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FLORAL ANALYSIS AS A NEW APPROACH TO EVALUATE THE NUTRITIONAL STATUS OF OLIVE TREES

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□ *The main objective of this work was to evaluate if inflorescence analysis could be considered as an alternative to foliar diagnosis in determining the nutritional status of the olive orchards. Olive leaves from 'Arbequina' and 'Chetoui' cultivars in irrigated and rained systems were sampled within 8 phenological growth stages (dormant inflorescence bud, cluster development, petals whitening, fruit set, fruit development, stone hardening, fruit color break, and fruit ripening) from different sites of Tunisia during 2006 and 2007. Inflorescence samples were taken at petal whitening stage. Results showed that when ignoring the site of experimentation, some significant correlations were obtained between leaves and inflorescence during both years for 'Arbequina', at the stone hardening stage: standard date for leaf sampling, for nitrogen (N), phosphorus (P), copper (Cu), zinc (Zn), and manganese (Mn). Further work is required to assess the possibility of using inflorescence analysis to diagnose the nutritional status of olive trees.*

Keywords: flower analysis, nutritional status, olive trees

INTRODUCTION

Tunisia is classified as a forefront regarding the areas devoted to production of olive. The Tunisian olive groves cover 1,620,000 ha (30% of arable land), which corresponds to more than 62 million trees. Olive tree cultivation has seen an important intensification in the last years. But this progress was not accompanied with progress in terms of irrigation and fertilization.

The diagnosis of nutritional status of fruit trees has, in the past, been based almost exclusively on leaf analysis (Sanz and Montañés, 1995). The method is based on the fact that the leaf is the main site of plant metabolism. The proven relationship between the quantity of a plant's nutrient content and yield enables us to use leaf for improving the elemental nutritional

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needs of trees and to increase the quantitative and qualitative productivity (Sanz et al., 1994). This method represents an important tool to determine future fertilization requirement.

The possible improvement in yield in quantity and quality of crops is effective by supplementing the fertilization requirement when necessary. However, for many fruit species, the use of leaves faces several limitations such as the time needed for corrections in the season of possible deficiencies in mineral nutrient, which is normally defined as late when foliar diagnosis is used. Mid-July is the standard time for leaf sampling in olive tree in Mediterranean regions (Fernàndez-Escobar, 1997), but at this date improvement in yield by supplementing the fertilization will not be effective.

Recently flower analysis has been used as an alternative method to evaluate earlier the nutritional status of the plant. This diagnosis allows sufficiently for the correction of possible anomalies in mineral nutrients quiet earlier to improve the production progressively at the exact season.

Floral analysis has been developed for a number of deciduous fruit trees except citrus, which is an evergreen species, to assess the nutritional status in pear (Sanz et al., 1994), peach (Sanz and Montañés, 1995; Zarrouk, 2001), citrus (Pestana et al., 2001), apple (Sanz et al., 1998), almond (Bouranis et al., 2001) coffee (Martínez Herminia et al., 2003) and avocado (Razeto and Salgado, 2004).

In our case, the floral data on the olive-tree found by Fernández-Hernández et al. (2007) which worked on five olive varieties contrast with the previous authors. Their results suggest that the floral diagnosis cannot be considered as an alternative to the foliar diagnosis to establish the nutritional status of the olive orchards.

Therefore, the objective of this work has been to determine possible correlations between the mineral composition of the olive inflorescences at the stage of white button and leaves at different stages of development of the olive tree.

MATERIALS AND METHODS

The extended area included in this study allows the investigation of olive orchards grown under different climatic floors. Indeed the rainfall rate is decreasing from 537.2 mm year^{-1} (Mornag region) to 383.4 mm year^{-1} (Bir Mcharga region) (Table 1).

The plant materials used in this study derive from two varieties of olive trees that are grown for oil production (*Olea europaea* L.), 'Chetoui' and 'Arbequina I18'. 'Chetoui' cultivar with erected harbor is the main prevailing variety in the north of Tunisia. 'Arbequina I18' cultivar is recently introduced in all regions of Tunisia.

