International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.9, No.08 pp 104-113, 2016

Effect of GA_3 and Some Nutrients on Pomegranate under South Sinai Governorate Conditions

***[1]Merwad, M. A.; [2]Eisa R.A. and [3]A.M. M. Merwad**

[1]Pomology Dept., National Research Centre, Dokki, Giza, Egypt
[2]Hort. Tech. Crop Dept., National Research Centre, Dokki, Giza, Egypt
[3]Soil Dept. Fac. Agric. Zagazig University, Egypt

Abstract: The present experiment was carried out during two successive seasons of 2013 and 2014 seasons, to study the effect of foliar spray with potassium at 3000 ppm as potassium nitrate, calcium at 2500 ppm as calcium chelate and GA_3 at 25 ppm individually or in combinations on fruit retention, cracking, yield and fruit quality of four years old pomegranate trees Wonderful cv. grown in sandy soil at South Sinai Governorate.
The obtained results show that , the trees sprayed with the mixture of $K+Ca+GA_3$ recorded the highest fruit retention and fruit size , yield /fed., fruit weight, grain weight and grain / fruit ratio, TSS, vitamin C and Anthocyanin contents in grain and peel, N, P, K and Ca in leaves also K and Ca in peel and grain. This treatment recorded the lowest cracking in fruits. Fruit diameter was the highest with the plants sprayed with the double mixture of $K+GA_3$. The highest value of peel weight was recorded with the combination between $Ca+ GA_3$. Sprayed trees with K + Ca gave the highest value of TSS/ acid ratio. On the other hand, the lowest value of yield as well as quality of fruits and the highest value of cracking in fruit were recorded by control treatment.
Kew words: Pomegranate, Wonderful cv., Potassium, calcium, GA_3, Cracking, Yield.

Introduction

Pomegranate (*Punica granatum* L.) is considered one of the oldest known edible fruits which mentioned in the Bible and Quran[1]. The pomegranate is native to Iran and grown extensively in arid and semi-arid regions worldwide[2]. Pomegranate trees can be grown in tropical to hot temperate climates. However, the best pomegranate fruit quality is produced in regions with cool winters and hot dry summer[3]. It is well known that pomegranate trees grow well in semi arid climate and are adapted to many types of soils from pure sand to heavy clay. Pomegranates are fairly drought resistant but require normal watering to grow and produce good fruit crops. Pomegranate trees are able to withstand irrigation with saline water ranged between 1600- 2500 ppm[4]. Pomegranate fruit has been traditionally known to include high level of nutrients and many health benefits. Recent scientific findings confirm traditional usage of pomegranate for medical purposes[5] and reported that tissues of pomegranate fruit, flowers, bark and leaves contain bioactive phytochemicals that are antimicrobial, reduce blood pressure and act against serious diseases such as diabetes and cancer. It is also a good source of antioxidants, three times of wine or green tea, vitamins as it includes vitamin A, C, E and a good source of potassium, calcium, magnesium, iron and zinc[6].

Calcium is an essential macronutrient required for plant growth and has been implicated as a factor influencing tuber quality**;** moreover, calcium has attracted much interest in plant physiology and molecular biology because of its function as a second messenger in the signal conduction between environmental factors

and plant responses in terms of growth and development[7]. Moreover, Ca^{2+} plays a pivotal role in membrane stabilization and in regulation of enzymes synthesis e.g. protein-kinase or phosphatase[8].

Gibberellic acid is used widely in various horticultural crops for improving fruit set and also to control cracking of pomegranate fruit[9]**.**

Fruit cracking is a serious problem in pomegranate which hinders its cultivation to a large extent. Cracking varies from 10 to 70% depending upon the prevailing environmental conditions. Various factors are responsible for fruit cracking which include fluctuation in soil moisture regimes, climate, tree and nutrition[10]. It may also occur due to micronutrient deficiency in young fruits, while in mature fruits it might be due to moisture imbalance or due to extreme variations in day and night temperatures[11]. Cracked fruits lose their value for the fresh market and are used for processing only as fruit juice if not affected by fungi. Cracked fruits are susceptible to storage disease and have a shorter storage as well as shelf-life.

