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STUDY THE EFFECT OF FOLIAR APPLICATION OF GIBBERELLIC ACID (GA3) AND LIQUID CALCIUM ON GROWTH AND FRUIT QUALITY OF POMEGRANATE TREES (PUNICA GRANATUM L.) CV. SAWA

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Abstract

This study was carried out during the growing season 2021 in a local private orchard located outskirts of Erbil city nearby to Bahrka, Kurdistan Region/ Iraq. On pomegranate trees (*Punica granatum* L.) cv. Sawa which were 12 old years, all trees that chosen had uniform in size and growth were trained with multi stems system and planted at 4x4 m, to study the effect of foliar application of Gibberellic acid at three concentrations (0, 150, 300 mg. L^{-1}), and liquid Calcium at (0, 1.5, 3 ml. L^{-1}) on growth and fruits quality. Three rates of GA_3 and liquid Calcium were applied twice the first one after two weeks of complete fruit set, and the second time when the fruit pill was change in color. The study was arranged as a factorial experiment in (RCBD) with three replications by using one tree as the experimental unit. The results were summarized that: foliar spray of (GA_3) at (300 mg. l^{-1}) rates led to a significant increase and gave the highest mean values of leaf content of (nitrogen, phosphor, potassium and calcium), leaf content of chlorophyll, leaf area, fruit size, epicarps content of Ca, TSS, anthocyanin and vitamin - c content. While foliar spray of liquid Calcium at (3 ml. l^{-1}) gave the best results of leaf content of (nitrogen and potassium), leaf area, fruit size, epicarps content of Ca, TSS, anthocyanin and vitamin - c content.

Keywords: Pomegranate, GA3, Liquid calcium, Foliar application, Fruit quality.

دراسة تأثير الرش الورقي لحامض الجبرليك (GA_3) والكالسيوم السائل على النمو ونوعية الثمار لا شجار الرمان (*Punica granatum* L.) صنف ساوا

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الخلاصة

نفذت هذه الدراسة خلال موسم النمو 2021 في أحد البساتين الخاصة يقع على أطراف مدينة أربيل بالقرب من بحركة، إقليم كوردستان / العراق. على اشجار الرمان (*Punica granatum* L.) صنف Sawa بعمر 12 سنة متجانسة من ناحية الحجم والنمو ومرباة بنظام متعدد السيقان ومزروعة بأبعاد 4 x 4 م لدراسة تأثير الرش الورقي لحامض الجبريليك بثلاثة تراكيز 0، 150، 300 ملغم. لتر$^{-1}$ وثلاثة تراكيز من الكالسيوم السائل 0، 1.5، 3 مل. لتر$^{-1}$ على النمو وجودة الثمار. تم تطبيق ثلاث مستويات من حامض الجبرليك والكالسيوم السائل والتي رشت مرتين، المرة الأولى بعد أسبوعين من عقد الثمار، والمرة الثانية عند تغير لون قشرة الثمرة. نفذت تجربة عاملية وبثلاثة مكررات وفق تصميم القطاعات العشوائية الكاملة (RCBD) وباستخدام شجرة واحدة كوحدة تجريبية ولخصت النتائج لهذه التجربة كالاتي: أن الرش الورقي بحامض الجبرليك عند مستوى 300 ملغم. لتر$^{-1}$ ادت الى زيادة معنوية وأعطت أعلى القيم لمعظم الصفات المدروسة، محتوى الأوراق من النتروجين والفسفور والبوتاسيوم والكالسيوم ومحتوى الأوراق من الكلوروفيل ومساحة الورقة وحجم الثمار ومحتوى القشرة من الكالسيوم والمواد الصلبة الذائبة الكلية ومحتوى العصير من الأنثوسيانين وايضا محتوى فيتامين C في العصير، بينما أعطى الرش الورقي للكالسيوم السائل عند مستوى 3 مل. لتر$^{-1}$ أفضل النتائج لمحتوى الأوراق من النتروجين والبوتاسيوم ومساحة الورقة وحجم الثمرة ومحتوى القشرة من الكالسيوم ونسبة المواد الصلبة الذائبة الكلية ومحتوى العصير من الأنثوسيانين وايضا محتوى فيتامين C في العصير.

كلمات مفتاحية: الرمان، GA3، الكالسيوم السائل، الرش الورقي، جودة الثمار.

