Nutrient element variability of peach trees and tree mortality in relation to cultivars and rootstocks

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ABSTRACT: Leaf samples from 12 peach cultivars (*Prunus persica* [L.] Batsch.) (Early Crest, May Crest, Flavor Crest, Sun Crest, Fayette, Katherina, Loadel, Andross, Everts, May Grand, Firebrite and Fairlane) grafted on four peach rootstocks were analyzed for their nutrient content. The analysis of variance for leaf nutrient concentrations indicated very significant effects and interactions among cultivars and rootstocks. The rootstock effect on the absorption of nutrient elements was higher for Ca, K, P, Mg, N, and lower for Cu, Zn, Fe, Mn, and B. Generally cultivars grafted on GF 677 had higher N, K, Fe, Cu and lower Zn, Mn, and B, while leaves from cultivars grafted on wild seedlings were found to contain higher Mg and lower P, K, Fe concentrations. Leaf B and Ca were higher for cultivars grafted on Sant Julien GF 655/2, while cultivars on Damas GF 1869 had higher P, Zn, Mn and lower N, B, Ca, Cu concentrations. Leaf N was lower for Fayette on all four rootstocks and significantly different from all other cultivars. Leaf P was lower for Everts and higher for Katherina. Lower concentrations were observed in Early Crest for Fe and Zn, in Andross for Mn, and in Loadel for B, while Flavor Crest had higher concentrations of all these elements. Leaf Zn was the highest for Sun Crest on wild seedling and the lowest for Early Crest on the same rootstock. Similarly leaf N was the highest for Katherina on Damas and the lowest for Fayette on the same rootstock. Also leaf Mg was the highest for Fayette on Damas and the lowest for Fairlane on Damas. Peach tree mortality was the highest for Damas 1869 and lowest for Sant Julien. Also tree mortality was highest for Early Crest and Sun Crest and lowest for May Grand, Firebrite, and Katherina. The observed trends in the leaf nutrient composition, as regards the cultivars, rootstocks and their interactions, emphasize the importance of these factors on a new peach orchard establishment and macro-microelement fertilization.

Keywords: peaches; cultivars; rootstocks; nutrients; elements content; tree mortality; leaf analyses, fertilization

Peach rootstocks have been reported to influence performance, and survival of the scion cultivars and rootstock choice is an important factor to consider in establishing a successful orchard (HANSEN 1955; JACKSON 1958; ROGERS 1978; WILLIAMSON, COSTON 1989; YADAVA, DOUD 1989; YOUNG, HOUSER 1980; HARPER, GREENE 1998; PERRY et al. 2000). Rootstock effects on stem water potential and carbohydrate content of buds and shoots have been determined (KNOWLES et al. 1984; YADAVA, DOUD 1989). Nutrient status of peach trees has been associated with yield and survival of the tree (GALLAHER et al. 1974; LAYNE et al. 1976), both of which could be affected by the rootstock.

Scions may differ in nutrient content due to differential nutrient absorption and/or translocation, but little information is available on the rootstock and scion influence on scion nutrient content. The influence of fertilizers on yield and fruit quality has been reported by many workers (DUDZINSKI 1986; DUDZINSKI, HOLUBOWICZ 1986; GALLAHER et al. 1974; LAYNE et al. 1976; LILLELAND et al. 1962; MONASTRA et al. 1980). Usually, the quantities of fertilizers used are higher than needed (BUSSI, DEFRANCE 1986; DARFELD, LENZ 1986; DUDZINSKI, HOLUBOWICZ 1986; KNOWLES et al. 1984) with negative results on yield (MONASTRA et al. 1980; ROGERS 1973; ROGERS et al. 1974), fruit quality (ROGERS 1973; ROGERS et al. 1974), consumer's health, fruit cost, and on the environment (pollution, decrease of energy reservoirs etc.).

The present work deals with mineral absorption efficiency and tree mortality of peach cultivars, rootstocks and their interactions, in order to supply adequate amounts of fertilizers and to find the best combinations of cultivars and rootstocks for the soil – climatic conditions of the Pomology Institute.