TABLE 1 Sampled parcels and cultivars distribution according to regions

Region	Situation	Cultivar	Number of parcels
Mornag region (Experimental farm of INRAT)	North	'Chetoui'	1
Mornag region (Sadira company)	North	'Arbequina'	2
Bir Mcharga region (Private farm)	North-East	'Arbequina'	1
Jbel ouest region (Private farm)	North-East	'Arbequina'	1

'Chetoui' trees, 50 years old, spaced 12 × 12 m apart, belong to a rained olive orchard in the region of Mornag (north of Tunisia). 'Arbequina I18' is planted in high-density planting system (2 × 4 m) with 4 years old when starting the experiments in four parcels of cultivation in different localities in Tunisia (Mornag, Bir Mcharga and Jbel Ouest) (Table 1) . The soil of orchard region in Mornag has a sandy- clayey texture. In the Bir Mcharga and Jbel Ouest regions, the texture is clay-loamy. Orchards under high density planting system received irrigation and fertilization by drip system.

The choice of selected parcels was based on well-kept olive groves, planted in conformity with overall region's management system, and productivity.

Sixteen blocks were taken in each parcel. Samples of leaves and inflorescences were taken from trees of each block and were randomly selected. The block is considered as replication and is composed of twelve trees for 'Arbequina I18' and six trees for 'Chetoui.'

Leaf Samples

Leaves were collected 1.5 meter above the ground, from 'Chetoui' and 'Arbequina' variety from four locations (east, south, west, and north). Mature leaves were sampled under natural growth conditions from the middle portion of non-bearing, current-season shoots, lower and apical leaves were discarded. Olive leaves were collected at eight phenological growth stages (dormant inflorescence bud, cluster development, petals whitening, fruit set, fruit development, stone hardening, fruit color break, and fruit ripening) during two years from January 2006 to November 2007. One sample from each block was taken and was composed of 100 leaves for the determination of the nutrient concentration

Inflorescence Samples

Inflorescence were taken at the stage of white button (when the corolla changes from green to white colors), this stage is normally reached yearly at the end of April where the inflorescence development is completed at this stage (Bouranis et al., 1999). Complete inflorescences were collected

from the middle of different reproductive shoots of the tree. Around 40 inflorescences at least were taken to have 4 g of dry matter from each block.

Foliar and floral samples were analyzed at the Laboratory of Soil Science and Environment of the National Agronomic Institute of Tunis. Once it reached the laboratory, leaves and inflorescences were washed in distilled water, dried at 60°C, ground and stored in closed plastic containers until analysis. After leaves and flowers mineralization and mineral elements extraction, potassium and calcium amounts were measured by flame photometry. Iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), and magnesium (Mg) leaf and flowers contents are determined by atomic absorption. Whereas, phosphorus (P) and boron (B) amounts were analyzed by colorimetry, using an UV spectrophotometer following the Olsen method for P and the method described by Lachica for B. Nitrogen (N) was determined by the Kjeldahl procedure. Results were expressed as a percentage of dry weight for macronutrients [N, P, potassium (K), calcium (Ca), and Mg] and as parts per million of dry weight for micronutrients (Fe, Zn, Mn, and B).

Statistical calculations were carried out using the STATISTICA (Statsoft, Tulsa, OK, USA) computer program.

RESULTS AND DISCUSSION

For 'Chetoui' cultivar, the correlation between the nutrient concentration of leaves taken at different growth stage of the tree and inflorescences at petals whitening stage were not significant. When correlations were obtained for B at color break in 2006, it was not repeated in the second year at the same stage. Also, at the stone hardening stage (July), which was considered a standard time for leaf sampling, there was no significant correlation (Tables 2 and 3)

For 'Arbequina', the result of each parcel of experimentation showed that there were not significant correlations for mineral nutrients between leaves and inflorescences for the two years of the study. When ignoring the region of experimentation, some significant correlations were obtained for macronutrients (N, P, K, Ca, and Mg) and micronutrients (Cu, Zn, B and Mn) between leaves and inflorescence. In fact, the increase of variability of the sample by merging the parcels of all regions together leads to some correlation for both years of experimentation 2006 and 2007 for calcium ($-0.97^*$and -0.76^*) at fruit set stage and zinc (-0.97^* and -0.52^*) at stone hardening stage (July) (Tables 4 and 5).

