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Pomegranate (*Punica granatum* L.) leaf analysis: Correlation with harvest

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SUMMARY – In the following work an exhaustive analysis is made of the knowledge of pomegranate (*Punica granatum* L.) leaf levels and their correlation with harvest in order to establish corresponding standard ranks. The following elements have been studied: nitrogen, phosphorus, potassium, calcium, magnesium, iron, zinc, manganese, copper, boron, and sodium. The leaf analysis technique has been used in order to determine the contents of such elements. The variety studied was a clone selection belonging to the population variety Mollar (MC1). This variety is one of those most commonly grown in the south-east of Spain, as well as another well-known Israeli early variety.

Key words: Leaf levels, microelements, macroelements, high yield, average yield, low yield, leaf analysis.

RESUME – *"Analyse des feuilles de grenadier (*Punica granatum *L.) : Corrélation avec la récolte". Dans le travail suivant une analyse exhaustive a été faite concernant les connaissances sur les niveaux des feuilles de grenadier (*Punica granatum *L.) et leur corrélation avec la récolte afin d'établir les ordres standards correspondants. Les éléments suivants ont été étudiés : azote, phosphore, potassium, calcium, magnésium, fer, zinc, manganèse, cuivre, bore, et sodium. La technique pour l'analyse des feuilles a été utilisée afin de déterminer les teneurs en ces éléments. La variété étudiée était une sélection de clones appartenant à la variété population Mollar (MC1). Cette variété est l'une de celles qui sont le plus couramment cultivées dans le sud-est de l'Espagne, ainsi qu'une autre variété précoce israélienne très connue.*

Mots-clés : *Niveaux de feuilles, microéléments, macroéléments, haut rendement, rendement moyen, faible rendement, analyse des feuilles.*

Introduction

This work aims to study and gain deeper knowledge of pomegranate fertilisation (*Punica granatum* L.), based on studies already carried out in our Department where we observed in citrus crops that the recommended leaf levels are not appropriate for all varieties, as large differences exist between them. Using the previous reasoning as a starting point, we designed a study whose purpose was to research whether there are differences in pomegranate (*Punica granatum* L.) leaf levels according to the variety studied as occurs with citrus varieties, where leaf levels show great differences according to variety. If, therefore, we use the leaf analysis technique to make a diagnosis and subsequent recommendation, we may make large mistakes, which would have a negative effect on the crop (Giménez Montesinos, 1991).

In order to carry out the study, we selected a plantation where two varieties are grown under the same conditions, using the leaf analysis technique. The normal ranks are obtained for each of the mineral elements in the plant, having previously made a division within each variety into three production levels: high, medium and low. Furthermore, in this way, an attempt is made to find correlations between the values of these mineral elements and their production or harvest level.

The biostatistical computer program SIGMA has been used for this study.

Material and methods

The study was carried out on an estate situated in the municipality of Crevillente, with a total surface area of 50 ha. The crop was drip-irrigated. The climatology of the estate corresponds to a typically Mediterranean climate, with mild winters, occasional frosts and hot summers. Annual rainfall

is below 300 mm (in recent years even less than 150 mm) almost always concentrated in the spring and autumn equinoxes. Furthermore, rainfall occurs on very few days of the year meaning that it is almost always torrential.

The varieties studied are the two on the estate: (i) Mollar, of local origin, from the south-east of Alicante; and (ii) the Israeli variety, from Israel. Both are population varieties, the latter an early variety beginning in mid-August. Mollar is also outstanding for its exceptional organoleptic characteristics.

Samples were taken for the study from both varieties and within each variety separations were made according to the three levels of production: high, medium and low. For each level, replicas were made. In the Israeli variety 6 replicas were taken for each production level, taking a total of 18 samples. In the Mollar variety, 12 replicas were taken for each production level meaning a total of 36 samples.

