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Prunus persica L.: análisis nutricional de flores y hojas para predecir su estado mineral

Prunus persica L.: nutritional analysis of flowers and leaves to predict their mineral status

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RESUMEN

El análisis mineral foliar se utiliza para determinar el estado nutricional de las plantas en muchos cultivos, pero en cultivos de árboles, como el durazno (*Prunus persica* L.), tiene un valor limitado para determinar la fertilización correctiva durante la temporada de crecimiento y se emplea principalmente para establecer los requerimientos de fertilización al inicio de la temporada siguiente. En contraste, el análisis mineral floral proporciona una medida más actualizada del estado mineral del árbol, permitiendo una intervención más oportuna para prevenir o, al menos, mitigar una variedad de desórdenes fisiológicos que afectan el rendimiento y la calidad del fruto en la cosecha. Este estudio correlaciona el estado nutricional de flores y hojas con parámetros clave del fruto para determinar si el análisis floral puede utilizarse para el diagnóstico y corrección de deficiencias de nutrientes a mitad de temporada. Se evaluaron siete cultivares de durazno (*Prunus persica* L.): 'Baby Gold 8', 'Autumn L', 'Catherin', 'Fairtime', 'Carnaval', 'Baby Gold 5' y 'Arkansas'

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muestreados de forma aleatoria simple contemplado diez unidades de muestreo por cultivar. Se encontró un mayor número de relaciones significativas entre los nutrientes florales y los atributos de calidad del fruto en comparación con los nutrientes foliares. Se concluye que el análisis mineral floral tiene un buen potencial para el diagnóstico y ajuste nutricional a mitad de temporada en los siete cultivares de durazno estudiados.
Palabras clave: Estado nutricional, *Prunus persica*, análisis mineral.

ABSTRACT

Leaf mineral analysis is used to determine plant nutritional status in many crops, but in tree crops, such as peach (*Prunus persica* L.), it is of limited value in determining corrective fertilisation during the growing season and is instead used mainly to determine fertilisation requirements at the start of the following season. In contrast, floral mineral analysis provides a more up-to-date measure of the mineral status of the tree, allowing more timely intervention to prevent or at least mitigate a range of physiological disorders that affect fruit yield and quality at harvest. This study correlates flower and leaf nutrient status with key fruit parameters to determine if flower analysis can be used for mid-season diagnosis and correction of nutrient deficiencies. Seven cultivars of peach (*Prunus persica* L.) are being studied: 'Baby Gold 8', 'Autumn L', 'Catherin', 'Fairtime', 'Carnaval', 'Baby Gold 5' and 'Arkansas'. Sampled by simple random sampling, considering ten sampling units per cultivar. A greater number of significant relationships with fruit quality attributes were found for floral nutrients than for foliar nutrients. It is concluded that floral mineral analysis has good potential for mid-season nutritional diagnosis and adjustment in the seven peach cultivars studied.
Keywords: Nutritional status, *Prunus persica*, mineral analysis.

INTRODUCTION

With over 3000 named peach cultivars (*Prunus persica* L.) in cultivation globally (Zhao et al., 2015). Recent studies indicate that there is substantial variation in the mineral nutrient requirements of these cultivars. This variability highlights the importance of monitoring and managing the nutritional status of each cultivar individually to ensure optimal orchard performance (El-Jendoubi et al., 2013; Menegatti et al., 2021).

Leaf tissue analysis is a common practice among growers of various crops, as it allows for the precise adjustment of fertilizer applications based on the uptake of different mineral nutrients by the root system (Wójcik and Filipczak, 2019; Santos et al., 2021). However, some authors, including Campisi-Pinto et al. (2017), have noted that for certain tree crops like avocado, leaf analyses lack sufficient sensitivity to detect changes in primary macronutrient levels that impact fruit yield and quality. Consequently, while leaf analyses remain a valuable tool for managing initial fertilization needs at the beginning of each growing season, they may be limited in their capacity to guide nutrient adjustments during the season (Du et al., 2022).

