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FRUIT ANALYSIS AS AN ALTERNATIVE TO LEAF ANALYSIS FOR DIAGNOSING IRON STATUS OF AVOCADO TREE

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Leaf chemical analysis generally does not represent the status of iron in avocado and other fruit trees. In order to find a better diagnostic tool for iron, an experiment was performed in a 'Hass' orchard where trees with different degrees of iron chlorosis existed. Four trees with no symptoms, four with moderate iron chlorosis and four with severe chlorosis were randomly selected. Fifteen leaves, 15 fruits and 40 inflorescences per tree were collected. Iron concentration in these tissues was measured via atomic absorption spectrophotometry after calcination and hydrochloric acid extraction. Chlorophyll concentration in the leaves was measured by spectrophotometry after extraction with ethanol. Iron concentration in the leaf and inflorescence did not show significant differences among trees. In contrast, iron in the fruit pulp was higher in the normal trees, and lower in the other trees according to their severity of chlorosis. Furthermore, chlorophyll concentration in the leaf (which was representative of the chlorosis intensity) appeared highly correlated with iron concentration in the fruit (R^2=0.84), but poorly correlated with that in the leaf (R^2=0.22) and that in the inflorescence (R^2=0.02). These results suggest that iron analysis in the leaf and the inflorescence are unreliable indicators and support the postulation that iron analysis of fruit pulp is a promising tool for diagnosing the iron status of avocado trees.

Key words: *Persea americana* Mill., Hass, chemical analysis, fruit pulp, inflorescence, iron concentration, chlorophyll, leaf color.

ANÁLISIS DE FRUTOS, COMO UNA ALTERNATIVA AL ANÁLISIS FOLIAR, PARA DIAGNOSTICAR EL NIVEL DE HIERRO EN EL ÁRBOL DE PALTO

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A diferencia de lo que ocurre con los otros nutrientes, el hierro de las hojas, determinado mediante análisis foliar, generalmente no resulta confiable para diagnosticar su carencia (clorosis férrica) en palto y otros frutales. Con el objetivo de encontrar una mejor herramienta para evaluar el nivel de hierro del árbol, se realizó un estudio en un huerto variedad "Hass", donde se seleccionaron, aleatoriamente, 4 árboles con follaje normal, 4 árboles con clorosis férrica leve y 4 con clorosis intensa. En cada árbol se colectaron, 15 hojas, 15 frutos y 40 inflorescencias. En estos tejidos se determinó concentración de hierro, mediante espectrofotometría de absorción atómica, previa calcinación y extracción con ácido clorhídrico. En las hojas, además se midió concentración de clorofila con espectrofotometría, previa extracción con etanol. La concentración de hierro en la hoja y en la inflorescencia no presentó diferencias significativas entre los árboles. En cambio, en la pulpa del fruto fue mayor en los árboles normales y menor en los otros, según el nivel de clorosis presente. Además, la concentración de hierro de la pulpa, se presentó altamente asociada (R^2=0,84) con la concentración de clorofila de la hoja, lo cual no ocurrió en el caso del hierro de la hoja y

de la inflorescencia. Estos resultados, junto con descartar al análisis de hierro en la hoja y en la inflorescencia, permiten postular al análisis de hierro en la pulpa del fruto, como un promisorio método de diagnóstico, para evaluar el nivel de este nutriente en el árbol de palto.

Palabras clave: *Persea americana* Mill., Hass, análisis químico, pulpa del fruto, inflorescencia, concentración de hierro, clorofila, color de hoja.

INTRODUCTION

Iron deficiency is a common problem in avocado and other fruit trees. However, the total Fe concentration in the leaves (leaf analysis) usually does not indicate the status of Fe in the plant. Several authors did not find a relationship between Fe chlorosis and the Fe concentration in the leaves of various fruit trees (Abadía *et al*., 2000; Guzmán *et al.* citados por Lucena, 1997; Hurley *et al*., 1986; Koseoglu, 1995; Razeto, 1982; Razeto and Valdés, 2006; Ruiz *et al*., 1980).

Chemical analysis of different fruit tissues has been proposed as an indicator of the status of some nutrients in trees: boron in almond husk (Nyomara and Brown, 1997), nitrogen in the fruit peduncle of avocado (Razeto and Salgado, 2004), iron in the fruit pulp of nectarine and kiwi (Razeto and Valdés, 2006), and boron in the fruit pulp of avocado (Razeto and Castro, 2007).