MATERIAL AND METHODS

A planting of 476 peach trees was established in January 1984 on a calcareous soil (Table 5) at the Pomology Institute. The orchard site was prepared following local recommendations, but was not fumigated. Peaches had not grown on the site for at least 15 years. Ten trees (two as peripheral), each of the 12 scion cultivars (Early Crest,

Table 1. Effect of rootstocks on leaf nutrient content (dry weight basis)+

Rootstock	N (%)	P (%)	K (%)	Mg (%)	Ca (%)	Mn (ppm)	Zn (ppm)	B (ppm)	Cu (ppm)	Fe (ppm)
W. Seedling	2.9a**	0.11d	2.0b	0.77a	2.7b	45.9b	41.3a	12.3a	16.3a	73.9d
GF 677	3.0a	0.12b	2.9a	0.52b	2.2c	45.8b	39.89b	11.6b	16.7a	81.1a
St. Julien	2.8b	0.12b	2.1b	0.73a	3.6a	47.5a	40.2a	12.9a	16.4a	79.3ab
Damas 1989	2.7b	0.14a	2.0b	0.57b	1.6d	47.7a	41.6a	11.3b	15.6b	76.5bc

May Crest, Flavor Crest, Sun Crest, Fayette, Katherina, Loadel, Andross, Everts, May Grand, Firebrite, Fairlane) on four peach rootstocks (wild seedling, GF 677, St. Julien GF 655/2, and Damas GF 1869), were planted at a spacing of 5 × 2.5 m (FACTORIAL experiment with four replications and two trees as an experimental unit).

Locally recommended cultural and management practices were followed, and no post plant fumigation was conducted. Trees were pruned to a slender spindle bush system by hand-pruning. Five to six irrigations were provided yearly. The spraying program included application of a Bordeaux mixture at the fall stage. Five months before sampling, zinc sulfate at a level of 2.5% was sprayed. In the last two years, nitrogen was provided as $(NH_4)_2SO_4$ at 120 N units (kg) per hectare. Samples of 100 leaves per pair of trees were taken from the middle portion of the extension shoots on 12th of July. The samples were washed by gentle scrubbing in a detergent solution (Tide 1), and rinsed first in tap water, and then twice in distilled water. The washed leaves were placed in a warm air draught to remove surface moisture and then dried in a forced draught oven at 70°C till constant weight. Chemical analyses of the leaf material was carried out for the determination of the total Ca, Mg, P, Zn, Mn, Cu, Fe, B, and N. One gram of dry-leaf matter was placed in a porcelain crucible, pre-ached on a hot plate and ached in a furnace at 525°C (JACKSON 1958).

The ash was transferred quantitatively in a 100 ml beaker by means of 20 ml 1N HCL, and the suspension was filtrated through Watman filter paper No 589 in two 100 ml volumetric flasks. The determination of Fe, Mn, Zn, Cu was made by atomic absorption spectroscopy. Phosphorus was determined by the molybdophosphoric blue-colour method. Potassium was measured by flame photometer, and Ca and Mg were measured by EDTA titration. Kjeldahl and Curcumine procedures determined total nitrogen and boron, respectively.

Tree mortality was measured at the end of the experimental work, by numbers of dead trees.

RESULTS

The analysis of variance for leaf nutrient concentrations indicated very significant main effects and interactions among cultivars and rootstocks (Tables 1, 2, 3, Figs. 1, 2). The rootstock effect on the absorption of nutrient elements was higher for Ca, K, P, Mg, N and lower for Cu, Zn, Fe, Mn, B. For the later group, the cultivar effect was higher. Generally cultivars grafted on GF 677 had higher N, K, Fe, Cu and lower Zn, Mn, B, while leaves from cultivars grafted on wild seedlings were found to contain higher Mg and lower P, K, Fe concentrations. Leaf B and Ca were higher for cultivars grafted on St. Julien GF 655/2, while cultivars on Damas GF 1869 had higher P, Zn, and Mn and lower N, B, Ca, Cu concentrations.