As for the response of pomegranate to K, Ca and GA_3, spraying pomegranate trees with GA_3 at 200 mg/L had demonstrated effectiveness in reducing fruit cracking[12]. On the other hand, treating fig trees with Ca and GA_3 in single way or combination together with N produced a significant increase in leaf area , total , chlorophyll and contenting fruits from percentage of carbohydrate, calcium pectate, firmness and reduced percentage of type of cracking and total cracking percentage compared with control treatment[13]. In this respect, spraying pomegranate trees with 3% of KNO_3 and $CaNO_3$ of each had increased total yield / tree and P, K, Ca, Mg, Fe, Zn, Mn, Cu and Na contents of leaves[14]. Also it found that the extent of fruit cracking was reduced significantly with application of 300 ppm pacloputrazol, and grain %, fruit juice %, TSS % and acidity % were increased[15]. Moreover, yield and fruit weight were increased with applying pacloputrazol or by using 3 % Ca + 0.3 % B + 0.3 % Zn. Application of 80 ppm GA_3 significantly increased fruit length and fruit diameter and total anthocyanin. A study on pomegranate showed that the highest value of yield and its components i.e., fruit weight, fruit number /tree and yield /tree were recorded when pomegranate trees treated with GA_3 at 50 or 100ppm, $CaCl_2$ 4 %, kaolin 2.5 or 5 % and bagging treatment[16]. The lowest percentage of fruit creaking and sunburn were obtained with bagging treatment followed by kaolin 5% and spraying by $CaCl_2$ and GA_3 treatments compared with the control treatment. The highest fruit length and diameter were obtained by GA_3 50 or 100ppm and $CaCl_2$ 2 or 4% treatment. The effect of spraying Washington navel orange trees by calcium chloride at 0.5, 1 and 1.5% and potassium sulphate at 1, 2 and 3% was studied. The results showed that all treatments were very effective in improving yield as well as average fruit weight (g), average fruit volume (cm^3), average fruit diameter (cm), average fruit length (cm), vitamin C and TSS (%) rather than control. Also, the used treatments led to significant decreases in the juice acidity percentage compared with the control treatment. The best results with regard to yield and fruit quality were significantly obtained due to spraying Washington navel orange trees with 2 and 3% potassium sulphate treatments[17].

Foliar application of K, Mg, Mn and Mn combined with K or Mg significantly increased the concentration of all macro (N, P, K, Ca and Mg) and micro (Fe, Mn, Zn and Cu) nutrients in pomegranate leaves, fruit peel and grains[18]. The results showed that foliar nutrient spray led to significant increases in fruit yield per shrub and fad, fruit physical properties as well as leaves and fruit nutrient contents, and fruit quality as compared with unsprayed treatment. The highest fruit yield, means of fruit weight (peel and grains), and fruit dimensions were recorded by potassium (K) at 10000 ppm and manganese (Mn) at 1600 ppm foliar spraying in both growing seasons. Also, foliar spray with nutrients had a positive effect on leaves nutrient concentration and improved fruit chemical properties which related to the quality

Materials and Methods

The present experiment was carried out during two successive seasons of 2013 and 2014 on 4 years old pomegranate trees cv. Wonderful. The experimental trees were planted at 5 m. apart in sandy soil at Al-Tor, South Sinai Governorate.

Twenty four pomegranate trees (Wonderfull cv.) were carefully selected and devoted for this work during the two studied seasons. These trees were nearly similar in their growth vigor, size, shape and diseases - free as well as they received the same horticultural management adopted in this station. Mechanical and chemical analyses of orchard soil are shown in Table, 1.

Table (1): Some physical and chemical properties of the investigated soil.

Soil characteristics	Values
Soil particles distribution	
Sand ,%	91.32
Silt,%	5.14
Clay,%	3.54
Textural class	Sandy
Field capacity (FC),%	9.26
$CaCO_3$, (g kg^{-1})	5.19
Organic matter,(g kg^{-1})	3.52
pH*	7.95
EC,(dSm^{-1}) **	1.55
Available nutrient, (mg kg^{-1}soil)	
N	56.34
P	7.95
K	69.87

* Soil-water suspension 1: 1 ** Soil water extract 1: 1
The experiment included eight treatments as follows:

1. Spraying trees with water (control).
2. Spraying tress with K at 3000 ppm in from of potassium nitrate.
3. Spraying tress with Ca at 2500 ppm in the form of calcium chelate (16 % CaO).
4. Spraying tress with GA_3 at 25 ppm.
5. Spraying tress with K +Ca.
6. Spraying tress with K+GA_3.
7. Spraying tress with Ca+GA_3.
8. Spraying tress with K+Ca+GA_3.

These treatments were arranged in a randomized complete block design with three replications for each treatment using one trees as a single replicate (8 treatments x 3 replicates x 1 plants = 24 trees).

Trees were sprayed with different treatments twice, after one and two months from fruit set.

The common fertilizer applications were used as following: 15 m^3/feddan of FYM during December. N and P rates were 80 Kg N/ feddan as ammonium nitrate (33.5 % N), 30 Kg P_2O_5 /feddan as phosphoric acid (60 % P_2O_5 per year) through fertigation with drip irrigation system application divided along the growing season. Other horticultural practices were done as the same in the regain.