For sampling, the estate was divided into two zones, each occupied by a variety under study. In each zone, the samples were carried out diagonally, as the trees were drip-irrigated. Selection was made upon visual observations in the three production states. Leaves were taken from shoots without terminal fruit. The leaves were of spring bloom, the middle third of the branch, at a height of between 1-1.5 m, on the four points of the compass of the tree, including the petiole. We avoided taking samples from trees that presented abnormal symptoms, such as abnormally small or large, with some type of mechanical lesion or caused by a pest or disease (Martin-Prével *et al.,* 1984). We also avoided taking samples from trees situated at the borders of the plot so that the border effect would not affect data. Each sample was made up of 100 leaves and 4 leaves were taken for each point of the compass for each tree.

Harvesting took place on 14 July 1996, within the optimum period for the study of pomegranate leaf levels (Millán *et al.,* 1993).

Samples were later sent in duly identified perforated paper bags to the laboratory of the Department of Plant Production of the Higher Polytechnical School of Orihuela (EPSO), where they were later prepared for dispatch to the laboratory where the analysis would be made. First they were washed with tap water, then with distilled water and a non-ionic detergent. They were then dried with an air oven at 60°C, for 24 hours, and finally the samples were ground and put into flasks to be sent to the laboratory.

The methods used by the laboratory for the determination of the elements were the following:

(i) Nitrogen: Kjeldahl method
(ii) Phosphorus: spectrophotometry
(iii) Potassium: flame photometry
(iv) Calcium: atomic absorption spectrophotometry
(v) Magnesium: atomic absorption spectophotometry
(vi) Iron: atomic absorption spectrophotometry
(vii) Manganese: atomic absorption spectrophotometry
(viii) Zinc: atomic absorption spectrophotometry
(ix) Copper: atomic absorption spectrophotometry
(x) Sodium: flame photometry
(xi) Boron: spectrophotometry

Upon reception of the results from the laboratory, we went on to carry out the statistical study. This began with a purification of data, eliminating values that did not belong to confidence limits of their mean values, in order to avoid errors in the final results. The study began with the study of possible correlations between the leaf levels and the three production scales defined previously. Finally the analysis of variance was performed and in cases where there were significant differences, a multiple comparison of averages was carried out.

Results and discussion

The results obtained in the leaf analyses carried out on the Israeli variety are reflected in Tables 1, 2 and 3.

Table 1. Israeli variety: low state of production

Sample no.	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)
1	2.15	0.15	1.20	2.86	0.42	60	11	40	21	24	107
2	1.84	0.12	1.10	2.69	0.36	58	13	25	16	22	117
3	1.70	0.12	1.14	2.09	0.28	80	16	26	15	19	97
4	1.80	0.12	1.06	2.38	0.31	50	10	14	15	18	147
5	1.91	0.14	1.20	2.28	0.34	45	12	26	19	21	122
6	1.36	0.08	0.82	1.82	0.32	168	7	22	13	19	157

Table 2. Israeli variety: average state of production

Sample no.	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)
1	1.52	0.10	0.95	2.14	0.29	45	12	9	13	20	125
2	1.57	0.09	0.82	2.00	0.35	63	12	12	12	18	105
3	1.51	0.09	0.83	2.21	0.39	118	11	7	13	18	105
4	1.84	0.11	1.04	2.55	0.28	43	14	13	18	17	110
5	1.71	0.10	0.96	2.05	0.31	55	12	12	14	20	97
6	1.82	0.10	0.98	2.04	0.38	63	14	19	15	18	137

Table 3. Israeli variety: high state of production

Sample no.	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)
1	1.59	0.10	0.97	2.13	0.33	45	14	8	13	21	95
2	1.81	0.10	0.96	2.53	0.40	68	15	10	16	23	132
3	1.66	0.09	0.93	2.32	0.34	73	14	15	16	22	110
4	1.70	0.10	0.94	2.29	0.32	43	13	12	17	22	130
5	1.50	0.09	0.88	2.12	0.34	80	11	15	18	22	110
6	1.71	0.10	0.91	2.26	0.40	38	12	12	15	23	117

The results we obtained in the leaf analysis carried out in the Mollar variety are reflected in Tables 4, 5 and 6.