At stone hardening stage, which coincides with the standard date for leaf sampling according to Fernández-Escobar (1997) significant correlations between leaves and inflorescences were obtained for 'Arbequina' cultivar for Zn ($r = -0.97^*$) in 2006 and for N ($r = 0.59^*$), P ($r = -0.92^*$),

TABLE 2 Correlation coefficients between the concentration of mineral nutrients in inflorescences at the stage of white button and leaves in different phenological growth stages of 'Chetoui' cultivar during 2006

2006	N	P	K	Ca	Mg	Cu	Zn	Mn	B	Fe
Dormant inflorescence bud	0.14^{Ns}	-0.16^{Ns}	-0.13^{Ns}	-0.21^{Ns}	0.83^{Ns}	-0.81^{Ns}	-0.46^{Ns}	-0.92^{Ns}	0.94^{Ns}	-0.55^{Ns}
Cluster development bud	0.92^{Ns}	-0.73^{Ns}	-0.87^{Ns}	-0.2^{Ns}	0.24^{Ns}	-0.75^{Ns}	0.69^{Ns}	-0.78^{Ns}	0.13^{Ns}	0.37^{Ns}
Petals whitening	0.33^{Ns}	-0.7^{Ns}	0.78^{Ns}	-0.0^{Ns}	-0.62^{Ns}	-0.55^{Ns}	0.45^{Ns}	-0.86^{Ns}	0.26^{Ns}	0.85^{Ns}
Fruit set	-0.55^{Ns}	0.42^{Ns}	0.34^{Ns}	0.84^{Ns}	-0.6^{Ns}	-0.67^{Ns}	-0.55^{Ns}	0.9^{Ns}	-0.8^{Ns}	0.7^{Ns}
Fruit development	0.51^{Ns}	0.53^{Ns}	-0.68^{Ns}	-0.83^{Ns}	-0.7^{Ns}	-0.13^{Ns}	0.67^{Ns}	-0.7^{Ns}	0.30^{Ns}	-0.16^{Ns}
Stone Hardening	0.34^{Ns}	-0.57^{Ns}	0.25^{Ns}	-0.378^{Ns}	0.55^{Ns}	0.88^{Ns}	0.06^{Ns}	0.47^{Ns}	-0.67^{Ns}	0.83^{Ns}
Fruit colour break	-0.21^{Ns}	0.31^{Ns}	-0.66^{Ns}	0.68^{Ns}	0.44^{Ns}	0.76^{Ns}	-0.58^{Ns}	0.68^{Ns}	0.95^{*}	0.61^{Ns}
Fruit ripening	0.61^{Ns}	-0.22^{Ns}	-0.13^{Ns}	0.94^{Ns}	0.31^{Ns}	0.23^{Ns}	0.41^{Ns}	-0.59^{Ns}	-0.34^{Ns}	0.29^{Ns}

Ns, *: Non significant or significant in the 5% level of probability, respectively.

