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Nutrient element variability in the leaves of almond trees in relation to variety, rootstock and the vegetative part of the tree

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ABSTRACT

Leaf samples from eight almond varieties viz. 'Non Pareil', 'Ferragnès', 'Texas', 'Retsou', 'Phyllis', '44/1/68', '30/1/68' and '24/16/68', grafted on almond and peach rootstocks, were analyzed for N, P, K, Ca, Mg, Fe, Mn, Zn and B.

The analysis of variance of the leaf nutrient concentrations indicated significant main effects and interactions among varieties, rootstocks and leaf positions.

Leaf N was highest for Retsou and lowest for 'Phyllis'. 'Nonpareil' and 'Ferragnès' had a lower leaf N content than 'Texas', '44/1/68', '30/1/68' and '24/1/68'. Leaf P was lowest for 'Texas' and highest for '24/16/68'. Leaf K of 'Retsou' and 'Ferragnès' was lower than that of '44/1/68', 'Nonpareil' and 'Phyllis'. Leaf Ca was highest for 'Texas' and lowest for '24/16/68'. 'Phyllis', 'Retsou' and '30/1/68' were lower than 'Ferragnès', '44/1/68', 'Nonpareil' and 'Texas', in leaf Ca. Leaf Mg was highest for 'Retsou' and lowest for 'Phyllis' and '24/16/68'. Considerable differentiation was noted as well, in the micronutrient content of leaves of these varieties.

Higher leaf levels of N, K, Mg and B were associated with peach rootstocks. Mid-shoot leaves were higher in N and P than spur leaves.

The observed trends in the leaf nutrient composition, as regards the varieties, rootstocks and leaf positions, emphasize the importance of these factors when chemical analysis of leaves is used for diagnosing the nutrient status of almond trees.

RESUME

VARIABILITE DES ELEMENTS NUTRITIFS DANS LES FEUILLES D'AMANDIER EN FONCTION DES VARIETES, DES PORTE-GREFFES ET DE L'EMPLACEMENT DES FEUILLES

Des échantillons de feuilles de huit variétés d'amandier ('Non Pareil', 'Ferragnès', 'Texas', 'Retsou', 'Phyllis', '44.1.68'), '30.1.68', et '24.16.68' greffées sur Amandier et sur Pêcher ont été analysés pour leur teneur en N, P, Mg, Fe, Mn, Zn et B.

L'analyse de variance des teneurs mesurées de ces différents éléments révèle des effets principaux et des interactions significatifs parmi les variétés, les porte-greffes et l'emplacement des feuilles.

La teneur en N a été maximum pour 'Retsou' **et minimum pour** 'Phyllis'. 'Non Pareil' **et** 'Ferragnès' **ont eu une teneur inférieure à celle de** 'Texas', '44.1.68' **et** '30.1.68'.

La teneur en P fut maximum pour '24.16.68' **et minimum pour** 'Texas'.

La teneur en K fut plus faible pour 'Retsou' **et** 'Ferragnès' **que pour** '44.1.68', 'Non Pareil' **et** 'Phyllis'.

La teneur en Ca fut la plus élevée pour 'Texas' **et la plus faible pour** '24.1.68'. 'Phyllis', 'Retsou' **et** '30.1.68' **eurent des teneurs plus faibles que** 'Ferragnès', '44.6.68', 'Non Pareil' **et** 'Texas'.

La teneur en Mg fut la plus élevée pour 'Retsou' **et la plus faible pour** 'Phyllis' **et** '24.16.68'.

Des différences importantes furent également observées pour les oligoélements dans les feuilles de ces variétés.

La teneur la plus élevée en N, K, Mg et B était associée au porte-greffe pêcher.

Les feuilles situées au milieu des rameaux moyens ont une teneur plus élevée en N et P que celle des bouquets de mai.

Ces observations sur la variation de la teneur des feuilles en éléments minéraux selon les variétés, les porte-greffes et l'emplacement sur le rameau, montrent l'importance des précautions à prendre pour l'échantillonnage destiné à renseigner le producteur sur l'état nutritionnel des arbres.

INTRODUCTION

Inorganic leaf analysis has been used extensively as a diagnostic tool for a direct assessment of the nutritional status of crop plants, and especially of fruit trees. This method of diagnosis is based on the existing relationship between the concetration of nutrient elements in specific leaves at certain stages of plant development and the growth and crop performance of plants (5, 16, 19).

