for increasing the size of fruit. In addition, the improvement in fruit quality grade obtained by the different bio-regulators might have been due to increased cell enlargement and carbohydrate sink strength [21].

In addition, the increase of yield can be explained by the findings of El Sabagh [22] who reported that young developing fruits have rapidly dividing cells and the seeds contained within them are rich sources of cytokinins, suggesting that they play an important role in fruit growth. Similarly, Stern *et al*. [23] also stated that the positive effects of sitofex on fruit weight and dimensions, as well as on reducing pre-harvest fruit drop, resulted in increased fruit yield in apple.

As for the effects of leaf thinning, the obtained data clearly showed that thinning was the most effective treatment regarding fruit weight and fruit dimensions. These findings resembled those of Taghipour *et al*. [24] on apricot, who showed that hand thinning significantly increased fruit weight, volume and quality, achieving the highest leaf-to-fruit ratio. Removing excessive fruits by fruitlet thinning prevents the draining of energy of the tree by pits. The increases in fruit size and weight with increased thinning intensity indicate the greater availability of nutrients for fruit growth and development [25].

Correlations of yield with shoot length, number of leaves/shoots, leaf area, leaf chlorophyll and number of days from full-bloom stage until harvest in the 2017, 2018 seasons and across 2 years of apricot cv. Aml:

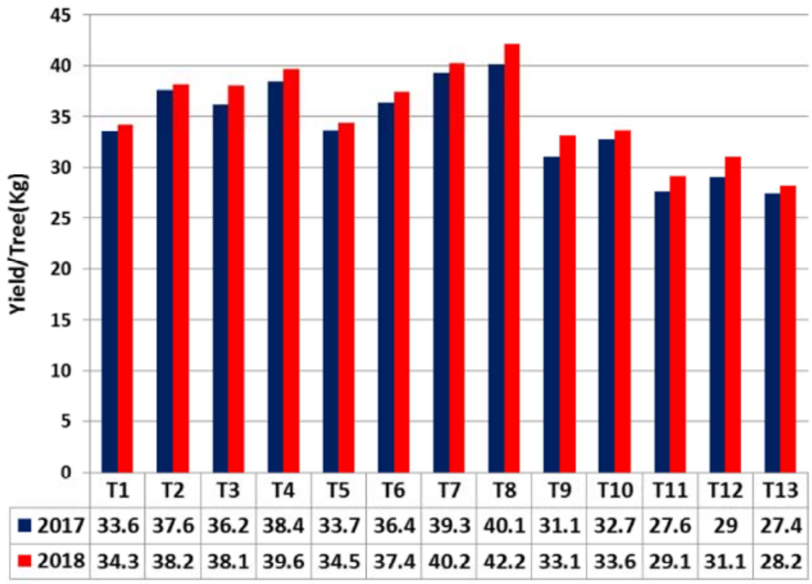

Fig. 1: Effect of GA_3, CPPU, stema and hand fruit thinning on fruit yield/tree (kg) of apricot cv. ? Aml ? during 2017 and 2018 seasons

Table 6: Correlations of yield with shoot length, number of leaves/shoots, leaf area, leaf chlorophyll and number of days from full-bloom stage until harvest in the 2017, 2018 seasons and across 2 years of apricot cv. Aml

	Years		
Traits	Yield 2017	Yield 2018	Yield under 2 years (2017–2018)
Shoot length (cm)	-0.010406272	-0.46446	-0.144740956
No. of leaves/shoots	0.014539	0.017203	0.028735024
Leaf area (cm^2)	-0.1321	-0.02697	-0.070204897
Leaf chlorophyll (mg/g)	-0.2971	-0.23261	-0.24901976
Number of days	0.98523**	0.988004**	0.971481804**