Leaf N was lower for Fayette on all four rootstocks and significantly different from all the other cultivars. Leaf P was lower for Everts and higher for Katherina. Lower concentrations were observed in Early Crest for Fe and Zn, in Andross for Mn, and in Loadel for B, while Flavor Crest had higher concentrations of all these elements. Leaf Zn was the highest for Sun Crest on wild seedling and the lowest for Early Crest on the same rootstock. Similarly leaf N was the highest for Katherina on Damas and the lowest for Fayette on Damas. Also leaf Mg was the highest for Fayette on Damas and the lowest for Fairlane on Damas.

Peach tree mortality was highest for Damas GF 1869 and lowest for Saint Julien GF 655/2. Also tree mortality was high for Early Crest, and Sun Crest and low for May Grand, Firebrite, and Katherina.

DISCUSSION AND CONCLUSIONS

Many factors contribute to the variation of leaf nutrients, and they must be studied and evaluated in any attempt to apply leaf analysis as a diagnostic method in crop nutrition. The present work indicates this should take into account the effect of the date of harvest (Table 4) and soil analysis (Table 5). The mobilizing ability of hormones synthesized by the seed and fruit has been reported by GRANE (1968); once the fruit has commenced growth, it develops an ability to attract nutrients, and different limitations in accumulation then operate (GOOMBE 1960).

The calcareous and relatively poor soil where the experimental orchard was established is not suitable for evaluating the rootstock Damas GF 1869. But a relative high nutrient level in the soil also would tend to mask any rootstock influence on mineral content of the scion leaves. Trees on Damas GF 1869 were smaller and poor tree survival was observed; for this reason, in some cases peripheral trees were used. The low Ca in scion leaves may be related to poor survival of trees on Damas GF 1869. It has been suggested that Ca transport in plants is hindered by the graft union (MONASTRA et al. 1980).

Table 2. Effect of cultivars on leaf nutrient content (dry weight basis)[+]

Variety	N (%)	P (%)	K (%)	Mg (%)	Ca (%)	Mn (ppm)	Zn (ppm)	B (ppm)	Cu (ppm)	Fe (ppm)
Early Crest	2.90a[++]	0.129cde	2.72a	0.727ab[++]	2.63abcd[++]	46.87cd	34.87	12.42bc	17.437bc	52.94f
May Crest	2.78a	0.132bcde	2.42bcd	0.603cd	2.36e	45.25de	36.94cd	12.36cd	14.56d	71.25e
Flavor Crest	2.80a	0.138abcd	6.62ab	0.636bcd	2.47cde	50.31a	43.00ab	14.35a	14.62d	94.19a
Sun Crest	2.86a	0.141abc	2.40cd	0.670abcd	2.40de	48.44abc	43.56a	12.36cd	19.37a	86.12bc
Fayette	2.60b	1.121ef	2.48bc	0.762a	2.32e	49.44ab	42.81ab	11.17de	15.69cd	86.63ab
Katherina	2.96a	0.148a	2.45bcd	0.594cd	2.36e	46.19de	42.25ab	10.95e	17.56d	74.69de
Loadel	2.93a	0.114f	1.77f	0.687abc	2.54bcde	45.81de	38.50c	10.14e	16.56bc	78.87d
Andross	2.92a	0.134bcde	2.39cd	0.686abc	2.82a	44.38e	40.313	12.28cd	16.19bc	69.56e
Everts	2.95a	0.114f	1.78f	0.611cd	2.73ab	45.56de	42.44ab	11.98cd	14.31d	74.56de
May Grand	2.90a	0.122ef	2.42bcd	0.598cd	2.52bcde	44.87e	43.12ab	10.56e	15.62cd	81.75bcd
Fairlane	2.89a	0.116f	2.089e	0.639bcd	2.68abc	47.44bcd	38.37c	13.59ab	16.56bc	81.75bcd
Firebrite	2.91a	0.145ab	2.34cd	0.574d	2.53bcde	46.56cd	42.81ab	12.39bcd	16.69bc	80.19bcd

[+]Values presented are the average of the peach cultivars on four rootstock with four replications
[++]Mean separation by L.S.D. within 0.05 level

Couvillon (1982) reported lower Ca levels in peach leaves of cultivars budded onto different rootstocks than in the same cultivars on their own roots. Possibly, the graft union may hinder Ca transport more with Damas 1869 as the rootstock than with other rootstocks, or perhaps a strain of *Plum pox virus* causes scion isolation (split) and depressed Ca translocation. Chlorotic leaves contained less Fe and Zn than normal leaves.

