International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN: 0974-4290
Vol.8, No.6, pp 858-867, 2015

Nutritional Status and Improving Fruit Quality by Potassium, Magnesium and Manganese Foliar Application in Pomegranate Shrubs

Hamouda, H. A.[1] Elham, Zinhoum Abdel Motty[2] and Nagwa G. Zahran[3]

[1]Fertilizer Technology Department, National Research Centre, Dokki, Cairo, Egypt.
[2]Pomology Research Department, National Research Centre, Dokki,
[3]Pomology Department, Faculty of Agriculture, Cairo University, Egypt.

Abstract: The study was carried out during 2011 and 2012 growing seasons on pomegranate (Mnfalouty cv.) with four years old grown under sandy soil condition. The study aimed to investigate the influence of foliar spraying with K, Mg, Mn and Mn combined with K or Mg nutrients on fruit yield, fruit quality as well as leaves and fruit nutrient contents. Foliar spraying treatments were done three times at mid of March, April and June in the both seasons with the following concentrations 10000, 4000 and 1600 ppm from K, Mg and Mn, respectively in the form of sulphate. Fruit fresh and dry weights were significantly influenced by foliar spraying nutrients in both seasons as compared with the control treatment. The results also, showed that foliar applied 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. The results showed that foliar nutrient spraying 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 spraying nutrients had positive effect on Leaves nutrient concentration and improved fruit chemical properties which related to the quality.

Key words: Pomegranate (*Punica granatum L.* Manfalouty), potassium, magnesium, manganese, foliar application, nutrient status fruit, physico –chemical properties, fruit quality.

Introduction

Pomegranate (*Punica granatum* L.) is one of the most important fruit shrubs grown successfully in Egypt, not only in the old soil but also in the newly reclamated soils.

Pomegranate is an important commercial fruit crop that is extensively cultivated in many parts of Asia, North Africa, the Mediterranean and the Middle East regions[1].

Pomegranate fruits are widely consumed fresh or processed into juice, jams, syrup and sauce. The edible portion (arils) of fruit is about 55 – 60% of the total fruit weight and consists of about 75 – 85% juice and 15 – 25% seeds[2].

The Manfalouty pomegranate cultivar is one of the most commonly cultivation grown in the Upper Egypt which it's concentrated in Assiut, Governorate, since a long time ago. Recently, pomegranate area cultivations are increased due to the cultivation expansion in newly reclamated which took a more attention not only in one province but on whole country, as well as introducing some new cultivars.

The increasing amount of pomegranates fruit which export were increased in the last decade recently, due to its highly content in antioxidants, plus some vitamin and minerals.

The chemical composition of pomegranate fruits is strongly dependent on the cultivar type, growing region, climate, maturity and agricultural practices[3,4].

The nutrients play main role in improving plant growth and fruit quality incidence in pomegranate Fertilization is consider the main agricultural practices which had significant effects on fruit quality, in this context potassium, magnesium and manganese are essential plant mineral nutrients having a significant influence on many human- healths related quality compounds in fruits and vegetable [5]. In addition, the fruits chemical characteristics particularly total soluble solids, total sugars, ascorbic acid and anthocyanin contents play a major role in crop due to their essentiality in fruit quality and postharvest life of harvested produce [6].

The incompletely of fruit grain color was observed especially in the extremely hot seasons. This observation gave the ideal of fertilizer transactions due to that it's have a fundamental role in completion of grain color. Thus, reduce phenomenon of white grains in fruits (delayed pigment anthocyanin in fruits) and increasing fruit color, especially in the hot summer seasons.

Thus, the aim of this study was to investigate the possibility effect of the foliar spraying treatments with K, Mg, Mn and Mn combined with K or Mg to reduces the phenomenon of white grains in fruits (delayed pigment anthocyanin in fruits) and increasing fruit color, especially in the hot summer seasons, as well as fruit yield/ shrubs, nutritional status of shrubs and fruits physical and chemical quality.