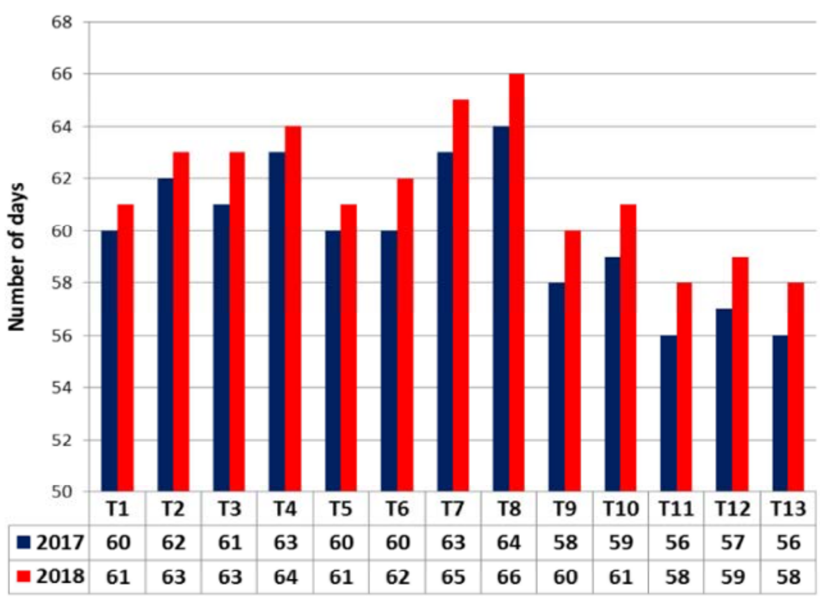

Fig. 2: Number of days from full-bloom stage until harvesting date of apricot cv. Aml during 2017 and 2018 seasons

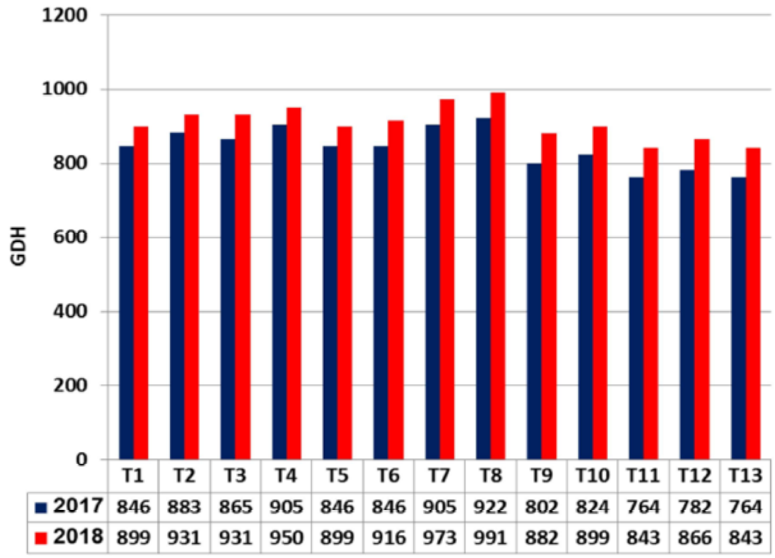

Fig. 3: Accumulated growing degree hours GDH from full-bloom stage until fruit harvesting of apricot cv. Aml during 2017 and 2018 seasons

The data in Table (6) show that the yield and number of days from the full-bloom stage until the harvest date had a very significant positive correlation, while the correlations with the rest of the traits were not significant. The yield had non-significant negative correlations with the shoot length and leaf area, but a non-significant positive correlation with the number of leaves/shoots.

Number of Days Between Full-Bloom Stage and Harvest Date: The data in (Fig. 2) show that the longest periods (in number of days) from the full-bloom stage until the harvest date (64 & 66 days) in the 2017 & 2018 seasons occurred for T_8 [GA_3 (50 ppm) + CPPU (15 ppm)], while the shortest periods (56 & 58 days) in the 2017 & 2018 seasons occurred, respectively, for T_{13} (control) and T_{11} (hand thinning at 5 cm). This can be explained by the fact that the higher yield was associated with a delay in ripening of the fruit and thus a delay in the harvest time.

Growing Degree Hours (GDH): The data in (Fig. 3) show the accumulated GDH in Regwa in two successive seasons, 2017 and 2018, from the full-bloom stage until the harvest date. The highest accumulation of GDH was 991.04°C in the second season in T_8 [GA_3 (50 ppm) + CPPU (15 ppm)]. As previously noted by El-Agamy *et al.* [26] GDH was a more accurate method than the number of days to determine fruit maturity.

Leaf Chemical Composition: Generally, the data in Table (7) revealed that treatments of GA_3, CPPU, stema and hand thinning significantly increased the leaf mineral content of apricot leaves compared with the levels in untreated trees. However, the maximum nitrogen content was found in leaves from trees treated with GA_3 at 50 ppm combined with CPPU at 15 and 10 ppm, as well as stema at 400 and 200 ppm. The minimum N content was found in the control. Hand-thinning treatment showed an increase in N content compared with the control, but this was not significant. In addition, the maximum phosphor content was found in leaves from trees treated with GA_3 at 25 ppm combined with CPPU at 10 or 15 ppm, while hand-thinning treatments were associated with the highest potassium concentration. In addition, significantly higher calcium content was observed in trees treated with GA_3 at 25 ppm alone, CPPU at 10 ppm alone, GA_3 at 50 ppm combined with CPPU at 10 ppm and GA_3 at 25 ppm combined with CPPU at 15 ppm, as well as hand-thinning treatments. Moreover, the maximum copper content was from trees treated with GA_3 at 25 and 50 ppm combined with CPPU at 10 ppm. Furthermore, the highest zinc content was found in leaves treated with GA_3 at 25 ppm combined with CPPU at 15 ppm. Finally, hand thinning at 10 cm achieved the highest manganese content.