The studied treatments were evaluated through the following parameters:

1. Fruit retention percentage

The number of harvested fruits on the tree was counted. The percentage of fruit retention was calculated according to the following equation:

$$\text{Fruit retention} = \frac{\text{Number of harvested fruits}}{\text{Number of perfect flowers}} \times 100$$

2. Total yield and its component's

Yield (kg)/tree and total yield /feddan.

At harvest time (July, 20th to August. 15th) in both seasons, fruits of each treated tree were picked, weighted and total yield (ton /feddan were estimated.

Fruit weight (g): A sample of ten fruits per replicate (tree) was weighed at mature stage.

3. Fruit cracking

The percentage of cracked fruits was calculated at mature stage as follows:

$$\text{Cracking (\%)} = \frac{\text{Number of cracking fruits/tree}}{\text{Total number of fruits/tree}} \times 100$$

4. Mineral contents in leaves: Sample of twenty leaves was taken from middle position of non-fruiting shoots of each replicate tree in July of both seasons to determine total nitrogen (%), phosphorus (%), potassium (%) and calcium (%) as the methods described, respectively due to[19, 20, 21].

5. Fruit physical characteristics:

- Fruit size (cm^3) was determined by immersing fruits in water in a graduated cylinder.
- Fruit diameter (cm) was measured by using Vernier caliper.
- Fruit peel, grain and albino were weighted by digital balance.
- Grain/fruit ratio was calculated by using the following formula:

$$\text{Grain/ fruit ratio} = \frac{\text{Grain}}{\text{Fruit}}$$

6. Fruit chemical characteristics:

- **Total soluble solids (TSS %)** was determined in fruit juice using a Carl Zeiss hand refractometer.
- **Titratable acidity** in fruit juice was determined as citric acid according to[19], TSS/acid ratio was also calculated
- **Total sugars (%):** It was determined in juice according to the method of Lane and Eynon as described due to[19].
- **Vitamin C (mg. ascorbic acid/100 ml juice):** It was determined according to[22].
- **Total anthocyanin content (%) in grain and peel**: It was estimated according to the methods described by[23].
- **Potassium and Calcium contents** in peel and grain: were determined as previously mentioned in the leaves.

Statistical analysis

The data were subjected to the statistical analysis of variance and means separation was done at 5 % level according to[24].

Results and Discussion

Fruit retention, fruit diameter and fruit size

Results in Table (2) show that, there were significant differences with all treatments than control treatment regarding fruit retention, fruit diameter and fruit size in 2014 and 2015 seasons under El-Tor region. Spraying pomegranate trees with the triple mixture of $K+Ca+GA_3$ had significantly increased fruit retention and fruit size and reached 33.33 and 33.66 % for fruit retention and 435.0 and 468.33 for fruit size, in the 1st and 2nd seasons, respectively. As for fruit diameter, the double mixture of $K+GA_3$ recorded the highest values (10.53 and 10.86) in the 1st and 2nd seasons, respectively. The lowest values of fruit retention, fruit diameter and fruit size were recorded with control treatment in both seasons.

Table (2). Effect of GA_3 and some nutrients on fruit pomegranate trees during 2013 and 2014 seasons.

Treatments	Fruit retention (%)		Fruit diameter (cm)		Fruit size (cm^3)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	14.66 e	15.00 e	7.00 f	7.16 d	300.00 bc	306.67 bc
K at 3000 ppm	11.00 f	11.33 f	9.86 ab	10.20 ab	420.00 a	433.33 a
Ca at 2500 ppm	24.33 c	25.00 c	8.96 cde	9.63 bc	263.33 c	273.33 c
GA_3 at 25 ppm	21.33 d	22.00 d	9.70 abc	10.36 ab	423.33 a	430.00 a
K + Ca	23.66 cd	24.00 cd	8.56 e	8.90 c	310.00 bc	313.33 bc
K +GA_3	29.00 b	29.66 b	8.76 de	9.10 c	343.33 b	353.33 b
Ca+GA_3	16.66 e	17.00 e	10.53 a	10.86 a	428.33 a	438.33 a
K+Ca+GA_3	33.33 a	33.66 a	9.50 bcd	9.50 bc	435.00 a	468.33 a

Gibberellins are involved in cell division and cell elongation. They are known to influence fruit size[25]. Also, gibberellic acid is also reported to promote growth by increasing plasticity of the cell wall followed by the hydrolysis of starch into sugars which reduces the cell water potential, resulting in the entry of water into the cell and causing elongation[26].

The effect of spraying Washington navel orange trees by calcium chloride at 0.5, 1 and 1.5% and potassium sulphate at 1, 2 and 3% was studied. The results showed that all treatments were very effective in improving average fruit volume (cm^3), average fruit diameter (cm) compared to the control treatment[17]. Similar results were found on mango[27, 28].