Chemical analysis of flowers has also been suggested for the diagnosis of nutrient status in peach (Sanz and Montañes, 1995; Sanz *et al.,* 1997) and avocado (Razeto and Salgado, 2004; Razeto and Castro, 2006.

For these reasons a trial was conducted on avocado, with the objective of defining whether Fe analysis of fruit pulp and inflorescence could be used as a tool for diagnosing the Fe status of the tree.

MATERIALS AND METHODS

Twenty two-year-old 'Hass' avocado trees on seedling rootstock located at Quillota, Region V of Chile (lat. 32º 51`S, long. 71º 6`W), were used. The orchard, on a soil pH 7.4, was planted at 7x7m and microsprinkler irrigated. Four trees with no symptoms, four with moderated iron chlorosis, and four with severe iron chlorosis were randomly selected.

Representative samples of 15 midshoot spring leaves and 15 fruit were collected throughout the canopy of the tree on 30 August, 2002 (i.e., late winter, 40 weeks after former year bloom). Forty inflorescences per tree were collected on 2 October, 2002, at bloom. Colour was measured on each leaf with a chroma meter (CR-300; Minolta Co., Ltd. Osaka, Japan) and was expressed as L*, a* and b* values. Chlorophyll concentration was measured in 9-mm-diameter disks taken from the same leaves, using

the modified Lichtenthaler and Wellburn (1983) method in a spectrophotometer (UV-1601; Shimadzu Corp., Kyoto, Japan).

The leaf and the inflorescence samples were washed with distilled and double-distilled water and dried at 70º C for 36 h. Two peeled slices of pulp (from surface to seed) were longitudinally cut from opposite sides of each fruit, previously washed with distilled water, and dried at 70º C for 60 h. All samples were ground with a porcelain mortar. Total Fe concentration was determined via atomic absorption spectrophotometry, with previous calcination (520º C for 15 h) and uptake in volume of 1N hydrochloric acid.

Trees were selected in a completely randomized design with three levels of chlorosis and four single-tree replications per level. The experimental unit was a whole tree. The results were analyzed by analysis of variance (ANOVA) using Tukey`s multiple range test at 5% level. A simple regression analysis was carried out between pairs of different variables.

RESULTS AND DISCUSSION

L*, a*, and b* values of colour in the leaf showed differences among the trees according to their degree of chlorosis (Table 1). Nevertheless, b*, that indicates tendency to yellow, had the highest correlation (R^2= 0.95) with chlorophyll concentration in the leaf (Figure 1). This result confirms chlorophyll analysis as a good indicator of the leaf chlorosis level (Lucena, 1986; Peryea and Kammereck, 1997; Ruiz *et al*., 1980; Yadava, 1986), but several other nutritional disorders also cause a reduction in chlorophyll level in the leaf (Porro *et al*., 2001; Yadava, 1986).

Iron concentration in the leaf did not show significant differences among the trees (Table 2), confirming this parameter as not useful for diagnosing Fe status in fruit tees. Iron concentration in the inflorescence did not have differences among trees either. which discards its benefit as indicator of iron chlorosis in the avocado tree.

In contrast, Fe concentration in fruit tissue increased as chlorosis diminished in the trees (Table 2). In fact, fruit Fe was 38 and 62% higher in the normal trees than in those with moderate and severe chlorosis, respectively. In addition, iron in fruit pulp presented a high degree of association (R^2= 0.84) with chlorophyll in the leaf (Figure 2), much higher than that obtained with leaf or inflorescence iron (R^2= 0.22 and 0.02, respectively). The critical level for pulp iron would situate around 12 $mg \cdot kg^{-1}$.

The results obtained in this work are similar to those obtained later in nectarine and kiwi (Razeto and Valdés, 2006), where iron concentration in the fruit pulp showed a high relationship with tree iron chlorosis and fruit production.

CONCLUSION

Fruit pulp appears more accurate than the leaf and inflorescence as a tissue to be analyzed to represent the iron status of the avocado tree, which allows its postulation as a promising nutritional tool.

REFERENCES

Abadía, J., Tagliavini, M., Grasa, R., Belkhodja, R., Abadía, A., Sanz, M., Araujo, E., Tsipouridis, C. and Marangoni, B. 2000. Using the flower Fe concentration for estimating chlorosis status in fruit tree orchards: a summary report. J. Plant Nutrition 23:2023-2033.

Hurley, A., Walser, R., Davis, T. and Barney, D. 1986. Net photosynthesis, chlorophyll, and foliar iron in apple trees after injection with ferrous sulfate. HortScience 21:1029-1031.