The obtained results for GA_3 in terms of leaf mineral content of Aml apricot trees are in line with those of Kabbel and Fawazz [20], who found that spraying gibberellic acid on 'Le Conte' pear trees greatly enhanced leaf mineral contents. In addition, Woolley *et al.* [27] found that the physiological effect of CPPU was to increase the amount of carbon allocated to fruit growth, stimulating both cell division and cell expansion.

Table 7: Effects of GA_3, CPPU, stema and hand thinning on leaf chemical composition of N, P, K, Ca (mg/100g fw), Cu, Zn and Mn (ppm) of apricot cv. Aml during 2017 and 2018 seasons

	N		P		K		Ca		Cu		Zn		Mn	
Treatment	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
T1:GA_3 (25 ppm)	2.37b	2.42 bc	0.216 cde	0.223 ef	3.82 c	3.84 c	2.81 a	2.73 ab	6.25 ab	6.41 ab	21.7 c	22.3 b	80.5 c	82.3 c
T2:GA_3 (50 ppm)	2.48 b	2.51 b	0.274 b	0.232 def	3.01 e	3.11 d	2.08 b	2.01 c	4.5 ef	4.82 ef	17.8 d	18.3 c	61.25 f	67.4 f
T3:CPPU (10 ppm)	2.18 de	2.23 de	0.252 bcd	0.261 bcde	3.94 c	3.98 bc	2.81 a	2.73 ab	5.5 c	5.6 cd	15.8 e	16.2 d	73.0 d	74.3 d
T4:CPPU(15 ppm)	2.08 e	2.14 e	0.216 cde	0.226 ef	3.70 c	3.74 c	1.98 b	1.72 de	4.75 de	4.83 ef	13.8 fg	14.4 ef	69.0 e	71.2 e
T5:GA_3(25 ppm) +CPPU(10 ppm)	2.08 e	2.11 ef	0.367 a	0.368 a	4.28 b	4.21 b	2.04 b	1.65 de	6.5 a	6.63 a	15.0 ef	15.3 de	72.0 d	74.1 d
T6 GA_3(25 ppm) +CPPU (15 ppm)	2.27 cd	2.32 cd	0356 a	0.361 a	3.36 d	3.39 d	2.84 a	2.81 ab	5.5 c	5.87 bc	25.8 a	25.9 a	79.5 c	83.3 c
T7:GA_3(50 ppm)+CPPU(10 ppm)	2.88 a	2.94 a	0.211 de	0.235 cdef	3.28 de	3.31 d	2.93 a	2.86 a	6.5 a	6.6 a	18.6 d	13.3 f	73.50 d	75.4 d
T8:GA_3(50 ppm)+CPPU(15 ppm)	2.98 a	2.99 a	0.263 bcd	0.272 bcde	3.70 c	3.72 c	2.02 b	1.98 c	5.0 d	5.21 de	12.80 g	12.9 fg	57.75 g	62.2 g
T9:Stema at 200ppm	2.82 a	2.89 a	0.267 bc	0.271 bcde	3.88 c	3.89 c	1.69 c	1.63 e	5.7 c	6.1 abc	24.2 b	25.9 a	68.6 e	71.2 e
T10:Stema at 400ppm	2.84 a	2.89 a	0.274 b	0.281 bcd	3.94 c	3.95 bc	1.76 c	1.68 de	5.9 bc	5.97 bc	25.0 ab	26.8 a	69.5 e	73.6 d
T11:Hand thinning (5 cm)	1.84 f	1.97 f	0.289 b	0.288 bc	4.61 a	4.59 a	2.87 a	2.65 b	5.6 c	5.73 cd	14.8 ef	15.7 de	91.0 b	92.2 b
T12:Hand thinning (10 cm)	1.82 f	1.96 f	0.289 b	0.292 b	4.70 a	4.72 a	2.83 a	2.71 ab	5.71 c	5.77 cd	15.50 e	16.6 d	94.0 a	94.8 a
T13:Control	1.66 f	1.54 g	0.177 e	0.189 f	3.22 de	3.41 d	1.79 c	1.84 cd	4.08 f	4.33 f	11.12 h	11.36 g	57.1 g	61.3 g
New LSD at 0.05	0.184	0.168	0.053	0.053	0.296	0.271	0.150	0.199	0.476	0.595	1.345	1.565	1.886	2.012

