An. Aula Dei (1991), 20 (3-4): 67-73.

Foliar diagnosis in peach tree: reference nutrient contents throughout the season*

by **M. SANZ, L. HERAS and L. MONTAÑES**

Estación Experimental de Aula Dei. ZARAGOZA
Received: 2-XII-91

Key Words: Peach tree, Prunus persica, L., Foliar Diagnosis.

ABSTRACT

Sanz, M.; L. Heras and L. Montañés. 1991. Foliar diagnosis in peach: reference nutrient contents throughout the season. **An. Aula Dei**, 20 (3-4): 67-73.

This paper give the optimum leaf contents of N, P, K, Ca, Mg and their ten binary ratios as a function of yield, in five different stages of the vegetative cycle of peach trees (Prunus persica L., Batsch). The optimum contents were selected as those leading to the highest yields, by using the calculation methodology described by Recalde, extended and improved with the SPSS computer program. This methodology has been applied to the nutrient contents and their ten binary ratios obtained from leaf samples taken 60, 90, 120, 150, and 180 days after full bloom. In separate calculations, correlations between each of the nutrient contents, binary ratios and yield have been performed. The following reference values are proposed: 60 days after full bloom: 3.84% N, 0.26% P, 2.68% K, 1.49% Ca and 0.61% Mg; 90 days after full bloom: 3,67% N, 14.02 K/P or 3.79 Mg/P, 2.69% K, 1.89% Ca and 0.73% Mg; 120 days after full bloom: 3.32% N, 0.16% P, 2.58% K, 2.05% Ca and 0.82% Mg; 150 days after full bloom: 3.01% N, 21.17 N/P, 2.80 K/Mg, 2.52 Ca/Mg and 0.84% Mg; 180 days after full bloom: 20.25 N/P, 0.15% P, 13.42 K/P, 2.57 Ca/Mg and 2.49 K/Mg.

INTRODUCTION

In previous paper we have studied the evolution of the leaf content of N, P, K, Ca, Mg and their binary ratios throughout the season as well as the significance level

* This paper is part of the CA 11/86 project. funded by "The Consejo Asesor de Investigación" (Advisory Research Council) of Diputación General de Aragón.

of their differences between trees with two different yield levels (Montañés et al., 1990).

Leaf sampling may be carried out at stages of the vegetative cycle other than those considered to be best. The usual sampling time for foliar diagnosis of fruit trees is mid summer, i.e., from July 15th to August 15th in the Northern hemisphere. These dates have been set based on physiological criteria, as they cover the periods where the foliar content of most nutrient is though to be most stable, thus avoiding the interpretation problems that would result from variations in nutrient and dry matter contents throughout the vegetative cycle of plants. Unfortunately, the application of tree foliar diagnosis at these dates is greatly restricted, because the crop yield response to possible correcting action within the same growing season is very limited.

To compare the nutrient contens obtained at other stages of the vegetative cycle with the standard reference values it has been necessary to use correction factors. For instance, such corrections factors have been established for peach (Leece and Gilmour, 1974), apricot (Leece and van den Ende, 1975), plum (Leece, 1975a) and cherry (Leece, 1975b) trees growing in Australia to adjust the leaf nutrient contents from samples taken before or affter the regular sampling time.

The objetive of this paper is to define the optimum leaf contents of N, P, K Ca, Mg and their ten binary ratios as a function of maximum yield in five different stages of the vegetative cycle of peach trees. It should be emphasized that these studies have been carried out following our approach based on the evaluation of reference nutrient values on a crop yield basis. Some of the parameters analyzed at different stages during the season have been found to have highly significant correlations with yield.

MATERIALS AND METHODS

The study was carried out on 180 trees distributed in several peach (*Prunus persica*, L., Batsch, cv. "Calanda") orchards located in the main growing area (Bajo Aragón) of this cultivar. Nutrient contents (N, P, K, Ca, and Mg) were analyzed (three replicates) as in CII (1969), Pinta et CII (1973) and Pinta et Dewele (1975), for samples taken at 60, 90, 120, 150 and 180 days after full bloom.

From the frequency distributions of each of the elements and the binary rations at each sampling date, we calculated the values for these parameters leading to the highest yield. For each one of these values (i.e. N content 60 days after full bloom) we calculated also its value corresponding to each of the other 14 parameters (nutrient contents and nutrient ratios). Using this calculation methodology, we obtained 15 values for each nutrient content or nutient ratio at each sampling date. The average of these 15 values was considered as the optimum nutrient content or nutrient ratio at the specific sampling date considered. This type of calculation methodology was first proposed by Recalde (1965) and used for grape vine by Lachica and González (1976). This method has been carried out with the SPSS computer program, thus allowing the introduction of a greater number of cases for the calculation of optimum nutritional values. The correlation of each nutrient content or nutrient ratio with yield has been calculated independently using same software.