TABLE 3 Correlation coefficients between the concentration of mineral nutrients in inflorescences at the stage of white button and leaves in different phenological growth stages of 'Chetoui' during 2007

2007	N	P	K	Ca	Mg	Cu	Zn	Mn	B	Fe
Dormant inflorescence bud	-0.65^{Ns}	0.9^{Ns}	0.44^{Ns}	0.38^{Ns}	0.63^{Ns}	0.91^{Ns}	-0.99^{*}	-0.56^{Ns}	-0.65^{Ns}	-0.53^{Ns}
Cluster development bud	-0.67^{Ns}	0.05^{Ns}	-0.0^{Ns}	0.12^{Ns}	0.75^{Ns}	-0.23^{Ns}	-0.19^{Ns}	0.78^{Ns}	0.95^{*}	-0.57^{Ns}
Petals whitening	0.4^{Ns}	-0.75^{Ns}	-0.99^{*}	0^{Ns}	-0.77^{Ns}	0.26^{Ns}	0.66^{Ns}	-0.87^{Ns}	0.43^{Ns}	0.48^{Ns}
Fruit set	-0.67^{Ns}	-0.89^{Ns}	0.65^{Ns}	0.49^{Ns}	0.6^{Ns}	0.75^{Ns}	-0.19^{Ns}	-0.28^{Ns}	0.95^{*}	0.51^{Ns}
Fruit development	0.92^{Ns}	0.75^{Ns}	-0.67^{Ns}	-0.25^{Ns}	-0.6^{Ns}	-0.17^{Ns}	0.55^{Ns}	-0.99^{Ns}	0.66^{Ns}	-0.07^{Ns}
Stone Hardening	-0.83^{Ns}	-0.41^{Ns}	-0.41^{Ns}	-0.59^{Ns}	-0.25^{Ns}	-0.04^{Ns}	-0.68^{Ns}	-0.94^{Ns}	-0.84^{Ns}	-0.37^{Ns}
Fruit color break	-0.29^{Ns}	0.9^{Ns}	-0.56^{Ns}	0.62^{Ns}	-0.94^{Ns}	-0.24^{Ns}	0.33^{Ns}	0.72^{Ns}	-0.79^{Ns}	-0.05^{Ns}
Fruit ripening	0.61^{Ns}	-0.22^{Ns}	-0.13^{Ns}	0.94^{Ns}	0.31^{Ns}	0.23^{Ns}	0.41^{Ns}	-0.59^{Ns}	-0.34^{Ns}	0.29^{Ns}

Ns, *: Non significant, or significant in the 5% level of probability, respectively.

TABLE 4 Correlation coefficients between the concentration of mineral nutrients in inflorescences at the stage of white button and leaves in different phenological growth stages of 'Arbequina' cultivar without taking into consideration the region of experimentation during 2006

2006	N	P	K	Ca	Mg	Cu	Zn	Mn	B	Fe
Dormant inflorescence bud	-0.11^{Ns}	0.41^{Ns}	-0.93^{Ns}	0.47^{Ns}	-0.5^{Ns}	-0.99^{*}	-0.01^{Ns}	0.05^{Ns}	0.33^{Ns}	0.05^{Ns}
Cluster development bud	0.61^{Ns}	-0.49^{Ns}	0.77^{Ns}	0.79^{Ns}	0.69^{Ns}	-0.85^{Ns}	-0.66^{Ns}	-0.07^{Ns}	-0.96^{Ns}	-0.68^{Ns}
Petals whitening	0^{Ns}	-0.89^{Ns}	-0.55^{Ns}	0.85^{Ns}	-0.23^{Ns}	-0.67^{Ns}	-0.22^{Ns}	0.85^{Ns}	0.81^{Ns}	-0.27^{Ns}
Fruit set	-0.38^{Ns}	-0.0^{Ns}	0.51^{Ns}	-0.97^{*}	-0.94^{Ns}	0.91^{Ns}	-0.0^{Ns}	-0.08^{Ns}	-0.91^{Ns}	-0.84^{Ns}
Fruit development	-0.33^{Ns}	0.83^{Ns}	0.04^{Ns}	-0.23^{Ns}	0.11^{Ns}	-0.04^{Ns}	0.94^{Ns}	0.06^{Ns}	-0.58^{Ns}	0.75^{Ns}
Stone Hardening	-0.64^{Ns}	-0.42^{Ns}	-0.78^{Ns}	-0.63^{Ns}	-0.98^{Ns}	-0.72^{Ns}	-0.97^{*}	0.01^{Ns}	0.85^{Ns}	-0.14^{Ns}
Fruit colour break	0.73^{Ns}	-0.38^{Ns}	-0.64^{Ns}	-0.08^{Ns}	0.85^{Ns}	-0.86^{Ns}	-0.81^{Ns}	-0.14^{Ns}	0.81^{Ns}	-0.83^{Ns}
Fruit ripening	-0.39^{Ns}	-0.54^{Ns}	0.015^{Ns}	0.49^{Ns}	-0.78^{Ns}	-0.86^{Ns}	-0.81^{Ns}	-0.14^{Ns}	-0.90^{Ns}	-0.27^{Ns}