Though the nutrient composition of leaves is controlled primarily by nutrient supply, it is also influenced by internal and external factors (1, 2). Owing to these influences, considerable variation occurs in the nutrient content, even in leaf samples taken from plant species growing in soils with similar nutrient availability. Therefore, the magnitude and significance of the influences of such factors become of utmost importance in leaf sampling and the intepretation of the results of chemical analysis of leaves.

With regard to almond trees, available information in the literature indicates that the nutrient status of leaves has been related to the presence of deficiency or excess symptoms of nutrients (7, 12), as well as to crop performance of trees (4, 8, 15, 18). However, data concerning the factors which affect the composition of leaves are very limited. These refer to the stage of growth (18), the rootstock (3,10), the excess of sodium chloride (3, 6, 9, 14) and the age of plants (17). Leaf samples taken for analysis included basal or mid-shoot leaves (7, 15) or leaves from nonbearing spurs (4, 13).

In Greece almond orchards are grown mostly without irrigation in regions of low rainfall in late spring and summer. They include about twelve millions of trees and are grown in a wide range of soil and climatic conditions. Almond industry has been expanded quite recently in Greece and very limited work has been conducted for the assessment of the nutritional status and the fertilizer requirements of this crop. In this connection, it should be noted that visual deficiency symptoms and low leaf nutrient levels have been observed in many instances and they indicate that nutritional disorders might constitute one of the main causes of low yields in many almond growing areas.

For these reasons, in the framework of a project for the improvement of almond production in Greece, particular emphasis is given to the diagnosis and control of nutritional disorders of this crop. Almond orchards are scattered in different districts and any effort to detect and identify nutritional problems in large scale should be relied on diagnostic leaf analysis. Thus, it was felt necessary to obtain some experimental data which would allow comparison of leaf nutrient levels and interpretation of analytical results.

The experimental results given in this report refer to variety, rootstock and leaf type, as factors affecting the nutrient levels of almond leaves.

MATERIAL AND METHODS

Leaf samples were collected form young bearing almond trees which form the variety collection of the Pomology Institute of Naoussa. The trees are grafted on almond and peach rootstocks and produced a moderate yield in the year of sampling. Leaf samples were taken individually from four trees per variety and a total of eight varieties were used. Two samples were taken per tree, each of 100 leaves; one sample included leaves from the middle portion of extension shoots of an average length, and the other leaves from nonberaring spurs. Immediately after collection, leaf samples were placed in the refrigerator. Next day, leaves were washed by gentle scrubing in a detergent solution, and rinsing first in tap water and then, twice in distilled water. Washed leaves were placed in a warm air draught to remove surface moisture and then dried in a forced draught oven at 70° C.

Nutrient content of leaves was determined with the analytical procedures currently used at the Benaki Plant Pathology Institute for diagnostic purposes (11). In this way, dried leaves were ground in a Micro Hammer Mill to pass a 1 mm sieve and stored in plastic containers. Small quantities of the ground material were digested in sulphuric acid for the determination of N, P and K or in a mixture of nitric and perchloric acid for the determination of Ca, Mg, Fe, Mn, and Zn. For B determination, leaf material was dry ashed at 550° C. Nitrogen was determined as ammonia, by distillation in the Markham apparatus, P by the vanadomolybdophosphoric method, and K by flame photometry. Other metallic elements were determined by atomic absorption spectroscopy, and B by the quinalizarine colorimetric method.

Of the eight varieties used, four are commercially grown viz., *'Nonpareil', 'Ferragnès', 'Texas'* and *'Retsou'*; the other four are hybrids produced at the Pomology Institute and are designated as *'44/1/68', '30/1/68', '24/16/68'* and *'Phyllis'*(1). All trees were in a good growth condition and leaves were taken from different sites of their canopy. The variety *'Ferragnès'* bears fruits on short spurs, and the varieties *'Nonpareil', 'Phyllis', 'Texas'* and *'24/16/68'* form fruits on short shoots of the last year's growth. *'Retsou'* has longer fruiting spurs than *'Nonpareil'* and *'44/1/68'*, whereas *'30/1/68'* is placed between *'Retsou'* and *'Nonpareil'*, with respect to fruiting spur length.