Fruit physical properties:

Table 3 indicate that , spraying pomegranate tree with K, Ca and GA_3 singly, double or triple had significant effect on fruit , peel , and grain weights as well as grain/ fruit ratio than control treatment in both seasons. Sprayed plants with the mixture of K+Ca+GA_3 recorded the highest values of fruit weight (590.33 and 597.0g), grain weight (396.0 and 396.67 g) and grain / fruit ratio (0.67 and 0.66) in the 1st and 2nd seasons, respectively. On the other side, sprayed plants with Ca+GA_3 recorded the highest values of peel weight (198.33 and 200.67 g) in the 1st and 2nd seasons, respectively. Regarding albino weight, control treatment recorded the highest values (85.33 and 86.33 g) in the 1st and 2nd seasons, respectively.

Table (3). Effect of GA_3 and some nutrients on physical fruit characteristics of pomegranate during 2013 and 2014 seasons.

Treatments	Fruit weight (g)		Peel weight (g)		Grain weight (g)		Albino weight (g)		Grain / fruit ratio	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	309.33 f	312.67 e	114.00 cd	115.67 d	110.00 f	110.67 f	85.33 a	86.33 a	0.35 e	0.35 d
K at 3000 ppm	469.67 c	476.33 c	170.00 b	171.33 b	240.00 c	241.33 c	59.66 ab	63.66 abc	0.51 cd	0.50 c
Ca at 2500 ppm	340.00 ef	343.33 de	98.33 de	101.67 e	177.00 e	177.67 e	64.66 ab	64.00abc	0.52 cd	0.52 c
GA_3 at 25 ppm	474.67 c	481.33 c	180.33 b	182.00 b	241.67 c	242.67 c	52.66 b	56.66 bc	0.51 cd	0.50 c
K + Ca	352.00 de	362.00 d	87.67 e	89.33 e	201.67 d	203.00 d	62.66 ab	69.66 abc	0.57 b	0.56 b
K +GA_3	376.00 d	369.33 d	130.67 c	137.33 c	183.33 de	185.00 de	62.00 ab	47.00 c	0.48 d	0.50 c
Ca+GA_3	531.67 b	541.67 b	198.33 a	200.67 a	280.67 b	282.33 b	52.66 b	58.66 bc	0.53 c	0.52 c
K+Ca+GA_3	590.33 a	597.00 a	122.67 c	126.00 cd	396.00 a	396.67 a	71.66 ab	74.33 ab	0.67 a	0.66 a

These results go in line with those found when K, Mg, Mn and Mn combined with K or Mg was sprayed. The results showed that treatments significantly increased the fruit physical properties as compared with unsprayed trees[18]. Also, similar results were found on mango[29] and on Medjool date palms[30] regarding the effect of potassium as foliar spray.

Yield and cracking

Results in table 4 indicate that, there were significant differences between all tested treatments and control treatment, except K treatment regarding yield / tree and per feddan in the 1st season.

Table (4). Effect of GA_3 and some nutrients on yield of pomegranate trees during 2013 and 2014 seasons.

Treatments	Yield / tree (g)		Yield (ton/fed.)		Carking (%)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	6.53e	7.19 f	1.097 e	1.209 f	34.13 a	37.46 a
K at 3000 ppm	8.92 e	9.59 e	1.500 e	1.612 e	11.93 c	10.93 c
Ca at 2500 ppm	14.28 d	15.61 d	2.399 d	2.623 d	0.000 d	0.000 d
GA_3 at 25 ppm	17.50bc	18.50 c	2.940 bc	3.108 c	18.53 b	19.53 b
K + Ca	14.42 d	15.42 d	2.424 d	2.592 d	0.000 d	0.000 d
K +GA_3	18.81 b	19.81 b	3.161 b	3.329 b	0.000 d	0.000 d
Ca+GA_3	15.32 cd	16.65d	2.574 cd	2.798 d	0.000 d	0.000 d
K+Ca+GA_3	28.34 a	29.01a	4.762 a	4.874 a	0.000 d	0.000 d

The highest yield/ tree (28.34 and 29.01 kg) and total yield /fed. (4.762 and 4.874 ton) were obtained when sprayed pomegranate tree with the triple mixture of K+Ca+GA_3 in the 1st and 2nd seasons, respectively. Regarding cracking (%), the unsprayed trees recorded the highest cracking value (34.13 and 37.46 %) in the 1st and 2nd seasons, respectively. The relative increases in total yield /feddan due to sprayed plants with the triple mixture were about 434 and 403 % in the 1st and 2nd seasons, respectively than control treatments.