Ns, *: Non significant, or significant in the 5% level of probability, respectively.

TABLE 5 Correlation coefficients between the concentration of mineral nutrients in inflorescences at the stage of white button and leaves in different phenological growth stages of "Arbequina" cultivar without taking into consideration the region of experimentation during 2007

2007	N	P	K	Ca	Mg	Cu	Zn	Mn	B	Fe
Dormant inflorescence bud	0.98*	0.81*	-0.06^{Ns}	-0.45^{Ns}	−0.59*	0.97*	-0.17^{Ns}	0.94*	0.72*	-0.16^{Ns}
Cluster development bud	0.98*	0.86*	-0.24^{Ns}	-0.23^{Ns}	-0.03^{Ns}	0.93*	-0.21^{Ns}	0.98*	0.96*	-0.37^{Ns}
Petals whitening	0.90*	0.13^{Ns}	0.54*	−0.69*	0.27^{Ns}	0.88*	−0.3*	0.91*	0.97*	0.23^{Ns}
Fruit set	0.98*	−0.51*	0.05^{Ns}	−0.76*	0.42^{Ns}	0.97*	-0.26^{Ns}	0.87*	0.53^{Ns}	-0.01^{Ns}
Fruit development	0.97*	−0.97*	-0.32^{Ns}	−0.74*	0.5*	0.56*	0.01^{Ns}	0.83*	0.53^{Ns}	0.29^{Ns}
Stone Hardening	0.59*	−0.92*	-0.17^{Ns}	0.19^{Ns}	0.20^{Ns}	0.83*	−0.52*	0.90*	0.11^{Ns}	-0.30^{Ns}
Fruit color break	0.60*	−0.79*	0.31^{Ns}	-0.30^{Ns}	0.42^{Ns}	0.18^{Ns}	−0.58*	0.71*	-0.4^{Ns}	-0.29^{Ns}
Fruit ripening	0.73*	−0.57*	−0.28*	-0.25^{Ns}	0.17^{Ns}	0.64*	0.12^{Ns}	-0.06^{Ns}	0.94*	0.36^{Ns}

Ns, *: Non significant, or significant in the 5% level of probability, respectively.

Cu ($r = 0.83^*$), Zn ($r = -0.52^*$), and Mn ($r = 0{,}90^*$) in 2007 at the level of 5% of probability (Tables 4 and 5). However, Fernández-Hernández et al. (2007) indicated that nutrient concentration on leaves collected in July and nutrient concentration of flower buds at different development stages showed a lack of signification in five studied cultivars and during the two years of study. The same authors reported that when a significant coefficient was obtained, the signification was not maintained for the other year or it had the opposite trend. Only in 'Picual' cultivar was a significant correlation coefficient for P between leaves and inflorescences taken at pit hardening stage maintained for the two years of experiment.

In our study, it must be pointed out that the olive tree is an alternate bearing species, which may influence the concentration of nutrient element from one year to another (Fernández-Escobar et al., 2004), and especially in varieties with strong alternate phenomenon like 'Chetoui' cultivar. This could in one case explain the differences obtained in the correlation between flower and leaves coefficient for olive for the two years of the study. Moreover, all the others species studied for floral analysis to determine the nutritional status of the tree are fruits like peach, apple and pear (Sanz et al., 1994, 1998; Sanz and Montañés, 1995; Zarrouk, 2001) except citrus (Pestana et al., 2001).