RESULTS

The analysis of variance of the nutrient concetrations of leaves indicated significant main effects and interactions among the varieties, the rootstocks and the two types of leaves (table 1).

The results for individual leaf nutrients are given in the following.

Nitrogen

As shown in Table 2, leaf N fluctuated among the varieties and in many instances significant differences were found between them. *'Retsou'* was the highest and *'Phyllis'* the lowest in leaf N. Nitrogen levels of mid-shoot leaves were higher than those of spur leaves in all varieties but *'Phyllis'* and *'Retsou'*, when grafted on peach. Rootstocks affected leaf nutrient concentration significantly but their effects were not consistent.

Phosphorus

Mean values of leaf P concentrations are shown in Table 3. The varieties and the types of leaves influenced the P content of leaves significantly. The variety *'24/1/68'* was the highest and *'Texas'* and *'Ferragnes'* the lowest in leaf P. Leaves from the middle portion of shoots had a higher leaf P level than those from nonbearing spurs. Peach rootstocks tended to decrease leaf P levels, but this effect was not found to be statistically significant.

Potassium

The average K content of leaves is shown in Table 4. The varieties *'44/1/68', 'Nonpareil'* and *'Phyllis* were higher in leaf K than the varieties *'Retsou'* and *'Ferragnès'*. Leaf K levels of the other varieties did not differ significantly. Also, no significant differences were found between the two types of leaves, but there was a tendency for spur leaves to contain more K in all varieties, except *'30/1/68'*, on almond and *'Retsou'* and *'Texas'*, on peach. The increased leaf K values associated with peach rootstocks were found to be significant in many varieties.

Calcium

As shown in Table 5, leaf Ca fluctuated considerably among the varieties; in many instances significant differences were found between them. The variety *'24/16/68'* was the lowest and *'Texas'* the highest in leaf Ca. The varieties *'Phyllis', 'Retsou'* and *'30/1/68'* had a lower Ca content than the varieties *'Ferragnès', '44/1/68'* and *'Nonpareil'*. Though there was a tendency for spur leaves to contain more Ca than mid-shoot leaves, no significant differences were found between them. Increases in the levels of leaf Ca associated with almond rootstocks, were found to be significant in most varieties.

Magnesium

Mean values of the Mg content of leaves of eight almond varieties are presented in Table 6. *'Retsou'* was the highest and *'Nonpareil'* and *'Texas'* next to highest in leaf Mg. Varieties differed significantly in their Mg content. The hybrids *'24/16/68'* and *'30/1/68'* contained less Mg content. The hybrids *'24/16/68'* and *'30/1/68'* contained less Mg than their parents viz., *'Retsou'* and *'Nonpareil'*. Leaf Mg was not affected by leaf position, but it was higher in varieties grafted on peach.

Iron

The results for the mean iron content of leaves are given in Table 7. Many varieties differed significantly

(1) They come from crossing as follows : Retsou × DS No 3, Retsou × Nonpareil, Retsou × Nonpareil, and Texas × Italian variety, respectively.

in their leaf Fe content. The varieties *'24/16/68'* and *'Nonpareil'* were the highest in leaf Fe. Leaf position and rootstock did not influence significantly the iron level of leaves.

Manganese

Mean values of the Mn content of leaves of eight almond varieties are shown in Table 8. Varieties differed significantly with respect to leaf Mn concentration, but leaf position had no effect on it. Almond rootstocks increased the concentration of Mn in the leaves of all varieties, except hybrid *'30/1/68'*.

Zinc

The results for the average zinc content of leaves of the eight almond varieties used in this study are presented in Table 9. A relatively wide range of leaf Zn values was found among the varieties. The hybrids *'30/1/68'* and *'24/16/68'* had the highest Zn content which exceeded that of their parents viz., *'Nonpareil'* and *'Retsou'*. Spur and mid-shoot leaves did not differ in their Zn content significantly, but there was a trend for the former to have a higher Zn level; this was more pronounced in *'Ferragnès'*, on peach and in the hybrid *'30/1/68'*, on almond. An opposite trend was observed in *'Retsou'*, when grafted on peach.