In contrast, flower tissue analysis may serve as a more effective tool for identifying specific mineral deficiencies that could lead to physiological disorders, thus impacting yield and fruit quality at harvest. Flower analysis enables nutrient adjustments during fruit development,

before visible deficiency symptoms arise. During the flowering phase, trees experience heightened nutrient demands, and any deficiencies at this stage can significantly influence final fruit quality. Immediate effects of mineral inadequacies include prolonged flowering and reduced fruit set (Huang et al., 2022). Furthermore, Oliveira et al. (2020) and Santos et al. (2021) observe that floral organs, due to their short lifespan, exhibit less complex metabolic activity compared to leaves and stems, resulting in minimal disparity between total nutrient content and the fraction available for physiological processes. Consequently, nutrient measurements in floral tissues show a strong correlation with fruit yield and display lower variation coefficients compared to leaf analyses.

Studies across various commercial tree crops—including almond (Prunus dulcis, cv Texas) (Bouranis et al., 2001), coffee (Coffea canephora) (Santos et al., 2021), mandarin (Citrus unshiu Marc.) (Gui et al., 2014), apple (Malus domestica Borkh.) (Wójcik and Filipczak, 2019), and peach (*Prunus persica* L.) (Forcada et al., 2020)—indicate that analyses of floral tissues, inflorescences, and pedicels can offer more precise insights into the current nutritional status of trees than leaf analyses alone (Uçgun et al., 2018). However, flower tissue analyses, similar to leaf analyses, are subject to various influences, including genus, species, cultivar, rootstock, phenological sampling stage, orchard pedoclimatic conditions, and management practices (Betemps et al., 2020). Nonetheless, flowering, as a critical precursor to fruit set, exerts a particularly direct effect on both fruit production and quality (Ramírez and Davenport, 2020; Gui et al., 2014). This study aimed to evaluate whether flower tissue analysis could serve as a more effective diagnostic tool than leaf analysis for early detection and correction of nutrient deficiencies in seven peach cultivars: 'Baby Gold 8,' 'Autumn L,' 'Catherin,' 'Fairtime,' 'Carnival,' 'Baby Gold 5,' and 'Arkansas.'

MATERIALS AND METHODS

Experimental area

The study was conducted at the commercial orchard 'Vivero Sacramento' in the municipality of Chihuahua, Chihuahua, Mexico, during the 2021 season. The research focused on eight-year-old trees grafted onto Criollo rootstock, planted in 10-meter square grid spacing. The region is characterized by an arid climate, with a mean annual maximum temperature of 30 ± 5° C and a mean annual minimum temperature of 11.9° C, and an average annual rainfall of approximately 500 mm.

Soil physical and chemical properties were analyzed before flower sampling. The following soil parameters were measured: pH 6.83, electrical conductivity 4.90 mmhos cm^{-1}, organic matter content 4.7 g kg^{-1}, and bulk density 1.5 g cm^{-3}. Macronutrient concentrations in the soil included: N-NO_3^- 19 ppm, phosphorus (P^+) 9 ppm, potassium (K^+) 273 ppm, calcium (Ca^{2+}) 5.5 ppm, and magnesium (Mg^{2+}) 310 ppm. Micronutrient concentrations included: iron (Fe^{2+}) 140 ppm, manganese (Mn^{2+}) 16 ppm, and copper (Cu^{2+}) 13 ppm.

Orchard management followed standard commercial practices for phytosanitary control (weeds, pests, and diseases), mineral nutrition (120-80-80, with ammonium sulfate as the nitrogen source, diammonium phosphate as the phosphorus source, and potassium sulfate as the potassium source), and irrigation scheduling throughout the experiment period (February to October).

Plant material and sample design

The study targeted seven peach cultivars [*Prunus persica* (L.)], namely, 'Baby Gold 8,' 'Autumn L,' 'Catherin,' 'Fairtime,' 'Carnival,' 'Baby Gold 5,' and 'Arkansas.' Leaf and petal samples were collected using a simple random sampling approach, with ten sampling units per cultivar. Each sampled tree, serving as a replicate, was eight years old, with an average height of 2.5 ± 0.5 m and trunk diameter of 40 ± 10 cm.

Flower and leaf sampling

Flower samples consisted of central flowers within each cluster, collected at full bloom, with 200 flowers gathered per experimental unit. Leaf samples were collected 125 days post-flowering, with 200 flowers collected per experimental unit. Both leaf and flower samples were sent to the Plant Nutrition Laboratory at the Faculty of Agrotechnological Sciences for analysis. Leaves were washed three times with tap water, followed by a rinse in 4 mol/L HCl solution, and finally with deionized water. Surface moisture was removed by air-drying, after which leaves and flowers were dried at 70° C for 24 hours to a constant weight in a ventilated oven (Heratherm VCA 230®, Thermo Scientific, Waltham, USA). Each sample was subsequently ground to a fine consistency using a mill (Willey R-TE-650/1, 1 mm mesh, Tecnal, São Paulo, Brazil).