Introduction

The Pomegranate (*Punica granatum* L.) is a member of the Punicaceae family plants. It is one of the most widely consumed table fruits. It is a favorite fruit in temperate, tropical and sub-tropical regions of world. The Pomegranate is native from Iran to the Himalayas in northern India and has been cultivated and naturalized over the Mediterranean region and the Caucasus region of Asia since ancient time (46). Pomegranate is classified as a non-climacteric fruit with no detectable levels of ethylene produced during storage. Pomegranate fruit in Iraq start maturity from the end of July to the end of November that relies on climate, cultivar, cultivating fields, and service processes such as pruning, fertilization, irrigation and the fruit are generally harvested fully ripe (53).

Pomegranate is tolerant to drought, salt, iron chlorosis and active calcium carbonate. It is widely cultivated throughout china, Iran, India, the drier parts of Southeast Asia, Malaya, the East Indies, and dry, hot areas of the United States and Latin America. It typically grows below 1000 m in altitude, is mainly confined to the tropics and subtropics and grows well in arid and semi-arid climates (23). Favorable growth takes place where winters are cool and summers are hot. It has the ability to withstand frosty conditions, but frosts in the early fall can destroy the fruit in late varieties, but below ($^{-}$10 °C) will not survive long. Secondary metabolites can be found in fruit peels, leaves, tree stems and root bark such as, dyes, tannins and alkaloids (36).

A temperature of (38 °C) and a dry climate during fruit development produce the best quality fruits. Areas with high relative humidity or rain are totally unsuitable for its cultivation, as fruits produced under such conditions tend to taste less sweet and are prone to cracking. Although, pomegranate is well adapted to a wide range of growing conditions and soils. (48).

Plant growth regulators have advantageously used in the recently to increase the fruit production and to improve the quality of several fruit crops. The effects of applying GA_3 on the pomegranate trees to improve plant growth, yield, fruit quality parameters and lessening of cracking as well as the retardation of maturity and it enhances the rapid changes in physiological and biochemical characters and improves crop productivity (24).

Gibberellic acid was widely used in various horticultural crops for improving fruit set, fruit weight and dimensions, aril %, firmness, peel thickness, yield and its components, total sugars, vitamin- c, total anthocyanins and total soluble solids percentage. Spraying pomegranate with various concentrations of GA_3 reduced the percentage of fruit cracking (35).

Calcium plays an important role to improve fruit growth and creates a state of water balance between epicarps and inside fruit tissue, as well as maintains fruit cell wall elasticity and firmness. Applying calcium before harvest improves various fruits quality. Calcium is the most important mineral in ensuring the cell structure stability and mechanical strength. (17) Indicated that calcium was an important component of plant tissue, taking part in the protection of plant cells. (21) Also indicated that calcium played an important role in the regular maturity process. The application of calcium to fruits both prior to and after harvesting provides protection against physiological deterioration, retardation of maturity and improvement fruit quality (15).

The aim of the study is to increase the production of pomegranate (Sawa) variety and to improve the physical and chemical characteristics of the fruits through foliar spraying with gibberellic acid and liquid calcium.

Materials and Methods

The Research Site: The research was carried out during the season of 2021 at a private orchard of pomegranate in Darashkran located, 43 kilometers from south-western Erbil city, Kurdistan-Iraq. Latitude 36°41 44°01 N, Longitude 43°59 ' 39°65 E, and elevation 414 meters above sea level. The pomegranate tree (*Punica granatum* L.) was chosen as the subject of the experiment. The tree was 12 years old and cultivated 4 x 4 meters. Sawa cultivar characterized by its medium sized fruits, rounded shape, the arils are pink to red in color and sour-sweet taste as it progresses fruit maturity increases and less acidity. Twenty seven trees nearly uniform in shape and size and were trained to three steams, as well as being under a drip irrigation system.

Experimental design and statistical analysis: In this experiment, we used a foliar application of GA_3, coupled with a foliar application of Liquid Calcium. The experiment is designed according to a Randomized Completely Block Design (RCBD) with three replications by using one tree as the experimental unit thus the number of trees will be used in this study (3 x 3 x 3 = 27 tree). The mean values will be compared using Duncan multiple range tests (DMRT) at 0.05 of probability. (11). and the data was analyzed by utilize SAS institute (43).