Boron

The average B content of the leaf samples taken from eight almond varieties is presented in Table 10. Varieties differed significantly, but leaf position had no effect on the B levels of leaves. Grafting on peach resulted in a higher B concentration in the leaves.

DISCUSSION AND CONCLUSIONS

The success of diagnostic leaf analysis in almonds, as in other crops, depends largely on sampling procedure; this should take into account the variability in the nutrient content of leaves, so that leaf samples taken for analysis to reflect better the nutrient status of trees.

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. Such studies have not been conducted for almond trees and current use of foliar diagnosis relies on standard leaf nutrient values which do not take into account stionic and other effects on the nutrient levels of leaves.

The varieties included in this study showed significant differences in the concentration of nutrients in their leaves. This result could be taken as an indication of differences in nutrient requirements or the ability to obtain mineral nutrients. The varieties *'Texas'* and *'Ferragnès'*, which were found relatively low in leaf B exhibit often fruit drop early in the spring due to B deficiency (Stylianides, D. and Loupassaki, unpublished results). This deficiency should be attributed rather to a limited capacity of *'Texas'* and *'Ferragnes'* varieties to use soil B than to a lack of this nutrient; other varieties grown on the same orchard do not show this disorder. On the other hand, the higher leaf N levels of *'Retsou'* would indicate a more efficient use of soil N, and this might be one of the factors which enable this variety to crop well on soils of moderate fertility.

It is noteworthy the differences in the leaf nutrient concentrations of the varieties associated with the two rootstocks. Almond orchards are intended mainly for marginal soils, with respect to nutrient availability therefore, such effects might be decisive in the aquisition of nutrients of low availability in the soil. Peach rootstocks were associated with higher leaf B levels, but the opposite is true for leaf Zn.

Regarding the composition of the two types of leaves, it should be noted that it was not consistent and altered with the nutrient element, the variety or the rootstock. However, there existed a tendency for shoot leaves to have higher N, P, and Mn and less Ca, Mn, B, and Zn concentrations than spur leaves.

The results obtained in this work emphasize the importance of the variety, the rootstock and the position of leaves as sources of variability in the inorganic composition of almond leaves. These data on leaf nutrient concentrations should be taken rather as indicating some tendencies and not actual ranges of nutrient elements in the leaves of the respective varieties. A more extensive leaf sampling is necesary for an assesment of these ranges and the magnitude of the components of the overall variability of the concentration of nutrients in the leaves of almond trees.

Table 1

The variability of the concentration of nutrient elements in the leaves of almonds in relation to variety rootstock and leaf position. Significance of F ratios for the main effects and interactions.

Source of variability	Degrees of freedom	F ratios N	P	K	Ca	Mg	Fe	Mn	Zn	B
Variety (V)	7	0.871**	$8.2X10^{-4}$**	0.242**	4.862**	0.247**	2582.2**	396.2**	1338.1**	286.7**
Rootstock (R)	1	0.104*	$1.3X10^{-5}$	3.582**	12.519**	1.449**	97.6	1288.0**	2651.3**	1603.9**
Leaf position (L)	1	1.053**	$5.9X10^{-3}$**	0.104	33.836**	0.219**	205.7	495.7**	2691.7**	107.9**
Interaction V X R	7	0.144**	$9.6X10^{-5}$	0.208*	0.727**	0.046**	3157.2**	448.8**	266.5**	22.7*
Interaction V X L	7	0.122**	$1.7X10^{-4}$*	0.014	0.261	0.010	141.5	24.0	104.2	18.3
Interaction R X L	1	0.689**	$1.4X10^{-4}$	0.0009	1.988	0.002	0.001	97.9	152.0	47.2*
Interaction V X R X L	7	0.373**	$4.1X10^{-5}$	0.022	0.154	0.002	649.2*	26.0	82.2	19.8
Error	96	0.025	$7.4X10^{-5}$	0.074	0.214	0.0091	239.6	81.7	72.0	10.0
CVo/o		6.5	7.9	18.7	10.9	12.1	20.0	25.2	25.7	8.4

Significance at 5o/o and 1o/o levels is designated by * and ** respectively.

