INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
07–386/AUM/2008/10–4–459–462
http://www.fspublishers.org

Full Length Article

Prognosis of Nutrient Status and Vegetative Vigor in Peach Trees by Floral Analysis

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ABSTRACT

Iron-chlorosis is an important problem in peach trees in calcareous soils of Iran and affects over 60% of Iranian soils. The purpose of this investigation was to prognosticate nutrient status and vegetative vigour of Redhaven peach tress grafted on GF677 and Missouri rootstocks in a lime soil such as Kamalabad soil in Karaj. The experiment was condutcted in a Randomized Complete Block Design with 3 replications. Two rootstocks (GF 677 & Missouri) were considered as treatments. Relationship among different indices of flowers and leaf parameters (leaves were gathered at 120 days after full bloom) and vegetative characters were studied by linear regression analysis. Data were analysed using least significant difference test (LSD). The results showed that the most important factor for predicting leaf chlorophyll concentration of Redhaven cultivar on GF677 rootstock was flower-Fe content and for those grafted on Missouri rootstock was flower-Zn content. Differences in leaf chlorophyll concentration between treatments were not significant, while Fe content in flowers and leaves of Redhaven on Missouri rootstocks was significantly higher. The data presented also suggest that some of indices of flowers (mineral concentration in flowers and dry & wet weight of flowers at fullbloom time) could be considered as prognosis tools for an early estimation of vegetative vigour of peach trees.

Key Words: Redhaven peach trees; Missouri and GF677 rootstocks; Lime soils; Flower analysis

INTRODUCTION

Statistical data of peach trees in Iran are 456.29 thousand tones for production, 28.86 thousand hectare for area harvested and averaging 158.097.00 kg ha^{-1} for yield (FAO, 2007).

Peach production in Iran, especially, in high lime soils, suffers from iron chlorosis. An accurate and early diagnosis of these peach trees may help tree management, soil treatment, or foliar sprays on trees and also may help avoid losses in yield and quality. For an accurate estimation of the nutrient status of fruit crops especially in high lime soils several researches have published papers Abadia *et al*. (2000), Bouranis *et al*. (1999), Igartua *et al*. (2000), Sanz and Montanes (1995), Bouranis *et al*. (2001), Toselli *et al*. (2000), Vemmos (1999), Sanz *et al*. (1998) and Pestana *et al*. (2004). These reports suggeted that flower analysis has the potential to be used for diagnosis of nutritional status of different fruit species. The most usefull diagnostic tool for orchard is leaf analysis (Bergmann, 1992). However these practices have several limitation. For instance the world wide standard time for leaf sampling in fruit crops is 120 days after full bloom (Bergmann, 1992). By this time in the growing season any nutrition input would be very un-likely to result in yield increase. This type of leaf analysis could be adequately described as "postmortom" since it may give accurate information on nutritional disorders that it can only be correlated adequately in the next growing season (Abadia, 1992). Sanz and Montanes (1995) reported that the average macroelement concentrations of dry peach flowers were found to be 2.95% N, 0.40% P, 1.64% K, 0.59% Ca and 0.22% Mg and the microelement concentrations were 292.8 mg Fe, 241 mg Mn and 55.6 mg Zn kg dry wight. Correlation coefficient for the regression between nutrient concentrations in the flowers and leaves taken 60 days after full bloom were 0.309 for N, 0.342 for P, 0.319 for K, -0.214 for Ca, -0.012 for Mg, 0.222 for Fe, 0.455 for Mn and 0.026 for Zn. It is concluded that flower analysis has the potential to be used for diagnosing nutritional status. The aim of the investigation was to analyze and estimate the suitability of flowers for prognosing nutrient status and vegetative growth of Redhaven peach trees grafted on GF677 and Missouri rootstocks in high lime soil condition.