Fruit cracking is a serious problem in pomegranate which hinders its cultivation to a large extent. Cracking varies from 10 to 70% depending upon the prevailing environmental conditions. Various factors are responsible for fruit cracking which include fluctuation in soil moisture regimes, climate, tree and nutrition[10]. Gibberrellic acid is used widely in various horticultural crops for improving fruit set and also to control cracking of pomegranate fruit[9]. Calcium has attracted much interest in plant physiology and molecular biology because of its function as a second messenger in the signal conduction between environmental factors and plant responses in terms of growth and development and then reducing cracking fruits[7].

These results are in agreement with those reported on fig since the treated trees with Ca and GA_3 in single way or combination together with N produced a significant reducing percentage of type of cracking and total cracking value compared with control treatment[13]. Also, spraying pomegranate trees with 3% of KNO_3 and $CaNO_3$ of each shows an increase in total yield / tree[14]. The extent of fruit cracking was reduced significantly with application of 300 ppm pacloputrazol[15]. In this regard , the highest values of yield and its components i.e., fruit weight, fruit number /tree and yield /tree were recorded when pomegranate trees treated with GA_3 at 50 or 100ppm, $CaCl_2$ 4 %, kaolin 2.5 or 5 % and bagging treatment[16]. The lowest percentage of fruit creaking and sunburn were obtained with bagging treatment followed by kaolin 5% and spraying by $CaCl_2$ and GA_3 treatments compared with the control treatment. Similar results were found on mango[31, 32, 33].

TSS and acidity

Results in Table (5) show significant differences between treatments regarding TSS, acidity and TSS / acid ratio in both seasons. Trees sprayed by the mixture of (K+Ca+GA_3) treatment recorded the highest value of TSS (17.59 and 17.92 %) in the 1st and 2nd seasons, respectively without significant differences than the mixture of (K+GA3) 17.39 and 17.62 in the 1st and 2nd seasons, respectively, while the lowest values in this respect were recorded by control treatment (14.63 and 14.96 %) in the 1st and 2nd seasons, respectively.

Table (5). Effect of GA_3 and some nutrients on chemical fruit characteristics of pomegranate trees during 2013 and 2014 seasons.

Treatments	TSS (%)		Acidity (%)		TSS/ acid ratio	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	14.63 e	14.96 d	3.44 b	3.61 a	4.24 f	4.16 e
K at 3000 ppm	15.43 d	15.76 c	2.53 d	2.66 c	6.11 c	5.94 b
Ca at 2500 ppm	15.38 d	15.85 c	3.13 c	3.20 b	4.90 e	4.94 cd
GA_3 at 25 ppm	15.86 c	16.26 bc	3.65 a	3.59 a	4.34 f	4.54 de
K + Ca	16.19 c	16.46 bc	2.17 e	2.11 d	7.44 a	7.80 a
K +GA_3	17.39 a	17.62 a	3.20 c	3.27 b	5.43 d	5.40 bc
Ca+GA_3	16.61 b	16.78 b	3.22 c	3.19 b	5.15 de	5.25 c
K+Ca+GA_3	17.59 a	17.92 a	2.49 d	2.39 cd	7.05 b	7.50 a

As for acidity content in fruit, spraying trees with GA_3 gave the highest value (3.65 and 3.59 %) in the 1st and 2nd seasons, respectively without significant differences than the control treatment in the 2nd season. The lowest values of acidity were recorded by the trees sprayed with the mixture of K+Ca+GA_3 (2.49 and 2.39 %) in the 1st and 2nd seasons, respectively.

Regarding TSS/acid ratio, the same results in table show that , the trees sprayed with the mixture of K+ Ca gave the highest values of TSS/ acid ratio (7.44 and 7.80) in the 1st and 2nd seasons, respectively without significant differences than the mixture of K+Ca+GA_3. On the other hand, the lowest TSS/acid ratio was recorded by control treatment (4.24 and 4.16) in the 1st and 2nd seasons, respectively.

These results are in agreement with those reported on pomegranate since the application of 300 ppm pacloputrazol increased TSS % and acidity % in pomegranate fruits[15]. Also, similar results were observed regarding the effect of NAA on total acidity[34].

Vitamin C and anthocyanin content:

Results in table 6 show that, spraying pomegranate trees with the mixture of (K+Ca+GA_3) had significant effect on vitamin C and anthocyanin contents in grain and peel of pomegranate fruits in both seasons and recorded the highest values of vitamin C and anthocyanin contents in grain and peel (7.71 and 7.87 mg/100 ml juice), (3.81 and 3.87 mg/100 ml) and (20.00 and 20.33 mg/100 ml) in the 1st and 2nd seasons, respectively. The lowest values were recorded by control treatment (5.80 and 5.87 mg/100 ml juice of vitamin C), (2.60 and 2.67) and (16.41 and 16.91 mg/100 ml) for anthocyanin contents in grain and peel in the 1st and 2nd seasons, respectively.