Studied characteristics

Leaf Content (N, P, K and Ca %): Leaf mineral content such as (N, P, K and Ca) as percentage, in dry leaves were determined by collecting 60 leaves randomly from the top mid and bottom at the different sides of a tree, and washed well with water to remove any residue after washing dried. After that, place the samples in the oven at 70 °C for 72 hours, until the weight of the samples become constant. As the methods described in (1).

Leaf Relative Chlorophyll Content (SPAD unit): The relative content of chlorophyll in the leaves was measured using the SPAD meter randomly from 40 leaves for each tree (experimental unit), and then the rate was determined (20).

Leaf Area (cm^2): Thirty leaves of each tree were collected randomly from the top, middle and bottom of the tree canopy. Leaf area was measured non-destructively using the (Easy Leaf Area Image Program) software windows.

Tree Yield (kg): The total yield (kg) of each replicate tree was calculated using the average fruit weight (gm) and the total number of fruits per tree. According to the following equation:

Tree yield = Number of fruit per tree X Average weight of fruit

Fruit Size (cm^3): The average size was obtained by randomly taking 10 fruits from each tree (experimental unit) to determine the size of the fruits, and a numerical cylinder filled with water was used. The size of the fruit is equal to the amount of displaced water. (10).

Weight of 100 Arils (g): It took a hundred arils from the all of 10 fruits for each tree (experimental unit) to determine the weight of 100 arils on a sensitive electronic balance. (37).

Juice Percentage (%): The juice percentage was calculated by weighting the juice the juice using this equation: (30).

$$\text{Juice \%} = \frac{\text{Weight of juice of 100 aril (g)}}{\text{Weight of 100 aril (g)}} \times 100$$

Fruit Epicarps Content of Ca (%): Some Epicarps samples were taking randomly from 10 fruit of pomegranate (experimental unit), and dried for three day. After that, place the samples in the oven at 70 °C for 72 hours, until the weight of the samples became constant. To assess epicarps content of Ca. (13).

Total Soluble Solids (TSS %): A drop of juice was placed on the prism of digital Refractometer and direct reading was taken. Firstly the calibration was made with distilled water and the prism was carefully rinsed between reading two samples as described in. to characterize the maturity and quality of the fruit TSS was determined (1).

Total Acidity (TA %): Total acidity was determined by the method of (1), a known volume of filtered juice titrated with 0.1 N (NaOH) using phenolphthalein indicator. The appearance of light pink color was marked as the end point. Acidity was compared and expressed as the percent of citric acid.

Anthocyanin Content (mg.100g^{-1} fresh weight). (40).

$$\text{Anthocyanin content (\%)} = \frac{Abs\ 535 * Ve * Tv}{Vu * Wts} \times 100$$

Abs 535 = reading of spectrophotometer at 535 nm.

Ve = Volume of extracts which is used for color measurement by spectrophotometer.

Tv = Total volume.

Vu = Volume of taken extracts.

Wts = Weight of the sample.

Vitamin – C Content (mg.100 ml^{-1} juice). (26).

Results and Discussion

Effect of GA_3 and Liquid Calcium on Growth Characteristics:

Table 1 Effect of GA_3 and Liquid Calcium application and their interactions on vegetative characteristic of pomegranate tree cv. Sawa.

Treatments		N %	P %	K %	Ca %	Chlorophyll (SPAD)	Leaf area (cm2)
GA3 (mg.l-1)	0	1.206 c	0.240 c	0.640 c	1.587 b	45.74 b	9.710 b
	150	1.525 b	0.299 b	0.813 b	1.573 b	51.31 a	11.158 a
	300	2.190 a	0.349 a	0.998 a	1.904 a	49.13 a	10.074 b
Liquid Calcium (ml.l-1)	0	1..404 b	0.278 a	0.725 b	1.519 a	47.70 a	10.086 b
	1.5	1.571 b	0.299 a	0.854 a	1.803 a	48.25 a	9.858 b
	3	1.946 a	0.310 a	0.871 a	1.743 a	50.23 a	10.997 a
0	0	1.063 d	0.214 e	0.595 d	1.047 c	41.56 c	8.276 e
	1.5	1.178 cd	0.258 bcde	0.686 bcd	1.821 a	46.90 b	10.076 cd
	3	1.378 cd	0.248 de	0.640 cd	1.895 a	48.76 ab	10.776 bc
	0	1.418 cd	0.252 cde	0.786 bc	1.868 a	53.80 a	11.633 ab