MATERIALS AND METHODS

Plant material were 3 years-old peach trees (cv. Redhaven) grafted on GF677 (vegetative) and Missouri (seedling) rootstocks. The experimental orchard was located at kamalabad Research Station in Karaj. The experiment

To cite this paer: Mirabdolbaghi, M. and R. Zarghami, 2008. Prognosis of nutrient status and vegetative vigor in peach trees by floral analysis. *Int. J. Agri. Biol.,* 10: 459–62

was conducted in a Randomized Complete Block Design (R.C.B.D) with 2 treatment (every treatment contained 4 trees) and 3 replications during 2002-2006. Treatments included peach trees grafted on GF677 and Missouri rootstocks. Evaluated attributes included: flower indices (fresh & dry weight & mineral content of flowers at full blooming time), parameters at 120 days after full bloom including leaf chlorophyll (SPAD value), chlorophyll a, chlorophyll b, chlorophyll a+b, leaf surface area, mineral content of leaves and vegetative characteristics such as shoot length, height, trunk cross sectional area (TCSA) and canopy extension (at dormancy time). From each tree, 15 flowers and 15 newly expanded leaves were randomly selected and collected. Leaf chlorophyll concentration was estimated by a SPAD-502 m (Minolta Co. oska. Japan) in all leaves sampled. SPAD values were converted to chlorophyll concentration (µMol m^{-2}) by using the calibration equation:

$$Y= 0.15 x^2 + 1.49 x+ 85$$

Where (Y) is the chlorophyll concentration and (X) the SPAD value in leaves (Pestana *et al.*, 2001). Leaf chlorophyll a, leaf chlorophyll b and leaf chlorophyll a+b were analysed by spectrophotometry. Data were analysed using least significant difference test (LSD). Chemical properties of soil at the beginning of experiment were determined following ordinary methods of soil analysis (Walkley & Black, 1934; Drouineau, 1942; Isaac & kerber, 1971; Olsen & Sommers, 1982). Correlation coefficient between flower indices and leaf parameters and with vegetative vigour were studied.

RESULTS

Analysis of the soil was done at 0-30 cm depth. According to this analysis the soil was a calcarcous clay loam with: 0.8% organic matter (Walkley & Black, 1934), 13% active lime (Drouineou, 1942) and a pH in water of 7.7. The soil had 11 mg P kg^{-1} (Olsen & Sommers, 1982) and 435 mg K kg^{-1} (Isaac & Korber, 1971). In general, Iran has an arid climate in which most of relatively scant annual precipation (250 mm or less) falls from October through April and relatively humidity remains around 42%. Average rainfall of research region was 250 mm, with an average

Table I. Mean comparison of several indices in Redhaven peach trees grafted on GF 677 and Missouri rootstocks at Kamalabad station, Karaj, Iran

Treatments	Indices of flower								Leaf parameters												Vegetutive Characteristics			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Redhaven* GF677	9.44	2.09	0.51	1.89	0.37	0.21	176.83	59.45	87.26	0.94	2.34	0.97	17.86	1.56	0.23	1.93	1.86	0.51	229.67	25.05	25.83	73.58	5.25	119.50
Redhaven * Missouri	3.92	1.00	0.48	2.37	0.63	0.28	320	68.27	88.07	0.89	2.23	0.99	17.60	1.72	0.19	1.98	1.56	0.54	285.50	24.75	18.83	50.58	4.58	96.08
LSD 5%	1.25	0.78	0.73	0.34	0.11	0.32	63.5	9.3	1.85	0.47	0.28	0.59	13.99	0.86	0.19	1.03	0.37	0.10	19.08	4.72	4.85	31.29	1.41	118.9

++ The number of observations was 12

1= Fresh weight of flowers at full bloom time (g/15 flower sample per tree). 2= Dryweight of flowers(g/15 flower sample per tree). 3= flower P(% DW). 4- flower K (% DW). 5= flower Ca (%DW). 6= flower Mg (% DW). 7= flower Fe (mg kg^{-1}DW). 8= flower Zn (mg kg^{-1}DW). 9= leaf chlorophyll (converted from SPAD value (µMol m^{-2}). 10= leaf chlorophyll a (mg/100g leaf fresh weight). 11= leaf chlorophyll b (mg/100g leaf fresh weight). 12= leaf chlorophyll a+b (mg/100g leaf fresh weight), 13- leaf surface area (cm^2). 14= leaf N (%DW). 15= leaf P(%DW). 16= leaf K (%DW). 17= leaf Ca (%DW). 18= leaf Mg (DW%). 19= leaf Fe (mg kg^{-1}DW). 20- leaf Zn (mg $^{kg1-}$ DW). 21= mean shoot length (cm). 22= height (cm). 23=trunk cross sectional area (TCSA) (cm). 24= canopy extension (cm).