Table (6). Effect of GA_3 and some nutrients on vitamin C and anthocyanin contents in grain and peel of pomegranate fruit during 2013 and 2014 seasons.

Treatments	Vitamin C (mg/100 ml)		Anthocyanin in grain (mg/100 ml)		Anthocyanin in peel (mg/100 ml)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	5.80 d	5.87 d	2.60 e	2.67 d	16.41 e	16.91 d
K at 3000 ppm	5.78 d	5.85 d	2.62 e	2.69 cd	16.57 e	17.14 cd
Ca at 2500 ppm	5.89 d	6.03 d	2.64 de	2.74 cd	17.70 d	17.70 c
GA_3 at 25 ppm	5.89 d	5.99 d	2.66 de	2.76 bcd	17.60 d	17.60 cd
K + Ca	6.44 c	6.54 c	2.71 cd	2.71 cd	18.49 c	18.82 b
K +GA_3	7.20 b	7.30 b	2.87 b	2.90 b	19.67 a	20.00 a
Ca+GA_3	6.68 c	6.84 c	2.78 bc	2.84 bc	18.92 b	18.92 b
K+Ca+GA_3	7.71 a	7.87 a	3.81 a	3.87 a	20.00 a	20.33 a

The above mentioned results are in harmony with those found on pomegranate since the results showed that application of 300 ppm pacloputrazol increased total anthocyanin in pomegranate fruits[15].

In this regard, spraying Washington navel orange trees with calcium chloride and zinc sulphate at 0.5, 1, 1.5% and potassium sulphate at 1, 2 and 3% showed that 2 and 3% potassium sulphate treatments were very effective in improving vitamin C rather than control treatment[17].

Mineral contents in leaves

Results in Table 7 show the effect of different treatments on N, P, K and Ca in leaves in both seasons. All tested treatments had significant effect on N, P, K and Ca in leaves than the control treatment in both seasons.

Table (7). Effect of GA_3 and some nutrients on mineral contents in leaves of pomegranate trees during 2013 and 2014 seasons.

Treatments	N (%)		P (%)		K (%)		Ca (%)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	1.55 c	1.60 c	0.17 de	0.19 de	0.83 d	0.86 c	2.25 cd	2.46 c
K at 3000 ppm	2.50 a	2.74 a	0.20 b	0.22 b	1.27 ab	1.34 ab	2.34 c	2.53 c
Ca at 2500 ppm	2.17 b	2.34 b	0.18 cd	0.20 bcd	1.12 c	1.24 b	2.96 b	3.19 b
GA_3 at 25 ppm	2.60 a	2.87 a	0.16 e	0.18 e	1.20 abc	1.30 ab	2.05 d	2.24 d
K + Ca	2.52 a	2.72 a	0.19 bc	0.21 bc	1.18 bc	1.27 b	3.27 a	3.54 a
K +GA_3	2.47 a	2.74 a	0.18 d	0.19 cde	1.31 a	1.42 a	2.27 cd	2.52 c
Ca+GA_3	2.57 a	2.78 a	0.17 de	0.19 cde	1.18 bc	1.28 b	2.77 b	2.99 b
K+Ca+GA_3	2.59 a	2.90 a	0.22 a	0.24 a	1.41 a	1.42 a	3.34 a	3.64 a

Spraying trees with the mixture of (K+Ca+GA_3) recorded the highest values (2.59 and 2.90), (0.22 and 0.24 %), (1.41 and 1.42 %) and (3.34 and 3.64%) for N, P, K and Ca in the 1st and 2nd seasons, respectively, while control treatment gave the lowest values in this respect in both seasons.

Fruit mineral constituents

There were significant differences between the most treatments and control treatment regarding the content of K and Ca in peel and grain in both seasons (Table, 8). In general, the tree sprayed with the mixture of K+Ca+GA_3 recorded the highest values of K and Ca in peel and grain in both seasons. While the lowest values of these parameters were obtained by the control treatment.

Table (8). Effect of GA_3 and some nutrients on K and Ca contents in pomegranate fruits during 2013 and 2014 seasons.

Treatments	K(%)				Ca (%)			
	Peel		Grain		Peel		Grain	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	0.92 c	0.99 c	0.97 c	1.01 c	0.48 e	0.55 d	0.59 d	0.64 d
K at 3000 ppm	1.37 ab	1.49 ab	1.42 b	1.55 b	0.62 cd	0.67 c	0.63 cd	0.68 cd
Ca at 2500 ppm	1.29 b	1.40 b	1.37 b	1.46 b	0.76ab	0.82 ab	0.79 ab	0.85ab
GA_3 at 25 ppm	1.32 b	1.46 ab	1.35 b	1.45 b	0.63 cd	0.68 c	0.66 cd	0.70 cd
K + Ca	1.31 b	1.41 b	1.34 b	1.43 b	0.79 a	0.85 a	0.88 a	0.94a
K +GA_3	1.42 ab	1.54 ab	1.44 ab	1.54 b	0.61 d	0.69 c	0.70 bc	0.75 bc
Ca+GA_3	1.35 ab	1.46ab	1.32 b	1.44 b	0.70 bc	0.75 bc	0.70 bc	0.75 bc
K+Ca+GA_3	1.48 a	1.59 a	1.62 a	1.76 a	0.79 a	0.89 a	0.86 a	0.92 a

The previous experiments showed that application of potassium increased mineral content in leaves and fruits[35].