Cation concentrations (K^+, Ca^{2+}, Mg^{2+}, Fe^{2+}, Mn^{2+}, Cu^{2+}, and Zn^{2+}) were quantified following triacid digestion with a 10:10:25 mixture of HNO_3, $HClO_4$, and H_2SO_4 (25 mL total volume). Total nitrogen content was determined using the micro-Kjeldahl method, and all elemental analyses were conducted using an atomic absorption spectrophotometer (Thermo Scientific Analysis 3000®, Thermo Scientific, Waltham, USA). Total phosphorus was quantified by the ammonium vanadate-molybdate colorimetric method (Wagle et al., 2011).

Chlorophyll Content and Leaf Area Measurement

Chlorophyll indices were determined using a SPAD 502 meter (Konica Minolta Sensing America Inc., Ramsey, NJ) on the midsection of each leaflet, avoiding major veins. This instrument estimates chlorophyll content by comparing differences in optical density at two specific wavelengths (650 nm and 940 nm). Leaf area was calculated by scanning all leaves with a flatbed scanner and processing the digital images using image analysis software (Scion Image; Scion Corp., Frederick, MD). Alternatively, leaf area was also measured using a leaf area meter (CI-202®, Cid Bio-Science, Camas, USA).

Fruit Yield Assessment

Fruit yield per tree was determined by harvesting fruits at consumption maturity, as defined by NMX-FF-060-1993, and weighing them using Torrey® brand digital scales (El-Jendoubi et al., 2012).

Statistical Analysis

Data from leaf and flower analyses were subjected to univariate analysis of variance (ANOVA) using the general linear model (PROC GLM) procedure within the Statistical Analysis System (SAS, 1991). Levene's test (for homogeneity of variances) and Shapiro-Wilks test (for normality) were employed to validate the ANOVA assumptions. Significant ANOVA results were followed by Tukey's post-hoc test ($P \leq 0.05$) to separate means. Pearson's correlation analysis was conducted to examine the relationships between foliar and floral nutritional variables across the studied cultivars. All data were analyzed using SAS/STAT software version 9.3.

RESULTS AND DISCUSSION

The results are presented in Tables 1, 2, and 3 for the reader's convenience. The highest values of the coefficient of variation for the nutrient concentration of flowers and leaves were observed for Cu^{2+} (34.44) and Mg^{2+} (26.72). The lowest values of the coefficient of variation were observed for N^{+} (3.23) and Fe^{2+} (4.91). These findings are consistent with those previously reported by Wójcik and Filipczak (2018) for blackcurrant (Tisel) and by Wójcik and Filipczak (2019) for apple (Malus domestica Borkh.). The results of the floral and foliar analyses of the seven peach cultivars revealed considerable variability in nutritional status among the cultivars.

The floral values indicated a general calcium deficiency when evaluated against the sufficiency ranges proposed by El-Jendoubi et al. (2012). The three cultivars with the highest floral nutrient balances were Arkansas, Baby Gold 5, and Carnival, which exhibited Ca^{2+} deficiencies of only 0.19, 0.25, and 0.26 g kg^{-1}, respectively. It is postulated that this may be attributable to disparities in xylem morphology among the seven cultivars (Hocking et al., 2016). It is established that calcium (Ca^{2+}) transport in plants is primarily directed to foliar tissues via the transpiration stream (2108), as observed in 'Baby Gold 5' and 'Fairtime', which exhibited foliar Ca^{2+} sufficiency ranges of 1.51 and 2.00 $g.kg^{-1}$, respectively. This indicates that 'Baby Gold 5' and 'Fairtime' exhibit superior nutritional efficiency with respect to Ca^{2+} compared to the other cultivars. Xing et al. (2021) observed that maximum values for biomass, photosynthesis, and root activity were attained at moderate concentrations of Ca^{2+} in dwarf apple seedlings, suggesting a role for Ca^{2+} in nitrogen metabolism. The present study revealed a strong correlation between foliar Ca^{2+} concentration and foliar chlorophyll content (Table 2). It is plausible that the elevated calcium concentration observed in 'Baby Gold 5' may have influenced the leaf chlorophyll content (52.60 SPAD). In terms of yield, 'Baby Gold 5' exhibited the third highest productivity among the seven cultivars (Table 3).