Table II. Correlation cofficient between different flower indices and leaf parameter and vegetative vigours of Redhaven peach trees grafted on GF677 and Missouri rootstocks at kamalabad station/ karaj/ Iran

	Indices of flower	Leaf parameters												Vegetative characteristics			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
GF677	Fresh weight of flower	-0.08$^{n.s}$	0.48$^{n.s}$	-0.26$^{n.s}$	-0.18$^{n.s}$	0.01$^{n.s}$	0.34$^{n.s}$	-0.21$^{n.s}$	0.11$^{n.s}$	0.55*	0.05$^{n.s}$	0.10$^{n.s}$	0.28$^{n.s}$	0.32$^{n.s}$	-0.13$^{n.s}$	-0.04$^{n.s}$	-0.14$^{n.s}$
	Dry weight of flower	-0.01$^{n.s}$	0.37$^{n.s}$	-0.39$^{n.s}$	-0.38$^{n.s}$	-031$^{n.s}$	-0.05$^{n.s}$	0.14$^{n.s}$	-0.21$^{n.s}$	-0.01$^{n.s}$	0.20$^{n.s}$	0.06$^{n.s}$	0.05$^{n.s}$	-0.17$^{n.s}$	-0.49$^{n.s}$	-0.48*	-0.45$^{n.s}$
	Flower P- content	-0.06$^{n.s}$	-0.26$^{n.s}$	-0.32$^{n.s}$	-0.17$^{n.s}$	0.01$^{n.s}$	0.39$^{n.s}$	-0.32$^{n.s}$	0.08$^{n.s}$	0.74*	-0.02$^{n.s}$	0.50$^{n.s}$	-0.31$^{n.s}$	0.69*	0.31$^{n.s}$	0.40$^{n.s}$	0.55*
	Flower k-content	-0.45$^{n.s}$	0.04$^{n.s}$	-0.10$^{n.s}$	-0.27$^{n.s}$	0.06$^{n.s}$	0.16$^{n.s}$	0.31$^{n.s}$	-0.22$^{n.s}$	0.36$^{n.s}$	0.19$^{n.s}$	-0.37$^{n.s}$	0.48	0.52*	0.29$^{n.s}$	0.21$^{n.s}$	0.20$^{n.s}$
	Flower Ca-content	0.19$^{n.s}$	0.46$^{n.s}$	0.11$^{n.s}$	0.34$^{n.s}$	-0.39$^{n.s}$	0.25$^{n.s}$	-0.04$^{n.s}$	-0.11$^{n.s}$	-0.34$^{n.s}$	0.22$^{n.s}$	0.26$^{n.s}$	-0.19$^{n.s}$	-0.39$^{n.s}$	-0.57*	0.14$^{n.s}$	-0.56*
	Flower Mg- content	-0.05$^{n.s}$	0.26$^{n.s}$	0.22$^{n.s}$	-0.12$^{n.s}$	-0.39$^{n.s}$	0.41$^{n.s}$	0.20$^{n.s}$	-0.50*	0.41$^{n.s}$	0.37$^{n.s}$	-0.44$^{n.s}$	0.42$^{n.s}$	0.15$^{n.s}$	0.07$^{n.s}$	0.07$^{n.s}$	0.02$^{n.s}$
	Flower Fe-content	0.58*	-0.19$^{n.s}$	-0.22$^{n.s}$	0.14$^{n.s}$	0.27$^{n.s}$	0.57*	0.14$^{n.s}$	-0.70*	0.14$^{n.s}$	-0.01$^{n.s}$	-0.2$^{n.s}$	0.39$^{n.s}$	0.08$^{n.s}$	0.26$^{n.s}$	0.04$^{n.s}$	0.20$^{n.s}$