RESULTS AND DISCUSSION

The optimun values of the 15 parameters as a function of yield at 60, 90, 120, 150 and 180 days after full bloom are shown in Table 1. The degree of correlation between each parameter and yield at 60, 90, 120, 150 and 180 days after full bloom is also shown in Table 1.

It should be noted that although according to our working hypothesis and methodology the values of the nutrient contents and binary ratios at each sampling stage could be considered as optimum in relation to the yield obtained, some parameters at each sampling stage may have little correlation with yield. In fact, our data (Table 1) indicate that the correlation between the contents of the nutrients analyzed (and their binary ratios) with yield is not significant in every stage of the cycle. Therefore, in this type of analysis one must always consider the information coming from the two different approaches used i.e. the optimum values for each parameter and their correlations with yield.

Sixty days after full bloom, 14 parameters were significantly correlated with yield (13 of them at the $p<0.001$). Only for the K/Ca ratio there was no significant correlation. Therefore, in our working conditions, most parameters obtained through mineral analysis of leaves sampled 60 days after full bloom can be considered as valid for the diagnosis of the nutritional situation of peach trees.

One month later (90 days after full bloom) the correlation was significant ($p<0.001$) for eight parameters, while in tree cases (P content, and N/P and K/Mg ratios) there was no significant correlation with yield. Regarding the nutrient contents, only K and Mg contents were strongly correlated ($p<0.001$) with yield. However, the N/K, N/Mg, K/P, Mg/P, K/Ca and Ca/Mg binary ratios were found to be highly correlated ($p<0.001$) to yield. Since the leaf P content was not significantly correlated with yield, the K/P and/or Mg/P ratios, that show a very high degree of correlation with yield, can be used as an alternative to interpret the situation of this nutrient. On the other hand, and bearing in mind that the correlation between N and Ca contents and yield was significant at the $p<0.01$ level, an alternative to improve the diagnosis of these nutrients is the use of N/K ratios for N, and K/Ca and/or Ca/Mg for Ca.

On day 120 after full bloom, which is the usually recommended sampling time, 10 out of the 15 parameters considered were correlated at the $p<0.001$ level with yield, two (P and K) at the $p<0.01$ level and three (N/P, K/Ca and Ca/Mg) were not significantly correlated. As discussed before, the P and K nutrient status could be assessed best by some of the binary ratios that were stongly correlated with yield: i.e. Ca/P or Mg/P for P and K/Mg, for K. The approach used in this work confirms that this period (2nd fortnight of July) is adequate for foliar diagnosis of fruit trees.

On day 150 after full bloom, only four parameters (N, Mg, N/Mg and Ca/Mg) had a high correlation ($p<0.001$) with yield; another two parameters (N/P and K/Mg) were also highly correlated, but to a lower degree ($p<0.01$). The other parameters were not significantly correlated with yield. From the data obtained here, it seems difficult at this point of the season to make a reliable assessment of the nutritional status of peach trees. In order to diagnose the situation of P and K it can be possible

Table 1. Optimum nutritional values of peach trees throughout the season and significance level of the correlation between nutrient leaf contents and nutrient ratios with yield (in parenthesis).

Parameters	Days after full bloom				
	60	90	120	150	180
N (%)	3.84 (***)	3.67 (**)	3.32 (***)	3.01 (***)	3.04 (--)
P (%)	0.26 (***)	0.19 (--)	0.16 (**)	0.14 (--)	0.15 (***)
K (%)	2.68 (***)	2.69 (***)	2.58 (**)	2.32 (--)	2.01 (--)
Ca (%)	1.49 (***)	1.89 (**)	2.05 (***)	2.11 (--)	2.14 (--)
Mg (%)	0.61 (***)	0.73 (***)	0.82 (***)	0.84 (***)	0.84 (--)
N/P	14.88 (***)	19.11 (--)	21.09 (--)	21.17 (**)	20.25 (***)
N/K	1.51 (***)	1.39 (***)	1.32 (***)	1.33 (--)	1.56 (--)
N/Ca	2.70 (***)	1.98 (**)	1.67 (***)	1.47 (--)	1.50 (--)
N/Mg	6.79 (***)	5.16 (***)	4.14 (***)	3.67 (***)	3.78 (**)
K/P	10.48 (***)	14.02 (***)	16.31 (***)	16.28 (--)	13.42 (***)
Ca/P	5.85 (***)	9.88 (**)	13.13 (***)	14.42 (--)	14.41 (--)
Mg/P	2.38 (***)	3.79 (***)	5.30 (***)	5.94 (--)	5.62 (--)
K/Ca	1.84 (--)	1.45 (***)	1.29 (--)	1.13 (--)	0.99 (--)
K/Mg	4.60 (**)	3.75 (--)	3.19 (***)	2.80 (**)	2.49 (***)
Ca/Mg	2.51 (***)	2.63 (***)	2.51 (--)	2.52 (***)	2.57 (***)