Table 2

Nitrogen content of mid-shoot and nonbearing spur leaves of eight almond varieties grown on almond and peach rootstocks

N, as per cent leaf dry matter

Rootstocks	Leaf Position	Varieties Nonpareil	Ferragnes	Phyllis	44/1/68	24/16/68	Retsou	Texas	30/1/68	
Almond	mid-shoot	2.36	2.56	1.97	2.67	2.76	3.12	2.66	2.64	2.59
	spur	2.16	2.29	1.91	2.31	2.42	2.32	2.28	2.42	2.26
Peach	mid-shoot	2.50	2.35	2.17	2.54	2.73	2.59	2.56	2.58	2.50
	spur	2.15	2.18	2.38	2.38	2.46	3.56	2.17	2.46	2.47
LSD 0.05		0,110								0.055
Almond		2.26	2.43	1.96	2.49	2.59	2.72	2.47	2.53	2.43
Peach		2.32	2.27	2.28	2.46	2.60	3.08	2.37	2.52	2.49
LSD 0.05		0.110								0.055
Mid-shoot		2.43	2.46	2.07	2.61	2.75	2.86	2.61	2.61	2.55
spur		2.16	2.24	2.15	2.35	2.44	2.94	2.23	2.44	2.37
LSD 0.05		0.110								0.055
Varieties		2.24	2.35	2.11	2.48	2.59	2.90	2.42	2.53	2.45
LSD 0.05		0.110								

Table 3

Phosphorus content of mid-shoot and nonbearing spur leaves of eight almond varieties grown on almond and peach rootstocks

P, as per cent leaf dry matter

Rootstocks	Leaf Position	Nonpareil	Ferragnes	Phyllis	44/1/68	24/16/68	Retsou	Texas	30/1/68	
Almond	mid-shoot	0.128	0.116	0.115	0.125	0.128	0.118	0.107	0.119	0.120
	spur	0.096	0.098	0.095	0.118	0.115	0.106	0.094	0.109	0.104
Peach	mid-shoot	0.114	0.099	0.113	0.109	0.123	0.109	0.105	0.117	0.111
	spur	0.093	0.091	0.100	0.107	0.113	0.104	0.085	0.103	0.100
LSD 0.05		n. s.								n. s.
Almond		0.112	0.108	0.105	0.122	0.122	0.112	0.101	0.114	0.112
Peach		0.104	0.095	0.107	0.108	0.118	0.107	0.095	0.110	0.106
LSD 0.05		n. s.								n. s.
Mid-shoot		0.121	0.108	0.114	0.117	0.126	0.114	0.106	0.118	0.116
spur		0.094	0.095	0.098	0.113	0.114	0.105	0.090	0.106	0.102
LSD 0.05		0.006								0.003
Varieties		0.108	0.101	0.106	0.115	0.120	0.109	0.098	0.112	0.108
LSD 0.05		0.006								

Table 4

Posasium content of mid-shoot and nonbearing spur leaves of eight almond varieties grown on almond and peach rootstocks

K, as per cent leaf dry matter

Rootstocks	Leaf Position	Nonpareil	Ferragnes	Phyllis	44/1/68	24/16/68	Retsou	Texas	30/1/68	
Almond	mid-shoot	1.032	1:087	1.424	1.240	1.365	1.079	1.371	1.178	1.222
	spur	1.288	1:126	1.532	1.387	1.463	1.216	1.443	1.087	1.318
Peach	mid-shoot	1.884	1:457	1.632	1.606	1.389	1.450	1.541	1.735	1.587
	spur	1.966	1:503	1.682	1.825	1.499	1.334	1.511	1.858	1.647
LSD 0.05		n. s.								n. s.
Almond		1.160	1:106	1.478	1.313	1.414	1.147	1.407	1.132	1.269
Peach		1.925	1:480	1.657	1.715	1.444	1.392	1.626	1.796	1.629
LSD 0.05		0.191								0.095
Mid-shoot		1.458	1:272	1.528	1.423	1.377	1.264	1.456	1.456	1.404
spur		1.627	1:314	1.607	1.606	1.481	1.275	1.477	1.472	1.482
LSD 0.05		n. s.								n. s.
Varieties		1.542	1:293	1.567	1.514	1.429	1.270	1.466	1.464	1.444
LSD 0.05		0.191								

Table 5

Calcium content of mid-shoot and nonbearing spur leaves of eight almond varieties grown on almond and peach rootstocks