The obtained results are go in line with those reported on pomegranate where foliar spray with K significantly increased the content of K in peel and juice of pomegranate fruits[36]. Also, foliar application of K, Mg, Mn and Mn combined with K or Mg significantly increased the concentration of all macro (N, P, K, Ca and Mg) and micro (Fe, Mn, Zn and Cu) nutrients in pomegranate leaves, fruit peel and grains[18].

Finally, it could concluded that , sprayed pomegranate trees with the mixture of K+Ca+GA_3 gave high yield and best quality of pomegranate and reduced cracking in the fruits under the this experiment conditions.

References

1. Blumenfeld, A., F. Shaya and R. Hillel. 2000. Cultivation of Pomegranate. CIHEAM: Options Mediterranean's. http:// resources. ciheam.org/ om/pdf/a42/00600264.
2. Hepaksoy, S., Y. S. Kukul, H. Engin, D. Erogul and M. Aksehirli. 2009. Leaf water potential of pomegranate (*Punica granatum* L.) under different irrigation levels. Acta Hort., (818) 193-198.

3. Sheets, M.D., M.L. DuBois and J.G. Williamson (2008). The Pomegranate. Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural. HS44. 1-3.
4. Maas R, Van Der. 1996. Adjust water application to expected fruit size. Fruitlet 86:14-15.
5. Jurenka, J. M. T. (2008). "Therapeutic Applications of Pomegranate (*Punica granatum* L.): A Review", Alternative Medicine Review, 13 (2):128-144.
6. Haidari, M.M. Ali, S.W. Casscells and M. Madjid, (2009). "Pomegranate (*Punica granatum*) purified polyphenol extract inhibits influenza virus and has a synergistic effect with oseltamivir", Phytomedicine, 16, No. 12.
7. Reddy A.S. (2001) Calcium: silver bullet in signaling. Plant Sci. 5;160 (3):381-404.
8. Schmitz-Eiberger, M., R. Haefs, and G. Noga. (2002). Calcium deficiency – influence on the antioxidative defense system in tomato plants. Journal of Plant Physiology 159:733-742.
9. Sepahi, A. (1986). GA_3 concentration for controlling fruit cracking in pomegranates. Iran Agric. Res., 5:93-99.
10. Kumar R., P. Bakshi and J.N. Srivastava (2010). Fruit Cracking: A Challenging Problem of Fruit Industry. http://www.krishisandesh.com/fruit-cracking-a-challenging-problem-of-fruit-industry/
11. Abd El-Rhman, I.E. (2010). Physiological studies on cracking phenomena of Pomegranates. J. Appl. Sci. Res. 6 (6): 696-703.
12. Singh, R.P., Y.P. Sharma and R.P. Awasthi (1993). Influence different cultural practices on premature fruit cracking of pomegranate. Progressive Hort., 22 (1 – 4). (C. F. Hort. Abst. 1995 .Vol. 63. No. 7148).
13. Abass M. S., R. M. H. Al–Numani and W. H. M.AL - Shemmeryi (2011). Effect of pruning and spraying with N, Ca and GA3 on some characters of fruits and percentage of cracking of Fig cv. Asowd Diala. Researches of the first International Conference (Babylon and Razi Universities).
14. Güneri, M., M. Yıldıztekin; A. L. Tuna, and I. Yokaş, (2014). Effects of the calcium and potassium fertilizers on yield and nutrition in Hicaz pomegranate (Punica granatum cv. hicaz) orchards. Journal Ege Üniversitesi Ziraat Fakültesi Dergisi. 51 (2): 165-174.
15. Khalil H. A. and Aly S.H. (2013). Cracking and Fruit Quality of Pomegranate (*Punica granatum* L.) As Affected by Pre-Harvest Sprays of Some Growth Regulators and Mineral Nutrients. Journal of Horticultural Science & Ornamental Plants 5 (2): 71-76.
16. Hegazi, A.; N. R.Samra, E. E. T. El-Baz, Bahan. M.Khalil and M.S. Gawish (2014). Improving fruit quality of manfaloty and wonderfull pomegranates by using bagging and some spray treatments with gibberellic acid, calcium chloride and kaolin. J. Plant Production, Mansoura Univ., 5 (5): 779-792.
17. Aly, M. A., M. M. Harhash, Rehab M. Awad and H. R. El-Kelawy (2015). Effect of foliar application with calcium, potassium and zinc treatments on yield and fruit quality of Washington Navel Orange Trees. Middle East J. Agric. Res., 4(3): 564-568.
18. Hamouda, H. A., Elham, Zinhoum Abdel Motty and Nagwa G. Zahran (2015). Nutritional Status and Improving Fruit Quality by Potassium Magnesium and Manganese Foliar Application in Pomegranate Shrubs. International Journal of Chem Tech Research, 8 (6): 858-867.
19. A.O.A.C. (1990). Association of Official Agricultural Chemists. Official methods of analysis. 10th ed. A.O.A.C., Washington, D.C, USA.
20. John, M. K. (1970). Colorimetric determination of phosphorus in soil and plant material with ascorbic acid. Soil Sci., 109: 214-220.
21. Brown, J. D. and O. Lilleland (1946). Rapid determination of potassium and sodium in plant material and soil extracts by flame photometry. Proc. Amer. Soc. Hort. Sci., 48: 301-304.
22. Lucoss. E. H. (1944). Determining ascorbic acid in large numbers of plant samples. Ind. Eng. Chem. Anal. Ed. 15: 649 – 652.
23. Geza, H.; G.F. Parsons and L.R. Mattick 1984. Physiological and biochemical events during development and maturation of grape berries. Am. J. Enol. Vitic., 35 (4): 220 – 227.
24. Duncan, D.B.1955. Multiple rang and multiple F test. Biometrics, 11: 1-42.
25. Zhang, C. and M.D. Whiting, 2011. Improving 'Bing'sweet cherry fruit quality with plant growth regulators. Scientia Horticulturae, 127: 341-346.
26. Richard, M., 2006. How to grow big peaches. Dep. of Hort. Virginia Tech. Blacksburg, VA 24061. Internet, www. Rce.rutgers.edu. 8 pages, August.
27. Nkansah, G.O.; Ofosu-Anim, J. and Mawuli A. (2012). Gibberellic acid and naphthalene acetic acid affect fruit retention, yield and quality of Keitt Mangoes in the Coastal Savanna Ecological zone of Ghana. American Journal of Plant Physiology, 7 (6): 243-251.