(***) $p<0.001$
(**) $p<0.01$
(--) not significant

to use N/P and K/Mg ratios, respectively, because of their high correlations with yield ($p<0.001$).

One hundred and eighty days after full bloom, five parameters (P, N/P, K/P, K/Mg and Ca/Mg) were correlated with yield at the $p<0.001$ level, whereas one (N/Mg) shows a correlation with yield at the $p<0.01$. For the other parameters the correlation was nor significant. Our data indicate that 180 days after full bloom the ratios N/P, K/P (or K/Mg) and Ca/Mg could be used for assesing N, K and Ca status, respectively. For Mg, either the Ca/Mg or the K/Mg ratios could be used.

Binary nutrient ratios have been used in the literature as a means to diagnose a specific nutritional situation, such as nutrient deficit or excess, or to detec imbalance between nutrients. For instance, some authors (Levy, 1964; Delas et Molot, 1967; Delas, 1968; Delas et al. 1976 and Loue et al. 1987) have used binary nutrient ratios in leaf grape vine analysis interpretation. Casero and Carpena (1987), based on their own experiments and those of others, proposed standard values of nutrient ratios that are required to obtain high apple yield. Recalde and Chaves (1975) proposed the use of some binary ratios (N/P and N/K) for assesing the nutrient status of olive trees.

The results obtained in the present work emphasize the usefulness of nutrient binary ratios in plant nutrition studies. The high significance level of the correlation between certain binary ratios and yield found here (Table 1) gives a different perspective to the use of those ratios as an instrument in the practice of foliar diagnosis, by providing new reference points or values to interpret a nutritional situation. One question which requires further study is whether or not it is better to use as reference values binary ratios having a signficant correlation with yield at the $p<0.001$ level instead of considering the nutrient contents with a correlation with yield at the $p<0.01$ level. In any case, the nutritional status of plant with regard to a specific nutrient, appears to be defined not only by the content of such nutrient in the leaf, but also by the value of the ratios of this element to the others. In other words, the two aspects that define correct nutrition are right amount and balanced supply of nutrients. This supports the ideas put forward by Recalde (1965) that more important than the absolute deficiency of a specific nutrient is its deficiency relative to another nutrient.

CONCLUSIONS

1. In the conditions of our study it is possible to diagnose the nutritional situation of peach trees in any stage of their vegetative cycle.

2. The following parameters are proposed as being the most reliable ones for this diagnosis based on the significance level of their correlation with yield:

60 days after full bloom: 3.84% N, 0.26% P, 2.68% K, 1.49% Ca and 0.61% Mg.

90 days after full bloom: 3.67% N, 14.02 K/P or 3.79 Mg/P, 2.69% K, 1.89% Ca and 0.73% Mg.

120 days after full bloom: 3.32% N, 0.16% P, 2.58% K, 2.05% Ca and 0.82% Mg.

150 days after full bloom: 3.01% N, 21.17 N/P, 2.80 K/Mg, 2.52 Ca/Mg and 0.84%Mg.

180 days after full bloom: 20.25 N/P, 0.15% P, 13.42 K/P, 2.57 Ca/Mg and 2.49 K/Mg.

ACKNOWLEDGEMENTS

The authors express their thanks to: C. Fustero, C. Lope, J. Pascual and the Agricultural Extension Services of the area under study for their technical contribution, and especially to J. L. Espada of the "Diputación General de Aragón".

RESUMEN

En este trabajo se presentan los contenidos foliares óptimos de N, P, K, Ca y Mg y sus diez relaciones binarias en melocotonero (*Prunus persica*, L., Batsch). Estos óptimos se obtuvieron en base a los valores que correspondian a la máxima cosecha,