Material and Methods

The study was conducted on pomegranate shrubs Cv. Manfalouty (Punica granatum L.), of four years old in a private orchard at El-Tall El-Keppeer, Ismailia Governorate Egypt under sandy soil conditions, during two successive years, 2011 and 2012. The shrubs were cultivated under drip irrigation systems and were uniform in growth and cultivated at 4x3 m (350 shrubs/ fad.). The common fertilizer applications were used as following: 15 m^3 fad^{-1} of farmyard manure during December - January. NPK rates were 80 Kg N/ fad^{-1} as ammonium nitrate (33.5 % N) and calcium nitrate (15.5 % N), 30 Kg P_2O_5 fad^{-1}, as phosphoric acid (60 % P_2O_5) and 70 Kg K_2O fad^{-1}as potassium sulfate (48-52%) Kg fad $^{-1}$ year) were using a fertigation with drip irrigation system application divided along the growing season. Other horticultural practices were done as follows in the regain.

Soil sampling: Soil samples were randomly collected in November from the root zone tips of the shrubs at the end of the canopy. Depth of the soil sampling was 0 - 60 cm. The samples were air dried, ground to pass through a 2 mm sieve using a wooden grinding and stored in plastic bottles prior to the physical and chemical analysis.

Leaf sampling: The leaf samples were collected randomly around the tree from the fully mature leaves of spring flush (4 to 7 month old young shoots) to determine the nutrient contents. Samples were washed with tap water, 0.001 N HCl and distilled water respectively, then dried at 70 °C and ground in a stainless steel mill, then passed through a 40 mesh nylon sieve and stored in plastic bottles.

Fruit sampling: At harvest, three fruits from four sides of each shrub were randomly picked and were used for determination of fruit physical and fruit juice quantitative and qualitative characteristics in the laboratory. The mineral analysis was done in the total fruit including the peel and grains to estimate the total mineral nutrient contents in the harvested fruits. Commercially ripe fresh fruits were harvested in (mid-August 2011 for the first season and mid-September 2012 for the second season.

Treatments: Treatments of potassium sulphate at K (10000 ppm), magnesium sulphate at Mg (4000 ppm) and manganese sulphate at Mn (1600 ppm) were sprayed alone and their combinations. In each season, the foliar spraying treatments were applied at three times at mid of March, April and June. The foliar spraying were 6 L/ shrub (2100 L Fad^{-1}).

Table (1): Soil phsico-chemical properties of the experimental site:

Mechanical analysis %			Tex.	Physical properties				Macronutrients (mg/100 g)					Micronutrients (mg/Kg)			
Sand	Silt	Clay	Sandy	pH	EC (ms/m)	CaCO3 (%)	O.M (%)	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu
88.8	4.0	7.2		8.9	0.18	3.6	0.35	0.26	18.2	420	10.2	32	3.5	4.0	1.6	0.4

The results of soil analysis of the experimental field indicated that P, K, Mg, Fe, Mn, Zn, and Cu were deficiency according to [27].

Chemical analysis: Soil samples were analyzed (Table 1) for texture, pH and electric conductivity (EC) using water extract (1: 2.5) method, total calcium carbonate (CaCO3 %) determined with calcimeter method and for organic matter (O.M %) was determined with using potassium dichromate[7]. Phosphorus was extracted using sodium bicarbonate [8]. Potassium (K), calcium (Ca) and magnesium (Mg) and sodium (Na) were extracted using ammonium acetate [9]. Iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) were extracted using DTPA[10].

Fruit physical characteristics: Average fruit weight (g), fruit peel weight (g), fruit grains weight (g) and fruit peel thickness (cm) were measured.

The fruit length and diameter (cm): were measured by a Digital Electronic calliper and the fruit shape index (length/ diameter ratio) was calculated.

Fruit chemical properties:

Soluble solids content (SSC %): A refract meter was used to determine the soluble solids content in fruit fresh (juice) according to[11].

Titrable acidity (%): It was determined according to the method described in[11], 10 ml of the extracted juice was diluted to 100 ml and titrated against 0.1 N NaOH to pH 8.3.