Trees with less than 52 ppm Fe showed symptoms of chlorosis. An adequate amount of Zn in most cultivars was due to zinc sulfate application. Considering magnitudinal differences, rootstock had a more important effect on Ca, K, P, Mg, and N content than on Cu, Zn, Fe, Mn, and B content of scion leaves. For the later group, the cultivar effect was higher. Generally, cultivars on GF 677 had higher N, K, Fe, Cu (perhaps due to a better root system) and these results show the importance of this rootstock for poor calcareous dry soil. On the contrary, the rootstock Damas GF 1869 seems to be an unsuitable rootstock for most Greek soil-climatic conditions (rootstock/scion incompatibility probably increased by PPV strain II, poor survival etc. – Table 3).

Leaf N was lower for Fayette on all four rootstocks and significantly different from all other cultivars. This means that orchards with Fayette need higher amounts of N fertilizers. The varieties Early Crest and Sun Crest had the highest tree mortality among cultivars due to severe iron chlorosis, while cultivars May Grand, Firebrite, and Andross had less chlorosis even when trees were budded on susceptible rootstock.

The observed trends in the leaf nutrient composition, as regards cultivars, rootstocks and their interactions, emphasize the importance of these factors on a new peach orchard establishment and on macro-microelement fertilization. Therefore, by choosing the best combinations of rootstocks and cultivars for each soil-climatic condition, and by applying only the necessary fertilizers for each case, it is possible to:

1. use less fertilizers (less pollution, lower cost, healthier fruits),
2. improve peach fruit quality and yield,
3. extend peach tree cultivation to different soil types and to decrease tree mortality.

The task of the horticulturists is to try to feed the population with adequate, healthy foods with the least damage to the environment (waste of energy, pollution etc).

References

BUSSI C., DEFRANCE H., 1986. Fertilizing irrigation in a peach orchard. Results of three years of trials. Arboric. Fruit., *33* (387): 45–48.

COUVILION G.A., 1982. Leaf elemental content comparisons of own rooted peach cultivars to the same cultivars on several peach seedling rootstocks. J. Amer. Soc. Hort. Sci., *107*: 555–558.

DARFELD H.J., LENZ F., 1986. Long term effects of different nutrient supplies on pears. Hort. Abst., Vol. *56*, 1614: 169.

Table 3. Effect of peach cultivars and rootstocks on tree mortality

Varieties	W. Seedlings	GF 677	St. Julien GF 655/2	Damas GF 1869	**Means**	L.S.D.
Early Crest	50 a[z]	10 b	10 ab	100 a	**42.5**	
May Crest	10 b	0 b	0 b	100 a	**27.5**	
Flavor Crest	20 b	20 a	0 b	75 b	**28.7**	
Sun Crest	50 a	20 a	0 b	100 a	**42.5**	
Fayette	20 b	10 ab	0 b	100 a	**32.5**	
Katherina	0 b	10 ab	20 a	75 b	**26.2**	5.21**
Loadel	20 b	0 b	10 ab	75 b	**26.2**	
Andross	20 b	0 b	0 b	75 b	**23.7**	
Everts	20 b	20 a	0 b	100 a	**35.0**	
May Grand	0 b	10 ab	10 ab	75 b	**23.7**	
Firebrite	0 b	0 b	10 ab	100 a	**27.5**	
Fairlane	20 b	10 ab	10 ab	100 a	**35.0**	
Means	**19.2**	**9.2**	**5.8**	**89.6**		Interaction L.S.D.
L.S.D.			9.03**			18.06**