Ca, as per cent leaf dry matter

Rootstocks	Leaf Position	Nonpareil	Ferragnes	Phyllis	44/1/68	24/16/68	Retsou	Texas	30/1/68	
Almond	mid-shoot	4.08	4.16	3.26	4.65	3.15	3.52	4.67	3.81	3.91
	spur	5.84	5.52	4.41	5.55	4.21	4.87	6.45	4.67	5.19
Peach	mid-shoot	4.27	3.61	3.53	3.66	2.58	3.16	3.93	3.56	3.54
	spur	4.65	4.47	4.52	4.26	3.15	4.26	5.07	4.15	4.32
LSD 0.05		n. s.								n. s.
Almond		4.69	4.84	3.84	5.10	3.68	4.19	5.56	4.24	4.52
Peach		4.46	4.04	4.02	3.96	2.86	3.71	4.50	3.85	3.92
LSD 0.05		0.325								0.163
Mid-shoot		4.18	3.88	3.39	4.15	2.86	3.34	4.30	3.68	3.72
spur		5.25	4.99	4.46	4.90	3.68	4.56	5.76	4.41	4.75
LSD 0.05		n. s.								0.163
Varieties		4.71	4.44	3.93	4.53	3.27	3.95	5.03	4.05	4.239
LSD 0.05		0.325								

Table 6

Magnesium content of mid-shoot and nonbearing spur leaves of eight almond varieties grown on almond and peach rootstocks

Mg, as per cent leaf dry matter

Rootstocks	Leaf Position	Nonpareil	Ferragnes	Phyllis	44/1/68	24/16/68	Retsou	Texas	30/1/68	
Almond	mid-shoot	0.724	0.597	0.488	0.647	0.580	0.745	0.632	0.677	0.636
	spur	0.772	0.715	0.535	0.753	0.596	0.888	0.808	0.747	0.726
Peach	mid-shoot	1.058	0.836	0.703	0.743	0.731	1.110	0.938	0.738	0.857
	spur	1.042	0.940	0.770	0.795	0.774	1.248	1.070	0.843	0.935
LSD 0.05		n. s.								n. s.
Almond		0.748	0.656	0.511	0.700	0.588	0.816	0.720	0.712	0.677
Peach		1.050	0.888	0.736	0.769	0.752	1.179	1.004	0.790	0.896
LSD 0.05		0.0672								0.0342
Mid-shoot		0.891	0.716	0.595	0.695	0.655	0.927	0.785	0.707	0.746
spur		0.907	0.827	0.652	0.774	0.685	1.068	0.939	0.795	0.830
LSD 0.05		n. s.								0.0342
Varieties		0.900	0.772	0.624	0.734	0.670	0.997	0.862	0.751	0.788
LSD 0.05		0.0672								

Table 7

Iron content of mid-shoot and nonbearing spur leaves of eight almond varieties grown on almond and peach rootstocks

Fe, as p.p.m. leaf dry matter

Rootstocks	Leaf Position	Varieties: Nonpareil	Ferragnes	Phyllis	44/1/68	24/16/68	Retsou	Texas	30/1/68	
Almond	mid-shoot	95.53	66.38	62.75	59.71	129.57	55.00	76.95	68.90	76.85
	spur	69.44	77.14	78.76	69.68	127.05	62.22	64.97	85.78	79.38
Peach	mid-shoot	94.10	63.92	61.25	86.77	69.15	75.91	65.93	103.50	77.57
	spur	103.63	70.00	55.14	88.34	64.38	79.12	73.45	60.61	74.33
LSD 0.05		10,89								n. s.
Almond		82.48	71.76	70.75	64.69	128.31	58.61	70.96	77.34	78.11
Peach		98.86	66.96	58.19	87.55	66.76	77.51	69.69	82.02	75.94
LSD 0.05		n. s.								n. s.
Mid-shoot		94.81	65.15	62.00	73.24	99.36	65.45	71.44	86.20	77.21
spur		86.53	73.57	66.95	79.01	95.71	70.67	69.21	73.19	76.85
LSD 0.05		n. s.								5.45
Varieties		90.67	69.36	64.47	76.12	97.54	68.06	70.32	79.70	77.03
LSD 0.05		10.89								