Total sugars (%): Total sugars was determined by the method given in[11] 25 ml of pittered juice was naturalized to pH 7.5 to 8.0 with 1 N NaOH and 2 ml of lead acetate was added along with few drops potassium oxalate and diluted, 5 g of citric acid was added to the filtrate and neutralized using phenolphthalein as an indicator with 20 % NaOH until pink color is obtained. The end point of titration on was colorless.

pH of juice: pH was measured by using pH meter (JENWAY – 3505).

Ascorbic acid content (Vitamin C): Juice was measured by titration with 2-6 dichlorophenol indophenols blue dye, as described by[11].

Total anthocyanin content (%): Anthocyanin pigments undergo reversible structural transformations with a change in pH manifested by strikingly different absorbance spectra [12]. The colored oxonium from predominates at pH 1.0 (25 mM with potassium chloride buffer) and the colorless from at pH 4.5 (0.4 m with sodium acetate buffer). The samples were diluted by potassium chloride buffer until the absorbance of the sample at a 510 nm wavelength was within the linear range of the spectrophotometer. This dilution factor was used later to dilute the sample with the sodium acetate buffer. At two wavelengths of 510 and 700 nm, readings were performed after 15 min of incubation, four times per sample diluted in the two different buffers. The absorbance was then calculated according to the following equation: A = (A510 - A700), pH 1.0 (510 - A 700 pH 4.5)

Statistical analysis: Randomized complete block design with four replicates was used in this study. The results were submitted to analysis of variance according to[13]. Differences among treatment means were determined as using the LSD test at a significance level of 0.05 according to[14].

Results

Fruit physical properties and yield:

Fruit peel and grains weights (g): Data concerning the effect of K, Mg, Mn and Mn combined with K or Mg foliar application on fruit physical properties and fruit yield during the two experimental seasons are listed in Table (2).

Fruit fresh and dry weights (g): The data in Table (2) showed that fruit fresh and dry weights were significantly influenced by foliar applications with K or Mg or Mn and the combined of K and Mn or Mg and Mn in both seasons as compared with the control treatment. The highest results were obtained from the foliar application of K and Mn treatment followed by Mg and Mn treatment. In addition, foliar application of individual K surpassed either Mg or Mn in both seasons. These results are in agreement with [15,16] they found that the heaviest fruit weight of pomegranate was observed on shrubs treated by potassium and manganese [17] found that fruit size (both length and diameter) were increased with foliar spray of 0.6% $MnSO_4$ foliar spray and the increase in fruit size was associated with Mn, N and K concentrations in pomegranate leaves and fruits. It is clear that fruit dimensions (length and diameter) were took the same trend of fruit weight in their response to foliar application of K, Mg and Mn in both seasons.

Peel fresh weight / fruit: The highest significant fruit peel fresh weight was obtained from the treatment of K at 10000 ppm + Mn at 1600 ppm compared with other treatments. These results are in agreement with[18]**;** they found that increasing concentrations of potassium and manganese caused a gradual increased in fruit peel weight.

Grains fresh weight / fruit: Treatment of potassium and manganese gave the highest fruit grains weight (258.74g, 272.33g) for fruit in both seasons followed by treatment of Mg at 4000 and Mn at 1600 ppm recorded that (214.01g, 227.63g) in both seasons Table (2). In this sphere, [19'20] reported that the fruits grains of Manfalouty pomegranate increased by increasing levels of potassium treatments.

Juice volume: The greatest significant increasing fruit juice volume was recorded with shrubs sprayed with potassium at 10000 ppm and Mn at 1600 ppm (136.22, 143.34 cm^3 in both seasons, respectively while the control treatment gave the lowest fruit juice volume (64.81, 72.0 cm^3) in two seasons Table (2). These results are in harmony with those obtained by [18] on fruits pomegranate.