150	1.5	1.491 cd	0.313 abcd	0.793 bc	1.686 ab	48.60 ab	10.056 cd
	3	1.665 bc	0.332 ab	0.859 b	1.165 bc	51.53 ab	11.786 a
300	0	1.732 bc	0.368 a	0.795 bc	1.642 ab	47.73 b	10.350 cd
	1.5	2.044 b	0.328 abc	1.084 a	1.901 a	49.26 ab	9.443 d
	3	2.794 a	0.352 a	1.116 a	2.170 a	50.40 ab	10.430 c

Leaf content of (N %): According to the (table 1), the foliar application of GA_3, significantly affected the leaf content of N. the maximum value of leaf content of N (2.190 %) was recorded at the level (300 mg. l^{-1}) and the minimum value (1.206 %) was noted (0 mg. l^{-1}) treatment. In the same table indicated that Liquid calcium had a significant effect on nitrogen content, the best value (1.946 %) was observed in the treatment of (3 ml. l^{-1}) compared to lowest value (1.404 %) in (0 ml. l^{-1}) treatment. Data presented in the same table display that interactions of GA_3 and Liquid calcium caused a significant effects on nitrogen content, the highest value (2.794 %) was recorded from the interaction of (300 mg. l^{-1} of GA_3 and 3 ml.l^{-1} of Liquid calcium) compared to lowest value (1.063 %) in the (0 mg. l^{-1} of GA_3 + 0 ml.l^{-1} of Liquid calcium) treatment.

Leaf content of (P %): Results in the (table 1) indicated that GA_3 had a significant effect on phosphorus content, the best value (0.349 %) was observed at a level (300 mg. l^{-1}), while the lowest value (0.240 %) was recorded at the (0 mg. l^{-1} GA_3). It is obvious from the same table notice that foliar spray with Liquid calcium did not significant affected on phosphorus content of the leaf. The obtained results in the same table exhibits that interaction of GA_3 and Liquid calcium had a significant effect on phosphorus content, the highest Phosphorus content was (0.368 %) recorded from the interaction of (300 mg. l^{-1} of GA_3 and 0 ml. l^{-1} of Liquid calcium) compared to lowest value (0.214 %) in the control treatment.

Leaf content of (K %): Data presented in (table 1) shows that GA_3 had significant effect on potassium content, the best value (0.998 %) was observed from the level (300 mg. l^{-1}). In the equal table the results indicated that the Liquid calcium had a significant effect on potassium content, the highest value (0.871 %) was observed in (3 ml.l^{-1}). Data enclosed in the same table notices that interaction of GA_3 and Liquid calcium had a significant effects on potassium content, the highest potassium content (1.116 %) was recorded from (300 mg. l^{-1} of GA_3 and 3 ml.l^{-1} of Liquid calcium), compared to lowest value (0.595 %) which was recorded in control treatment.

Leaf content of (Ca %): As shown in (table 1) the use of foliar spray with GA_3 had a significant effect on leaf Calcium content. The highest value of calcium in the consist of leaf (1.904 %) was recorded at a level of (300 mg. l^{-1}), while the lowest value 1.573 was recorded at the (150 mg. l^{-1}) treatment. As indicated in the same table, foliar spray with liquid calcium did not significant affected on calcium content of leaf. It was the combination of foliar spray with GA_3 and Liquid calcium that resulted in a significant increase in leaf content of calcium on leaf of pomegranate trees. The maximum value (2.170 %) was recorded at levels (300 mg. l^{-1} of GA_3 and 3 ml. l^{-1} of Liquid calcium). While the lowest value (1.047 %) was noted in control treatment.

Leaf relative chlorophyll content (SPAD unit): The (table 1) shows that the GA_3 had a significant effect on leaf content of chlorophyll, the best value (51.31 SPAD unit) were observed from the level of (150 mg. l^{-1}). It is obvious from the same table; foliar spray with Liquid calcium did not significant affected on calcium content of leaf. It was cleared from the same table that interactions of GA_3 and Liquid calcium had a significant effects on leaf content of chlorophyll, the highest value (53.80 SPAD unit) was obtained from the interaction of (150 mg. l^{-1} of GA_3 and 0 ml. l^{-1} of Liquid calcium) compared to lowest value (41.56 SPAD unit) which was recorded in the control treatment.