	Flower Zn-content	-0.08$^{n.s}$	-0.33$^{n.s}$	-0.02$^{n.s}$	-0.27$^{n.s}$	0.24$^{n.s}$	0.36$^{n.s}$	-0.57*	0.07$^{n.s}$	0.36$^{n.s}$	-0.30$^{n.s}$	0.06$^{n.s}$	0.05$^{n.s}$	0.44$^{n.s}$	0.30$^{n.s}$	0.41$^{n.s}$	0.44$^{n.s}$
Missouri	Fresh weight of flower	-0.21$^{n.s}$	-0.50$^{n.s}$	-0.56*	-0.18$^{n.s}$	-0.02$^{n.s}$	0.43$^{n.s}$	0.13$^{n.s}$	0.30$^{n.s}$	-0.56*	-0.43$^{n.s}$	0.34$^{n.s}$	-0.02$^{n.s}$	0.42$^{n.s}$	-0.58*	-0.74*	-0.42$^{n.s}$
	Dry weight of flower	0.08$^{n.s}$	-0.20$^{n.s}$	-0.39$^{n.s}$	0.14$^{n.s}$	-0.49*	0.497*	-0.32$^{n.s}$	0.59*	0.09$^{n.s}$	-0.20$^{n.s}$	0.36$^{n.s}$	0.07$^{n.s}$	-0.16$^{n.s}$	-0.07$^{n.s}$	-0.22$^{n.s}$	0.47$^{n.s}$
	Flower P- content	0.02$^{n.s}$	-0.04$^{n.s}$	0.003$^{n.s}$	0.025$^{n.s}$	-0.26$^{n.s}$	0.59*	0.08$^{n.s}$	0.26$^{n.s}$	-0.06$^{n.s}$	-0.34$^{n.s}$	0.10$^{n.s}$	-0.02$^{n.s}$	0.04$^{n.s}$	0.12$^{n.s}$	0.09$^{n.s}$	-008$^{n.s}$
	Flower k-content	-0.32$^{n.s}$	-0.40$^{n.s}$	-0.13$^{n.s}$	-0.11$^{n.s}$	-0.27$^{n.s}$	021$^{n.s}$	-0.30$^{n.s}$	0.40$^{n.s}$	-0.52*	-0.66*	0.30$^{n.s}$	-0.56*	-0.15$^{n.s}$	-0.02$^{n.s}$	0.24$^{n.s}$	-0.26$^{n.s}$
	Flower Ca-content	0.12$^{n.s}$	0.37$^{n.s}$	0.17$^{n.s}$	-0.05$^{n.s}$	0.11$^{n.s}$	-0.02$^{n.s}$	0.25$^{n.s}$	-0.34$^{n.s}$	0.51$^{n.s}$	0.42$^{n.s}$	-0.05$^{n.s}$	0.27$^{n.s}$	0.64*	-0.04$^{n.s}$	0.24$^{n.s}$	-0.18$^{n.s}$
	Flower Mg- content	0.18$^{n.s}$	0.09$^{n.s}$	-0.02$^{n.s}$	0.06$^{n.s}$	-0.13$^{n.s}$	0.10$^{n.s}$	0.004$^{n.s}$	-0.77*	0.49$^{n.s}$	0.20$^{n.s}$	0.05$^{n.s}$	0.27$^{n.s}$	0.29$^{n.s}$	0.37$^{n.s}$	0.55*	0.17$^{n.s}$
	Flower Fe-content	-0.07$^{n.s}$	-0.20$^{n.s}$	-0.17$^{n.s}$	-0.25$^{n.s}$	-0.31$^{n.s}$	-0.18$^{n.s}$	-0.40$^{n.s}$	-0.74*	0.58*	0.03$^{n.s}$	-0.42$^{n.s}$	-0.51*	0.49$^{n.s}$	0.57*	0.66*	0.49$^{n.s}$
	Flower Zn-content	-0.09$^{n.s}$	0.57*	0.20$^{n.s}$	0.01$^{n.s}$	-0.14$^{n.s}$	0.40$^{n.s}$	0.07$^{n.s}$	-0.72*	0.54*	0.25$^{n.s}$	0.51*	0.33$^{n.s}$	0.14$^{n.s}$	-0.20$^{n.s}$	0.0$^{n.s}$	0.49$^{n.s}$