Fruit Yield: Results in Table (2) showed that foliar application of K, Mg alone or in combinations were led to significant increases in fruit yield of pomegranate in both seasons as compared with the control treatment. The highest fruit yield per shrub and faddan were obtained from the treatment of foliar application with K and Mn followed by Mg and Mn treatment in the two growing season. In addition data revealed that K foliar application recorded the highest fruit yield in comparison with Mg or Mn respectively, however there were slightly differences between the three elements in the two seasons. Similar results were reported by [19,2] they found that foliar spray of potassium and manganese increased fruit yield of "Ganesh" pomegranate.

Chemical properties of pomegranate fruits as affected by K, Mg and Mn foliar spraying are presented in Table (3), as follows:

Soluble Solids Content (SSC) (%): Soluble solids content (SSC) was significantly increased by foliar application of K, Mg, Mn and Mn combined with K or Mg treatment as compared with the control treatment in both seasons. The highest value was recorded by foliar K or Mg mixed with Mn foliar application treatment and there were slightly differences between other treatments. Similar results were found by [21] on pomegranate they concluded that, fruit produced on shrubs under nutrient foliar application from treatment of potassium and manganese increased fruit SSC compared with the control treatment.

Total Sugars (%): Treatment of K or Mg combined with Mn had significant effect on total sugars of fruit in both seasons as compared with the control treatment, and the highest values were obtained by K or Mg combined with Mn treatment.

Total Acidity (%): First and second seasons results as shown in Table (3) indicated that, total acidity (%) of fruit was significantly decreased by treatments and the highest depression of total acidity was resulted from K foliar application treatment followed by K combined with Mn treatment in two seasons, in this connection [22] on

pomegranate fruits, who found that the lowest fruit acidity was recorded by treatment of potassium combined with manganese.

Table (3): Effect of K, Mg and Mn foliar application on chemical properties of Manfalouty pomegranate fruits

Treatments	SSC (%)	Total sugars (%) (g/100 FW)	Acidity (%)	Anthocyanin (mg/100ml)	V.C (mg/100ml)	pH
K (10000 ppm)	17.50	15.25	1.55	5.77	18.84	4.07
Mg (4000 ppm)	17.33	15.13	2.17	5.43	18.06	3.94
Mn (1600 ppm)	17.00	15.11	1.93	5.39	17.94	4.19
K (10000 ppm + Mn 1600)	17.50	15.46	2.38	5.79	18.87	4.08
Mg (4000 ppm + Mn 1600)	17.50	15.18	1.68	5.44	18.06	4.19
Control	13.50	13.26	2.46	4.02	17.54	4.07
L.S.D at $_{0.05}$	**0.43**	**0.46**	**0.02**	**0.17**	**0.11**	**0.02**

Total Anthocyanin (%): Results showed that all treatment had significant effect on anthocyanin in the two seasons as compared with the control treatment. The highest anthocyanin content was results from K foliar application treatment followed by K combined with Mn foliar application treatment. These results are in parallel to those reported by [23] they found that potassium increased phenolic compounds compared to control in pomegranate fruit. In this line,[24] foliar spraying nutrient of potassium significantly increased the content of anthocyanin, phenolic compound and antioxidant activity of fruit juice.

Vitamin C content (V.C): The highest V.C content was resulted from shrubs which treated with potassium (10000 ppm) combined with manganese (1600 ppm) followed by K alone foliar application, while control treatment had the middle V.C content in both seasons. This result was confirmed by [18] on Manfalouty pomegranate.

pH: In the first and second season, the results as shown in Table (3) indicate that pH of fruits juice was slightly affected by the treatment, however Mg foliar spray clearly decreased pH of fruit juice. In this context[25,26] on pomegranate fruit found that, the lowest pH of fruit juice was recorded by treatment of potassium and manganese.

Leaves macro and micronutrients content: The effect of K, Mg, Mn and Mn combined with K or Mg as a foliar application on N, P, K, Ca, Mg, Fe, Mn, Zn and Cu concentration in pomegranate leaves are listed in Tables (4 & 5). Data showed that leaf mineral contents of (P, K, Mg, Fe, Mn and Zn) were significantly increased by foliar application of K, Mg, Mn and Mn combined with K or Mg in the study. On the other hand, N was significantly affected by Mn and Mn combined with Mg treatment. In addition, all treatments except Mn led to increase in leaf Mg content. On the contrary Cu content of leaf was decreased by all treatments compared with the control treatment.