TABLE 6 Nutrient concentration in olive inflorescences at the stage of white button and in leaves at stone hardening stage of 'Chetoui' cultivar for the two years of experimentation

	Nutrient Concentration (Mean)		Ranges (min-max)		Variance	
	Flowers	Leaves	Flowers	Leaves	Flowers	Leaves
			2006			
% N	1.7	0.74	1.7–1.75	0.62–0.78	0.0005	0.006
% P	0.3	0.093	0.27–0.32	0.08–0.11	0.00049	0.0001
% K	1.52	0.91	1.5–1.57	0.89–0.94	0.00096	0.00043
% Ca	0.081	2.14	0.079–0.084	2.1–2.16	0.0005	0.0008
% Mg	0.08	0.08	0.07–0.092	0.078–0.1	0.00014	0.0001
Cu ppm	23.54	9.35	22.75–24.08	9.22–9.51	0.34	0.023
Zn ppm	26.34	20.17	25.96–26.72	20.16–20.19	0.18	0.00014
Mn ppm	16.11	24.72	15.89–16.28	24.59–24.86	0.016	0.014
B ppm	14.84	21.02	22.2–22.87	20.4–21.7	0.031	0.28
Fe ppm	65.67	102.76	65.35–66	102.4–103	0.081	0.066
			2007			
% N	2.37	1.078	2.36–2.39	1.06–1.08	0.00016	0.00015
% P	0.38	0.13	0.37–0.40	0.12–0.15	0.00022	0.00027
% K	1.53	1.045	1.42–1.63	0.98–1.12	0.007	0.003
% Ca	0.4	1.23	0.095–0.12	1.22–1.27	0.21	0.00052
% Mg	0.10	0.086	0.095–0.12	0.072–0.11	0.00014	0.00031
Cu ppm	11.76	6.22	11.7–11.87	5.1–6.61	0.0073	0.56
Zn ppm	23.7	18.02	23.5–23.8	18.0–18.04	0.006	0.00012
Mn ppm	15.45	19.62	15.37–15.66	19.4–19.89	0.018	0.064
B ppm	12.02	19.07	11.2–13.3	18.9–19.22	0.83	0.017
Fe ppm	71.35	60.38	71.2–71.5	60.2–60.52	0.017	0.018

TABLE 7 Nutrient concentration in olive inflorescences at the stage of white button and in leaves at stone hardening stage of "Arbequina" cultivar for the two years of experimentation

	Nutrient Concentration (Mean)		Ranges (min-max)		Variance	
	Flowers	Leaves	Flowers	Leaves	Flowers	Leaves
			2006			
% N	1.78	1.3	1.71–1.82	1.27–1.4	0.0027	0.004
% P	0.28	0.07	0.23–0.31	0.043–0.1	0.0013	0.0005
% K	0.73	0.93	0.7–0.75	0.89–0.96	0.00026	0.00096
% Ca	1.52	2.81	1.48–1.53	2.8–2.83	0.00049	0.00016
% Mg	0.12	0.14	0.11–0.14	0.1–0.15	0.00016	0.00016
Cu ppm	82.15	23.72	81.3–82.7	23.61–23.79	0.34	0.007
Zn ppm	38.1	33.94	37.5–38.46	31.8–36.4	0.15	3.55
Mn ppm	18.7	46.16	18.5–18.28	45.6–46.7	0.016	0.20
B ppm	22.46	21.33	22.2–22.87	21.3–21.4	0.089	0.002
Fe ppm	113.63	131.8	113.2–114	131–132	0.108	0.057
			2007			
% N	2.31	1.64	2.14–2.49	1.52–1.82	0.022	0.013
% P	0.4	0.2	0.36–0.42	0.16–0.27	0.00036	0.0017
% K	1.54	1.07	1.38–1.77	0.97–1.26	0.012	0.0066
% Ca	0.35	1.41	0.18–0.47	1.35–0.52	0.008	0.0027
% Mg	0.098	0.125	0.082–0.13	0.11–0.14	0.000	0.000
Cu ppm	24.07	11.88	15.6–35	8.82–14.09	59.62	3.96
Zn ppm	36.78	22.77	35–39.56	18.6–27.8	2.83	12.36
Mn ppm	21.83	37.95	16.42–30.6	31.4–45.25	31.56	36.9
B ppm	10.76	17.02	4.9–15.6	7.6–25.35	18.55	50.9
Fe ppm	75.31	61.71	61.3–92.4	47.7–73.8	77.48	79.1