Leaf area (cm^2): It is clear from (table 1) noticed that the GA_3 had a significant effect on leaf area. The highest value (11.158 cm^2) was observed at the level of (150 mg. l^{-1}). The same table shows that the foliar application of Liquid calcium caused a significant effect on leaf area. The maximum value (10.997 cm^2) was noted from (3 ml. l^{-1}). In the same table also shows that the interaction of GA_3 and Liquid calcium had a significant effects on leaf area, the highest value (11.786 cm^2) was recorded from the interaction of (150 mg. l^{-1} of GA_3 and 3 ml. l^{-1} of Liquid calcium) compared to lowest value (8.276 cm^2) which was obtained from control treatment.

Effect of GA_3 and Liquid Calcium on Yield Characteristics:

Table 2 Effect of GA_3 and Liquid calcium application and their interactions on yield characteristic of pomegranate tree cv. Sawa.

Treatments		Tree yield ($Kg.tree^{-1}$)	Fruit size (cm^2)	Weight of 100 arils (g)	Juice percentage (%)	Epicarps content of (Ca %)
GA_3 ($mg.l^{-1}$)	0	88.99 a	372.39 b	36.08 a	62.63 a	1.66 c
	150	94.38 a	408.19 a	38.41 a	66.04 a	2.16 b
	300	86.56 a	399.58 a	38.63 a	65.24 a	2.61 a
Liquid Calcium ($ml.l^{-1}$)	0	86.23 a	369.23 b	37.07 a	63.90 a	1.82 b
	1.5	83.31 a	405.14 a	38.20 a	64.51 a	2.07 b
	3	100.39 a	405.78 a	37.85 a	65.50 a	2.53 a
0	0	38.44 b	297.33 b	31.69 b	59.30 b	1.17 e
	1.5	103.19 ab	401.67 a	38.03 a	63.91 ab	1.53 de
	3	125.35 a	418.17 a	38.51 a	64.70 ab	2.30 bc
150	0	119.44 a	412.47 a	38.58 a	67.26 a	1.88 cd
	1.5	83.09 ab	408.27 a	37.49 a	65.18 ab	2.15 bc
	3	80.62 ab	403.83 a	39.16 a	65.69 ab	2.44 ab
300	0	100.79 ab	397.90 a	40.93 a	65.16 ab	2.43 ab
	1.5	63.66 ab	405.50 a	39.09 a	64.44 ab	2.54 ab
	3	95.21 ab	395.33 a	35.87 ab	66.12 ab	2.85 a

Tree yield (kg): The result in (table 2) shows that there were no significant effects of GA_3 and Liquid calcium on tree yield (kg). The recorded data in the same table indicated that interactions of GA_3 and Liquid calcium concentrations had a significant effects on yield per tree, the maximum value (125.35 kg) was recorded from the interaction of (0 mg. l^{-1} GA_3 and 3 ml. l^{-1} Liquid calcium) compared to lowest value (38.44 kg) in control treatment.

Fruit size (cm^2): The (table 1) exhibits significant effect of GA_3 on fruit size, the maximum value (408.19 cm^2) was observed from (150 mg. l^{-1}). The same table indicates that Liquid calcium had a significant effect on fruit size, the highest value (405.78 cm^2) was observed from (3 ml. l^{-1}). The same table shows that the interaction of GA_3 and Liquid calcium led to significant effect on fruit size, the highest size

(418.17 cm^2) was recorded from the interaction of (0 mg. l^{-1} of GA_3 and 3 ml. l^{-1} of Liquid calcium) compared to lowest value (297.33 cm^2) which recorded from control treatment.

Weight of 100 arils (g): The result in (table 2) shows that there were no significant effects of GA_3 and Liquid calcium on weight of 100 arils (g). in the same table observed that the interaction of GA_3 and Liquid calcium caused a significant effects on weight of 100 arils, the best value (40.93 g) was recorded from the interaction of (300 mg. l^{-1} of GA_3 and 0 ml. l^{-1} of Liquid calcium) compared to minimum value (31.69 g) which recorded from control treatment.

Juice percentage (%): Results in (table 2) indicate that there were no significant effects of GA_3 and Liquid calcium on juice percentage (%). In the same table observed that the interaction of GA_3 and Liquid calcium led to significant effect on juice percentage, the highest value (67.26 %) was recorded from the interaction of (150 mg. l^{-1} of GA_3 and 0 ml.l^{-1} of Liquid calcium) compared to lowest value (59.30 %) which recorded from control treatment.