Koseoglu, A. 1995. Effect of iron chlorosis on mineral composition of peach leaves. J. Plant nutrition 18:765-776.

Lichtenthaler, H. and Wellburn, A. 1983. Determination of total carotenoids and chlorophyll *a* and *b* of leaf extract in different solvents. Biochem. Soc. Trans. 603:591-592.

Lucena, J. 1997. Methods of diagnosis of mineral nutrition of plants: a critical review. Acta Horticulturae 448:179-192

Morales, F., Grasa, R., Abadía, A. and Abadía, J. 1998. Iron chlorosis paradox in fruit trees. J. Plant Nutrition 21:815-825.

Nyomara, A. and Brown, P. 1997. Fall foliar-applied boron increased tissue boron concentration and nut set in almond. J. Amer. Soc. Hort. Sci. 122(3):405-410.

Peryea, F. and Kammereck, R. 1997. Use of Minolta SPAD-502 chlorophyll meter to quantify the effectiveness of mid-summer trunk injection of iron on chlorotic pear trees. J. Plant Nutrition 20:1457-1463.

Porro, D., Dorigatti,C., Stefanini, M. and Ceschini, A. 2001. Use of SPAD meter in diagnosis of nutritional status in apple and grapevine. Acta Horticulturae 564:243-252.

Razeto, B. 1982. Treatments for iron chlorosis in peach trees J. Plant Nutrition 5:917-922.

Razeto, B. and Castro, M. 2006. Diagnosis of boron status in avocado trees (*Persea americana* Mill.) using alternative tissues. Acta Horticulturae 721: 291-293.

Razeto, B. and Castro, M. 2007. Fruit analysis as a new approach to evaluate boron status in avocado. J. Plant Nutrition 30:1-5.

Razeto, B. and Salgado, J. 2004. The inflorescence and fruit peduncle as indicators of nitrogen status of the avocado tree. HortScience 39:1173-1174.

Razeto, B. and Valdés, G. 2006. Fruit analysis as an indicator of the iron status of nectarine and kiwi Plant. HortTechnology 16 (4): 579-582.

Römheld, V. 2000. The chlorosis paradox: Fe inactivation as a secondary event in chlorotic leaves of grapevine. J. Plant Nutrition 23: 1629-1643.

Ruiz, R., Helle, M. and Espinoza, R. 1980. Análisis de clorofila como índice indirecto de clorosis férrica en nectarinos. Agricultura Técnica (Chile) 40:161-163.

Sanz, M. and Montañés, L. 1995. Flower analysis as a new approach to diagnosing the nutritional status of the peach tree. J. Plant Nutrition 18:1667-1675.

Sanz, M., Belkhodja, R., Toselli, M., Montañés, L., Abadía, A., Tagliavini,M., Marangoni, B. and Abadía, J. 1997. Floral analysis as a possible tool for the prognosis of iron deficiency in peach. Acta Horticulturae 448:241-246.

Yadava, U: 1986. A rapid and nondestructive method to determine chlorophyll in intact leaves. HortScience 21:1449-1450.

Table 1. Leaf color according to the degree of iron chlorosis in 'Hass' avocado trees.

Color			
Tree chlorosis	L*	a*	b*
Absent	32.5 a	-6.6 a	7.8 a
Moderate	42.5 b	-15.5 c	27.4 b
Intense	61.5 c	-11.0 b	50.0 c

Means followed by different letter indicate significant difference between the respective group of trees ($p \leq 0.05$).

Table 2. Iron concentration in the fruit pulp according to the degree of iron chlorosis in 'Hass' avocado trees.

Tree clorosis	Fruit Fe concentration ($mg \cdot kg^{-1}$)
Absent	13.8 a
Moderate	10.0 b
Intense	8.5 b

Means followed by different letter indicate significant difference between the respective group of trees ($p \leq 0.05$).