Table 8

Manganese content of mid-shoot and nonbearing spur leaves of eight almond varieties grown on almond and peach rootstocks

Mn, as p.p.m. leaf dry matter

Rootstocks	Leaf Position	Varieties: Nonpareil	Ferragnes	Phyllis	44/1/68	24/16/68	Retsou	Texas	30/1/68	
Almond	mid-shoot	37.30	45.03	42.93	43.69	54.35	35.31	35.63	26.76	40.12
	spur	37.79	40.57	44.47	32.84	52.29	31.00	36.67	26.07	36.67
Peach	mid-shoot	35.94	38.07	37.57	42.29	35.15	31.59	22.10	41.10	35.51
	spur	25.25	31.69	32.40	35.50	30.26	26.65	17.30	39.62	23.83
LSD 0.05		n. s.								n. s.
Almond		37.54	42.80	43.70	38.26	53.32	33.15	36.00	26.41	38.89
Peach		30.59	34.88	34.98	38.87	32.70	29.12	19.70	40.51	32.66
LSD 0.05		6.359								3.180
Mid-shoot		36.62	41.55	40.25	42.96	44.75	33.45	28.86	34.08	37.81
spur		31.52	36.13	38.43	34.17	41.27	28.82	26.83	32.84	33.75
LSD 0.05		n. s.								3.180
Varieties		34.07	38.84	39.34	38.58	43.01	31.14	27.85	33.46	35.79
LSD 0.05		6.359								

Table 9

Zinc content of mid-shoot and nonbearing spur leaves of eight almond varieties grown on almond and peach rootstocks

Zn, as p.p.m. leaf dry matter

Rootstocks	Leaf Position	Nonpareil	Ferragnes	Phyllis	44/1/68	24/16/68	Retsou	Texas	30/1/68	
Almond	mid-shoot	30.24	26.80	26.29	25.99	56.47	24.21	26.53	43.66	32.52
	spur	36.96	34.73	41.61	39.47	63.43	32.35	37.95	60.00	43.42
Peach	mid-shoot	26.72	15.90	22.09	26.91	24.75	34.69	12.34	36.94	25.04
	spur	26.84	27.02	30.51	34.11	47.26	26.30	18.92	45.30	32.03
LSD 0.05		n. s.								n. s.
Almond		33.60	30.76	33.95	32.73	59.95	28.28	32.24	51.83	37.92
Peach		26.78	21.46	26.30	30.51	36.00	30.49	15.63	41.12	28.54
LSD 0.05		5.972								2.941
Mid-shoot		28.48	21.35	24.19	26.45	40.61	29.45	19.43	40.30	28.78
spur		31.90	30.87	36.06	36.79	55.34	29.32	28.43	52.65	37.67
LSD 0.05		n. s.								2.941
Varieties		30.19	26.11	30.12	31.62	47.98	29.39	23.93	46.47	33.087
LSD 0.05		5.972								

Table 10

Boron content of mid-shoot and nonbearing spur leaves of eight almond varieties grown on almond and peach rootstocks

B, as p.p.m. leaf dry matter

Rootstocks	Leaf Position	Nonpareil	Ferragnes	Phyllis	44/1/68	24/16/68	Retsou	Texas	30/1/68	
Almond	mid-shoot	33.8	27.0	32.7	31.1	33.1	42.2	31.8	39.4	33.9
	spur	34.9	27.8	32.0	32.2	35.5	44.5	32.1	37.3	34.5
Peach	mid-shoot	44.0	34.2	40.6	36.0	40.0	43.8	37.5	42.0	39.8
	spur	38.1	37.5	45.6	36.2	46.6	50.0	41.5	46.9	42.8
LSD 0.05		n. s.								1.114
Almond		34.3	27.4	32.3	31.6	34.3	43.3	31.9	38.3	34.2
Peach		41.0	35.8	43.1	36.1	43.3	46.9	39.5	44.4	41.3
LSD 0.05		2.227								1.114
Mid-shoot		38.9	30.6	36.6	33.5	36.5	43.0	34.6	40.7	36.8
spur		36.5	32.6	38.8	34.2	41.0	47.2	36.8	42.1	38.6
LSD 0.05		n. s.								1.114
Varieties		37.7	31.6	37.7	33.9	38.8	45.1	35.7	41.4	37.74
LSD 0.05		2.227								

BIBLIOGRAPHY

1) ALDRICH, S. R., 1973. *Plant analysis: Problems and opportunities. In Soil testing and Plant Analysis.* pp. 213-221. (L. M. Walsh & L. D. Beaton, Eds) Soil Sci. Soc. Amer. Inc. Madison, Wisconsin, U.S.A.