The cultivars "Baby Gold 8" and "Catherin" exhibited suboptimal values for flower K^+, Ca^{2+}, and Cu^{2+}, while "Baby Gold 8" also demonstrated suboptimal levels of Fe^{2+} and Zn^{2+}. In contrast, the 'Autumn' and 'Fairtime' cultivars demonstrated floral sufficiency for N^+, P^+, K^{2+}, Mg^{2+}, Mn^{2+} and Zn^{2+} while exhibiting floral deficiency for Ca^{2+}, Cu^{2+} and Fe^{2+} (Table 1). In contrast, the cultivars Arkansas, Baby Gold 5, and Carnival exhibited suboptimal values for calcium only, while displaying sufficiency values for all other nutrients. These observations align with those reported by Schmitt and Perfecto (2020), who documented higher concentrations of the nutrient in flower petals than in the leaves of Coffea arabica.

Analyses of the mineral composition of flowers have the potential to facilitate the identification of deficiencies in tree mineral nutrition, thereby enabling the implementation of corrective measures prior to the onset of adverse effects on fruit set. This approach has the additional benefit of increasing fruit yield, size, and quality of the current crop (Matsuoka, 2020). The processes of flowering and fruit set together determine the number of fruits, which is one component of fruit yield (fruit mass x fruit number = fruit yield). In numerous fruit tree species, including peach, flowering occurs prior to leaf emergence. Consequently, the incorporation of floral nutrient analyses into the diagnostic procedures utilized to evaluate tree nutritional status has the potential to facilitate early interventions, thereby preventing or mitigating physiological disorders in a multitude of tree-fruit species. As Zabini et al. (2021) observe, this technique has already been applied in Europe to peach, pear, and orange trees. Campisi-Pinto et al. (2017) indicates that in the case of the 'Hass' avocado, leaf analysis is employed to ascertain the concentrations of nutrients that are likely to influence yield in the subsequent year. However, they also indicate that avocado leaf analyses are not reliable indicators of change in the current status of the primary macro-elements. Consequently, they propose flower analyses as a complementary tool in the diagnosis of nutritional status in 'Hass' avocado.

The results of our study demonstrated considerable variation in leaf nutrient concentrations, with deficiency values observed for K^+, Mn^{2+}, and Zn^{2+} across all seven cultivars analyzed (Table 1). With regard to Mg^{2+}, the cultivars that exhibited sufficiency values, as indicated by Johnson (2008), were "Arkansas," "Baby Gold 5," and "Fairtime" (Table 1). With regard to N^+, P^+, Cu^{2+} and Fe^{2+}, the concentrations in the seven cultivars examined were found to be within the sufficiency range indicated by Johnson (2008) for peach (Table 1). It should be noted that the total mass of a micronutrient found in a leaf does not indicate the physiologically active fraction of that element, which is the factor that determines whether a physiological sufficiency or insufficiency exists. This issue is less prevalent in the context of floral organ analyses, as the metabolic reactions occurring in these organs are comparatively less complex. Therefore, in a flower, there is less discrepancy between the total concentration of a mineral and the concentration of the physiologically active fraction of that mineral (Uçgun et al., 2020).

Similarly, Ben et al. (2020) report deficiencies in K^{2+}, Mn^{2+}, and Zn^{2+} in a range of Prunus rootstock genotypes, consistent with the findings of our study. El-Jendoubi et al. (2012) report significant decreases in N^+, P^+, and Zn^{2+} concentrations and increases in Mg^{2+} and Fe^{2+} in

peach leaves on two sampling dates. Similarly, they report higher floral and foliar nutrient concentrations than those observed in our study. However, these discrepancies may be attributed to the different cultivars analysed and the varying phenological stages of the specimens at the time of analysis. Wójcik and Filipczak (2018) and Partelli et al. (2018) posit that the utility of flower analyses in predicting nutritional status is contingent upon species, cultivar, and flower phenological stage. The correlation analyses conducted in this study revealed a greater number of significant relationships between floral nutrients than between foliar nutrients (Table 2).