Our results indicated that macronutrients concentration in inflorescences and leaves varied lowly between plots and experimental sites (Tables 6 and 7). Data on the nutrient concentration in olive inflorescences had not been published previously. Compared with leaves taken at the standards time in July in Mediterranean region, the concentrations of nitrogen and phosphorus were present in high quantity in flowers than in leaves of the two cultivars of olive tree, while the opposite is true for Ca (Tables 6 and 7). Phosphorus concentration in flowers ranged between 0.27 to 0.4% of dry weight for 'Chetoui' and between 0.27 to 0.42% of dry weight for 'Arbequina I18' and N concentration ranged between 1.7 to 2.4% of dry weight for 'Chetoui and between 1.71 to 2.5% of dry weight for 'Arbequina I18'. Calcium concentration in flowers varied between 0.04% of dry weight in 'Chetoui' to 1.53% of dry weight in 'Arbequina I18'. For peach tree, the same results were observed for P concentration in flowers which were higher than those of leaves collected at 60 and 120 days after bloom (Sanz and Montañés, 1995) and also in coffee tree flowers (Martínez Herminia et al., 2003). They reported that P concentrations were higher in flowers because P is a phloem mobile element, which accumulates in reproductive organs where it carries out important functions in the polinic tube growth, pollen

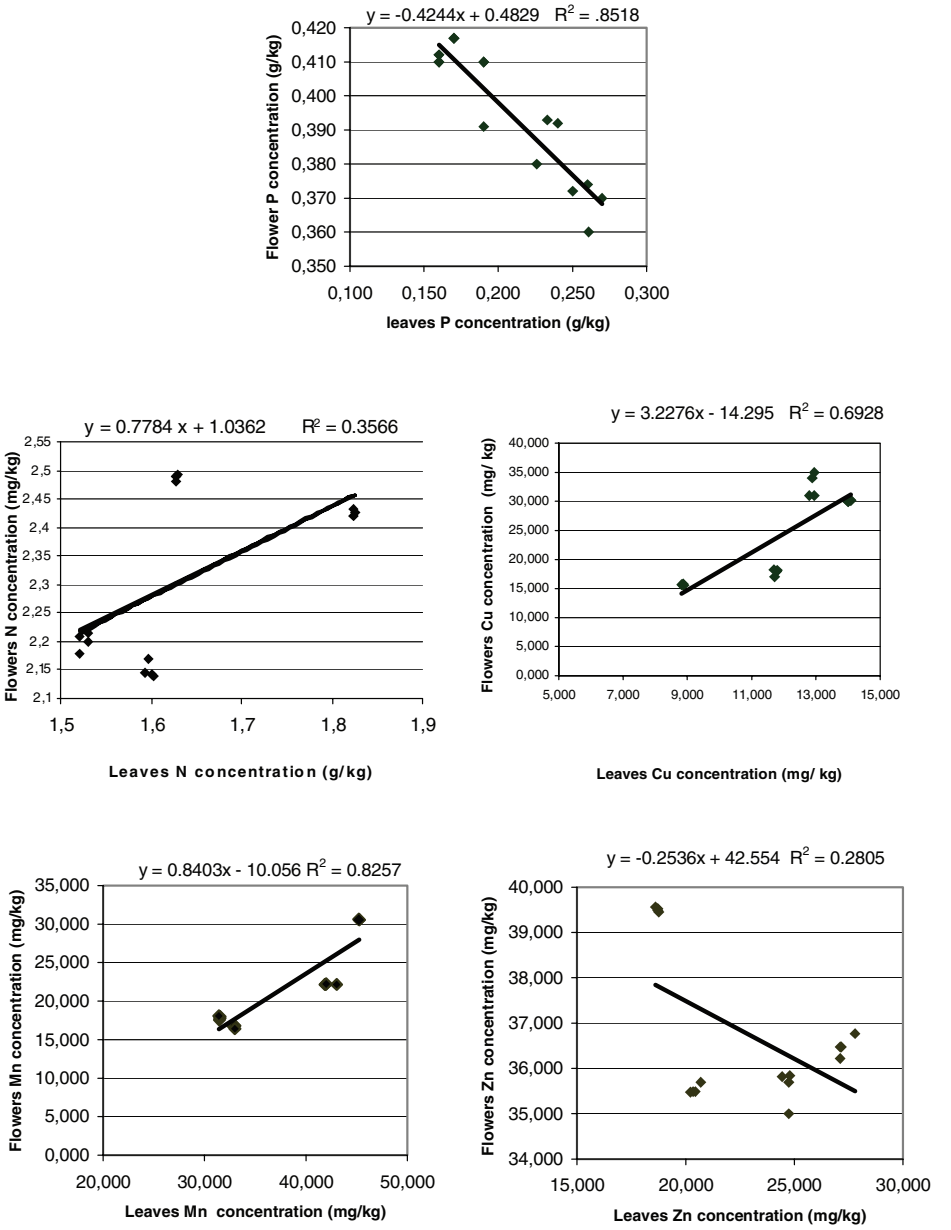

FIGURE 1 Relationship between macro- and micronutrient concentrations in 'Arbequina' flowers and leaves taken at the stone hardening stage in 2007.

grain maturation and the first phase of fruit formation. For Citrus, P and K concentration were lower in leaves than in flowers (Pestana et al., 2001)

Zinc and Cu concentration in flowers were higher than those of leaves for the two cultivars of olive tree in both years of study, when Mn and B

concentrations were lower in flowers than in leaves; only B concentration was in similar quantities for 'Arbequina I18' cultivar in 2006. Fe was one time higher in leaves than in flowers and another time the opposite. Magnesium was in similar quantities in both leaves and flowers.