Comparison between varieties

When comparing both the Israeli and the Mollar varieties (Table 7), by comparing the means with the SIGMA programme, we observe that significative differences do exist between the leaf values of the following macroelements: nitrogen, phosphorus, potassium and calcium. All these levels were lower except phosphorus in the Mollar variety.

We also observed significant differences in the following microelement levels: manganese, zinc, boron and sodium. The greatest values were those of manganese and sodium in the Mollar variety.

The rest of the elements, magnesium, iron and copper did not present significative differences between both varieties.

Table 4. Mollar variety: low state of production

Sample no.	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)
1	1.46	0.14	0.86	1.57	0.32	53	5	28	14	15	207
2	1.63	0.13	0.96	1.61	0.34	73	6	37	12	16	150
3	1.66	0.16	0.89	2.01	0.35	78	3	38	14	2	310
4	1.59	0.14	0.91	1.73	0.38	60	5	39	20	22	232
5	1.54	0.15	0.99	1.67	0.33	48	8	60	21	22	217
6	1.52	0.17	0.99	1.48	0.29	98	5	37	14	20	180
7	1.36	0.08	0.82	1.83	0.30	40	4	33	14	20	275
8	1.37	0.10	0.89	1.63	0.30	55	4	34	13	20	230
9	1.32	0.13	0.82	1.67	0.35	45	2	33	13	20	182
10	1.47	0.11	0.91	2.12	0.32	85	3	28	14	21	197
11	1.65	0.10	0.96	2.42	0.28	58	6	37	18	19	162
12	1.66	0.10	0.93	2.07	0.32	45	7	44	16	17	145

Table 5. Mollar variety: average state of production

Sample no.	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)
1	1.68	0.14	0.94	1.87	0.33	63	5	34	18	20	175
2	1.80	0.12	1.00	2.15	0.34	105	5	52	14	22	195
3	1.56	0.12	0.82	1.42	0.32	85	8	46	15	19	170
4	1.69	0.11	0.84	1.79	0.36	58	7	51	17	20	142
5	1.55	0.09	0.80	1.51	0.30	73	6	42	12	19	157
6	1.59	0.19	0.90	1.61	0.38	83	4	49	17	19	195
7	1.54	0.12	0.92	2.06	0.37	98	4	64	15	14	165
8	1.50	0.13	1.00	1.97	0.35	95	5	56	16	21	195
9	1.75	0.17	0.80	1.65	0.32	55	5	39	16	18	130
10	1.36	0.11	0.83	2.26	0.34	63	6	24	15	16	212
11	1.41	0.13	0.57	0.82	0.29	48	4	27	14	15	195
12	1.60	0.11	0.52	0.99	0.27	85	2	39	10	14	202

Table 6. Mollar variety: high state of production

Sample no.	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)
1	1.63	0.13	0.61	0.72	0.34	110	4	32	15	14	262
2	1.93	0.16	0.68	0.67	0.36	150	5	39	17	12	245
3	1.52	0.10	0.55	0.99	0.29	63	4	30	10	12	245
4	1.62	0.12	0.77	1.27	0.29	60	4	40	12	11	280
5	1.48	0.14	0.55	0.70	0.39	140	3	37	14	12	297
6	1.51	0.16	0.63	0.97	0.27	40	2	39	11	11	187
7	1.50	0.11	0.69	1.06	0.31	725	2	66	16	12	270
8	1.47	0.12	0.54	0.83	0.35	65	4	27	11	10	232
9	1.81	0.13	0.63	1.33	0.34	50	3	38	14	11	190
10	1.40	0.10	0.62	1.54	0.40	78	2	31	54	15	207
11	1.10	0.11	0.54	0.83	0.31	73	2	27	9	15	230
12	1.65	0.13	0.66	2.11	0.34	100	8	23	14	15	265