2) BATES, T.E. 1971. *Factors affecting critical nutrient concentrations in plants and their evaluation:* A review. Soil Sci., 112: 116-130.

3) BERNSTEIN, L. ; BROWN, J.U. ; and HAYWARD, H. E. 1956. *The influence of rootstock on growth and salt accumulation in stone fruit trees and almonds.* Proc. Amer. Soc. hort. Scoi., 68: 86-95.

4) BEUTEL, J. ; URIU, K. ; and LILIELAND, O. 1978. *Leaf analysis for California deciduous fruits. In Soil and Plant Tissue Testing in California.* pp. 11-14.

5) BOULD, C. 1968. *Lead analysis as a diagnostic method and advisory aid in crop nutrition.* Exp. Agric., 4: 17-27.

6) BROWN, J. W. ; WADLEIGH, C. H. ; and HAYWARD, H. E. 1953. *Foliar analysis of stone fruit and almond trees on saline substrates.* Proc. Amer. Soc. hort. Sci, 61: 49-55.

7) CHAPMAN, O. 1966. *Diagnostic criteria for plants and soils.* University of California, Division of Agricultural Sicences.

8) CLEM, M. ; WARREN, C.M. ; and RIZZI, A. D. 1974. *Almond production.* Coperative Extention, University of California.

9) EHLIG, C. F. ; and BERNSTEIN, L. 1959. *Foliar absorption of sodium and chloride as a factor in sprinkler irrigation.* Proc. Amer. Soc. Hort. Sci, 74: 661-670.

10) 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.

11) HOLEVAS, C. D. 1978. *A brief report on chemical methods used for diagnostic plant analysis at the Benaki Plant Pathology Institute.* Compte-Rendu de la 37 ème session. Comite Inter-Institut d'Etudes des Techniques Analytiques du Diagnostic Foliaire. Bolognia, Italy, March 30-31, 1978.

12) KENWORTHY, A. L. ; and MARTIN, Lloyd, 1966. *Mineral content of fruit crops. In Nutrition of Fruit Crops.* pp. 813-870. (N. F. Chiders, Ed.) Horticultural publications, Rutgershe State University, New Brunswick, New Jersey, U.S.A.

13) KESTER, D. E. ; URIU, K. ; and ALDRICHT, T. 1961. *Copper deficiency in almond and its response to treatment.* Proc. Amer. Soc. hort. Sci, 77: 286-294.

14) LILELAND, O. ; BROWN, J. G. ; and SWANSON, C. 1945. *Research shows that sodium may cause leaf tip burn.* Almond Facts, 9: 1-5.

15) MONASTRA, F. 1975. *Application du diagnostic foliaire à la fumure des amandiers.* 2 éme Colloque du G.R.E.M.P.A. Centre International des Hautes Etudes d'Agronomiques Méditerranénnes, Montpellier, Numes, Septembre 8-11, 1975.

16) MUNSON, R. D. ; and NELSON, W. L. 1973. *Principles and practices in plant analysis. In Soil Testing and Plant Analysis.* pp. 223-248. (L. M. Walsh and J. D. Beaton, Eds.) Soil Sci. Soc. Amer. Inc., Madison, Wisconsin, U.S.A.

17) PROCOPIOU, J. ; PAPANICOLAOU, X. ; HARITOU, A. ; and WALLANCE, A. *Leaf elemental concentration and variability of 30 young almond seedlings grown in Athens.* Option Méditerrannéennes, pp. 161-163.

18) PROEBSTING, E. L. ; and STERR, E. F. 1966. *Edible nuts. In Nutrition of Fruit Crops.* pp. 262-275. (N. F. Childers, Ed.). Horticultural publications, Rutgers-the State University, New Brunswick, New Jersey, U.S.A.

19) SMITH, P.F. 1962. *Mineral analysis of plant tissues.* Ann Rev. Plant Physiol. 13: 81-108.