mediante la metodología de cálculo descrita por Recalde, ampliada y mejorada con el programa informático SPSS. Esta metodología ha sido aplicada a los contenidos de nutrientes en hoja y a sus diez relaciones binarias, obtenidas en muestras tomadas a 60, 90, 120, 150 y 180 días después de la plena floración. Mediante cálculo separado han sido establecidas las correlaciones entre contenidos de cada nutriente, sus diez relaciones binarias y cosecha. Para el diagnóstico foliar en melocotonero se proponen los siguientes valores de referencia (contenidos en % sobre materia seca): 60 días después de la plena floración: 3.84% N, 0.26% P, 2.68% K, 1.49% Ca y 0.61% Mg; 90 días después de la plena floración: 3.67% N, 14.02 K/P y/ó 3.79 Mg/P, 2.69% K, 1.89% Ca y 0.73% Mg; 120 días después de la plena floración: 3.32% N, 0.16% P, 2.58% K, 2.05% Ca y 0.82% Mg; 150 días después de la plena floración: 3.01% N, 21.17 N/P. 2.80 K/Mg, 2.52 Ca/Mg y 0.84% Mg; 180 días después de la plena floración: 20.25 N/P, 0.15% P, 13.42 K/P, 2,57 Ca/Mg y 2.49 K/Mg.

REFERENCES

Casero, T. y O. Carpena. 1987. Relaciones nutritivas en melocotonero "Sudanell". **Inv. Agrar.: Prod. Prot. veg.** 2 (1): 19-30.

Comité Inter-Institutos (CII).1969. Métodos de referencia para la determinación de elementos minerales en vegetales. **An Edaf. Agrobiol.** XXVIII: 403-417.

Delas, J. et C. Molot. 1967. Fertilisation potasique du vignobles bordelais. **Bull. Assoc. Fr. Etud. du Sol.** 1: 1-11.

Delas, J. 1968. Etude par analyse foliaire, de la carence en magnesium dans la vignoble bordelais. **2ème Coll. Europ. et Mediter. Contr. Fert. Pl. Cult.** Sevilla (España). pp 343-350.

Delas, J.; P. Dumartin; C. Molot; J. C. Boniface, 1976. Le dessechement de la rafle dans la vignoble bordelais. **Connaiss. Vigne et Vin.** 10: 227-248.

Lachica, M. y C. González, 1976. La vid en Chile. Determinación del equilibrio nutritivo óptimo. **An. Edaf. Agrobiol.** XXXV: 917-946.

Leece, D.R. and A.R. Gilmour, 1974. Diagnostic leaf analysis for stone fruit 2. Seasonal changes in the leaf composition of peach. **Austral. J. Exp. Agric. Anim. Husb.** 14: 822-827.

Leece, D.R. 1975a. Diagnostic leaf analysis for stone fruit 4. Plum. **Austral. J. Exp. Agric. Anim. Husb.** 15: 112-117.

Leece, D.R. 1975b. Diagnostic leaf analysis for stone fruit 5. Sweet cherry. **Austral. J. Exp. Agric. Anim. Husb.** 15: 118-122.

Leece, D.R. and B. van den Ende, 1975. Diagnostic leaf analysis for stone fruit. 6. Apricot. **Austral. J. Exp. Agric. Anim. Husb.** 15: 123-128.

Levy, J.F. 1964. Identification et étude par l'analyse foliaire du quelques carénces alimentaires de la vigne. **1ére Colloque. Contr. Nutr. Min. et Fert. Cult. Mediterr.** Montpellier (Francia). pp 220-226.

Loue, A.; J. Gagnard, and P. Morard, 1987. Vignes. In: P, Martin-Prevel, J. Gagnard and P. Gautier (ed). **Plant Analysis as a Guide to the Nutrient Requirements of Temperate and Tropical Crops.** Lavoisier. Paris. p. 193.

Montañés, L.; M. Sanz; V. Gómez y L. Heras. 1990. Evolución de nutrientes en hoja de melecotonero (*Prunus persica*, L., Batsch) y producción. **An. Aula Dei** 20 (1-2): 15-26.

Pinta, M. et CII. 1973. Méthodes de référence pour la détermination des éléments mineraux dans les végétaux. Détérmination des éléments Ca, Mg, Fe, Mn, Zn, et Cu par absorption atomique. **Oléagineux.** 28: 87-93.

Pinta, M. et J. Dewele. 1975. Etalons végétaux par l'analysis foliaire. En: P. Kozna (Ed). **Le contrôle de l'alimentation des plantes cultiveés.** Akademiai Kiado. Budapest (Hungría) pp 159-172.

Recalde, L. 1965. El equilibrio nutritivo del olivo y su producción. Comunicación al Coloquio **"Aportación de las investigaciones Tecnológicas y Agrícolas a la lucha del mundo contra el hambre".** Madrid. 13 pp.

Recalde, L. y M. Chaves. 1975. Fertilización. Ponencia 3. **Seminario Oleícola Internacional.** Córdoba (España). pp 51-70.