The fact that a great concentration of Cu and Zn elements were found in flower than in leaves and also the variance of those elements was also greater (Tables 6 and 7), could lead to early detection of possible deficiencies in these elements by floral diagnosis.

In inflorescences as well as in leaves the data variability obtained for macronutrients was low in contrast for micronutrients the variability was quite high (Tables 6 and 7)

When variance increased for some macronutrients concentration in 'Arbequina I18' inflorescence in 2007 such as the variance for N (0.022) and micronutrients such as for Cu (59.62) as compared to 2006, more significant correlations were obtained (Table 5).

A linear regression equation according to Tranchefort (1974) can be used to predict nutrient content of leaves taken at the stone hardening stage, which coincides with the standard date for leaf sampling, based on flower analysis (Figure 1).

In summary, we can conclude that floral analysis seems to be a reliable technique to predict macronutrient (N, P) and micronutrient (Cu, Zn, and Mn) levels for olive in a variety that has a low alternate bearing phenomenon like 'Arbequina I18' but it cannot substitute for foliar diagnosis for the other varieties of high alternate bearing one. The application of floral analysis on olive tree growing under irrigated conditions like 'ArbequinaI18' could permit corrections of nutritional problems at an earlier stage by supplementing the fertilization requirement when necessary. For 'Chetoui', those experiments should be continued for at least two others years seeing that the tree has a strong alternate bearing phenomenon and the results are more significant after two bi-annuls cycles of 'on' and 'off' years. This study is required to assess the possibility of using the inflorescence analysis as an alternative to foliar diagnosis and should be continued by increasing the variability by the increase of the number of experimental sites.

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