Ns and *: Not significant, Significant at 5% probability levels, respeetively

+ The number of observations was 12

1= leaf chlorophyll (SPAD value). 2= leaf chlorophyll a. 3= leaf chlorophyll b. 4= leaf chlorophyll a+b. 5= leaf surface area. 6= leaf N. 7= leaf P. 8= leaf K. 9= leaf Ca, 10= leaf Mg 11= leaf Fe. 12= leaf Zn. 13= annual shoot length. 14=height 15= trunk cross sectional area. 16= canopy extension.

Table III. Linear regression equations between some indices of flower with nutrient status of leaves and with vegetative growth of Redhaven peach trees

1) Redhaven peach trees *GF677 rootstock:			
1-1) Y= flower Fe-content		Y=0.0178 x+ 0.7268	
X= leaf chlorophyll (SPAD value)	R^2=0.29		P<0.05
1-2) Y= freshweight flower		Y=0.6517 x+ 2.7069	
X= leave Ca- content	R^2=0.30		P<0.1>05
1-3) Y= flower P-content		Y=0.058 x+ 0.4038	
X= leave Ca-content	R^2=0.54		P<0.01
1-4) Y= flower K-content		Y=0.0019 x+ 1.6515	
X= annual growth of shoot	R^2=0.27		P<0.1<05
1-5) Y= flower P-content		Y=0.0042 x+ 0.4037	
X= annual growth of shoot	R^2=0.47		P<0.02>0.01
1-6) Y= flower P-content		Y=0.005 x+ 0.4555	
X= Canopy extension	R^2=0.31		P<0.1>0.05
1-7) Y= flower Fe- content		Y=33.104 x+ 125.33	
X= Leave N-content	R^2=0.31		P<0.1>0.05
2) Redhaven peach trees * Missouri rootstock:			
2-1) Y= Dryweight of flower		Y=0.6133 x+ 0.8787	
X= Leave K content	R^2=0.35		P<0.05
2-2) Y= flower P-content		Y=0.0738 x+ 0.3485	
X= leave N- content	R^2=0.35		P<0.05
2-3) Y= flower Ca-content		Y=0.2576 x+ 0.2283	
X= leave Ca- content	R^2=0.2616		P<0.1>0.05
2-4) Y= flower Mg- content		Y=0.0085 x+ 0.2425	
X= trunk cross sectional area	R^2=0.299		P<0.1>0.05
2-5) Y= flower Fe- content		Y=64.688 x+ 229	
X= leave Ca-content	R^2=0.33		P<0.05
2-6) Y= flower Fe-content		Y=0.9548 x+ 280.5	
X= height of tree	R^2=0.32		P<0.05
2-7) Y= flower Fe- content		Y=12.772 x+ 277.69	
X= trunke cross sectional area	R^2=0.43		P<0.02>0.01
2-8) Y= flower Zn- content		Y=32.392 x+ 37.801	
X= leaf chlorophyll (a)	R^2=0.33		P<0.05
2-9) Y= flower Zn- content		Y=38.83 x+ 8.042	
X= Leave Ca-content	R^2=0.29		P<0.1>0.05
2-10) Y= flower Zn- content		Y=0253 x+ 2.6553	
X= Leave Fe- content	R^2= 0.26		P<01>0.05

temperature of 13.7^{o}C and the mean of relative humidity was recorded about 50%. Peach trees grafted on Missouri rootstock showd higher concentration of flower-Fe, flower-Mg, Leaf-P content and greater mean shoot length at the current season than those grafted on GF 677, but no significant differences between treatments for leaf surface area, chlorophyll leaf-N, K, Ca, Mg and Zn content, height of tree, trunk cross sectional area and canopy extension were found (Table I).