Results also, indicated that foliar application of K led to the highest leaf content from K and Fe, while K mixed with Mn treatment gave the highest content of P, Ca and Zn. Also, Mg treatment gave the highest content of Mg. Meanwhile, Mn foliar application gave the highest leaf N and Mn content. In this connection [16] found that applied of Mn insignificant decreased the concentrations of Zn and Cu and significantly increased concentration of N in pomegranate leaves.

Fruits macro and micronutrients content: The results in Tables (4 & 5) showed that foliar applied 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 fruit peel and grains. It is also, clear from the results that K (10000 ppm) treatment gave the highest values of K and Zn in both peel and grains, as well as Ca in the grains. The results are agreement with [24] they found that foliar application of K significantly increased the content of K in peel and juice of fruits.

In addition, Mg foliar application treatment gave the highest Mg and Ca content of both peel and grains. Meanwhile, the increasing slightly differences were found between Mg and Mg combined with Mn treatment.

Data also, clearly indicated that Mn foliar application led to the highest peel and grains content from N, P, Ca, Fe and Mn as compared with the other treatment. Also, the same treatment gave the highest values of Fe and Mn (132 and 35 ppm, respectively) in fruit grains of pomegranate.

Foliar application of Mn increased the concentrations of N, P, Ca, Fe and Mn but decreased Zn and Cu concentration in fruit peel and grains.

Table (2): Effect of K, Mg and Mn foliar application on physical properties and yield fruits of Manfalouty pomegranate

Treatments	Fresh weight (g/fruit)				Dry weight (g/fruit)			Dimension			Juice volume/fruit (ml)	Yield/	
	Fruit	Peel	Grains	Fruit: Peel ratio	Fruit	Peel	Grains	Diameter (D)	Length (L)	D/L		Shrub (kg)	Fed. (ton)
K (10000 ppm)	324.42	114.75	209.80		68.33	30.36	37.97	9.41	9.73	0.967	116.44	12.98	4.54
Mg (4000 ppm)	321.23	113.58	207.65		67.63	30.05	36.92	9.31	9.63	0.967	109.30	12.84	4.49
Mn (1600 ppm)	288.10	101.92	186.33		60.90	26.95	33.93	8.36	8.64	0.967	98.08	11.53	4.04
K (10000 ppm + Mn 1600)	400.34	141.48	258.85		84.28	37.43	46.85	11.61	11.89	0.976	136.22	16.01	5.61
Mg (4000 ppm + Mn 1600)	331.07	117.06	214.01		72.70	30.77	38.93	9.60	9.92	0.968	112.65	13.24	4.74
Control	190.46	67.34	123.12		40.10	17.82	22.28	5.53	5.71	0.968	64.81	7.62	3.57
L.S.D at $_{0.05}$	**13.75**	**4.80**	**8.88**		**4.85**	**1.29**	**2.21**	**0.40**	**0.38**		**5.86**	**0.55**	**1.17**

Table (4): Effect of K, Mg and Mn foliar application on macronutrient composition leaf, peel and grains pomegranate shrubs Final