It is proposed that floral analyses offer greater potential than leaf analyses as a diagnostic tool for nutritional status for the seven peach cultivars analysed. This is based on the observation that floral tissues exhibited greater stability of nutrient content than foliar tissues. A similar conclusion was reached by Zabini et al. (2021) in their comparison of the mineral compositions of flowers and leaves in coffee trees (Coffea arabica L. cv Catauí). Nevertheless, it is imperative to devise an optimal protocol for the collection of flowers as part of the floral nutritional diagnostic protocol, as the position of the flower can impact the resulting nutrient concentration (Zabini et al., 2021).

Table 1. Nutrient concentrations in flowers and leaves of seven cultivars of peach (*Prunus persica* L.).

Variety	Macronutrients (g kg^{-1})									
	N		P		K		Ca		Mg	
	Flowers	Leaves	Flowers	Leaves	Flowers	Leaves	Flowers	Leaves	Flowers	Leaves
Arkansas F106	23.3±0.40c	28.6±7.60a	3.10±0.30bc	3.00±0.30c	14.5±0.60b	19.9±0.40a	1.9 ±0.02b	14.3±0.40bc	2.7±0.10dc	3.3±0.30ab
Baby G8 F81	24.1±0.70b	30.5±6.70a	3.90±0.80ab	3.90±0.80ab	7.0±0.60e	16.0±0.20b	1.0±0.01e	11.9±0.20cd	2.7±0.10dc	2.7±0.30c
Catherin F103	25.2±0.30a	26.3±6.00a	3.10±0.34c	3.20±0.50ab	11.0±0.20d	11.4±0.60d	2.6±0.11a	11.5±0.20d	2.5±0.10d	1.6±0.20e
Baby G5 F127	25.2±0.30a	27.2±7.70a	3.90±0.60a	3.90±0.70a	13.5±0.40c	19.8±0.60a	2.5±0.02a	15.1±0.12b	1.4±0.10e	3.4±0.30a
Auttum L F73	25.2±0.30a	32.4±7.70a	3.90±0.70a	3.10±0.31c	16.5±0.40a	15.1±0.30c	1.5±0.01c	14.0± 2.10b	3.1±1.20^{a}	2.2±0.20d
Carnival F102	24.9±0.40a	31.9±5.80a	3.10±0.30b	3.90±0.80ab	14.5±0.70b	16.5±0.20b	2.6±0.01a	14.3±1.90a^{a}	2.8±0.30bc	3.0±0.20bc
Fairtime F97	24.9±0.40a	29.9±6.90a	3.90±0.70a	3.00±0.30c	16.5±0.40f	9.8±0.30e	1.3±0.01d	20.0±1.20a	2.9±0.20ba	1.9±0.30de
Reference range	2.2-3.2	11.5-38.5	0.3-2.5	0.3-2.3	13.0-25.0	4.5-21.5	0.4-0.9	7.2-32.6	1.0-3.0	1.8-8.0
Significance	**	ns	**	**	**	**	**	**	**	**
CV	3.23	23.69	20.13	20.06	13.64	23.59	29.69	19.21	10.26	26.72

	Micronutrients (mg kg^{-1})							
	Cu		Fe		Mn		Zn	
	Flowers	Leaves	Flowers	Leaves	Flowers	Leaves	Flowers	Leaves
Arkansas F106	21.2±1.87b	7.0±0.82f	112.0± 2.7c	101.7±1.03d	19.5±0.73b	30.0±1.76d	35.0±1.83b	15.6±0.52b
Baby G8 F81	7.5±0.09e	12.2±1.48b	57.5± 1.48g	113.2±2.1a	12.5±1.06e	25.5±2.92a	22.0±1.63e	17.7±0.52a
Catherin F103	13.0±1.49c	8.3±0.38e	98.0± 1.25d	108.3±1.67c	19.5 ±0.83b	32.8±1.16bc	27.0±2.40d	14.1±1.20c
Baby G5 F127	19.5±0.94b	14.3±0.69a	122.5± 2.5b	110.4±1.35bc	19.5±1.24b	33.7±0.73b	33.5±1.49b	14.3±1.06c
Auttum L F73	10.5±0.75d	11.0±1.25c	66.5± 1.28f	99.3±1.89e	14.5±1.49d	28.1±1.19e	30.0±1.23c	13.2 ±0.90c
Carnival F102	26.0±1.23a	9.6±0.51d	139.0± 2.31a	102.1±1.20d	22.5±1.66a	32.3±1.08bc	42.5±2.38a	11.7±0.65d
Fairtime F97	11.0±1.56d	7.8±0.39ef	83.5±1.89e	110.5±1.24b	17.5±1.26c	31.6±0.91cd	25.5±0.99d	11.3±0.949d
Reference range	19.0-717.9	5-16	84.6-317.1	80-250	8.7-42.9	40-200	25.8-106.1	20-50
Significance	**	**	**	**	**	**	**	**
CV	34.44	25.71	28.67	4.91	18.87	10.14	21.50	15.92