Epicarps content of (Ca %): It is obvious from (table 2) that GA_3 had a significant effect on epicarps content of Ca, the best value (2.61 %) was observed in (300 mg. l^{-1}) treatment. The same table shows that Liquid calcium led to significant effect on epicarps content of Ca. the highest value (2.53 %) was recorded from (3 ml.l^{-1}). It was cleared from the same table that interactions of GA_3 and Liquid calcium had a significant effects on epicarps content of Ca, the highest value (2.85 %) was observed from the interaction of (300 mg. l^{-1} of GA_3 and 3 ml. l^{-1} Liquid calcium), while the lowest value (1.17 %) which was recorded in the control.

Effect of GA_3 and Liquid Calcium on Chemical Characteristics:

Table 3 Effect of GA_3 and Liquid calcium application and their interactions on Chemical characteristic of pomegranate tree cv. Sawa.

Treatments		TSS (%)	T.A (%)	Anthocyanin content (mg.100g^{-1} f.wt.)	Vit - C content (mg.100ml^{-1} juice)
GA_3 (mg.l^{-1})	0	15.65 b	0.901 a	8.124 c	7.067 c
	150	16.23 ab	0.781 b	9.348 b	8.825 b
	300	16.90 a	0.631 c	11.677 a	11.632 a
Liquid Calcium (ml.l^{-1})	0	15.46 b	0.820 a	9.102 b	8.258 c
	1.5	16.52 a	0.742 a	9.662 ab	9.032 b
	3	16.80 a	0.751 a	10.385 a	10.234 a
0	0	13.66 b	1.034 a	6.137 e	6.090 d
	1.5	16.73 a	0.868 b	8.907 d	7.690 c
	3	16.56 a	0.802 bc	9.327 cd	7.421 c
150	0	16.16 a	0.751 bcd	10.282 bcd	8.182 c
	1.5	16.03 a	0.740 bcde	8.645 d	7.914 c
	3	16.50 a	0.852 b	9.119 cd	10.378 b
300	0	16.56 a	0.676 cde	10.889 bc	10.503 b
	1.5	16.80 a	0.619 de	11.434 ab	11.491 b
	3	17.33 a	0.599 e	12.710 a	12.904 a

Total soluble solid (TSS %): It is quite clear from (table 3) indicate that GA_3 had a significant effect on (TSS), the best value (16.90 %) was observed in (300 mg. l^{-1}). In the same table shows that Liquid calcium had a significant effect on TSS, the maximum value (16.80 %) was observed from treatment (3 ml. l^{-1}). It was cleared from (table 3) exhibits that interaction of GA_3 and Liquid calcium significant effects on TSS, the highest value (17.33 %) was recorded from the interaction of (300 mg. l^{-1} of GA_3 and 3 ml. l^{-1} of Liquid calcium) compared with the lowest value (13.66 %) from the control treatment.

Total acidity (TA %): The result in (table 3) shows that GA_3 had a significant effect on (TA) on Pomegranate tree, the lowest value (0.631 %) was recorded in (300 mg. l^{-1} GA_3), while the highest value (0.901 %) was recorded in (0 mg. l^{-1} GA_3) treatment. It was cleared from the same table that there were no significant effects of Liquid calcium on (TA %). Data enclosed in (table 3) notice that interaction of GA_3 and Liquid calcium led to significant effects on (TA %), the lowest total acidity value (0.599 %) was observed in (300 mg. l^{-1} of GA_3 and 3 ml. l^{-1} of Liquid calcium), compared to highest value (1.034 %) which recorded in control treatment.

Anthocyanin content (mg.100 g^{-1} fresh weight): The (table 3) displayed that GA_3 had a significant effect on anthocyanin content, the best value (11.677 mg.100g^{-1} f. wt.) was observed at level (300 mg. l^{-1}). In the same table result indicate that Liquid calcium caused a significant effect on anthocyanin content and the best value of anthocyanin (10.385 mg.100 g^{-1} f. wt.) was observed from the level (3 ml. l^{-1}). The result in the same table recorded that interaction of GA_3 and Liquid calcium significant effects on anthocyanin content, the best value (12.710 mg.100 g^{-1} f. wt.) was recorded from (300 mg. l^{-1} of GA_3 and 3 ml.l^{-1} of Liquid calcium) compared to lowest value (6.137 mg. 100 g^{-1} f. wt.) in the control treatment.