Treatments	Macronutrients (%) in leaf					Macronutrients (%)in peel					Macronutrients (%) in grains				
	N	P	K	Ca	Mg	N	P	K	Ca	Mg	N	P	K	Ca	Mg
K (10000 ppm)	2.07	0.64	1.11	4.38	0.44	2.12	0.25	1.80	0.50	0.70	2.36	0.49	1.58	0.60	0.53
Mg (4000 ppm)	2.31	0.63	0.80	4.50	0.45	2.12	0.26	1.18	0.50	0.97	2.38	0.51	1.20	0.60	0.97
Mn (1600 ppm)	2.77	0.70	0.88	4.63	0.33	2.27	0.17	1.38	0.48	0.82	2.72	0.41	1.30	0.55	0.87
K (10000 ppm + Mn 1600)	2.39	0.91	1.00	5.38	0.44	1.86	0.33	1.53	0.63	0.63	2.25	0.57	1.38	0.60	0.50
Mg (4000 ppm + Mn 1600)	2.48	0.66	0.76	4.25	0.45	1.93	0.19	1.15	0.48	0.95	2.34	0.45	1.10	0.55	0.96
Control	1.90	0.48	0.63	3.38	0.37	1.76	0.17	0.90	0.43	0.56	1.90	0.37	1.03	0.45	0.31
L.S.D at $_{0.05}$	**0.05**	**0.03**	**0.03**	**0.05**	**0.05**	**0.08**	**0.02**	**0.02**	**0.02**	**0.04**	**0.04**	**0.001**	**0.01**	**0.01**	**0.02**

Table (5): Effect of K, Mg and Mn foliar application on micronutrient composition leaf, peel and grains pomegranate shrubs

Treatments	Micronutrients (ppm) in leaf				Micronutrients (ppm) in peel				Micronutrients (ppm) in grains			
	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
K (10000 ppm)	578	28	30	7.0	64	12	16	9	132	20	29	5
Mg (4000 ppm)	513	27	27	8.0	54	12	16	10	105	21	34	5
Mn (1600 ppm)	464	31	35	8.0	51	19	14	9	103	35	27	5
K (10000 ppm + Mn 1600)	370	29	34	9.0	45	11	18	9	62	33	39	5
Mg (4000 ppm + Mn 1600)	383	24	26	8.0	38	10	15	8	81	32	28	5
Control	251	19	23	6.0	29	8	11	8	46	13	21	3
L.S.D at $_{0.05}$	**9.2**	**1.7**	**2.2**	**1.0**	**1.9**	**1.0**	**1.5**	**0.4**	**3.5**	**1.4**	**1.4**	**0.5**

Conclusion

Foliar spraying of potassium, magnesium, manganese and manganese combined with potassium or magnesium each had significant effects on yield and quality of pomegranate. The foliar application improved fruit yield of shrub, fruit weight, fruit diameter, juice volume, soluble solids content, total sugars, anthocyanin and vitamin C. Also, foliar treatments reduced the phenomenon of white grains in fruits which reflected by increasing anthocyanin in fruits and increase color. K treatment increased leaves, fruit peel and grains content from K and Fe. In addition, Mn foliar spraying had antagonistic effects on Zn and Cu contents in leaves and fruit peel and grains.