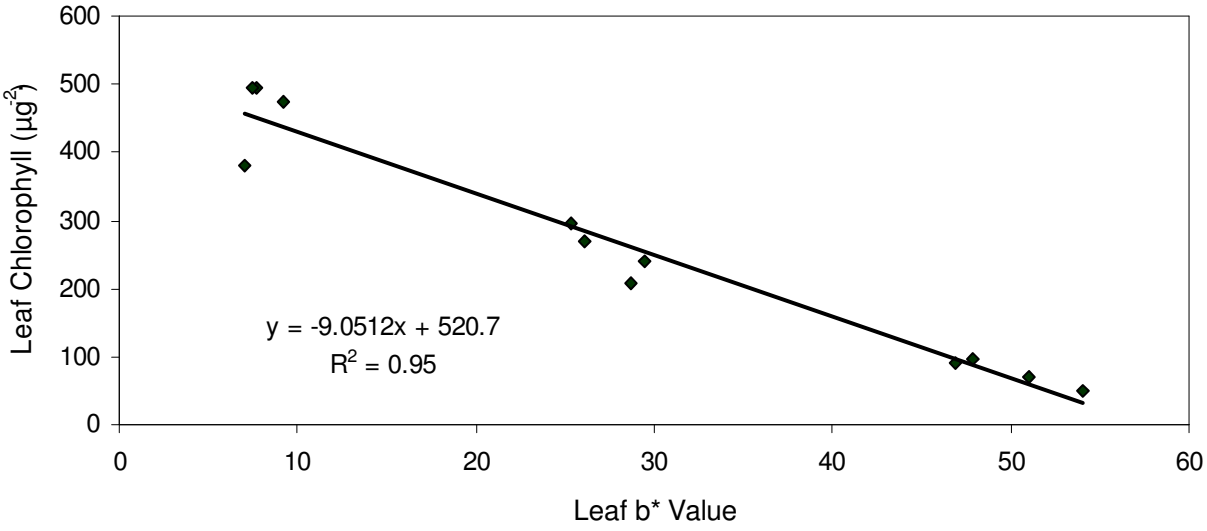

Figure 1. Relationship between color b* value and chlorophyll concentration in the leaf of 'Hass' avocado.

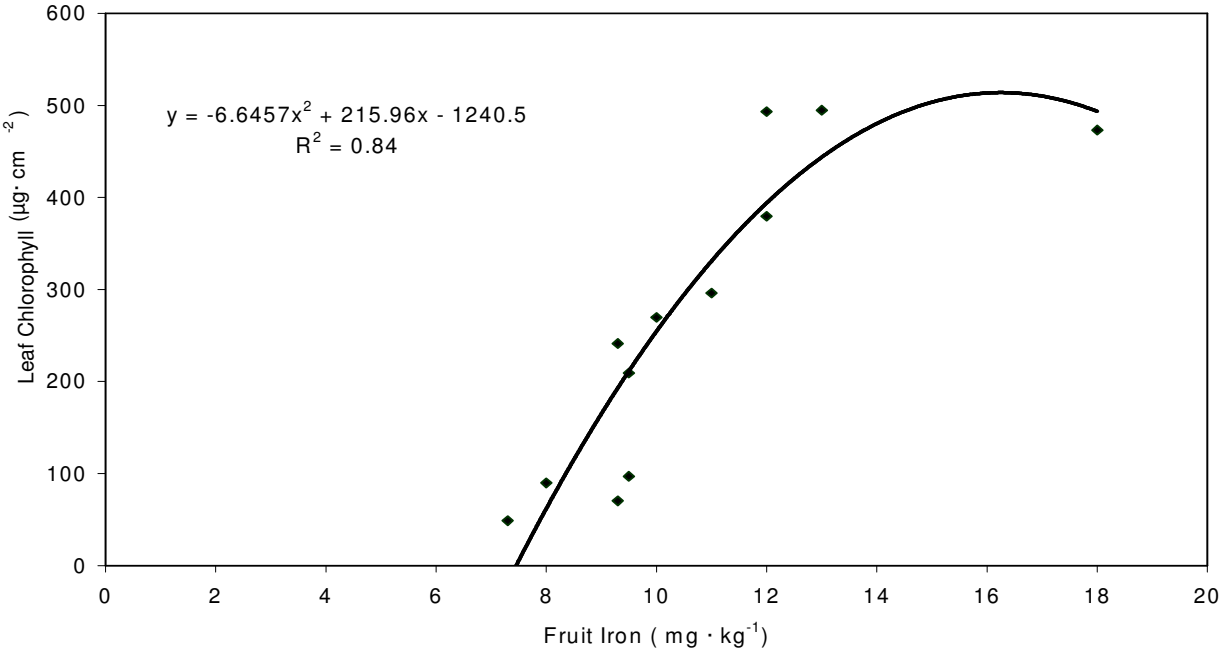

Figure 2. Relationship between iron concentration of the fruit pulp and chlorophyll concentration of the leaf in 'Hass' avocado.