Table 7. Comparison of averages between varieties

Nutrient	Mollar		Israeli		Significative	Probability
	Mean	Sd	Mean	Sd		
Macro (%)						
Nitrogen	1.5608	0.1381	1.7056	0.1841	Yes	0.00208
Phosphorus	0.1266	0.0247	0.1055	0.0182	Yes	0.00229
Potassium	0.7872	0.1577	0.9827	0.1191	Yes	0.00002
Calcium	1.5258	0.4954	2.2700	0.2618	Yes	0.00000
Magnesium	0.3288	0.0334	0.3422	0.0423	No	0.21262
Micro (ppm)						
Iron	73.65	26.32	66.38	31.81	No	0.37966
Zinc	4.50	1.76	12.38	2.06	Yes	0.00000
Manganese	38.88	10.78	16.50	8.42	Yes	0.00000
Copper	15.52	7.10	15.50	2.40	No	0.98322
Boron	16.13	4.41	20.38	2.11	Yes	0.00001
Sodium	209.16	45.62	117.77	17.47	Yes	0.00000

Correlation between harvest and leaf levels (Mollar)

In the correlation sought between the different levels of production and the macro and microelement contents (Table 8), we have detected that a correlation does exist between the harvest level and the macroelements potassium and calcium. Likewise, there is a correlation between harvest and iron and boron.

Table 8. Correlation coefficients between the different levels of production and the macro and microelement contents in Mollar varieties

Nutrient	Harvest
Potassium	-0.7568
Calcium	-0.6121
Iron	0.3597
Boron	-0.5001

We must point out that the correlation is positive in the case of iron, that is, production increases with the increase in iron. On the other hand, the potassium, calcium and boron present a negative correlation, that is, as production increases, the level of these elements in the leaf decreases.

Correlation between harvest and leaf levels (Israeli)

In the correlation sought between the different levels of production and the content of macro and microelements (Table 9), we have detected that a correlation does exist between the harvest level and the macroelements phosphorus and potassium.

Table 9. Correlation coefficients between the different levels of production and the macro and microelement contents in Israeli varieties

Nutrient	Harvest
Phosphorus	-0.5763
Potassium	-0.5466
Manganese	-0.6731

Likewise, there is a correlation between harvest and the microelement manganese. In this case there is a negative correlation in all cases: as production rises the fore-mentioned values decrease.

Normality ranges

Finally and starting with average values of each nutrient, plus minus the standard deviation, we have obtained the values which comprise the table of ranges of normality for the macronutrientes of both varieties (Tables 10, 11 and 12).

Table 10. Leaf levels of macroelements for Mollar and Israeli varieties

Element	Mollar	Israel
Nitrogen	1.40-1.70	1.50-1.90
Phosphorus	0.10-0.15	0.09-0.12
Potassium	0.55-0.69	0.90-1.00
Calcium	0.66-1.50	2.14-2.45
Magnesium	0.30-0.36	0.30-0.38

Table 11. Differences that can be attributed to production: Mollar variety

Element	High production	Low production
Potassium	0.55-0.69	0.85-0.96
Calcium	0.66-1.50	0.85-0.97

Table 12. Differences that can be attributed to production: Israeli variety

Element	High production	Low production
Potassium	0.90-1.00	0.95-1.23
Calcium	2.14-2.45	1.97-2.73

Conclusions

(i) There are significative differences between leaf values both in the macro and the micronutrients for the different pomegranate varieties. This indicates that we should continue to work in this direction in order to elaborate different interpretative tables, specific for each variety.

(ii) There is a negative correlation, particularly of potassium, due mainly to the shift of this element from the leaves to the fruit in filling.

(iii) The positive correlation between the Mollar variety, iron content and production is pointed out.

(iv) Finally, normality ranges are proposed for the macroelements for both varieties studied.

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