Vitamin C – content (mg.100ml^{-1} juice): Results in the (table 3) indicated that GA_3 had a significant effect on vitamin – C content and the maximum value (11.632 mg.100 ml^{-1} juice) was observed at concentration (300 mg. l^{-1}) of GA_3. It is obvious from the same table notices that Liquid calcium caused significant effect on vitamin – C content, the maximum value (10.234 mg.100 ml^{-1} juice) was observed from the level (3 ml. l^{-1}) of Liquid calcium treatment. The obtained results in the same table exhibit that interactions of GA_3 and Liquid calcium caused a significant effects on vitamin – C content, the highest value (12.904 mg.100ml^{-1} juice) recorded from the interaction of (300 mg. l^{-1} of GA_3 and 3 ml. l^{-1} of Liquid calcium) compared to lowest value (6.090 mg.100 ml^{-1} juice) in the control treatment.

The results presented in Table 1 show that the application of GA_3 through the leaves had a significant impact on the growth properties of plants compared to the control treatment. The impact includes an increase in the content of essential nutrients (N, P, K, and Ca) in the leaves, an increase in leaf area and chlorophyll content, which could be attributed to the positive role of gibberellic acid (GA_3) as a plant hormone that regulates key processes such as respiration, cell division and expansion, enzyme effectiveness, and chloroplast preservation from photosynthesis oxidation (22). GA_3 also increases the concentration of carbohydrates in the shoot system, leading to increased vitality and nutrient manufacturing in the leaves, improving root activity and nutrient absorption from the soil. GA_3 movement is essential for plant development, and these findings are consistent with previous studies (32, 39, 42 and 44). that have shown similar results.

The reason behind the increase in leaf size and chlorophyll content may be due to Gibberellic acid (GA_3), which promotes vegetative growth by inducing cell division, cell elongation, enhancing photosynthesis, and increasing protein content. GA_3 is transported through the plant in the shoot and spraying leaves with GA_3 at (300 mg. l^{-1}) can increase the nitrogen percentage in the leaves, which also promotes growth, carbohydrate synthesis, and increases GA_3 activity (21). This leads to an increase in leaf area and chlorophyll content, as well as the building of new chlorophyll molecules, resulting in enhanced growth and photosynthesis. GA_3 also helps to accumulate nutrient elements in plant parts and positions where it is accumulated, some of which become part of new chlorophyll molecules (29). These findings are consistent with previous studies (2, 5 and 8).

The maximum impact was observed at a calcium concentration of (3 ml. l^{-1}). Calcium is a vital plant nutrient that improves soil structure, enhances water penetration, and creates a favorable environment for plant roots and soil microorganisms. This effect can be attributed to the transfer of calcium from leaves to roots through the bark, where it undergoes oxidation through respiration, resulting in the formation of HCO3, which reacts with NO3 in the soil solution (27). This leads to an increase in the concentration of calcium in the soil solution, which increases the absorption of ammonia NH3 and its incorporation into protein compounds and amino acids within the plant (35).

Increased growth and efficiency of the photosynthesis process lead to an increase in potassium percentage in the leaves, as well as an increase in the soil's potassium content, resulting in increased absorption of potassium by the plant. Potassium plays a vital role in the plant's overall vital activities, such as transferring nitrates from roots to leaves, increasing nitrogen absorption, and stimulating the nutrient cycle. Calcium in the nutrient solution also positively impacts chlorophyll content and carotenoids in photosynthesis and contributes to cell wall division and elongation in leaves, leading to an increase in leaf area (31). These findings are consistent with previous studies (4, 6 and 34).

The increase in fruit size can be attributed to the role of gibberellic acid in activating vital plant growth and development activities, such as stimulating the division, expansion, and permeability of cell membranes, which allows for increased water absorption and nutrient uptake (14). GA_3 also promotes the synthesis of IAA, which stimulates the growth of tree tissues, and accelerates the synthesis of hydrolytic enzymes responsible for growth stimulation. In addition, GA_3 increases the efficiency of photosynthesis by increasing the chlorophyll content and leaf area, leading to an increase in the size of the fruits (16). (19) mentioned that spraying with gibberellic acid led to an increase in diameter and length, and thus leads to an increase in its size and weight, also promotes growth by increasing the flexibility of the cell wall by hydrolyzing starch into sugars, which reduces the water potential in the cell, which leads to water entering the cell and causing it to elongate (41). The results of this study are consistent with the results obtained by (24, 35 and 49).