*Values within a column with the same letter are not significantly different according to the least significant difference (LSD) test at $p < 0.05$

Moreover, Ismail *et al*. [28] showed that the levels of some leaf macronutrients (N, P, K and Ca) responded to CPPU treatment at 10 mg/l, resulting in significant increases in their leaf contents compared with the levels in the control.

As for the effects of amino acids on leaf mineral content of Canino apricot trees, these are in line with an earlier study by Fayek *et al*. [29] on pear. They reported that amino acid treatments improved the nutritional status of the trees. El-Badawy [18], also revealed that the highest levels of N, P, K, Fe, Zn and Mn in leaf were obtained by using a mixed treatment of amino acids at 3 ml/l and micronutrients at 150 ppm.

Regarding the effects of thinning on leaf mineral contents, these are in line with the findings of Zarei *et al*. [30] they found that, in leaf tissues, the concentrations of all minerals increased in response to thinning. Chemical thinning of fruit at the stage of 8 to 10 mm in diameter caused increases in some minerals, especially P and K and influenced fruit quality in cv. Soltani apples. Moreover, Nachtigall *et al*. [31] showed that the increase in leaf Ca concentration throughout the season can be explained by Ca immobility in plant tissues and its lack of redistribution to other plant organs. In contrast, Blanco *et al*. [32] reported that crop load did not affect leaf Mg concentration in peaches.

CONCLUSION

From the obtained results it is worthy to suggest that Hand thinning at 10 cm (after 15days/full bloom) increased apricot vegetative growth parameters , highest levels of K and Mn in leaf and TSS/Acid ratio. Also foliar spray at full bloom with GA_3 at 50 ppm + CPPU at 15 ppm could be used for grain yield per plant estimation useful in yield prediction.

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REFERENCES

1. FOOD and Agriculture Organization, 2018. Stat. Food Agric. Organ. U. Nation.
2. Lurie, S., 2010. Plant growth regulators for improving postharvest stone fruit quality. Acta Hortic., 884: 189-197.
3. Zahoor, A.B., 2011. Rizwan, R., Javid, A.B., Effect of plant growth regulators on leaf number, leaf area and leaf dry matter in grape. Natl Sci. Biol., 3: 87-90.
4. Singh, D.P., A.M. Jermakow and S.M. Swain, 2002. Gibberellins are required for seed development and pollen tube growth in Arabidopsis. Plant Cell, 14: 3133-3147.
5. Pires, E.J.P., R.V. Botelho and M.M. Terra, 2000. Effect of CPPU and gibberellic acid on the cluster characteristics of seed less table grapes. Ciencia e Agrotecnologia, 27(2): 305-311.
6. Kappel, F. and R.A. MacDonald, 2002. Gibberellic acid increases fruit firmness, fruit size and delays maturity of sweetheart sweet cherry. Journal of American Pomology Society, 56(4): 219-222.
7. Cruz-Castillo, J.G., D.J. Woolley and G.S. Lawes, 2002. Kiwifruitsize and CPPU response are influenced by the time of anthesis. Sci. Hortic., 95(1-2): 23-30.