Our result demonstrated that the most important factor for predicting leaf chlorophyll was flower-Fe content for Redhaven trees on GF677 and flower-Zn content for Redhaven trees on Missouri rootstock. Also our data showed that some indices of flowers could be considered as prognosis tool for an early estimation of nutrient status and vegetative growth of Redhaven peach trees grafted on GF677 and Missouri rootstocks in lime soils (Table II & III).

DISCUSSION

The chemical analysis of plant material for diagnostic purposes is based on the assumption that causal relationships exist between growth states of plants and nutrient content in the dry matter (Marschner, 1995). The interpretative values of leaf analysis given by Bergmann (1992) for peach trees refer to mature mid-summer leaves from new growth. It is obvious that the chemical diagnosis of the nutritional status of peach trees by such a leaf analysis is done too late to allow any deficiencies to be corrected. In such cases Sanz and Montanes (1995) and Sanz *et al*. (1997) have proposed the use of flower analysis as an approach for the diagnosis of the nutritional status of the peach tree.

Data on the mineral composition of Redhaven peach flowers on 2 rootstocks (GF677 & Missouri) are shown in Table I. Compared with leaves, the concentrations of Fe, Zn, Ca, P and K were greater in flowers of peach with Missouri rootstock, while the opposite was true for Fe and K on trees with GF 677 rootstock. With the exception of Fe and K on trees with GF 677 rootstock, similar results were obtained by Sanz *et al*. (1995 & 1997). Our results were in accordance with Belkhodja *et al*. (1998) in which the concentration of Mg in flower was smaller than in leaves of trees with both rootstocks.

To use floral analysis as a tool to diagnose nutrient status and vegetative vigour we used Linear Regression Analysis (Table II & III). Some correlations between mineral concentration in flowers and dry and wet weight of flowers (at full bloom time) with different parameters of leaves (120 days after full bloom) and also with vegetative vigoiur (at dormancy time) were found in trees grafted of both rootstocks in this study. In peach with GF 677, the Fe concentrations of flowers correlated well with the chlorophyll content (r=0.58 P<0.05) and with leave N-content (r=0.57 P<0.1>0.05). In peach with Missouri, the iron content of flowers was negatively correlated with chlorophyll content, though it was a poorer indicator than the content of Zn. Zinc may share with iron the acquisition and translocation mechanisms in plants (Grusak *et al*., 1999). In agreement with this, the Zn concentrations of flowers correlated well with the Fe concentrations in leaves (r=0.51; P<0.1>0.05). The content of chlorophyll in leaves was also correlated with the Zn concentrations in flowers (r=0.57; P<0.05).

The good correlation of the Zn concentration with that of Ca concentrations in leaves (r=0.54; P<0.1>0.05) also found in peach with Missouri rootstock. in peach with GF 677 rootstock, correlation coefficient for the regression between P and K-concentrations in the flowers and the annual growth of shoot were (r=0.52; P<0.1<0.5) for K and (r=0.69; P<0.02>0.01) for P. In peach with Missouri rootstock, correlation coefficient for the regression between Mg and Fe-concentrations in the flowers and trunk cross sectional area were r=0.55 (P<0.1>0.05) for Mg and r=0.66 (p<0.02>0.01) for Fe.

Results indicate that the use of floral rather than foliar analysis can bring forward the prognosis of nutritional status and vegetative vigour later in season in a lime soil, as recently reviewed by Abadia *et al*. (2001). An early prognosis of tree chlorophyll can benefit growers, since it allows them to detect and correct any deficiencies before fruit set, thus giving sufficient time for nutrient applications to improve yield.

CONCLUSION

Clay-loam-induced chlorosis is the most important problems of the peach production in Iran. An early prognosis of nutrient status and vegetative vigour based on floral analysis can benefit producers, since it allows them to apply treatments in time to prevent loss of fruit yield and quality due to nutrient disorders. Our result demonstrated that flower nutrient concentrations seems to have a high correlation with chlorophyll and some of vegetative characteristics of Redhaven trees on both rootstocks.

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(Received 01 November 2007; Accepted 18 March 2008)