Means in the same row followed by the same letter are not significantly different (Tukey's test, $p \leq 0.05$).

Table 2. Correlation between nutrients concentrations in flower and leaves of seven cultivars of peach (*Prunus persica* L.).

Flowers									
	N	P	K	Ca	Mg	Cu	Fe	Mn	Zn
N	1	0.164	-0.081	0.256*	0.012	-0.235	0.036	0.083	-0.011
P		1	0.217	-0.382**	0.046	-0.280*	-0.350**	-0.421**	-0.293*
K			1	-0.558**	0.511**	-0.216	-0.288*	-0.280*	0.003
Ca				1	-0.402**	0.621**	0.831**	0.778**	0.647**
Mg					1	-0.382**	-0.327**	-0.174	0.004
Cu						1	0.785**	0.687**	0.679**
Fe							1	0.897**	0.838**
Mn								1	0.703**
Zn									1

Leaf												
	N	P	K	Ca	Mg	Cu	Fe	Mn	Zn	Chlorophyll	Leaf area	AST	Yield
N	1	0.066	0.011	0.025	-0.029	-0.061	-0.139	-0.150	-0.168	-.234*	-.113	-.061	-.183
P		1	0.263*	-0.199	0.373**	0.348**	0.240*	0.038	0.060	.170	-.466**	-.134	-.306**
K			1	-0.269*	0.871*	0.397**	-0.254*	-0.055	0.406**	-.012	-.142	-.697**	.009
Ca				1	-0.046	-0.187	0.080	0.280*	-0.570**	-.302**	-.162	.094	-.110
Mg					1	0.344**	-0.111	0.043	0.283*	-.045	-.327**	-.666**	-.194
Cu						1	0.287*	-0.120	0.293*	.408**	-.380**	.131	-.163
Fe							1	-0.011	0.277*	.525**	-.088	.632**	-.335**
Mn								1	-0.493**	.189	-.310**	-.182	.395**
Zn									1	.310**	.393**	.096	-.109
Chlorophyll										1	.060	.418**	.242*
Leaf area											1	.326**	.517**
AST												1	.010
Yield													1

Table 3. Chlorophyll content, leaf area, trunk sectional area (TSA) and yield of seven cultivars of peach (*Prunus persica* L.).

Variety	Chlorophyll (SPAD)	Leaf área (cm)	TSA (cm)	Yield (kg·tree^{-1})
Arkansas F106	42.58±1.04c	18.17±0.57a	131.60±1.73e	37.50±0.92c
Baby G8 F81	47.50±0.82b	14.91±0.29c	163.54±1.28b	25.00±0.42f
Catherin F103	51.87±0.88a	16.99±0.47b	163.54±0.77db	41.50±0.78a
Baby G5 F127	52.60±0.63a	12.50±0.45d	149.50±0.83d	37.50±1.00c
Auttum L F73	40.50±0.62d	16.50±0.62b	154.50±0.57c	38.50±0.61b
Carnival F102	37.53±0.56e	9.23±0.34e	128.94±0.49f	28.50±0.45e
Fairtime F97	40.62±0.46d	14.65±0.29c	167.17±0.53a	31.50±0.47d
Significance	**	**	**	**

Means in the same column followed by the same letter are not significantly different (Tukey's test, $p \leq 0.05$).

CONCLUSIONS

The greater stability of flower nutrient content in comparison to leaf nutrient content indicates that flower analyses are a more useful tool for nutritional diagnosis in the seven peach cultivars examined here. Nevertheless, it is imperative to establish optimal protocols for flower collection, as the position of the flower can also influence its nutrient content.

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