8. Berg, C.L., 1986. Farm chemical Handbook (ed). Meister publishing company, Willoughty, U.S.A., pp: 10-16.
9. Pérez-Pastor, A., M.C. Ruiz-Sánchez, R. Domingo and A. Torrecillas, 2004. Growth and phenological stages of Búlida apricot trees in south-east Spain. Agronomie, 24(2): 93-100.
10. Arnon, D.I., 1949. Copper enzymes in isolated choloroplasts polyphenol oxidase in Beta vulgaris. Plant Physiol., 24(1): 1-15.
11. Tabuenca, M.C. and J. Herrero, 1966. Influencia de la temperatura en la época de floración de los frutales, An. Aula Dei., 8: 115-153.
12. Snedecor, W. and W.G. Cochran, 1989. *Statistical methods* (8th edn.). Ames. IA., U.S.A: Iowa State University Press.
13. Haouari, A., M. C .Van Labeke, K. Steppe, F.B. Mariem, M. Braham and M. Chaieb, 2013. Fruit thinning affects photosynthetic activity, carbohydrate levels and shoot and fruit development of olive trees grown under semiarid conditions. Funct. Plant Biol., 40(11): 1179-1186.
14. Rai, V.K., 2002. Role of amino acids in plant responses to stress. Biol. Plant., 45: 471-478.
15. Hota, D., D.P. Sharma and N. Sharma, 2017. Effect of Forchlorfenuron and N-acetyl thiazolidine 4-carboxylic acid on vegetative growth and fruit set of apricot (*Prunus armeniaca* L.) cv. New Castle. J. Pharmacogn. Phytochem., 6(2): 279-282.
16. Thomas, J.C. and F.R. Katterman, 1986. Cytokinin activity induced by thidiazuron. Plant Physiol., 81(2): 681-683.
17. Shahin, M.F.M., M.I.F. Fawzi and E.A. Kandil, 2010. Influence of foliar application of some nutrient (Fertifol Misr) and gibberellic acid on fruit set, yield, fruit quality and leaf composition of "Anna" apple trees grown in sandy soil. J. Am. Sci., 6(12): 202-208.
18. El-Badawy, H.E.M., 2019. Effect of spraying amino acids and micronutrients as well as their combination on growth, yield, fruit quality and mineral content of Canino apricot trees. J. Plant Prod., 10(2): 125-132.
19. El-Boray, M.S., A.M. Shalan and Z.M. Khouri, 2013. Effect of different thinning techniques on fruit set, leaf area, yield and fruit quality parameters of *Prunus persica*, L. Batsch cv. Floridaprince. Trends Hortic. Researeh, 3(1): 1-13.
20. 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. Minufiya. J. Agric. Res., 3(3): 173-193.
21. Dokooslain, N.K., 2000. Plant growth regulator use for table grape production in California. Proceedings of the therapeutic 4th international symposium. Tabel Grape Growers Council, pp: 129-143.
22. El-Sabagh, A.S., 2002. Effect of sitofex (CPPU) on “Anna” apple fruit set and some fruit characteristics. Alex. J. Agric. Res., 47(3): 85-92.
23. Stern, A.R., R. Ben-Arie, S. Applebaum and M. Flaishman, 2006. Cytokinins increase fruit size of 'Delicious' and 'Golden Delicious' (*Malus domestica*) apple in a warm climate. J. Hortic. Sci. Biotechnol., 81(1): 51-56.
24. Taghipour, L., M. Rahemi and P. Assar, 2012. Thinning with NAA, NAD, ethephon, urea and by hand to improve fruit quality of ‘Gerdi’ apricot. Braz. J. Plant Physiol., 23(4): 279-284.
25. Peter, K.V. and Z. Abraham, 2007. Biodiversity in horticulture crop, Delhi, Daya, 1: 364.
26. El-Agamy, S.Z., A.K.A. Mohamed, F.M.A. Mostafa and A.Y. Abdallah, 2001. Effect of GA_3, hydrogen cyanamide and decapitation on budbreak and flowering of two apple cultivars under the warm climate of Southern Egypt. Acta Hortic., 565: 109-114.
27. Woolley, D.J., G. S. Lawes and J.G. Cruz-Castillo, 2008. The growth and competitive ability of *Actinidia deliciosa* "Hayaward" fruit carbohydrate availability and response to the cytokinin active compound CPPU. Acta Hortic., 297: 386-392.
28. Ismail, E.A., S.M. Hussien and F.I. Abou Grah, 2014. Studies on Improving Fruit Yield and Quality of Peach CV. "Early sweeling". NIDOC-ASRT, 41(1): 83-95.
29. Fayek, M.A., T.A. Yehia, E.M.M. El-Fakhrany and A.M. Farag, 2011. Effect of ringing and amino acids application on improving fruiting of “Le Conte” pear trees. J. Hort. Sci., 3(1): 1-10.
30. Zarei, M., B. Baninasab, A. A. Ramin and M. Pirmoradian, 2013. The effect of chemical thinning on seasonal changes of mineral nutrient concentrations in leaves and fruits of ‘Soltani’ apple trees. Iran Agric. Res., 32(2): 89-100.
31. Nachtigall, G.R. and A.R. Dechen, 2006. Seasonality of nutrients in leaves and fruits of apple trees. Sci. Agric. (Piracicaba Braz.), 63(5): 493-501.
32. Blanco, A., A. Pequerul, J. Val, E. Monge and J. Gomez Aparisi, 1995. Crop-load effects on vegetative growth, mineral nutrient concentration and leaf water potential in ‘Catherine’ peach. J. Hortic. Sci., 70(4): 623-629.