References

1. Sarkhosh A.; Z. Zamani; R. Fatahi, and A. Ebadi, 2006. RAPD markers reveal polymorphism among some Iranian pomegranate (Punica granatum L.) genotypes, Sci. Hort. 111, 24-29.
2. Al-Maiman S. A. and D. Ahmad, 2002. Changes in physical and chemical properties during pomegranate (Punica granatum L.) fruit maturation. Food Chemistry. 76:437-441.
3. Melgarejo P.; D. M. Salazar, and F. Artes, 2000. Organic acids and sugar composition of harvested pomegranate fruits. European Food Research and Technology. 211: 185 - 190.
4. Ozgen, M. Durgac, C. Serce, and S. Kaya, 2008. Chemical and antioxidant properties of pomegranate cultivars grown in Mediterranean region of Turkey. Food Chem. 111, 703-706.
5. Usherwood, N.R. 1985. The role of potassium in crop quality. In Munson, R.D. (ed). Potassium in Agriculture ASA-CSSA-SSSA, Madison, WI. Pp 489-513.
6. Mir M. M.; I. Umar; S. A. Mir; M. U. Rehman; G. H. Rather, and S. A. Banday; 2012. Quality evaluation of pomegranate crop – a review. International Journal of Agriculture & Biological.14(4):658–667.
7. Chapman, H.D. and P.E. Pratt, 1978. Method of analysis for soil plant and water. University of California, Dep. of Agric. Sci. U.S.A. pp. 1-309.
8. Olsen, S. R.; C. W. Cole; S. S. Watnable and L. A. Dean, 1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. Washington: USDA Dep. Agric. Circular No. 939: 1-19.
9. Jackson, M.I. 1973. Soil chemical analysis Prentice Hal Inc. N.J, U.S.A.
10. Lindsay, W.L. and W. A. Norvell, 1978. Development of a DTPA micronutrient soil tests for
11. AOAC, (2000) **.**Associate of Official Analytical Chemists. Official Methods of Analysis 7th ed. Washington D.C., USA.
12. Giusti, M. and R. Wroistad, 2001. Characterization and measurement of anthocyanin by UV visible spectroscopy, In Current Protocol in Food Analytical Chemistry, John Willy & Sons, Inc. New York, F1.2.1. F1.2.13
13. Snedecor, G. W. and W. G. Cochran, (1967). Statistical methods. Iowa State College Press, Iowa, USA.
14. Waller, R.A. and D.B. Duncan, (1969). A bays rule for the symmetric multiple comparisons problem. Am Stat. Assoc. J.
15. Abd El-Rhaman, I. E. 2010. Physiological studies on cracking phenomenon of pomegranate. Journal of Applied Science Reseasrch, Vol 6. Issue 6, 696.
16. Hasani, M.; Z. Zamani,; G. Savaghehi, and R. Fatahi, 2012. Effect of zinc and manganese as foliar spray on pomegranate yield, fruit quality and leaf minerals. Journal of Soil Science and Plant Nutrition, 12 (3): 471-480.
17. Tariq, M., and C. I. B. Mott, 2007. Effect of boron on the behavior of nutrients in soil plant systems a review. Asian J. Plant Sci. 6, 195-202.
18. El-Khawaga, A. S., 2007. Reduction in fruit cracking in Manfaluty pomegranate following a foliar application with paclobutrazol and zinc sulphate. Journal of Applied Sciences Research. 3(9): 837-840.
19. Balakrishnan, K., K. Venkatesan, and S. Sambandamurti, 1996. Effect of foliar application of Zn, Fe, Mn and B on yield and quality of pomegranate cv. Ganesh. Orissa Journal of Horticulture. 24, 1, 33-35.
20. Aref, F. 2011. Concentration and uptake of zinc and boron in corn leaf as affected by zinc sulphate and boric acid fertilizers in a deficient soil. Life sci. J. 8 (1), 26-32.
21. Khayyat, M.; A. Tehranifar,; M. Zaree, ; Z. Karimian, ; M. H. Aminifard, ; M. R. Vazifeshenas, ; S. Amini, ; Y. Noori, and M. Shakeri, 2012. Effect of potassium nitrate spraying of fruit characteristics of "Malas Yazdi" pomegranate. J. Plant Nutr. Vol. 35: No, 9, pp 1387-1393.
22. EL-Kassas, Sh. E., 1984. Seasonal changes in growth and maturation of Manfalouty pomegranate fruit under certain soil moisture levels. Assiut J.of Agric. Science, 14(2): 167-179

23. Mirdehghan S. H.; G. Vatanparast; H. R. Karim, and M. H. Vazifeshenas, 2012. Preharvest foliar application of methyl jasmonate, salicylic acid and potassium sulfate on improving the quality of pomegranate fruit. Options MÈditerranÈennes, 103: 183-189.
24. Tehranifar, A.; S. M. Tabar 2009. foliar application of potassium and bron during pomegranate (punica granatum) fruit development can improve fruit quality). Hoh. Enrisi. Bior$not 50 (3)1- 6.
25. El-Nemr, S. E.; I. A. Ismaill and M. Ragab, 1990. Chemical composition of juice and seeds of pomegranate fruit. Nahrung, 34: 601-605.
26. Fayed, T. A. 2010. Effect of compost tea and some antioxidants applications on leaf chemical constituents, yield and fruit quality of pomegranate. World Journal of Agricultural Science 6 (4): 402-411.
27. Ankerman, D. and L. Large, 1974. Soil and Plant Analysis, Agricultural Laboratories Inc., New York, USA. pp: 82.

*****