Furthermore, the significant increase in epicarps calcium content observed as a result of GA_3 treatment may be attributed to its role in increasing the supply of water and nutrients necessary for ideal growth in the leaves, leading to increased growth of the fruits. GA_3 also contributes to the building of stronger cell walls in the cortex, which prevents breakage and increases the thickness of the cortex as a result of the accumulation of nutrients which increasing its strength and preventing its breakage (50). This leads to an increase in the transfer of nutrients processed in the leaves, and then transfer to the fruits, including the peels (34). This finding is consistent with previous studies as well (12, 18, 28 and 44).

Applying liquid calcium with a concentration of (3 $ml.l^{-1}$) to the leaves has a significant effect on the size and calcium content of the fruit's epicarps. Calcium is a vital nutrient for plant growth and development, as it is involved in various physiological processes such as cell division, cell expansion, photosynthesis, and cell wall formation. Adequate calcium levels in plants help maintain the strength and integrity of the cell walls, which leads to stronger and more robust fruits. Spraying calcium on plants can increase the size of fruits (25) and the amount of calcium in the peel, leading to better fruit quality. Similar findings have been reported in previous studies (6, 18, 45 and 52).

Spread over a high concentration of gibberellic acid (300 mg. l^{-1}) to the leaves significantly affects the chemical characteristics of pomegranate trees. This includes an increase in TSS, Vitamin-C, and Anthocyanin content, while decreasing the percentage of TA%. Gibberellic acid plays a vital role in plant physiological processes, particularly photosynthesis and respiration. It increases the concentration of chlorophyll in leaves, leading to the accumulation of more dry matter, minerals, and carbohydrates in fruits, resulting in higher outputs of this process (9). Gibberellic acid also increases the activation of amylases enzymes, converting starch into sugars, which increases the TSS content in fruits (47). However, the decrease in T.A may be due to the accumulation of sugars in the fruit, neutralization during metabolic pathways, or being used as a substrate in the respiratory process. Previous research has also shown that the acid content of fruits after the application of plant growth regulators is converted into sugar and its derivatives or used in respiration or both.

The increase in vitamin - C content observed in the treated fruits was a result of the vital role played by gibberellic acid in photosynthesis. This led to an increase in chlorophyll content and leaf area, resulting in improved efficiency of the process of photosynthesis, and the transfer of sugars from leaves to other parts of the tree. Additionally, gibberellic acid increased the synthesis, translocation, and accumulation of TSS and other sugars in fruits (51), which prevented their oxidation. The increase in anthocyanin pigment in the fruits was also observed, and this was due to the factors that caused an increase in carbohydrates in the fruits before harvest (9). Furthermore, the genetic nature of the variety might induce the formation of a special enzyme that allowed the representation of the anthocyanin pigment in the kernels. These results were supported by previous studies. In addition, foliar application of Liquid calcium at a high concentration (3 ml. l^{-1}) significantly improved the chemical properties of fruits, such as TSS %, Vitamin-C, and Anthocyanin content. Calcium played a vital role in improving tree growth, including chlorophyll in the leaves, leaf area, absorption of water, and nutrition. It also increased the assimilation and utilization of photosynthesis by the developing fruit and promoted the synthesis of sugars and polysaccharides that were translocated to fruits and increased TSS content (4). Calcium was also essential in increasing vitamin - C content in fruits by activating the (Carbonic anhydrase) enzyme and stimulating the activity of the (Ribonuclease) enzyme (33). Calcium was crucial for balancing carbohydrates and maintaining quality characters, and carbohydrates played a significant role in developing fruit color, an indicator of maturity. The increase in fruit color was due to the increase in anthocyanin content, which was due to greater accumulation of carbohydrates under the influence of bioregulators. These results were supported by previous studies (3, 12, 24 and 38).

Conclusions: On the light at previously results, it could be concluded that sprayed the pomegranate trees cv. Sawa with Gibberellic acid at 300 mg. l^{-1} and liquid Calcium at 3 ml. l^{-1} two times, were the best treatments, whereby they gave the highest increments in vegetative properties (N, P, K, Ca, Chlorophyll and Leaf area), also it gave the highest value of (Fruit size and Epicarps content of Ca %) and fruit chemical quality (TSS, Anthocyanin and Vitamin – C content in fruit juice) attributes as compared to the other applied treatments. Moreover, they also decreased the percentage of Titrable acidity (T.A) in fruit juice.

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