[Z]Mean separation within columns by Duncan's multiple range test ($P \leq 0.05$)
**Significant at $P \leq 0.01$

Table 4. Peach fruit harvesting and leaf sample dates

Varieties	Ripening time in relation to Red Haven	Harvesting date
Early Crest	–36 days	1/6
May Crest	–28 days	7/6
Flavor Crest	–2 days	7/7 + 15/7
Sun Crest	+18 days	8/8
Fayette	+30 days	17/8 + 22/8
Katherina	+9 days	22/7
Loadel	+12 days	25/7
Andross	+34 days	17/8
Everts	+49 days	2/9
May Grand	–15 days	27/6
Firebrite	+2 days	15/7
Fairlane	+52 days	9/9 + 14/9

Table 5. Soil analyses of the experimental orchard

Soil deep	Soil type	pH	Free $CaCO_3$	Organic matter	Mmhos/cm	P Olsen (ppm)	K (ppm)
0–30	SC–SL	7.6	37.70	1.31	0.53	32.75	51
30–60	SC–SCL	7.8	49.47	–	–	–	–
60–90	SCL	7.9	47.52	–	0.44	–	–

Means from four soil sections

DUDZINSKI F., 1986. Effect of soil management and fertilization on cropping of the peach cultivars. Hort. Abst., Vol. *56*, No. 1, 4020: 432.

DUDZINSKI, F., HOLUBOWICZ T., 1986. Effect of pruning and fertilization on the regeneration and cropping of the peach cultivar Siewka Rakoniewicka. Hort. Abst., Vol. *56*, No. 1, 4019: 432.

GALLAHER R.N., PERKINS H.F., JONES J.B. Jr., 1974. Calcium concentration and distribution in healthy and decline peach tree tissue. Hort. Sci., *10* (2): 134–137.

GOOMBE B.G., 1960. Relationship of growth and development to changes in sugars auxins and gibberellins in fruit of seeded and seedless varieties of vitis. Plant Physiol., *35*: 241–250.

GRANE J.C., 1968. The role of hormones in fruit set and development. HortScience, *4*: 108–111.

HANSEN C.J., 1955. Influence of rootstock on injury from excess of boron in Nonpareil almond and Elberta peach. Proc. Amer. Soc. Hort. Sci., *65*: 128–132.

HARPER J.K., GREENE G.M., 1998. Impact of production risk on the selection of peach rootstocks. Fruit Var. J., *52* (1): 41–46.

JACKSON M.L., 1958. Soil chemical analysis. Prenstice Hall ink. Inglewood Cliffs N.J.

KNOWLES J.W., DOZIER W.A., EVANS C.E., CARLTON C.C., MCGUIRE J.M., 1984. Peach rootstock influence on foliar and dormant stem nutrient content. J. Amer. Soc. Hort. Sci., *109* (3): 440–444.

LAYNE R.E.C., WEAVER G.M., JACKSON H.O., STROUD F.D., 1976. Influence of peach seedling rootstock on growth, yield, and survival of peach scion cultivars. J. Amer. Soc. Hort. Sci., *101* (5): 568–572.

LILLELAND O.K., URIU K., MURAOKA T., PEARSON J., 1962. The relationship of potassium in the peach leaf to fruit growth and size at harvest. Proc. Amer. Soc. Amer. Soc. Sci., *81*: 162–167.

MONASTRA F., PROTO D., FIDEGHELLI C., GRASSI G., 1980. Influence of nitrogen fertilization on yield and quality of canned fruits. Acta Hort., *92*: 292–293.

PERRY R., REIGHARD G., FERREE D., BARDEN J., BECKMAN T., BROWN G., CUMMINS J., DURNER E., GREENE G., JOHNSON S., LAYNE R., MORRISON F., MYERS S., OKIE W.R., ROM C., ROM R., TAYLOR B., WALKER D., WARMUND M., YU K., 2000. Performance of the 1984 Nc-140 cooperative peach rootstock planting. J. Amer. Phonol. Soc., *54* (1): 6–10.