28. Merwad, M.A., R.A., Eisa and M.M.S. Saleh (2016). The beneficial effect of NAA, Zn, Ca and B on fruiting, yield and fruit quality of Alphonso mango trees. International Journal of ChemTech Research 9 (3):147-157.
29. Baiea M. H. M., El-Sharony T. F. and Eman A. A. Abd El- Moneim (2015). Effect of different forms of potassium on growth, yield and fruit quality of mango cv. Hindi. International Journal of ChemTech Research., 8(4):1582-1587.
30. Esam, A. M. M, N. E. Ashour, Omaima, M. Hafez, Malaka, A. Saleh (2016). Effects of Application Commercial Product Rates and Times on Yield and Fruit Quality of CV. Medjool Date Palms. International Journal of ChemTech Research, 9 (4): 43-50.
31. Saleh, M.M.S. and Eman, A.A. Abd El-Monem (2003). Improving productivity of "Fagri Kalan" mango trees grown under sandy soil conditions using potassium, boron and sucrose as foliar spray. Annals Agric. Sci., Ain Shams Univ., 48 (2): 747-756.
32. Shinde, A. K.; Patil, B. P.; Pujari, K. H.; Jadhav, B. B.; Chandelkar, A. B. and Kandalkar, M.P. (2006). Investigations on the control of fruit drop in "Alphonso" mango. Indian Journal of Plant Physiology. 11(1):93-99.
33. Negi, S.S.; Singh, A.K.; Singh, C.P. (2009). Effect of foliar application of nutrients on fruit-set, yield and quality of mango cv. Dashehari. Haryana Journal of Horticultural Sciences, 38 (1/2): 20-22.
34. Merwad M.A., R.A. Eisa and A.M.M. Merwad (2016). Effect of some Potassium Fertilizer Sources on Growth, Yield and Fruit Quality of Grand Nain Banana Plants. International Journal of ChemTech Research .9 (4): 51-61.
35. El-Safty, M. A., E. A.El-Menshawy and R. S. Rabeii, 1998.Response of Washington navel orange trees to different doses of potassium sulphate. A-yield, fruit quality and mineral composition. J. Agric. Sci. Mansoura Univ., 23: 2611-2618
36. Tehranifar, A. and S.M. Tabar (2009). Foliar application of potassium and boron during pomegranate (*Punica granatum*) fruit development can improve fruit quality). Hoh. Enrisi. Bior$not 50 (3)1- 6.

*****