ROGERS E., 1973. Iron-induced Mn deficiency in 'July Elberta' peach tree. J. Amer. Soc. Hort. Sci., *98*: 19–22.

ROGERS E., JOHNSON G., JOHNSON D., 1974. Iron-induced Mn defficiency in 'Sungold' peach and its effects on fruit composition and quality. J. Amer. Soc. Hort. Sci., *99* (3): 242–244.

ROGERS E., 1978. Iron chlorosis and mineral content of 'Fay Elberta', 'Shippers Late Red' and 'Redhaven' peach trees as affected by iron chelates. J. Amer. Soc. Sci., *103* (5): 608–612.

WILLIAMSON J.G., COSTON D.C., 1989. The relationship among root growth, shoot growth, and fruit growth of peach. J. Amer. Soc. Hort. Sci., *114* (2): 180–183.

YADAVA U.L., DOUD S.L, 1989. Rootstock and scion influence growth, productivity, survival, and short life-related performance of peach trees. J. Amer. Soc. Hort. Sci., *114* (6): 875–880.

YOUNG E., HOUSER J., 1980. Influence of Siberian C rootstock on peach bloom delay, water potential, and pollen meiosis. J. Amer. Soc. Hort. Sci., *105* (2): 242–245.

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Variabilita obsahu živin a úhyn stromů u broskvoní

ABSTRAKT: Chemickými rozbory byl zjišťován obsah živin u vzorků listů dvanácti odrůd broskvoní (Early Crest, May Crest, Flavor Crest, Sun Crest, Fayette, Katherina, Loadel, Andross, Everts, May Grand, Firebrite a Fairlane), které byly hodnoceny na čtyřech broskvoňových podnožích. Analýza variance prokázala velmi významný vliv odrůd a podnoží na obsahy jednotlivých živin v listech a také významnost vzájemné interakce těchto dvou faktorů. Vliv podnoží na příjem jednotlivých živin byl vyšší u vápníku, draslíku, fosforu, hořčíku a dusíku a nižší u mědi, zinku, železa, manganu a boru. Odrůdy štěpované na podnoži GF 677 měly obecně vyšší obsah dusíku, draslíku, železa, mědi a nižší obsah zinku, manganu a boru, kdežto listy odrůd naštěpovaných na broskvoňovém semenáči obsahovaly více hořčíku a méně fosforu, draslíku a železa. Obsahy boru a vápníku byly vyšší u odrůd naštěpovaných na Sant Julien GF 655/2, zatímco odrůdy na podnoži Damas GF 1869 obsahovaly více fosforu, zinku, manganu a méně dusíku, boru, vápníku a mědi. Obsah listového dusíku byl nejnižší u odrůdy Fayette a obsah této živiny se průkazně odlišoval u všech ostatních odrůd. Obsah fosforu byl nejnižší u odrůdy Everts a nejvyšší u odrůdy Katherina. Odrůda Early Crest měla nejnižší obsah železa a zinku, odrůda Andross nejméně manganu a Loadel nejméně boru. Naproti tomu odrůda Flavor Crest měla vyšší obsah všech těchto živin. Obdobně obsah dusíku byl nejvyšší u odrůdy Katherina na podnoži Damas a u Fayette na této stejné podnoži. Také obsah hořčíku byl nejvyšší u odrůdy Fayette na podnoži Damas a naopak nejnižší u odrůdy Fairlane na této stejné podnoži. Úhyn stromů byl nejvyšší na podnoži Damas 1869 a nejnižší na Sant Julien. Z odrůd byl nejnižší úhyn stromů May Grand, Firebrite a Katherina. Zjištěné trendy v obsazích listových živin u odrůd i podnoží a jejich vzájemné interakce ukazují na značnou důležitost těchto faktorů při zakládání broskvoňových výsadeb a pro hnojení makroprvky i mikroprvky v těchto výsadbách.

Klíčová slova: broskvoně; odrůdy; podnože; živiny; obsah prvků; úhyn stromů; rozbory listů; hnojení

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